



# HCAS Supplementary Documents

2019–2021 Biennium

PREPARED BY

**ECON**orthwest

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# Appendix A: Glossary

## GLOSSARY OF HIGHWAY COST ALLOCATION TERMS

### LIST OF ACRONYMS

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

### 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).

**AMT:** See Axle Miles of Travel

**Arterial:** A road or highway used primarily for through traffic.

**ATR:** See Automatic Traffic Recorder

**Automatic Traffic Recorder:** A device that records the number of vehicles passing a point on a road. May be permanent or temporary, may record individual lanes separately, may identify vehicle configurations, and may also record vehicle speeds.

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

**Axle Miles of Travel (AMT):** Vehicle miles of travel multiplied by number of axles. Because 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 aging 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 individuals 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.

**ESAL:** See Equivalent Single Axle Load

**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.

**FHWA:** Federal Highway Administration, an agency within the US Department of Transportation that supports State and local governments in the design, construction, and maintenance of the Nation's highway system.

**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.

**HCAS:** See Highway Cost Allocation Study

**Heavy 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.

**HPMS:** See Highway Performance Measurement System

**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 more than 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.

**MCTD:** See Oregon Motor Carrier Transportation Division

**NAPCOM:** See National Pavement Cost Model

**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:** 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.

**ODOT:** Oregon Department of Transportation

**Operating Weight:** The actual weight of a vehicle at a particular time.

**Oregon Motor Carrier Transportation Division:**

A division within the Oregon Department of Transportation that regulates commercial trucking within the state.

**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.

**PCE:** See Passenger Car Equivalent

**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 98,000 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.

**SRT:** Study Review Team

**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.

**VMT:** See Vehicle Miles of Travel

**Weigh in Motion:** A device embedded in the roadway that captures the weight of each axle passing over it. May also record transponder IDs of transponder-equipped trucks, axle spacing, and speeds.

**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.

**WIM:** See Weigh in Motion

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# Appendix B: Other State HCASs

## INTRODUCTION

This document summarizes three highway cost allocation studies (HCAS) published during 2009 to 2016: Nevada 2009, Idaho 2010, and Minnesota 2012. This review of recent HCAS is intended to investigate HCAS processes and methods used in other states, with particular attention paid to innovations, issues, or other methodologies or data that might be of use or interest for the Oregon HCAS process. The document also summarizes the findings from recent papers and reports on HCAS methods.

## SUMMARY

### OVERVIEW OF HCAS STUDIES

#### 2009 Nevada Highway Cost Allocation Study

The Nevada HCAS used the FHWA State HCAS software and methodology, conducted the study using ten vehicle classes (based on the HPMS vehicle classes), and presents equity ratios for vehicle weight using 2,000 lb. increments. The study included revenues from the vehicle sales tax and ad valorem tax for passenger vehicles. As a result, total state revenues were roughly 75% higher than total state expenditures in calculating the unadjusted state equity ratios. Inclusion of revenues that are diverted to non-highway increases the revenue shares for passenger vehicles. Two other unique aspects of the study are the inclusion of deferred maintenance costs for vehicle cost responsibility and the subtraction of federal stimulus funding from deferred maintenance. The study found that heavy vehicle user fees do not increase as fast as heavy vehicle cost responsibility. Light

vehicle classes have equity ratios greater than 1.0 and heavy vehicles have equity ratios less than 1.0.

#### 2010 Idaho Highway Cost Allocation Study

The report considers the equity of Idaho's tax structure for highway users and whether different vehicle classes are paying their proportional share of highway costs. The Idaho HCAS used a refined version of the FHWA State HCAS Model. The model was used to consider how adjustments to the current tax and fee structure and the implementation of a vehicle miles travelled (VMT) fee could affect equity ratios. The study differentiates user classes by vehicle class and weight for a total of 20 user classes. For state and federal programs combined, the study finds that highway user payments fall short of expenditures by 20% (\$139.5 million per year). The study also finds that when collections from state and federal programs are combined, payments from combination trucks fall short of cost responsibility by 33%, whereas payments from automobiles exceed cost responsibility by 47%. At a state level, similar results hold, with combination trucks' payments falling 27% short of cost responsibility and automobiles' payments exceeding cost responsibility by 26%.

#### Minnesota Highway Cost Allocation and Determination of Heavy Freight Truck Permit Fees, 2012

The report examines the pros and cons of different highway cost allocation methods to use in Minnesota and presents a methodology that is most appropriate for the conditions in Minnesota. The report first presents the results of using the State HCAS tool developed by the

FHWA. The report then develops and presents the results from a HCAS that was customized for the state, Minnesota Highway Cost Allocation Tool (MHCAT). The report also presents the findings from experiments on auction-based permitting systems.

### OREGON'S HCAS AND DIFFERENCES WITH OTHER STATES

#### Cost-Occasioned Approach and Incremental Method

Oregon, in addition to other states, uses the cost-occasioned approach for its HCAS. The basic idea behind this approach is that each class of road user should pay for the road system in proportion to the costs associated with the road use by that class.

Within the cost occasioned approach, Oregon uses the incremental method. This method divides particular aspects of highway costs into increments. It allocates the costs of successive increments to only the vehicles needing the higher cost increment.

A primary example of the incremental method is with bridge allocation costs. The first increment for a new bridge identifies the cost of building the bridge to support its own weight and other non-load related stresses. This is a common cost responsibility, and allocated across vehicle classes on basis of each user class's share of total VMT. The next increments identify the additional cost of building the bridge to accommodate progressively heavier weight classes of vehicle and the costs are allocated on the basis of relative VMT within a truncated range of vehicle weight classes.

## Oregon's Weight Mile Tax

A key difference between Oregon and other states is that Oregon implements a weight mile tax in addition to a fuel tax. The Federal FHWA HCAS tool does not support a weight mile tax. Oregon has developed its own HCAS tool that supports a weight mile tax. The weight mile tax is structured in terms of 2,000 pound increments.

Oregon's use of a weight mile tax means that it is able to achieve much better equity ratios. Without a weight mile tax, a state would have to rely on high truck registration fees since the fuel tax alone does not recover the damage to roads imposed by heavy trucks. As vehicle weights increase, the damages imposed to roads increases super-linearly, but fuel consumption increases sub-linearly. This means that as vehicle weights increase, the costs they impose on the road are increasingly higher than the amount of fuel taxes they pay. The inclusion of a weight mile tax allows the State to capture the higher costs from heavier vehicle weights.

It is interesting to note that the 2012 Minnesota report examines the hypothetical effects of including a weight-mileage fee where the user pays a usage fee based on vehicle miles traveled and the tax rate per mile is determined by the registered gross weight of the vehicle. Currently, Minnesota charges only a weight fee that is determined by a commercial vehicle's RGW (e.g., a registration fee). The report finds that adjusted equity ratios under both hypothetical weight-mile fee scenarios are closer to the target ratio (one) than the weight fees for most vehicle classes. Exhibit 2 (p. 105)

shows the adjusted ratios at the state level for the weight fees and the weight-mile fees.

### Other Differences

- Oregon uses 2,000 pound increments in its HCAS whereas most other states use 5,000 pound increments. This allows Oregon's HCAS to have a finer grain of analysis than other states.
- Oregon, Nevada, and Idaho use the National Pavement Cost Model (NAPCOM) for pavement costs. However, Oregon has modified NAPCOM to use 2,000 pound increments instead of 5,000 pound increments. The 2012 Minnesota report uses regression coefficients from NAPCOM for Minnesota to allocate pavement repair costs.
- Oregon uses different PCE VMT (regular and congested) allocators depending on the type of cost. For example, the common cost portion of projects that add highway capacity are allocated based on congested PCE VMT. Congested PCE VMT uses the shares of PCE-weighted VMT that are present during the most congested hour of the day on that functional class. Using congested PCE VMT in cases where costs are incurred to add capacity means that a portion of those costs is allocated based on the users that are driving the need for additional capacity.
- Unlike Nevada's 2009 HCAS, Oregon's HCAS does not include deferred maintenance. Oregon has looked at deferred maintenance when determining an efficient fee. However, Oregon does not

include deferred maintenance in its HCAS because it has very well-defined costs that are within the upcoming biennium.

- Oregon includes a studded tire adjustment that takes into account the additional damage that they cause to the roads.
- Oregon uses truncated VMT allocators for different types of costs to allocate those costs to a subset of all vehicles. For example, the collection costs of the motor carrier Transportation Division are allocated on the basis of VMT for vehicles over 26,000 pounds.
- Oregon's adjusted equity ratios reflect adjustments for subsidized vehicles. In contrast, Nevada's adjusted equity ratios do not consider subsidized vehicles and instead are calculated based on share of revenue and cost responsibility share, rather than gross dollar amounts.
- Exhibit 4 (pp. 109-110) provides a high-level overview of different states' HCASs. The table provides information on the states' HCAS methods, key allocators, types of revenue examined, and cost responsibility for heavy vehicles.

## OVERVIEW OF HCAS METHODS

### Models for Highway Cost Allocation, 2013

The report reviews the traditional HCAS methods (incremental, proportional, or a combination of the two), and then presents an alternative, non-traditional HCAS method that is based on concepts from the theory of cooperative games.

**A Road Pricing Methodology for Infrastructure Cost Recovery, 2010**

The broad motivating question for the report is: How can governments equitably recover infrastructure costs from truck users based on real-time operations and individual vehicles? The report presents a framework for charging commercial vehicles using weigh-in-motion (WIM) systems.

**Bridge Structure Comparative Analysis, Comprehensive Truck Size and Weight Limits Study, 2013**

This study provides a list of agencies that provide technical support through research, ongoing studies, and practice. The study provides a list of documents that the study reviewed with short summaries. A number of the documents address the issue of how to recover costs from heavy vehicles in proportion to the damage they cause on bridges.

**State Highway Cost Allocation Studies: A Synthesis of Highway Practice**

This report is intended to help states with HCAS methods by laying the foundation on current HCAS methods and areas of improvement for HCAS methods. The report reviews the HCAS methods used by different states, the conceptual foundation of HCAS methods, methods for revenue attribution, and arising issues with HCAS methods.

**HCAS BY OTHER STATES**

**2009 NEVADA HIGHWAY COST ALLOCATION STUDY**

The 2009 Nevada HCAS used a refined version of the 1997 FHWA State HCAS program (HCASP). The study covers the eight-year time horizon between 2009 and 2016. Ten vehicle classes (auto, bus, and eight single unit or tractor trailer truck classes) are used, based on the twelve HPMS vehicle classes. Equity ratios are tabulated by vehicle class and also by registered vehicle weight (using 2,000 lb. increments).

The 1999 Nevada HCAS adopted many of the recommendations from the 1994 audit of the Nevada HCAS process. Two additional recommendations were adopted in the 2009 HCAS:

- The use of more vehicle classes. Previously only basic and heavy vehicle classes were differentiated for reporting purposes.
- Inclusion of highway user fees that are diverted to non-highway uses (e.g., inclusion of federal highway funds diverted to mass transit and inclusion of state vehicle sales tax and ad-valorem tax revenues which are diverted to general fund).

Nevada calculates unadjusted and adjusted equity ratios. Unlike Oregon, Nevada’s adjusted equity ratios do not reflect subsidized vehicles. Rather, Nevada’s adjusted equity ratios are calculated based on share of revenue and cost responsibility share, rather than gross dollar amounts.

The primary difference between the equity ratios in the 1999 Nevada HCAS and 2009 Nevada study is the inclusion of revenues from the vehicle sales tax and the ad valorem (government service) tax. Another difference in the 2009 study from previous Nevada DOT studies is the use of the improved NAPCOM model and more accurate weigh-in-motion (WIM) data for operating weights of heavy vehicles.

Nevada DOT data sources were used when available for calculating revenue, determining future VMT, and determining expenditure classifications. The VMT forecast is based on the Nevada DOT VMT forecast and is validated by applying an assumed per-person annual mileage to Nevada’s forecasted population growth rate. There is no mention of differentiating VMT growth rates by vehicle class, although there is some discussion of per person mileage in rural versus urban areas of the state.

**Revenue Attribution**

The Nevada HCAS includes both federal and state revenues, and also includes all revenue sources regardless of their use (e.g., includes highway revenues diverted to non-highway purposes). As a consequence of including the vehicle sales tax and ad valorem tax, state revenues are forecast to exceed state highway expenditures by 75%. The study notes that this difference is “counterbalanced” by local expenditures, which exceed local user payments (since the state and local governments direct a portion of general funds to local roadways).

## Cost Responsibility

Assignment of expenditures to work categories is based on previous expenditures, funded projects data (e.g., STIP, etc.), and trends in project expenditures. In addition to funded future expenditures, the Nevada HCAS also includes estimates of deferred pavement and bridge preservation for allocation of system preservation costs. Nine project work types, covering the typical project categories for pavement, bridges, maintenance, preservation, etc., were used to classify highway expenditures.

Nevada received \$201 million in federal stimulus funding, of which \$130 million is deducted from the backlog of preservation and the remaining (\$71 million) is applied to projects along the National Highway System and urban projects in the STIP. The forecast of future expenditures was developed using recent trends in expenditures and anticipated revenues and consultation with NDOT. Projects were assigned work types based on recent year expenditures and programmed expenditures in the STIP. The FHWA State HCAS Model was used to estimate cost responsibility by vehicle class using the categorized expenditures and allocators for each type of expenditure. Cost allocation by work type is summarized based on the information in the HCAS report:

Pavement cost responsibility is determined using NAPCOM and vehicle class weight distributions developed from weigh-in-motion data. New bridge construction costs were allocated based on an incremental method, as applied in the FHWA HCASP model.

- Bridge replacement costs were allocated based on the replacement attributed to deficient load-bearing capacities relative to total degradation using the FHWA Bridge Sufficiency Rating formula.
- Bridge rehabilitation costs were apportioned based on determining the share of load-related costs relative to all costs based on a sample of bridge repair projects and default values from the FHWA's Bridge Needs and Investment Process.
- DMV expenditures related to the Motor Carrier Program were allocated to heavy vehicles, based on heavy vehicle VMT. The remaining DMV expenditures are allocated across all vehicle classes, based on shares of travel.
- Department of Public Safety expenditures include the State Emergency Response Commission (SERC), which responds to highway incidents. Heavy vehicles are allocated half of the SERC costs, based on the rationale that heavy vehicle crashes are more severe and require more time and expense to clear. The remaining DPS expenditures are allocated based on shares of travel.
- Administrative and overhead costs are allocated to vehicle classes in the same proportion as the sum of the capital and maintenance programs.
- Bond expenditures, both capital expenditures and debt service, are allocated in the same proportion as capital expenditures on urban interstate systems where the bond-financed projects are located.

## Equity Ratios and Findings

The study results are presented as unadjusted and adjusted equity ratios for each vehicle class and by registered gross vehicle weight. Unadjusted equity ratios are constructed as the ratio of gross (dollar amounts) revenues to expenditures from each vehicle class. Adjusted equity ratios are constructed as the ratio of the vehicle class share of revenues to share of expenditures.

As a result of the inclusion of the state vehicle sales tax and ad valorem taxes, state revenues exceed state expenditures. This results in an "overpayment" of highway revenues compared to expenditures and produces a total unadjusted equity ratio for state-only revenues and expenditures of 1.75, reflecting that state revenues exceed state expenditures by 75%.

The effect of including revenues used for non-highway purposes is partially obscured by the inclusion of deferred maintenance and the subtraction of federal stimulus dollars from those deferred preservation expenditures. Excluding vehicle sales tax and ad valorem tax revenues from the total state revenues increases the adjusted heavy vehicle class share of state revenues to 31.1% from 18.9%. The heavy vehicle adjusted equity ratio goes from 0.42 up to 0.74 (state revenues and expenditures only) when these non-highway revenues are excluded.

The findings from the study suggest that Nevada's heavy vehicle fee structure does not increase proportionally with registered weight; hence heavy vehicles tend to underpay. Only vehicles less than 8,000 lbs. have an adjusted equity ratio of 1.50. This is consistent with the findings from other states' HCAS.

## 2010 IDAHO HIGHWAY COST ALLOCATION STUDY

The report considers the equity of Idaho's tax structure for highway users and whether different vehicle classes are paying their proportional share of highway costs. The 2010 Idaho HCAS used a refined version of the FHWA State Highway Cost Allocation Tool (HCAT). The HCAT was used to consider how adjustments to the current tax and fee structure and the implementation of a vehicle miles travelled (VMT) fee could affect equity ratios.

Two factors affecting the 2010 Idaho HCAS include the repeal of the weight-distance tax in favor of a mileage-based registration fee system and the types of projects that are funded by the Grant Anticipation Revenue Vehicle (GARVEE) bonds influence the equity ratios in the report. Idaho issued GARVEE bonds that are backed by federal aid to advance its construction program. The GARVEE bond program affects the cost allocation, as a higher portion of expenditures are pavement-related, which in turn affects the cost responsibility for heavy trucks. Under the reduced GARVEE scenario, expenditures are equal to the annual debt service payments during the six-year time period.

The study uses 20 vehicle classes. Vehicle classes are differentiated by vehicle type and weight. The study has a six-year time period from 2007 to 2012. The study considers three levels of government: state, federal, and local expenditures and revenues. Travel and expenditure data are broken down by rural and urban highway functional classes. Rural includes interstate, principal arterials, minor arterials, major collectors, minor collectors

and local. Urban includes interstate, principal arterials, minor arterials, collectors and local. Travel data includes total vehicle miles traveled by the 20 vehicle classes and 11 functional road classifications.

Key findings from the Idaho HCAS include:

- Highway user payments fall short of expenditures by 20% (\$139.5 million per year) for state and federal programs combined.
- With state and federal programs combined, combination trucks' payments fall 33% short of cost responsibility (28% under reduced GARVEE scenario), whereas automobiles' payments exceed cost responsibility by 47% (38% under reduced GARVEE scenario).
- Considering state programs alone, combination trucks' payments fall 27% short of cost responsibility (14% under reduced GARVEE scenario), whereas automobiles' payments exceed cost responsibility by 26% (8% under reduced GARVEE scenario).

### Revenue Attribution

Revenue data include state and federal historical data from 2007 to 2009 and revenue forecasts based on Idaho Transportation Department (ITD) forecasts from 2010 to 2012. Revenue data include receipts from highway users from the tax and fee structure (e.g., registration fees, motor fuel taxes, driver's license fees, permit fees, and title fees).

The study obtained federal revenues that are attributable to highway users in Idaho for 2008 and 2009 from FHWA 2009 Highway Statistics. The FHWA estimates were forecast forward until

2012 using the revenue forecasts prepared by ITD. The federal tax revenue estimates reflect what Idahoans pay into the Federal Highway Trust Fund.

The study attributed revenue to the 20 vehicle classes and to registered gross weight classes in 2,000 lb. increments above 8,000 lbs. Some of the default data estimates in the FHWA HCAT were replaced with Idaho-specific inputs. The study worked with the ITD and other data sources to estimate the following characteristics for each vehicle class: VMT, percentage of VMT outside of Idaho, MPG, and number of registered vehicles. This allowed tax revenue to be attributed to each vehicle class. Fuel tax

revenues were attributed by vehicle class based on the VMT estimates and the vehicle class's MPG. Revenues from registration fees were attributed based on the breakdown of fees by vehicle class (passenger vehicles, trucks, and buses). The study also estimated the number of full fee equivalent vehicles by registered weight class based on total VMT and the average VMT per vehicle estimates.

### Cost Responsibility

The study uses expenditure data for nine categories: new pavements, rehabilitated pavements, new bridge, replacement bridge, repair bridge, grading, other construction, maintenance, and administration and other expenditures. Expenditure data were obtained for capital expenditures from ITD for the 2007-2012 time period.

The study estimated cost responsibility for each vehicle class using the FHWA HCAT. Idaho updated the FHWA HCAT to reflect Idaho's



highway system and vehicle use. The study used weigh-in-motion (WIM) data to refine weight-related HCAT model inputs. The study used a recent FHWA run of the National Pavement Cost Model (NAPCOM) with 2007 highway section data from ITD. The study uses bridge cost allocation procedures developed by the FHWA in the Federal HCASs in 1982 and 1997.

**Travel Data**

The study derived VMT data by functional road class and by vehicle class using vehicle classification data from 2004-2008, breakdowns of VMT by functional class from 2008 and 2009, and weigh-in-motion (WIM) data from 2008 and 2009 from ITD. The Idaho Highway Performance Monitoring System (HPMS) has 12 vehicle classes but the FHWA HCAT uses 20 vehicle classes. Idaho used the two years of WIM data to map the 12 HPMS vehicles classes estimated from the classification count data into the 20 vehicle classes. WIM data were only provided for three functional classes: rural interstate, rural principal arterial, and rural minor arterial. The study had to make further assumptions on how to apply the vehicle splits to other roads.

**Equity Ratios and Findings**

The Idaho HCAS reports the unadjusted and adjusted equity ratios for the state level as well as the state and federal levels combined. Similar to HCAS in other states, as registered gross weights increase, equity ratios decrease.

One particularity of the Idaho HCAS is the GARVEE bond program. The GARVEE bond program affects the cost allocation, in that a much higher proportion of highway funds are directed toward pavement expenditures. Since

most pavement costs are a result of the impact of heavy trucks, the bond program significantly increases the cost responsibility to heavy trucks (in particular, trucks with 12,000-18,000 lbs. per axle or 28,000-34,000 lbs. per pair of axles).

The researchers performed a sensitivity analysis to explore the effects of the GARVEE program on the HCAS findings. The researchers considered the scenario where expenditures are equal to the annual debt service payments during the 2007-2012 time period. The annual debt service payments over the six years are approximately equal to 26% of the GARVEE bond expenditures over the same time period. In the reduced GARVEE bond scenario, construction expenditures decrease by \$96.9 million. Under this scenario, adjusted equity ratios increase for combination trucks and decrease for automobiles. On the state level, there is a greater difference in results between the two scenarios than on the level where state and federal are combined. On the state level, the adjusted equity ratio for automobiles drops from 1.26 to 1.08 under the reduced GARVEE scenario and increases for combination trucks from 0.73 to 0.86.

The other notable change for Idaho was the repeal of the weight-distance tax on trucks in favor of a mileage-based registration fee system in 2001. According to the study, if the weight-distance tax had remained in place, revenues were forecast to increase to \$60.4 million in 2008 (based on analysis of historical trends).

Instead, under the mileage-based registration fee system, revenues were \$48.8 million in 2008 (\$11.6 million lower than the forecasts under the weight-distance tax).

**Policy Analysis**

The Gubernatorial Task Force on Modernizing Transportation Funding evaluated 19 possible sources of revenue. They considered eight criteria in their evaluation: fairness, public acceptance, revenue predictability, trend (up or down), cost-effectiveness of implementation, readiness, competitiveness, and out-of-state equity. The top ten revenue sources are (from highest to lowest): fuel tax of 5 cents per gallon, fuel sales tax, index fuel tax, state

truck registration fee, index passenger vehicle registration fee, county vehicle registration fee, sales tax on auto sales, parts, tires and accessories, weight distance tax, electric vehicles, and alternative fuels tax.

The study examines the equity impacts from seven different policy options. The seven policy options are listed below along with their outcomes on equity (equity ratios are for the state and federal levels combined):

1. *Gasoline and special fuel tax rates increase by 5 cents per gallon.* Revenues forecast to increase by \$46.2 million annually. Tax falls on passenger vehicles and trucks equally, and there is little change in adjusted equity ratios.
2. *Gasoline tax rate increases by 5 cents per gallon.* Adjust the special fuel tax rate such that the equity ratio for vehicles with RGWs of over 26,000 lbs. is equal to one. Revenues forecast to increase by \$307.6 million annually. Equity ratios improve across vehicle classes (move closer to one). Adjusted equity ratios for automobiles and DS8+ change from 1.47 to 1.06 and 0.49 to 0.67, respectively.

3. *Special fuel tax rate increases by 5 cents per gallon, and gasoline tax rate adjusts to the level needed to achieve equity.* Revenues forecast to decrease by \$147.0 million annually. Equity is almost realized between broad vehicle classes (between vehicles above and below 26,000 lbs.).

4. *All vehicle registration fees increase by 10%.* Revenues forecast to increase by \$11.6 million annually. Fees are applied to all vehicle classes, and have almost no effect on equity.

5. *Passenger car vehicle registration fees increase by 10% and heavy truck registration fees increase by level needed to achieve equity.* Revenues forecast to increase by \$165.8 million annually. Heavy truck registration fees would need to increase by a factor of 4.07 to achieve equity. Equity would be achieved between light and heavy vehicle classes. However, payments from heaviest vehicle classes would still fall short of cost responsibility by up to 45%.

6. *Heavy truck registration fees increase by 10% and passenger car vehicle registration fees increase by level needed to achieve equity.* Revenues forecast to decrease by \$47.7 million annually. Passenger car (light vehicle) registration fees would be eliminated. Equity would improve with the automobiles adjusted equity ratios decreasing from 1.47 to 1.38.

7. *Vehicles over 26,000 lbs. RGW pay a VMT tax.* Revenues forecast to increase by \$81.9 million annually. VMT fees are around 5.3 cents per mile for vehicles with RGW of 80,000 lbs. and 11.1 cents per mile for RGW of 105,500 lbs. Equity ratios for heavy

vehicles improve significantly. The adjusted equity ratio for the DS8+ vehicle class would increase from 0.49 to 0.85. For the LT4 vehicle class, the adjusted equity ratio would decrease from 1.18 to 1.03.

### **2012 MINNESOTA HIGHWAY COST ALLOCATION AND DETERMINATION OF HEAVY FREIGHT TRUCK PERMIT FEES**

Minnesota conducted an HCAS in 2009 that used the FHWA's State Highway Cost Allocation Tool (HCAT), relying on some national default data and state specific data when it was available. In 2012, the Minnesota Department of Transportation (MnDOT) and the University of Minnesota developed a customized highway cost allocation tool for Minnesota based on the FHWA's tool, and compared the results of the customized tool to the results from the general tool. The report also presents the findings from the HCAS using the FHWA HCAT that are using the same methods as the 2009 HCAS (see 2009 Minnesota HCAS summary at the end of the paper after References).

In the 2012 HCAS, Minnesota compares the results from the FHWA HCAT and a customized tool for MnDOT, Minnesota Highway Cost Allocation Tool (MHCAT). MHCAT fixes known bugs in the FHWA HCAT and is intended to work with Minnesota-specific data. The FHWA HCAT does not allow certain tax revenues (e.g., registration and weight fees) to be attributed to a specific subset of vehicle classes. Additionally, the FHWA HCAT does not correctly allocate administrative costs associated with the collection of registration and weight fees. Another issue the study found was

that the registered gross weight breakdowns

for the vehicle configurations are based on representative data from 2001. Furthermore, the mapping of the 12-vehicle configurations to the 20-vehicle configurations is based on national VMT data from 1997.

MHCAT classifies vehicles according to Highway Performance Monitoring System, (HPMS) 12-class whereas FHWA HCAT classifies them according to HCA 20-class. Without a customized tool, use of the FHWA HCAT requires mapping the HPMS classification onto the HCA classification (as in the case of the 2010 Idaho HCAS and the previous 2009 Minnesota HCAS). The customized tool removes unnecessary data manipulation and increases accuracy. MHCAT also allows the user to enter up to eight customized vehicle classes. This is a useful tool for research purposes, such as considering specific changes to tax rules and cost allocation for specific vehicle classes.

The FHWA HCAT cannot allocate external costs such as environmental impacts, congestion, and accident costs. External costs are a result of highway use, and can be significant. However, they are difficult to include into the HCAT since they are dependent on the time of travel and route selected, and they do not depend solely on the type of vehicle and VMT. This is not an issue that is resolved in the MHCAT.

The report also evaluates the HCAS methods, with particular emphasis on tax equity (vertical and horizontal) and efficiency. In particular, the report compares a fuel versus a weight-distance tax using a stylized mathematical model.

The results support that a weight-distance tax or other mileage-based tax that can be differentiated by truck class can help achieve a

more equitable tax policy than a universal fuel tax. However, the examples presented also indicate that equity can be improved if the universal tax encourages the truck industry to use trucks that cause less damage. The alternative is to achieve equity through a tax policy that differentiates by truck class and truck usage.

The report lists two categories with two options in each category as directions for future research that are associated with the equity and efficiency of the road-use tax structure.

- **Mileage-Based Taxation:** This can be implemented using a comprehensive *Electronic Road Pricing System (ERPS)* or a *weight-distance tax system*.
  - With an *ERPS*, tax rates can be set based on vehicle type, vehicle weights, number of axles, congestion levels, and the road conditions for the individual trip.
  - *Weight-distance* taxes are charged based on the vehicle's registration weight, distance travelled, and axle configuration.
- **Special Permits and Willingness-to-Pay:** The state currently issues special permits to oversized or overloaded trucks, but there is a need for a better pricing mechanism. Options to improve the pricing mechanism include:
  - Estimating *Willingness-to-Pay (WTP)* using contingent valuation.
  - Implementing an *auction-based permitting system (ABPS)*.

Minnesota Department of Transportation (MnDOT) provided revenue and expenditure data and traffic data for the 2003-2007 time period. MHCAT, like HCAT, requires pavement

parameters, bridge parameters, and vehicles' features and travel-related data. The inputs are in nine different Excel tabs in the MHCAT workbook. Default bridge parameters are imported from HCAT but can be modified to reflect the state's conditions through assistance from the state engineer. The report uses VMT numbers from MnDOT that represent an average from 2004 to 2007.

The workbook requires registered gross weight distributions by vehicle class by 2,000 lb. increments from 8,000 lbs. to 152,000 lbs. These data were obtained from the Vehicle Inventory and Use Survey from 2002 (VIUS 2002) collected by the U.S. Census Bureau. The default data for MPG by vehicle class and RGW, the average annual distance travelled by vehicle class, and the distribution of vehicles by fuel type are all from VIUS 2002. Axle weight distribution data are from WIM systems from 2006.

#### Revenue

The MHCAT includes both federal and state revenues. At the federal level, inputs include fuel taxes, heavy vehicle use tax, vehicle sales taxes, and tire taxes. At the state level, inputs include fuel taxes, weight fees (only applicable to trucks), registration fees (passenger vehicles and light trucks), vehicle sales taxes, and permit fees.

#### Expenditures

MHCAT inputs related to expenditures are categorized into six parts: state level construction and maintenance, state level administration, state-aid administration, state-aid construction and maintenance, federal-aid administration, and federal-aid construction and maintenance. Each part requires expenditures

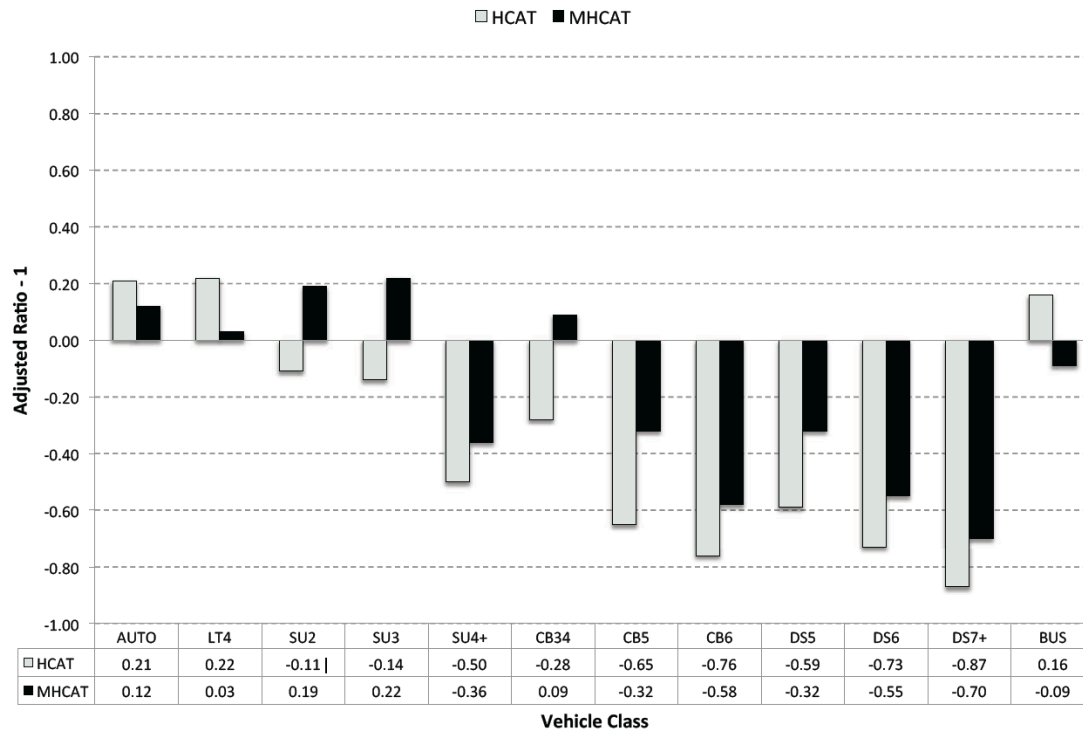
disaggregated by highway functional class for 25 categories. The categories include typical highway project categories such as pavement (new, repair, etc.), bridge (new, replacement, rehabilitation), and maintenance and administrative categories. MHCAT includes the costs of collecting user fees on fuel, which are assumed to be zero by many states.

The default inputs on how non-load-related expenditures are allocated are based on FHWA HCAT. These include grading, residual allocators, other costs, and systemwide and DMV costs. The user can specify the percentage of grading costs by vehicle weight. For residual allocators, other costs that are distributed by highway functional class, and systemwide costs and DMV administration costs, the user can specify VMT or PCE-VMT, or a fraction between 0 and 1 (e.g., 0.3 means that 30% is allocated based on VMT and 70% is allocated based on PCE-VMT).

#### Equity Ratios and Findings

The report compares the equity ratios obtained from FHWA HCAT and MHCAT. It considers the difference between the adjusted equity ratios from the two tools to the target ratio (one). Like the 2009 Nevada HCAS, unadjusted equity ratios are constructed as the ratio of gross (dollar amounts) revenues to expenditures from each vehicle class. Adjusted equity ratios are constructed as the ratio of the vehicle class share of revenues to share of expenditures.

**Exhibit 1. HCAT (FHWA) and MHCAT: Adjusted Ratios minus Target Ratio (one), State Revenue and Expenditures Only**



Source: Minnesota HCAS 2012, Figure 4.1, p. 52.

In general, the equity ratios from MHCAT are less extreme than those from FHWA HCAT. Exhibit 1 shows the differences between the ratios for FHWA HCAT and MHCAT by vehicle class. The report attributes some of the differences to the fact that RGW, OGW, and axle distributions are based on Minnesota specific data in MHCAT, as opposed to national averages in the FHWA HCAT.

The report finds that automobiles, light trucks, and single-unit trucks (three axles or less) have equity ratios greater than one. The report also finds that all combination trucks (except for

single trailer with four or fewer axles) have adjusted equity ratios less than one. As is the case in other states' HCASs, the study indicates that heavy trucks are not paying taxes in proportion to the damage they cause to road infrastructure.

**Effects of a Weight-Mileage Fee**

Currently, Minnesota charges a weight fee that is determined based on a commercial vehicle's RGW (e.g., a registration fee). The report examines the effects of including a weight-mileage fee where the user pays a usage fee based on vehicle miles traveled and the tax

**Exhibit 2. Adjusted Equity Ratios for Weight Fees (RGW registration fee) and Weight-Mile Fees, State**

VC	Weight Fees	W-M Fees (Scenario 1)	W-M Fees (Scenario 2)
AUTO	1.12	1.12	1.08
LT4	1.03	1.03	1.00
SU2	1.19	0.89	0.86
SU3	1.22	0.89	1.00
SU4+	0.64	0.67	0.80
CB34	1.09	0.95	1.07
CB5	0.68	0.75	0.88
CB6+	0.42	0.57	0.71
DS5	0.68	0.81	0.93
DS6	0.45	0.63	0.77
DS7	0.30	0.52	0.67
BUS	0.91	0.91	0.88

Source: Minnesota HCAS 2012, Table 4.15, p. 56.

rateper mile is determined by the registered gross weight of the vehicle. The report considers two scenarios. The first scenario assumes that total revenues from trucks are not changed (Minnesota collects \$98 million from the weight-mileage fee). The second scenario assumes that the state collects \$160 million from the weight-mileage fee (the amount of load-related expenditures (pavement and bridge) allocated to trucks). The study estimates the cost per mile for each vehicle-RGW class and then sets the tax rate to be proportional to the estimated cost.

Exhibit 2 shows the adjusted ratios at the state level for the weight fees and the weight-mile fees under both scenarios. As the table illustrates, adjusted equity ratios under both weight-mile fee scenarios are closer to the target ratio (one) than the weight fees for most vehicle classes.

### Auction-Based Permit System (ABPS)

This section discusses the development and testing of an ABPS that a state transportation agency could implement to learn the demand for permits and freight companies' willingness-to-pay for the permits. The researchers considered multi-item auctions and picked three mechanisms: Vickrey auction with reserve price, Ascending clock auction, and Clinched ascending clock auction. These three mechanisms were picked because they satisfied the following criteria:

- The price paid by a winning bid depends only on the opposing participants' bids.
- Bidders do not gain from over-bidding or under-bidding their true demand.
- The objective of the auction mechanism is to maximize revenue per permit sold.

The report explores the three auction mechanisms and how utility maximizing freight companies would bid under a competitive Nash equilibrium for each mechanism. The researchers then designed an experiment to test the different mechanisms using University of Minnesota graduate students and MnDOT staff members. The results of the experiment indicate that the ascending clock mechanism provided the maximum revenue per permit sold. Issues of auction fairness were not discussed in the report. The report considers the outcome of an auction as efficient when the individual item is sold to the bidder with the highest valuation for the item.

## HCAS METHODS

### A ROAD PRICING METHODOLOGY FOR INFRASTRUCTURE COST RECOVERY, 2010 (BY CONWAY & WALTON)

The broad motivating question for the report is, "What future method of truck user charging can be employed to equitably recover infrastructure costs from individual vehicles based on real-time operations?" (Conway & Walton, 2010, p. 3). The report presents a framework for charging commercial vehicles using weigh-in-motion (WIM) systems. The WIM systems collect real-time vehicle weight and configuration information that can be used to charge vehicles on a toll structure. The report proposes using highway cost allocation methods to estimate a more equitable toll structure based on the individual axle weights that can be measured real-time using the WIM systems. The report presents a hypothetical case study using information from Texas State Highway 130 to consider the improvements in equity that could be realized using the proposed methodology. The study proposes a two-part toll. The first part is a base toll that is charged to all commercial and passenger vehicles that is calculated such that all common costs and basic infrastructure costs are recovered. The second part is an additional toll for heavy vehicles that is estimated using the "axle-load" estimation (preferred) or the "number-of-axle" estimation. Exhibit 3 (on the following page) illustrates the process.

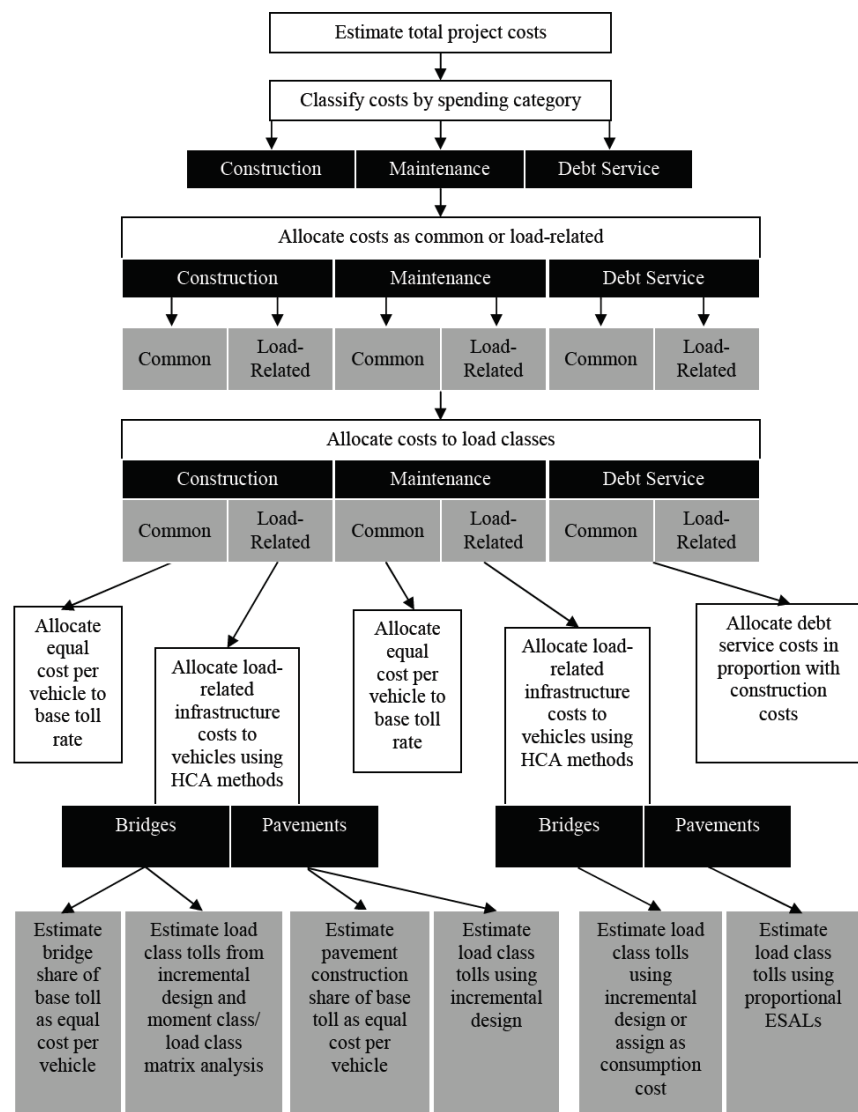
Under an axle-load toll structure, heavy vehicles pay an additional cost per axle-load to recover infrastructure costs (pavement and bridge costs) that are required in order to support their weight. Pavement impacts are estimated as a function

of individual axle loads, so initial load classes must be developed using the relative impacts on pavement by loads from individual classes. The particular characteristics of the facility with respect to traffic volumes, truck profiles, and axle load distribution need to be identified to determine the relative impacts of each class. Traffic analysis provides vehicle volumes, and WIM data can provide axle load distributions and truck profile information. This information can be used to calculate the probability that a load belongs to a given class and estimate the toll rates for each individual load class.

The case study considers State Highway 130 in Texas. The results indicate that the "axle-load" tolling structure recovers costs more equitably for heavy vehicle consumption than a "number-of-axle (n-1)" structure. The addition of an axle can lessen the load at a given point, reducing the pavement and bridge impacts. The pavement impact is lower from a 20,000 lb. load split across two axles than the same load on one axle. The "axle-load" structure is more effective at mirroring the estimated cost responsibility of different vehicle classes.

**Exhibit 3. Center for Transportation Research/Southwest Region University Transportation Center - Cost Allocation Method for Toll Rate Determination**

**MODELS FOR HIGHWAY COST ALLOCATION, 2013  
(BY GARCIA-DIAZ & LEE)**



Source: Conway & Walton, 2010, Figure 9, p. 90.

The report reviews the traditional HCAS methods, incremental or proportional (or a combination of the two) and then presents an alternative, non-traditional HCAS method that is based on concepts from the theory of cooperative games. The study considers how well different HCAS methods fulfill three fundamental properties: completeness, rationality, and marginality. Completeness means that highway costs are fully recovered by all participating vehicle classes. Rationality means that each vehicle class will have a lower cost by participating in the large group of all vehicle classes. Marginality means that each vehicle class pays the incremental cost that is incurred by including it in the grand coalition. Traditional HCAS methods, incremental and proportional, satisfy completeness. The incremental method sometimes satisfies marginality.

The non-traditional method presented in the paper, the Generalized Method (known as the Nucleolus Method in game theory) is based on concepts from the theory of cooperative games. Villarreal and Garcia-Diaz (1985) first proposed the use of this method in HCAS.<sup>1</sup> With this method, all three properties are forcibly satisfied as a result of constraints in the method’s mathematical formulation. The generalized method guarantees “that every vehicle class will be allocated a lower cost in the grand coalition (all vehicle classes), as compared to any other smaller coalition (one with fewer vehicle classes than the grand coalition)” (Garcia-Diaz & Lee, 2013, p.137).

The average marginal cost for a vehicle class, considering all the permutations of vehicles in the grand coalition, is the Shapley Value. The Shapley Value represents the average marginal cost contribution that each vehicle class would make to the grand coalition if it were forming one vehicle class at a time (Garcia-Diaz & Lee, 2013, p.138). The Aumann-Shapley Value considers two types of costs, the sum of which is the total cost allocated to a vehicle class. The first cost is for ESALs (pavement thickness) and the second is for highway lanes (traffic capacity). The method calculates a cost per ESAL and a cost per lane. This procedure has a number of advantages and tackles some obstacles often found in traditional HCAS. It “allows the consideration

<sup>1</sup>A Development and Application of New Highway Cost Allocation Procedures. Villarreal-Cavazos A, Garcia-Diaz Transportation Research Record 1009: 34-41. 1985.

of the number of lanes as being a variable and depending on the composition of the traffic using a highway (Garcia-Diaz & Lee, 2013, p.138). This “addresses how seemingly conflicting objectives: lighter vehicles require less pavement thickness and more lanes while heavy vehicles require fewer lanes but thicker pavements” (Garcia-Diaz & Lee, 2013, p. 138). After calculating a cost per ESAL and a cost per lane, the method uses the Shapley Value to allocate the number of available lanes between vehicle classes. The paper provides examples using three vehicle classes.

The paper states that the Generalized Method distributes traffic-related costs more equitably than any other HCAS method, as it considers traffic loads and traffic capacity. The combination of the Aumann-Shapley Value (average cost per ESAL and average cost per lane) and the Shapley Value (used to allocate the total number of lanes among vehicle classes), allows for the possibility to calculate the cost per mile for each vehicle class. The paper also proposes a method for separating bridge construction and traffic capacity costs that is similar to the method for separating pavement thickness and traffic capacity costs. There is the additional step that allocates the traffic-load cost to each weight group in a vehicle class using the incremental method. The paper provides examples using three vehicle classes and four weight intervals.

### **BRIDGE STRUCTURE COMPARATIVE ANALYSIS, COMPREHENSIVE TRUCK SIZE AND WEIGHT LIMITS STUDY, 2013**

This study provides a list of agencies that provide technical support through research, ongoing studies, and practice. This list includes national programs such as the Transportation Research Board (TRB), National Cooperative Highway Research Program (NCHRP) and Strategic Highway Research Program, (SHRP 2). It also includes federal and state transportation agencies and universities.

The second section of the study provides a list of documents that the study reviewed with a link to the document, a summary of the findings, and a discussion of the document’s relevance to one of the Comprehensive Truck Size and Weight (CTSW) Study topics. A key discussion area is how to recover the relatively high structural and infrastructure costs on bridges from heavy trucks. The study examines resources in the literature from 1997 to 2013 that may inform approaches that may help recover these costs more equitably.

### **STATE HIGHWAY COST ALLOCATION STUDIES: A SYNTHESIS OF HIGHWAY PRACTICE, 2008 (BY BALDUCCI & STOWERS)**

This report is intended to help states with HCAS methods by laying the foundation on current HCAS methods and areas of improvement for HCAS methods. The report reviews the HCAS methods used by different states, the conceptual foundation of HCAS methods, methods for revenue attribution, and arising issues with HCAS methods.

Since the 1997 Federal HCAS, there have not been many major changes in HCAS practice. A significant development in the past few years was FHWA’s completion of the development and refinement of the National Pavement Cost Model (NAPCOM) and its development of NAPCOM into a model that can be used in state level HCAS. The FHWA also developed generalized state level HCAS software and documentation for the software.

Exhibit 4 summarizes recent state HCASs. Much of the data in the table is from a previous study by ECONorthwest in 2005, but has been updated through 2008 by the research team. The results in the method column indicate that the Incremental and Federal Methods are most commonly used for state HCASs. These fall under the cost-occasioned approach that determines cost responsibility using the costs imposed on the highway by the highway-user class and not just by relative use. A key issue in HCAS is the cost responsibility of heavy-truck vehicle classes. Studies consistently find that heavy trucks payments do not fully cover their cost responsibility.

**Exhibit 4. State Highway Cost Allocation Studies**

State	HCAS Years Completed	Method	% Heavy Vehicle Cost Responsibility	Key Allocators	Types of Revenues Examined
Arizona	1993, 1999, 2000, 2001, 2002, 2005	Federal	31.4% (1999)	VMT, Axle-Load, Gross Weight	State, Federal, and Local Funds Combined
Arkansas	1978	Incremental/Cost Function			
California	1987, 1997	Federal and Incremental	18.90%	ESALs	State, Federal, and Local Funds Analyzed Separately
Colorado	1981, 1988	Federal	37%	VMT, Truck-VMT, ESALs, Ton-Miles	
Delaware	1992, 1993	Federal and Incremental	20.33%	VMT, ESALs, PCE, Axle-Miles, Registrations	State and Federal Funds Combined Only
Florida	1979	Incremental	64.50%	VMT, ESALs, Axle-Miles, Registrations	State and Federal
Georgia	1979, 1982	Incremental	51.2% (1979)	VMT, ESALs, GVW, AMT	State and Federal
Idaho	1987, 1994, 2002, 2010	Prospective Cost-Occasioned, Modified Federal, NAPCOM	Federal & State: 43.5% or 40.9%* State: 40.6% or 34.1%*	VMT, ESALs, ADT	State, Federal, and Local Funds Combined
Indiana	1984, 1988, 1989, 2000	Incremental/Consumption	53.20%	ESALs	State, Federal, and Local
Iowa	1983, 1984	Federal	48.94%	VMT, ESALs, Ton-Miles, AMT, PCE	
Kansas	1978, 1985	Hybrid	41.85%	VMT, ESALs, PCE, AMT, Ton-Miles, Number of Vehicles	State Funds
Kentucky	1992, 1994, 1996, 1998, 2000	Federal	54.92%	VMT, ESAL-VMT, PCE, Axle-Miles	State and Federal Funds Combined
Maine	1956, 1961, 1982, 1989	Hybrid/Expenditure Allocation	35.60%	VMT, ESALs, PCE, Delphi, TMT, Standard Vehicle Equivalent	State and Federal funds
Maryland	1989, 2009	Federal	33.30%		State and Local Funds
Minnesota	1990 2009, 2012	Federal and Incremental, Modified Federal	Federal & State: 29.47%	VMT, ESALs, ADT	State and Federal Funds Combined and State
Mississippi	1980	Incremental	36%	VMT, Truck-VMT	



**Exhibit 4 (continued). State Highway Cost Allocation Studies**

State	HCAS Years Completed	Method	% Heavy Vehicle Cost Responsibility	Key Allocators	Types of Revenues Examined
Missouri	1984, 1987, 1990	Federal		VMT, Vehicle Size, Vehicle Weight	
Montana	1992, 1999	Federal	33%	VMT, ESALs, AMT	
Nevada	1984, 1985, 1988, 1990, 1992, 1994, 1999, 2009	Modified Incremental, Modified Federal with NAPCOM (2009)	All Levels: 34.66% State: 38.26%	VMT, ESALs, Axle-Miles, Ton-Miles	State, Federal, and Local Separately and Combined
New Mexico	1972				
North Carolina	1983	Federal		VMT, ESALs, PCE, Weight Axle-Miles	State and Federal Funds
Oregon	1937, 1947, 1963, 1974, 1980, 1984, 1986, 1990, 1992, 1994, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015	Cost-Occasioned with NAPCOM for Pavement Costs (Since 1999)	31.20%	VMT, Congested PCE, Uphill PCE, Truck-VMT, Basic Vehicle VMT	State, Federal, and Local Combined for Cost Allocation Purposes but State Only for Revenue Attribution Purposes
Pennsylvania	1989, 1990	Federal/Cost-Occasioned			
Texas	1984, 1985, 1994, 2002				
Vermont	1990, 1993, 2006	Federal	25.70%	VMT, ESALs, ADT	State and Federal Funds
Virginia	1991, 1992	Federal	21.70%	VMT, ESALs, ADT	State and Federal Funds Combined
Washington	1977	Incremental			
Wisconsin	1982, 1992	Federal (1982)	31.70%	VMT, ESALs, PCE, Ton-Miles	State and Federal Funds Combined
Wyoming	1981, 1999	FHWA State HCAS Model	55.80%	VMT, Vehicle Size, Horsepower, Weight	

Source: Balducci and Stowers 2008. Adapted from ECONorthwest et al. (2005). Updated by ECONorthwest through 2014.

**Exhibit 4 (continued). State Highway Cost Allocation Studies**

State	HCAS Years Completed	Method	% Heavy Vehicle Cost Responsibility	Key Allocators	Types of Revenues Examined
Missouri	1984, 1987, 1990	Federal		VMT, Vehicle Size, Vehicle Weight	
Montana	1992, 1999	Federal	33%	VMT, ESALs, AMT	
Nevada	1984, 1985, 1988, 1990, 1992, 1994, 1999, 2009	Modified Incremental, Modified Federal with NAPCOM (2009)	All Levels: 34.66% State: 38.26%	VMT, ESALs, Axle-Miles, Ton-Miles	State, Federal, and Local Separately and Combined
New Mexico	1972				
North Carolina	1983	Federal		VMT, ESALs, PCE, Weight Axle-Miles	State and Federal Funds
Oregon	1937, 1947, 1963, 1974, 1980, 1984, 1986, 1990, 1992, 1994, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013	Cost-Occasioned with NAPCOM for Pavement Costs (Since 1999)	31.20%	VMT, Congested PCE, Uphill PCE, Truck-VMT, Basic Vehicle VMT	State, Federal, and Local Combined for Cost Allocation Purposes but State Only for Revenue Attribution Purposes
Pennsylvania	1989, 1990	Federal/Cost-Occasioned			
Texas	1984, 1985, 1994, 2002				
Vermont	1990, 1993, 2006	Federal	25.70%	VMT, ESALs, ADT	State and Federal Funds
Virginia	1991, 1992	Federal	21.70%	VMT, ESALs, ADT	State and Federal Funds Combined
Washington	1977	Incremental			
Wisconsin	1982, 1992	Federal (1982)	31.70%	VMT, ESALs, PCE, Ton-Miles	State and Federal Funds Combined
Wyoming	1981, 1999	FHWA State HCAS Model	55.80%	VMT, Vehicle Size, Horsepower, Weight	

Source: Balducci and Stowers 2008. Adapted from ECONorthwest et al. (2005). Updated by ECONorthwest through 2014.

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*Comprehensive Truck Size and Weight Limits Study. Bridge Structure Comparative Analysis-Final Draft Desk Scan.* U.S. Department of Transportation, Federal Highway Administration. November 2013.

### **ADDITIONAL HCAS STUDIES** **Highway Cost Allocation and Determination of Heavy Freight Truck Permit Fees (MN/DOT): Task 1 Report – 2009 Minnesota Highway Cost Allocation Study.**

Prior to the 2009 HCAS, Minnesota had conducted only one HCAS, roughly twenty years ago (published in 1989). Minnesota's 2009 HCAS was conducted by a faculty member and research assistant in the Engineering Department at the University of Minnesota. The study was conducted using FHWA's State HCAS program (HCASP), relying on some national default data and state-specific data when available. MNDOT provided financial (revenue and expenditure) and traffic data for the four-year period of July 2003 to 2007. Thus, the study is retrospective, in that it uses prior year expenditures and VMT; the study does not forecast future year spending, future expenditure work types, or VMT.

Following the Federal HCASP methodology, the study relied on the mapping of twelve HPMS vehicle classes into the 20 HCASP vehicle classes. The study used data from eleven weigh stations to develop distributions of registered Gross Weight for the vehicle classes. Default weight distributions from HCASP were used for those vehicle classes where the raw weigh station data could not be mapped into the HCASP vehicle classes.

The study found that the share of revenues from heavy vehicles is less than their share of costs.

Three "what-if" scenarios were analyzed to determine equity ratios under three different tax policies:

1. Increase in fees paid by vehicles greater than 16,000 lbs. by 26%.
2. Increase in the diesel tax by 25%.
3. Introduction of a weight-distance tax for vehicles more than 57,000 lbs.

### **Revenue Attribution**

All federal, state, and local highway user revenues were included in the Minnesota HCAS. Federal revenues are based on those reported in the FHWA's Highway Statistics. The Federal HCASP contains default federal tax rates and attributes federal revenues to vehicle classes based on those rates and the VMT inputs. State highway user fees include motor fuel taxes, registration and license fees, vehicle sales tax, and an ad valorem tax. Similar to Nevada, Minnesota seems to include revenues that are diverted to non-highway uses. In the Minnesota HCAS, attributed state revenues exceed allocated state expenditures by 27%.

**Cost Responsibility**

Following the Federal State HCAS Program, the Minnesota HCAS categorized highway-related expenditures into 18 work categories. The work categories are typical highway project categories such as pavement (new, repair, etc.), bridge (new, replacement, rehabilitation), maintenance and administrative categories. Expenditures are also categorized by functional class, though administrative expenditures, rest area maintenance, state police and fuel/registration collection costs are not assigned a road functional class.

**Equity Ratios and Findings**

Like the Nevada HCAS, the Minnesota HCAS reports unadjusted and adjusted equity ratios. The unadjusted equity ratio is computed as gross revenues divided by expenditures for each vehicle class and the adjusted equity ratios are the ratio of a vehicle class' revenue share to their share of expenditures. Revenue per mile and cost per mile for each vehicle class is reported along with equity ratios, with equity ratios for state and federal reported separately.

The study finds that vehicle classes with weights greater than 16,000 lbs. have adjusted ratios less than 1.0 for state ratio and vehicles under 26,000 lbs. have federal plus state adjusted equity ratios greater than 1.0.

The scenario analysis demonstrates that a 25% increase in the diesel fuel tax is more effective at bringing the heavy vehicle equity ratios closer to 1.0 than a 25% increase in heavy vehicle fees. Both of these two policy scenarios are more effective at bring equity ratios closer to 1.0 for vehicles between 16,000 and 50,000 lbs., but adjusted equity ratios remain rather low for vehicles weighing more than 50,000 lbs.

The third "what-if" scenario examined equity ratios using weight-mile tax applied to vehicles weighing 57,000 lbs. and greater. The weight-mile tax rates were estimated by fitting a segmented regression model to the difference between the allocated cost per mile and current revenue per mile using registered gross vehicle weight categories. Equity ratios for heavy vehicle classes are closer to 1.0—in particular the equity ratio for five-axle tractor trailers is 1.03 under the weight-mile tax. However many vehicle classes still have equity ratios under 1.0.



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# Appendix C: 2019-2021 SRT Minutes

## **TEAM MEETING MINUTES: APRIL 24TH, 2018**

10:00 a.m. to 12:00 p.m.

ECONorthwest Offices, 222 SW Columbia, Suite 1600

Portland, Oregon 97201

Attendees:

### **Study Review Team Members**

Jerri Bohard, Oregon Department of Transportation (via phone)

Waylon Buchan, Oregon Trucking Association

Craig Campbell, AAA Oregon/Idaho (representing Tim Morgan)

Gerik Kransky, The Street Trust

Mazen Malik, Legislative Revenue Office

Mike McArthur, Association of Oregon Counties (via phone)

Mark McMullen, Office of Economic Analysis (Chair)

Don Negri, Willamette University

### **Support Staff and Friends of the SRT**

Joel Ainsworth, ECONorthwest

Carl Batten, ECONorthwest

Patrick Brennan, Legislative Policy & Research Office

Kevin Campbell, representing AAA Oregon/Idaho

Erin Haswell, ECONorthwest

Jana Jarvis, Oregon Trucking Association

Josh Lehner, Office of Economic Analysis

Ralph Mastromonaco, ECONorthwest

Lani Pennington, Oregon Department of Transportation

Daniel Porter, Oregon Department of Transportation (via phone)

Bob Russell, Oregon Trucking Association

Kristen Sheeran, Governor's Office (via phone)

Amy Williams, Oregon Department of Administrative Services

Brian Worley, Association of Oregon Counties (via phone)

### **Welcome, Introduction and Opening Remarks**

The meeting began at 10:00 a.m. Mr. McMullen welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves. Craig Campbell announced he will be taking a new position and is passing his Highway Cost Allocation Study

(HCAS) responsibilities to his associate, Kevin Campbell. The draft minutes from the SRT meeting on January 22 were presented and unanimously approved.

### **Discussion of Scope and Timing of the Cap & Invest Issue Paper**

Mr. McMullen recapped House Bill 2017 (2017) as passed and noted it required a feasibility study of how to perform a cost allocation at a local level rather than statewide, as well as a cap and invest study. There were concerns about having enough resources to do both, but the cost allocation feasibility study was rescinded during the 2018 legislative session. The SRT discussed whether the local cost allocation study should still go forward because this requirement will likely be reinstated during the 2019 legislative session. The Portland Metro area may be voting on a local tax increase in 2020 for lightrail along Barbur Boulevard and other local road projects. The HCAS SRT is the correct group for local governments to consult to determine how to allocate costs for local taxes between cars and trucks.

Some in the group questioned whether it is beyond the scope of the SRT to perform a study on something not yet required. In addition, the Constitution requires cost allocation only for the state highway fund, not cost allocation for local taxes. Another member countered that if a local entity was interested in performing cost allocation, the HCAS SRT is the only group to have enough experience to provide sound advice on how to go about doing it. If the SRT considers doing this, perhaps its greatest value would be in identifying the key issues needing consideration and where the biggest difficulties may lie. In addition, while the Constitution does not require a cost allocation for local taxes, it does require that any local revenues raised from the operation of vehicles or fuels must be spent on road-related improvements.

It was noted that during the SRT's January meeting, there appeared to be more interest in understanding the implications of cap and invest, and because there are workload capacity issues, it may be better to do one issue paper well versus two papers that may not capture all the important data. Another member pointed out that even though the feasibility study for a local cost allocation was removed



with House Bill 4059 (2018), Rep. McLain feels strongly that it move forward and plans to reintroduce it during the 2019 legislative session. The problem is that this delay will cause the data to be unavailable when Metro introduces its tax increase ballot measure in 2020.

It was also pointed out that the funding specification for the Highway Cost Allocation Study has changed from being specified in ODOT's budget to being part of a bigger budget transfer to the Office of Economic Analysis and therefore subject to being decreased. Giving the HCAS its own funding again could allow for more research to be done during the study. Mr. McMullen said he would talk with Mr. Batten to determine if some preliminary steps for a feasibility study on a local cost allocation could be performed as part of this year's overall HCAS. Part of the core study will be to take a closer look at the pavement factors for non-highway roads since there is not as much data available on those. Roger Mingo will attend a meeting of the SRT this summer to discuss this.

Mr. McMullen provided some background on the cap and invest white paper. When the SRT commissioned the carbon pricing study, much work had already been done to determine a base line model and then the SRT worked off of that. For the cap and invest paper, the order is reversed. The new carbon office will be studying these things in some detail, but it is only now getting off the ground. This means the SRT's work is going to come before there is a broader impact study of what could happen with these different cap and invest policies. As a result, Mr. McMullen has reduced the scope of the paper to be more manageable. The scope will include determining the likely impacts of cost allocation in terms of revenue (levying indirectly through fuel taxes on both cars and trucks; how it will affect the current system of cost allocation; and how to change the current weight-mile gas taxes in order to maintain equity in these different programs) and spending (many of the cap and invest programs have specific guidelines for the sort of infrastructure projects that are allowed to be funded by this). In addition, a local cost allocation may differ from the pattern of cost allocation for the highway fund, so any resulting impact on the existing HCAS will also need to be examined.

Another consideration with a local study is the data that would be required from DEQ, ODOT, and other agencies to study the cost allocation, in addition to determining any barriers to implementation. Creating a few reasonable scenarios illustrative of what would happen to the equity system if a local cost allocation were enacted would be helpful. One simple scenario would be not to change the spending at all and only analyze the revenue. The spending side is more complicated when considering the types of infrastructure spending that would be allowed. ODOT has created a list of projects that would qualify but it is not yet final and also not exhaustive. It illustrates of the types of projects that meet the constitutional restrictions and adhere to the requirements of the program to address greenhouse gas mitigation or adaptation. ODOT committed to providing this list of projects by the next meeting of the SRT.

To determine the highway cost allocation, the proposed projects and programs are placed in different categories based on their allocators. For the revenue package, the projects to receive funds were chosen. For HB 2017, the projects were allocated and a cost responsibility was determined with a certain amount to come from light vehicles and a certain amount to come from heavy. For the revenue that might be raised from cap and invest, there needs to be a list of desired projects in order to allocate the revenue raising measure for the responsibility of light versus heavy vehicles.

One participant said that because of the fee-based program the dollars going into the highway trust fund should be used to further the goals of the cap and trade program, which include emissions mitigation, climate change adaptation and resilience. ODOT should be able to help determine how many different highway investment projects fall within the highway right of way and satisfy that criteria of mitigation/adaptation/resilience. This is both a legal and a technical issue. The legal issue is the assumption that if the dollars go into the highway trust fund they are also restricted to the use of activities that meet the aims of the cap and trade program. The technical issue is, if that legal question was answered definitively and the dollars must go to mitigation/adaptation/resilience, then how broad is the suite of projects and activities on the ground that would satisfy that

criteria within the highway right of way? ODOT will need to help in understanding the technical possibilities.

There was a discussion regarding Legislative Counsel's advice on the topic of highway fund revenue, with some believing that any funds coming into the highway fund are governed by the highway fund. Others believe that allowances sold to fuel distributors and importers under the cap and trade program are restricted to the highway trust fund, but it is unclear whether those highway trust fund dollars are restricted to the use of greenhouse gas reducing activities.

The cap and trade process works by the state selling a certain number of carbon allowances to fuel dealers in the primary market, then at settlement time three years later the dealers need to pay for every ton of carbon they emitted. That price is the settlement price in the primary market. The secondary market, however, is where fuel dealers buy or sell allowances from a variety of sources: this state, other states, utilities, or other fuel dealers. Once allowances enter the secondary market there are no direct sales from one entity to the next. As an extreme example, the state theoretically might not auction a single allowance in the primary market but entities could trade amongst themselves or pick up any shortfall they think they will experience in the secondary market and then not a dollar would come back to the state. While that is unlikely, it is still a possibility for a cap and trade program in which the state would not see any money moving into the highway trust fund.

An individual fuel importer, as a regulated entity, will be required at the end of every year to surrender an amount of allowances equal to the amount of emissions for which that entity is responsible. At that point, the state does not care where the allowances come from, whether directly from the state at auction or the secondary market, and there is no fixed requirement for any individual entity to reduce emissions under cap and trade. This is where it gets very tricky. If it is assumed the state will auction some allowances, then if the state happens to sell allowances to an Oregon-based fuel distributor or importer, the money the state collects at that point goes to the highway trust fund. If that fuel distributor or importer either doesn't buy enough at auction, decides

that their emissions will be larger than anticipated and wants to buy them on the secondary market, finds a better deal somewhere else, or uses saved allowances from a previous year, it doesn't matter. There is not a fixed number of allowances they are required to buy from the state. The only requirement is if they are regulated, then they must surrender allowances at the end of the year in a quantity equal to their emissions.

A variety of assumptions may be required to conduct the modeling. If Oregon fuel suppliers purchase 100% of their compliance obligation from the state, how many dollars would go to the highway trust fund? On the other end of this extreme, if they buy no allowances directly from the state, then zero dollars go to the highway trust fund. A third, reasonable assumption in between those two extremes should also be made. Because of the constitutional restriction, Oregon will have to track this differently than other states. When California sells allowances at auction, they do not track who buys them; it could be a utility, a manufacturer, a fuel refinery or an importer. They also do not track whether the buyer is in-state or out-of-state or one of the linked jurisdictions; the allowances are still sold at the going price. If Oregon sells allowances, we will need to know whether they were purchased by an in-state fuel distributor because those dollars - and those dollars alone - will go to the state highway trust fund.

The number of allowances auctioned by Oregon is equal to the quantity of emissions in that particular year by all the regulated sectors. If the fuel entities that are required to comply only purchase their allowances from the state of Oregon at auction, then each ton of carbon emitted equals one allowance sold and can be mapped dollar for dollar to the highway trust fund. However, if one of the fuel entities buys its allowance in a secondary market or in an integrated WCI market platform generated in California or Ontario or Quebec, then those dollars do not go to the state highway trust fund. In addition, it is possible for Oregon to raise no money from the auction sale of allowances if the market rate in the secondary market is lower than the auction price offered by the state, or if a regulated entity reduces its emissions to zero. Because of the policies and programs in place that are driving down emissions, and because people are finding

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other ways to reduce emissions that are less expensive than the auction market's floor price, allowances have not been selling out.

There was a spirited discussion surrounding how the bill was written, and whether the number of allowances are allocated to the number of fuel units, or whether the cap is a fixed amount of allowances for the entire economy and not assigned to any particular sector.

The benefit of the HCAS SRT is determining which allocators should be assigned to the different types of projects. The bill as currently written has certain criteria for the selection of projects. ODOT is working on a list that would meet those criteria, and it is appropriate for the SRT to determine how those projects should be allocated and which allocators should be used. That determination is within the SRT's purview. Determining what qualifies for the highway fund is a legal question.

There will be an undetermined amount of revenue generated from the sale of the allowances, and that amount would be allocated to projects. The SRT's task is to decide how to allocate the funds in those projects between cars and trucks.

There was some concern about trucks currently paying through a weight-mile system. When the allowance system is implemented, the revenue could come either through fuel taxes or indirectly through the allowances, but how much of that would be subject to the highway fund? In addition, currently there is a steady flow of income from the tax mechanisms. The carbon cap and invest program could create a wave effect and cost allocation is not conducive to rapid change so there needs to be a moderating factor. The weight-mile tax may need to be adjusted biennially.

While DEQ's greenhouse gas emissions track diesel and gasoline separately, they are currently unable to determine the amount attributable to trucks 26,000 pounds and heavier. This should be highlighted in the issue paper as a data need.

Mr. Batten asked if there is any potential for integrating this with the International Fuel Tax Agreement (IFTA). There are a number of

restrictions within IFTA making it equipped to deal with diesel fuel taxes. If this were treated like a diesel fuel tax then it could be done with IFTA, but other states have no obligation to participate. It could work if there were contemporaneous information about how much money was coming into the highway fund from cap and invest, but since the information won't be available until after the end of the year it will be more challenging. Balancing in the future is very different from what is done today. If it is balanced on the pro forma year in the future it might work.

Another assumption that will have to be made relates to the price of allowances in the market. One extreme assumption would be that Oregon would become part of a linked WCI market, in which case it would probably be a price taker and assumptions could be made based on what is known about those floor prices and what that market looks like. The other extreme assumption is what prices would be if Oregon never links as a market and therefore would meet these emissions reductions goal within the state's borders. Those are the bookends in terms of what the allowance prices are likely to be, based on how the program has been designed.

Because this issue paper is scheduled to be finished in August, which is before any of the new data will be ready, it was determined that the last study would be used as a model for the issue paper, along with the list of new projects. The details year to year aren't as important as the structural changes. Delivering the paper as close to the August deadline as possible is a priority.

Ms. Sheeran invited the ECONorthwest team to utilize the manager of DEQ's greenhouse gas program, who will soon be working in the Carbon Policy Office, if they need to understand how he's collecting data, the status of the conversation over the market design, or anything else.

#### **Review Status of Data Collection Efforts**

Much of the key data does not yet exist. This agenda item will be monitored at the next SRT meeting.

### **Invited Presentation on House Bill 2017 (2017)**

Mr. Malik and Mr. Brennan presented on HB 2017. In addition to traditional increases to rates and revenues that would occur in any package, there were also innovations that set Oregon at the forefront of transportation funding once again.

The most common increases in HB 2017 were to the taxes on gas and diesel for light to medium-heavy vehicles. There was a four-cent increase in January of 2018, and there will be two cent increases in 2020, 2022 and 2024. The two-cent increases will now be conditional on reports the Oregon Transportation Commission (OTC) has to submit to the Joint Transportation Committee (JTC).

There is also a \$13 increase to the vehicle registration fee through December of 2019, as well as increases to title fees and many other fixed fees in order to supplement the variable revenue from the weight-mile tax and the fuel tax. The innovative portion of these fees is that beginning January 1, 2020, registration fees will be based on a vehicle's miles per gallon (MPG), with drivers paying more if their vehicles have better gas mileage. The original idea was to charge less for vehicles with higher MPG, but that contradicts the idea of cost responsibility. A person who owns a high MPG vehicle and therefore pays less in fuel tax at the pump, and then receives a lower registration fee as well, would exacerbate the issue of those vehicles using the road but not paying equitably into the system. These tiered registration fees are a surcharge and in addition to the standard registration fees now. Electric vehicles will have a \$110 registration fee unless the owner has registered the vehicle in the OReGO pay-per-mile program.

This came to be one of the most interesting and robust revenue raising sections of the bill because vehicles with 0-19 miles per gallon hardly exist anymore. Even the heaviest of SUVs today has 20+ MPG. As a result, as vehicles become more and more efficient, the revenue to the state will keep increasing. The same tiered surcharges are also being applied to vehicle titles, with higher MPG vehicles costing more.

The OTC will study and report on different vehicles' contributions to cost by 2023. The weight-mile and flat fees will increase to 53.3% in four

increments (2018, 2020, 2022, and 2024) in order to align with the increases for the light vehicles. This equates to a cost responsibility for the whole program of 62.87% for light and 37.13% for heavy. Once HB 2017 is fully implemented, the overall percentage increase in highway revenue will have gone up by 46.5%.

Most of the new taxes in the package would be administered by the Department of Revenue (DOR). This includes a privilege tax, which is 0.5% of a vehicle's retail price. Legislative Counsel has concluded this type of tax does not fall under the highway fund restrictions because the dealer is the one who is supposed to be paying it. This is now in court. In the meantime, DOR is allowed to collect the 0.5% on new vehicles but cannot distribute the money until the case is resolved. If the court determines the tax is subject to the state highway fund, the tax would be repealed. The privilege tax is on vehicles sold in Oregon. If a vehicle is purchased from a dealer outside of Oregon, the dealer would pay a use tax of an equal amount and this would go to the state highway fund. This is in an effort not to push business out of the state. The use tax would also be repealed if the court strikes down the privilege tax.

The privilege tax would have \$12 million of its revenue allocated to the Zero Emission Incentive Fund and the balance to the Connect Oregon Fund. While the vehicle title and registration fees were increased the most for electric vehicles, the state also wants to encourage people to buy these vehicles because of their benefits to the environment. The Zero Emission Incentive Fund subsidizes the purchase of electric and hybrid vehicles with two rebate programs: the Zero-Emission Vehicle Rebate Program providing up to \$2,500 for new electric or plug-in hybrid vehicles depending on the vehicle's battery capacity, and the Charge Ahead Oregon Rebate Program for qualified low income owners of new or used electric or plug-in hybrid vehicles. These programs are on hold pending the court decision over the vehicle privilege tax.

Another innovation in HB 2017 is the bicycle excise tax, which was highlighted in Forbes Magazine as the first of its kind in the nation. It is a \$15 flat fee paid at the point of sale for bikes costing over \$200.

This revenue is dedicated to bicycle and pedestrian programs not eligible for state highway fund money. There is an additional \$4 million from the State Parks subaccount to enhance the bicycle tax. DOR is putting all the new HB 2017 taxes under the umbrella of a single program in order to offset the cost of administering them.

The final innovative way HB 2017 raises revenue is through a 0.1% payroll tax beginning July 1, 2018. This is transformational for transit because incoming revenue begins at \$105 million for the 2017-19 biennium and continues to increase gradually to \$320 million by the 2025-27 biennium. It will provide a variety of funding for transit districts, mass transit, counties, and connecting small cities.

Between the highway fund, the privilege tax, the payroll tax and the bike excise tax, HB 2017 is anticipated to raise a net revenue of \$5.23 billion between now and full implementation at the end of the 2025-27 biennium. However, this bill never sunsets so by 2027 it will be raising \$500 million per year for the highway fund and \$200 million per year for all other transit in perpetuity.

There were also changes in distribution. Projects of statewide importance would be funded off the top and before other distributions, with \$30 million per year going to Rose Quarter bonding and \$10 million per year going to the "Safe Routes to School" program (increasing to \$15 million by 2022). The original plan was to improve a one-quarter mile radius around every school in Oregon within ten years, but this increased to a full one-mile radius. It will provide for lighted crosswalks, stepouts, curbs, sidewalks, and other safety improvements. It requires a 40% spending match for most schools, although rural, Title I schools, and schools in hazard corridors have only a 20% match requirement.

Other revenue distribution includes the "Small City" program; authority to the Travel Information Council to oversee and manage several additional rest areas and submit reports on those properties; and other special projects. The remainder of the revenue would have 40% dedicated to bridge improvements, 30% to seismic improvements, 24% to maintenance and culverts, and 6% to preservation and safety. There are four identified multimodal projects, including the Willamette

Valley and Treasure Valley transmodal facilities, rail expansion at the Port of Morrow, and expanding the rail siding at Brooks. In addition, all five ODOT regions have identified highway/pedestrian/safety projects for funding, along with increased funding for the small city and small county programs. The total planned projects would require approximately \$61 million, but only \$30 million has been allocated so far. The assumption is the privilege tax would generate enough revenue to cover the gap.

The Marine Navigation Improvement Fund requires the Department of Administrative Services to determine how much gasoline is used by power boats and then transfer the amount of revenue attributable to the tax collected, net of refunds and collections cost, to the Oregon State Marine Board. This statute was amended by HB 2017 to transfer an amount equivalent to two cents of gasoline tax to Business Oregon's Marine Navigation Improvement Fund to operate the State of Oregon's portable dredge. It also changes the Fund to allow it to accept and spend money for the operation of the state's dredge.

Connect Oregon has been split into two parts depending on the cost of projects. Connect Oregon One is for projects costing less than \$75 million and will be the traditional program minus transit since it now has its own revenue stream. It will also include the bicycle pedestrian projects, which are still administered by ODOT although they are now funded separately. Connect Oregon Two is for the funding of projects of statewide significance costing \$75 million or more.

The Statewide Transportation Improvement Fund will be funded by the 0.1% statewide employee payroll tax. Ninety percent of the funds will be distributed to transit districts, providers and counties by a formula, 5% to competitive grant programs for which those same groups will be eligible, 4% to intercity transit coordination outside the metro area, and 1% to ODOT in order to administer this program. The fund cannot be used for light rail capital projects and it requires the entities receiving money to submit plans for future distributions to ODOT in order to prove the funds are being used for the projects that were approved.

HB 2017 also directed the OTC to request approval from the Federal Highway Administration (FHWA) for congestion pricing (tolls) on Interstate 5 from the Columbia River to its intersection with Interstate 205, and on Interstate 205 in its entirety within Oregon. If the FHWA grants approval of this request, OTC will be required to impose congestion pricing on these specified interstate highways, and will be authorized to impose congestion pricing in other areas as well.

With regard to legislative committees on transportation, the Legislature created two new entities, one permanent and one temporary. The temporary entity is the Task Force on Mega-Transportation Projects, which is designed to include members of the Legislature, the OTC, and highway users. It will look at only the largest of the transportation projects with an estimated cost of \$360 million or more. Of the total allocations on the current project list, the only one that reaches that threshold is the Rose Quarter project.

The other entity is the Joint Committee on Transportation. During the interim, it was a seven senator and seven representative committee that did a statewide tour. The tour was so successful they have decided to do an education tour with the Joint Education Committee and also to make this committee statutory as a part of this bill. This group will receive a number of statutorily required reports on a variety of issues over the next ten years.

HB 2017 had several provisions relating to the OTC and ODOT and adjusts the relationship between those two entities. The Director of ODOT is now appointed by the OTC rather than the Governor and serves at the pleasure of the OTC. The OTC is also directed to create a 20-year multimodal transportation plan. ODOT is directed to compile and update an inventory of the real property within its purview and create a project website to include all transportation projects at the state level, as well as expenditures and major projects at the county and city levels. ODOT will also make biennial reports to the Legislature on the overall condition of the state's transportation infrastructure, and before any new projects are added to the State Transportation Improvement Program, ODOT must provide a cost-benefit analysis projects over \$15 million. HB 2017 also formalized ODOT's internal audit function and to

whom reports will be made and requires the OTC to provide biennial reports about the internal audits to the Legislature. This is all to ensure the revenue generated by HB 2017 is being carefully monitored. Finally, HB 2017 also created the Continuous Improvement Advisory Committee, which is made up of members of the OTC and ODOT staff with the goal of continually working toward internal improvements and efficiencies at the agency. It will develop key performance measures for each ODOT division, and the OTC will report on its progress biennially to the Joint Committee on Transportation.

### **Next Steps**

Mr. McMullen noted the agenda items for the next meeting of the SRT:

- Continue discussing a feasibility study for a local cost allocation study.
- Delve more deeply into the cap and invest issue paper by examining potential infrastructure projects and allocators, as well as the credit markets and to what extent the highway trust fund is exposed to the revenue for the different alternative assumptions.
- Presentation from Dan Porter of ODOT on the details of the fuel and traffic forecast.
- A meeting later this summer should include Roger Mingo to discuss pavement factors.

The next meeting of the SRT is scheduled for June 13, 2018, from 1:30 p.m. to 3:30 p.m. at the DAS Executive Building in Salem.

**Meeting adjourned:** 12:10 p.m.



## **TEAM MEETING MINUTES: JULY 26, 2018**

10:00 a.m. to 12:00 p.m.

ECONorthwest Offices, 222 SW Columbia, Suite 1600

Portland, Oregon 97201

Attendees:

### **Study Review Team Members**

Jerri Bohard, Oregon Department of Transportation (via phone)

Waylon Buchan, Oregon Trucking Association

Mazen Malik, Legislative Revenue Office

Mike McArthur, Association of Oregon Counties (via phone)

Mark McMullen, Office of Economic Analysis (Chair)

Tim Morgan, AAA Oregon/Idaho (represented by Kevin Campbell)

Don Negri, Willamette University

### **Support Staff and Friends of the SRT**

Greg Alderson, Carbon Policy Office

Brendan Finn, Governor's Office

Drew Hagedorn, Tonkon Torp

Erin Haswell, ECONorthwest

Jana Jarvis, Oregon Trucking Association

Josh Lehner, Office of Economic Analysis

Ralph Mastromonaco, ECONorthwest

Colin McConnaha, Carbon Policy Office

Lani Pennington, Oregon Department of Transportation

John Rakowitz, Associated General Contractors

Bob Russell, Oregon Trucking Association

Amy Williams, Oregon Department of Administrative Services

### **Welcome, Introduction and Opening Remarks**

The meeting began at 10:05 a.m. Mr. McMullen welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves. The draft minutes from the meeting held on June 13 were reviewed.

Representatives from the Oregon Trucking Association (OTA) did not agree with how the local HCAS issue paper was characterized in the

minutes from the June meeting. Because the local HCAS requirement was removed from the highway bill during the 2018 session, ODOT representatives offered to perform in-house research on the types of technology that would be needed to conduct a local HCAS so the SRT would be better prepared if the requirement is reinstated during the 2019 session. There was a lengthy discussion of whether ODOT or the SRT is better equipped to conduct the research. ODOT worked with Mr. Malik of the Legislative Revenue Office on a problem statement to guide their research, which will be sent to the SRT.

The two problems related to performing a local HCAS are that no one yet knows how to do it, and then even if the math can be determined, it is unknown what type of technology would be required to capture the data and impose taxes based on VMT or weight-mile. If the regional HCAS is proposed again during the 2019 session, it would be extremely helpful if the research of how to implement it was done now.

OTA disagrees with a current weight-mile tax imposed by the City of Portland, which was implemented without any input by OTA, and they are concerned that this local HCAS issue will be handled the same way. Mr. Malik and Ms. Bohard explained the purpose of the research is only to determine the technology needed to perform a local HCAS, not how the allocation itself is performed or any other policy issues. For example, how would the state put an electronic circle around a metropolitan area, monitor all the vehicles within that area including those entering or leaving, and collect from them all electronically? OTA expressed displeasure at having ODOT staff perform the research rather than the SRT and perceived an unnecessary delay in the ability to perform the local HCAS. It was noted by others that the language of HB 2017 called for the Department of Administrative Services to "conduct a study to determine the feasibility of performing a highway cost allocation study within the boundaries of the county..." not to conduct the actual allocation. Ms. Bohard said the research on the technology required to gather VMT data on a local level won't be concluded until the beginning of 2019, with the goal of having it ready in time for the legislative session. Mr. McMullen requested the research staff attend a future SRT meeting to discuss



their work and progress.

With the requested edits incorporated into the June minutes and the objection from the Oregon Trucking Association noted, the minutes were approved by the group.

[Note: Subsequent to the meeting, the problem statement for the research project was sent to the group by Mr. Malik and it reads as follows:

The goal of this research is to assess the feasibility of developing one or more state imposed regional highway tax and fees structures within the state while maintaining cost responsibility. To meet this goal the research will:

- Identify the basic criteria that should be met for regional and statewide highway tax and fees structures to coexist.
- Examine the capacity of existing technology needed to impose regional highway taxes and fees structures (e.g. GPS devices and electronic tracking and payment mechanisms)
- Identify the costs and infrastructure to implement such technology
- Identify risks and opportunities.

This is a feasibility analysis of a hypothetical scenario; therefore, policy recommendations will not be developed. Collecting stakeholder input is not a part of this scope.

We envision the final deliverable is an independently produced whitepaper. The intended purpose of the whitepaper is to provide technical analysis to highway tax and fee stakeholders.]

#### **Review Progress on Issue Paper**

Mr. Mastromonaco said two decisions they have made on how to model the program have been to decide where the revenues are coming from and how much they are, and what happens with the costs. On the cost side, the only scenario modeled thus far used the 2017 model with added money, and that additional revenue was pushed through the system pro rata.

Two revenue scenarios are being studied right now, one with a low carbon price of \$10 and one with a high carbon price of \$20. Those scenarios also use the 2017 model but with a cap and invest program added. The model needs to be changed to include a new revenue source that applies to anyone who uses fuel regardless of their current fee system, whether weight-mile tax or gas tax or diesel tax is being paid. The assumption is that the cost will occur as the fuel comes into the state, which will raise the cost of doing business for fuel suppliers so prices will be implicitly higher. The slightly different tax on gas versus diesel is due to the different carbon content between the two fuels. The issue paper will focus on how both VMT and MPG are being calculated and whether what was done in previous studies is sufficient. The number of gallons in a specific weight class may not have been as important in previous studies, but the group may need to consider how to do this differently in a cap and invest scenario.

There was a discussion regarding previous HCAS studies and whether MPG was included by 2,000 pound increments. It was determined the model includes only aggregated data on heavy vehicles from the International Fuel Tax Association (IFTA), but IFTA represents only interstate long-haul trucks, not intrastate short-haul vehicles which have much lower MPG. Short-haul would include log trucks, construction equipment, dump trucks, etc. In order to determine an accurate MPG, there would need to be a combination of IFTA data and weight-mile data and clear diesel fuel consumption where the diesel tax is not applied. The MPG number will require a lot of work.

Mr. McMullen said Dan Porter of ODOT will attend the next meeting of the SRT to discuss the VMT forecast. It is important for the group to get a better idea of the diesel consumed by light versus heavy vehicles and the breakdown of VMT.

Mr. Mastromonaco said the fuel tax figures and the carbon tax figures in a cap and invest program will help to determine the difference in the diesel gallons, and that would be applied to weight classes over 26,000 pounds. Fuel suppliers need to know the difference

between gas and diesel to calculate their carbon incidence when they are bringing in fuel. Mr. McConnaha said in his previous role at DEQ he oversaw the mandatory greenhouse gas reporting program which applies to fuel suppliers and they do this already. They report to DEQ the volume of gasoline and volume of diesel and they also provide a list of approximately twenty different fuel blends and grades.

Mr. Mastromonaco asked if the diesel being used by operators paying a weight-mile tax, along with exempt alternative fee-paying diesel cars, could be determined since they wouldn't be paying a diesel use tax. Mr. Malik was not sure if a clean of separation between red and clear diesel exists. The isolation of heavy vehicles (26,000 pounds or more) by weight class that are using diesel and paying the weight-mile tax is needed. Mr. Russell believed between the motor carrier and the fuels tax branch that data should be captured already. He offered to meet with Dan Porter regarding the sources of the different data points.

Mr. Mastromonaco reviewed calculations the team prepared on potential revenues from user fees by weight class with both \$10 and \$20 permits, and a baseline scenario representing the 2017 HCAS. The amount of revenue potentially generated from the low and high scenarios was allocated proportionally to the 2017 study among state and local costs; the mix of projects was the same, there were just more of them. This means, however, that in these scenarios revenue is being spent on things that do not necessarily qualify as GHG reduction and/or climate adaptation, which would be a requirement as the bills have been written.

The group discussed project types identified by ODOT as potential GHG reduction or climate adaptation projects and whether they would be Highway Fund eligible. Mr. Malik suggested that if the baseline scenario has an equity ratio of one, then it should remain as one in all other scenarios so equity ratios aren't rising for one class and falling for another. The question should be how the funds could be spent so the equity ratios don't change. Run the model based on the projects that need to be done and extend the program as it is today. If the equity ratio cannot be maintained for one class then they need to pay either more or less. OTA requested that transit service improvements and rail

support projects be categorized as "All VMT" or administrative costs, since these could not be justified as freight costs.

Mr. McMullen suggested the white paper should determine the mixes of spending that would tilt the equity ratio toward the cars and the mixes that would tilt it toward the trucks and move away from the status quo. It was said there may need to be a significant increase in truck taxes or a significant decrease in car taxes with this new revenue source because so much more of it is coming from cars than trucks. Based on this revenue source, how much would you have to adjust car or truck taxes in order to maintain the baseline.

Mr. Mastromonaco said if the SRT wants to do something besides pushing the new money through pro rata, it needs to come up with scenarios for how carbon fee money will be spent. Two possible alternative scenarios have been discussed already, one being a collection of investments geared toward reducing GHG emissions, and the other a collection of investments that were geared toward climate adaptation. New allocators may be needed if the existing allocators cannot be applied to the new types of projects.

The SRT will need to come to a consensus on which work type is assigned to each project and, if there is a category with different sets of allocators, how to split up the money. "All VMT," is based on VMT and the congestion Passenger Car Equivalent (PCE) is based on the weight in car units, speed of acceleration and speed of deceleration of heavy vehicles, although this is tilted about four times more toward heavy vehicles because they take up the space of four smaller vehicles. OTA noted that if light vehicles are removed from the road through a transit function, the flow is increased for heavy vehicles but not at four times the rates so they fundamentally disagree with congestion PCE.

It was suggested the PCE VMT for each 2,000 pound weight class be determined and then see what it would look like when an allocator is applied to that weight class. Some weight classes might not have as many VMTs as others so they will have less responsibility.

It was asked whether the group should be concerned with new allocators and if they had existed in the last study would they have been used. There was concern about comparability to previous results. Some were against revising history and if the allocators are truly new then they never would have been used before. Others were not against changing something if it was done incorrectly and the SRT understands why.

#### **Future Meetings**

August's meeting of the HCAS SRT will include Dan Porter's detailed VMT forecast with a focus on diesel consumption by different weight classes and non-taxed sources. The group will also look more closely at the allocators to see what different GHG reducing or climate adaptation scenarios would do. There is no meeting scheduled for September. October's meeting will include an examination of the pavement factors with Roger Mingo, and in either October or November the preliminary full HCAS numbers should be available for the group to review.

**Meeting adjourned:** 11:25 a.m.

## TEAM MEETING MINUTES: SEPTEMBER 18, 2018

1:30 p.m. to 3:30 p.m.

DAS Executive Building, 155 Cottage Street N.E. Salem, Oregon 97301

Attendees:

### Study Review Team Members

Jerri Bohard, Oregon Department of Transportation (via phone)

Waylon Buchan, Oregon Trucking Association

Mazen Malik, Legislative Revenue Office

Mike Eliason, Association of Oregon Counties (represented by Brian Worley)

Mark McMullen, Office of Economic Analysis (Chair)

Tim Morgan, AAA Oregon/Idaho (via phone)

Don Negri, Willamette University

### Support Staff and Friends of the SRT

Joel Ainsworth, ECONorthwest

Greg Alderson, Carbon Policy Office

Lindsay Baker, Oregon Department of Transportation

Jocelyn Blake, Association of Oregon Counties

Kevin Campbell, AAA Oregon/Idaho

Erin Haswell, ECONorthwest

Jana Jarvis, Oregon Trucking Association

Josh Lehner, Office of Economic Analysis (via phone)

Ralph Mastromonaco, ECONorthwest

Colin McConnaha, Carbon Policy Office

Amanda Pietz, Oregon Department of Transportation

Dan Porter, Oregon Department of Transportation

John Rakowitz, Associated General Contractors

Bob Russell, Oregon Trucking Association

Kristen Sheeran, Carbon Policy Office

Amy Williams, Oregon Department of Administrative Services

### Welcome, Introduction and Opening Remarks

The meeting began at 1:35 p.m. Mr. McMullen welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves. The draft minutes from the meeting held on August 21 received unanimous approval.

### Flat Fee Study

A “flat-fee” is something paid by carriers in lieu of paying weight-mile taxes. Flat-fee carriers typically include chip trucks, dump trucks and log trucks. The number of flat-fee carriers has been dwindling over time, and is now low enough to cause non-disclosure issues in terms of the carriers’ privacy, and the next report will likely need some of the data redacted. It was asked whether the study is still necessary since there are so few carriers using it. Mr. Malik said the flat-fee study could be eliminated legislatively and all trucks could be required to use the weight-mile system, but until that happens the study is required.

### Review Progress on Issue Papers

The feasibility study for a local cost allocation, which was required as part of House Bill 2017 (2017), was repealed during the 2018 legislative session and is therefore no longer part of the 2019-2021 Highway Cost Allocation Study. However, ECONorthwest has been asked to provide an issue paper examining VMT estimates on side roads where the travel by weight class data is limited. The issue papers had originally been due October 1, but because Roger Mingo will not be presenting on pavement factors until the SRT meeting on October 10, the group agreed to postpone the due date for this paper until the broader HCAS is due. A draft of this issue paper will be provided to the group before it is published.

Mr. Mastromonaco presented his team’s progress on the cap-and-invest issue paper. At this point they have provided three cost scenarios:

- Business as usual (BAU) scenario which reflects the distribution of costs across work types that existed in the 2017-2019 HCAS but with more money added to the revenue;
- Greenhouse Gas (GHG) reduction scenario.
- Climate adaptation scenario.

These scenarios are based off input from ODOT's Statewide Transportation Strategy (STS) on how to reduce carbon emissions in the transportation system, and what would or would not be eligible for highway trust fund money. ECONorthwest randomly selected two of the several scenarios provided in the STS, and the SRT would like it clear that these are hypothetical scenarios only.

Mr. Negri said the responsibility of the SRT is to ensure equity for cost responsibility across cars and heavy trucks. Those cars and trucks are the beneficiaries of the expenditures, but now with cap-and-invest the beneficiaries of the expenditures for GHG reduction is the entire world. The logic of how to allocate is gone. It needs to be clear that there are underlying logistical problems with considering how to allocate these funds. The Constitution discusses cost responsibility in proportion to damage to the highway system, but cap-and-invest is about damage to the air.

Mr. Campbell asked about the potential new expenditures in the report described as eligible for Highway Trust Fund dollars. At a previous meeting of the SRT, ODOT explained that a list of project types had been submitted to the Department of Justice (DOJ) for their guidance on whether the individual project types would be eligible for the Highway Trust Fund. Mr. Buchan objected to the statement on the bottom of page 7 of the draft issue paper which states ODOT provided guidance on the type of investments that would be eligible for State Highway Trust Fund dollars, when that has not actually been determined. He also felt the STS is a biased document and should not be used as a data source.

Ms. Pietz said the STS is a document required by the Oregon Legislature to identify ways to reduce GHG emissions. The process of creating the STS was public and included some of the HCAS SRT members. The group reached an agreement on important ways to reduce emissions. When ODOT was asked to provide information to ECONorthwest for this issue paper, they based it on this publicly vetted document. Any of the scenarios listed represent the gap between present day and the STS goal. The STS should not be viewed as a biased document from ODOT, but created by a collective

group determining what goals to achieve with regard to GHG emissions and how to achieve them.

All scenarios listed in the STS represent projects that have received Highway Trust Fund dollars in the past. Some project types on the handout provided Ms. Pietz at a previous SRT meeting had an asterisk. These were categorized as "likely Highway Fund eligible." In the past, ODOT has asked for DOJ guidance on individual project types, but now ODOT has submitted a comprehensive list of all project types to DOJ and asked for their guidance in order to consolidate all previous opinions. All scenarios provided to ECONorthwest have had highway funds spent on them in the past, so are considered "likely Highway Fund eligible" until definitive guidance comes from DOJ. To date, DOJ has not constrained anything previously considered allowable by ODOT. Mr. Malik said this could be specified in the paper.

While the paper's scenarios include only projects that have received Highway Trust Fund dollars in the past, Mr. Russell said that because the STS is referenced, the paper should also note that the STS contains projects that have not received Highway Fund money in the past.

Mr. Buchan noted that the STS does not address highway capacity expansion at all, when that is a key issue to consider. Is highway expansion at odds with cap-and-invest? Highway expansion is a very important matter to drivers of both freight trucks and passenger vehicles. If the STS is providing the basis for the discussion and does not address highway capacity expansion, then any opportunity to have a meaningful analysis or discussion on the topic appears to be rejected. Mr. McMullen said the paper should not endorse the STS but keep it at arm's length and note that the scenarios taken from the STS do not include any capacity expansion. He added that the BAU scenario does include capacity increases since money has been spent on it in the past two years, and that should be pointed out in the paper. Mr. Campbell said the capacity issue is very important both from the perspective of public sentiment and also the potential transition to electric vehicles, which could be a big part of the future.

Regarding the issue paper, Mr. Mastromonaco said he was surprised to find that it does matter what projects he used for the model. He could arbitrarily change the project mix to arrive at any equity ratio. In other words, the way the money is allocated will completely determine what happens to the equity ratios. While the discussion on which projects to include is important, the weights are almost more important. The results are completely dependent upon the assumptions. He said two options for the paper are to have either a hundred cost scenarios that outline every possible project, or move away from projects completely so it's not related to GHG reduction or climate adaptation but just car-heavy or truck-heavy. In addition, even if the group could agree on which projects to include it would still argue about which weights to use.

Mr. Russell said at the beginning of this paper the group had two questions it wanted answered: Could you use cost allocation to get a GHG scenario, and could you reduce highway user taxes and fees to offset the increases in GHG fees or taxes. The answer to both is yes. As long as the caveats are provided with the examples, it will be helpful to legislators.

Mr. McMullen said the reason to conduct a study like this is the potential of finding unexpected results. Mr. Mastromonaco and his team were surprised by how sensitive some of the scenarios are to the spending mix, and Mr. McMullen wondered what other kinds of scenarios could be added to better illustrate some of that sensitivity. Currently it's very dependent upon the mix of project types, so it would be good to illuminate how that dependence works and which levers move it in which direction.

Mr. Mastromonaco said under cap-and-invest, new revenue is attributed more to vehicles under 10,000 pounds and less to vehicles 10,000 pounds and up. The money coming in is allocated more toward cars based on the amount of fuel they use and having 90 percent of the VMT. With that in mind, any cost scenario that doesn't make up for that gap is going to result in an equity ratio that's higher for cars and lower for trucks. If the new cost scenario is more car heavy, then it will appear that trucks are under-paying. The break-even point of what the truck-heavy or car-heavy scenarios would need to be in order to flip from

2017-2019 results can be calculated. In addition, a \$20 permit causes the revenue attribution to be even more car heavy.

The scenarios provided in the draft paper include BAU, GHG reduction and climate adaptation. The BAU cost allocation ratios are the same as what was done in 2017. The GHG reduction cost responsibility compared to BAU is more car heavy and less truck heavy, which means more expenditures would be assigned to cars. The adaptation scenario is similar but less extreme than GHG. Based on this, we can predict the GHG and adaptation scenarios will have an equity ratio for cars that is lower than the BAU. Because the cost scenarios are relatively more car heavy, the revenue coming in will need to be balanced out.

It was noted that the project types have a large impact on the spending side of cost allocation, but equity can still be achieved at least to a certain point. The higher the credit price the more carefully it needs to be done.

Mr. Campbell said the \$20 credit price causes a larger equity disparity, but this can be resolved by changing the expenditure. However, if the equity disparity is big enough then the cost to cars may need to be adjusted to make up the difference. For instance, the fuel tax could be reduced. At what point does the equity disparity force a legislative action? Mr. Russell asked what would happen if the gas tax was reduced, or if the weight-mile tax was increased? The legislature needs to be aware that they can do one or the other or both, so those three options should be illustrated. Mr. Mastromonaco said there is way to spend the money that would preclude having to adjust the rates. The money can be spent in a certain way that matches exactly how it's coming in.

Mr. Malik pointed out that projects are not selected in order to maintain equity. Projects are done because they need to be done and the cost implication is secondary. Mr. Russell said a cap-and-invest bill would include language relating to project types and this paper would inform that. Mr. McMullen asked Mr. Mastromonaco to provide a table in the paper depicting the types of projects that tend to be more car heavy or more truck heavy. Mr. Negri pointed

out that the axes change across the various charts in the draft paper and they should be consistent. Mr. Russell asked for a “margin of error” statement to be added and said he would submit additional suggestions via email. Mr. Buchan asked for an increase from three charts with three scenarios each to nine charts with three scenarios each.

**Future Meetings**

Mr. Mastromonaco will incorporate the today’s feedback into the issue paper and produce another draft on or about September 26. The next official meeting of the SRT is not until October 10, but because the due date of the issue paper is October 1, Mr. McMullen suggested scheduling a tentative conference call for September 28 in the event there are substantive issues with the next draft. If edits are not substantive, they can be submitted via to Mr. Mastromonaco via email.

**Meeting adjourned:** 3:05 p.m.

## **TEAM MEETING MINUTES: OCTOBER 23, 2018**

1:00 p.m. to 3:00 p.m.

DAS Executive Building, 155 Cottage Street N.E. Salem, Oregon 97301

Attendees:

### **Study Review Team Members**

Jerri Bohard, Oregon Department of Transportation (via phone)

Waylon Buchan, Oregon Trucking Association

Mazen Malik, Legislative Revenue Office

Mike Eliason, Association of Oregon Counties (represented by Brian Worley via phone)

Mark McMullen, Office of Economic Analysis (Chair)

Tim Morgan, AAA Oregon/Idaho (represented by Kevin Campbell)

Don Negri, Willamette University

### **Support Staff and Friends of the SRT**

Joel Ainsworth, ECONorthwest

Jocelyn Blake, Association of Oregon Counties

Jana Jarvis, Oregon Trucking Association

Ralph Mastromonaco, ECONorthwest

Roger Mingo, Roger Mingo & Associates

Lani Pennington, Oregon Department of Transportation

Dan Porter, Oregon Department of Transportation (via phone)

Amy Williams, Oregon Department of Administrative Services

### **Welcome, Introduction and Opening Remarks**

The meeting began at 1:07 p.m. Mr. McMullen welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves. The draft minutes from the meeting held on September 18 received unanimous approval.

### **Invited Presentation on Pavement Factors: Roger Mingo**

Mr. Mingo, of Roger Mingo & Associates in Washington DC, attended the meeting to present on pavement factors. Mr. Mingo is a subcontractor for the Highway Cost Allocation Study (HCAS) through ECONorthwest and his work serves as a large component on the cost side for the cost responsibility.

Mr. Mingo said there are six easy steps to the model: (1) Developing a use profile for each highway type, (2) Determining the importance of each distress type, (3) Applying load equivalence factors to each axle, (4) Accumulating damage shares, (5) Applying damage shares to cost buckets, and (6) Aggregating results for summary tables.

One data point Mr. Mingo receives from ECONorthwest is the estimate of Vehicle Miles Traveled by number of axles, by operating weight, and by the twelve functional highway classes from interstate through local (both rural and urban). This is the master array that drives everything in the HCAS, including pavement analysis. Mr. Mingo uses the Weight-In-Motion (WIM) data provided by ODOT to examine how weights are distributed across axles for each number of axles and the operating weight groups. Just having the operating weights and the number of axles is not enough; the distribution of the weight is what makes a significant difference in the results.

Mr. Negri asked if a truck scale can distinguish the weights on the different axles as the truck moves across the scale. Mr. Mingo confirm that yes, they can. The WIM data has the axle weights and spacing, and from the spacing the type of axle can be inferred. There can be significant statistical noise so judgment is required in applying the WIM data to the axle weights. Despite having 30 million WIM records, Mr. Mingo said there are still gaps in the data, with one of the larger issues being the sparse data for the heaviest loads. Approximately six years ago, analysts began adding phantom observations which helped to smooth out the data. For example, a 120,000 pound seven-axle vehicle may be the only one of its kind, and there may be nothing in the adjacent weight groups. The analysts then simulate data and hold the same pattern for 10,000 pounds on each side of that observation. The data is generated based on one observation that is real, and doing this has helped make sense of the results. Mr. Negri asked if Mr. Mingo and his team spot check the phantom cells retroactively as years go by and new data becomes available. Mr. Mingo acknowledge it is a good idea but they have not done that to date.



Ms. Pennington asked whether Mr. Mingo is referring to registered weight or actual weight when discussing a truck weighing 120,000 pounds. Mr. Mingo said he works only with operating weights and ECONorthwest performs the crosswalk between the twelve functional classes and the type of ownership.

Mr. Mingo said the next step is to determine the importance of each distress type and why pavement was replaced. There are different exponents for the damage type. Mr. Mingo tries to use HPMS condition data but it has been a little sparse. Oregon's HPMS data is doing better every year, including the pavement conditions, so analysts can look for patterns for how pavements fail. The overall array originally used in Oregon was based on modeling conducted by pavement management experts who know why states replace pavements nationally. This helps with understanding the weighting factors.

The types of damage for flexible pavements include longitudinal cracking, alligator cracking, surface rutting, total rutting (which goes into the sub-base), and IRI (the International Roughness Index). Flexible pavements are all asphalt. Oregon has unpaved and rigid (concrete) roads; not flexible.

Rigid pavement damage types include: bottom up cracking (which occurs when a load is placed in the center of a slab and the slab cracks at the bottom and curves upward); top-down cracking (which occurs when a slab is curled due to temperature differences and a heavy vehicle runs over both sides at once and creates a crack at the top); and "all cracking" (which includes both bottom up and top down cracking as well as surface rutting and longitudinal cracking. Faulting occurs when a slab is intact but is displaced by the vehicles going over it which results in a gap creating roughness.

Ms. Pennington asked if "non-load" distress reflects weather. Mr. Mingo said non-load distress is from damage that occurs when there is no traffic on it at all. Rigid pavements with no traffic should last for decades. A 2% non-load distress on rural interstate roads would mean that when the pavement is replaced, 2% of the cost

is attributable to age. It was asked how studded tires are factored in. Mr. Mingo said studded tires are not included in the analysis anymore because in 2013 ODOT determined there is no longer significant damage to roads caused by studded tires since they are predominantly used by older generations and therefore have fewer people using them each year. Ms. Jarvis said she has read numerous studies that indicate otherwise. Mr. Mingo said studded tire damage generally affects skid resistance, which used to be modeled directly by NAVCOM, but the consensus is that at least on major highways other damage must occur before repaving is necessary; skid resistance alone does not cause an overlay.

A report released by ODOT in February of 2015 entitled, "Review of Studded Tires in Oregon," found the use of studded tires to be very generational. A survey in the year 2000 found studded tire use to be very high, but by 2014 it had decreased substantially. Older generations use studded tires while younger generation use all-weather tires, and all-weather tires damage pavement at the same rate as standard tires. Road ruts are usually caused by tire chains, and the width of the ruts indicates whether they were caused by cars or trucks. Ms. Jarvis asked how the impacts of studded tires and chains are calculated, and Ms. Bohard referred her to the 2015 studded tire report.

Mr. Mingo said Load Equivalence Factors (LEFs) are the heart of the model. Significant work was done once pavement models were available that could reexamine Equivalent Single Axle Loads (ESALs). ESALs are a fourth power rule based on a 60-year-old road test and measure roughness in only one area. In 1979, the trucking industry took a strong stand against ESALs and said the damage needed to be reevaluated for whether it really was a fourth power exponent and whether the relationship between the single and double axles was correct.

When the federal HCAS began in 1982, the trucking industry made a powerful argument that something much better than single axle loads was needed. The country's preeminent pavement experts developed consensus of what should be used in place of ESALs.

There was not enough time to develop new models for the 1982 study, but NAVCOM was created four or five years later when ARA, Texas A&M, the University of Texas and the University of Maryland came up with a new set of empirical models that use theory. It was the beginning of the Mechanistic-Empirical Pavement Design Guide (MEPDG), which examines pavement response rates to load and arrive at individual models for each type of distress. At that time, there was no unified overall national pavement model available so they used a set of ad hoc models that in some cases used ESALs as an assumption and then added an exponent to ESALs to explain. NAVCOM did this for many years, but the consensus of the pavement experts at the national level was that the MEPDG models starting in 2007 or 2008 were the best available and should be used to develop a new set of pavement factors. In 2009 and 2010, Mr. Mingo was part of a major project to do that. The project developed a whole set of LEFs for every distress modeled by MEPDG to replace ESALs. Beginning in 2011, the same factors have been used for Oregon. These factors have not been modified for the last three studies and will not be modified for the current study. These LEFs show the effect of one axle and one type versus another. A working paper completed in 2012 went into great detail for how these were derived and explained the derivation of the factors. ESALs are no longer used as an input and have not been used in Oregon since 2011, although earlier versions of NAVCOM used ESALs as a starting assumption for rigid pavements.

For single axles, at the moderate single axle level, the new load equivalence factors are all lower than ESALs, so the heavier single axles benefit from the new models. This results in a slightly higher basic vehicle share. The ESALs used the 18,000-pound single axle as their standard, but the LEFs use a 34,000-pound tandem as their standard. The 34,000-pound tandem is being used because it was between the tridem and the singles and seemed more plausible than an 18,000-pound single. Tandems have a spacing of four or five feet, and there are also spread tandems that go out to eight feet. A typical 18-wheeler has a tandem for the steering axle and two additional tandems on the tractor and on the back of the trailer. This is the most common heavy vehicle in use today around the country.

Tridem axles are difficult to define. Tandems have two axles with a common mechanism, but there are many axles classified as tandems but based on their spacing or independent suspensions are not really tandems. Tridems are much more likely to have independent suspensions. A true tridem suspension is very rare. They are three closely spaced axles less than twelve feet apart. Three axles closely spaced is the most important factor for pavement damage. There are subtleties in load distribution that prevent suspension information from being discerned from WIM data. For modeling purposes it does not matter whether the truck is a tandem with a single or three singles, but it probably does make a difference to pavement damage just like tire pressure, how wide the tires are, and how close the truck is to the edge of the pavement.

Rigid pavement generally has much higher ESALs and LEFs than flexible pavement because rigid pavements are concrete slabs designed for combat vehicles and light vehicles do not do any measurable damage. The models purpose is to determine which axles cause which types of damage. Once that is determined, all the damage is summed for the total number of LEFs. Mr. Mingo provides ECONorthwest with the relative shares, which are that portion of LEFs divided by the total LEFs on the pavement.

#### **Review Issue Paper**

Mr. Buchan inquired about the last several studies showing only 4.3% of VMT on local roads made by heavy trucks, but the percent of cost responsibility on local roads by heavy vehicles creeping up over time. He asked if there was a change to the model itself or a methodology change that may have occurred in 2011 between the OEMs and the diesels.

The second issue paper discusses the cost responsibility of heavy trucks on locally owned roads, as opposed to local roads. This is an important distinction because ownership and functional class are not the same thing. There could be state or federally owned local roads but the issue at hand is specific to locally owned, local roads. Locally owned roads aren't necessarily local roads from a functional class

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perspective. Ms. Bohard said ODOT examines this every ten years after the census has taken place. It takes two years to gather the data and then another year is spent determining if anything has changed with regard to urban growth boundaries and whether roads are inside or outside of certain areas.

Mr. Mastromonaco said his team is trying to determine why the model is showing trucks over 10,000 pounds represent only 4.3% of local road VMT but have a cost responsibility for local roads of 50.7%. Part of the reason can be attributed to pavement factors, since local roads are designed differently and are thinner resulting in more damage caused by trucks.

Mr. Mastromonaco explained that the ECONorthwest team does a mathematical procedure called Iterative Proportional Fitting (IPF) to solve for missing VMT. IPF begins with an estimate, which then is updated. VMT by functional class data are obtained from the ODOT forecast, which comes from the HPMS submittal. The heavy VMT is the weight-mile data, while the light and medium-heavy VMT are based off the fuel consumption forecast. There is not a unique solution to this math problem. In a typical HCAS iteration, ECONorthwest uses the result of the last study as the starting point for the new study. This means any errors in previous studies would carry on to a lesser extent in future studies. In addition, there used to be data provided from automatic traffic recorders that is no longer available, but that information lives on because of this process.

The solution with which the team begins will guide them to the new solution but it is not necessarily the same solution. What will have a tendency to exist throughout time is the general distribution of weight across functional classes. Mr. Mastromonaco said the issue paper will include an examination of how the results would be different if different initial values were used.

The analysis estimates there are 678 million miles of heavy vehicle VMT on local roads, which equals approximately 4.3% of the total VMT on local roads, with 96% of the VMT being attributed to cars. In other words, if all the VMT on local roads was split between cars and

trucks, the answer would be 96% to 4%. Another angle is to ask how much of all the heavy VMT is on local roads, and that answer is 22.2% of total heavy (truck) VMT.

The group thought 22.2% of travel for heavy trucks on local roads seemed very high. Mr. Porter asked if the same calculation is available for trucks over 26,000 pounds, because he thinks many of the trucks in the 10,000 to 26,000 pound range are going to be local delivery trucks rather than big trucks. Mr. Mastromonaco responded that about 32% of total VMT is on locally owned roads for trucks in that weight range, and for heavy trucks over 26,000 pounds it is 18% of the total VMT. Locally owned roads includes roads that are collectors and arterials that are owned by cities and counties. This information will be included in the report.

Mr. Mastromonaco said \$692 million dollars were spent on locally owned roads during the 2017-2019 biennium and almost 60% of all those expenditures were pavement related. Every mile traveled by that weight/axle/functional class is up-weighted by the pavement factor. Pavement factors for trucks could be hundreds, while the pavement factors for light vehicles are fractional. The reasons for the high pavement factors for trucks is the road ownership and pavement being a large share of the expenditure.

The pavement factors utilized to up-weight VMT in order to calculate heavy vehicle responsibility vary by functional class, and the amount of money that each ownership is spending on pavement is different. Therefore, the combination of these two factors point toward heavier truck responsibility in local roads because the damage is higher and they spend more.

Mr. Buchan was still uncomfortable with trucks having only 4% of the local road VMT yet is paying half the cost. Mr. Mastromonaco said the data they receive from ODOT is the VMT and WIM data, in addition to everything Mr. Mingo discussed as well as the IPF. The one variable there is still not a good understanding of is how the initial condition for IPF affects the results, but the SRT will have an answer to that as a result of this paper. The one thing that could add more reliability to the

data is knowing the amount of expenditures local government actually spend on the work, but this is part of the survey they are required to take. HB 2017 (2017) requires local governments to record their expenditures more accurately.

There are several moving pieces that determine the cost responsibility of heavy vehicles on local roads. It was observed that delivery vehicles cube out before they weigh out, so some in the group thought vehicles are not getting heavier on average. Mr. Mastromonaco pointed out that from 2015 to 2017, the total VMT driven on major collectors dropped from 26% to 21%, but the average truck driving that route got heavier. Meanwhile, the amount of miles driven on rural local roads increased from 12.1% to 17.3% and those trucks also got heavier. Pavement factors for that class of road is twice as the one that saw the mileage decrease. This shift within the rural functional classes would generate much higher costs.

#### **Staff Transitions**

Mr. McMullen announced that Mr. Mastromonaco will be leaving ECONorthwest within the week and the HCAS project will be transitioned to his colleague, Matthew Kitchen, who has previous experience with transportation-related projects. In addition, Mr. McMullen announced that Ms. Williams will be leaving the Department of Administrative Services and will no longer be serving as project manager of the Study. Her replacement has not yet been named.

#### **Future Meetings**

The final study numbers will not be available in time for the next HCAS meeting currently scheduled for Nov. 8. The meeting will be pushed out one week to Nov. 15, and a Doodle poll will be sent shortly to establish the time of the meeting.

**Meeting adjourned:** 2:55 p.m.



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# Appendix D: Model User Guide

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## I. INTRODUCTION

The 2019 Oregon Highway Cost Allocation Study (HCAS) Model User Guide describes the steps required to update and run the 2019 version of the Oregon HCAS Model. A user should be able to modify the model assumptions and update the input data and then rerun the model with the information in this user guide, along with instructions in the model tabs.

[Section 2, Model Overview and Summary](#), provides a general overview of the HCAS model and describes the input data structure.

[Section 3, System and Software Requirements](#), describes the computer system requirements and software required to run the model.

[Section 4, Initial Model Setup](#), describes the model distribution and its folder and file setup.

[Section 5, Install Python and Openpyxl](#), describes how to install Python 2.7 and Openpyxl on a Windows operating system.

[Section 6, Set Up a New Scenario](#), describes how to set up a new scenario to run the Python HCAS model on (e.g., if the user wants to use different inputs and/or assumptions).

[Section 7, Run the HCAS Python Model](#) describes how to run the HCAS Python model using a Graphic User Interface (GUI) for Python.

[Section 8, Input Data and Data Preparation](#), describes the data and any data pre-processing required to update the HCAS model.

[Section 9, Input Text Files](#), describes the input text files. Each input file is described in terms of the file contents and the data required to update the input text file.

[Section 10, Inputs Workbook](#), describes the inputs workbook. The tab-by-tab explanation of

the model displays a screen shot of the model tab, and then describes the contents of the tab, how the data on the tab are used in the model, and the process for updating the data and other user-specified assumptions.

[Section 11, Output Files](#), guides the user through the outputs workbook and output text files.

[Section 12, Policy Analysis of Alternative Rates](#), is a user guide for an alternative rate analysis using the HCAS model. This section describes the various revenue instruments of the model, along with how alternative rates for each instrument will affect the HCAS model results. The *Alt. Rates* input tab and *Alt. Attributed Revenues*, *Alt. Equity*, and *Alt. Summary* output tabs are explained in a tab-by-tab fashion.

This section also has case studies that provide step-by-step examples of how to conduct an alternative rates analysis for different revenue instruments.

## 2. MODEL OVERVIEW AND SUMMARY

The purpose of the HCAS is to determine whether each class of highway users is paying its 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's share of costs and then the user class's share of revenues to calculate equity ratios for each user class. Equity ratios close to one indicate that the user class is paying its fair share of costs. An equity ratio less than one indicates the user class is paying less than its share of costs, and an equity ratio greater than one indicates the user class is paying more than its share of costs.

The 2019 Oregon HCAS model is written in Python and requires data inputs in the form of an input Excel workbook and input text files. The input workbook is the user interface for updating data and assumptions used in the model calculations. An output workbook and text files are the result of running the HCAS model.

The 2019 Oregon HCAS model differs from the model structure used in the 2013 HCAS in terms of how the HCAS Python model is actually run and how the folders and files are structured. However, the core of the HCAS Python model and the required inputs and outputs remain unchanged. In the 2013 HCAS, there was one Excel workbook that had both input and output workbook tabs and had Visual Basic Application (VBA) code that called the HCAS Python model code.

Since the 2015 HCAS, the user runs the HCAS Python model through a Python Graphic User Interface (GUI) (steps to run a Python file are discussed in-depth in [Section 7, Run the HCAS Python Model](#)). This allows the model to be more interchangeable between operating systems and improves reliability of outputs. Another change is that instead of one large workbook with input and output tabs, there are two separate workbooks; one for the inputs ("*HCAS Inputs.xlsx*", oftentimes referred to as the "inputs workbook") and one for the outputs ("*HCAS Outputs.xlsx*", often referred to as the "outputs workbook"). The change from one workbook to two workbooks provides more clarity on the model input-output process.

Model assumptions and many data inputs are located in the inputs workbook. The workbook is described in detail in [Section 10, Inputs Workbook](#). The rest of the input data are in the input text files. These files are described in detail in [Section 9, Input Text Files](#).

The tabs in the inputs workbook are oriented from left to right, with the main control and assumption tab (*General*) at the far left, followed by the tabs for VMT inputs, cost inputs, revenue inputs, and other inputs (e.g., *MPG, Policy*).

To update and run the model, the user edits the model input data, parameters and assumptions as needed, saves the inputs workbook and then runs the Python HCAS model code. Instructions to run the Python HCAS model code are provided in [Section 7, Run the HCAS Python Model](#).

Running the HCAS Python model code will read in the data from the inputs workbook and the input text files. Using these data, the HCAS model will perform the VMT analysis, cost allocation, revenue attribution, and alternative rates revenue attribution calculations. The HCAS model will then generate a set of output text files in an outputs folder and populate an outputs Excel workbook with the HCAS model results [Section 11, Output Files](#), describes these output files. The structure of the Python code and model calculations are provided in Appendix E.

### 3. SYSTEM AND SOFTWARE REQUIREMENTS

This section describes the computer system and software requirements to update and run the HCAS model.

As noted in [Section 2, Model Overview and Summary](#), the 2019 Oregon HCAS model is a model written in Python that requires data inputs in the form of an input Excel workbook and input text files. The model also requires these input files along with an output template Excel workbook to be in a particular folder setup. This section discusses the system and software requirements for the model. The following section discusses the distribution format of the model and the folder and file setup for the model.

#### SYSTEM AND SOFTWARE REQUIREMENTS

The HCAS model can be updated and run using standard computer software and available open-source programming software. The user must install the requirements listed below prior to implementing the HCAS model.

##### System Requirements

The HCAS model works on Windows and Macintosh Operating Systems. The steps outlined in [Section 5, Install Python and Openpyxl](#), provide screenshots of the process to install Python on a computer running Windows 7. The process may look different if the user is running a different version of Windows.

##### Excel

The HCAS model requires Excel input and output workbooks using a version of Microsoft Office Excel 2007 or later. The file extension format of all Excel workbooks is “.xlsx.”

##### Python

Python is an open-source, object-oriented programming language. The user must download and install the Python software maintained by the Python Software Foundation.<sup>1</sup> The user must also install the Python package Openpyxl that is used to read and write Excel workbooks.<sup>2</sup> (See [Section 5, Install Python and Openpyxl](#).)

##### Text Editor

A text editor or Excel can be used to view input and output tab-delimited text 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 can be done using desktop database software such as PostgreSQL or Microsoft Access. PostgreSQL is an open-source object-relational database management system (DBMS) that supports the SQL programming language.

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<sup>1</sup> Python can be downloaded from: <http://www.python.org/download>. The Python Software Foundation website also contains documentation and other related material. Instructions on how to install Python 2.7 are provided in [Section 5, Install Python and Openpyxl](#). The user should consult the Python documentation for additional information on how to install the program and open the Python editor.

<sup>2</sup> Openpyxl can be downloaded using Pip, a Python package installer or can be downloaded directly from <https://pypi.python.org/pypi/openpyxl>. Pip is automatically installed in the default installation of Python 2.7 from the Python Software Foundation.

## 4. INITIAL MODEL SETUP

### MODEL DISTRIBUTION

The 2019 HCAS model is available to download in a ZIP archive file format (“2019 Oregon HCAS Model.zip”). Unzipping this file will automatically set up the correct folder structure and includes all of the 2019 HCAS input files that are required to run the model.

### INITIAL FOLDER AND FILE SETUP

First, the user must unzip the model distribution file, “2019 HCAS.zip.” This can usually be done by double clicking on the file. Doing this will create a new folder, “2019 HCAS.” [Figure 1](#) shows an example of the distribution ZIP file and the result of unzipping the ZIP file.

[Figure 2](#) shows the first level folders of the “2019 HCAS” folder (this may be referred to as the “base model folder”). The base model folder has four first level folders: src, processed scenarios, scenarios, and templates. [Figure 3](#) shows the contents of these four folders.

#### src

The src folder contains “HCASModule.py”, a Python file that contains the HCAS model code and is what the user will open to run the HCAS model. Executing this file will run the HCAS model code that performs the model calculations (e.g., VMT analysis, cost allocation and revenue attribution). Section 7, Run the HCAS Python Model, describes how to open this file and run the HCAS model in Python. The user should not make any modifications to files in the src folder. The src folder also contains “requirements.txt” which will list the version of Openpyxl that is required to run the model.

#### scenarios

The *scenarios* folder is a place to put scenarios that the user is actively working on (i.e., scenarios the user wants to run through the HCAS model). Each scenario will have its own folder in the *scenarios* folder (this folder can be named whatever the desired scenario name is).

The final HCAS scenario is provided in the standard model distribution in the folder entitled “<YEAR>\_final.” For example, for the 2019 HCAS, this will be “2019\_final”. The contents of this folder are illustrated in [Figure 4](#). Each scenario folder must have an inputs folder. The *inputs* folder must have an Excel inputs workbook and a *txt folder*. All of the input text files should be placed in the *txt folder*.

[Figure 4](#) shows the required structure for the *inputs* folder along with the required filenames. The Excel inputs workbook should be entitled “HCAS Inputs.xlsx” and the input text files must have specific names (see names listed in the *txt folder* [Figure 4](#)).

The “<YEAR>\_final” folder and its inputs folder also serves as a template that the user may use as a starting point to create the scenario the user wants to run. The primary HCAS model user interface to change assumptions and input data is the Excel inputs workbook, “HCAS Inputs.xlsx”. (See [Section 6, Set Up a New Scenario](#) for more information).

Figure 1. Model Distribution Files

Name
<DATE> HCAS.zip
> <DATE> HCAS

Figure 2. Model Base Folders

Name	Kind
> <DATE> HCAS	Folder
>> processed scenarios	Folder
>> scenarios	Folder
>> src	Folder
>> templates	Folder

Figure 3. Model Base Folder Contents

Name	Kind
> <DATE> HCAS	Folder
>> processed scenarios	Folder
>> scenarios	Folder
>>> <YEAR>_final	Folder
>>>> inputs	Folder
>>>> outputs	Folder
>>> src	Folder
>>>> HCASModule.py	Python source
>>>> requirements.txt	Plain Text Document
>>> templates	Folder
>>>> HCAS Outputs.xlsx	Microsoft Excel Workbook (.xlsx)

Figure 4. Scenario Input Files

Name	Kind
> <DATE> HCAS	Folder
>> processed scenarios	Folder
>> scenarios	Folder
>>> <YEAR>_final	Folder
>>>> inputs	Folder
>>>>> HCAS Inputs.xlsx	Microsoft Excel Workbook (.xlsx)
>>>>> txt	Folder
>>>>>> AxleShares.txt	Plain Text Document
>>>>>> BasicSharePeak.txt	Plain Text Document
>>>>>> Bonds2003-2005.txt	Plain Text Document
>>>>>> Bonds2005-2007.txt	Plain Text Document
>>>>>> Bonds2007-2009.txt	Plain Text Document
>>>>>> Bonds2009-2011.txt	Plain Text Document
>>>>>> Bonds2011-2013.txt	Plain Text Document
>>>>>> Bonds2013-2015.txt	Plain Text Document
>>>>>> Bonds2015-2017.txt	Plain Text Document
>>>>>> Bonds2017-2019.txt	Plain Text Document
>>>>>> DeclaredOperating.txt	Plain Text Document
>>>>>> DeclaredRegistered.txt	Plain Text Document
>>>>>> PaveFactors.txt	Plain Text Document
>>>>>> PCEFactors.txt	Plain Text Document
>>>>>> SeedData.txt	Plain Text Document
>>>>>> SimpleFactors.txt	Plain Text Document

## processed scenarios

Once the user runs a scenario through the HCAS Python model and is satisfied with the model results, the user should move the *scenarios* folder from the scenarios folder to the *processed scenarios* folder. The user may click on the folder and drag it from the *scenarios* folder to the *processed scenarios* folder. Alternatively, the user may open the scenarios folder, right click on the scenario's folder and select "Cut." The user should then open the processed scenarios folder, right click and select "Paste." (See Section 6, Set Up a New Scenario for more information).

## templates

The *templates* folder has one file, an Excel workbook "HCAS Outputs.xlsx." This workbook serves as a template workbook with some basic text and header formatting, but does not have HCAS model output data. The user should not make any modifications to template Excel workbook in the *templates* folder.

When the user runs the HCAS Python model for a scenario, this template workbook, "HCAS Outputs.xlsx", is copied into the scenario's *outputs* folder and is filled with the results of the HCAS model for that scenario.

The scenario's name is added to the filename. For example, if the scenario's folder name is "Final", a result of running the model is the creation of a new workbook in the *outputs* folder entitled, "HCAS Outputs Final.xlsx." Similarly, if the scenario's folder name is "Scenario 1", the result of running the model is the creation of a new workbook entitled "HCAS Outputs Scenario 1.xlsx."

## 5. INSTALL PYTHON AND OPENPYXL

The user should complete the steps outlined in this section to install Python 2.7 and Openpyxl on the user's operating system.

These instructions are for a Windows 7 operating system. The general steps should be the same for other Windows operating systems, but some things may differ. For example, the way to search for a program or the way the window screen looks may differ from the directions provided in this user guide.

### 1. INSTALL PYTHON 2.7

This sub-section describes the steps to install Python 2.7. If the user already has Python 2.7 installed, the user may try to skip to the following sub-section, 2. Install Openpyxl.

If the user runs into issues later on when trying to install Openpyxl or running the HCAS Python model, reinstalling a new, clean version of Python 2.7 by following these steps may resolve those issues.

#### Steps:

- Step 1.1: Go to "<https://www.python.org/downloads/windows/>" and download the latest Python 2 Release. This will lead you to a page with a list of files. Download the Windows x86 MSI installer. This should download a file entitled, "python-2.7.13.msi. Open this file.

- A Python 2.7.13 Setup window (similar to the one displayed in Figure 6) should open up. In the Python 2.7.13 Setup window, select the option "Install for just me (not available on Windows Vista)." Click "Next."

Figure 5. Step 1.1: Open python-2.7.9.msi

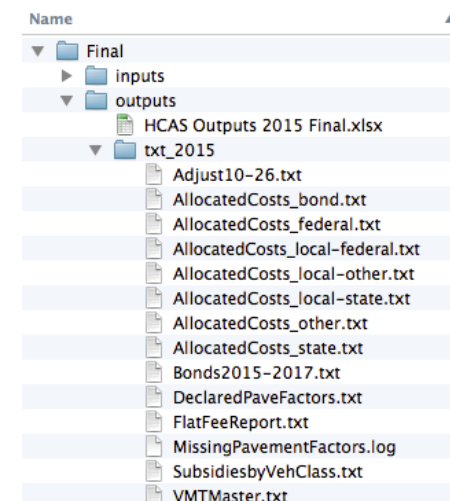


Figure 6. Step 1.2: User Install Options



- Step 1.3: The next window sets up the installation directory for Python 2.7 (see Figure 7). The installer should automatically select the correct folder to install Python 2.7 in. The default installation location is “C:\Python\27”. If the text in the bottom-most

Figure 7. Step 1.3: Directory Install Options

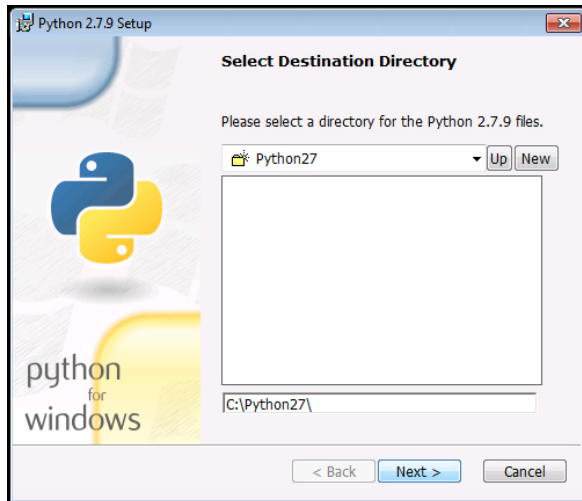
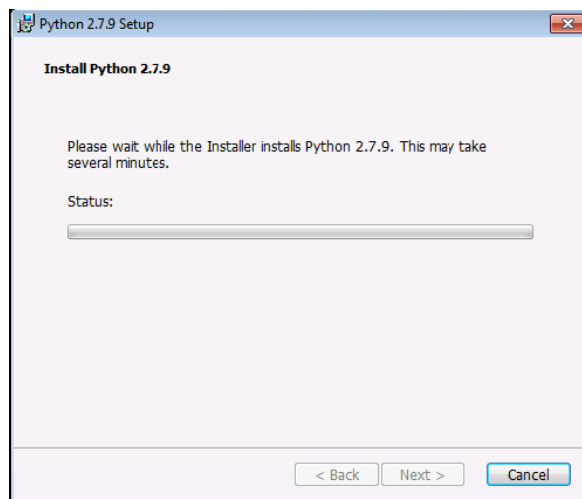


Figure 8. Step 1.4: Start Installation



white text box does not say “C:\Python\27”, modify the text in the box so that it says “C:\Python\27”. Click “Next.”

- Step 1.4: The next window will start the installation of Python 2.7 (see Figure 8). Wait until the installation finishes. This may take a couple minutes, and there may be some additional windows that pop up during the process. If a window pops up asking whether the user wishes to continue with the installation, the user should click “Yes” to continue. An example of what this type of window might look like is illustrated in Figure 9. Another window that looks similar to the window illustrated in Figure 10 (on

Figure 9. Step 1.4 (Example): Popup Window

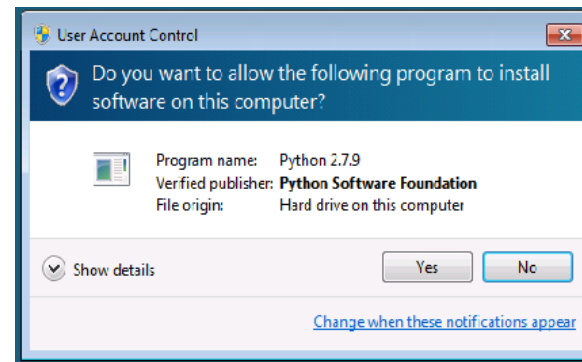
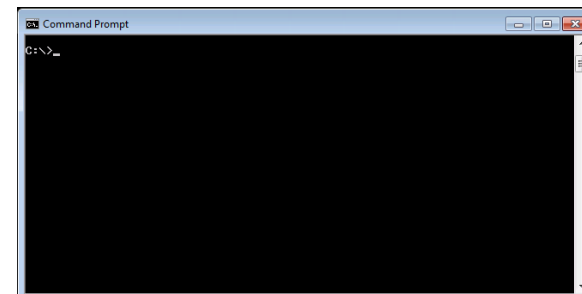


Figure 10. Step 1.4 (Example): Popup Window



the following page) may also pop up - this window will open and close automatically, the user should not try to close this window.

- Step 1.5: The installation has finished when the “Finish” button option becomes an available option to click on (see Figure 11). Click “Finish.”

Figure 11. Step 1.5: Finish Installation



## 2. INSTALL OPENPYXL

The following steps walk the user through installing Openpyxl. Openpyxl is a Python package that reads and writes Excel files. It is easiest to install through Pip, a Python package manager that is automatically installed when the user installs Python 2.7 using the default installation options. The steps provided in the previous sub-section, [1. Install Python 2.7](#), install the default version of Python 2.7.

It is recommended to try to install Openpyxl using Pip. Installing Openpyxl through Pip requires the user to use a Windows program called Command Prompt.

If the user already had an existing version of Python 2.7 and did not do a new installation, the existing version of Python may not have Pip installed. If the existing version does not have Pip installed, the user will run into an error during Step 2.5. If this occurs, the user should try installing the default version of Python 2.7 using the directions provided in the previous sub-section, [1. Install Python 2.7](#).

### Steps:

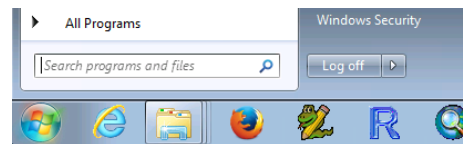
- Step 2.1: Click on the Start menu (e.g., the Windows Logo Icon in the bottom-left corner of the computer screen, see [Figure 12](#)). In the Start menu, click on “Search for programs and files” (see [Figure 13](#)). In this box, type “Command Prompt”.
- Step 2.2: Typing “Command Prompt” into the search box should change the menu to look similar to [Figure 14](#). Click on the listing for “Command Prompt” under “Programs”.

- Step 2.3: Clicking on Command Prompt should open a window that looks similar to the one illustrated in [Figure 15](#) (on the previous page). What is printed in the window when the user opens it may vary by computer. For the purposes of installing Openpyxl, it should be fine if what is displayed in the user’s window differs from what is illustrated in the figure.

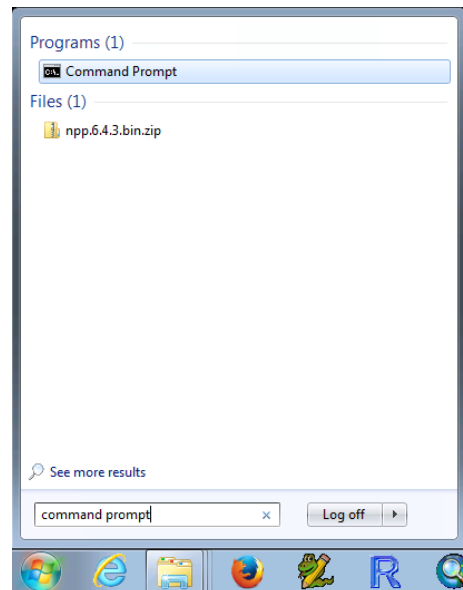
**Figure 12. Step 2.1: Windows Start Menu Icon**



**Figure 13. Step 2.1: Search for Program**



**Figure 14. Step 2.2: Search Results**



- Step 2.4: In the Command Prompt window, the user should type the following:

```
C:\Python27\Scripts\pip.exe _install
_openpyxl==2.4.2
```

**Note:** The only spaces are between “C:\Python27\Scripts\pip.exe” and “install”, and between “install” and “openpyxl==2.4.2”. There should not be any line breaks, just a space.

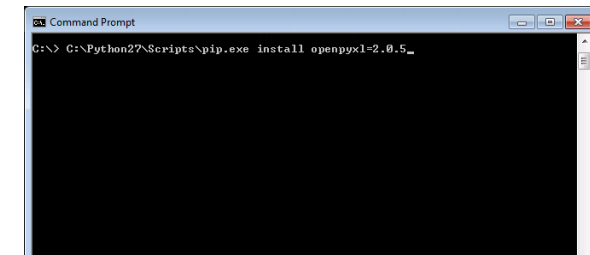
[Figure 16](#) illustrates how this command looks on the Windows computer used for this guide. Once the user has typed the command, the user should press Enter (or Return).

- Step 2.5: After the user presses Enter, Openpyxl should start to download. If the user installed Python 2.7 following the steps in the previous sub-section, this command should work and the result of pressing Enter should look something like the output in [Figure 17](#) (on the following page), with the end result being the successful installation of Openpyxl.

**Figure 15. Step 2.3: Open Command Prompt**



**Figure 16. Step 2.4: Command to Install Openpyxl**



**Figure 17. Step 2.5: Installation of Openpyxl**

```

Command Prompt
Downloading/unpacking openpyxl==2.0.5
Running setup.py (C:\Python27\Scripts\python.exe) egg_info for package openpyxl
no previously-included directories found matching 'openpyxl\tests'
no previously-included directories found matching 'openpyxl\sample'
no previously-included directories found matching 'openpyxl\benchmarks'
Downloading/unpacking jdcal (From openpyxl==2.0.5)
Downloading jdcal-1.0.tar.gz
Running setup.py (C:\Python27\Scripts\python.exe) egg_info for package jdcal
Installing collected packages: openpyxl, jdcal
Running setup.py install for openpyxl
no previously-included directories found matching 'openpyxl\tests'
no previously-included directories found matching 'openpyxl\sample'
no previously-included directories found matching 'openpyxl\benchmarks'
Running setup.py install for jdcal
Successfully installed openpyxl jdcal
Cleaning up...
    
```

Troubleshooting: If the output in the Command Prompt window does not look like that displayed in Figure 17, (e.g., the user does not see something along the lines of “Successfully installed openpyxl”, “Cleaning up...”), the user may need to reinstall the default installation of Python 2.7. The user should try deleting their current version of Python 2.7, located in the “My Computer” folder (i.e., the “C” folder), and then reinstalling a new, default installation of Python 2.7 by following the steps listed in the previous sub-section, 1. [Install Python 2.7](#). However, if the user uses Python for a different project, the user should contact the appropriate parties to make sure deleting the version of Python the user has installed doesn’t cause other problems.

## 6. SET UP A NEW SCENARIO

If the user wants to run a new scenario (e.g., entitled “Scenario 1” in this guide) where the user may see what happens under different model assumptions, the user may create a new folder in the *scenarios* folder. This guide uses the name “Scenario 1” as an example. The user may rename this folder any name they want. Figure 18 shows where in the folder structure the user should create the new folder. The easiest way to set up a new scenario is to copy the *<YEAR>\_final*

folder and then rename the copy *Scenario 1* (or any other scenario name). The user may then open “HCAS Inputs.xlsx” in the *inputs* folder and change assumptions and inputs in that workbook. The user should then resave it, and run the HCAS Python model. Figure 19 shows all of the required input files and their placement within the *Scenario 1* folder. While the actual folder names in the *scenarios* folder may change (e.g., the folder names in the *scenarios* folder in Figure 18 could just as easily be “Final” or “Scenario One”), it is important that the user does not change the file names in the *inputs* folder (i.e., the user should not change the names of the input text files or the name of the inputs Excel workbook).

**Figure 18. Add a New Scenario Folder**

Name	Kind
processed scenarios	Folder
scenarios	Folder
<YEAR>_final	Folder
Scenario 1	Folder
src	Folder
templates	Folder

**Figure 19. Add New Scenario Input Files**

Name	Kind
Scenario 1	Folder
inputs	Folder
HCAS Inputs.xlsx	Microsoft Excel Workbook (.xlsx)
txt	Folder
AxleShares.txt	Plain Text Document
BasicSharePeak.txt	Plain Text Document
Bonds2003-2005.txt	Plain Text Document
Bonds2005-2007.txt	Plain Text Document
Bonds2007-2009.txt	Plain Text Document
Bonds2009-2011.txt	Plain Text Document
Bonds2011-2013.txt	Plain Text Document
Bonds2013-2015.txt	Plain Text Document
Bonds2015-2017.txt	Plain Text Document
Bonds2017-2019.txt	Plain Text Document
DeclaredOperating.txt	Plain Text Document
DeclaredRegistered.txt	Plain Text Document
PaveFactors.txt	Plain Text Document
PCEFactors.txt	Plain Text Document
SeedData.txt	Plain Text Document
SimpleFactors.txt	Plain Text Document

When the user runs the HCAS Python model, the model will create an outputs folder that it will fill with all of the model outputs. Figure 20 shows the file structure and files that will be created when the model is run. Section 7, [Run the HCAS Python Model](#) describes how to run the model.

Once the user is satisfied with the model outputs, the user may move the *Scenario 1* folder from the *scenarios* folder to the *processed scenarios* folder. Figure 21 shows the result of moving the *Scenario 1* folder to the *processed scenarios* folder.

**Figure 20. New Scenario Output Files**

Name	Kind
Scenario 1	Folder
inputs	Folder
outputs	Folder
HCAS Outputs Scenario 1.xlsx	Microsoft Excel Workbook (.xlsx)
txt	Folder
Adjust10-26.txt	Plain Text Document
AllocatedCosts_bond.txt	Plain Text Document
AllocatedCosts_federal.txt	Plain Text Document
AllocatedCost...ocal-federal.txt	Plain Text Document
AllocatedCosts_local-other.txt	Plain Text Document
AllocatedCosts_local-state.txt	Plain Text Document
AllocatedCosts_other.txt	Plain Text Document
AllocatedCosts_state.txt	Plain Text Document
Bonds2019-2021.txt	Plain Text Document
DeclaredPaveFactors.txt	Plain Text Document
FlatFeeReport.txt	Plain Text Document
MissingPavementFactors.log	Log File
SubsidiesByVehClass.txt	Plain Text Document
VMTMaster.txt	Plain Text Document

**Figure 21. Move New Scenario Folder**

Name	Kind
processed scenarios	Folder
Scenario 1	Folder
scenarios	Folder
2019_final	Folder
src	Folder
templates	Folder

## 7. RUN THE HCAS PYTHON MODEL

The steps outlined in this section may need to be repeated each time the user wants to run a scenario through the 2019 Oregon HCAS Model.

If the user does not have an IDLE window open, the user should start at 1. [Open IDLE](#). If the user already has an IDLE window open, the user should start at 2. [Run the HCAS Python Model](#).

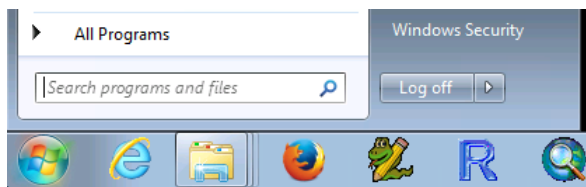
### 1. OPEN IDLE

Once the user has Python and Openpyxl installed, the user is ready to run the HCAS Python model. The most straightforward way to run the HCAS Python model is through a graphical user interface (GUI) for Python. IDLE is a standard Python GUI that works on Windows, Mac OS X, and Unix.<sup>3</sup> IDLE should be automatically installed when the user installed a new version of Python 2.7 by following the steps in [Section 5, Install Python and Openpyxl](#).

#### Steps:

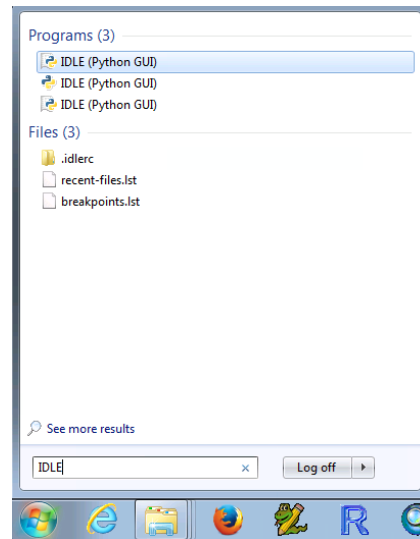
- Step 1.1: Click on the Start menu (e.g., the Windows Logo Icon in the bottom-left corner of the computer screen). In the Start menu, click on “Search for programs and files” (see [Figure 22](#)). In this box, type “IDLE”.

**Figure 22. Step 1.1: Search for IDLE**

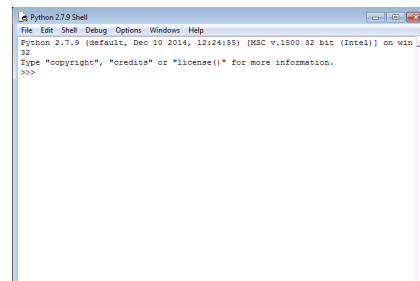


- Step 1.2: Typing “IDLE” into the search box should change the menu to look something like what is illustrated in [Figure 23](#). There may be more than one listing for IDLE, as illustrated in the figure. Click on any one of the listings for “IDLE” under “Programs”.
- Step 1.3: Clicking on IDLE should open a window that looks similar to the one illustrated in [Figure 24](#).

**Figure 23. Step 1.2: Search Results for IDLE**



**Figure 24. Step 1.3: Open IDLE**



### 2. RUN THE HCAS PYTHON MODEL

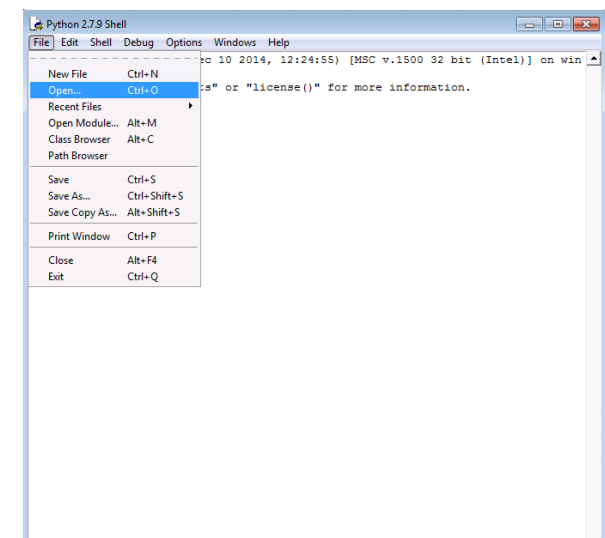
Once the user has an IDLE window open (the result of completing the steps in the previous sub-section, 1. [Open IDLE](#)) the user is ready to run the HCAS Python model.

Make sure there is a window open like the one displayed in [Figure 24](#) (if there is not, go back to the previous sub-section, 1. [Open IDLE](#), and follow those steps). The following lists steps to run the HCAS Python model, HCASModule.py, using IDLE.

#### Steps:

- Step 2.1: As illustrated in [Figure 25](#), click on the “File” menu icon in the top-right corner of the IDLE window. In the File drop down menu, click on “Open.”

**Figure 25. Step 2.1: Open a File in IDLE**



<sup>3</sup>Documentation and more in-depth instructions on how to use IDLE are available at: <https://docs.python.org/2/library/idle.html>.



- Step 2.2: Clicking on Open will make a new window pop up similar to the one illustrated in Figure 26. In this window, find the location on the user’s computer with the “2019 Oregon HCAS Model” folder (i.e., the unzipped model distribution folder, see Figure 1). Within this folder, click on the *src* subfolder, and then select “HCASModule.py”. In the window, click on “Open” in the bottom-left corner of the window (see Figure 26).

Figure 26. Step 2.2: Select File to Open

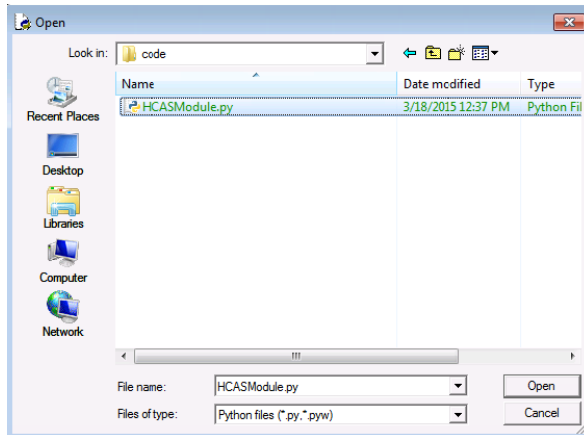
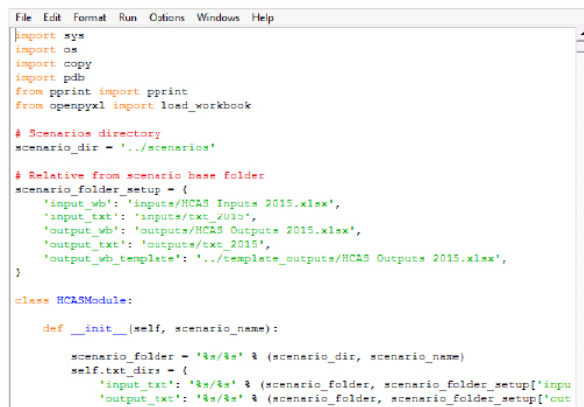


Figure 27. Step 2.3: Open the HCAS Python Mode



- Step 2.3: Opening “HCASModule.py” will open a new window with the HCAS Python model code displayed. This window will look similar to the window illustrated in Figure 27. The user should not make any changes to the code displayed in this window.

- Step 2.4: Figure 28 illustrates how to run the HCAS Python model in IDLE. In the menu bar in the top of the IDLE window, click on the “Run” menu icon in the top-center of the IDLE window. In the Run drop down menu, click on “Run Module.”

- Step 2.5: Clicking on “Run Module” will open up a new IDLE window similar to the one illustrated in Figure 29. Initially, only the black text at the top of the window will show up.

As the HCAS Python model runs, text in blue will gradually appear. The lines in blue tell the user the progress of the HCAS Python model and what point it is at in the calculations and model process.

The blue text may also provide some troubleshooting instructions for the user in case the HCAS Python model tries to open a file or folder and cannot find it.

- Step 2.6: The model has finished running shortly after “>>>” shows up in black text (see the last line in Figure 29). At this point, the user may go to the scenario’s folder (e.g., Scenario 1). In this folder, there will be an *outputs* folder where the user may examine the model outputs. If the user is satisfied with the model outputs, the user should move the scenario’s folder (Scenario 1) from the *scenarios* folder to the *processed scenarios* folder.

Note: If the user moves the scenario’s folder to the *processed scenarios* folder, but then wants to make other modifications to the scenario’s inputs and re-run the scenario, the user should move the scenario’s folder back to the *scenarios* folder and then repeat the steps in this section.

Figure 28. Step 2.3: HCAS Python Model

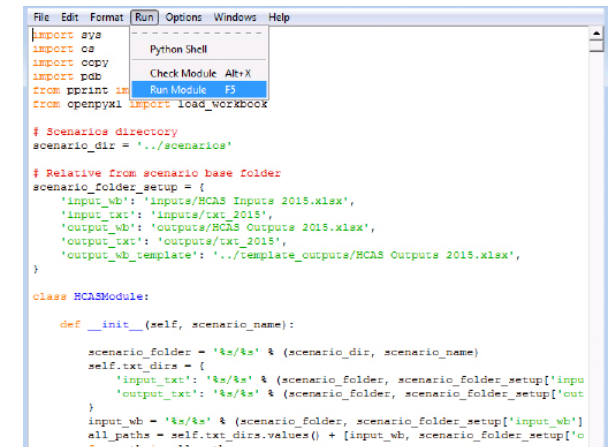
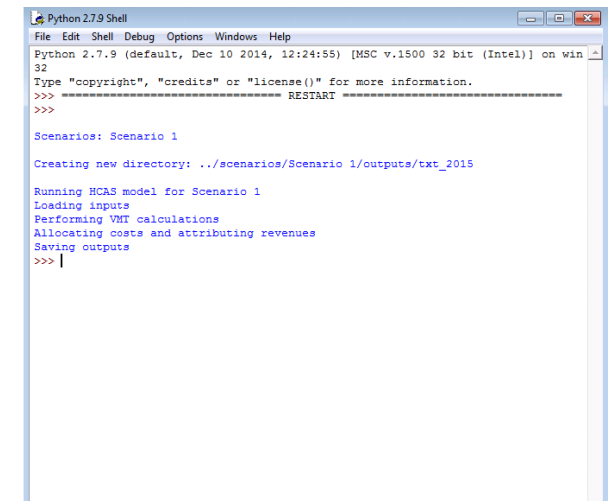


Figure 29. Step 2.5: IDLE Run Window



## 8. INPUT DATA AND DATA PREPARATION

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 (ODOT) and are produced or adapted specifically for the Oregon HCAS. For each data set, the data files, sources for the data, and any pre-processing of the data outside of the model are described.<sup>4</sup> Appendix F provides a full list of the data sources and the original filenames.

### WEIGH-IN-MOTION DATA

*Source:* ODOT Transportation Data Section

Weigh-in-motion (WIM) sensors weigh every truck passing over multiple points on Oregon's freeway system and at other, non-freeway locations. WIM data provide a good description of the distribution of operating weights.

### Pre-Processing of WIM Data

The WIM data are used to calculate distributions of operating weight classes and numbers of axles for each declared weight (and number of axles for declared weights over 80,000 pounds). For each declared weight and axle category, calculate the distribution of WIM observations among vehicle operating weight classes and number of axles (coding 9 or more axles as 9). These data are used to create the *DeclaredOperating.txt* input text file.

The input file should have four columns: Declared (declared weight category identified by the lowest weight in the category, e.g., 1, 10001, 12001, 14001,...), DeclaredAxles

(declared number of axles; zero for declared weights up to 80,000 pounds), Operating (operating weight class), OperatingAxles (actual number of axles, but not more than 9), and Share (share of vehicles for the declared weight and declared axles category by operating weight and operating axles). For each declared weight and axles category, the sum of the shares in the table should equal one.

### HPMS DATA

*Source:* ODOT

The Highway Performance Monitoring System (HPMS) is a federal program that collects data from each state every year. Over the years, the number of data elements that must be reported has changed, but the data are still extremely useful in highway cost allocation and in developing pavement factors.

### Pre-Processing of HPMS Data

The entire HPMS data set is an input file for the NAPCAS model. The HPMS data are also used in the process of estimating distributions of VMT by functional class and ownership in the *VMT by FC* tab in the inputs workbook.<sup>5</sup>

To perform the data tabulation of the HPMS data for the *VMT by FC* tab, divide the HPMS section average annual daily traffic (AADT) by the section length in miles and multiply by 365 days to calculate the section VMT. Since HPMS is a sample, each sample section VMT is expanded by multiplying it by its section weight. A summary table of VMT by functional system and ownership is tabulated and pasted into the *VMT by FC* tab such that the rows are the functional system, the column headings are ownership, and the cell entries are the sum of VMT.

## FEDERAL AND TRANSIT VMT DATA

### 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 VM-2 from 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 (Year) 1/Annual Vehicle-Miles, is pasted into the *VMT by FC* tab in the appropriate row. The Oregon row from Table MV-7, Publicly Owned Vehicles, is used in the *Federal VMT* tab. FHWA usually begins to release tables and chapters from *Highway Statistics* in late fall or winter of the following year. Use the *Highway Statistics* report corresponding to the study base year. If base year statistics are unavailable, use the most recent data that are available.

The appropriate rows from these tables should be pasted into the yellow-shaded cells in the inputs workbook where indicated on the *Federal VMT* and *VMT by FC* tabs.

### GSA Federal Fleet Report Data

*Source:* U.S. General Services Administration, [www.gsa.gov/vehiclepolicy](http://www.gsa.gov/vehiclepolicy)

The *Federal Fleet Report* is an annual publication produced by the U.S. General Services Administration (GSA). The *Federal Fleet Report* provides data on the number of federal vehicles and vehicle miles traveled by vehicle type and department or agency in the base year. These data are used in the *Federal VMT* tab as

<sup>4</sup>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.

part of the federal vehicle class VMT calculations which help develop the *Base VMT* tab. 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 VMT* tab lists the tables and rows from the *Federal Fleet Report* that should be pasted into the yellow-shaded cells on the tab.

**Transit VMT Data**

*Source:* ODOT Financial and Economic Analysis Unit

Transit bus VMT is updated on the *Transit VMT* tab with VMT information obtained from ODOT who compiled average miles by bus weight and fuel type for the calendar year. The underlying data for this compilation were from the Transit Network Exploration Tool (TNexT) which provides estimates of fixed route transit vehicle miles, and The Oregon Public Transit Information System (OPTIS), which provides information about transit vehicles funded through ODOT.

This data source is new for the 2019 study and is a departure from previous approaches used for estimating transit bus VMT. Due to the methodological change, transit bus VMT estimates by weight class are not directly comparable to previous studies.

**MOTOR CARRIER DATA**

The Motor Carrier Transportation Division (MCTD) of ODOT produces data on truck registrations, WMT collections, and flat-fee

collections. These data are cleaned and consolidated into a set of reports called Highway Use Statistics. The cleaned, unconsolidated data are used in the study.<sup>6</sup>

**Motor Carrier Registrations Data**

*Source:* MCTD, ODOT

The Motor Carrier Registrations data are used to develop distributions of registered weights by declared weights for the *DeclaredRegistered.txt* input text file. For each declared weight category, the text 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 used to develop the *DeclaredRegistered.txt* input text file. The share of vehicle registrations for the distribution of registered weights for each declared weight should be calculated from the count of registrations. The final processed table for the *DeclaredRegistered.txt* input text file should contain the declared weight, the registered weight, and the share of registrations at that declared weight.

**Flat Fee Collections Reports**

*Source:* MCTD, ODOT

The Flat Fee Collections Reports are used to calculate the Flat Fee VMT for the *MCTD VMT* tab which links to the *Base VMT* tab. The data are also used to estimate VMT per month and axle shares for the *Rates* tab.

**Pre-Processing of the Flat Fee Collections Reports**

A summary table of the monthly miles and count of the monthly reports from the Flat Fee Collections Reports should be created using a series of pivot tables. The pivot table rows are commodity, weight class, and axle count. A “mile\_non\_zero” indicator can be created and used in the page fields so that the pivot table can produce results for all observations or for records where miles are non-zero. 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. Because the analysis will account for the empty log truck.

**Figure 30. Flat Fee**

Weight	Flat Fee Miles		
	Logs	Dump	Chip
26,001	0	289	0
28,001	0	0	0
30,001	0	0	0
32,001	0	0	0
34,001	0	0	0
36,001	0	0	0
38,001	0	0	0
40,001	0	0	0
42,001	0	0	0
44,001	0	985	0
46,001	0	82,043	0
48,001	0	14,251	0
50,001	0	12,367	0
52,001	0	10,984	0
54,001	0	40,341	0
56,001	0	13,594	0
58,001	0	0	0
60,001	0	0	0
62,001	0	0	0
64,001	0	9,260	0
66,001	0	0	0
68,001	0	0	0
70,001	0	0	0

<sup>6</sup> 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 inputs workbook. Basic vehicles are those vehicles weighing less than 10,001 pounds. For vehicles from 10,001 to 200,001 pounds, weight classes are defined in 2,000-pound increments, (e.g. 10,001, 12,001, ...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 from the entered weight, divide by 2,000, truncate or round to the decimal point, then multiply by 2,000 and add one (e.g., Round((Weight-1)/2000,0)\*2000+1 in Excel).

HCAS axle classes are zero, five, six, seven, eight or nine (or more). If the weight class is under 80,001, the axle class is zero. For 80,001 and above, a record with five or fewer reported axles is assigned to axle class five, and nine or more axles are assigned to axle class nine. If the reported axle count is six, seven, or eight, the axle class is set equal to the reported number of axles.

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 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.

For the Flat Fee Miles table (see [Figure 30](#) on the previous page) in the MCTD VMT tab, the miles reported in the Flat Fee Collections Reports are summed for each commodity and axle class and then the number of non-zero records and total number of records are counted.

For the *Rates* tab, create a pivot table or summary table results using the Flat Fee Collections Reports data. The records where miles are non-zero (“non-zero miles”) are used to calculate the average VMT per month and the axle share of VMT for each weight class.

**Road Use Assessment Fee Data**

Source: MCTD, ODOT

The road use assessment fee (RUAf) data are the records from the vehicles paying the RUAf at weight classes of 96,001 pounds and above. Each RUAf record contains an ID number, issue date, axles, weight, miles, and tax. The RUAf data are tabulated to determine the VMT by RUAf vehicles by weight and axle class, which are then pasted into RUAf table in the *MCTD VMT* tab (see [Figure 31](#)).

**WMT Collections Reports**

Source: MCTD, ODOT

The WMT Collections (or Payments) Reports are pre-processed and used to develop the *MCTD VMT* tab and determine the VMT for the various WMT vehicle classes.

**Figure 31. RUAf**

RUAf	
Weight	Miles
26,001	0
28,001	0
30,001	0
32,001	0
34,001	0
36,001	0
38,001	0
40,001	0
42,001	0
44,001	0
46,001	0
48,001	0
50,001	0
52,001	0
54,001	0
56,001	0
58,001	0
60,001	0
62,001	0
64,001	0
66,001	0
68,001	0
70,001	0
72,001	0
74,001	0
76,001	0
78,001	0
80,001	0
82,001	0
84,001	0
86,001	0

**Figure 32. WMT**

A	B	C	D	E	F	G
Weight	Weight-Mile Tax					
	Any Axles	5 Axles	6 Axles	7 Axles	8 Axles	9 Axles
26,001	2,866,691	0	0	0	0	0
28,001	4,559,806	0	0	0	0	0
30,001	9,552,825	0	0	0	0	0
32,001	22,592,747	0	0	0	0	0
34,001	4,688,468	0	0	0	0	0
36,001	2,708,640	0	0	0	0	0
38,001	3,864,649	0	0	0	0	0
40,001	2,987,501	0	0	0	0	0
42,001	3,352,060	0	0	0	0	0
44,001	31,943,364	0	0	0	0	0
46,001	13,430,413	0	0	0	0	0
48,001	15,961,987	0	0	0	0	0
50,001	14,865,875	0	0	0	0	0
52,001	22,155,684	0	0	0	0	0
54,001	25,661,091	0	0	0	0	0
56,001	10,429,474	0	0	0	0	0
58,001	8,389,532	0	0	0	0	0
60,001	1,671,415	0	0	0	0	0
62,001	2,499,763	0	0	0	0	0
64,001	11,310,374	0	0	0	0	0
66,001	2,698,457	0	0	0	0	0
68,001	5,545,025	0	0	0	0	0
70,001	3,921,367	0	0	0	0	0
72,001	2,321,225	0	0	0	0	0
74,001	4,976,077	0	0	0	0	0
76,001	1,156,997	0	0	0	0	0
78,001	1,065,472,974	0	0	0	0	0
80,001	0	6,488,201	243,509	272,535	2,988	1,813
82,001	0	7,624,312	1,075,976	59,738	50,080	2,469
84,001	0	8,543,751	3,832,396	248,029	96,586	4,843
86,001	0	1,413,626	11,233,666	904,514	92,527	9,692

**Pre-Processing of the WMT Collections Reports**

The size of the WMT Collections Report data set requires that the data pre-processing take place outside of the HCAS model.

Assign all of the records in the WMT Collections Report data to a weight class and axle class using the HCAS weight class and axle class categories. Then, create a summary table that has the sum of the miles traveled for the HCAS weight and axle class categories from the WMT Collections Report data. This summary table is then pasted into Weight-Mile Tax table in the *MCTD VMT* tab (see [Figure 32](#)).

**VMT ESTIMATES AND FORECAST**

Source: ODOT Financial and Economic Analysis Unit

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. The base-year VMT from the ODOT forecast are used to control total VMT for light and medium-heavy vehicle classes in the *Base VMT* tab.

**DMV VEHICLE REGISTRATIONS**

Source: Department of Motor Vehicles, Request by ODOT Financial Services

The DMV registrations data are used to build the estimates of VMT by weight class and tax class for the base year for certain vehicle tax classes. For the 2019 HCAS, ODOT Financial Services was granted permission to obtain de-identified registration records from DMV.

**Pre-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.

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 other, special categories of vehicle registrations by fuel type and weight class.

The DMV registrations data are used to create 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, and E-Plate (exempt). For this table, a weight class is assigned to each registration record by converting the registered vehicle weight to the corresponding HCAS weight class. Fuel type is available from the “motive power” field.

The license plate string is used to identify the vehicle tax class using the plate vehicle class designations (T for commercial truck, TW for tow truck, F for farm, CN for charitable/non-profit, or E for exempt; followed by numerals).

The summary table of DMV registrations data should be pasted into the yellow-shaded cells (columns B through M) in the left-most table on the DMV VMT tab (see [Figure 33](#)).

**Figure 33. DMV-OtherRUAF**

Weight	Gas						Diesel & Other						Assumed Miles per Registration				
	CN	E	F	T	TOW	MH	CN	E	F	T	TOW	MH	CN	E	F	T	TOW
1	114	29,452	1,869	927	86	0	40	10,929	568	766	315	0	10,000	13,000	3,000	0	15,000
10,001	128	34	428	1,836	21	12,213	70	31	391	2,112	70	1450	10,000	12,000	3,000	19,000	15,000
12,001	97	33	209	911	22	2,847	41	27	251	1,533	86	373	10,000	12,000	3,000	19,000	15,000
14,001	223	52	383	1,212	29	7,886	93	134	508	3,242	160	355	10,000	12,000	3,000	19,000	15,000
16,001	21	6	229	482	11	4,905	28	33	398	1,944	104	360	10,000	12,000	3,000	19,000	15,000
18,001	16	5	423	391	15	3,263	64	55	765	2,224	186	750	10,000	12,000	3,000	19,000	15,000
20,001	7	2	157	144	2	0	18	37	275	491	30	0	10,000	12,000	3,500	19,000	15,000
22,001	8	6	319	172	1	1,455	22	10	420	693	43	455	10,000	12,000	3,500	19,000	15,000
24,001	20	7	699	650	19	1,109	141	63	1,503	6,026	661	1177	10,000	12,000	3,500	19,000	15,000
26,001	4	3	310	5	0	572	37	11	241	31	0	621	10,000	11,000	3,500	15,000	15,000
28,001	3	5	279	4	0	287	21	80	364	30	0	912	10,000	11,000	3,500	15,000	15,000
30,001	4	2	187	0	0	447	34	47	325	11	0	3539	10,000	11,000	3,500	15,000	15,000
32,001	1	1	51	4	0	0	40	39	288	34	0	0	10,000	11,000	3,500	15,000	15,000
34,001	0	1	37	2	0	0	10	25	131	18	0	0	10,000	11,000	3,500	15,000	15,000
36,001	1	2	17	0	0	0	10	80	56	9	0	0	10,000	11,000	3,500	15,000	15,000
38,001	0	1	31	2	0	0	5	19	153	11	0	0	10,000	11,000	3,500	15,000	15,000
40,001	2	0	30	1	0	0	1	1	53	6	0	0	10,000	11,000	4,000	15,000	15,000
42,001	1	3	77	0	0	0	3	4	128	3	0	0	10,000	11,000	4,000	15,000	15,000
44,001	1	0	104	0	0	0	4	4	581	11	0	0	10,000	11,000	4,000	15,000	15,000
46,001	0	1	71	1	0	0	7	6	591	19	0	0	10,000	11,000	4,000	15,000	15,000
48,001	0	0	39	1	0	0	4	5	583	9	0	0	10,000	11,000	4,000	15,000	15,000
50,001	0	0	5	0	0	0	3	3	206	11	0	0	10,000	11,000	4,500	15,000	15,000

Motorhome registrations data do not include vehicle weight, so registrations are tabulated by vehicle length and assigned a HCAS weight class based on their reported vehicle length.

## PAVEMENT FACTORS

*Source:* RD Mingo & Associates

RD Mingo & Associates produce Oregon-specific pavement factors using the Oregon HPMS submittal data in the new 2010 National Pavement Costs Model (NAPCOM). Pavement factors are used to update *PavementFactors.txt* input file and the pavement allocators in the Policy tab. Minimal processing of the pavement factors data may be necessary to get the pavement factors into the correct format for *PavementFactors.txt*.

## ESTIMATED AVERAGE BASIC-VEHICLE MPG

*Source:* ODOT Financial and Economic Analysis Unit

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* table in the *General* tab in the inputs workbook. 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* table in the *General* tab should be generally consistent with the assumptions made by ODOT.

## EXPENDITURE AND REVENUE DATA

### Local Government Revenues and Expenditures

*Source:* ODOT-conducted Local Roads and Streets Survey

Prior-fiscal-year (corresponding to the model year) revenues and expenditures by local governments come from the Local Roads and Streets Survey (LRSS) compiled by ODOT.

Paste the LRSS data into the Local Costs tab and the formulas in that tab will produce 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 and are required to update the *Non-Project Costs* tab. These data are available around the end of August and are completed by the ODOT Finance Section. The Highway Programs Office provides the breakdown of non-project maintenance costs by maintenance work type. The non-project expenditure data do not require any pre-processing. The non-project expenditure data are pasted into the *Non-Project Costs* tab.

### Project Expenditure Data

*Source:* 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 per month. Upon request, project expenditure files are produced that contain 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. Project expenditures data are requested when the Agency Request Budget data become available (generally in August or September) so that the project data are consistent with the budget.

### Pre-Processing of Project Expenditure Data

Given the number of different sources, some in non-standardized formats, used to create the project expenditures input data, there is no formalized method for processing and developing the project costs table. The general steps for processing and creating the project costs 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 PCS.*
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 a bridge type.*

Using the list of projects in the Cash Flow Projection and 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 an unknown functional system.

For each project, determine the share of project expenditures by funding source. Project expenditure shares by funding source reflect the total project funding, not necessarily the expenditures during the study period. Shares or dollar amounts by funding source are provided in the PCS 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 have already 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 costs 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 bridge 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. Lists of work types and bridge types are located in the Codes tab in the inputs workbook.

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<sup>7</sup> 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 2019 HCAS, the project expenditure file was first created by working in a file where each project was a single record with columns for 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 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.

<sup>7</sup>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.

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. Because a project may have up to four funding sources and up to three work types, each project can potentially be turned into twelve separate entries in the *Project Costs* table. Paste the final project costs table into the *Project Costs* tab in the inputs workbook using the format shown in [Table 1](#).

[Table 1](#) displays an example of the *Project Costs* tab entries for a project that has three funding sources (state, federal, and other) and three work types (20, 21, and 41). The “Dollars” column is produced by multiplying the total project expenditures in the biennium by the fund source share and work source share. The key number is included for project identification but is not read into the model.

**Budgeted Revenue Control Totals**

*Source:* ODOT Financial and Economic Analysis Unit

Budgeted revenue control totals come from spreadsheets used to develop the Agency Request Budget by the ODOT Financial and Economic Analysis Unit. These data are usually available at the end of August before the upcoming biennium.

The data in these spreadsheets are pasted into the yellow-shaded cells on the *Revenue Forecast* tab in the inputs workbook. Gross revenue amount by revenue source is linked to the appropriate revenue control total on the *Revenue Forecast* tab.

**Current-Law Tax Rates and Fee Schedules**

*Source:* Oregon Revised Statutes, 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. The WMT Schedule A and B tables can be found at the MCTD website, where the WMT rates are calculated for each weight class and axle combination for Table B.

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 Statutes in the *Rates* tab in the inputs workbook.

**9. 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.

***AxleShares.txt***

This file contains the distribution of VMT by number of axles for each weight class. These shares change little from year to year and do not need to be updated every biennium. The source is the weigh-in-motion data.

***BasicSharePeak.txt***

This file contains the share of VMT during the peak hour of the day by functional class that are by basic vehicles.<sup>8</sup> These shares change little from year to year and do not need to be updated every biennium. The source is 24-hour automatic traffic recorder data from ODOT.

**Table 1. Example of Project with Multiple Work Types and Funding Sources**

Funding	Work Type	Functional Class	Bridge Type	Dollars	Key Number
state	20	0	0	164,498	K16239
state	21	0	0	65,178	K16239
state	41	0	0	80,697	K16239
federal	20	0	0	307,266	K16239
federal	21	0	0	121,747	K16239
federal	41	0	0	150,734	K16239
other	20	0	0	190,733	K16239
other	21	0	0	75,573	K16239
other	41	0	0	93,567	K16239



**Bonds**

- *Bonds2005-2007.txt*
- *Bonds2007-2009.txt*
- *Bonds2009-2011.txt*
- *Bonds2011-2013.txt*
- *Bonds2013-2015.txt*
- *Bonds2015-2017.txt*
- *Bonds2017-2019.txt*
- *Bonds2019-2021.txt*

These files contain the prior allocated bonds from the previous eight studies. 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. These files are not updated.

**DeclaredOperating.txt**

This file contains a distribution of operating weights for each declared weight from the weigh-in-motion data. The *DeclaredOperating.txt* 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 from the Motor Carrier Registrations data. The *DeclaredRegistered.txt* data are used to attribute registration and title fee revenues.

**PaveFactors.txt**

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 and weigh-in-motion data in the NAPHCAS-OR model.

**PCEFactors.txt**

This file contains the passenger-car equivalents (by weight class and number of axles) on regular, uphill, and congested roadways as estimated by Battelle for the most recent (1997) federal HCAS. This file is not updated.

**SimpleFactors.txt**

This 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-pound 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 pounds is applied to the VMT master. This file does not need to be updated for new studies unless the allocators are changed.

**SeedData.txt**

This file contains an initial guess as to the distribution of VMT by weight class, functional class, ownership, and number of axles. It does not need to be updated.

## 10. INPUTS WORKBOOK

This section provides a tab-by-tab explanation of the tabs in the input workbook. One input Excel workbook must be included in the scenario's *inputs* folder ("HCAS Inputs.xlsx") for the processing of input data. The input workbook is read in when the HCAS model is run in Python. The majority of the required calculations and data tables are automatically updated when the yellow-shaded input cells are modified.

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, and select the *Name* option. From the *Name* menu, select the *Define* option. In the window that pops up, select the named range, and review and change (if necessary) the *Refers to* cell references.

**SET UP BASE VMT**

In the 2013 HCAS study, the *Base VMT* tab in the primary inputs workbook was developed using a supplemental Base VMT workbook. Starting with the 2015 HCAS study, the *Base VMT* tab and the tabs that it links to it are consolidated in the main inputs workbook, "HCAS Inputs.xlsx". The *Base VMT* tab is built using *DMV VMT*, *MCTD VMT*, *Federal VMT*, and *Bus VMT* tabs.

Since the 2015 HCAS study, the approach for calculating the base VMT has been formalized with the intermediate calculations performed in other VMT tabs in the main inputs workbook. 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 that build the *Base VMT* tab. Some tabs were already discussed in the section, [Section 8, Input Data and Data Preparation](#).

**MCTD VMT**

The *MCTD VMT* tab contains calculations and data related to flat fee VMT, WMT VMT, and RUA. The pre-processing steps for those data are described and illustrated in [Section 8, Input Data and Data Preparation](#).

**Bus VMT**

The *Bus VMT* tab contains transit bus VMT and school bus VMT.

**Transit**

The columns B through H in the *Bus VMT* tab provide estimates of 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.

Transit bus VMT is updated on the *Transit VMT* tab with VMT information from the OPTIS and TNexT data provided by ODOT. To update this tab, the transit bus VMT by weight class for diesel and non-diesel are collected for the base year and entered into the yellow-shaded input cells

**School Bus**

The Bus VMT tab contain 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. School bus registrations by fuel type (gasoline or diesel) from the DMV-Other table is applied to the 2006 school bus VMT to determine the fuel-type split for the school bus VMT.

**Federal VMT**

The Federal VMT tab has three primary tables:

*Federal, Federal VMT Spread, and Federal Summary VMT.*

**Federal**

Paste the indicated table rows from the FHWA *Highway Statistics* (Table MV-7) and the GSA *Federal Fleet Report* into the yellow-shaded cells in the Federal table on the *Federal VMT* tab (see [Figure 36](#) on the following page). The input data the *Federal* table are used with the *Federal VMT Spread* table to calculate the *Federal Summary VMT* table. It is important that the input data are pasted into the exact cells as indicated by the row and column headings because the cells are referenced in the VMT calculations at the bottom of the *Federal VMT* 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.

**Figure 34. Bus VMT**

Bus VMT by Area and Assumed Shares					Bus VMT by Type		
Weight	Diesel	Non-Diesel	Total	Assumed School Shares	Gas School Buses	Diesel School Buses	Diesel Transit Buses
10,001	393,427	21,953,213	22,346,640	0.0030	43,473	145,541	393,427
12,001	0	0	0	0.0656	956,411	3,201,897	0
14,001	17,546,833	17,074,721	34,621,555	0.0048	69,557	232,866	17,546,833
16,001	0	0	0	0.0036	52,168	174,649	0
18,001	0	0	0	0.0042	60,862	203,756	0
20,001	0	0	0	0.0418	608,625	2,037,570	0
22,001	0	0	0	0.0585	852,075	2,852,599	0
24,001	3,068,729	5,665,345	8,734,074	0.2649	3,860,421	12,924,020	3,068,729
26,001	0	0	0	0.1259	1,834,570	6,141,820	0
28,001	0	0	0	0.1169	1,704,150	5,705,198	0
30,001	4,091,638	393,427	4,485,065	0.1712	2,495,362	8,354,039	4,091,638
32,001	0	0	0	0.0477	695,571	2,328,652	0
34,001	0	0	0	0.0901	1,312,891	4,395,332	0
36,001	0	0	0	0.0012	17,389	58,217	0
38,001	13,226,987	0	13,226,987	0.0006	8,695	29,108	13,226,987
40,001	0	0	0	0.0000	0	0	0
School bus VMT		63,357,486					
% Diesel		77%					

### Federal VMT Spread

The *Federal VMT Spread* table uses the share of VMT for school buses and transit buses (*Bus VMT* tab) by weight classes to spread the federal bus VMT across vehicle weight classes. Similarly, the State and Local Government (SLG) VMT are used to spread the federal heavy vehicle VMT across weight classes. This table essentially creates the shares or weights for each weight class, which are then applied to the federal VMT input from the Federal table.

All of the calculations on this tab are linked to other tabs that help develop the *Base VMT* tab. The user 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 VMT* tab.

### Federal Summary VMT

The *Federal Summary VMT* table sums the federal VMT by weight class from the *Federal* table and the *Federal VMT Spread* table.

Federal VMT for basic vehicles is the sum of the basic VMT from the Federal table and the federal bus VMT from the *Federal VMT Spread* table. Federal VMT for vehicles 10,001 pounds and above are the federal bus and truck VMT from the *Federal VMT Spread* table. 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.

Figure 35. Federal

Federal Vehicle VMT																											
A	B	C	D	E	F	G	H	I	J	K	L	M	N														
<b>Sources:</b>																											
2014 FHWA Highway Statistics, Table MV - 7, Publicly Owned Vehicles 2014.				<a href="http://www.fhwa.dot.gov/policy/information/statistics/2014/mv7.htm">http://www.fhwa.dot.gov/policy/information/statistics/2014/mv7.htm</a>																							
2015 Federal Fleet Report, US General Services Administration (GSA).				<a href="http://www.gsa.gov/portal/category/102859">http://www.gsa.gov/portal/category/102859</a>																							
<b>2014 FHWA Highway Statistics</b>																											
Table MV - 7, Publicly Owned Vehicles 2012, Federal - Motor Vehicles (1)																											
<b>State</b>		<b>Automobiles</b>		<b>Buses</b>		<b>Trucks &amp; Truck</b>		<b>Total</b>																			
Oregon		2,494		59		6,168		8,721																			
<b>2015 Federal Fleet Report</b>																											
Table 2-5: Passenger Vehicles*																											
<b>Department or Agency</b>		<b>Low-Speed</b>		<b>Sub-Compact</b>		<b>Compact</b>		<b>Midsize</b>		<b>Large</b>		<b>Limousines</b>		<b>Light SUVs</b>		<b>Medium SUVs</b>		<b>Light Pass Vans</b>		<b>Medium Pass Vans</b>		<b>Total</b>					
Total Civilian Agencies		737		11,470		21,027		19,220		6,761		77		62,483		7,571		17,350		5,347		152,013					
U.S. Postal Service Agencies		0		120		4,068		2,725		120		0		1,294		0		689		2		9,018					
<b>Table 2-6: Trucks* and Other Vehicles</b>																											
<b>Department or Agency</b>		<b>Light Duty 4x2</b>		<b>Light Duty 4x4</b>		<b>Medium Duty</b>		<b>Heavy Duty</b>		<b>Ambulances</b>		<b>Buses</b>		<b>Total</b>													
Total Civilian Agencies		15,162		35,770		32,281		11,738		452		3,008		98,409													
U.S. Postal Service Agencies		188,708		1,777		7,958		4,897		0		2		203,342													
<b>Table 4-2: Average Miles Per Vehicle</b>																											
<b>Department or Agency</b>		<b>Low-Speed</b>		<b>Sedans</b>		<b>Pass Vans</b>		<b>SUVs</b>		<b>Pass Subtotal</b>		<b>Light Trucks</b>		<b>Medium Trucks</b>		<b>Heavy Trucks</b>		<b>Truck Subtotal</b>		<b>Ambulances</b>		<b>Buses</b>		<b>Other Subtotal</b>		<b>Total</b>	
Total Civilian Agencies		1,054		10,170		8,702		8,872		9,770		8,864		7,638		4,869		7,928		9,024		13,404		12,832		9,113	
Total U.S. Postal Service		0		7,250		6,401		6,208		7,055		6,085		5,784		25,150		6,832		0		1,893		1,893		6,563	

Figure 36. Federal VMT Spread

Federal VMT Spread Table																											
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	Percent of Buses		Spread Federal Buses		Gas SLG		Diesel & Other SLG		SLG Totals		SLG Medium Percent		SLG Heavy Percent		Spread Federal Trucks		SLG Gas Percent			
	1	0	0	0	0	0		0	0.00%	0	0	Gas SLG	SLG	SLG Totals	SLG Medium Percent	SLG Heavy Percent	Trucks	Trucks	Trucks	Trucks	Trucks	Trucks	Trucks	Trucks	Trucks	Trucks	Trucks
10,001	45,757	0	153,186	0	0	198,943	0.21%	1,693	408,000	372,000	780,000	20.90%	6,628,400	52,31%	0	72,94%	0	0	0	0	0	0	0	0	0	0	
12,001	1,008,659	3,370,085	0	0	4,378,743	4.71%	37,254	396,000	324,000	720,000	19.29%	6,118,523	55.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,001	73,211	245,098	0	0	318,309	0.34%	2,709	624,000	1,608,000	2,232,000	59.81%	18,967,423	27.96%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16,001	54,908	183,823	0	0	238,731	0.26%	2,032	72,000	396,000	468,000	7.00%	1,351,081	15.38%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18,001	64,059	214,459	0	0	278,518	0.30%	2,371	60,000	660,000	720,000	10.78%	2,078,586	8.33%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20,001	940,594	2,144,598	0	0	2,785,193	3.00%	23,707	24,000	444,000	468,000	7.00%	1,351,081	5.13%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22,001	896,832	3,002,439	0	0	3,899,271	4.20%	33,190	72,000	120,000	192,000	2.87%	554,289	37.50%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24,001	4,063,200	13,602,886	486,853	0	18,152,939	19.55%	154,513	84,000	756,000	840,000	12.57%	2,425,016	10.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26,001	1,030,935	6,484,435	14,444,093	22,839,463	24.80%	194,403	33,000	121,000	154,000	275,000	2.31%	444,588	21.43%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28,001	1,793,655	6,004,878	6,548,948	14,747,481	15.88%	126,524	65,000	880,000	938,000	1,000,000	13.99%	2,699,274	5.88%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30,001	2,626,438	8,792,856	234,138	11,653,431	12.56%	99,191	22,000	517,000	539,000	600,000	8.07%	1,555,052	4.08%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32,001	732,108	2,450,971	0	0	3,183,079	3.43%	27,094	11,000	429,000	440,000	6.59%	1,270,247	2.50%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34,001	1,381,854	4,626,207	0	0	6,008,062	6.47%	51,139	11,000	275,000	286,000	4.28%	825,660	3.85%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36,001	18,303	81,275	794,687	874,245	0.94%	7,441	22,000	880,000	902,000	1,000,000	13.50%	2,604,006	2.44%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38,001	9,191	30,837	1,114,879	1,154,867	1.87%	13,231	11,000	229,000	229,000	250,000	3.29%	635,123	5.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40,001	0	0	1,749,634	1,749,634	1.88%	14,892	0	11,000	11,000	12,000	0.16%	31,756	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42,001	0	0	0	0	0	0	0	0	33,000	44,000	77,000	1.15%	222,293	42.86%	0	0	0	0	0	0	0	0	0	0	0	0	0
44,001	0	0	0	0	0	0	0	0	0	44,000	44,000	0.66%	127,025	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0
46,001	0	0	0	0	0	0	0	0	11,000	66,000	77,000	1.15%	222,293	14.29%	0	0	0	0	0	0	0	0	0	0	0	0	0
48,001	0	0	0	0	0	0	0	0	0	66,000	66,000	0.82%	158,781	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0
50,001	0	0	0	0	0	0	0	0	0	33,000	33,000	0.49%	95,269	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0
52,001	0	0	0	0	0	0	0	0	0	44,000	44,000	0.66%	127,025	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 37. Federal Summary VMT

Federal VMT Summary for Gas and Diesel Vehicles			
	Federal VMT	Federal Gas	Federal Diesel
1	19,577,617	14,278,992	5,298,625
10,001	6,630,094	3,468,049	3,162,045
12,001	6,155,777	3,385,677	2,770,100
14,001	18,970,132	5,303,478	13,666,654
16,001	1,353,113	208,171	1,144,941
18,001	2,080,956	173,413	1,907,543
20,001	1,374,787	70,502	1,304,285
22,001	587,479	220,305	367,174
24,001	2,579,529	257,953	2,321,576
26,001	638,990	136,926	502,063
28,001	2,824,798	166,165	2,658,634
30,001	1,655,243	67,561	1,587,682
32,001	1,297,340	32,434	1,264,907
34,001	876,799	33,723	843,076
36,001	2,611,447	63,694	2,547,753
38,001	648,355	32,418	615,937
40,001	46,649	0	46,649
42,001	222,293	95,269	127,025
44,001	127,025	0	127,025
46,001	222,293	31,756	190,537
48,001	158,781	0	158,781
50,001	95,269	0	95,269
52,001	127,025	0	127,025
54,001	158,781	0	158,781
56,001	31,756	0	31,756
58,001	31,756	0	31,756
60,001	0	0	0
62,001	31,756	0	31,756
64,001	95,269	0	95,269
66,001	0	0	0
68,001	31,756	0	31,756
70,001	0	0	0
72,001	0	0	0
74,001	0	0	0
76,001	63,512	31,756	31,756
78,001	63,512	0	63,512
80,001	0	0	0
82,001	0	0	0
84,001	0	0	0
86,001	0	0	0
88,001	0	0	0
90,001	0	0	0

**BASE VMT**

The *Base VMT* tab contains the base-year VMT by weight class and vehicle tax class. The base-year VMT are used in the model to calculate the model-year VMT. The base-year VMT are used to allocate costs and attribute revenues by vehicle tax and weight class. The *Base VMT* tab is built using the *General*, *DMV VMT*, *MCTD VMT*, *Federal VMT*, *Bus VMT*, and *VMT Growth* tabs.

The *Base VMT* tab adjusts the basic and medium-heavy VMT so that the total for these two weight groupings equals their corresponding VMT forecast from the ODOT Economic and Revenue Forecast (for the base year). 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 *VMT*

*Growth* tab (see [Figure 44 on page D26](#)). The VMT estimates for the base year are the control totals for the basic vehicle and medium-heavy vehicle classes. The *Base VMT* and *DMV VMT* tabs 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. A more detailed discussion of the *VMT Growth* tab is provided later on in this section.

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 medium-heavy control total adjustment factor is applied to the VMT for medium-heavy vehicle classes (vehicles

between 10,001 and 26,000 pounds).

The WMT VMT reflect the WMT VMT reported in the WMT Collection Reports. The WMT VMT are adjusted to include an assumed WMT evasion factor. The WMT evasion factor<sub>9</sub> adjusts the WMT VMT to account for the additional VMT not reported for WMT payments. The WMT evasion factor is a user-specified assumption located on the *General* tab in the Control table.

Since the 2015 HCAS, all inputs that build the *Base VMT* tab are linked to it and the tab automatically updates. Similarly, a number of other tabs reference the *Base VMT* tab and also update automatically (e.g., development of growth factors on the *VMT Growth* tab for weight classes 26,001 to 104,001 pounds).

**Figure 38. Base VMT**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Weight Class	Private Passenger	Gas Commercial 10-26	Diesel & Other Commercial 10-26	Gas Tow Trucks	Diesel & Other Tow Trucks	RUAUF Vehicles	Flat Fee Vehicles Log	Flat Fee Vehicles S&G	Flat Fee Vehicles Chip	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	Gas Farm
2	WC	Cars	GasComm	DieselComm	GasTow	DieselTow	RUAUF	FlatFeeLog	FlatFeeSG	FlatFeeChip	WMTA	WMTB5	WMTB6	WMTB7	WMTB8	WMTB9	GasFarm
3		30,421,163,637	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	10,001	18,225,160	42,402,635	48,822,431	420,000	1,110,000	0	0	0	0	0	0	0	0	0	0	1,374,000
5	12,001	12,079,652	17,787,227	35,662,992	345,000	1,380,000	0	0	0	0	0	0	0	0	0	0	669,000
6	14,001	33,084,448	25,907,645	74,592,998	510,000	2,415,000	0	0	0	0	0	0	0	0	0	0	1,212,000
7	16,001	20,526,236	9,115,653	44,367,413	135,000	1,620,000	0	0	0	0	0	0	0	0	0	0	798,000
8	18,001	16,697,756	7,196,568	44,710,106	135,000	2,580,000	0	0	0	0	0	0	0	0	0	0	1,386,000
9	20,001	0	2,535,933	10,760,583	45,000	465,000	0	0	0	0	0	0	0	0	0	0	637,000
10	22,001	7,684,876	4,249,402	15,421,217	15,000	765,000	0	0	0	0	0	0	0	0	0	0	1,235,500
11	24,001	9,311,980	15,421,217	132,805,237	405,000	9,885,000	0	0	0	0	0	0	0	0	0	0	2,684,500
12	26,001	4,709,828	0	0	0	0	0	0	10,935	0	2,391,059	0	0	0	0	0	1,218,000
13	28,001	4,949,108	0	0	0	0	0	0	0	0	3,995,673	0	0	0	0	0	1,102,500
14	30,001	15,728,672	0	0	0	0	0	0	0	0	9,726,469	0	0	0	0	0	735,000
15	32,001	0	0	0	0	0	0	0	0	0	22,936,441	0	0	0	0	0	196,000
16	34,001	0	0	0	0	0	0	0	0	0	4,679,480	0	0	0	0	0	154,000
17	36,001	0	0	0	0	0	0	0	0	0	2,514,291	0	0	0	0	0	56,000
18	38,001	0	0	0	0	0	0	0	0	0	3,537,992	0	0	0	0	0	147,000
19	40,001	0	0	0	0	0	0	0	0	0	3,564,339	0	0	0	0	0	124,000
20	42,001	0	0	0	0	0	0	0	0	0	3,423,305	0	0	0	0	0	400,000
21	44,001	0	0	0	0	0	0	0	300	0	32,983,660	0	0	0	0	0	520,000
22	46,001	0	0	0	0	0	0	0	105,713	0	12,898,123	0	0	0	0	0	324,000
23	48,001	0	0	0	0	0	0	0	0	0	14,930,438	0	0	0	0	0	288,000
24	50,001	0	0	0	0	0	0	0	14,124	0	14,215,658	0	0	0	0	0	31,500
25	52,001	0	0	0	0	0	0	0	0	0	25,372,851	0	0	0	0	0	67,500
26	54,001	0	0	0	0	0	0	0	42,344	0	24,570,818	0	0	0	0	0	27,000
27	56,001	0	0	0	0	0	0	0	73,174	0	8,615,805	0	0	0	0	0	0
28	58,001	0	0	0	0	0	0	0	0	0	8,154,367	0	0	0	0	0	18,000
29	60,001	0	0	0	0	0	0	0	0	0	1,505,577	0	0	0	0	0	0
30	62,001	0	0	0	0	0	0	0	0	0	2,531,394	0	0	0	0	0	4,500
31	64,001	0	0	0	0	0	0	0	12,960	0	10,622,171	0	0	0	0	0	13,500
32	66,001	0	0	0	0	0	0	0	0	0	2,624,002	0	0	0	0	0	4,500
33	68,001	0	0	0	0	0	0	0	0	0	5,319,462	0	0	0	0	0	0
34	70,001	0	0	0	0	0	0	0	0	0	3,222,945	0	0	0	0	0	10,000
35	72,001	0	0	0	0	0	0	0	0	0	2,297,238	0	0	0	0	0	0
36	74,001	0	0	0	0	0	0	0	0	0	5,445,831	0	0	0	0	0	10,000
37	76,001	0	0	0	0	0	0	0	0	0	989,228	0	0	0	0	0	0
38	78,001	0	0	0	0	0	0	0	0	0	1,026,162,913	0	0	0	0	0	150,000
39	80,001	0	0	0	0	0	0	0	31,303,827	185,984	0	0	0	0	0	0	6,000
40	82,001	0	0	0	0	0	0	0	2,638,939	0	0	7,326,703	241,909	252,735	25,628	12,784	6,000
									0	0	0	8,853,886	851,597	91,222	57,051	8,431	0

**GENERAL**

**Control**

Enter the biennium study period and the bond factor in the *Control* table.

To update the study biennium, enter the first year of the biennium in the yellow-shaded cell next to the “Study biennium” cell. 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 by using Excel’s PMT function. 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 2019 HCAS and previous studies, the bond factor has been calculated using a repayment period of 20 years and an interest rate of 5 percent. The bond factor is used in the model to calculate the portion of bond expenditures allocated to the current study.

Assumptions located in the bottom of the portion of the *Control* table include user-specified assumptions for the gas, diesel, and WMT avoidance or evasion rates; the percent of basic VMT by diesel-fueled vehicles; the RUAF registration revenue allocation; empty log truck miles and weight; and the percentage of taxed gallons that are diesel.

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 these assumptions by entering a percentage in the yellow-shaded evasion cells.

Similarly, the WMT evasion rate is expressed as the percent of total WMT VMT that evades the WMT. The WMT evasion rate is applied to WMT vehicle class VMT to calculate WMT revenues. The WMT evasion rate is also used to adjust the WMT base VMT in the *Base VMT* tab because 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 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. Change the assumption by entering a percentage in the yellow-shaded “Basic Diesel” cell.

RUAF vehicles are credited with a portion of the heavy vehicle registration revenues using the RUAF registration assumptions. The first RUAF registration assumption is the RUAF Registration 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 registration 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. RUAF Reg. from 78,001, RUAF Reg. from 96,001, and RUAF Reg. from 104,001 must be entered as

**Figure 39. Control**

	A	B	C	D	E
1					
2		<b>Control</b>			
3	<b>Study biennium</b>	2017	to 2019		
4	Base year	2015			
5	Model year	2018			
6					
7	<b>Bond Factor</b>	0.1344	(biennial repayment amount per dollar of bonded expenditure; assumes 20-year repayment)		
8					
9	<b>Gas Tax Avoidance</b>	3.53%	(percent of total that is avoided)		
10	<b>Diesel Tax Evasion &amp; Avoidance</b>	4.53%	(percent of total that is avoided or evaded)		
11	<b>WMT Evasion</b>	5.00%	(percent of total that is evaded)		
12	<b>Basic Diesel</b>	5.00%	(percent of basic VMT by diesel-powered vehicles)		
13	<b>RUAF Registration Adjustment</b>	0.0450	(dollars per mile)		
14	<b>RUAF Reg. from 78,001</b>	14%	(percent of total)		
15	<b>RUAF Reg. from 96,001</b>	15%	(percent of total)		
16	<b>RUAF Reg. from 104,001</b>	71%	(percent of total)		
17	<b>Log truck miles empty</b>	55%	(percent of VMT empty)		
18	<b>Empty log truck declared weight</b>	42,001	(declared weight category, use valid 2,000 lb weight class)		
19	<b>Taxed diesel</b>	10.50%	(percent of taxed gallons that are diesel)		

percentages in the yellow-shaded cells. The total of these three assumptions must equal 100 percent.

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.

**Gas and Diesel**

The *Gas and Diesel* table uses VMT from the *Base VMT* tab and rates from the *VMT Growth* tab 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.

The middle portion of the table is the average annual gas and diesel tax revenues. Gas tax revenues and diesel tax revenues from the *Revenue Forecast* tab are added and divided by two to calculate the average annual revenue (“Total” column). This is then allocated between basic and non-basic and divided by the gas/diesel tax rate per gallon to calculate the total implied gallons.

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 about 20 for basic vehicles and about 10 for non-basic vehicles, with the gas MPG higher than the diesel MPG.

Using VMT by weight class from the *Base VMT* tab and MPG assumptions by weight class from the *MPG* tab, the “Percent of taxed gallons that are basic” is equal to the taxed gallons for vehicles under 10,000 pounds divided by the total taxed gallons.

The yellow-shaded assumptions are percent of basic gallons that are diesel and percent of RV gallons that are diesel. 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” is entered as a percent. A reasonable range for this assumption is between 5 and 8 percent.<sup>10</sup>
- The “Percent of RV gallons that are diesel” is entered as a percent. A reasonable range for this assumption is between 30 and 60 percent.<sup>10</sup>

**Figure 40. Gas and Diesel**

Gas and Diesel					
VMT from Model		Taxed Gas	Taxed Diesel	Taxed Unknown	Total
	Basic	426,104,109	5,684,848	35,133,836,928	35,565,625,885
	Non-Basic	189,291,791	542,595,606	190,139,913	922,027,310
	All	615,395,900	548,280,454	35,323,976,841	36,487,653,195
Percent of basic gallons that are diesel		7.20%	Change these until the green cells look reasonable		
Percent of RV gallons that are diesel		40.00%			
Percent of taxed gallons that are basic		94.21%			
Implied Gallons		Gas	Diesel	Total	
Basic		1,630,401,363	126,496,658	1,756,898,021	
Non-Basic		38,601,797	69,308,182	107,909,979	
All		1,669,003,160	195,804,840	1,864,808,000	
Implied MPG		Gas	Diesel	Total	
Basic				20.24	
Non-Basic		7.86	8.93		
All					

**Bridge Splits**

The *Bridge Splits* table (see [Figure 42](#) on the following page) 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

<sup>10</sup> The ranges for these user-specified rates are only guidelines; the objective should be reasonable MPG estimates.

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 may adjust the share for each bridge type and work type, such that the sum of the shares by bridge type equals one.

**Studded Tires**

The *Studded Tires* table contains the state and local studded tire-related expenditures. A 2014 review of studded tires in Oregon by ODOT provided projected studded tire expenditures for state roads.<sup>11</sup> The 2019 HCAS uses the same distribution by work type as the 2017 HCAS.

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 and Above” 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.

**VMT GROWTH**

The *VMT Growth* tab has VMT controls (base-year and model-year VMT) and VMT growth by vehicle class (light, medium, heavy) and then detailed growth rates and growth factors by weight class.

The VMT growth rates are calculated from the change in VMT from the base year to the model year in the ODOT Economic and Revenue Forecast. To update the growth rates, paste the

ODOT Economic and Revenue Forecast VMT by vehicle class (light, medium, heavy) into the yellow-shaded cells in the table displayed in [Figure 44](#) so that the base year and model year match the Base Year and Model Year columns. The compound VMT growth rates are automatically calculated for light, medium, and heavy vehicle classes.

VMT growth rates by weight class for the basic and medium vehicle classes as well as weight classes over 106,001 pounds (heavy) are set equal to their calculated compound vehicle class growth rates.

For weight classes between 26,001 and 104,001, growth factors are developed such that variation across heavy weight classes exists. The heavy vehicle growth rates for these weight classes are automatically adjusted such that the total heavy vehicle VMT growth rate matches the target VMT growth rate, but variation still exists across the weight classes within the heavy vehicles. Using the distribution of VMT from 2011, base-year VMT and model-year VMT, growth factors are automatically developed for weight classes between 26,001 to 104,001 pounds (see [Figure 45](#)).

Small modifications in the VMT growth rates for the weight classes from 78,001 and 104,001 pounds 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 VMT growth rates by weight class are applied to the base-year VMT data to calculate the model-year VMT.

**Figure 41. Bridge Splits**

	A	B	C
42			
43	Bridge Splits		
44	Bridge Type	Work Type	Share
45	0	60	0.6849
46	0	61	0.2520
47	0	62	0.0000
48	0	63	0.0000
49	0	64	0.0631
50	1	60	0.6666
51	1	61	0.2999
52	1	62	0.0000
53	1	63	0.0000
54	1	64	0.0335
55	2	60	0.6849
56	2	61	0.2520
57	2	62	0.0000
58	2	63	0.0000
59	2	64	0.0631
60	3	60	0.7221
61	3	61	0.1697
62	3	62	0.0000
63	3	63	0.0514
64	3	64	0.0568
65	4	60	0.8713
66	4	61	0.1029
67	4	62	0.0000
68	4	63	0.0000
69	4	64	0.0258

**Figure 42. Studded Tires**

	A	B	C	D	E
71					
72	Studded Tires				
73	Funding	Work Type	Facility Class	Dollars	Distributon by Work Type
74	state	1	0	407,453	5%
75	state	11	0	6,790,885	79%
76	state	26	0	1,372,441	16%
77	local-state	101	-2	44,820	
78	local-state	111	-2	746,997	
79	local-state	126	-2	150,968	
80					
81	Study biennium projected studded tire expenditures by road type:				
82				state	8,570,779
83				local-state	942,786
84	Speed-Adjusted Local to State Basic VMT on Urban Principal Arterials and Above				0.11

	E	F	G	H	I
1	ODOT Forecast	Base 2013	Model 2016	Forecast Growth	Weighted Average
2	Light	31,058,764,544	32,927,262,617	1.97%	
3	Medium	780,033,522	843,275,225	2.63%	
4	Heavy	1,770,824,870	1,951,715,914	3.30%	3.30%

<sup>11</sup> The projected expenditures for the study biennium include half of the projected expenditures for July 1, 2019 through June 30, 2021.

**Figure 44. Development of VMT Growth Rates for Heavy Vehicles (26,001 to 104,001 pounds)**

Weight Class	Prior 2013	Scaled 2015	Shift	Shifted Again	Re-scaled	Grown 2018	Growth Factor
26,001	34,433,084	32,269,558	0.9372	31,626,109	31,434,826	33,590,098	0.9954
28,001	36,197,464	29,240,592	0.8078	24,701,870	24,552,467	26,235,862	0.8580
30,001	44,657,557	40,134,540	0.8987	37,720,486	37,492,343	40,062,938	0.9545
32,001	31,779,615	28,972,714	0.9117	27,622,651	27,455,582	29,338,025	0.9683
34,001	14,238,856	12,234,149	0.8592	10,992,794	10,926,307	11,675,449	0.9126
36,001	9,332,254	7,271,581	0.7792	5,925,251	5,889,413	6,293,210	0.8276
38,001	9,903,480	6,870,423	0.6937	4,984,421	4,954,274	5,293,955	0.7368
40,001	6,232,457	5,091,449	0.8153	4,332,629	4,306,424	4,601,686	0.8660
42,001	5,109,162	4,482,614	0.8774	4,112,904	4,088,029	4,368,317	0.9319
44,001	36,106,406	34,985,367	0.9690	35,450,655	35,236,240	37,652,150	1.0291
46,001	16,523,693	16,482,242	0.9975	17,193,374	17,089,384	18,261,086	1.0594
48,001	18,089,331	18,702,150	1.0339	20,220,701	20,098,401	21,478,412	1.0981
50,001	15,376,746	16,034,544	1.0428	17,485,757	17,379,999	18,571,627	1.1075
52,001	27,383,279	24,050,520	0.8783	22,090,173	21,956,566	23,461,979	0.9328
54,001	26,399,073	27,329,940	1.0353	29,588,594	29,409,635	31,426,053	1.0996
56,001	9,019,443	10,673,243	1.1834	13,208,355	13,128,467	14,028,597	1.2568
58,001	8,700,849	8,890,617	1.0218	9,600,961	9,443,486	10,090,962	1.0853
60,001	1,577,577	1,738,323	1.1019	2,003,117	1,991,001	2,127,511	1.1703
62,001	2,694,376	2,834,508	0.9778	2,693,868	2,677,575	2,861,158	1.0385
64,001	11,025,095	11,671,018	1.0586	12,920,246	12,842,101	13,722,596	1.1243
66,001	2,689,002	2,778,321	1.0332	3,001,990	2,983,834	3,188,415	1.0974
68,001	5,504,944	5,704,057	1.0362	6,180,882	6,143,499	6,564,716	1.1005
70,001	3,282,945	4,033,162	1.2285	5,181,594	5,150,254	5,503,372	1.3048
72,001	2,362,238	2,408,176	1.0194	2,567,369	2,551,841	2,726,803	1.0828
74,001	5,581,313	5,085,231	0.9111	4,845,300	4,815,995	5,146,195	0.9677
76,001	1,265,193	1,356,327	1.0720	1,520,574	1,511,377	1,615,002	1.1386
78,001	1,065,348,027	1,101,118,953	1.0336	1,190,179,930	1,182,981,413	1,264,090,401	1.0978
80,001	10,588,699	9,138,654	0.8631	8,248,169	8,198,282	8,790,382	0.9167
82,001	9,988,186	9,095,873	0.9107	8,662,392	8,609,999	9,200,328	0.9672
84,001	15,247,962	15,300,865	1.0035	16,056,683	15,959,568	17,053,807	1.0658
86,001	30,157,503	24,353,651	0.8075	20,566,880	20,442,486	21,844,088	0.8577
88,001	35,021,011	34,807,074	0.9939	36,177,788	35,958,975	38,424,438	1.0556
90,001	18,607,869	20,321,703	1.0921	23,209,148	23,068,773	24,650,442	1.1599
92,001	4,178,925	3,496,215	0.8366	3,058,914	3,040,413	3,248,874	0.8886

**Figure 45. VMT by FC Ownership**

Functional System	VMT by Functional Class						
	1	2	4	21	25	64	66
1	3,758,956,699			0	0	0	0
2	3,909,574,550	196,201,231		0	0	0	0
3	1,375,964,728	386,922,085		0	0	829,505	0
4	324,323,360	1,418,850,481	19,227,609	0	0	36,525,375	40,036,657
5							
6							
1	5,537,060,044			0	0	0	0
2	1,346,423,788	28,659,800	11,908,125	0	0	0	0
3	4,259,830,178	214,145,320	1,023,114,769	3,760,960	20,193,421	0	0
4	309,033,696	1,529,325,486	2,435,632,782	0	0	0	0
5	116,282,550	760,064,248	1,777,488,954	4,147,608	0	0	0
6	277,839	125,571,953	136,915,961				
	State	County	City	Other State	Other Local	USFS	National Parks

**Figure 46. Oregon VMT from Highway Statistics: Rural and Urban**

	A	B	C	D	E	F	G	H
18	Oregon VMT from Highway Statistics							
19	Rural							
20	Other Principal Arterial							
21	State	Interstate	Arterial	Minor Arterial	Major Collector	Minor Collector	Local	Total
22	Oregon	4,103	4,387	2,052	2,025	508	1,456	14,531
18	Oregon VMT from Highway Statistics							
19	Urban							
20	Other Freeways & Expressways							
21	Interstate	Other Freeways & Expressways	Other Principal Arterial	Minor Arterial	Collector	Local	Total	Total
22	4,455	1,320	4,767	3,722	2,277	2,099	18,642	33,173

**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 tabs.

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 (see [Figure 46](#)).

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 (see [Figure 47](#)).

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 (see [Figure 48](#) on the following page) 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. The *Non-Project Costs* tab includes the DMV and Motor Carrier collection costs, ROW costs, and PE costs. Non-project maintenance costs are broken out by their specific maintenance work category. The data for the *Non-Project Costs* tab are based on ODOT's proposed budget. ODOT staff complete a worksheet with the same format as the tables of the *Non-Project Costs* tab. When pasting the data into the tables, it is important that the row and column headings match exactly because the non-project cost entries at the bottom of the tab are referenced by work type to the input data.



Figure 47. Non-Project Costs

	A	B	C	D	E	F	G	H
1	Work	Funded	Federal	Bond	Other	OTIA	JTA	Category
2	Type	State	Funded	Funded	Funded	Funded	Funded	
2	2	7,111,207	25,115,052	0	7,202,369	0	2,575,754	Project Right of Way and Utilities
3	1	19,241,968	67,957,944	0	19,488,639	475,167	500,021	Other Project-Related (PE)
4	20	1,500,000	0	0	0	0	0	Safety Rest Area Improvements & Access Mgmt
5	22	13,255,613	7,700,000	0	0	0	0	Traffic Operations Centers, ITS, Incident Response & Traffic Signal Services
6	50	24,263,505	0	0	0	0	0	Local Government Support - Regional and Central (Locals may participate)
7	50	174,127,562	0	0	0	0	0	Special Programs (Central, Regional, Tech Services Construction support)
8	55	80,107,319	5,940,865	0	0	0	0	Motor Carrier (All) & Central Services Collection Costs-Trucks Only
9	58	3,846,370	0	0	0	0	0	Fuel Tax Collection Costs (includes CS)
10	56	39,849,597	0	0	0	0	0	Reg Fee Collection Costs-Basic Only (includes CS)
11	58	3,355,142	0	0	0	0	0	Reg Fee Collection Costs-Non-Basic Only (includes CS)
12	56	54,007,529	0	0	0	0	0	Title Collection Costs - Light (includes CS)
13	57	1,242,087	0	0	0	0	0	Title Collection Costs - Heavy (includes CS)
14	50	115,834,483	278,321	0	0	0	0	Central Services budget: ARB Hwy Division portion of CS assessment
15	43	5,606,754	55,823,130	0	0	0	0	Transit: STP Funds
16	42	1,400,000	22,551,911	0	0	0	0	Rail: Grade Crossing Protection Fund (from Highway Fund)
17	21	4,981,951	18,669,948	0	0	0	0	T. Safety: Highway Funded Positions & STP
18	50	98,339,786	178,980	33,976,920	0	0	0	Transportation Program Development
19	40	11,922,463	0	0	0	0	0	OPS/SpPgms/Permits
20	40	16,061,008	0	0	0	0	0	State Radio System
21	26	122,417,001	15,000,000	0	0	0	0	Surface/Shoulder/Contract
22	28	19,641,056	0	0	0	0	0	Drainage
23	30	60,505,518	0	0	0	0	0	Roadside & Vegetation
24	32	62,094,533	4,757,000	0	0	0	0	Traffic Services & ITS
25	29	18,576,955	0	0	0	0	0	Bridge (Structures)
26	34	122,085,856	0	0	0	0	0	Snow & Ice/Extraordinary
27	40	19,719,533	0	0	0	0	0	Risk Mgmt
28								
29		167,924,803	577,438,850	0	170,064,561	10,335,158	213,025,277	Project Construction
30		287,093,064	0	0	0	56,146,426	160,182,166	Counties
31		182,987,244	0	0	0	41,099,933	106,788,110	Cities

Figure 48. Local Costs

A	B	C	D	E	F
<b>RECEIPTS FOR ROAD AND STREET PURPOSES</b>					
					<b>TOTAL RECEIPTS</b>
<b>A. RECEIPTS FROM LOCAL SOURCES</b>					
1. Special Assessments					
a.	Permanent Property Tax or Assessment	12,354,528			
b.	Limited Duration Property Tax or Assessment	12,245,821			
c.	Traffic Impact Fee or System Development Charges	40,221,882			
d.	Transportation Utility Fees	24,299,118			
e.	Local Improvement Districts (or similar)	16,336,312			
f.	Urban Renewal District	9,539,803			
2. General Fund and Non-Dedicated City/County Fund Transfers					72,216,549
3. Local Option Road User Fees (include only what you actually keep)					
a.	Fuel taxes (indicate rate _____)	0			
b.	License Collection Expense	0			
c.	Please see instructions	15,670,761	Net Fuel Tax		
d.	Motor Vehicle Registration fees	15,933,291			
4. Other Local Receipts					
a.	Interest Income	7,830,774			
b.	Traffic fines	414,275			
c.	Parking meters and fines	32,100,687			
d.	Permits and land use fees	11,261,536			
e.	Sales of Surplus Land & Equipment and Rentals	4,792,420			
f.	Hotel/Motel taxes	2,720,422			
g.	Franchise fees	6,224,139			
h.	Other (Please specify source and amount for each source)	44,664,074			
5. Receipts from Other Local Governments					
a.	From Cities	3,721,627			
b.	From Counties	5,056,043			
c.	Other (Please specify source and amount for each source)	46,288,078			
6. Proceeds from Sale of Bonds and Notes					
a.	Bonds (Must equal Part III, Item B.1)	174,661,277			
b.	Notes (Must equal Part III, Item B.2)	43,415,726			
<b>B. PRIVATE CONTRIBUTIONS</b>					10,814,922
<b>C. RECEIPTS FROM STATE GOVERNMENT</b>					
1. State Highway Fund Apportionment (including 1% Bike/Pedestrian Path money)					
					330,742,769
2. Special County Allotment					
					1,966,467
3. State Highway Fund Exchange Program					
					15,639,438
4. ODOT Issued Permit Fees					
					528,120
5. Other State Highway Fund Grants (Please specify source and amount for each source)					
					23,900,187
6. State Forestry					
					967,799
7. Other State Funds (Please specify source & amount for each source)					
					10,587,871
<b>D. RECEIPTS FROM FEDERAL GOVERNMENT</b>					
1. US Forest Service Annual Distribution					
					37,755,072
2. USFS and OAC Title II					
					325,978
3. Sale Distribution of BLM Land Sales					
					67,288
4. BLM Mineral Leases					
					168,872
5. U.S. Taylor Grazing Apportionment					
					153,369
6. Federal Flood Control					
					320,203
7. Housing and Urban Development					
					159,488
8. Economic Development Administration					
					0
9. Federal Receipts for FHWA Grants					
					3,046,416
10. Other Federal Fund Receipts (Please specify source & amount for each source)					
					28,371,575
11. Federal Receipts for Federally Declared Emergency Events:					
a.	FEMA - Public Assistance	2,008,710			
b.	FHWA - Emergency Relief	393,271			
<b>E. RECEIPTS FOR NON-JURISDICTION ROAD/STREET WORK (see instructions)</b>					
1. Non-road and street work					28,195,368
2. Work for other jurisdictions					6,448,156
<b>TOTAL RECEIPTS</b>					1,110,299,052

LOCAL COSTS

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 because 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 Costs* tab calculations automatically update the local costs table at the bottom of the *Local Costs* tab.

Figure 49. Project Costs

	A	B	C	D	E	F
1	Funding	Work	Functional	Bridge	Dollars	Key
2	Type	Type	Class	Type		Numt
2	federal	5	0	0	4,913,904	K0943
3	other	5	0	0	533,347	K0943
4	state	5	0	0	478,827	K0943
5	federal	11	0	0	47,500	K1101
6	other	11	0	0	1,159	K1101
7	state	11	0	0	452	K1101
8	state	5	0	0	60,038	K1119
9	other	5	0	0	16,056	K1119
10	state	41	0	0	168,856	K1119
11	state	41	0	0	146,342	K1119
12	other	41	0	0	45,157	K1119
13	other	41	0	0	39,136	K1119
14	federal	5	0	0	2,684,324	K1125
15	state	5	0	0	307,233	K1125
16	federal	44	0	0	2,477,837	K1125
17	state	44	0	0	283,600	K1125
18	federal	14	0	2	155,559	K1200
19	other	14	0	2	42,202	K1200
20	federal	15	0	3	120,714	K1265
21	state	15	0	3	13,816	K1265
22	federal	4	0	2	12,735,763	K1272
23	other	4	0	2	1,576,794	K1272
24	state	4	0	2	1,455,381	K1272

PROJECT COSTS

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, but the project may have up to four funding sources (federal, state, local, bond), 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 may change the *Project Costs* input data by pasting project expenditures into the rows. The model ignores entries in the Key Number column and stops reading data at the first empty row, so be sure eliminate spaces between entries.

**REVENUE 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 *Revenue Forecast* tab. The ODOT Revenue Forecast is provided by the Financial and Economic Analysis Unit of ODOT. 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 because

**Figure 50. Revenue Forecast**

	A	B
1	<b>Revenue Source</b>	<b>Gross</b>
2	Basic/Motorcycle/Moped Light Reg	314,161,649
3	Truck Normal Reg	33,550,449
4	Bus Normal Reg	738,168
5	Farm Reg	6,258,719
6	Charitable/Non-Profit Reg	285,138
7	Tow Reg	603,028
8	Heavy Fixed Load Vehicle Reg	187,357
9	E-Plate Reg	32,693
10	School Bus Reg	4,866
11	Light Trailer Reg	14,314,240
12	Heavy/Special/Rental Trailer Reg	265,084
13	Light Titles - New/First OR/Transfer	140,733,179
14	Heavy Titles - New/First OR/Transfer	3,654,763
15	Motor Carrier Interstate Reg	58,988,864
16	Motor Carrier Intrastate Reg	24,489,529
17	Motor Carrier Trip Permits	8,688,481
18	Weight-Mile Tax (includes late fees)	595,237,237
19	Road Use Assessment Fee	4,648,781
20	Weight Receipts	7,244,413
21	Gas Tax	951,703,440
22	Use Fuel (diesel) Tax	99,554,088

the revenues by summary revenue source will automatically calculate the revenue control totals in the left-most summary table of the *Revenue 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.

**RATES**

The *Rates* tab contains revenue instrument rates (tax rates and fees) that are used in the revenue attribution calculations along with other revenue inputs in the *Revenue Forecast* (revenue control totals) and *General* (evasion rates, etc.) tabs.

The tax and fee rates for the revenue instruments are located in the *Rates* 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 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. Divide the two-year registration fee by two to annualize the registration fee. The Normal Reg is the passenger vehicle registration fee for basic vehicles. The Heavy Vehicle Registration Fee table is 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 \$0.40 per year, using the assumption that each public vehicle has a 5-year service life.

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 pounds 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.

**Figure 51. Rates**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Rates															RUAF Rate		
2	Weight Class	Axes	Gas Tax (per gallon)	Use Fuel Tax (per gallon)	VMT Tax	WMT Rate	Normal Reg	Farm Reg	Tow Reg	CN Reg	E-Plate Reg	LT Reg	HT Reg	Title	Weight Class	Axes	RUAF Rate	
3	1	0	0.30	0.30	0.00	0.0000	43	35	43	43	0.40	43	0	77	1	0	0.0000	
4	10,001	0	0.30	0.30	0.00	0.0000	391	53	122	60	0.40	43	0	77	10,001	0	0.0000	
5	12,001	0	0.30	0.30	0.00	0.0000	438	68	132	65	0.40	43	0	77	12,001	0	0.0000	
6	14,001	0	0.30	0.30	0.00	0.0000	485	76	153	75	0.40	43	0	77	14,001	0	0.0000	
7	16,001	0	0.30	0.30	0.00	0.0000	532	91	163	80	0.40	43	0	77	16,001	0	0.0000	
8	18,001	0	0.30	0.30	0.00	0.0000	593	99	183	90	0.40	43	0	77	18,001	0	0.0000	
9	20,001	0	0.30	0.30	0.00	0.0000	640	114	193	95	0.40	43	0	77	20,001	0	0.0000	
10	22,001	0	0.30	0.30	0.00	0.0000	703	121	214	105	0.40	43	0	77	22,001	0	0.0000	
11	24,001	0	0.30	0.30	0.00	0.0000	764	137	224	110	0.40	43	0	77	24,001	0	0.0000	
12	26,001	0	0.30	0.30	0.00	0.0498	375	144	244	120	0.40	0	10	90	26,001	0	0.0000	
13	28,001	0	0.30	0.30	0.00	0.0528	391	159	255	125	0.40	0	10	90	28,001	0	0.0000	
14	30,001	0	0.30	0.30	0.00	0.0552	422	167	275	135	0.40	0	10	90	30,001	0	0.0000	
15	32,001	0	0.30	0.30	0.00	0.0576	438	182	285	140	0.40	0	10	90	32,001	0	0.0000	

**MPG**

There are two *MPG* tabs (one in the inputs workbook and one in the outputs workbook) that contain initial assumed MPG (input) and adjusted MPG (output) by weight class.

In the inputs workbook, 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 become available; 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 (see columns A and B in [Figure 53](#)). 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 pounds 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 saved in *MPG* tab in the outputs workbook where it may be examined for reasonableness (see columns D and E in [Figure 53](#)). 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-pound vehicles. The reasons for using this approach are detailed in Issue Paper 6 of the 2007 HCAS.

**POLICY**

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 may enter the allocator share (a percent value between 0 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.

**CODES**

The *Codes* tab has Summary Work Types (SWT) and the Summary Weight Class lookup tables which are used by the model to aggregate the costs to allocate and allocated costs.

**Figure 54. Initial and Adjusted MPG**

Inputs Workbook			Outputs Workbook		
	A	B	D	E	
	Declared	MPG	Weight Class	Adjusted MPG	
1					
2	10,001	20.00	1	20.89	
3	10,001	10.85	1	15.53	
4	12,001	10.27	12,001	14.89	
5	14,001	9.77	14,001	13.97	
6	16,001	9.33	16,001	13.35	
7	18,001	8.94	18,001	12.79	
8	20,001	8.59	20,001	12.29	
9	22,001	8.27	22,001	11.83	
10	24,001	7.98	24,001	11.42	
11	26,001	7.15	26,001	7.15	
12	28,001	7.04	28,001	7.04	
13	30,001	6.94	30,001	6.94	
14	32,001	6.85	32,001	6.85	
15	34,001	6.76	34,001	6.76	
16	36,001	6.67	36,001	6.67	
17	38,001	6.59	38,001	6.59	

**Figure 52. Policy**

	A	B	C	D	E	F
	Work Type Description	Work Type	Allocator 1	Share 1	Allocator 2	Share 2
1						
2	Preliminary and Construction Engineering (and etc.)	1	CongestedPCE	0.5595	Other_Construction	0.4405
3	Right of Way (and Utilities)	2	CongestedPCE	0.7375	Other_Construction	0.2625
4	Grading and Drainage	3	CongestedPCE	1.0000	None	0.0000
5	New Pavements-Rigid	4	CongestedPCE	0.0399	Rigid	0.9601
6	New Pavements-Flexible	5	CongestedPCE	0.0543	Flex	0.9457
7	New Shoulders-Rigid	6	CongestedPCE	1.0000	None	0.0000
8	New Shoulders-Flexible	7	CongestedPCE	1.0000	None	0.0000
9	Pavement and Shoulder Reconstruction-Rigid	8	CongestedPCE	0.0399	Rigid	0.9601
10	Pavement and Shoulder Reconstruction-Flexible	9	CongestedPCE	0.0543	Flex	0.9457
11	Pavement and Shoulder Rehab-Rigid	10	All_VMT	0.0399	Rigid	0.9601
12	Pavement and Shoulder Rehab-Flexible	11	All_VMT	0.0543	Flex	0.9457
13	Pavement and Shoulder Rehab-Other	12	All_VMT	1.0000	None	0.0000
14	New Structures	13	None	1.0000	None	0.0000
15	Replacement Structures	14	None	1.0000	None	0.0000
16	Structures Rehabilitation	15	None	1.0000	None	0.0000

**Figure 53. Codes**

	A	B	C	D	E
	Summary Work Types	Summary	Summary Weight Classes	Summary	Summary
	Work Type	Work Type	Weight Class	Weight Class	
1					
2	0	21	1	1	
3					
4	1	17	8,001	1	
5	2	22	10,001	10,001	
6	3	12	12,001	10,001	
7	4	12	14,001	10,001	
8	5	13	16,001	10,001	
9	6	12	18,001	10,001	
10	7	12	20,001	10,001	
11	8	12	22,001	10,001	
12	9	15	24,001	10,001	
13	10	18	26,001	26,001	
14	11	20	28,001	26,001	
15	12	18	30,001	26,001	
16	13	3	32,001	26,001	
17	14	3	34,001	26,001	
18	15	3	36,001	26,001	
19	16	14	38,001	26,001	
20	17	12	40,001	26,001	

## II. OUTPUT FILES

After the user has finished updating the inputs workbook for their scenario, the user must save the workbook in the *inputs* folder as specified earlier in this guide (see [Section 4, Initial Model Setup](#) and [Section 6, Set Up a New Scenario](#)). After the user has set up a new scenario, the user must run the scenario through the HCAS Python model. Steps to run the HCAS Python model are outlined in [Section 7, Run the HCAS Python Model](#).

Once the HCAS Python model has finished running, the user may open the scenario's *outputs* folder and open the outputs workbook that will have the scenario's name in its filename (e.g., "HCAS Outputs Scenario 1.xlsx"). The outputs workbook will have detailed and summary data on the VMT analysis, allocated costs, and attributed revenues from the model. There are also detailed text output files that are saved in the *txt* folder.

### AUDITING

Recalculating the model and saving the outputs should take a few minutes. 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 completed, review the model results to check that the VMT, cost allocation, and revenue attribution in the output tabs are reasonable.

The following are general checks that can be performed to audit the model output:

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 in the outputs workbook.

Check to see if any pavement factors are listed as missing by reviewing the *MissingPavementFactors.log* file in the *txt* folder. If the *MissingPavementFactors.log* 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 in the outputs workbook should equal their control totals from the *Revenue Forecast* tab in the inputs workbook.

### OUTPUT WORKBOOK TABS

Running the HCAS Python model will produce a new outputs workbook with model outputs and summary results.

#### Model VMT

The *Model VMT* tab contains the projected VMT in the forecast year by vehicle weight class and vehicle tax class. This table is analogous to the table in the *Base VMT* input tab but for the model year. The VMT growth rates are applied to the Base VMT to produce the Model VMT output.

Figure 55. Model VMT

	A	B	C	D	E	F	G	H	I	J	K
2	Weight Class	Private Passenger	Gas Commercial 8-26	Diesel & Other Commercial 8-26	Gas Tow Trucks	Diesel & Other Tow Trucks	R/UA/F Vehicles	Fiat Fee Vehicles Log	Fiat Fee Vehicles S&G	Fiat Fee Vehicles Crip	VMT Vehicles 26-80 Any Axle
3	1	32,251,303,582	0	0	0	0	0	0	0	0	0
4	10,001	19,702,776	45,840,455	52,780,740	454,052	1,159,994	0	0	0	0	0
5	12,001	13,059,017	19,240,148	38,554,392	372,971	1,491,884	0	0	0	0	0
6	14,001	35,766,790	28,008,123	80,640,672	551,349	2,610,798	0	0	0	0	0
7	16,001	22,190,413	9,854,710	47,964,528	145,945	1,751,343	0	0	0	0	0
8	18,001	18,051,537	7,780,034	48,335,006	145,945	2,789,175	0	0	0	0	0
9	20,001	0	2,741,536	11,633,004	48,648	502,700	0	0	0	0	0
10	22,001	8,307,932	4,593,925	16,671,502	16,216	827,023	0	0	0	0	0
11	24,001	10,066,955	16,671,502	143,572,504	437,836	10,686,433	0	0	0	0	0
12	26,001	2,516,480	0	0	0	0	0	5,843	0	0	1,277,552
13	28,001	4,587,697	0	0	0	0	0	0	0	0	3,703,887
14	30,001	14,736,282	0	0	0	0	0	0	0	0	9,112,784
15	32,001	0	0	0	0	0	0	0	0	0	24,648,677
16	34,001	0	0	0	0	0	0	0	0	0	4,348,035
17	36,001	0	0	0	0	0	0	0	0	0	4,791,243
18	38,001	0	0	0	0	0	0	0	0	0	6,813,337
19	40,001	0	0	0	0	0	0	0	0	0	6,132,121
20	42,001	0	0	0	0	0	0	0	0	0	4,250,566
21	44,001	0	0	0	0	0	0	0	333	0	36,568,868
22	46,001	0	0	0	0	0	0	0	124,810	0	15,228,160
23	48,001	0	0	0	0	0	0	0	0	0	15,187,191
24	50,001	0	0	0	0	0	0	0	15,752	0	15,854,551
25	52,001	0	0	0	0	0	0	0	0	0	30,823,833

#### Costs to Allocate by SWT

The *Costs to Allocate by SWT* tab (see [Figure 57](#) on the following page) 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 from the inputs workbook to produce this summary table, no other calculations are performed on the input data to produce the *Costs to Allocate by SWT* tab. 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 exhibits in the final HCAS report.

Figure 56. Costs to Allocate by SWT

	A	B	C	D	E	F	G
3	<b>Summary Work Type</b>	<b>Bond</b>	<b>Federal</b>	<b>Local-Federal</b>	<b>Local-Other</b>	<b>Local-State</b>	<b>State</b>
4	Admin	5,452,786	6,398,166	22,881,769	15,669,929	120,788,280	594,973,380
5	Bike and Pedestrian	0	42,791,867	175,979	120,514	928,958	11,404,562
6	Bridge-bridge and interchange	3,078,183	153,370,965	351,369	240,625	1,854,806	14,159,600
7	Bridge-bridge maintenance	0	14,922,283	0	0	0	1,707,922
8	Hsh	153,578	21,089,803	0	0	0	2,390,897
9	Hwy Planning	0	285,388	0	0	0	32,864
10	Hwy Safety	0	22,551,911	0	0	0	1,400,000
11	Maintenance	0	26,211,554	1,879,759	1,287,300	9,922,871	313,067,716
12	Maintenance-bridge maintenance	0	4,416,220	0	0	0	19,081,840
13	Maintenance-other pavement	0	472,759	0	0	0	39,884
14	Maintenance-pavement maintenance	0	3,094,216	45,459,211	31,131,449	239,819,109	124,292,644
15	Modernization	15,960,855	211,953,870	13,590,144	9,306,824	71,739,650	47,953,649
16	Modernization-new pavement	16,974,693	66,939,718	773,750	529,881	4,064,472	8,665,319
17	Modernization-other pavement	0	0	0	0	0	0
18	Modernization-pavement and shoulder	0	54,275,120	0	0	0	3,371,592
19	Multimodal	0	0	0	0	0	0
20	PE	156,503	75,977,486	941,845	644,996	4,926,992	18,834,515
21	Preservation	0	0	0	0	0	0
22	Preservation-other pavement	0	0	0	0	942,786	8,570,779
23	Preservation-pavement and shoulder	0	105,922,153	2,764,703	1,893,328	13,847,316	5,342,440
24	Prior Allc'd Bonds	392,009,761	0	0	0	0	0
25	ROW	413,370	25,115,652	232,073	158,929	1,225,067	7,111,207
26	Transit	0	61,383,493	0	0	0	5,888,744
27	Unknown	0	12,671,072	0	0	0	114,905,869
28	<b>Costs to Allocate Total</b>	<b>434,199,728</b>	<b>909,842,896</b>	<b>89,050,601</b>	<b>60,983,774</b>	<b>470,080,307</b>	<b>1,303,195,223</b>
29	<b>Annual Expenditures (thousands)</b>	<b>217,100</b>	<b>454,921</b>	<b>44,525</b>	<b>30,492</b>	<b>235,040</b>	<b>651,598</b>

Figure 57. Allocated Costs by SWT

	A	B	C	D	E	F	G	H	I	J	
3	<b>Funding</b>	<b>Summary Work Type</b>	<b>1</b>	<b>10.001</b>	<b>26.001</b>	<b>Summary Weight Class</b>	<b>78.001</b>	<b>80.001</b>	<b>104.001</b>	<b>105.501</b>	<b>Total</b>
4	bond	Other	4,997,797	127,995	62,269	173,970	49,007	41,271	477	5,452,786	
5	bond	Other	0	0	0	0	0	0	0	0	
6	bond	Bridge	1,980,036	188,694	87,399	330,140	175,599	140,868	175,647	3,078,183	
7	bond	Bridge	0	0	0	0	0	0	0	0	
8	bond	Other	136,884	4,107	1,902	7,185	1,935	1,550	16	153,578	
9	bond	Other	0	0	0	0	0	0	0	0	
10	bond	Other	0	0	0	0	0	0	0	0	
11	bond	Maintenance	0	0	0	0	0	0	0	0	
12	bond	Maintenance	0	0	0	0	0	0	0	0	
13	bond	Maintenance	0	0	0	0	0	0	0	0	
14	bond	Maintenance	0	0	0	0	0	0	0	0	
15	bond	Modernization	4,112,318	1,252,731	740,376	4,303,537	3,180,829	1,917,306	453,757	15,960,855	
16	bond	Modernization	2,492,838	1,402,157	943,486	5,707,248	3,566,070	2,895,857	167,035	16,974,693	
17	bond	Modernization	0	0	0	0	0	0	0	0	
18	bond	Modernization	0	0	0	0	0	0	0	0	
19	bond	Other	0	0	0	0	0	0	0	0	
20	bond	Other	108,226	6,831	4,287	19,955	8,773	7,006	1,446	156,503	
21	bond	Preservation	0	0	0	0	0	0	0	0	
22	bond	Preservation	0	0	0	0	0	0	0	0	
23	bond	Preservation	0	0	0	0	0	0	0	0	

Figure 58. Allocated Costs

	A	B	C	D	E	F	G	H	I	J
3	<b>Weight Class</b>	<b>Axes</b>	<b>Bond</b>	<b>Federal</b>	<b>Local-Federal</b>	<b>Local-Other</b>	<b>Local-State</b>	<b>Other</b>	<b>State</b>	<b>Total Allocated Costs</b>
4	10.001	0	221,548,336	518,668,122	51,681,894	35,392,877	273,475,961	136,439,276	974,907,406	2,075,674,595
5	12.001	0	3,166,467	4,379,132	323,665	221,653	1,704,579	1,701,960	4,456,680	14,255,195
6	14.001	0	2,326,401	3,077,872	289,298	198,118	1,523,144	1,136,528	3,020,748	10,435,580
7	16.001	0	4,104,784	7,336,245	742,656	508,587	3,909,111	2,407,028	6,630,952	23,242,336
8	18.001	0	2,393,163	4,391,082	522,894	358,089	2,751,940	1,361,383	3,786,494	14,205,683
9	20.001	0	2,388,956	5,008,028	680,006	465,683	3,578,386	1,456,395	4,122,616	16,243,672
10	20.001	0	849,484	1,568,197	266,384	182,425	1,401,657	421,318	1,222,644	5,490,790
11	22.001	0	1,296,238	3,064,435	544,509	372,892	2,864,931	772,776	2,281,539	10,404,545
12	24.001	0	5,615,248	20,896,091	4,137,149	2,833,209	21,766,432	4,820,203	14,467,486	69,715,613
13	26.001	0	1,019,686	1,005,580	166,647	114,124	876,958	266,805	4,857,452	8,047,536
14	30.001	0	995,566	1,993,592	380,733	260,734	2,003,414	510,683	2,773,596	8,407,838
15	32.001	0	1,932,653	2,501,410	496,432	339,967	2,612,197	627,548	3,461,814	11,344,473
16	34.001	0	1,326,243	2,505,038	493,129	337,705	2,594,645	592,827	3,062,614	10,319,376
17	36.001	0	576,788	882,709	153,773	105,307	809,142	204,858	1,136,302	3,686,020
18	38.001	0	591,269	1,184,334	258,032	176,706	1,357,708	264,945	1,522,806	5,090,854
19	40.001	0	898,289	1,311,328	165,055	113,033	868,539	116,611	4,824,343	6,971,513
20	42.001	0	270,926	785,006	116,947	80,088	615,342	189,146	956,484	2,806,793
21	44.001	0	564,771	478,577	81,128	55,557	426,853	114,160	565,149	2,189,033
22	46.001	0	1,830,960	3,073,989	494,762	336,824	2,603,260	726,381	3,668,355	12,919,850
23	48.001	0	1,094,758	1,447,475	234,649	160,693	1,234,643	349,061	1,770,836	5,843,053
24	50.001	0	1,121,236	1,376,155	232,174	158,997	1,221,804	332,337	1,676,283	5,789,449
25	52.001	0	835,113	1,435,702	249,135	170,613	1,310,800	334,052	1,645,965	5,647,327
26	54.001	0	1,594,977	2,750,135	446,384	305,693	2,348,619	647,949	3,173,528	10,619,156
27	54.001	0	1,700,495	2,544,839	425,202	291,187	2,237,143	595,729	2,906,514	10,105,379

Allocated Costs by SWT

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* tab has a summary table to create exhibits in the final HCAS 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* and *Summary* tabs 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 annual user fees and share of revenues for each vehicle class.

**MPG**

The *MPG* tab in the outputs workbook is discussed in the previous section on [page D29](#) and illustrated in [Figure 54](#).

Figure 59. Attributed Revenues

	A	B	C	D	E	F	G	H	I	J	K
3	<b>Weight Class</b>	<b>Axes</b>	<b>Gas Tax</b>	<b>Diesel Tax</b>	<b>WMT</b>	<b>Flat Fee</b>	<b>RUAF</b>	<b>Registration</b>	<b>Other MC</b>	<b>Subsidy</b>	<b>Full Fee VMT</b>
4	1	0	919,921,791	47,184,812	0	0	0	472,349,600	0	9,186,820	32,251,303,582
5	10.001	0	6,000,108	4,784,631	0	0	0	4,107,359	0	256,772	118,323,971
6	12.001	0	3,310,392	3,719,277	0	0	0	2,668,654	0	648,072	70,853,557
7	14.001	0	6,534,451	8,161,236	0	0	0	6,114,082	0	1,038,081	144,415,385
8	16.001	0	3,267,794	5,114,430	0	0	0	3,603,323	0	322,125	80,009,652
9	18.001	0	2,808,177	5,609,788	0	0	0	3,904,726	0	486,274	74,166,577
10	20.001	0	469,800	1,413,106	0	0	0	896,170	0	686,251	14,374,539
11	22.001	0	1,700,247	2,164,674	0	0	0	1,927,560	0	444,297	29,573,359
12	24.001	0	3,989,949	18,416,572	0	0	0	10,989,563	0	2,892,046	170,310,960
13	26.001	0	330,619	64,201	120,882	2,173	0	132,076	10,742	1,630,931	3,799,875
14	28.001	0	593,991	123,986	371,574	0	0	267,852	31,144	2,837,769	8,291,584
15	30.001	0	1,411,923	172,255	955,749	0	0	433,880	76,624	2,357,740	23,849,066
16	32.001	0	814,450	121,851	2,697,573	0	0	894,582	207,259	998,166	24,648,877
17	34.001	0	110,742	41,475	494,850	0	0	166,556	36,560	1,099,048	4,348,035
18	36.001	0	43,323	46,623	573,512	0	0	166,024	40,287	1,597,969	4,791,243
19	38.001	0	58,417	104,152	846,625	0	0	329,379	57,290	1,694,835	6,813,337
20	40.001	0	36,590	31,148	788,775	0	0	246,558	51,562	669,884	6,132,121
21	42.001	0	77,266	58,147</							

### SUMMARY WORKBOOK TABS

The *Equity* and *Summary* tabs summarize the model output tabs, displaying summary results and equity ratios. These tabs reference the model output tabs and do not require any user input.

#### Equity

The *Equity* tab calculates the Annual VMT, Annual Cost Responsibility, Annual User Fees, and Subsidy and Equity Ratios for each of 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 Full-Fee Scaled Equity Ratio is the ratio of the share of full-fee cost responsibility to the full-fee user fee share.

Figure 60. Equity

Weight Class	Axles	Annual VMT			Annual Cost Responsibility			Annual User Fees			Full-Fee Scaled Equity Ratio			
		All	Full-Fee	Alternative Fee	State	Federal	Local	All	Full-Fee	Subsidy				
3	1	0	32,957,262,617	32,251,303,582	675,959,035	595,227,871	259,334,081	180,275,938	719,728,102	709,492,020	4,593,410	1,116,931,689	0.9974	
4	10.001	to	15,000	19,301,458	19,301,458	3,149,071	2,156,366	1,124,984	7,445,040	7,445,040	159,366	6,145,157	1.9187	
5	12.001	to	15,000	86,084,647	70,853,557	14,231,090	2,673,574	1,538,938	4,846,181	4,307,938	538,243	3,240,336	1.4189	
6	14.001	to	15,000	167,185,542	144,415,588	22,769,957	5,302,888	3,076,123	10,406,894	9,437,262	969,632	9,104,041	10,339,619	1.2434
7	16.001	to	15,000	80,209,789	80,209,692	3,095,117	3,095,117	2,195,541	5,995,773	5,926,930	68,843	6,116,462	6,378,904	1.2380
8	18.001	to	15,000	86,895,101	74,186,577	12,708,524	3,255,786	2,504,013	2,382,237	6,181,345	5,355,409	825,936	6,791,458	1.1269
9	20.001	to	15,000	213,800,066	14,374,539	9,958,416	1,038,584	783,098	1,038,584	1,038,584	343,120	1,645,830	1,645,830	1.0000
10	22.001	to	15,000	39,254,935	29,573,359	9,681,576	1,778,889	1,532,218	1,891,166	2,896,240	224,149	3,919,219	4,856,7	0.8567
11	24.001	to	15,000	219,082,825	170,310,980	48,771,845	10,041,387	10,448,045	14,388,394	16,898,042	14,104,863	1,446,023	27,087,818	0.7439
12	26.001	to	15,000	16,307,735	3,799,875	14,507,860	1,247,972	952,790	378,864	330,346	286,556	815,465	480,376	0.7032
13	28.001	to	15,000	33,554,128	8,291,584	25,262,544	1,884,881	996,798	1,322,441	694,273	522,184	1,418,885	1,308,808	0.7184
14	30.001	to	15,000	41,839,917	23,849,036	17,990,851	2,897,234	1,250,705	1,724,298	1,525,216	1,541,349	1,179,870	3,233,217	0.6813
15	32.001	to	15,000	34,162,293	24,648,977	9,513,436	2,194,428	1,252,519	1,712,740	2,051,399	1,804,865	499,096	3,123,304	0.6928
16	34.001	to	15,000	13,230,328	4,348,035	8,882,291	887,545	441,354	534,111	425,091	541,249	549,524	602,403	0.7599
17	36.001	to	15,000	17,783,585	4,791,243	12,992,341	1,037,038	582,167	896,222	434,884	332,428	799,984	885,788	0.6928
18	38.001	to	15,000	19,071,766	8,813,327	12,258,439	1,933,194	959,641	973,314	697,921	592,074	847,417	891,142	0.9156
19	40.001	to	15,000	10,722,394	6,132,121	4,590,274	614,705	382,503	408,189	577,316	521,719	334,942	602,600	0.9290
20	42.001	to	15,000	6,404,116	4,280,965	2,113,149	573,480	238,289	281,198	480,095	387,878	68,499	733,360	0.7163
21	44.001	to	15,000	40,031,045	36,589,200	3,441,845	2,754,658	1,536,844	1,718,423	3,945,213	3,871,409	70,752	5,490,103	0.9557
22	46.001	to	15,000	19,509,687	15,392,870	4,116,717	1,432,797	723,737	814,892	1,817,896	1,024,350	119,081	2,338,336	0.8316
23	48.001	to	15,000	16,460,405	15,187,191	1,273,214	1,400,298	688,078	896,387	1,733,539	1,541,777	93,832	2,389,288	0.9219
24	50.001	to	15,000	17,149,489	15,870,303	1,279,186	1,240,539	717,851	1,375,088	1,734,487	1,641,094	38,884	2,613,044	0.8976
25	52.001	to	15,000	33,286,173	30,823,833	2,462,339	2,384,163	1,375,088	1,500,348	3,453,817	3,277,787	83,889	4,919,799	0.9522
26	54.001	to	15,000	34,137,315	28,098,510	2,038,805	2,203,304	1,272,419	1,476,766	3,916,209	3,185,302	100,216	4,710,873	0.9953
27	56.001	to	15,000	10,278,133	9,051,562	376,581	774,798	409,500	892,272	1,137,817	1,119,810	24,374	1,894,323	0.8447
28	58.001	to	15,000	8,944,222	9,228,740	618,483	711,044	496,886	897,010	1,120,441	1,074,238	29,810	1,930,076	0.9899
29	60.001	to	15,000	1,786,245	1,708,039	61,815	132,029	57,040	70,203	210,467	203,421	2,000	297,031	1.0311
30	62.001	to	15,000	3,285,788	3,088,241	197,547	253,849	160,065	201,113	389,469	389,467	15,528	577,824	0.9411
31	64.001	to	15,000	8,982,071	8,918,389	341,883	888,359	505,014	635,438	1,235,507	1,217,713	28,897	1,537,877	0.9981
32	66.001	to	15,000	2,545,015	2,478,617	61,399	239,590	136,648	179,413	342,356	337,670	3,984	541,595	0.8918
33	68.001	to	15,000	4,219,781	4,077,601	142,180	428,685	215,490	230,389	594,525	587,481	13,440	843,164	0.9959
34	70.001	to	15,000	3,887,604	3,787,102	70,303	383,854	224,421	151,142	681,205	676,919	4,518	129,688	1.1224
35	72.001	to	15,000	2,713,344	2,638,083	74,861	190,444	121,761	46,307	429,941	420,351	5,304	348,647	1.1720
36	74.001	to	15,000	7,070,688	6,899,053	173,635	585,222	449,409	276,908	1,163,060	1,156,604	22,524	1,279,702	1.2919

Figure 61. Summary

Declared Weight	All	Annual VMT			Annual Cost Responsibility			Annual User Fees			Scaled Equity Ratio				
		All	Full-Fee	Alternative Fee	State	Federal	Local	Full-Fee	Subsidy						
3	1	to	10,000	32,927,262,617	32,251,303,582	675,959,035	595,227,871	259,334,061	180,275,936	1,016,531,685	719,728,102	709,452,020	4,593,410	1,0091	1,0007
4	10.001	to	15,000	19,301,458	19,301,458	3,149,071	2,156,366	1,124,984	1,124,984	7,445,040	7,445,040	159,366	6,145,157	1.9187	1.0498
5	12.001	to	15,000	86,084,647	70,853,557	14,231,090	2,673,574	1,538,938	1,538,938	4,846,181	4,307,938	538,243	3,240,336	1.4189	1.0931
6	14.001	to	15,000	167,185,542	144,415,588	22,769,957	5,302,888	3,076,123	3,076,123	10,406,894	9,437,262	969,632	9,104,041	1.2434	1.3423
7	16.001	to	15,000	80,209,789	80,209,692	3,095,117	3,095,117	2,195,541	2,195,541	5,995,773	5,926,930	68,843	6,116,462	1.2380	1.0929
8	18.001	to	15,000	86,895,101	74,186,577	12,708,524	3,255,786	2,504,013	2,382,237	6,181,345	5,355,409	825,936	6,791,458	1.1269	1.0929
9	20.001	to	15,000	213,800,066	14,374,539	9,958,416	1,038,584	783,098	1,038,584	1,038,584	1,038,584	343,120	1,645,830	1.0000	1.0000
10	22.001	to	15,000	39,254,935	29,573,359	9,681,576	1,778,889	1,532,218	1,891,166	2,896,240	224,149	3,919,219	4,856,7	0.8567	0.7325
11	24.001	to	15,000	219,082,825	170,310,980	48,771,845	10,041,387	10,448,045	14,388,394	16,898,042	14,104,863	1,446,023	27,087,818	0.7439	0.7325
12	26.001	to	15,000	16,307,735	3,799,875	14,507,860	1,247,972	952,790	378,864	330,346	286,556	815,465	480,376	0.7032	0.7325
13	28.001	to	15,000	33,554,128	8,291,584	25,262,544	1,884,881	996,798	1,322,441	694,273	522,184	1,418,885	1,308,808	0.7184	0.7325
14	30.001	to	15,000	41,839,917	23,849,036	17,990,851	2,897,234	1,250,705	1,724,298	1,525,216	1,541,349	1,179,870	3,233,217	0.6813	0.7325
15	32.001	to	15,000	34,162,293	24,648,977	9,513,436	2,194,428	1,252,519	1,712,740	2,051,399	1,804,865	499,096	3,123,304	0.6928	0.7325
16	34.001	to	15,000	13,230,328	4,348,035	8,882,291	887,545	441,354	534,111	425,091	541,249	549,524	602,403	0.7599	0.7325
17	36.001	to	15,000	17,783,585	4,791,243	12,992,341	1,037,038	582,167	896,222	434,884	332,428	799,984	885,788	0.6928	0.7325
18	38.001	to	15,000	19,071,766	8,813,327	12,258,439	1,933,194	959,641	973,314	697,921	592,074	847,417	891,142	0.9156	0.7325
19	40.001	to	15,000	10,722,394	6,132,121	4,590,274	614,705	382,503	408,189	577,316	521,719	334,942	602,600	0.9290	0.7325
20	42.001	to	15,000	6,404,116	4,280,965	2,113,149	573,480	238,289	281,198	480,095	387,878	68,499	733,360	0.7163	0.7325
21	44.001	to	15,000	40,031,045	36,589,200	3,441,845	2,754,658	1,536,844	1,718,423	3,945,213	3,871,409	70,752	5,490,103	0.9557	0.7325
22	46.001	to	15,000	19,509,687	15,392,870	4,116,717	1,432,797	723,737	814,892	1,817,896	1,024,350	119,081	2,338,336	0.8316	0.7325
23	48.001	to	15,000	16,460,405	15,187,191	1,273,214	1,400,298	688,078	896,387	1,733,539	1,541,777	93,832	2,389,288	0.9219	0.7325
24	50.001	to	15,000	17,149,489	15,870,303	1,279,186	1,240,539	717,851	1,3						

**Bonds2019-2021.txt**

Bond expenditures allocated during the 2019-2021 study. It is important to keep the bond allocation output file because this file becomes an input file for future studies. Running the 2019 model generates the bond file for 2019-2021 that will be used in the 2021 HCAS study, along with the prior bond files from the previous three studies.

**DeclaredPaveFactors.txt**

The *DeclaredPaveFactors.txt* file contains the pavement factors by declared operating weight.

**FlatFeeReport.txt**

*FlatFeeReport.txt* contains a summary of the flat fee revenues and as-if revenues for each flat fee commodity by weight class and axle class.

**MissingPavementFactors.log**

*MissingPavementFactors.log* 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.

**SubsidiesbyVehClass.txt**

*SubsidiesbyVehClass.txt* is an output file that contains the calculated subsidies by weight class and axle class.

**VMTMaster.txt**

The *VMTMaster.txt* file contains the most disaggregated output of the calculated VMT. VMT are reported for each facility class by ownership, weight class, and axle class. This file is used to report the VMT by county and city ownership.

## 12. POLICY ANALYSIS OF ALTERNATIVE RATES

The HCAS model includes the option to analyze changes in revenue instrument taxes or fees. The Alternative Rate Analysis is an optional analysis; if alternative rates have not been specified in the model, the user should ignore the alternative rate analysis output tabs. This section

provides an explanation of the alternative rate analysis, a detailed

description of the revenue instruments and three alternative rate case studies to illustrate the alternative rate analysis.

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 rerunning the Python file, *HCASModule.py*. In the model calculations, the program calibrates the model to the rates and control totals in the *Rates* and *Revenue Forecast* input tabs, and then evaluates the effect of the modified rates specified by the user in the *Alt. Rates* input tab. The model reports the output from the current rates and alternative rates analyses in separate output tabs.

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:

- Enter the alternative rates in the *Alt. Rates* tab in the inputs workbook and re-save the inputs workbook.
- Run *HCASModule.py* (see [Section 7, Run the HCAS Python Model](#)).
- View the alternative rate results on the *Alt. Attributed Revenues*, *Alt. Equity*, and *Alt. Summary* tabs in the outputs workbook.

### ALTERNATIVE RATES INPUT TABS

#### Alt. Rates

The *Alt. Rates* tab in the inputs workbook contains the revenue instrument tax rates for gas, diesel, VMT, WMT, and registration fees, the RUAF and flat fee monthly rates, and VMT per month and axle shares. The setup of this tab is the same as the *Rates* tab (see [Figure 51 on page D28](#)).

## Revenue Instruments

In Oregon's current highway finance system, vehicles under 26,001 pounds pay registration fees and the gas or diesel tax, and vehicles over 26,000 pounds pay registration fees and a weight mile tax (WMT).

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:** 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 pounds have their own registration fee schedule; tow trucks over 26,000 pounds register with the MCTD 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 RUAF of 5.7 cents per equivalent single-axle load for the loaded portion of their trip and pay a 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 title transfers.

Tax rates for each of the unique revenue instruments can be copied from the *Rates* tab into the *Alt. Rates* tab and then modified by the user.

## 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 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 *General* 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. 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 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. In addition to having a higher share of diesel VMT, heavy vehicles also have lower 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.

#### ***Weight Mile Tax (WMT): Dollars per Mile***

The WMT is measured in dollars per mile. The ODOT WMT Table A lists the WMT 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 pounds pay the RUAF.

The WMT revenues and revenue attribution are calculated by multiplying the WMT tax 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 tax structure will affect the equity ratios for individual weight classes within the heavy vehicle group.

#### ***Vehicle Registration Fees: Dollars per Year***

The Oregon DMV registers most vehicles, with the exception of heavy vehicles (over 26,000 pounds), which must register with the 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 *Rates* and *Alt Rates* tabs.

- **Normal Vehicle Registration (Normal Reg):** Current normal registration for basic vehicles (under 8,000 pounds) is \$112 for a two-year registration (\$56 per year). The MCTD Registration Fee Schedule is used for vehicles 10,000 pounds 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 pounds, and the registration fee entered in the *Rates* and *Alt Rates* tabs should exclude the tow truck certificate fee. Tow trucks weighing more than 26,000 pounds must register with and pay registration fees according to the MCTD.
- **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 Motor 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 \$6. 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 \$1.20 per year in the 2019 HCAS.

- **Light Trailer Registration (LT Reg):** The per year registration fee paid by light trailers weighing less than 26,001 pounds.
- **Heavy Trailer Registration (HT Reg):** The per year registration fee paid by heavy trailers weighing more than 26,000 pounds.

**Title Fee: Dollars per Title Transaction**

A title fee is paid upon first-time purchase and registration of a vehicle in Oregon. As of January 2017 there were two different title fees depending on vehicle class. The title fee for vehicles weighing under 26,000 pounds was \$93 and the fee for vehicles above 26,000 pounds 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 (RUAF) 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 because the vehicle weight is being distributed over more axles, causing less road damage.

**Flat Fee: Monthly Fee**

A flat fee is a monthly fee paid by a 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 and sand and gravel haulers may pay \$9.10 per 100 pounds, sand and gravel haulers may pay \$7.53 per 100 pounds, and wood chip haulers may pay \$36.84 per 100 pounds. Flat fee rates apply to vehicles hauling log, sand and gravel, or chips that are over 26,000 pounds, with the monthly rate calculated as the flat fee rate paid by a hauler operating at the mid-point for the weight category (weight class plus 999 pounds).

**ALTERNATIVE RATES OUTPUT TABS**

The alternative rate analysis results are displayed in three tabs in the outputs workbook: *Alt. Attributed Revenues*, *Alt. Equity*, and *Alt. Summary*.

**Alt. Attributed Revenues**

The *Alt. Attributed Revenues* tab contains model output of the attributed revenues by major revenue instrument for each weight and axle class. The *Alt. Attributed Revenues* are summed to produce Annual User Fees in the *Alt. Equity* and *Alt. Summary* tabs.

**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 *Alt. Attributed Revenues*, and *Allocated Costs* tabs.

**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.



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# Appendix E: Model Documentation

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- E9 Description of Model Calculation Operations
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- E14 VMT Analysis Methods
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## MODEL OVERVIEW

The full source code for the 2019 Oregon Highway Cost Allocation Model is included with the model distribution. The model is written in Python and is implemented by running `HCASModule.py`. The process for running the model is described in depth in [Appendix D, the Model User Guide](#).

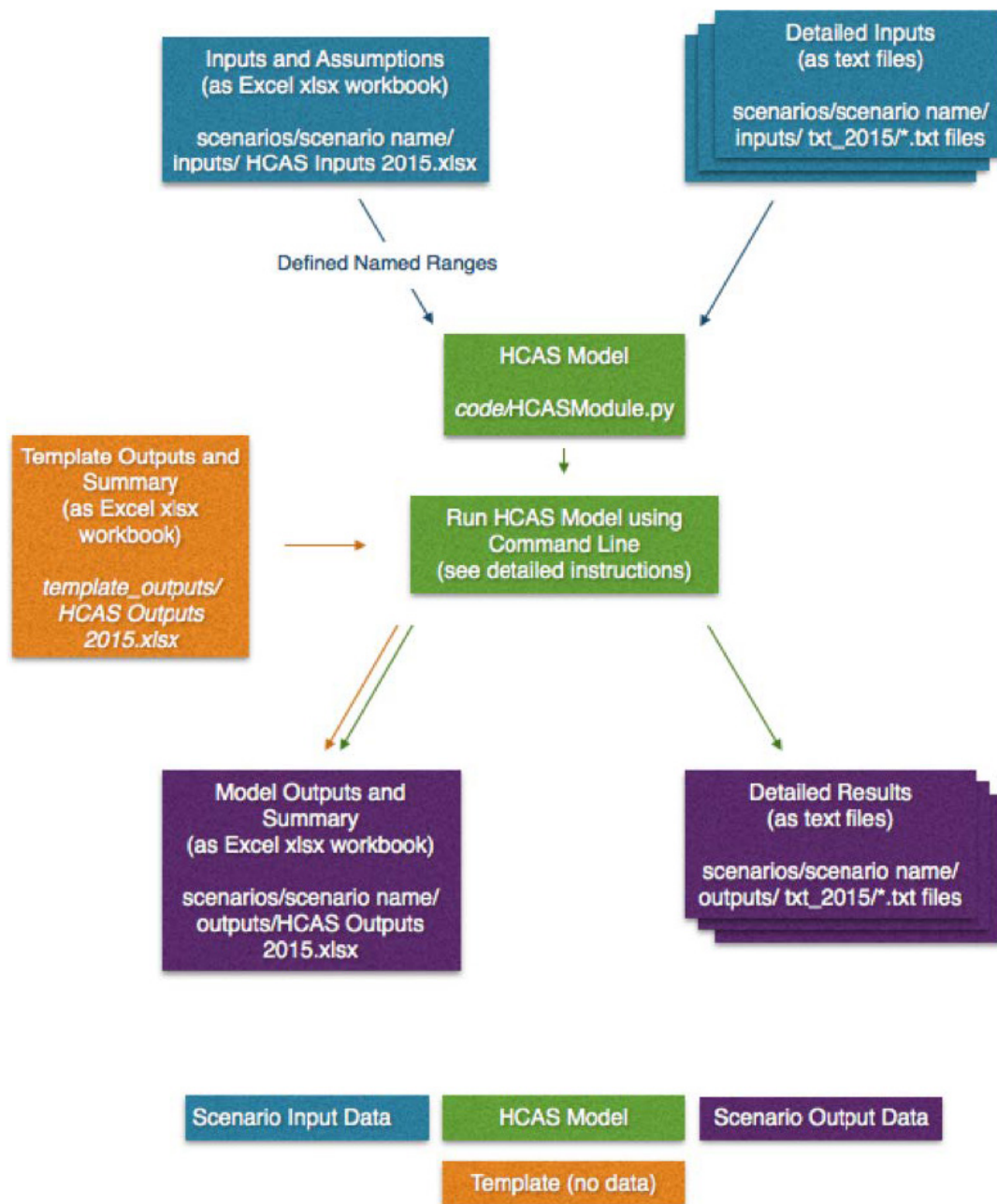
As described in the Model User Guide in [Appendix D](#), the user runs the HCAS Model with using a Graphic User Interface (GUI) in which the user can open and run the Python model. The HCAS Python code is centered on a class, `HCASModule`, that calls a series of methods when the Python file is executed.

This appendix provides a detailed description of each of the class methods that are called in the HCAS Python model, explaining the calculations and describing the internal data structures they use. [Figure 1](#) shows a graphical representation of the overall model process, including the Excel workbooks, the HCAS model, and the external data files. [Figure 1](#) shows the required inputs, templates and outputs of the model. Each box shows the general filepath from the base folder where the file(s) is located. Appendix D provides a detailed overview of how these files are setup and where they are located in the HCAS model folder.

[Table 1](#) describes the input ranges in various tabs of the “HCAS Inputs.xlsx” 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 loads the data into the HCAS model code, and the name of the data structure in the HCAS model code that accepts the data.

[Table 2](#) describes the tab-delimited text files that contain input data for the HCAS model, listing the file name, what data it contains, the units those data are in, and the data structure in the HCAS model that accepts the data.

**Figure 1. Oregon Highway Cost Allocation Model**



**Table 1. Input Ranges**

Named Range	Tab	Model Function	Model Variable Name	Units	Contains
GrowthRates	VMT Growth	simpleSetup(xls_inputs['GrowthRates'])	self.growthRates	Annual growth rate (e.g., 0.05 means 5% per year)	VMT growth rates
VMTByFC	VMT by FC	simpleSetup(xls_inputs['VMTByFC'])	self.VMTbyFC	Base-year vehicle-miles traveled	VMT by functional class and ownership
BaseVMT	Base VMT	setBaseVMT(xls_inputs['BaseVMT'])	self.baseVMT	Base-year vehicle-miles traveled	Base-year VMT by weight class and tax class
Evasion	General	setEvasion(xls_inputs['Evasion'])	self.gasEvasion, self.dieselEvasion, self.wmtEvasion, self.basicDiesel, self.ruafRegRate, self.ruafReg78, self.ruafReg96, self.ruafReg104, self.emptyLogPercent, self.emptyLogWeight	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	Assumptions for gas-tax avoidance, use-fuel tax evasion & avoidance, weight-mile tax evasion, share of basic 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, share of 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
Path	Policy	setPath(xls_inputs['Path'])	self.path	Names of allocators and shares	Allocator(s) to use for each work type
ProjectCosts	Project Costs	setProjectOrLocalCosts(xls_inputs['ProjectCosts'])	self.projectCosts	Biennial dollars	Costs to allocate for construction projects
NonProjectCosts	Non-Project Costs	setNonProjectOrStuddedTire(xls_inputs['NonProjectCosts'])	self.nonProjectCosts	Biennial dollars	Other costs to allocate
LocalCosts	Local Costs	setProjectOrLocalCosts(xls_inputs['LocalCosts'])	self.localCosts	Biennial dollars	Local-government costs to allocate
StuddedTire	General	setNonProjectOrStuddedTire(xls_inputs['StuddedTire'])	self.studdedTire	Biennial dollars	Studded-tire adjustments
BridgeFactors	General	setBridgeFactors(xls_inputs['BridgeFactors'])	self.bridgeFactors	Shares	Incremental factors for bridge work types
BondFactor	General	float(xls_inputs['BondFactor'])[0][0])	self.bondFactor	Share	Proportion of bonded expenditures to allocate in a biennium
Biennium	General	int(xls_inputs['Biennium'])[0][0])	self.biennium	Four-digit year	First year of model biennium
SWT	Codes	setSummaryTypesClasses(xls_inputs['SWT'])	self.summaryWorkTypes	Work type codes	Definitions of summary work types
SWC	Codes	setSummaryTypesClasses(xls_inputs['SWC'])	self.summaryWeightClasses	Pounds	Definitions of summary weight classes



Table 3 describes the outputs from the model code that populate the tabs in the “HCAS Outputs 2019.xlsx” workbook, listing the data structure in the HCAS model from which the data are extracted, the method called to calculate and retrieve the data, the tab into which the data are written, and the contents of the data.

Table 4 describes the tab-delimited text files that are written when the HCAS model runs, listing the data structure in the HCAS model from which the data are extracted, the method called to calculate and write the data, the file names, and the contents of the data.

**Table 1 (continued). Input Ranges**

Named Range	Tab	Model Function	Model Variable Name	Units	Contains
RevenueTotals	Revenue Forecast	setRevenueTotals(xls_ inputs['RevenueTotals'])	self.revenueTotals	Biennial dollars	Control totals for revenues by instrument
Rates	Rates	setRates(xls_ inputs['Rates'])	self.rates	Dollars per whatever	Current-law rates except RUAF and flat fee
RUAFRates	Rates	setRUAFRates(xls_ inputs['RUAFRates'])	self.RUAFRates	Dollars per mile	Current-law RUAF rates
FFRates	Rates	setFFRates(xls_ inputs['FFRates'])	self.flatfee	Dollars per month, miles per month, and shares	Current-law flat fee rates
MPG	MPG		self.MPG	Miles per gallon	Assumed miles per gallon
AltRates	Alt Rates	setRates(xls_ inputs['AltRates'])	self.altRates	Dollars per whatever	Alternative rates except RUAF and flat fee
AltRUAFRates	Alt Rates	setRUAFRates(xls_ inputs['AltRUAFRates'])	self.altRUAFRates	Dollars per mile	Alternative RUAF rates
AltFFRates	Alt Rates	setFFRates(xls_ inputs['AltFFRates'])	self.altFlatfee	Dollars per month, miles per month, and shares	Alternative flat fee rates

See: *HCAS Inputs 2017.xlsx*

**Table 2. Input Text Files**

File Name	Model Data Structure	Units	Contains
SeedData.txt	self.seedData	Unitless numbers	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	self.shares	Shares (e.g. 0.5 means 50%)	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	self.simpleFactors	Shares	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	self.paveFactors	Shares	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	self.pceFactors	Shares	<b>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.</b>
DeclaredRegistered.txt	self.declaredRegistered	Shares	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.
DeclaredOperating.txt	self.declaredOperating	Shares	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.
BasicSharePeak.txt	self.peakShares	Shares	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.
BondsYYYY-YYYY.txt	self.priorBondAmount	Biennial dollars	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".

**Table 3. Outputs**

Tab	Model Data Structure	Method to Create	Units	Contains
Model VMT	self.vmtByVehicles	makeVMTByVehicles()	Annual vehicle-miles traveled	Model year VMT by weight class and tax class
Allocated Costs	self.fullAllocatedCosts	allocateCosts()	Biennial dollars	Allocated costs by declared weight class, declared number of axles, and funding source
Allocated Costs by SWT	self.fullAllocatedCosts	getAllocatedCostsByWorkType()	Biennial dollars	Allocated costs by funding source, summary work type, and summary weight class
Costs to Allocate by SWT	self.projectCosts, self.nonProjectCosts, self.bondCosts, self. priorBondAmount	getCoststoAllocate()	Biennial dollars	Costs to allocate by funding source and summary work type
Attributed Revenues	attributedRevenues	attributeRevenues()	Biennial dollars	Attributed revenues by declared weight class, declared number of axles, and revenue instrument
Alt. Attributed Revenues	attributedRevenues	attributeAltRevenues()	Biennial dollars	Attributed alternative revenues by declared weight class, declared number of axles, and revenue instrument
MPG	self.adjustedMPG	getAdjustedMPG()	Miles per gallon	Calibrated estimates of miles per gallon by weight class

See: *HCAS Outputs 2019.xlsx*

**Table 4. Output Text Files**

Tab	Model Data Structure	Method to Create	Units	Contains
AllocatedCosts_bond.txt	self.fullAllocatedCosts	allocateCosts()	Biennial dollars	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.
AllocatedCosts_federal.txt	self.fullAllocatedCosts	allocateCosts()	Biennial dollars	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.
AllocatedCosts_local-federal.txt	self.fullAllocatedCosts	allocateCosts()	Biennial dollars	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.
AllocatedCosts_local-other.txt	self.fullAllocatedCosts	allocateCosts()	Biennial dollars	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.

**Table 4 (continued). Output Text Files**

File Name	Model Data Structure	Method to Create	Units	Contains
AllocatedCosts_local-state.txt	self.fullAllocatedCosts	allocateCosts()	Biennial dollars	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.
AllocatedCosts_other.txt	self.fullAllocatedCosts	allocateCosts()	Biennial dollars	Not used. This may be ignored.
AllocatedCosts_state.txt	self.fullAllocatedCosts	allocateCosts()	Biennial dollars	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.
BondsYYYY-YYYY.txt	allocatedBonds	allocateCosts()	Biennial dollars	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".
DeclaredPaveFactors.txt	self.pavement	makeVMTMaster()	Unitless factors	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.
FlatFeeReport.txt	ffRevenue, asifWMTRevenue	allocateCosts()	Biennial dollars	Reports fees paid by flat-fee vehicles and the fees they would pay if they paid weight-mile tax. The 'as-if' revenue is to determine the flat fee difference. As of the 2011 study, flat-fee vehicles are not considered alternative fee-paying vehicles. 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.
MissingPavementFactors.log	N/A	makeVMTMaster()	N/A	Lists any errors encountered while attempting to make pavement factors by facility class, 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.
VMTMaster.txt	self.VMTMaster	makeVMTMaster()	Annual vehicle-miles traveled	Contains annual VMT. Columns are functional class, ownership, declared weight class, declared number of axles, and vehicle-miles traveled. The first four are keys.
SubsidiesbyVehClass.txt	ffRevenue, regRevenue, ruafRevenue, wmtRevenue, gasTaxRevenue, dieselTaxRevenue, asifWMTRevenue	allocateCosts()	Biennial dollars	Contains calculated subsidies by subsidy type for WMT, Farm Registration, Tow Registration, Charitable Non-Profit Registration and E-Plate Registration for each weight class, and actual number of axles.

## DESCRIPTION OF MODEL CALCULATION OPERATIONS

The following describes what happens when the Python HCAS model, `HCASModule.py`, is run. [Figure 1 on page E3](#) illustrates the overarching process of the model. The model loads text files and tabs from the HCAS Inputs Excel workbook, performs calculations in Python, and then populates tabs with the results into the HCAS Outputs Excel workbook and saves output text files with detailed results.

### SEND BASE-YEAR VMT DATA AND RETRIEVE MODEL-YEAR VMT DATA

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 *General* tab, tell the model what evasion and avoidance rates to assume. Evasion and avoidance are combined.

The call to `makeVMTMaster()` tells the model to do its VMT calculations. The call to `makeVMTByVehicles()` tells the model to calculate model-year VMT by weight and tax class and populate the *Model VMT* tab in the outputs workbook.

### SEND COSTS TO ALLOCATE AND RETRIEVE ALLOCATED COSTS

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 is also defined in the path. The proportions must add up to one.

The model obtains costs to allocate 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 the project is not a bridge project.

The model obtains studded-tire adjustments from the Studded Tires table in the *General* 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.

The model obtains bridge factors from the Bridge Splits table in the *General* 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.

The model obtains the information necessary for the proper treatment of the expenditure of bond revenues from the *General* tab.

The *Codes* tab 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 in workbook, since it is faster, more reliable, and keeps the workbook size reasonable.

The `allocateCosts()` method allocates costs and returns the allocated costs by weight class and funding source, which then populate the *Allocated Costs* tab in the outputs workbook.

### SEND REVENUES AND RATES AND RETRIEVE ATTRIBUTED REVENUES

The model obtains revenue totals that are the control totals by instrument from the budget. Revenues are located in the *Revenue Forecast* tab in the inputs workbook. Rates are located in the *Rates* tab in the inputs workbook. 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 longer 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. The model obtains estimated miles per gallon by operating weight class from the *MPG* tab in the inputs workbook.

The `attributeRevenues()` method attributes revenues and returns the attributed revenues by weight class and revenue instrument, which then populate the *Attributed Revenues* tab in the outputs workbook.

The call to **getAdjustedMPG()** tells the model to return the adjusted miles per gallon (already calculated as part of the revenue attribution calculations), which then populate the *MPG* tab of the outputs workbook to the right of the initial MPG estimates. The initial estimates are adjusted to allow fuel tax revenues to add up the revenue control totals for fuel taxes.

### RETRIEVE SUMMARY TABULATIONS FOR REPORT TABLES

The **getAllocatedCostsByWorkType()** method gets allocated costs by summary work type, funding source, and summary weight class, which then populate *Allocated Costs by SWT* tab in the outputs workbook.

The **getCostsToAllocate()** method returns costs to allocate by summary work type and funding source, which then populate the *Costs to Allocate by SWT* tab in the outputs workbook.

### SEND ALTERNATIVE RATES AND RETRIEVE ATTRIBUTED ALTERNATIVE REVENUES

The model obtains alternative rates from the *Alt Rates* tab. 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.

The **attributeAltRevenues()** method attributes revenues using alternative rate schedules and returns results by weight class and revenue instrument, which populate the *Alt. Attributed Revenues* tab in the outputs workbook.

## DESCRIPTION OF MODEL CLASS METHODS

The following sections of the documentation serve two purposes: they describe in detail how the model does what it does and they provide a guide for following 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 in running the model. The first section describes the class methods that load the input data into the model. The subsequent sections describe the way the model analyzes VMT, allocates costs, and attributes revenues.

## METHODS TO LOAD DATA

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 loaded from the HCAS Inputs Excel workbook. Other class methods, described in later sections, make use of the data and return results to the HCAS Outputs Excel workbook and 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.

### LOAD TEXT INPUT DATA

The **readData()** method imports the following data sets from tab-delimited text files, which are expected to be in the inputs text folder:

- **AxleShares.txt** is read into `self.shares` and contains the shares of vehicles weighing more than 105,500 pounds by number of axles (5 to 9+) by weight class. These data are developed from Special Weighings data to describe the share of each weight class with each possible number of axles (nine or more axles are coded as nine-plus). There are three columns: weight class, axles, 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.
- **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 Weigh-in-Motion 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 and DMV registration data. There are three columns: declaredWeight, registeredWeight, and share. The first two are keys.

- **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.
- **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.
- **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 twelve columns: weight class,

axles, AllVMT, BasicVMT, Over10VMT, Over26VMT, Over50VMT, Under26VMT, Over80VMT, Over106VMT, Snow, and AllAMT. The first two are keys; the rest are allocators.

## LOAD EXCEL INPUT DATA

Input data from the HCAS Inputs Excel workbook are loaded from the workbook using `loadExcelInputData()` method. This function takes the filename of the input workbook as an argument. In the 2017 HCAS, the model expects the HCAS Inputs Excel workbook to be in the `inputs` folder and have the filename 'HCAS Inputs 2015.xlsx'. A more detailed explanation of the inputs workbook setup is provided in Appendix D.

### Load Data for VMT Analysis

The following class methods process the loaded data for the VMT calculations. The HCAS model calls these methods to process data for the model before it calls the `makeVMTMaster()` method.

- **simpleSetup** sets up data (in this case, Growth Rates and VMTbyFC) that has a shared format.
  - 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.
  - 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 FHWA Highway Statistics reports.
- **setBaseVMT()** 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 are typically 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()** captures evasion and avoidance rates, along with some other assumptions used in revenue attribution. These assumptions are specified by the analyst. The function puts the assumptions 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).

### Load Data for Cost Allocation

The following class methods capture data from the inputs workbook for the cost allocation calculations and are called before the model calls the **allocateCosts()** method.

- **setPath()** 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.

- **setProjectOrLocalCosts()** sets up data (e.g., `self.projectCosts` and `self.localCosts`) that has a shared format.

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 are typically derived from the ODOT Cash Flow Model and Project Control System.

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 are typically derived primarily from Local Roads and Streets Survey reports.

- **setNonProjectOrStuddedTire()** sets up data (e.g., `self.nonProjectCosts` and `self.studdedTire`) that has a shared format.

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 are typically derived from the Agency Request Budget.

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()** captures cost shares used to distribute bridge expenditures for incremental cost allocation and puts them into `self.bridgeFactors`, 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.



- **self.bondFactor** is defined as the proportion of bond-funded expenditures that will be repaid in a single biennium. This assumption is specified by the analyst. It represents the biennial repayment amount as a proportion of the principal amount.
- **self.biennium** is defined as the starting year of the model biennium. Specified by the analyst.

### Load Data for Revenue Attribution

The following class methods capture data from the inputs workbook for the revenue attribution calculations. The HCASModule calls these methods to give data to the model before calling the standard implementation **attributeRevenues()** method or the alternative implementation **attributeAltRevenues()** method. The alternative rates are specified by the analyst to test changes in policy.

- **setRevenueTotals()** captures revenue control totals and puts them into **self.revenueTotals**. The key is the name of the revenue instrument and the value is biennial dollars of revenue to attribute. These are typically derived from the Agency Request Budget and must be consistent with current-law rates and the VMT data and assumptions specified elsewhere.
- **simpleSetup** sets up data (in this case, MPG) that has a shared format. 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.
- **setRates()** captures current-law (or 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.rates** (or **self.altRates**). **self.rates** (or **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. For the standard implementation, these are specified by the analyst based on current law and must match the assumptions used to develop the

revenue control totals. For the alternative implementation, these are specified by the analyst to test proposed changes to rates.

- **setRUAFRates()** captures current-law (or alternative) road-use assessment fee rates and puts them into **self.RUAFRates** (or **self.altRUAFRates**). The key is a tuple consisting of weight class and number of axles and values are dollars per mile. For the standard implementation, these are specified by the analyst based on current law. For the alternative implementation, these are specified by the analyst to test proposed changes to rates.
- **setFFRates()** captures current-law (or alternative) monthly flat-fee rates, average monthly miles, and axle distribution and puts them into **self.flatfee** (or **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. For the standard implementation, 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. For the alternative implementation, rates are specified by the analyst to test proposed changes to rates.

### Load Data for Summary Tables

The following class methods capture data from the inputs workbook and use it to tabulate summary tables of allocated costs and costs to allocate. The HCASModule calls these methods to give data to the model before calling the **getAllocatedCostsByWorkType()** and **getCostsToAllocate()** methods.

- **setSummaryTypesClasses()**  
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.  
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 METHODS

The **makeVMTMaster()** method 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.seedData to 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()** sums VMTData by functional class and ownership across weight classes and numbers of axles.
- **findVCSums()** sums VMTData by weight class and number of axles across functional class and ownership.
- **scaleToFC()** multiplies each value in VMTData by the ratio of its FCTotal control total to its current FCSum.
- **scaleToVC()** multiplies each value in the VMTData by the ratio of its VCTotal control total to its current VCSum.
- **findSSE()** 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 more than 30 billion), it would be satisfied.*
6. *If the sum of squared errors is less than the threshold, stop. Otherwise, return 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 the Model VMT tab in the outputs workbook.

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 all locally 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.

The structure of `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 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 the HCAS Outputs workbook. `self.vmtByVehicles` is a nested dictionary. The outer key is the tax class and the inner key is the weight class.

## COST ALLOCATION METHODS

The `allocateCosts()` method performs the following processes:

- Combine local costs data from `self.localCosts` with project costs data from `self.projectCosts` into `self.projectCosts`.
- Do bridge splits on project costs. 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. 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. 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. 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.
- Build allocation vectors 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.

- Scale allocation vectors so that the elements of each vector sum to one. The resulting allocation vectors may then 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.
- Make Other Bridge and Other Construction allocators. Once bridge project costs other than “other bridge” have been allocated, a special allocation vector is built to allocate these costs in proportion to all previously allocated bridge project costs. The same is done to create a special allocation vector 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.
- Apply allocators to non-project costs. 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. Applies the allocators to bondstoAllocate and stores the result in allocatedBonds.
- Store allocated bonded costs. 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. Captures allocated, current payments due on bonds issued for projects in previous biennia (priorBonds).
- Add current and prior allocated bonded costs to allocatedCosts.
- Write out detailed allocation results to tab-delimited text files, one for each funding source. These are named AllocatedCosts\_federal.txt, AllocatedCosts\_state.txt, etc.
- Copy allocators to self.allocators and allocatedCosts to self.fullAllocatedCosts.
- Prepare a summary table of allocated costs and that is returned to the HCAS Outputs workbook. 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 gets the allocation vectors from self.allocators. Columns are allocators and rows are combinations of facility class, declared weight class, and declared number of axles.

The **getAllocatedCostsByWorkType()** method 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 the *Allocated Costs by SWT* tab in the outputs workbook. Columns are summary weight classes and rows are combinations of funding source and summary work type. Cells contain allocated biennial dollars.

The **getCostsToAllocate()** method 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 self.priorBondAmount and aggregates them by summary work type from self.summaryWorkTypes. It returns the aggregated costs to allocate to *Costs to Allocate* tab in the outputs workbook. 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 rows are summary work types. Cells contain biennial dollars.

## REVENUE ATTRIBUTION METHODS

The **attributeRevenue()** method performs the following processes:

- Attribute road-use assessment fee (RUAF) revenue. 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 (WMT) revenue and as-if WMT revenue. WMT revenues are attributed to weight classes by multiplying their model-year VMT in each combination of weight class and number of axles from `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  $(1.0 - \text{self.wmtEvasion})$ . 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. 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  $(1.0 - \text{self.emptyLogPercent})$  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, `FlatFeeReport.txt`, containing flat-fee VMT, revenues, and as-if WMT revenues by commodity and weight class is written out to disk as a text file.
- Attribute registration and title revenues. 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 pounds 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 pounds, 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. As of the 2011 Study, Flat Fee vehicles are no longer treated as 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 General tab of the HCAS Inputs 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. When a vehicle pays the road-use assessment fee, it is often 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. 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 pounds is then adjusted to bring those weight classes, as a group, to equity (before considering subsidies). The attribution to basic vehicles (those 10,000 pounds 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 returned to the *MPG* tab in the outputs workbook 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 avoidance, evasion, the portion of basic vehicles that do not burn gasoline, 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 is 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 are then 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. 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. 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.
- Prepare a table of attributed revenues and subsidy amounts to save to a tab in the outputs workbook.

Attributed revenues are saved in the *Attributed Revenues* tab of the outputs workbook. **getAdjustedMPG()** returns the calibrated miles-per-gallon assumptions from self.adjustedMPG to the *MPG* tab in the outputs workbook.

## ALTERNATIVE REVENUE ATTRIBUTION METHODS

The **attributeAltRevenues()** method repeats the revenue attribution process using alternative rates specified by the analyst in the *Alt. Rates* tab of the inputs workbook.

The process for alternative revenue attribution is essentially the same as for the primary revenue attribution, but there are important differences:

- 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.

Alternate attributed revenues are saved in the *Alt. Attributed Revenues* tab of the outputs workbook.

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# Appendix F: Model Input Tables

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- F1 Model Assumptions and Data Sources
- F7 Processing of Original Data

## MODEL ASSUMPTIONS AND DATA SOURCES

This appendix documents the assumptions and data used in the final run of the HCAS model for the 2019 Highway Cost Allocation Study. Data used in the final model run were collected between roughly June 2018 and January 2019. The final model run was completed and verified in April 2019.

Table 1 through Table 6 list assumptions in the HCAS Inputs Excel workbook that are used in the final run of the model. Table 1 and Table 2 have the HCAS Inputs workbook tab listed in the first column followed by the assumption name or brief description.

Like prior HCAS inputs workbooks, this workbook includes a *Base VMT* tab. Table 1 lists the assumptions used to develop the Base VMT tab in the inputs workbook. These assumptions are yellow-shaded cells in their respective workbook tabs. The key tabs that are linked to and build up the Base VMT tab are the VMT Growth, DMV VMT, MCTD VMT, Federal VMT, and Bus VMT tabs.

Table 2 lists the assumptions in the HCAS inputs workbook. Most of the assumptions listed in Table 2 correspond to yellow-shaded cells in their respective workbook tab.

Table 3 through Table 6 display the assumptions for studded tires, motor home weight classes, bridge splits, and initial mpg because these assumptions are tables or ranges, not single values.

Table 3 displays expenditures related to studded tires. It shows biennium expenditures by funding source, work type and facility class.

Table 4 displays the assumed weight classes by motor home length used to assign motor home VMT to weight classes in the *DMV VMT* tab in the HCAS Inputs workbook.

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 6 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 2019 Final HCAS model run.

**Table 1. Base VMT Worksheet Assumptions**

Tab	Assumption	Value
DMV VMT	Commercial Trucks & Buses Annual VMT per vehicle (10,001 to 26,000 weight class)	19,000
DMV VMT	Tow Truck Annual VMT per vehicle	15,000
DMV VMT	Farm Vehicle Annual VMT per vehicle (by weight class)	
	<i>less than 20,001 lbs</i>	3,000
	<i>20,001 to 40,000 lbs</i>	3,500
	<i>40,001 to 50,000 lbs</i>	4,000
	<i>50,001 to 70,000 lbs</i>	4,500
	<i>70,001 to 80,000 lbs</i>	5,000
	<i>80,001 to 90,000 lbs</i>	6,000
	<i>90,001 to 100,000 lbs</i>	7,000
	<i>100,001 to 104,000 lbs</i>	7,500
	<i>104,001 lbs and up</i>	8,000
DMV VMT	State & Local Annual VMT per vehicle (by weight class)	
	<i>less than 20,001 lbs</i>	13,000
	<i>10,001 to 26,000 lbs</i>	12,000
	<i>26,001 lbs and up</i>	11,000
DMV VMT	Charitable & Non-Profit Annual VMT per vehicle	10,000
DMV VMT	Motorhome Annual VMT per vehicle	3,988
DMV VMT	Motorhome length/weight class assumptions (from Winnebago vehicle spec. information)	See Table 4

See: HCAS Outputs 2019.xlsx

**Table 2. HCAS Model User-Specified Assumptions**

Tab	Assumption	Value	Justification/Source
General	Split of bridge expenditures across bridge reclassification work types	See <a href="#">Table 5</a>	2002 OBEC Bridge Allocation Study
General	Base Year	2017	Ch. 2, pg. 15
General	Biennium	2019	Ch. 2, pg. 15
General	BondFactor	0.1605	Ch. 3, pgs. 21-22
General	Forecast Year (also, Model Year)	2020	Ch. 2, pg. 15
General	Percent of basic gallons that are diesel	5%	NA
General	Percent of RV gallons that are diesel	40%	NA
General	Percent of taxed gallons that are basic	94%	NA
MPG	MPG (initial) by weight class	See <a href="#">Table 6</a>	Regression on 2002 VIUS data
Policy	Preliminary and Construction Engineering (and etc.) Share 1	55.95%	Ch. 3, pg. 17
Policy	Right of Way (and Utilities) Share 1	73.75%	Ch. 3, pg. 17
Policy	New Pavements-Rigid Allocator/Share 1	3.99%	Ch. 3, pg. 17
Policy	New Pavements-Flexible Allocator/Share 1	5.43%	Ch. 3, pg. 17
Policy	Pavement and Shoulder Reconstruction-Rigid Allocator/Share 1	3.99%	Ch. 3, pg. 17
Policy	Pavement and Shoulder Reconstruction-Flexible Allocator/Share 1	5.43%	Ch. 3, pg. 17
Policy	Pavement and Shoulder Rehab-Rigid Allocator/Share 1	3.99%	Ch. 3, pg. 17
Policy	Pavement and Shoulder Rehab-Flexible Allocator/Share 1	5.43%	Ch. 3, pg. 17
Policy	Surface and Shoulder Maintenance-Rigid Allocator/Share 1	3.99%	Ch. 3, pg. 17
Policy	Surface and Shoulder Maintenance-Flexible Allocator/Share 1	5.43%	Ch. 3, pg. 17
Policy	Local Gov: Preliminary and Construction Engineering (and etc.) Share 1	55.92%	Ch. 3, pg. 19
Policy	Local Gov: Right of Way (and Utilities) Share 1	55.92%	Ch. 3, pg. 19
Policy	Local Gov: New Pavements-Rigid Allocator/Share 1	3.99%	Ch. 3, pg. 19
Policy	Local Gov: New Pavements-Flexible Allocator/Share 1	5.43%	Ch. 3, pg. 19
Policy	Local Gov: Pavement and Shoulder Reconstruction-Rigid Allocator/Share 1	3.99%	Ch. 3, pg. 19
Policy	Local Gov: Pavement and Shoulder Reconstruction-Flexible Allocator/Share 1	5.43%	Ch. 3, pg. 19
Policy	Local Gov: Pavement and Shoulder Rehab-Flexible Allocator/Share 1	3.99%	Ch. 3, pg. 19
Policy	Local Gov: Pavement and Shoulder Rehab-Flexible Allocator/Share 1	5.43%	Ch. 3, pg. 19
Policy	Local Gov: Surface and Shoulder-Rigid Allocator/Share 1	3.99%	Ch. 3, pg. 19
Policy	Local Gov: Surface and Shoulder-Flexible Allocator/Share 1	5.43%	Ch. 3, pg. 19
Policy	All other Allocators Shares for work types not Prelim. Engineering, ROW, or Pavement	100%	Ch. 3, pgs. 17-20

**Table 2 (continued). HCAS Model User-Specified Assumptions**

Tab	Assumption	Value	Justification/Source
General	Gas Tax Avoidance Rate	3.53%	Ch. 3, pg. 26
General	Diesel Tax Evasion & Avoidance Rate	4.53%	Ch. 3, pg. 26
General	WMT Evasion Rate	5%	Ch. 3, pg. 26
General	Basic Diesel (Percent of basic VMT by diesel vehicles)	5%	
General	Taxed Diesel (percent of taxed gallons that are diesel)	9.47%	
General	RUAF Registration Adjustment	4.5%	NA
General	RUAF Reg. from 78001	14%	NA
General	RUAF Reg. from 96001	15%	NA
General	RUAF Reg. from 104001	71%	NA
General	Log truck miles empty	55%	Ch. 7, pg. 66
General	E-Plate Registration, annualized	40%	One-time registration fee of \$10 divided by 5 yrs.
General	Split of studded tire expenditures across funding sources and work types	See <a href="#">Table 3</a>	NA
General	State/Local-State split (speed adjustment factor)	11%	NA
General	Preservation costs inflation rate	3%	NA

See: HCAS Report; General, Policy and MPG tabs, HCAS Inputs.xlsx

**Table 3. Studded Tire Assumptions**

Funding	Work Type	Facility Class	Biennium Expenditures (\$)	Distribution by Work Type
state	-	0	8,570,779 <sup>1</sup>	100%
state	1	0	407,453	5%
state	11	0	6,790,885	79%
state	26	0	1,372,441	16%
local-state	-	-2	942,786 <sup>2</sup>	100%
local-state	101	-2	44,820	5%
local-state	111	-2	746,997	79%
local-state	126	-2	150,968	16%

See: General tab, HCAS Inputs.xlsx

<sup>1</sup> Figure 5.5, Review of Studded Tires in Oregon, Final Report, SPR 304-671, December 20, 2014, ODOT Research Section

<sup>2</sup> Equal to 11% of state expenditures (using state / local-state split, speed adjustment factor).

**Table 4. Motorhome 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

See: DMV VMT tab (Motorhomes Table), HCAS Inputs.xlsx

**Table 5. Bridge Split Assumptions**

Bridge Type	Work Type	Share
0	60	0.6849
0	61	0.2520
0	62	0.0000
0	63	0.0000
0	64	0.0631
1	60	0.6666
1	61	0.2999
1	62	0.0000
1	63	0.0000
1	64	0.0335
2	60	0.6849
2	61	0.2520
2	62	0.0000
2	63	0.0000
2	64	0.0631
3	60	0.7221
3	61	0.1697
3	62	0.0000
3	63	0.0514
3	64	0.0568
4	60	0.8713
4	61	0.1029
4	62	0.0000
4	63	0.0000
4	64	0.0258

See: General tab (Bridge Splits Table), HCAS Inputs.xlsx

**Table 6. MPG Assumptions (Initial MPG)**

Declared	MPG	Declared (cont.)	MPG (cont.)
1	20.00	110,001	5.07
10,001	10.85	112,001	5.04
12,001	10.27	114,001	5.01
14,001	9.77	116,001	4.99
16,001	9.33	118,001	4.96
18,001	8.94	120,001	4.93
20,001	8.59	122,001	4.91
22,001	8.27	124,001	4.88
24,001	7.98	126,001	4.86
26,001	7.15	128,001	4.83
28,001	7.04	130,001	4.81
30,001	6.94	132,001	4.79
32,001	6.85	134,001	4.76
34,001	6.76	106,001	4.74
36,001	6.67	108,001	4.72
38,001	6.59	136,001	4.70
40,001	6.52	138,001	4.67
42,001	6.45	140,001	4.65
44,001	6.38	142,001	4.63
46,001	6.31	144,001	4.61
48,001	6.25	146,001	4.59
50,001	6.19	148,001	4.57
52,001	6.13	150,001	4.55
54,001	6.07	152,001	4.53
56,001	6.02	154,001	4.51
58,001	5.97	156,001	4.49
60,001	5.92	158,001	4.47
62,001	5.87	160,001	4.45
64,001	5.82	162,001	4.43

**Table 6 (continued). MPG Assumptions (Initial MPG)**

Declared	MPG	Declared (cont.)	MPG (cont.)
66,001	5.78	164,001	4.42
68,001	5.73	166,001	4.40
70,001	5.69	168,001	4.38
72,001	5.65	170,001	4.36
74,001	5.61	172,001	4.34
76,001	5.57	174,001	4.33
78,001	5.53	176,001	4.31
80,001	5.49	178,001	4.29
82,001	5.45	180,001	4.28
84,001	5.42	182,001	4.26
86,001	5.38	184,001	4.24
88,001	5.35	186,001	4.23
90,001	5.31	188,001	4.21
92,001	5.28	190,001	4.19
94,001	5.25	192,001	4.18
96,001	5.22	194,001	4.16
98,001	5.19	196,001	4.15
100,001	5.16	198,001	4.13
102,001	5.13	200,001	4.12

See: MPG tab, HCAS Inputs.xlsx

## PROCESSING OF ORIGINAL DATA

The following section discusses data sets that require 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 appropriate workbook tabs or text files.

### DMV REGISTRATION DATA

DMV registrations by weight class and tax class are used to estimate the base year VMT in the *DMV VMT* tab in the HCAS Inputs workbook. 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. The “Fuel” column may also be labeled “Power.”

### DMV MOTORHOME REGISTRATIONS

Motorhome VMT were estimated using motorhome vehicle counts from the DMV data with an assumed annual VMT. Weights are not included for motorhomes in the DMV data so the vehicle length (in feet) is used with motorhome manufacturer’s data on vehicle lengths and weights to assign the motorhome vehicle counts to weight classes. The DMV data were used to create a table of motorhome registration counts by vehicle length. This table is available in the *DMV VMT* tab in the HCAS inputs workbook.

### 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 *MCTD VMT* tab in the HCAS inputs workbook.

### FLAT FEE COLLECTION REPORTS

In previous studies, the cleaned Flat Fee Reports were obtained in a raw, database format. Since the 2015 Study, Flat Fee Reports were provided in a series of tabs/tables in an Excel workbook. Given that the Flat Fee data were already in Excel, there was no need to read the Flat Fee Reports into a database and run SQL queries.

**Table 7. 2019 HCAS Data Files and Sources**

Data	Source	File Name
Bridge Project Information	ODOT	Costs to Allocate and Projects Expenditures 2018.xlsx
DMV Registration Data	ODOT	CurReg_122017_with_DataOne.csv
Federal Fleet Report	<a href="https://www.gsa.gov/policy-regulations/policy/vehicle-management-policy/federal-fleet-report">https://www.gsa.gov/policy-regulations/policy/vehicle-management-policy/federal-fleet-report</a>	2017 Federal Fleet Report. US General Services Administration (GSA).
FHWA Highway Statistics-Table MV7	<a href="https://www.fhwa.dot.gov/policyinformation/statistics.cfm">https://www.fhwa.dot.gov/policyinformation/statistics.cfm</a>	FHWA Highway Statistics-Table MV7 (2016): mv7.xls
FHWA Highway Statistics-Table VM2	<a href="https://www.fhwa.dot.gov/policyinformation/statistics.cfm">https://www.fhwa.dot.gov/policyinformation/statistics.cfm</a>	FHWA Highway Statistics-Table VM2 (2016): vm2.xls
Flat Fee Collections Reports	ODOT	OR_OGS_100%_95%_90%_85%_2017.xlsx, OR_S&G_100%_97%_95%_2017.xlsx, Final Report 2017 Flat Fee Study.pdf
OR HPMS Submittal Data	ODOT	TOPS_2017.xlsx, Submit_2017_41_Sample_Sections_Details.csv, hpms_field_manual_dec2016.pdf,
Local Costs: Local Roads and Streets Survey	ODOT	2017 Survey Form Combined City County.xls, 2017 Survey Part IV.xls
Motor Carrier Registrations	ODOT	2019 HCAS Plates.xls
Non-Project Costs	ODOT	Costs to Allocate and Projects Expenditures 2018.xlsx
Pavement Factors	Roger Mingo, Mingo and Assoc.	Pave Facs 2019 VMT V4 NewLV.xlsx
Project Costs	ODOT	Costs to Allocate and Projects Expenditures 2018.xlsx
Studded Tire Expenditures	ODOT	Figure 5.5, Review of Studded Tires in Oregon, Final Report, SPR 304-671, December 20, 2014, ODOT Research Section
VMT Forecast	ODOT	HCAS 2017-2020 VMT estimate and forecast.xlsx
Revenue Forecast	ODOT	Transactions Revenues 2019-21_2018-6 Forecast.xlsx
RUAF Collection reports	ODOT	RUAFRPT.TXT
Transit VMT: Tri-Met	ODOT	2017_Bus VMT.xlsx
Weigh-In-Motion Data	ODOT	WIM_2017.csv
WMT Collection Reports	ODOT	WMT_sans_flat-7_19_18.csv





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## INTRODUCTION

### PURPOSE OF ISSUE PAPER

The combustion of fossil fuels for transportation, electricity generation, and interior heating releases carbon dioxide and other greenhouse gases into the atmosphere. The accumulation of these gases over the past decades has resulted in, and will continue to contribute to, global climate change.

In the absence of comprehensive policy at the national level, individual states and provinces in the United States and Canada have begun to pursue sub-national carbon mitigation policies. California, British Columbia, Ontario, and Quebec have all introduced market-based climate change policies.

“Cap-and-Trade” has often been used interchangeably with “Cap-and-Invest” in the last few years. Cap-and-Trade in its purest form is a system of capping emissions and allocating limited allowances to the firms that emit pollution. Those private firms will start trading allowances freely on an exchange. Under that version of the Cap-and-Trade system, there are no government revenues and no impact on the State Highway Trust Fund will result.

However, if the government auctions the permits, it modifies the original system by generating revenue for the government. The government collections from the price on allowances used to cover the emissions from the combustion of transportation fuels becomes a source of revenue for the State Highway Trust Fund. The Oregon State Legislature considered, but did not pass, such a system in the 2018 session that

would institute a Cap-and-trade program that places a price on carbon by requiring emitters of greenhouse gases to purchase a permit from the state for each metric ton of carbon-equivalent emitted. The revenue from the sale of these permits would be directed into investments in clean energy, carbon-reducing transportation projects, and transition assistance for low-income households. Thus, the government revenues were committed to a concept of “investment.” The new system was termed “Cap-and-Invest.” This term will be used in this paper to describe a system by which the government auctions emissions allowances and invests the revenue in various programs, including but not limited to transportation projects.

This report will examine the impact that a Cap-and-Invest (C&I) program will have on Oregon’s Highway Cost Allocation Study (HCAS). Oregon’s HCAS is a biennial study of highway cost responsibility between light vehicles (cars) and heavy vehicles (heavy trucks). Light vehicles pay for roads via registration fees and fuel taxes while heavy vehicles pay for roads via registration fees and a weight-mile tax. Under C&I, light vehicles will indirectly pay for permits to cover emissions from the combustion of gasoline and diesel and heavy vehicles will pay for permits to cover emissions from the burning of diesel fuel. Those funds will then be spent on highway transportation projects.

To understand how a C&I policy would impact the allocation of cost responsibility, we revisit the 2017 HCAS and simulate the cost allocation assuming that a C&I program was recently passed. We assume that the cost of tradable permits that would be purchased by fuel

distributors is passed on to vehicle operators as a per-gallon excise tax. Our analysis is a short-run simulation, which does not allow for any behavioral response to the higher fuel costs.

### BACKGROUND

The interaction of any carbon-based climate policy in Oregon and the Oregon Constitution needs to be carefully accounted for. Section 3a of Article IX of the Oregon Constitution requires that all revenue from taxes and fees levied on motor vehicle fuels be spent on “... construction, reconstruction, improvement, repair, maintenance, operation and use of public highways, roads, streets and roadside rest areas...” It is likely that monies spent on carbon permits that are required for the combustion of motor vehicles fuels will be subject to this requirement.

This same section of the Oregon Constitution requires the legislature to commission a study to determine whether the revenues paid by light vehicles and heavy vehicles are spent in proportion to the cost responsibility of those groups, otherwise known as the Highway Cost Allocation Study. If C&I generates a new source of revenue from vehicles, and that source of revenue is not in proportion to the cost responsibility of the different vehicle classes, the legislature would be compelled to adjust sources of revenue to ensure equity between cost and revenue allocations.

We assume that readers are familiar with Oregon’s Highway Cost Allocation Studies. The 2017 Highway Cost Allocation Study contains summaries and detailed descriptions of how ECONorthwest, under the guidance of the Study

Review Team, conducts the analysis. The report is also a repository of information on the varied sources of data that we use as inputs.

## MODELING CAP-AND-INVEST IN HCAS

The goal of this issue paper is to understand whether Cap-and-invest is likely to change the distribution between heavy and light vehicles' cost responsibility and how a Cap-and-Invest program would impact the execution of the Highway Cost Allocation Study. We examine each of these issues in turn. In this section, we will detail the assumptions we need to make in the modeling of a C&I program in Oregon and how that translates into the HCAS model. In a subsequent section, we will use this experience to identify weaknesses in our current stable of data and recommend some changes various state agencies might need to make in order to successfully complete the HCAS under a C&I regime.

### ASSUMPTIONS ABOUT CAP-AND-INVEST IN OREGON

To model a C&I program's impact on HCAS, we need to make certain assumptions about the parameters and operation of the program. First, we assume that every gallon of gasoline and every gallon of diesel fuel purchased in the state of Oregon for use as transportation fuel will be covered by an emission permit. We further assume that all permits that are retired for the purpose of covering transportation fuel emissions are purchased directly from the State

of Oregon and there is 100% compliance.<sup>1</sup>

Second, we assume that fuel distributors and retailers will be able to pass on to consumers the added cost from permit fees needed to cover emissions from the combustion of transportation fuels. This assumption is likely to hold in the near term as demand for transportation fuels is relatively inelastic in the short run. Our results will then implicitly assume that drivers do not respond to the higher prices during the study period, which means VMT is unchanged.

Third, we will assume that there would be the same rate of avoidance with the program as there was without the program. Oregon's HCAS implicitly assumes that a certain percentage of miles are traveled on Oregon roads with fuel purchased out of state. If Oregon were to pass C&I, this would likely continue.

### TRANSLATING CAP-AND-INVEST INTO HCAS

To translate a hypothetical C&I program into the HCAS, we need to develop two related frameworks. First, we need to build a way to allocate the revenue that would be collected from permits sold for emissions from gasoline and diesel combustion that propels light vehicles and the revenue that would be collected from the combustion of diesel fuel to propel heavy vehicles. Second, we need a method to allocate the expenditures funded by these new revenues.

### ALLOCATING REVENUES

We assume that the additional cost of importing

fuels into Oregon will be passed on completely to purchasers of gasoline and diesel, in proportion to their carbon content. Specifically, we model the cost pass-through from a cap-and-invest program as an excise tax on gasoline and diesel fuel.<sup>2</sup> The relationship can be expressed with the following equation:

$$TPG_t = PP * CC_t$$

In words, the excise tax per gallon (*TPG*) of fuel type *t* (gasoline or diesel) is equal to the permit price (*PP*) for one ton of carbon times the carbon content (*CC*) of one gallon of fuel type *t*. The U.S. Energy Information Agency assumes that a gallon of gasoline produces 18.9 pounds of CO<sub>2</sub> when combusted.<sup>3</sup> Since there are 2204.6 pounds per metric ton, that means one gallon of gasoline generates 0.009 metric tons of CO<sub>2</sub>, so  $CC_{gas} = 0.009$ . Then, if for example the permit price is \$10, that means that the excise tax per gallon of gasoline,  $TPG_{gas}$ , would be \$0.09. Each assumed carbon market price will lead to a separate effective excise tax for gasoline and diesel inside the HCAS model.

For weight classes over 26,000 pounds, we assume that only diesel fuel will be used and apply the diesel-based rate. For the other weight classes, we calculate an effective excise tax as a weighted average between the diesel and

**Table 1: Carbon Content and Effective Excise Tax Level by Fuel Type**

Fuel Type	Carbon per Gallon	Effective Excise Tax		
		\$10 Permit Price	\$20 Permit Price	
Gasoline	0.009 tons	\$ 0.09	\$0.18	
Diesel	0.010 tons	\$ 0.10	\$0.20	

<sup>1</sup>This assumption guarantees that all revenue attributable to the combustion of transportation fuels will end up in the State Highway Trust Fund. We further assume that funds used by fuel distributors to purchase permits on the secondary market from non-state entities would not be subject to deposit into the State Highway Trust Fund.

<sup>2</sup>Our use of "excise tax" when referring to the increased cost from C&I is a choice we made to translate the government-imposed price into the model. We are not taking a position on the categorization of C&I as a tax.

<sup>3</sup><https://www.eia.gov/tools/faqs/faq.php?id=307&t=11>. EIA assumes 18.9 lbs per gallon for gasoline and 22.4 lbs for diesel fuel.

gasoline excise taxes, where the weights are estimated from the distribution of gallons of gasoline and diesel used within each weight class. The HCAS model will then calculate total revenue “received” from each weight class from the C&I program.

Modeling the additional cost as an excise tax is different than modeling the additional cost as a higher fuel tax rate. The current system of fuel taxes allows for exemptions. For example, payers of the weight-mile tax are exempt from the current fuel use tax (diesel tax). Within the context of our HCAS model, an excise tax is applied to all users, regardless of exemption status for existing fuel taxes.

Ultimately, the equity ratio that is paid most attention to is calculated only for full-fee paying vehicles. However, since we are assuming that there are no exemptions to the carbon fee passthrough, there will be funds that are deposited into the State Highway Trust Fund that are attributable to alternative fee and exempt vehicles. This does not impact the calculation of full-fee equity ratios, but our report of the revenue that is generated by full-fee vehicles will be understated relative to the actual amount that is collected.

This modeling choice is consistent with our assumed operation of the C&I program. Specifically, we assume that the permit cost will increase the cost of doing business for fuel suppliers and filter down to users of transportation fuels via higher retail prices. There would be no statutory tax that various end users could be exempted from.

## ALLOCATING COSTS

The second main task is to allocate the funds raised from the sale of permits related to transportation fuels from a C&I program. Generally speaking, we need a spending scenario which dictates how the hypothetical permit revenues *would have been spent* if the C&I program existed. To implement any policy scenario, we need to create a set of percentages, which sum to one, that describe how funds will be spread across project types. After adding funds to specific project types, the HCAS model will automatically allocate these costs to the appropriate class of vehicles.

This is the most uncertain part of the exercise because it is not clear whether any conditions would be placed on the expenditure of the permit revenue and how the funds would be spread across various potential projects. We will explore three separate scenarios of how funds could have been expended: status-quo, aggressive greenhouse gas reduction, and climate adaptation. We will not entertain any new types of transportation investment, rather, we will consider existing project types. We will detail each of these scenarios later in this report. It must be stressed that our scenarios are speculative and should not be construed to be a suggestion or indication of future transportation spending and policy.

In the appendix to this report, we provide some context and information about the various project types that are traditionally funded. Additionally, we discuss the various allocators that are assigned to each project or “work-type.” Allocators tell us how to assign costs between vehicles in different weight classes.

## USE OF 2017-2019 BIENNIUM

It is informative to use a demonstration to examine how C&I would impact highway cost allocation. Since we conducted the 2017-2019 Oregon HCAS, we can readily use this period as a test case for determining how a hypothetical C&I program would have impacted highway cost allocation *if it had been operational*. Throughout this report, we will be utilizing actual and forecast data that was used to complete the 2017-2019 HCAS. We assume that the observed behavior of drivers of all types of vehicles *would not have changed* in response to higher fuel prices. This assumption is not a strong one since the demand for transportation fuels is very inelastic in the short run. Moreover, this assumption is mainly relevant to the level of revenues that we estimate will result from the C&I program, but likely not relevant to our conclusions of how revenue mechanisms will need to change in order to maintain equity.

Using the 2017-2019 HCAS as a starting point provides many benefits. First, we will learn about the shortcomings that might exist in our current data sources which lead to difficulties in estimating revenue attribution and cost responsibility. Second, it grounds the discussion of the impact of a C&I program in real-world conditions. This report is not a full economic analysis of the prospective trading program, but our results are not generated from left-field. Our estimates are meant to be informative of the general trends in the highway funding system and are not meant to be an authoritative final estimate.





# MODELING COST SCENARIOS

## OVERVIEW OF SCENARIO MODELING

There are many details of the Cap-and-invest program that would only be resolved once it is implemented. This uncertainty translates into our modeling and results. The actual price of carbon permits in the future cannot be known with certainty. Furthermore, the final distribution of revenues from the State Highway Fund could be done in several different ways.

To deal with this uncertainty, we have modeled several different “cost” and “revenue” scenarios. The various cost scenarios will each expend permit revenues differently, potentially impacting the cost responsibility for heavy and light vehicles in different ways. The revenue scenarios are designed to cover the range in potential permit prices that might result.

## COST SCENARIOS

We consulted with the Oregon Department of Transportation (ODOT) to create cost scenarios for the allocation of funds. We were provided six hypothetical scenarios and arrived at three scenarios for this issue paper: “Business as Usual,” “GHG Reduction,” and “Climate Adaptation.”<sup>4</sup> ODOT’s scenarios were based on analysis in the Statewide Transportation Strategy (STS) which identified strategies for reducing GHG emissions.<sup>5</sup>

It should be noted that ODOT’s input was only for the purpose of informing the decisions of the Study Review Team and is not a prediction or commitment of how any carbon allowance money would be spent. It is not possible to know exactly how this money would be spent. The point of the scenarios is to guide our modeling choices in the direction of feasible and permissible investments and to determine whether the unknown future spending choices can be expected to impact equity ratios.

In reality there are an uncountable number of ways the money can be spent but we have chosen these three in order to provide some sensitivity analysis. In the analysis ODOT provided, they were clear that the scenarios provided were not the “right” or “only” way to spend the revenue but are a solid basis for understanding how revenue “could” be spent.

We note that some members of the Study Review Team believe capacity expansion could reduce GHG emissions and should therefore be included

in the “GHG Reduction” scenario. The ODOT STS does not consider capacity expansion to provide net reductions in GHG emissions and therefore the “GHG Reduction” and “Climate Adaptation” scenarios do not allocate any of the carbon allowance dollars towards new capacity.

From a technical perspective, the exercise is analogous to the creation of a set of anonymous, hypothetical projects and assigning them to the appropriate work-type in the HCAS model. A cost scenario is simply an allocation protocol for a given amount of money across these hypothetical projects. For example, if a cost scenario calls for allocating 20% of permit revenues to culvert maintenance and repair, we calculate the dollar value that is equal to 20% of revenues, create a new project with that amount of money, and assign the appropriate work-type.

## BUSINESS AS USUAL

The “Business as Usual” (BAU) scenario assumes that any new revenue that arrives will be distributed in the same proportion as we observed in the previous biennial study. We include this scenario as a baseline of how ODOT would likely spend additional funds without strings attached. It will inform the impact of the restriction on how funds are to be spent.

## GHG REDUCTION

The “GHG Reduction” (GHG) scenario is geared towards transportation expenditures that are meant to reduce the emissions of harmful greenhouse gasses within the transportation system. Importantly, this scenario is limited to project types that are currently eligible for State Highway Trust Fund money.

**Table 2: GHG Reduction Scenario**

Investment	Total Weight
Auxiliary lanes for speed smoothing and reduced delay	21.0%
Public transportation on-road infrastructure	15.0%
On-road biking and walking accessible connections to schools, jobs, downtowns, and shopping centers	15.0%
Carpool-only lanes	12.0%
Park-and-ride facilities	12.0%
Transit signal priority	6.0%
Infrastructure supporting per-mile road charges or value pricing	5.0%
Variable speed limits	3.5%
Traveler information	3.5%
Signal Timing and Ramp Metering	3.5%
Safety improvements to Reduce Intermittent Delay	3.5%

<sup>4</sup> See *Illustrative Investment Scenarios; HCAS Cap and Invest Issue Paper*, ODOT 9/2018, Technical Report.

<sup>5</sup> See Oregon Department of Transportation (2013), *Oregon Statewide Transportation Strategy, A 2050 Vision for Greenhouse Gas Emissions Reduction*, Volume 1. <https://www.oregon.gov/ODOT/Programs/Pages/OSTI.aspx>

Table 2 details the GHG Reduction scenario investments. ODOT provided spending allocations at a general level and the SRT allocated them to the investment types listed.<sup>6</sup> Investments that will reduce GHG emissions include expenditures on transit related facilities, bike and pedestrian centered projects, and traffic control and mitigation technologies.

**CLIMATE ADAPTATION**

The “Climate Adaptation” (ADAPT) scenario is meant to mimic a strategy of allocating allowance revenues to projects dedicated to the mitigation of and adaptation to the effects of extreme precipitation events that may result from climate change. Extreme precipitation can lead to flooding, inundation, scour, and additional need for snow and ice removal. Like the GHG Reduction scenario, projects in this scenario are limited to those that are currently eligible for State Highway Trust funds.<sup>7</sup>

**Table 3: Climate Mitigation Scenario**

Investment	Total Weight
Culvert maintenance, repair and replacement	35.0%
Planting and managing vegetation to stabilize slopes and sequester carbon	20.0%
Stabilizing slopes to prevent or lessen the severity of landslides	20.0%
Vegetation management such as clearing out underbrush	8.0%
Bridge work for areas at risk of flooding, higher sea levels, and seismic danger	5.0%
Recycled asphalt for road maintenance and repair	4.0%
Stormwater runoff and management	4.0%
Snow/Ice Removal	4.0%

**REVENUE SCENARIOS**

The amount of revenue that flows into the State Highway Fund will depend on the price of carbon allowances. We assume the revenue that is attributable to motor vehicles will be in direct proportion to the carbon content of the fuels used. For relatively high allowance prices, vehicles would indirectly be generating higher amounts of revenue.

Since we do not know the future price of carbon permits, we examine two scenarios: \$10 and \$20. Permits on the Western Climate Initiative exchange have recently traded around \$15 so the choice of \$10 and \$20 as lower and upper bounds provides plausible bookend scenarios.

<sup>6</sup> SRT is not endorsing, projecting, or recommending that any projects be funded or not funded from any real or potential expenditure plan. This scenario is for illustrative purposes only and there is no guarantee that there will be enough projects to actually expend all of the funds in that particular project category.

<sup>7</sup> The above disclaimer applies again.

**VMT DISTRIBUTION**

The operative assumption of this analysis is that the cost that fuel suppliers incur by having to purchase allowances will be passed on to fuel consumers in direct proportion to the average carbon content of the fuel. In effect, we assume the Cap-and-invest program will act as if there were an excise tax on each gallon of fuel. The amount of revenue collected from each weight class will be a function of the amount of fuel consumed by each weight class. The fuel consumed by each weight class will be related to the VMT of each weight class.

**Table 4: 2017-2019 Annual VMT by Weight Class for Full-Fee Vehicles**

Declared Weight	VMT	Percent of Total
1 to 10,000	35,133,836,928	92.63%
10,001 to 26,000	726,085,169	1.91%
26,001 to 78,000	282,237,183	0.74%
78,001 to 80,000	1,256,641,522	3.31%
80,001 to 104,000	246,158,186	0.65%
104,001 to 105,500	282,426,079	0.74%
105,501 and up	3,308,161	0.01%
<b>Total</b>	<b>37,930,693,228</b>	
10,001 and up	2,796,856,301	7.37%
26,001 to 80,000	1,538,878,705	4.06%
80,001 to 105,500	528,584,265	1.39%
26,001 to 105,500	2,067,462,971	5.45%
26,001 and up	2,070,771,132	5.46%

Table 4 reports the VMT estimation results from the 2017-2019 Oregon HCAS. Light vehicles, those under 10,000 pounds, account for 92.63% of the VMT in the state. Conversely, only 7.37% of the VMT in the state are attributed to vehicles over 10,000 pounds.

**Table 5: Model Fuel Efficiency by Weight Class**

Declared Weight		Avg. MPG
1	to 10,000	19.1
10,001	to 26,000	11.8
26,001	to 78,000	6.5
78,001	to 80,000	5.5
80,001	to 104,000	5.3
104,001	to 105,500	5.1
105,501	and up	4.7
<b>Total</b>		
<hr/>		
10,001	and up	7.2
26,001	to 80,000	5.7
80,001	to 105,500	5.7
26,001	to 105,500	5.6
26,001	and up	5.6

Table 5 displays the fuel efficiency assumed by the HCAS model by weight class. While heavy vehicles have lower miles per gallon which leads to more fuel consumption, the overwhelming imbalance in VMT indicates that the revenue attribution will tilt towards light vehicles as they pay a greater share of the Cap-and-invest allowance pass-through.

**Table 6: Fuel Consumption by Weight Class**

Declared Weight		Gallons Consumed
1	to 10,000	1,864,282,855
10,001	to 26,000	69,281,440
26,001	to 78,000	49,936,133
78,001	to 80,000	228,683,737
80,001	to 104,000	47,108,666
104,001	to 105,500	56,638,011
105,501	and up	713,381
<b>Total</b>		<b>2,316,644,224</b>
<hr/>		
10,001	and up	452,361,368
26,001	to 80,000	278,619,870
80,001	to 105,500	103,746,677
26,001	to 105,500	382,366,547
26,001	and up	383,079,928

Table 6 confirms this intuition. Here we've tabulated the gallons of fuel (gasoline and diesel combined) by weight class. While the carbon content of diesel is higher, and heavy vehicles use disproportionately more diesel than gasoline, the total balance of fuel use is skewed towards light vehicles. Accordingly, we would expect light vehicles to have a larger share of revenue attribution from the carbon allowance fees.

# RESULTS

## OVERVIEW OF RESULTS

The results of our simulations come in many forms and we will present them in turn. First, we will discuss how the revenue is attributed to vehicles of various weight classes under the two revenue scenarios. Second, we will look at how the three cost allocation scenarios take the expenditure of those revenues and allocate them across weight classes. Third, we will examine how the combination of these factors impact the equity ratio calculations. Finally, we will discuss what changes to fuel and weight-mile taxes could be used to restore balance to equity ratios.

**Table 7: Revenue by Weight Class**

Revenue Type	2017 Results	\$10 Permit	\$20 Permit
Total Revenue	\$1,173,087,853	\$1,382,035,116	\$1,590,982,378
Full-Fee User Revenue	\$1,173,087,853	\$1,173,087,853	\$1,173,087,853
Revenue from Carbon Allowances	\$0	\$208,947,263	\$417,894,525

Table 7 tabulates the total amount of user fees collected by weight class under the various scenarios. Our previous study for the 2017-2019 biennium estimated that there were approximately \$1.2 billion in fees collected from light and heavy vehicles. If the market for carbon allowances reached an equilibrium price of \$10, the allowance revenue collected from full-fee paying vehicles would reach \$209 million. At a carbon price of \$20, the total revenue would total \$418 million.

**Table 8: Revenue Attribution and Cost Allocation of Only Carbon Allowance Revenue**

Declared Weight	Permit Revenue Allocation	Annual Full Fee Cost Responsibility					
		\$10 Permit			\$20 Permit		
		BAU	GHG	ADAPT	BAU	GHG	ADAPT
1 to 10,000	79.3%	67.2%	96.3%	85.6%	67.2%	96.3%	85.5%
10,001 to 26,000	2.8%	4.2%	0.8%	2.8%	4.2%	0.8%	2.6%
26,001 to 78,000	2.1%	3.5%	0.4%	1.3%	3.5%	0.4%	1.3%
78,001 to 80,000	10.8%	15.1%	1.8%	6.8%	15.1%	1.8%	6.8%
80,001 to 104,000	2.2%	4.0%	0.3%	1.6%	4.0%	0.3%	1.6%
104,001 to 105,500	2.6%	5.7%	0.4%	2.0%	5.7%	0.4%	2.0%
105,501 and up	0.0%	0.4%	0.0%	0.1%	0.4%	0.0%	0.1%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>
10,001 and up	20.7%	32.8%	3.7%	14.4%	32.8%	3.7%	14.5%
26,001 to 80,000	12.9%	18.6%	2.2%	8.1%	18.6%	2.2%	8.1%
80,001 to 105,500	4.9%	9.7%	0.7%	3.7%	9.7%	0.7%	3.7%
26,001 to 105,500	17.8%	28.3%	2.9%	11.7%	28.3%	3.0%	11.8%
26,001 and up	17.8%	28.6%	2.9%	11.9%	28.6%	2.9%	11.9%

To help understand how the overall results will be affected by the introduction of the permit revenue and associated expenditures, it's helpful to understand the distribution of responsibility of the new funds in isolation. Table 8 displays the revenue attribution and the cost responsibility for *only the carbon allowance revenue*.

The money derived from carbon allowances is roughly 80% attributed to light vehicles and 20% to heavy vehicles. By comparison, the Business as Usual scenario expends those new funds at a ratio of roughly 67% to light vehicles and 33% to heavy vehicles. This suggests that light vehicles equity ratios will increase relative to the 2017-2019 study. Conversely, for the GHG and ADAPT scenarios, the cost responsibility for light vehicles is a higher ratio than the revenue attribution. We would expect the equity ratios for light vehicles to fall in these scenarios.

## REVENUE ATTRIBUTION RESULTS

We begin with the results of revenue attribution. Table 9 displays the allocation of user fees by weight class for three scenarios: 2017-2019 study results, \$10 carbon allowance price, and \$20 carbon allowance price. The 2017-2019 results can also be thought of as a scenario where the carbon permit price is \$0.

**Table 9: Revenue Attribution by Weight Class**

Declared Weight			Annual Full-Fee User Fees		
			2017 Results	\$10 Permit	\$20 Permit
1	to	10,000	64.5%	66.7%	68.4%
10,001	to	26,000	4.7%	4.4%	4.2%
26,001	to	78,000	2.6%	2.5%	2.5%
78,001	to	80,000	19.6%	18.2%	17.3%
80,001	to	104,000	3.8%	3.6%	3.4%
104,001	to	105,500	4.6%	4.3%	4.1%
105,501	and	up	0.2%	0.2%	0.2%
<b>Total</b>			<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>
10,001	and	up	35.5%	33.3%	31.6%
26,001	to	80,000	22.2%	20.8%	19.7%
80,001	to	105,500	8.4%	7.9%	7.5%
26,001	to	105,500	30.6%	28.7%	27.2%
26,001	and	up	30.8%	28.8%	27.4%

A key effect of a carbon allowance price visible in these results is that as the carbon price increases from \$0 to \$20, the revenue attribution for light vehicle increases while the attribution for heavy vehicles falls. In the 2017-2019 biennium, light vehicles were supplying 64.5% of full-fee revenues. That amount increases to 66.7% with a \$10 carbon allowance price and 68.4% with a \$20 carbon allowance price. Within the heavy vehicle class, the *relative* revenue attribution does not vary materially across heavy vehicle weight classes.

**COST ALLOCATION RESULTS**

The results of the cost allocation exercise depend on the permit price and the cost scenario. With two carbon allowance prices and three cost allocation scenarios, we have six sets of cost allocation results.

**Table 10: Cost Allocation Results**

Declared Weight			Annual Full Fee Cost Responsibility						
			2017 Results	\$10 Permit			\$20 Permit		
				BAU	GHG	ADAPT	BAU	GHG	ADAPT
1	to	10,000	64.0%	64.3%	67.6%	66.4%	64.6%	70.6%	68.3%
10,001	to	26,000	4.3%	4.3%	3.9%	4.1%	4.3%	3.6%	4.0%
26,001	to	78,000	3.4%	3.4%	3.1%	3.2%	3.4%	2.8%	3.0%
78,001	to	80,000	16.2%	16.1%	14.6%	15.1%	16.0%	13.3%	14.3%
80,001	to	104,000	5.0%	4.9%	4.5%	4.7%	4.8%	4.1%	4.4%
104,001	to	105,500	6.4%	6.4%	5.8%	5.9%	6.3%	5.2%	5.5%
105,501	and	up	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%
<b>Total</b>			<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>
10,001	and	up	36.0%	35.7%	32.4%	33.6%	35.4%	29.4%	31.7%
26,001	to	80,000	19.6%	19.5%	17.6%	18.3%	19.4%	16.1%	17.3%
80,001	to	105,500	11.5%	11.3%	10.3%	10.6%	11.1%	9.3%	9.9%
26,001	to	105,500	31.1%	30.8%	27.9%	28.9%	30.5%	25.4%	27.2%
26,001	and	up	31.7%	31.4%	28.5%	29.5%	31.1%	25.9%	27.7%

Table 10 displays the cost responsibility ratios for each of the six scenarios as well as the 2017-2019 biennium results. First, it should be noted that the BAU cost responsibility is essentially identical to that of the 2017-2019 results. This outcome is not surprising; the BAU case is specifically constructed to mimic the 2017-2019 biennium.<sup>8</sup>

Focusing on the \$10 carbon allowance price, the results reveal that both the GHG and ADAPT scenarios provide higher cost responsibility to light vehicles compared to the BAU case. Between the two, the GHG scenario is relatively more weighted towards light vehicle cost responsibility than the ADAPT scenario. These relative patterns are repeated within the \$20 carbon allowance price scenario.

<sup>8</sup> One reason that the allocations aren't exactly the same is that the revenue that we push through the model is only from state and local sources, not federal sources. This distorts the cost responsibility slightly relative to the 2017-2019 actuals.

<sup>9</sup> The Study Review Team has defined light vehicles as those between 1 and 10,000 pounds and heavy vehicles as those over 10,000 pounds.

When comparing the \$10 carbon allowance price results to the \$20 carbon allowance price results, Table 10 reveals that the higher carbon allowance price leads to more cost responsibility on light vehicles in both the GHG and ADAPT scenarios. If both the GHG and ADAPT scenarios tilt cost responsibility towards light vehicles when the price is \$10, this means that the new revenue is being allocated more towards light vehicles *relative* to the BAU case. When the permit price is \$20 this effect is twice as strong.

**EQUITY RATIO RESULTS**

Ultimately, HCAS is concerned with the relative balance of the ratios of cost responsibility and revenue attribution between light and heavy vehicles.<sup>9</sup> The main result from any Oregon HCAS is the equity ratio between light and heavy vehicles. For the 2017-2019 study, the light vehicles' equity ratio was 1.0076 and the heavy vehicles' equity ratio was 0.9865. In other words, light vehicles were overpaying by 0.76% and heavy vehicles were underpaying by 1.35%.

**Table 11: Equity Ratios by Weight Class**

Declared Weight			Equity Ratios						
			2017 Results	\$10 Permit			\$20 Permit		
				BAU	GHG	ADAPT	BAU	GHG	ADAPT
1	to	10,000	1.0076	1.0371	0.9864	1.0047	1.0582	0.9692	1.0006
10,001	to	26,000	1.0993	1.0364	1.1387	1.0815	0.9899	1.1807	1.0702
26,001	to	78,000	0.7705	0.7454	0.8314	0.8039	0.7268	0.8918	0.8356
78,001	to	80,000	1.2065	1.1332	1.2507	1.2037	1.0790	1.2992	1.2066
80,001	to	104,000	0.7513	0.7207	0.7876	0.7621	0.6983	0.8266	0.7753
104,001	to	105,500	0.7219	0.6835	0.7545	0.7308	0.6552	0.7898	0.7423
105,501	and	up	0.3133	0.2881	0.3106	0.3013	0.2687	0.3107	0.2926
<b>Total</b>			<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>
10,001	and	up	0.9865	0.9331	1.0285	0.9907	0.8936	1.0737	0.9987
26,001	to	80,000	1.1310	1.0654	1.1780	1.1347	1.0170	1.2285	1.1427
80,001	to	105,500	0.7348	0.6998	0.7690	0.7446	0.6739	0.8060	0.7568
26,001	to	105,500	0.9847	0.9314	1.0275	0.9916	0.8920	1.0737	1.0021
26,001	and	up	0.9712	0.9190	1.0134	0.9781	0.8804	1.0589	0.9885

Table 11 displays the equity ratios for various weight classes across the scenarios considered in this study. We've replicated the results from the 2017-2019 in the first column. Next, we present the equity ratios for the six scenarios, first separating by carbon allowance price and then by cost allocation scenario.

Overall, Table 11 makes it clear that the cost scenario matters. Within each permit price assumption, the BAU cost scenario leads to light vehicles overpaying and heavy vehicles underpaying. For the GHG and ADAPT scenarios, the equity ratios are closer to 1. GHG leans towards heavy trucks overpaying while ADAPT leans towards light vehicles overpaying.

The permit price has the biggest impact on equity ratios under the BAU scenario. As the permit price increases with that cost scenario, light vehicles' overpayment and heavy vehicles underpayment increases in magnitude. The permit price doesn't influence the results for the ADAPT scenario owing to the fact that the cost allocation in that scenario tracks the distribution of revenues from carbon allowances. Since the GHG scenario, amongst the three cost scenarios, tilts towards most heavily towards light vehicles, higher allowance prices push equity ratios more in the favor of heavy vehicles.

The simulation results underscore the importance of both the permit price and the cost scenarios. For the same level of revenue, the way in which those funds are spent can lead to very different equity ratio outcomes.

### EQUITY BALANCING REVENUE CHANGES

Each of the scenarios that we have run lead to different outcomes for equity ratios. In order to put those new equity ratios into context, we have calculated hypothetical changes that would be required to restore equity for the main tax instruments: fuel taxes and weight-mile taxes. There are many ways in which equity can be restored. We have focused on one method below. Specifically, for each scenario, we calculate the change fuel and weight-mile taxes that will be as close to "revenue neutral" as possible. For example, if light vehicles are underpaying, we calculate the simultaneous increase in fuel taxes and decrease in weight-mile taxes that will restore equity and not increase total revenue collected.

In these exercises, we calculate the simultaneous proportional change needed in fuel taxes and the proportional change needed in Table A and Table B weight-mile taxes. We do not change RUAF, registration fees, or flat-fees. Those are certainly policy levers available. However, for ease of illustration, we focus on just the fuel and weight-mile taxes.

In the appendix, we present results for other methods of restoring equity.

Specifically, we consider two sets of policies. First, we calculate the change only in fuel taxes needed to restore equity. Second, we repeat the exercise with only changing the schedule of weight-mile taxes.

### BUSINESS AS USUAL

First, we begin with the BAU scenario. At a permit price of \$10, this scenario resulted in light vehicles overpaying by 3.7% and heavy vehicles underpaying by approximately 6.7%. Here, to restore equity, we would need to lower fuel taxes and raise weight-mile taxes.

**Figure 1: Business As Usual Rate Changes**

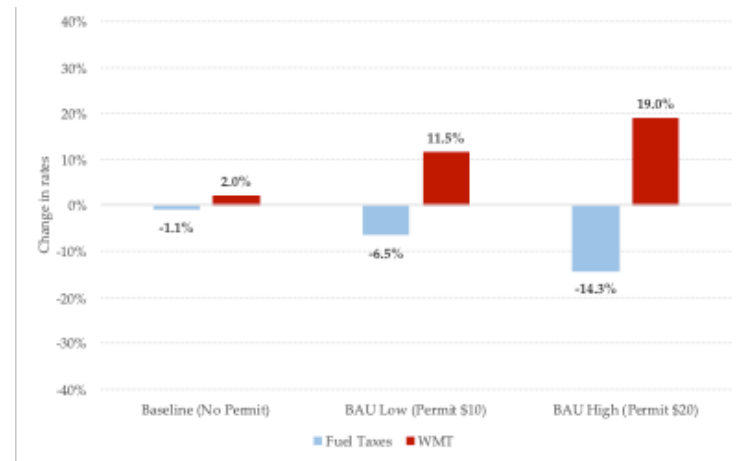
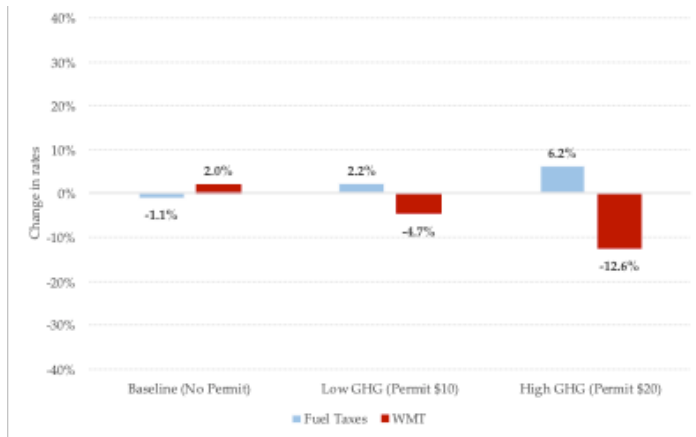


Figure 1 displays the required changes in rates to achieve equity. The left-most panel presents the changes we would need in the absence of a permit program. These are non-zero because the 2017-2019 equity ratios were not exactly equal to one. So, when looking at the results with a positive permit price, we need to compare them to the changes we would have made to achieve exact equity. Those changes are indeed small adjustments. In fact, the 2017-2019 study did not result in any legislative action to adjust rates.

Under the BAU scenario, we would need large increases to the weight-mile tax: 11.5% for the \$10 allowance price and 19% for the \$20 permit price. Those changes in fees come with large reductions in the fuel tax in order to maintain revenue neutrality.

## GHG REDUCTION

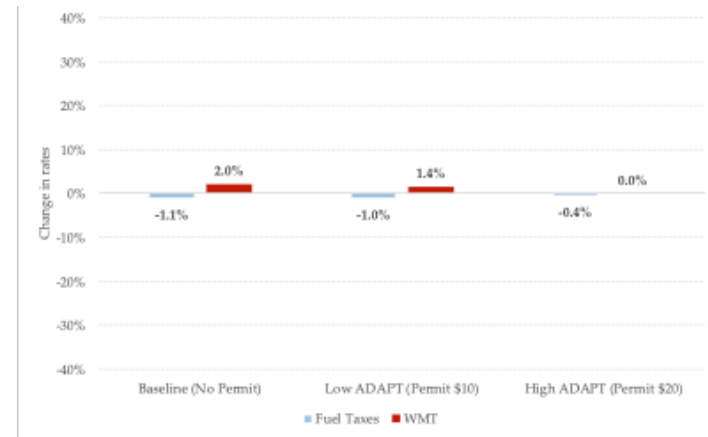
Figure 2: GHG Reduction Scenario Rate Changes



Changes in the rate structure move in the opposite direction for the GHG reduction scenario. Since the equity ratios indicated overpayment by heavy vehicles, we would need to reduce the weight-mile taxes and increase the fuel taxes on cars. These changes are of smaller magnitude than for the BAU case. Under the low permit price, the tax adjustments are similar to the adjustments indicated in the baseline, which were not acted upon. With a high permit price, those are twice as large and might meet the threshold for legislative action.

## ADAPTATION

Figure 3: Adaptation Scenario Rate Changes



The Climate Adaptation Scenario led to overpayment by light vehicles and underpayment by heavy vehicles. Accordingly, the model recommends increasing the weight-mile tax and decreasing the fuel tax. For the low and high permit price, the magnitude of the proposed changes is similar to that of the baseline which was deemed small enough to not act.



## LOGISTICAL RECOMMENDATIONS

### OVERVIEW OF STUDY RECOMMENDATIONS

The simulation exercise that we have completed is valuable for understanding where existing gaps in data or methodology would become problematic if a Cap-and-invest program were implemented. There are some assumptions that we had to make to complete the simulation that would be unnecessary if the program were in effect. Conversely, there are other areas where assumptions would still need to be made even with reasonable expectations on the data generated and collected by an operational carbon pricing mechanism. All of our recommendations have to do with the revenue side of the question. Expenditures would be reported through the normal channels. The largest areas that we forecast to be deficient for revenue attribution relate to fuel consumption, VMT estimates, fuel efficiency estimates, and the prevalence of diesel engines in light and medium weight classes.

### FUEL CONSUMPTION ESTIMATES

Currently, our estimates of gallons of fuel consumed rely on our estimates of MPG and the forecast of revenue and VMT from ODOT. Doing HCAS under a cap-and-invest system would be improved if we had access to better estimates of gasoline and diesel gallons used by full fee vehicles. During HCAS SRT meetings this biennium it has been revealed that DEQ and ODOT have different methods and different estimates of the quantity of fuel used in the State of Oregon. Work is ongoing to understand that discrepancy, but accurate independent estimates of these figures would be useful to our study.

### VMT/MILEAGE CALCULATIONS

VMT data for weight-classes subject to the weight-mile tax can be, and has been, reasonably trustworthy. VMT for the 10,001-pound to 26,000-pound weight class needs to be estimated from a combination of data sources: MPG estimates, taxed fuel gallons data, and DMV registrations data. Importantly, we make assumptions on the annual mileage that each vehicle registered with DMV contributes to the total. Our assumption on the number of miles per registration informs our estimate of the total VMT of that weight class. Combined with our MPG estimate, we arrive at an estimate of diesel gallons and gasoline gallons. With each of these, we multiply

the appropriate carbon allowance “fee” and sum to get the revenue contribution for this class.

Having more accurate VMT data for this weight class would improve our ability to determine the share of carbon allowance revenue to attribute to this group. This is an existing problem that would be exacerbated by Cap-and-invest.

### MPG CALCULATIONS

Currently, our base MPG calculations are derived from the Vehicle Inventory and Use Statistics (VIUS) 2002 data. We use linear regression to model the distribution between weight and fuel economy and then project fuel economy for each weight class in the study. This procedure yields an estimate of MPG that is applied to previously calculated VMT estimates to arrive at the amount of fuel consumed by each weight class. Revenue for the weight class is figured by applying the carbon allowance “fee” to the number of gallons of fuel.

If our MPG estimates are wrong, then we are miscalculating the amount of fuel consumed. If we are miscalculating fuel, our revenue attribution results will be wrong. The Study Review Team should explore an updated method or data source that could be used for the calculation of fuel economy. Moreover, the ability to separately account for gasoline engine and diesel engine fuel economy will improve accuracy.

### GASOLINE AND DIESEL ENGINE DISTRIBUTION

Currently, the HCAS model does employ information from the DMV on the number of diesel and gasoline engine vehicles in each weight class. As mentioned above, however, we do not have separate MPG estimate for each engine type. When this model feature is coupled with the fact that the fuel taxes on gasoline and diesel are the same amount, the distinction between diesel and gasoline engines has diminished importance.

Under our assumptions, we apply a different carbon allowance passthrough for diesel and gasoline. If Cap-and-invest were to pass in a form similar to what we’ve assumed, we would need to pay more attention to the differences between gasoline and diesel engines. Specifically, we would need to get estimates of MPG that differ by engine type and we would need to have better understanding of the VMT breakdown for the weight classes of 1-10,000 pounds and 10,001-26,000 pounds.

## **RECOMMENDATIONS**

We have a few recommendations on procedural steps that might be feasible for the state government to undertake that would lead to filling some of the gaps we have in the data. The recommendations revolve around getting better information on VMT and MPG for various weight classes.

### **REGISTRATION INFORMATION**

Currently we employ counts of registrations from the Division of Motor Vehicles. Part of our model requires us to make assumptions about the annual VMT for each registration type. It would be feasible for DMV to collect odometer information from each registration application. With a reasonable sample of registrations by weight class, we could estimate an average annual VMT. This data would be particularly useful for medium-heavy vehicles, those from 10,001 to 26,000 pounds.

### **LIGHT/MEDIUM HEAVY VEHICLE MPG ESTIMATES**

Division of Motor Vehicles has information about the type of vehicle for each vehicle registered in the State of Oregon. ODOT has access to Vehicle Identification Number (VIN) decoders that will identify key pieces of information for each registered vehicle. Matching this data to official MPG estimates can improve our estimates of fuel consumption in different weight classes.

### **MPG FOR HEAVY VEHICLES**

#### **New Survey**

Our estimates of MPG for Heavy Vehicles are based on the discontinued Vehicle Inventory and Use Statistics survey, last completed in 2002. The dataset was constructed from a survey of private and commercial trucks. ODOT could undertake a similar survey of heavy vehicles registered in the State of Oregon. This would provide an estimate of MPG that reflects improvements in technology since 2002 and segment the heavy truck population by weight class.

#### **IFTA Estimates**

IFTA compiles estimates of MPG by weight class based on the information that they collect. This data is readily available. However, there is concern that the sample of vehicles that are used to calculate the IFTA data are “long-haul” truckers that are achieving higher MPG than the median heavy vehicle. Work can be done to determine an intelligent method of adjusting the IFTA estimates in order to get a better estimate. Alternatively, there may be opportunities to work directly with IFTA to leverage additional information that they might have access to.

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## CONCLUSIONS

C&I legislation will have many impacts on the State of Oregon. The results and execution of the Highway Cost Allocation Study is no different. Such a program will introduce a new source of revenue into the Highway Trust fund. There will also be a corresponding increase in spending on transportation projects. The distribution of the revenues and expenditures between light and heavy vehicles could impact the recommendations made by the Study Review Team to the Oregon Legislature.

In this report we simulated the 2017-2019 HCAS under several counterfactual scenarios with the aim of informing and bounding the ways that Cap-and-invest could potentially impact the results and execution of HCAS. Our scenarios were constructed in such a way as to identify how resultant carbon market prices would affect equity ratios. Furthermore, we entertained three separate cost scenarios to ascertain the impact that spending choices would impact the balance between heavy and light vehicles.

Our simulations indicate that the bulk of new revenue coming from the sale of carbon allowances for transportation fuels would be allocated to light vehicles. This class of vehicles accounts for over 93% of the vehicle miles traveled in the State. While heavy vehicles have lower fuel economy, the difference is not sufficient to counteract the disparity in VMT.

The scenario analysis was helpful in revealing the importance of expenditures on the final calculation of equity ratios. Even though the revenue from carbon allowances fell heavily on light vehicles, one of the three cost scenarios we ran allocated expenditures in a way that more than compensated for the revenue imbalance. This cost scenarios led to an underpayment by heavy vehicles in spite of the revenue burden falling heavily on light vehicles.

In sum, while we can be fairly confident that the majority of carbon allowance revenue will be coming from light vehicles, the ultimate impact on equity ratios and proposed changes to highway funding sources will depend on the expenditure allocation. At this time, we cannot forecast how those additional dollars will be spent. As we describe earlier, the distribution of expenditures has a large impact on how carbon allowance revenue influences equity ratios.

We can, however, identify that there are several areas for improvement in the execution of HCAS. Specifically, improving our ability to estimate fuel economy, diesel and gasoline engine prevalence, and the vehicle miles traveled for vehicles not paying the weight mile tax will improve the precision and accuracy of our revenue attribution exercise. From a cost perspective, we believe that the necessary elements would continue to be available.



# APPENDIX

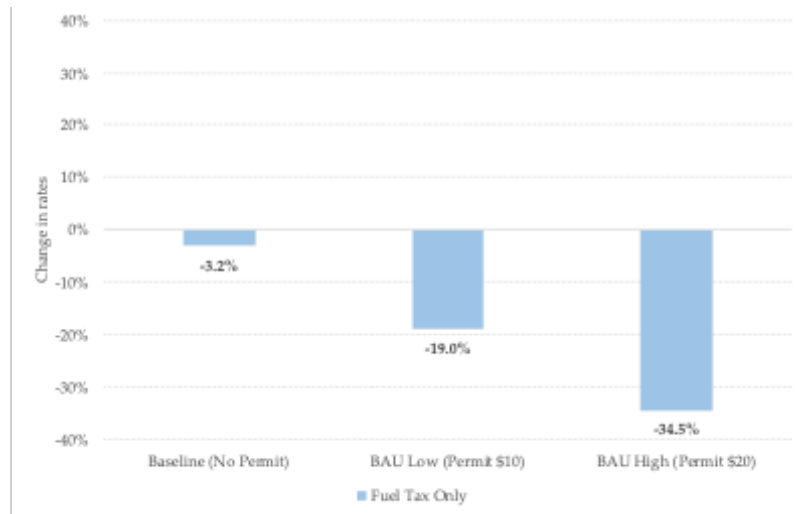
## ALTERNATE TAX CHANGES

In this section of the appendix we consider alternative changes to the system of taxes that would restore equity in each of our six scenarios. First, we consider changes in only the fuel taxes that would be required to achieve equity. Second, we consider changes in only the full weight-mile tax schedules. This contrasts with the analysis in the main body of the text where we consider simultaneous changes in both sets of tax rates.

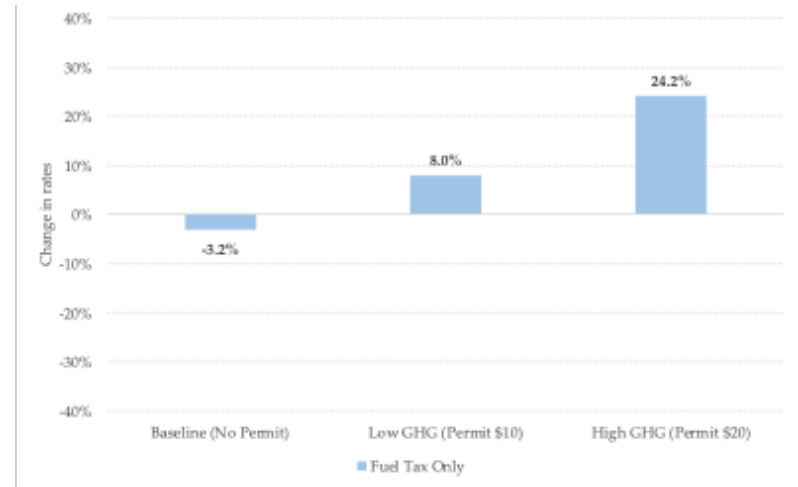
Below we present two charts for each of the six scenarios. Each bar represents the change in tax rates that would be needed *if that were the only rate to change in that scenario*. This contrasts with Figures 1 – 3 where *both changes needed to take place*.

## CHANGING ONLY FUEL TAXES

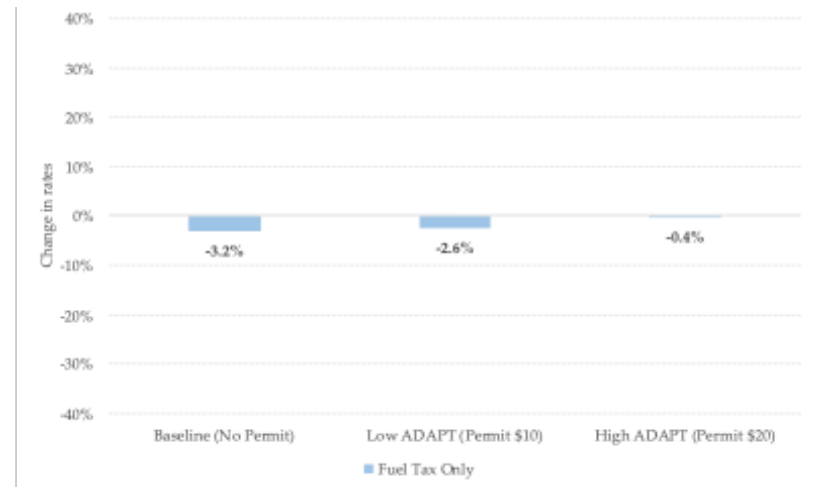
**Figure 4: Changes in Fuel Taxes Required for Equity; Business As Usual Scenario**



**Figure 5: Changes in Fuel Taxes Required for Equity; GHG Reduction Scenario**



**Figure 6: Changes in Fuel Taxes Required for Equity; Climate Adaptation Scenario**



CHANGING ONLY WMT TABLES A AND B

Figure 7: Changes in WMT Taxes Required for Equity; Business as Usual Scenario

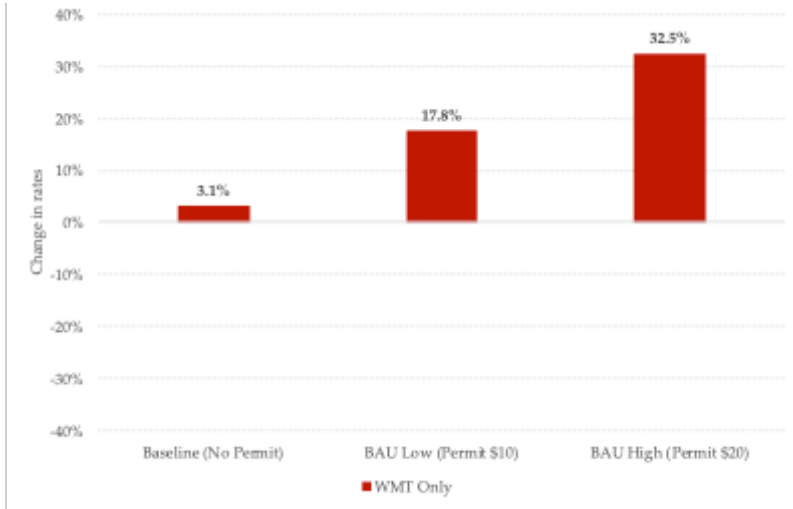


Figure 8: Changes in WMT Taxes Required for Equity; GHG Adaptation Scenario

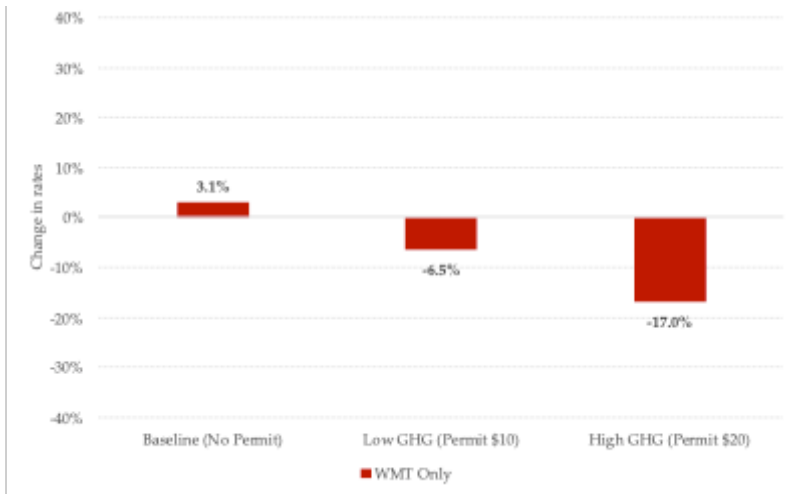
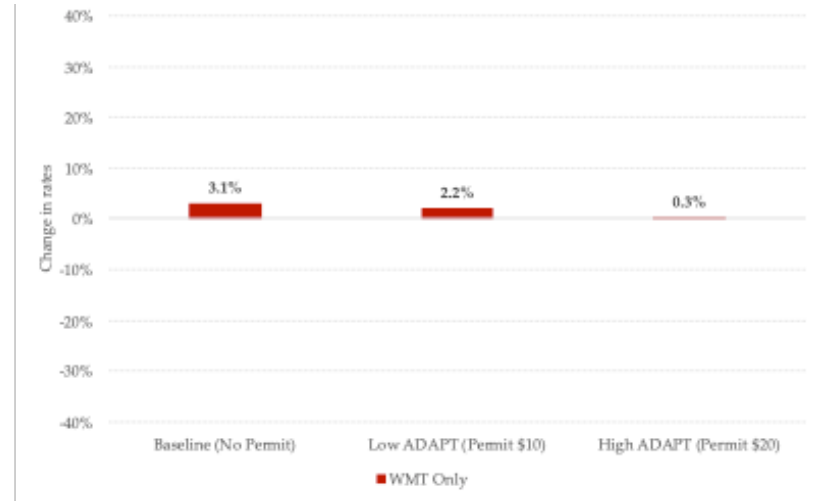


Figure 9: Changes in WMT Taxes Required for Equity; Climate Adaptation Scenario



UNDERSTANDING ALLOCATORS

Table 12: Cost Responsibility by Weight Class for Common Allocators

Weight Class	Cost Allocation			
	All VMT	Uphill PCE	Congested PCE	Basic VMT
1 to 10,000	92.1%	65.0%	83.3%	100.0%
10,001 to 26,000	2.2%	4.0%	3.1%	0.0%
26,001 to 78,000	1.0%	3.2%	2.0%	0.0%
78,001 to 80,000	3.3%	16.9%	7.7%	0.0%
80,001 to 104,000	0.6%	3.5%	1.6%	0.0%
104,001 to 105,500	0.7%	7.1%	2.2%	0.0%
105,501 and up	0.0%	0.2%	0.0%	0.0%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>

In this section we provide some context for the common allocators that we use. Table 12 details how an allocator spreads cost responsibility across weight classes for 4 common allocators: All VMT, Uphill PCE, Congested PCE, and Basic VMT. For example, if a project is assigned an “All VMT” allocator, then 92.1% of the cost of that project is allocated to light vehicles and 7.9% of the cost is spread over the heavy vehicle classes. Conversely, a project that is assigned the Basic VMT allocator has 100% of the cost assigned to light vehicles. Table 13 lists example projects by dominant allocator type.

**Table 13: Example Projects by Allocator**

Example Work Types and Allocators
<b>All VMT</b>
Bike/Pedestrian Projects
Bridge --All Vehicles Share
Bridge --All Vehicles Share (no added capacity)
Drainage Facilities Maintenance
Extraordinary Maintenance
Fish and Wildlife Enabling Projects
Fish, Wildlife Enabling Projects
Highway Planning
Miscellaneous Maintenance
Other Administration
Other Common Costs
Planning
Railroad Safety Projects
Reserve Money, Fund Exchange, Immediate Opportunity Fund
Roadside Improvements
Roadside Items Maintenance
Safety Items Maintenance
Sanding and Snow and Ice Removal (maintenance)
Seismic Retrofits
Seismic Retrofits on Structures
Structures Maintenance
<b>Basic VMT</b>
Other--Basic Only
Studded Tire Damage
<b>Congested PCE</b>
Bridge --All Vehicles Share (added capacity)
Grading and Drainage
Multimodal
New Shoulders-Flexible
New Shoulders-Rigid
Safety Improvements
Traffic Service Improvements
Traffic Service Items Maintenance
Transit and Rail Support Projects
Transportation Demand & Transportation System Management
<b>Uphill PCE</b>
Climbing Lanes





## PAVEMENT COST ALLOCATION FACTORS AND PROCEDURES USED IN OREGON

*Roger Mingo, P.E.*

*March 4, 2019*

Highway Cost Allocation Studies in Oregon have used the same pavement load equivalence factors since 2011, and have all followed the same major steps in assigning pavement costs. Each study sees variations in cost responsibilities based on changes in highway expenditure estimates, vehicle travel estimates, and vehicle axle weight estimates. The purpose of this summary paper is to briefly describe the procedures and data inputs that affect pavement cost assignment results. Some of the inputs have varied enough in recent years so as to produce seemingly large variations in the results. This paper may help understand some of the variations observed.

Pavement cost allocation in Oregon consists of the following steps:

1. *Develop Use Profile for Each Highway Type*
2. *Determine Importance of Each Distress Type*
3. *Apply Load Equivalence Factors to Each Axle*
4. *Accumulate Damage Shares*
5. *Apply Damage Shares to Cost Buckets*

### DEVELOP USE PROFILE FOR EACH HIGHWAY TYPE

Developing the highway system use profile starts with determining the vehicle miles travelled (VMT) array that is used throughout the study. This array specifies VMT by (1) highway type (12 functional classes), (2) number of axles (2 to 9+), and (3) operating gross weight (2,000-pound increments with upper limits from 10,000 to 200,000 pounds). This initial step has by far the largest impact on overall pavement cost assignments, as it does on all other aspects of cost allocation and revenue attribution. Because it is based on incomplete data and multiple alternative approaches, this VMT array is likely to be refined and revised throughout the study.

In addition to this master VMT array, pavement cost allocation also requires information about axle types (single, tandem, or tridem) and axle weights. The study uses weigh-in-motion (WIM) data to estimate the proportions

of each category of axle (three axle types, 100 axle weight increments) in each of the VMT array entries in the master VMT file. In addition, WIM data from Oregon, or, if necessary, other states, are used to further divide the under-10,000-pound category into finer gross vehicle weight increments.

Each year, Oregon collects millions of truck weight records, including axle weights and spacings, as part of their WIM program. These millions of WIM records still leave some gaps, however, for several reasons. First of all, most observations are on major roads—Interstate and principal arterial highways—and are biased toward rural areas. This may underrepresent some types of vehicles, and may especially bias the under-10,000-pound group toward pick-up trucks and away from lighter passenger vehicles. Second, the less-common heaviest trucks with the most axles are likely to have very few or no observations in some of the operating weight increments. This can result in widely-varying tabulated axle weights and types in adjacent cells of the VMT array.

The past several Oregon cost allocation studies addressed the sparse-data problem by adding simulated WIM observations to adjacent cells of the VMT array for the less-common vehicle classes, particularly vehicles with seven or more axles. Steering axles were left unchanged, but the weights on each load-carrying axle were proportioned upward or downward by the ratio of the gross weight midpoints of adjacent cells. Depending upon the number of observations for each type of vehicle, the simulated cells reached five or more cells in each direction. This has resulted in more consistent results with less need for smoothing the results after the analysis.

As for the second issue—dividing the under-10,000-pound weight increment into smaller slices—the current study used a very different approach than previous studies. In previous studies, Oregon DOT did not provide any WIM records for light vehicles. Filtering out these records is common practice in most states because light vehicle axle weights are widely ignored in pavement design. Earlier Oregon studies used national data from the six or seven states that did report light vehicle WIM records. This year, however, Oregon DOT included a large number of light vehicle observations, and the results were profoundly different than when using the national data. The team attempted to account for the rural and major road biases in analyzing the WIM data, but more analysis of this bias is probably warranted in future studies.

**DETERMINE IMPORTANCE OF EACH DISTRESS TYPE**

Pavement costs are assigned based on the load equivalence factors (LEFs) for each distress type for flexible and rigid pavements. Since LEFs vary by type of distress, the process relies upon weighting the relative importance of each distress type properly, as well as estimating the proportion of pavement damage that is not related to loads.

Non-load shares can be derived largely from applying the AASHTOWare Pavement ME Design damage model, while the distress shares are derived by HPMS condition data as well as pavement management experience. The following tables show the weighting factors used in the four most recent Oregon cost allocation studies.

6	Rural Local	0.0%	10.0%	15.0%	15.0%	20.0%	40.0%	12.0%
7	Urban Interstate	0.0%	5.0%	20.0%	15.0%	25.0%	35.0%	2.4%
8	Urban OFE	0.0%	5.0%	20.0%	15.0%	25.0%	35.0%	2.7%
9	Urban OPA	0.0%	10.0%	15.0%	15.0%	25.0%	35.0%	4.2%
10	Urban Minor Arterial	0.0%	10.0%	15.0%	15.0%	25.0%	35.0%	5.0%
11	Urban Collector	0.0%	10.0%	15.0%	15.0%	20.0%	40.0%	7.0%
12	Urban Local	0.0%	10.0%	15.0%	15.0%	20.0%	40.0%	8.0%

**Rigid Distress Shares**

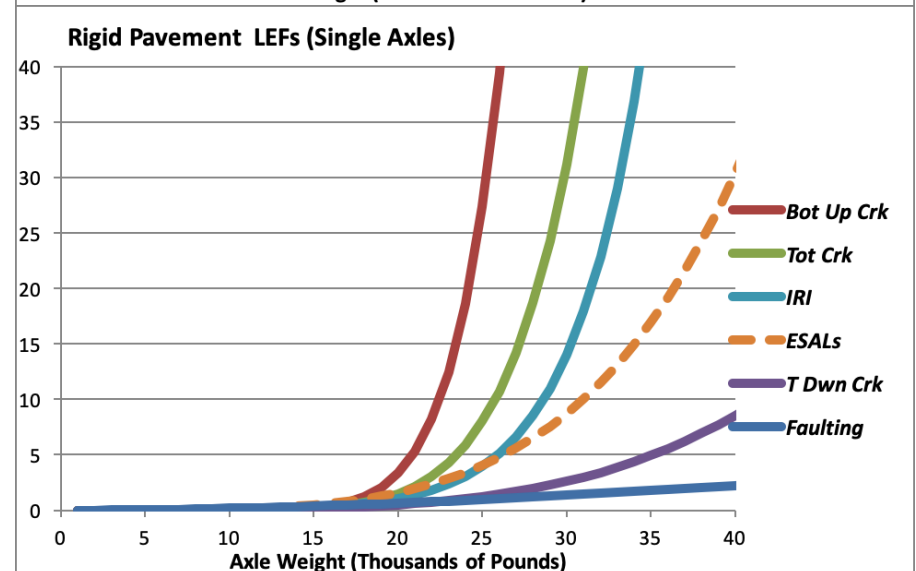
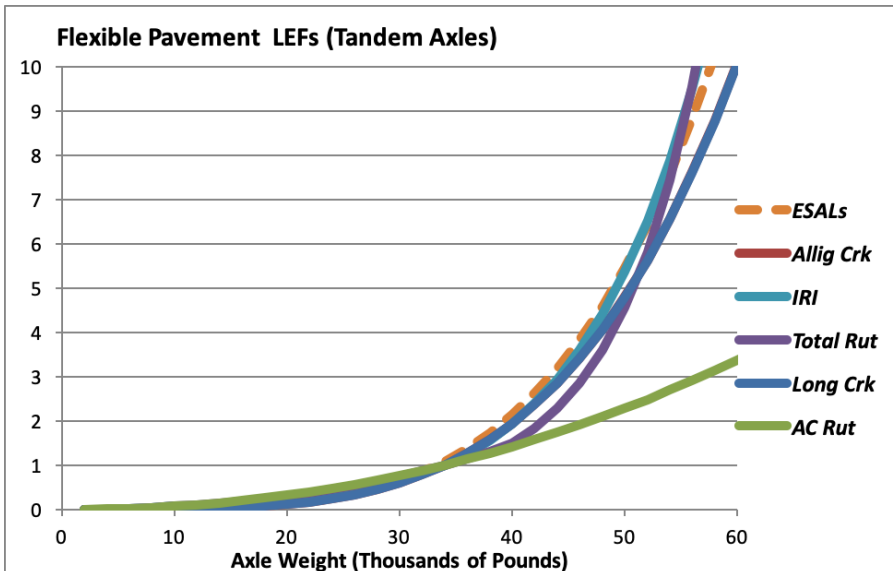
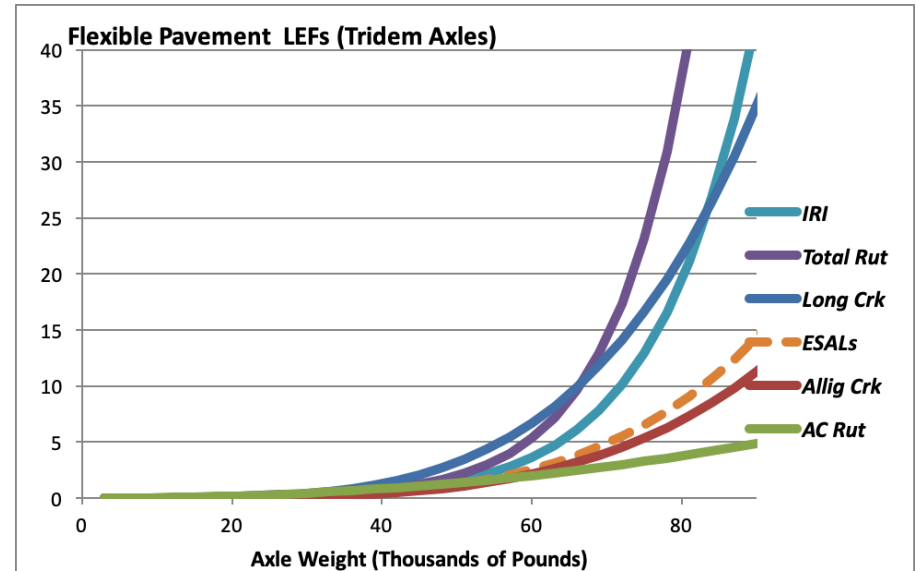
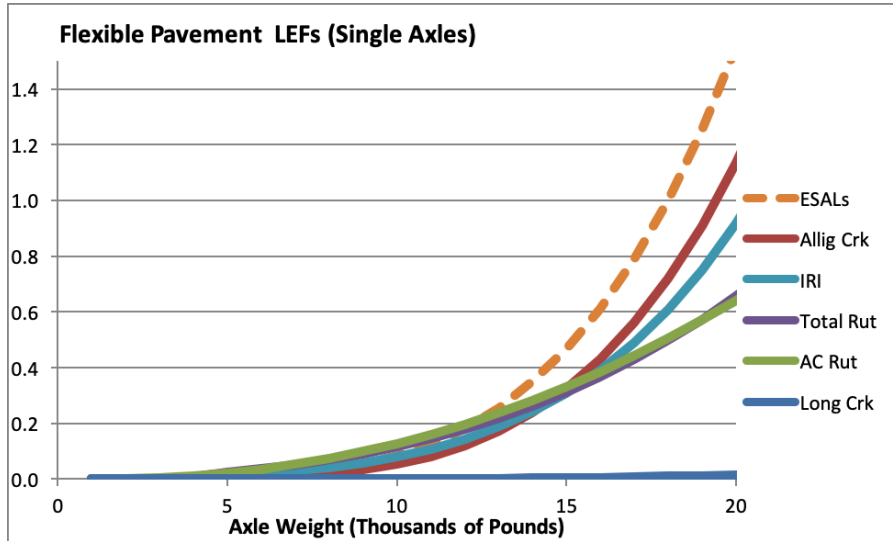
		ESALs	Bottom-Up	Top-Down	All Crack	Fault	IRI	Nonload
1	Rural Interstate	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	2.0%
2	Rural OPA	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	2.8%
3	Rural Minor Arterial	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	4.0%
4	Rural Major Collector	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	7.0%
5	Rural Minor Collector	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	8.0%
6	Rural Local	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	10.0%
7	Urban Interstate	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	2.0%
8	Urban OFE	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	2.0%
9	Urban OPA	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	3.0%
10	Urban Minor Arterial	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	4.0%
11	Urban Collector	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	6.0%
12	Urban Local	0.0%	25.0%	20.0%	10.0%	15.0%	30.0%	8.0%

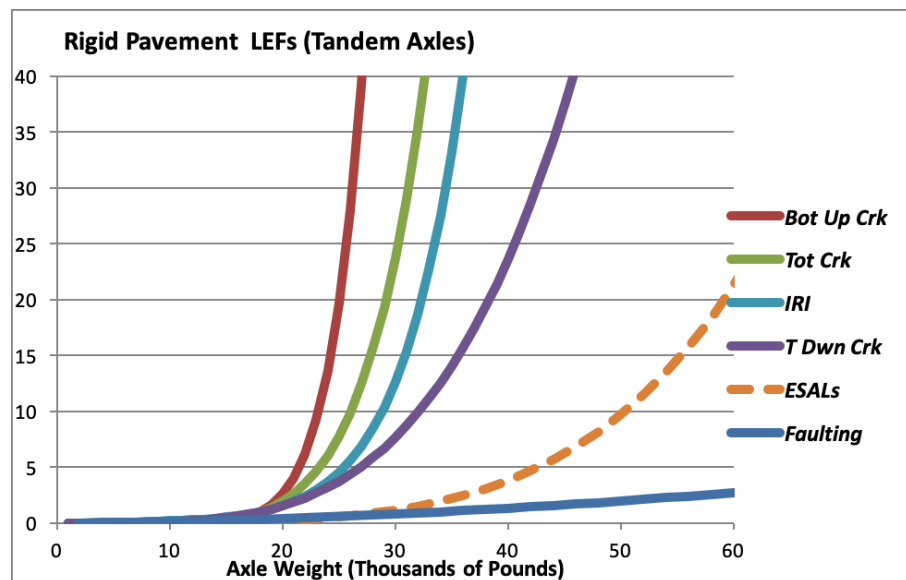
**Flexible Distress Shares**

		ESALs	Long Crk	Allig Crk	AC Rut	Total Rut	IRI	Nonload
1	Rural Interstate	0.0%	5.0%	20.0%	15.0%	25.0%	35.0%	4.5%
2	Rural OPA	0.0%	10.0%	15.0%	15.0%	25.0%	35.0%	5.2%
3	Rural Minor Arterial	0.0%	10.0%	15.0%	15.0%	20.0%	40.0%	7.5%
4	Rural Major Collector	0.0%	10.0%	15.0%	15.0%	20.0%	40.0%	8.0%
5	Rural Minor Collector	0.0%	10.0%	15.0%	15.0%	20.0%	40.0%	10.0%

**APPLY LOAD EQUIVALENCE FACTORS TO EACH AXLE**

LEFs used in Oregon pavement cost allocation were derived from repeated MEPDG model runs in a research project for FHWA. The current factors have been used in Oregon since 2011, and are described in more detail in a working paper prepared for the 2013 cost allocation study. LEFs go up sharply with increased axle weights, but the steepness of the LEF curves varies by distress type, as shown in the following graphs. Note that, for flexible pavements, LEF slopes for each distress type are fairly similar for tandem axles, somewhat less steep than ESALs for single axles, and somewhat steeper for tridem axles. These results correspond pretty well with observations by others that tridem ESALs, extrapolated from single and tandem Road Test results underestimate their relative damage.





### ACCUMULATE DAMAGE SHARES

The final step in the calculation of pavement cost shares by vehicle type and operating gross weight group is simply to sum all the LEFs for all the axles in each gross weight group and axle configuration class. After summing all the axles in all weight and configuration groups, the results for each cell are divided by the sum for all groups to derive a share for each cell.

### APPLY DAMAGE SHARES TO COST BUCKETS

After determining the load-related pavement cost shares for each cell in the master VMT array, shares are converted to cost assignments by simply multiplying these shares by the dollar costs for pavement costs on each highway type—perhaps the second largest determinant of pavement cost assignment.

