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Implementable Strategies for Shifting to Direct Usage-Based Charges for Transportation Funding

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The report was prepared by lead author Paul Sorensen of the RAND Corporation and research team members Martin Wachs and Liisa Ecola, RAND Corporation; Max Donath and Lee Munnich, University of Minnesota; and Betty Serian, Betty Serian Associates. The RAND team worked as a subconsultant to ICF International. The work was guided by an NCHRP project panel composed of Neil Schuster and Cian Cashin (co-chairs), American Association of Motor Vehicle Administrators; Stuart P. Anderson, P.E., Iowa DOT; Roberta Broeker, Missouri DOT; Karen Chappell, Virginia Department of Motor Vehicles; Lowell R. Clary, CPA, P3 Development Company, LLC; Ralph M. Davis, Commonwealth of Virginia; Cindy McKim, California DOT; Lynn Weiskopf, New York State DOT; James Whitty, Oregon DOT; and Jack Basso, Anthony R. Kane, Ph.D., and Joung H. Lee (AASHTO liaisons). The project was managed by Andrew C. Lemer, Ph.D., NCHRP Senior Program Officer.

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FOREWORD

By Andrew C. Lemer
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This report presents an analysis of ways that direct charges to road users, based on vehicle-miles of travel (VMT), could be implemented within approximately the next 5 years. VMT fees are possibly an alternative or supplement to fuel taxes that for many decades have been a principal mechanism for funding the transportation system. This document describes trends in fuel-tax revenue and VMT growth that suggest the motivation for considering such fees, and then describes how currently available technology and administrative structures might be used to implement direct usage-based charges. The analysis is informed by recent trials conducted by several states. The information will be useful to national- and state-level policy makers and to government officials and others who may be engaged in evaluating, designing, and implementing such direct usage-based charges.

For close to a century, motor-vehicle fuel taxes have been the primary source of funds supporting construction and operation of the nation's highways. Adopted as a means to charge road users for the costs of the system, these taxes are levied on a cents-per-gallon basis and must periodically be raised to offset the effects of inflation. The reluctance of many elected officials to make such increases, combined with improvements in fuel economy, fluctuations in travel, and the prospect of increasing reliance on alternative energy sources, have undermined the effectiveness of fuel taxes as a reliable revenue source. VMT fees are seen by many analysts and policy makers as a potentially viable way to generate revenues while maintaining the idea that users should pay for the system, an idea that originally gave rise to our current fuel taxes.

Directly charging road users based on their VMT or other indicators of their system usage has long been applied to travelers on toll roads. New electronics and communication technologies are making the idea increasingly attractive as a more broadly applicable revenue-raising tool. Many proponents envision that implementing direct charging will also enable more efficient management of the highway system, for example through pricing that varies by time of day and location to reduce congestion.

Most specific proposals have entailed use of in-vehicle metering equipment that might be phased in with the purchase of new vehicles. The implementation process for such proposals is then likely to be prolonged. This report, the product of National Cooperative Highway Research Program (NCHRP) Project 20-24(69), explores proposals that might be implemented more quickly, possibly enabling nationwide adoption of direct usage-based charges by 2015.

The project, requested by the American Association of State Highway and Transportation Officials (AASHTO), is one of a series of research studies intended to address the specific needs of chief executive officers (CEOs) and other top managers of state departments of transportation (DOTs). Project 20-24(69) was undertaken to assist CEOs and other senior officials at state and national levels considering practical options for generating revenue to support the nation's transportation system.

A team led by the RAND Corporation, Santa Monica, California, working under the auspices of ICF International, conducted the research. The project entailed a review of literature and current research and experimentation by others, in the United States and overseas, on ways to implement direct VMT charges. The research team also considered how currently available cellular communications and on-board vehicle monitoring devices might be used to enable direct VMT charging. The research described nine distinct options for implementing such charges. The options were evaluated with consideration for their revenue-generating potential, implementation costs and burden placed on road users, enforcement challenges, and applicability to the entire road network. The evaluation led to further definition and refinement of three options that appear to offer the greatest promise: metering mileage based on fuel-consumption, metering mileage based on a device combining cellular service and a connection to the vehicle's onboard diagnostics port, and metering mileage based on a device featuring a Global Positioning System (GPS) receiver. The report describes the advantages and disadvantages of each option.

The research project underlying this document was conducted under stringent time constraints and with substantial engagement of individuals representing the perspectives of many principal stakeholders in ongoing discussions of how the nation can ensure adequate funding to support its surface transportation system. The Transportation Research Board's (TRB) intent was to ensure that the project's results be a timely, fact-based, and balanced analysis of readily implementable means for collecting usage-based charges. Publication of the report as a web-based document reflects this intent by making the project results quickly available to the public. The report was reviewed in draft form by individuals not involved in the project, chosen for their expertise and perspective on the issues involved, to assist the authors and NCHRP to make the report as sound as possible. TRB thanks the following individuals for their review of this report: Jonathan L. Gifford, George Mason University School of Public Policy, Arlington, Virginia; Leslie N. Jacobson, Telvent Farradyne, Inc., Seattle, Washington; and Scott E. Stewart, IBI Group, Toronto, Canada.

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LIST OF ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ANPR	Automated Number Plate Recognition
AVI	Automated Vehicle Identification
BAR	Bureau of Automotive Repair
BEES	Board on Energy and Environmental Systems
BOE	Board of Equalization
BTH	Business, Housing, and Transportation
CAFE	Corporate Average Fuel Economy Standards
CBD	Central Business District
CSS	Citizen Services System
DMV	Department of Motor Vehicles
DVS	Driver and Vehicle Services
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
EIA	Energy Information Agency
FTB	Franchise Tax Board
GAO	Government Accountability Office
GPS	(Satellite-based) Global Positioning System
HPMS	Highway Performance Monitoring System
HTF	Federal Highway Trust Fund
HVUT	Heavy Vehicle Use Tax
IFTA	International Fuel Tax Agreement
IRP	International Registration Plan
IRS	Internal Revenue Service
MVA	Motor Vehicle Administration
NCHRP	National Highway Cooperative Research Program
NEMS	National Energy Modeling System
NHTSA	National Highway Traffic Safety Administration
OBD II	On-Board Diagnostics port, second generation (post-1996)
OBU	On-Board Unit
PAYD	Pay-As-You-Drive
PSRC	Puget Sound Regional Council
RFID	Radio Frequency Identification

RPC	Regional Processing Center
TIMA	Truth in Mileage Act
TRB	Transportation Research Board
VIN	Vehicle Identification Number
VMT	Vehicle Miles of Travel
VTR	Vehicle Titles and Registration
VTrans	Vermont Agency of Transportation

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ABSTRACT

Motor fuel taxes have been the principal source of highway revenue for close to a century. Levied on a cents-per-gallon basis, however, they must be periodically raised to offset the effects of inflation and improved fuel economy, and elected officials have grown increasingly reluctant to take on this unpopular task in recent decades. With the anticipated introduction of more fuel-efficient conventional vehicles and alternative fuel options in the coming years, the ability of fuel taxes to raise sufficient revenue may be further undermined. Based on these considerations, a growing number of analysts have argued, convincingly, that the nation should replace motor fuel taxes with a system of road use charges based on vehicle-miles of travel (VMT). Most proposals in this vein envision the use of sophisticated in-vehicle metering equipment, which might be phased in with new vehicle purchases. Yet this would require a prolonged transition period of many years, and the nation's transportation funding challenges are already urgent. There is thus interest in determining whether it might be possible to implement a system of VMT fees much more rapidly, commencing by 2015. The goal in this study was to identify a range of options that might support the near-term implementation of a national system of VMT fees and evaluate their relative strengths and weaknesses. Based on the research, three options appear to offer the greatest promise: metering mileage based on fuel-consumption, metering mileage based on a device combining cellular service and a connection to the onboard diagnostics port, and metering mileage based on a device featuring a GPS receiver. While each of these approaches has its own set of advantages and disadvantages, there are also significant uncertainties that make it difficult to determine the optimal configuration at this juncture. The upcoming reauthorization of the transportation bill, however, provides the opportunity to fund a set of activities—encompassing planning, analysis, technical research and development, expanded real-world trials, and education and outreach—that could resolve the uncertainties and set the stage for implementing VMT fees beginning in 2015.

EXECUTIVE SUMMARY

This summary provides an overview of work conducted under the National Cooperative Highway Research Program (NCHRP) project 20-24 (69), *Implementable Strategies for Shifting to Direct Usage-Based Charges for Transportation Funding*.

S.1. Motivation for Study

Excise motor fuel taxes, long the mainstay of highway finance at both the federal and state level, are typically levied on a cents-per-gallon basis. This means that they must periodically be raised to keep pace with inflation and improved fuel economy; elected officials, however, have grown increasingly reluctant to take on this politically unpopular task. As a result, fuel tax receipts, measured in real dollars per mile of travel, have fallen precipitously over recent decades, leaving insufficient revenue to maintain, let alone expand, the road network. In 2008, for instance, the federal Highway Trust Fund (HTF), traditionally funded by fuel tax receipts, required an $8 billion transfer from general funds to remain solvent. With the anticipated introduction of more fuel-efficient conventional vehicles and alternative fuel options in the coming years – desirable in other regards – the deterioration of highway revenue will be accelerated.

Against this backdrop, many analysts and decision makers believe that it will soon become necessary to replace fuel taxes with a system of user fees based on vehicle miles of travel (VMT). Enabled by recent advances in electronic tolling technologies, VMT fees offer the potential to:

- Preserve or augment transportation revenue, as the fees would not diminish with the adoption of more fuel-efficient conventional vehicles or alternative fuel options. Since 1980, VMT has doubled while fuel consumption has increased by only 50 percent. Available projections indicate that VMT growth will continue to outpace growth in fuel consumption through 2030. Although all such projections are uncertain, a system of VMT fees plausibly will better keep pace with the demands of maintaining the transportation system than continued reliance on fuel taxes.
- Address other challenging transportation policy goals, such as reducing traffic congestion or harmful pollutant emissions, by varying the per-mile charge based on relevant vehicle characteristics (e.g., size, weight, emissions class) or the time and location of travel (thus creating financial incentives to, for example, purchase less polluting cars or avoid peak hour travel when possible).
- Improve equity in transportation finance by aligning the level of fees owed with the benefits derived (or costs imposed) through use of the system.

The compelling advantages of VMT fees have stimulated a flurry of studies, trials, and fully-implemented distance-based road pricing programs over the past few years, including examples from Oregon, Puget Sound, the University of Iowa, the Netherlands, Austria, Switzerland, and Germany. Most of these involve or envision the use of sophisticated in-vehicle equipment that features a global positioning system (GPS) receiver to accurately meter mileage by both the time and location of travel. While this approach offers an extremely flexible mechanism for levying road use charges, it would also entail a significant cost to retrofit the entire existing fleet, and there are also concerns regarding the privacy implications of using GPS to monitor travel behavior. As a result of these obstacles, many informed observers have concluded that it would take at least 10 or 15 years to develop and phase in a system of VMT fees.

Yet the revenue challenges that motivate a transition from fuel taxes to VMT fees are urgent, and less sophisticated options for metering mileage are available. The purpose of this study has been to identify a broad range of potential VMT-fee implementation options, examine their relative strengths and weaknesses, determine whether any options would be suitable for near-term implementation at the national level, and, if so, outline the steps needed to accomplish such a transition. Though focused on prospects for a federal system of VMT fees, the analysis also considers the possibility that some states might choose, on an optional basis, to make use of the same system to levy their own VMT fees.

S.2. Summary of Findings

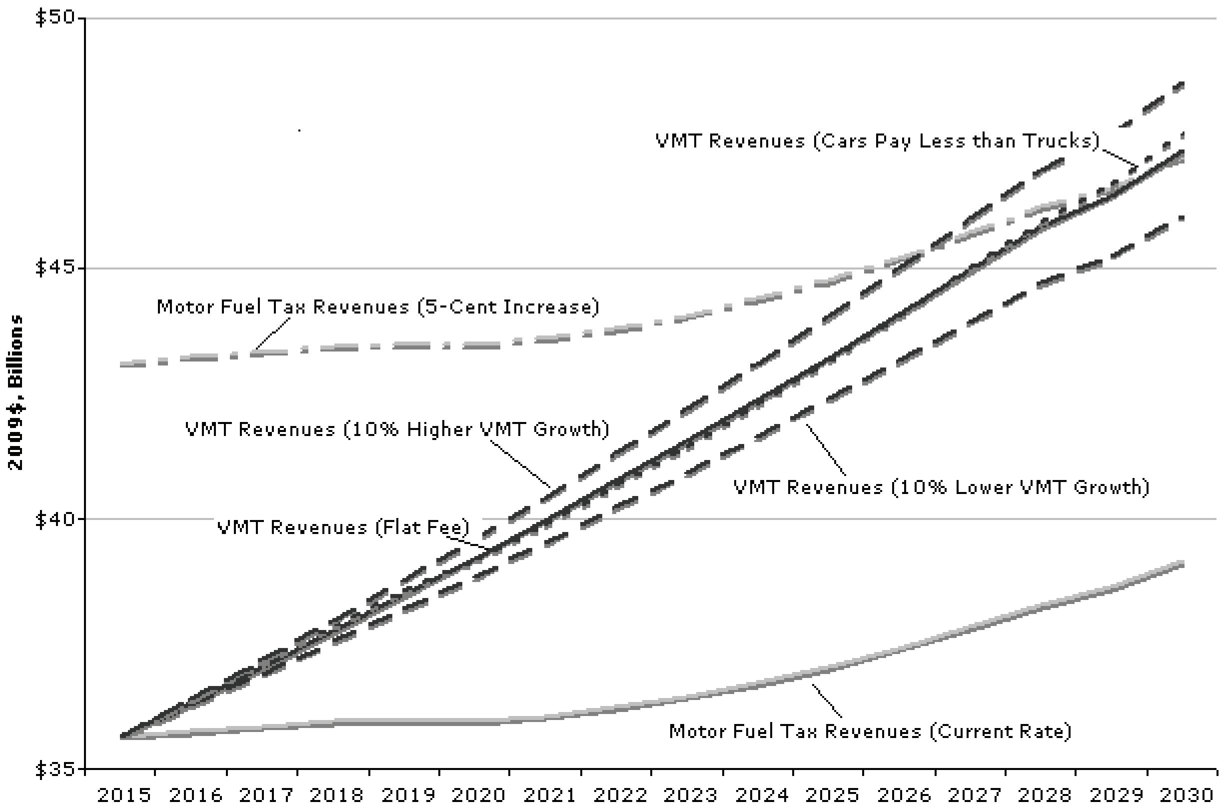
The analysis conducted by the research team, in concert with feedback from the project panel and other subject matter experts, leads to the following principal findings:

- The motivations for transitioning to a system of VMT fees—to raise revenue and potentially to address additional policy goals—are strong.
- VMT fees face two significant policy obstacles: first, it is not apparent that initial efforts to institute VMT fees, or subsequent efforts to increase VMT fees to keep pace with inflation, will face less opposition than increasing fuel taxes; and second, the administration of VMT fees will almost certainly be more costly and burdensome than fuel tax collection.
- Many potential VMT metering and charging systems could, from a technical perspective, be implemented within a few years.
- Each of the options considered in this research has one or more significant drawbacks that would argue against immediate implementation for all vehicles at the national scale.
- Transportation funding deliberations provide an opportunity to conduct activities to prepare the country for initiating a potential transition to VMT fees in 2015 or perhaps sooner.
- Once initiated, the transition to VMT fees may occur more rapidly than expected.
- In contrast to a general system of VMT fees for all vehicles, weight-distance truck tolls could be planned and implemented now.

S.3. Revenue Effects of Transitioning to VMT Fees

Among the motivations for instituting a system of VMT fees, current revenue shortfalls are clearly the most pressing. With more efficient conventional vehicles and alternative fuel vehicles expected to gain greater market share in the coming years, fuel taxes will likely become even less effective at raising sufficient revenue in relation to total travel. This effect could be countered, however, by switching from fuel taxes to VMT fees. Accordingly, the research team was asked to identify datasets and methodologies that states might employ to forecast VMT-fee revenue. As part of this exercise, the team used national VMT and fuel consumption forecasts provided by the Energy Information Agency (EIA) to examine the revenue effects of replacing fuel taxes with VMT fees on an initially revenue-neutral basis beginning in 2015. The results, which consider several alternate assumptions regarding the growth in VMT and the structure of the mileage charge, are shown in Figure S.1 (note that values are in unadjusted 2009 dollars).

Figure S.1. National VMT Fee Revenue Forecasts



Sources: Computed by authors based on data from EIA (2009 Tables 45, 60, 65, and 67)

Figure S.1 includes projections of fuel tax revenue under two different assumptions: rates (a) remain fixed at current levels and (b) are increased by five cents per gallon in 2015. There are also projections of revenues anticipated from a VMT fee of roughly 1.1 cents per mile (an amount calculated to result in a revenue-neutral shift in year 2015). The figure shows also the range of projected VMT-fee revenues if VMT growth rate were to be 10 percent higher or lower than the median estimate. As illustrated, the forecast revenues would differ only slightly if passenger vehicles were to pay slightly lower and trucks higher per-mile charges (0.8 cents per mile and 3.4 cents per mile, respectively). The projections illustrate why, absent an increase in fuel taxes, VMT fees are an attractive alternative revenue source; even under a conservative assumption that growth in VMT is 10 percent less than expected, VMT fees would generate roughly 20 percent greater revenue by 2030.

S.4. Related Programs, Proposals, and Studies

In considering the possible design of a nationwide system for VMT fee, there is much recent experience on which to build. The confluence of revenue shortfalls and advancements in electronic tolling technology has led to a blossoming of road pricing programs, proposals, and studies over the past decade. Taking stock of activity in the United States and abroad, one can discern three categories of distance-based pricing programs that may shed light on technical, administrative, or political issues relevant to the development of a system for levying VMT fees:

- **General-purpose distance-based road use charges.** This involves the application of distance-based road-use charges that would apply to all light-duty vehicles (e.g., passenger cars), and potentially apply to trucks as well. Well-known examples include trials conducted by the Oregon Department of Transportation, the Puget Sound Regional Council, and the University of Iowa.

- **Weight-distance truck tolls.** Conceptually similar to the previous category, the key distinctions here are that (a) the charges only apply to heavy trucks, and (b) the per-mile rate varies by some measure of vehicle weight to account for road wear. Automated weight-distance tolls have recently been implemented in Switzerland, Austria, and Germany.

- **Pay-as-you-drive (PAYD) insurance/leasing.** Automobile insurance and leasing costs are often fixed, structured as a set price for a fixed period of time (e.g., $1000 per year for insurance). The idea behind PAYD insurance and leasing is to vary these costs on a per-mile basis such that the less one drives, the less one owes. Well-known examples include PAYD insurance for OnStar customers offered by GM and a PAYD option offered by Progressive Insurance.

In reviewing existing programs, proposals, and studies in these categories, several high level observations emerged:

- **A broad array of metering mechanisms are feasible.** Options range from simple odometer readings to sophisticated in-vehicle equipment featuring GPS to determine the time and location of travel. All of the options have been demonstrated as feasible, either in existing programs or trial tests.
- **Metering capabilities vary considerably across the options.** Simpler metering mechanisms are only capable of metering total miles, while more sophisticated options can determine the time of travel, the jurisdiction in which travel occurs, and even the specific route of travel.
- **Desired policy goals influence technology choice.** Intended policy goals imply a minimal set of metering capabilities (e.g., to levy congestion tolls, it is necessary to meter the time and location of travel). The choice of technology, therefore, will inevitably be based, at least in part, by the policy goals that underlie the program.
- **There are no "low cost" options that can be easily verified and enforced.** The only low cost option identified in this study involves self-reported odometer readings, and this mechanism is difficult to verify, enforce, and administer. Additionally, unless states provide the option of billing on less than an annual basis, it could impose a financial burden on some drivers. Other options require either official odometer inspections (entailing high operational costs) or sophisticated in-vehicle equipment (entailing high capital cost).
- **Concerns over privacy remain a significant barrier to the use of GPS equipment to support general-purpose VMT fees.** Existing proposals and trials have taken significant steps to ensure that the privacy of travel data can be protected. However, the perception that GPS will be used to track and monitor travel remains a potent public concern despite the fact that technical approaches to the protection of privacy have already been developed and demonstrated. Beyond education and outreach, factors that may help overcome privacy concerns include (a) providing the opportunity to save money through use of the equipment (e.g., with pay-as-you-drive insurance), and (b) using the GPS technology to provide additional user features (e.g., navigation, real-time route-specific traveler information).

- **For weight-distance truck tolls, industry concerns center on the distribution of costs and benefits.** In many cases, trucking costs would rise with weight-distance truck tolls. To forestall strong stakeholder resistance, existing weight-distance truck tolls have been structured with additional features that benefit the trucking industry – for example, allowing larger truck loads in certain corridors (Balmer 2004), leveling the playing field with foreign competition (Worsley 2004), and dedicating the resulting revenue to highway investments that will benefit truckers (Ruidisch 2004).
- **Drivers respond to price signals.** Existing trials and programs demonstrate that drivers do respond to price signals embedded in the rate structure. Charging more for peak hour travel in busy corridors, for instance, will encourage drivers to shift their travel to other times or routes of travel (PSRC 2008, Whitty 2007), while charging a higher rate for more polluting vehicles will stimulate more rapid adoption of less polluting vehicles (Ruidisch 2004). The implication is that the concept of leveraging a system of VMT fees to achieve other policy goals has potential.

S.5. State Perspectives

Among the many potential mechanisms that could support a national system of VMT fees, some – for instance, annual odometer inspections as part of the vehicle registration process – would likely require significant support from the states. It is not clear, however, that all states would be eager to support efforts to levy VMT fees on behalf of the federal government. To gain greater insight on state perspectives and concerns as well as state-level implementation issues, the researchers conducted interviews with department of transportation (DOT) and department of motor vehicles (DMV) or motor vehicle administration (MVA) officials in four states selected for diversity in terms of geography, size, international borders, and institutional arrangements for vehicle registration: Texas, Minnesota, South Carolina, and Vermont. The researchers also obtained written responses to the set of state questions from members of the project panel representing Oregon, California, Virginia, and New York. The interviews led to many helpful insights and observations regarding technical, administrative, and public acceptance considerations. Key summary points include:

- **States are interested in the revenue potential of VMT fees.** The potential of VMT fees to offset declining revenue is attractive, and state officials are following current VMT fee pilot programs with great interest.
- **States would like the federal government to take the lead.** Officials believe that the federal government should take leadership in setting technical standards to prevent the development of multiple and potentially incompatible systems in different states and regions.
- **Odometer-based systems are not viewed favorably.** State officials indicate that levying VMT fees based on odometer readings would require major changes to DMV operations and databases.
- **Privacy issues constitute a significant barrier to public acceptance.** While there is general agreement on this point, there is little consensus regarding the best strategy for addressing privacy concerns.
- **States are worried about the potential for fraud and evasion.** This issue is of particular concern to states sharing international borders.

S.6. Framework for Evaluating VMT-Fee Mechanisms

Based upon insights from existing programs, proposals, and studies, interviews with state officials, and feedback from the project panel as well as other experts, the researchers developed a framework for evaluating the strengths and weaknesses of alternate VMT-fee implementation mechanisms.

Intended policy aims. The framework begins with the observation that a VMT-fee system could, in principal, be structured to foster a broad range of policy goals, including:

- Preserving or augmenting road use revenue
- Accurately apportioning road use revenue
- Accurately capturing maintenance costs
- Reducing congestion delays
- Reducing criteria pollutant emissions
- Reducing greenhouse gas emissions

Required metering capabilities. Many of these goals would be accomplished by varying the per-mile charge according to certain travel characteristics to provide a financial incentive for changes in travel choices and behavior. For example, increasing the per-mile rate for travel in congested corridors during peak hours would encourage drivers to seek alternate routes, modes, or times of travel. Likewise, increasing the per-mile charge for heavily polluting vehicles would provide an incentive for motorists to purchase more environmentally benign vehicles.

The implication, then, is that certain policy goals will require certain mileage metering capabilities. One way to consider the evaluation of alternate VMT-fee mechanisms, then, is to first consider the intended policy aims, and then identify the metering mechanisms that provide the metering capabilities that would enable those policies. Depending on the policy aims, the VMT-fee mechanism may need to support, determine, or incorporate:

- **Base mileage metering capabilities.** These include accurate (as opposed to approximate) mileage counts and the ability to meter mileage across the entire road network.
- **Specific travel characteristics.** These include the jurisdiction of travel, the type of road traveled, the specific route or area of travel, and the time of travel.
- **Relevant vehicle characteristics.** These include vehicle fuel efficiency, vehicle emissions class, and vehicle weight (or axle weight).

Additional evaluation criteria. Beyond metering capabilities, there are additional criteria that can be used to judge the strengths and weaknesses of alternate VMT-fee mechanisms. Specific categories of interest include:

- **Implementation costs.** These include in-vehicle technology cost, supporting infrastructure cost, collections cost, and enforcement cost.
- **Functional considerations.** These include technology risk, ease of enforcement, flexibility or extensibility (i.e., the ability to build on the system without major structural changes) of the system, ability to levy charges for all vehicle types on the road, and ability to levy charges for foreign vehicles lacking in-vehicle equipment.

- **Institutional considerations.** These include administrative complexity (with particular attention to the required level of state participation) and possible legal barriers.
- **User acceptability.** This includes additional burden on users, the ability to audit mileage fees, and privacy concerns.

S.7. Possible Near-Term VMT-Fee Mechanisms

Based on our review of recent programs, studies, and proposals, along with the concepts being discussed among senior elected officials, the research team identified and briefly evaluated nine VMT-fee mechanisms that might be pursued in the near term.

- **Self-reported odometer readings.** For this option, drivers would report their current mileage each year as part of the annual registration process. The state DMV or MVA would then assess a corresponding mileage fee, which would be added to the base vehicle registration fee (if paying the full amount in a lump sum proved to be burdensome for some drivers, an option of paying the fee in twelve monthly installments could be provided). The state would then pass along the mileage fee component, minus some administrative charge, to the federal government.
- **Annual odometer inspections.** Similar to the prior option, the key distinction here is that drivers would submit to periodic (likely annual) odometer readings at certified stations as the basis for assessing mileage fees. The odometer readings could be conducted either by a public agency, such as a state DMV or MVA, or contracted to authorized private stations. Here again, fees would be added to the base registration charge, and states would then remit the federal share of VMT fees to the Treasury Department.
- **Assumed annual mileage with optional odometer inspections.** With this approach, vehicle owners would be assessed an annual VMT fee based on the estimated mileage for the vehicle class (e.g., passenger vehicles vs. commercial trucks). Road users that travel significantly less than the assumed amount could submit to annual odometer readings to qualify for a reduced fee based on actual miles of travel, while users that travel more would simply choose to pay the estimated mileage charge. As with the previous option involving odometer inspections, states would still need to provide the infrastructure for road users that choose to have their odometers read, and they would likewise need to modify their vehicle registration systems to accommodate this new form of charging. VMT fees, once collected, would be remitted to the federal government.
- **Fuel consumption-based mileage estimates.** Under this approach, fuel consumption would serve as the basis for estimating travel distance. All vehicles would be equipped with some form of automated vehicle identifier, or AVI, device (likely a radio-frequency identification, or RFID, tag embedded in the license plate or registration sticker). When a vehicle visits a gas station to purchase fuel, electronic readers installed at the pump would detect the vehicle ID and use this information to determine the vehicle's fuel-economy rating (and, optionally, other characteristics such as weight or emissions class) based on the make and model. The expected mileage could then be estimated based on the number of gallons purchased. The corresponding charge could then be added to the fuel purchase price, while fuel taxes (already paid at the wholesaler level and therefore built into the retail price) would be subtracted. Vehicles not yet equipped with an AVI device (including foreign vehicles) would continue to pay the existing fuel taxes rather than mileage charges. The administration for this option would involve a significant expansion of the existing fuel tax system to include retail fuel stations along with wholesalers. Specifically, it would be necessary to account for

the difference between fuel taxes (paid at the wholesale level) and mileage fees (collected at the retail level) and interact with fuel retailers to either collect or refund the difference.

- **OBD II-based mileage metering.** For this approach, vehicles would be equipped with an on-board unit (OBU) that serves as the mileage metering device. The OBU would be connected to the on-board diagnostics port (second generation, or OBD II, available on vehicles manufactured since 1996), which provides data on vehicle speed that can be integrated over time to compute travel distance. The per-mile fee could be modified, if desired, by vehicle characteristics such as weight, fuel economy, or emissions class. Fees could be collected through the pay-at-the-pump model described above, or the OBU could transmit (via cellular) mileage data to a central collections agency that would subsequently bill for mileage fees.
- **OBD II / cellular-based mileage metering.** Like the previous approach, this would rely on an OBU connected to the OBD II port to meter mileage. The OBU would also be equipped with cellular communications, and this would make it possible to determine, with rough accuracy, the location of travel (via identification of the nearest cell phone tower or, alternately, by triangulating among multiple cell towers). This configuration would thus make it possible to vary rates by vehicle characteristics, by state or regional jurisdiction, or by smaller geographic area (e.g., area-based congestion tolls in a dense urban district). The location data would also make it possible to accurately allocate mileage fees among multiple jurisdictions. To collect fees, it would be possible to set up the pay-at-the-pump model, develop a central billing agency, or develop a debit card system under which fees would be deducted from pre-paid debit cards inserted into the OBU (this latter might be considered an option for users with privacy concerns, as it would not be necessary to transmit mileage data for fees to be invoiced).
- **Coarse-resolution GPS-based mileage metering.** From the perspective of metering capabilities, this option, employed in the Oregon trials, is identical to the previous approach. The only difference is that the OBU would rely on a coarse-resolution GPS receiver, rather than cellular-based location, to identify the jurisdiction or area of travel (the term "coarse-resolution" implies that the device could determine the general location of travel, but not the specific route). GPS could also be used to measure travel distance – by interpolating between subsequent location points – or the OBU could include a connection to the OBD II port for this purpose. This configuration would also enable similar payment mechanisms, including the pay-at-the-pump model, cellular transmission of mileage data to a central billing agency, and pre-paid debit cards inserted into the OBU.
- **High-resolution GPS-based mileage metering.** This option is similar to the prior approach, but would rely on differential GPS for sufficient accuracy (i.e., accurate within one to two meters) to determine the specific route of travel (again, travel distance could be measured either by GPS or via a connection to the OBD II port). This would enable the greatest flexibility in pricing; per-mile rates could vary by vehicle characteristics, by jurisdiction, by area within jurisdictions, by specific route or road class, and by time. The ability to meter by route may be most useful for heavy trucks, in that the damage caused by truck travel varies considerably depending on the engineering quality of the road. It would also make it possible, however, to develop facility-based congestion tolls for all vehicles without needing to install gantries. Similar payment options would be possible: paying at the pump, transmitting mileage data to a central billing agency, or making use of pre-paid debit cards inserted into the OBU.

- **RFID-based tolling on a partial road network.** With this option, all vehicles would be equipped with AVI devices featuring RFID tags. These would communicate, via dedicated short-range communication (DSRC) technology, with gantries set up along the most heavily traveled segments of the road network to support facility-based tolls – either flat tolls or tolls that vary by time and location. This approach would not support tolling across the entire road network, as it would not be practical, let alone cost effective, to install gantries on lightly traveled road segments. As such, this would likely be used to augment, rather than replace, fuel tax revenue. The two most likely options for collecting payments would be to set up a central billing agency or use pre-paid debit cards inserted into the in-vehicle equipment.

S.8. Identifying the Most Promising Options

In briefly evaluating each of the metering mechanisms described above, the goal was to distinguish a smaller set of options offering the greatest potential for near-term implementation. These judgments were based on several criteria:

- **Full road network metering.** The system should be capable of metering VMT across the entire road network.
- **Cost vs. metering capabilities.** If a system offers limited metering capabilities, then it should also be low cost; otherwise the VMT fees would need to be proportionately much higher than fuel taxes to preserve existing revenue. By the same token, if a system entails significant costs, it should also provide flexible metering capabilities to allow for additional forms of pricing (e.g., congestion tolls) that would make it possible to increase revenue while maintaining a lower base per-mile rate.
- **Enforceability.** The system should allow for at least reasonably effective enforcement, both to protect against revenue loss and to avoid resentment among law-abiding citizens.
- **Minimal required state support.** The interviews conducted with state officials made it clear that not all states would be eager or willing to exert significant effort to develop national VMT fees. Accordingly, while the system should allow for state participation in cases where states would like to levy their own VMT fees, it should not require excessive effort for states not interested in this policy.
- **Minimal burden on users.** Gaining public acceptance for the transition from fuel taxes to VMT fees will likely be difficult in its own right. Increasing the burden on users – for instance, by requiring regular odometer inspections – will make this even more difficult.

Least promising options. Based on these criteria, it was possible to dismiss the following mechanisms as being less suitable as a core mechanism for implementing VMT fees on a national scale:

- **Self-reported odometer readings.** This option, though the least expensive, would be too difficult to enforce.
- **Annual odometer readings.** This option would require significant effort among states, particularly those that do not currently conduct vehicle inspections. It would have high ongoing operational costs while offering limited metering flexibility, and it would also increase user burden (the need to submit to odometer readings).
- **Assumed annual mileage with optional odometer readings.** Though offering lower operational costs and user burden (as fewer drivers would choose to have their odometers

read), this would still require significant participation by all states and provide minimal pricing flexibility.

- **OBD II-based mileage metering.** This was judged as being roughly comparable in expense to the OBD II / cellular option while offering much less flexible metering capabilities.
- **High-resolution GPS-based mileage metering.** This option would require more expensive in-vehicle equipment than the coarse-resolution GPS option. While it does offer more flexible metering options – specifically the ability to determine specific route of travel – this additional flexibility is most useful for weight-distance truck tolls in which the per-mile rate would likely depend on the type of road on which travel occurs. If the decision is made to implement weight-distance truck tolls, then, this would be the preferred option. For a general-purpose system of VMT fees, however, the additional capabilities are not required.
- **DSRC-based tolling on a partial road network.** With this approach it would not be possible to meter mileage across the entire road network. On the other hand, it is worth noting that this option could be used to extend the metering capabilities for any of the mechanisms that involve either an AVI or OBU device – specifically by enabling facility-based tolls that could be layered on top of the base mileage fees.

Most promising options. The remaining three options appear to offer the greatest promise for implementing a national system of VMT fees; each has its own set of advantages and limitations:

- **Mileage metering based on fuel consumption.** Though offering limited metering flexibility, this option would likely prove the least expensive to develop and operate, given the low cost of RFID technology and the ability to expand the existing fuel tax system to encompass fuel retailers rather than developing an entirely new revenue system. It would also provide a fallback revenue system – existing fuel taxes – to charge vehicles lacking the required AVI device for road use. Finally, the pay-at-the-pump model could still be used to collect fees for most vehicles if a transition to more sophisticated metering equipment were pursued over the longer term.
- **OBD II / cellular-based metering.** While the technology remains to be demonstrated in the context of road pricing, this option could provide significant metering flexibility at lower cost than the GPS option.
- **Coarse-resolution GPS-based metering.** This option also provides flexible metering options, and the technology has been demonstrated in real-world trials. If the price of the equipment can be reduced through large scale production, and if current privacy concerns associated with the use of GPS can be overcome, this would be a promising option.

Shared obstacles. Though promising, the three mechanisms suggested for further consideration share several important obstacles related to cost, administrative complexity, and political acceptability. While additional work is needed to develop more precise cost estimates, current evidence suggests that any of the three options would be more expensive – potentially much more expensive – than collecting fuel taxes. Additionally, moving the point of collection from a relatively small number of entities (fuel wholesalers) to a much larger number (either retail fuel stations or individual motorists) would make it more difficult to prevent tax evasion. All three options would also entail greater administrative complexity; depending on the specific option, it may be necessary to develop or secure new tax collection channels; a new national agency or expanded state powers; cooperation from entities not currently involved with fuel tax collection, such as cellular providers and retail fuel stations; support from the Internal Revenue Service

(IRS); national technology specifications and certification; and enabling or conforming state legislation. Finally, while VMT are projected to grow more quickly than fuel consumption in future years, it would still be appropriate in principle to index, or periodically increase, VMT fees to prevent the erosion of real revenue due to inflation. There is no indication that such increases would be easier to make, politically, than raising current fuel taxes. These issues merit careful consideration in the debate of whether, and at what pace, to pursue a transition from fuel taxes to VMT fees.

S.9. The Path Forward

While each of the three most promising options for the near-term implementation of VMT fees presents its own set of strengths and limitations, there remain many uncertainties regarding the likely costs and capabilities of certain administrative and technical components. This makes it difficult, absent additional targeted research, to specify with precision the optimal configuration for implementation by 2015. Should the decision be made to develop a national system of VMT fees within an expedited timeframe, however, the evidence from prior studies and trials makes it possible to outline a set of planning and development steps that may offer sufficient flexibility to manage the risk surrounding remaining uncertainties. The steps include:

- **Pay at the pump.** Implement the pay-at-the-pump collection system as the base platform for charging conventionally-fueled vehicles. This option appears to offer the lowest collection cost over time, provides for a relatively seamless transition between fuel taxes and VMT fees as vehicles are equipped with the requisite metering technology, and can be used with any of the three recommended metering options.
- **Central billing.** Develop a central billing agency that supports wireless data transmission to provide a payment mechanism for alternative-fuel vehicles that do not need to visit fuel stations. Initially this will be needed for only a small percentage of cars, but the percentage should grow with time.
- **Targeted research.** Pursue targeted research to resolve uncertainties regarding the cost and capabilities of alternate in-vehicle equipment options.
- **In-vehicle metering equipment.** Proceed with the production of in-vehicle metering equipment based on the findings of the research and development efforts.

In addition to these specific steps on the path to implementation, the research suggests two additional strategies that may help to reduce system costs and speed the transition period. The first is the idea of a voluntary "opt-in" system in which vehicle owners, though not required to retrofit existing vehicles with metering equipment, are provided with incentives—reduced cost, increased convenience, and access to desired add-on functionality such as in-vehicle navigation or real-time traveler information—for choosing to do so. It is possible that the transition period, during which adoption of the metering equipment would be optional, could involve a large increase in fuel taxes to provide additional motivation for drivers to shift to VMT fees. The second idea, complementary to the first, can be described as an "open systems" approach to technology procurement. A national set of minimal requirements for the metering technology would be specified, and then multiple vendors would develop conforming products and compete for market share on the basis of price as well as attractive user-oriented features. This would serve to drive down the cost of the equipment over time, and it also allows for the ongoing adoption and incorporation of new technologies that emerge over time.

S.10. Preparatory Tasks

While the task of preparing to implement a national VMT fee system by 2015 would be complex and demanding, the goal could nonetheless be possible. To bolster the prospects for success, however, it would be extremely beneficial – likely necessary – to fund a coordinated set of preparatory activities, spanning the areas of planning, research, technology development, larger-scale trials, and education and outreach:

- **Planning.** Developing and implementing a national system of VMT fees would be a massive undertaking, likely requiring a designated entity, granted the requisite level of authority, to shepherd these efforts. Specific tasks include specifying the entity to lead this undertaking, including an avenue for the participation of relevant stakeholders, and providing funding commensurate with the entity's responsibilities.
- **Analytic studies.** To better understand the likely costs and benefits of alternate system design options, it would be beneficial to pursue several targeted analytic studies. Specific issues of interest include the behavioral response to alternate forms of pricing, revenue production for alternate forms of pricing, cost estimates for alternate in-vehicle equipment configurations produced at scale, cost estimates for the installation of alternate in-vehicle equipment configurations, cost estimates for equipping fueling stations with electronic readers, cost estimates for collecting revenue via the pay-at-the-pump model, and cost estimates for developing and operating a central billing agency.
- **Technical research and development.** Though many of the potentially relevant implementation technologies have already been proven in real-world trials and are well understood, there are several components that could benefit from further research and development. Specific areas of focus should include developing and demonstrating the use of cellular equipment to meter the location of travel, evaluating alternate AVI configurations to support pay-at-the-pump collections as well as DSRC tolling on specific road segments, and investigating low cost and effective enforcement options to prevent tampering with the OBU.
- **VMT-fee system trials.** Several significant VMT-fee system trials – in Oregon, in Puget Sound, at the University of Iowa, and at the Georgia Institute of Technology – have already been completed or are currently underway. While these efforts offer valuable insights and information, it would be beneficial to invest in additional VMT-fee trials on the path to implementation in 2015. Key goals for these trials would include evaluating certain technical options or components for which more practical experience would be valuable; exploring the cost and reliability of alternate collection and enforcement mechanisms; and scaling the experiments to include more participants and more states.
- **Public education and outreach.** In considering the public acceptability of VMT fees, the experts consulted in this project offered two salient observations. First, there is little public understanding of the current challenges in transportation finance, and in turn the motivations for a transition to VMT fees. Second, the privacy concerns associated with GPS remain a potent obstacle to the acceptance of sophisticated in-vehicle metering equipment. To bolster the prospects for transitioning to a VMT-fee system, concerted public education and outreach would likely be imperative. Key efforts here would include identifying the most promising education and outreach strategies, determining who should spearhead the effort, and conducting the education and outreach activities.

1. INTRODUCTION

Motor fuel excise taxes have served as the principal mechanism for raising highway revenue at the federal and state level for most of the past century. Despite several compelling advantages, their utility in this role over the coming decades may be limited by a combination of structural and political factors. This has led to the suggestion that fuel taxes should be replaced by a system of user fees, enabled by modern electronic tolling technology, based on vehicle miles of travel (VMT).

VMT fees would overcome some of the revenue challenges faced by fuel taxes while simultaneously providing a means for addressing several other important policy goals. The State of Oregon and the Puget Sound Regional Council have recently conducted trials demonstrating the feasibility and potential utility of VMT-based fee systems, and the University of Iowa is currently operating six additional research trials. While the results of these initial efforts are encouraging, the in-vehicle technology developed to support VMT fees is sophisticated, including the use of global positioning system (GPS) receivers. Because it would prove costly to retrofit the entire existing vehicle fleet with the necessary VMT metering equipment, and because many among the public are wary of the privacy concerns that arise with GPS, most recent proposals have suggested phasing in a VMT-fee system gradually, over a period of perhaps 10 to 15 years. This would allow the required technology to be installed with new vehicle purchases, and it would also provide more time for public education and outreach campaigns to explain the motivations for switching from fuel taxes to VMT fees and assure the public that the necessary technical and programmatic safeguards have been instituted to protect the privacy of their personal travel data.

Yet the challenges motivating a switch to VMT fees—in particular, the insolvency of the federal Highway Trust Fund (HTF) resulting from the real decline in fuel tax revenues—are urgent. As such, there is keen interest in determining whether it might be possible to develop a national system for VMT fees that could be implemented within the next few years. The goal of this project is to identify, evaluate, and suggest mechanisms for near-term implementation of VMT fees, considering a broad range of technical, political, administrative, and legal factors, and to outline the steps that would be required to put such a system in place by 2015. The analysis considers the possibility that states might wish to make use of this same system to implement their own VMT fees, but this would be optional.

1.1. Background

Motor fuel taxes have been the principal source of highway funding at the state and federal level for close to a century, accounting for about $68 billion—about 64 percent of all highway user fees and about 50 percent of all highway expenditures—as of 2004 (TRB 2005). As a source of highway revenue, fuel taxes have performed well in many regards. They are inexpensive to administer, typically costing less than one percent of revenue collections. And because gasoline taxes are levied at the wholesale level, enforcement is relatively straightforward (note, however, that enforcement issues are somewhat more challenging with diesel fuel taxes, which apply to on-road vehicles but not off-road uses). Fuel taxes also create a financial incentive for the purchase of more fuel-efficient vehicles. Finally, fuel taxes, as a form of user fees, create a principled linkage between the costs and benefits of using the road network, promoting greater equity and efficiency (Wachs 2003).

The Decline of Motor Fuel Taxes. Despite such advantages, the efficacy of fuel taxes as a source of highway revenue has been increasingly undermined in recent decades by a confluence of structural and political factors. Because motor fuel excise taxes at the federal level and in many states are levied on a cents-per-gallon basis, they must be raised periodically to offset the effects of inflation and improved fuel economy. With rising anti-tax sentiment among the populace, elected officials have become wary of this politically unpopular task, and the frequency and magnitude of the recent fuel tax increases has been grossly insufficient to maintain comparable purchasing power in terms of real revenue per mile of travel. Real highway spending per mile of travel in the United States has declined by about 50 percent since the federal Highway Trust Fund (HTF) was established in the late 1950s, and the federal gas tax has experienced a cumulative loss in purchasing power of 33 percent since 1993 – the year in which the gas tax was last raised (NSTIFC 2009). As another example, though the California state excise tax for gasoline has increased from 7 cents per gallon in 1970 to 18 cents today, the real revenue per mile of travel – considering inflation and improved fuel economy over the same period – has declined by about 70 percent (Sorensen et al. 2008). Such reductions help to explain the growing shortfall in funding available to maintain, let alone expand, our nation’s road infrastructure.

In the near term, these challenges could be overcome by raising existing fuel taxes and simultaneously indexing them for inflation. Continued reliance on fuel taxes as the primary source of road revenue over the longer term, however, becomes problematic, for several reasons. First, the prospect of significantly higher fuel prices in the future may stimulate demand for a much more efficient fleet of conventionally powered vehicles. Additionally, as alternative fuel vehicles begin to achieve market penetration, a greater share of the motoring public may be able to avoid paying motor fuel taxes by, for instance, charging an electric vehicle at home or at work. Finally, concerns regarding climate change and energy independence may well stimulate concerted federal policy action to sharply reduce fossil fuel consumption in the coming years. Relying heavily on fuel tax revenues while simultaneously striving to reduce fuel consumption would spell certain trouble for the future health of transportation finance in this country. Such considerations, in concert with the development of sophisticated electronic tolling technologies, have fostered a growing interest in transitioning to a system of road finance centered on VMT fees rather than fuel tax revenues.

The Allure of VMT Fees. Because VMT fees would be based on the amount of travel rather than the amount or type of fuel consumed, such a system would eliminate concerns over the effects of improved fuel economy or greater adoption of alternative fuel vehicles on available transportation revenues. Moreover, if the system is capable of establishing where the travel miles occur, the resulting revenue stream can be accurately apportioned among multiple jurisdictions. Additional potential benefits may include reducing traffic congestion, adverse health effects from criteria pollutant emissions, and mitigating the looming threat of climate change. For instance, the per-mile charge could be increased on busy routes during peak hours to combat congestion, and it could similarly be increased for the most heavily polluting vehicles to promote faster adoption of more environmentally benign options.

The Challenge of VMT Fees. Given the potential benefits of a system of VMT fees, the concept has received considerable attention to date. The State of Oregon (Whitty 2007) and the Puget Sound Regional Council (PSRC 2008) have recently conducted successful pilot tests demonstrating the feasibility and utility of VMT-based charging systems, the University of Iowa (Forkenbrock 2006) has six trials underway in various locations across the country, and the State of Minnesota is preparing to conduct a similar pilot program (Starr 2009). While the results are encouraging, the technical configuration of the in-vehicle equipment required to enable a highly flexible system of road use charges (e.g. allowing the per-mile fee to vary by jurisdiction, by time of travel, by route of travel, or by vehicle characteristics) is quite sophisticated, incorporating features such as GPS receivers, digital road network or jurisdictional maps, and one or more forms of wireless communications. Although it would be possible to retrofit the existing vehicle fleet with such equipment, it would no doubt prove a costly endeavor. At the same time, there is concern among the public that the use of GPS-based metering equipment would violate the privacy of personal travel information. Though the privacy of travel data can be protected through both technical and programmatic design, it is clear that further public education and outreach will be needed to convey the motivations for switching to VMT fees and provide the assurance of suitable privacy protection.

Accordingly, most proposals for implementing a robust and extensible system of VMT fees have envisioned a gradual transition of perhaps 10 to 15 years (e.g., Whitty 2003, TRB 2005, NSTIFC 2009). Over this period, the required in-vehicle equipment might be phased in with the purchase of new vehicles, or vehicle owners might choose to adopt the technology on a voluntary basis in return for certain incentives (e.g., lower road use charges, or the availability of additional GPS-enabled functionality such as navigation and real-time traveler information). Until the phase-in period is completed, vehicles lacking the required technology would continue to pay fuel taxes, while those with the technology would pay mileage charges instead.

1.2. Motivation for and Scope of Study

While a compelling case can be made for planning to phase in a sophisticated system of VMT fees over a longer period of time, the challenges that motivate this shift – notably the large and growing shortfall in transportation revenue at all levels of government – are urgent. With the HTF facing insolvency (NSTIFC 2009), there is growing interest among transportation decision makers in determining whether it would be possible to configure a simpler system for metering and assessing VMT fees that could be implemented on a national scale much more quickly – within approximately five years – and serve as an intermediate transition to a more sophisticated VMT-based system over the longer term.

To explore this possibility, the National Highway Cooperative Research Program (NCHRP), at the request of the American Association of State Highway and Transportation Officials (AASHTO), funded NCHRP Project 20-24 (69), “Implementable Strategies for Shifting to Direct Usage-Based Charges for Transportation Funding,” in early 2009. This report documents the results of this study.

As set forth in the request for proposals, the objectives of NCHRP Project 20-24 (69) include (1) identifying and evaluating potential solutions that could be developed between 2010 and 2015; (2) converging upon one or more options that offer the greatest promise for near-term implementation; (3) outlining the shorter-term actions necessary to achieve implementation of an interim VMT-fee system; and (4) identifying a longer-term strategy for making a smooth and effective transition from the near-term VMT-fee mechanism to a more sophisticated, robust, and sustainable system of VMT fees in future years. To fully address these questions, the analysis of options and strategies considers a range of salient factors such as capital and operating costs, revenue implications, administrative requirements and challenges, federal and state legislative issues, public and political acceptability, additional burden on users, privacy concerns, enforcement challenges, and ability to address additional policy aims of interest, such as reducing road wear, traffic congestion, and harmful emissions.

1.3. Research Approach

Within the request for proposals, the project panel for NCHRP Project 20-24 (69) specified a set of eight tasks needed to achieve the goals of the study. The tasks can be summarized as follows:

- **Task 1.** Holding a kickoff meeting between the project panel and research team to review project goals and research approach
- **Task 2.** Conducting background research into the conceptual, technical, legal, administrative, political, and practical issues that could affect the feasibility and relative desirability of alternate VMT-fee implementation mechanisms; additionally, identifying and summarizing available VMT forecasts
- **Task 3.** Distilling the key elements of a VMT-fee system and identifying a set of potential VMT-fee implementation mechanisms
- **Task 4.** Developing a general approach and relevant criteria for assessing the available mechanisms and evaluating each option according to that framework
- **Task 5.** Selecting one or more options that appears to hold the greatest promise and refining the analysis of administrative and enforcement costs, institutional considerations, and implementation obstacles; additionally, identifying data and methods that states could use to forecast VMT revenues
- **Task 6.** Conducting a one-day workshop with panel members and other subject matter experts to review findings and consider the necessary steps for transitioning to a VMT-based system of user fees
- **Task 7.** Drafting the final report
- **Task 8.** Revising the final report

Across these tasks, the research effort benefited, at multiple points, from input, comments, and feedback offered by a range of stakeholders and subject matter experts. These interactions can be summarized as follows:

- **Project panel interactions.** The research team met, via teleconference, with the project panel during Task 1 to receive guidance on project goals and the proposed research plan. At the conclusion of Task 4, the research team provided the panel with a document describing the preliminary results of Tasks 2, 3, and 4. At the beginning of Task 5, the research team again met with the panel via teleconference to discuss the results of the earlier tasks and select the most promising VMT-fee mechanisms for further exploration. After analyzing these options in greater depth, the research team provided additional documentation to the project panel at the end of Task 5. This served as the basis for discussion during the Task 6 workshop, which was attended by many of the panel members (along with other subject matter experts). Finally, for Task 7 the research team provided a draft version of the final report for panel feedback and comment.
- **State interviews.** Many of the potential near-term VMT-fee implementation options (for example, conducting annual odometer readings) would require the support of state governments. To gain greater insight into state perspectives on the prospects for VMT fees, during Task 2 the research team interviewed department of transportation (DOT) and department of motor vehicles (DMV) or motor vehicle administration (MVA) officials from seven states: California, Minnesota, Oregon, South Carolina, Texas, Vermont, and Virginia (several of these states were represented on the project panel; others were contacted independently). The interview questions focused on such issues as current revenue systems, perceptions of conceptually similar trans-state revenue collection and sharing programs such as the International Registration Plan (IRP) and the International Fuel Tax Agreement (IFTA), tax enforcement and evasion challenges, attitudes towards VMT fees, and potential barriers and solutions.
- **Other interviews.** As part of the research efforts in Tasks 2 through 5, the team also contacted experts in other related fields, including insurance companies offering pay-as-you-drive insurance, federal officials who forecast VMT, researchers involved with conducting VMT metering and pricing trials, and state tax collection agencies. These interviews helped the team understand the current state of technology, VMT forecasts, and tax collections.
- **Expert workshop:** In Task 6 the research team presented preliminary results from Tasks 2, 3, 4, and 5 to a panel of subject matter experts for review and commentary. In addition to many of the project panel members, the workshop included officials from the U.S. Treasury and Federal Highway Administration (FHWA), senior congressional staff, state DOT and DMV officials, representatives from road user advocacy organizations, and individuals with relevant expertise in the areas of state legislative issues, electronic tolling technology, VMT-fee trials, and pay-as-you-drive insurance.

1.4. Summary of Findings

The analysis conducted by the research team, in concert with feedback from the project panel and other subject matter experts, leads to a series of findings relevant to funding deliberations.

- **There are significant reasons to transition from fuel taxes to VMT fees.** First and foremost, this shift could help to preserve or augment transportation revenue. It could also provide a potent policy lever for mitigating such problems as traffic congestion and pollutant emissions, which could be achieved by varying the per-mile rate based on relevant vehicle characteristics (size, weight, fuel economy, emissions) as well as the time and location of travel. Finally, it could result in a more equitable system of transportation funding, in which the fees charged to each driver would align with the benefits received from (or costs imposed upon) the system.

- **VMT fees also present two significant challenges: first, switching to VMT fees from fuel taxes would not eliminate the need to periodically increase the rate in order to offset inflation; second, the administration of VMT fees would likely be more costly and burdensome than fuel tax collection.** A major limitation of current fuel taxes has been the political difficulty of instituting periodic increases to offset improved fuel economy and inflation. VMT fees would neutralize the issue of improved fuel economy (and, for that matter, fuel type), but it would still be appropriate in principle to index, or periodically increase, VMT fees to prevent the erosion of real revenue due to inflation. There is no indication that such increases would be easier to make, politically, than raising current fuel taxes. In addition, although further research is needed to provide more precise cost estimates, experience to date suggests that VMT fees would be more expensive – likely much more expensive – to collect than fuel taxes. They also would require either a significantly expanded or entirely new administrative apparatus to support collection and enforcement activities.

- **Many potential VMT metering and charging systems could, from a technical perspective, be implemented within a few years.** The options vary widely in their technical complexity and metering capabilities, ranging from simple odometer readings to capture total mileage to sophisticated in-vehicle equipment featuring GPS receivers to meter travel by time and location.

- **Each of the available options faces one or more significant drawbacks that would argue against immediate implementation for all vehicles at the national scale.** Some options would be very difficult to enforce or expensive to administer, undermining the near-term goal of raising transportation revenue. Others, while less expensive to administer, would require significant start up costs. Still others may face stiff public resistance, due in large part to concerns over privacy issues. Finally, some options would require significant support from state governments, regardless of whether states wished to implement their own state-level VMT fees. Given that there are no low cost, low risk solutions, it would be beneficial at this juncture to fund additional research, developing, and planning efforts to ensure the best and most efficient system design choices when the transition is made.

- **Transportation funding deliberations provide an opportunity to conduct activities to prepare for initiating a potential transition to VMT fees in 2015 (or perhaps sooner).** Areas include (a) targeted research and development to better understand the cost, feasibility, and effectiveness of alternate technical configurations to support the functions of metering, collections, enforcement, and privacy protection; (b) additional trials scaled to include trucks as well as passenger vehicles, both operating across multiple states; and (c) outreach and educational efforts to communicate the motivations for switching to VMT fees and clarify the manner in which privacy will be protected. To set public expectations, the messaging around these activities should be clear: the goal is not to determine whether it makes sense to pursue VMT fees, but rather to gain the necessary insight to ensure that the transition can be achieved as effectively and efficiently as possible.

- **Once initiated, the transition to VMT fees may occur more rapidly than expected.** Researchers and analysts have developed several intriguing options, involving both carrots and sticks, that would promote more rapid adoption of the required metering equipment on a voluntary basis. It may also be helpful to develop a set of minimum standards for the required in-vehicle equipment and then allow vendors to compete – on the basis of price and desirable add-on end-user features (navigation, real-time traffic and parking information, etc.) – for market share. This would lead to the development of devices that are more attractive to users, fostering voluntary adoption in the near term, while simultaneously driving down equipment costs. It would also open the door for the adoption of more advanced technology as innovations occur.
- **If desired, weight-distance truck tolls could be planned and implemented now.** The principal concerns limiting the deployment of GPS-based equipment for passenger vehicles in the near term – the high cost of retrofitting the existing vehicle fleet and public fears over the potential invasion of privacy – are less relevant for the trucking industry, which has a much higher cost structure and is already heavily regulated. To forestall opposition, it would likely prove necessary to structure the program in such a manner that the trucking industry receives clear benefits as well. Possibilities include allowing trucks to carry larger loads in dedicated corridors, dedicating some share of the revenue to truck-only infrastructure, and streamlining burdensome regulatory compliance requirements (e.g., automating the reporting of miles by state under the International Registration Plan). Successful implementations already exist in Switzerland, Austria, and Germany, and in each case the systems were developed in just a few years.

1.5. Organization of Report

The remainder of the report is organized as follows.

One of the key motivations for transitioning to VMT fees, as noted, is to maintain or augment available transportation revenue. To quantify this potential, Chapter 2 reviews data sources and methodologies that would enable states to forecast future VMT-fee revenue. It also provides illustrative VMT-fee revenue forecasts at the national scale under the assumption of an initially revenue-neutral transition from fuel taxes to VMT fees beginning in 2015. The results offer strong support for a shift to VMT fees.

The confluence of enabling technology and growing transportation revenue shortfalls have stimulated significant interest in mileage-based pricing options in recent years. Chapter 3 examines programs and proposals that may provide relevant technical, political, or institutional guidance relevant to the development of a VMT-fee system. The examples reviewed fall in three broad categories: general-purpose distance-based pricing programs, automated weight-distance truck tolls, and pay-as-you-drive insurance programs.

Depending on a range of system design choices, levying VMT fees at the national scale could require significant involvement and assistance by states. For this reason, the research team interviewed DOT and DMV/MVA representatives in several states to gain insight into their hopes, concerns, and perspectives regarding VMT fees. The results of these interviews are summarized in Chapter 4.

Chapters 5 and 6 synthesize information gleaned in the earlier research to identify the salient factors in assessing VMT-fee systems and the key functional and technical components of such systems. The evaluation framework presented in Chapter 5 considers the metering capabilities of alternate technical configurations along with other issues of interest such as the cost of infrastructure and ongoing operations, technical risk, administrative complexity, ease of enforcement, burden on road users, and privacy concerns. Chapter 6 describes the three crucial components required of any VMT-fee system—metering mileage, assessing and collecting fees owed, and enforcement—and enumerate the available technologies to support these functional requirements. The chapter also considers potential public and private roles in supporting different elements of a VMT fee system.

Building from the individual VMT system components, Chapter 7 presents nine integrated metering configurations that might support a national system of VMT fees in the near term and briefly considers their relative strengths and limitations. The goal is to identify the subset of options that appear to offer the greatest promise for instituting general-purpose VMT fees by 2015. Three candidates emerge from this analysis – one that involves estimating mileage based on fuel consumption and two that would require more sophisticated in-vehicle equipment. Chapter 8 provides further analysis of these three candidates, identifying (in greater detail) strengths, weaknesses, uncertainties, and key design decisions. Chapter 8 also considers the possibility of near-term implementation of weight-distance truck tolls via in-vehicle GPS equipment.

Finally, Chapter 9 outlines planning steps and strategies on the path to implementation, while Chapter 10 discusses specific investments in the upcoming transportation reauthorization that could prepare the country for a transition to VMT fees beginning in 2015.

The three appendices at the end of the report provide brief descriptions of the existing road pricing programs and development efforts discussed in Chapter 3 (Appendix A), a list of state interviews conducted and the questionnaire used to conduct them, as discussed in Chapter 4 (Appendix B), and summary observations from the expert workshop conducted in Task 6 of the work plan (Appendix C).

2. FORECASTING VMT FEES

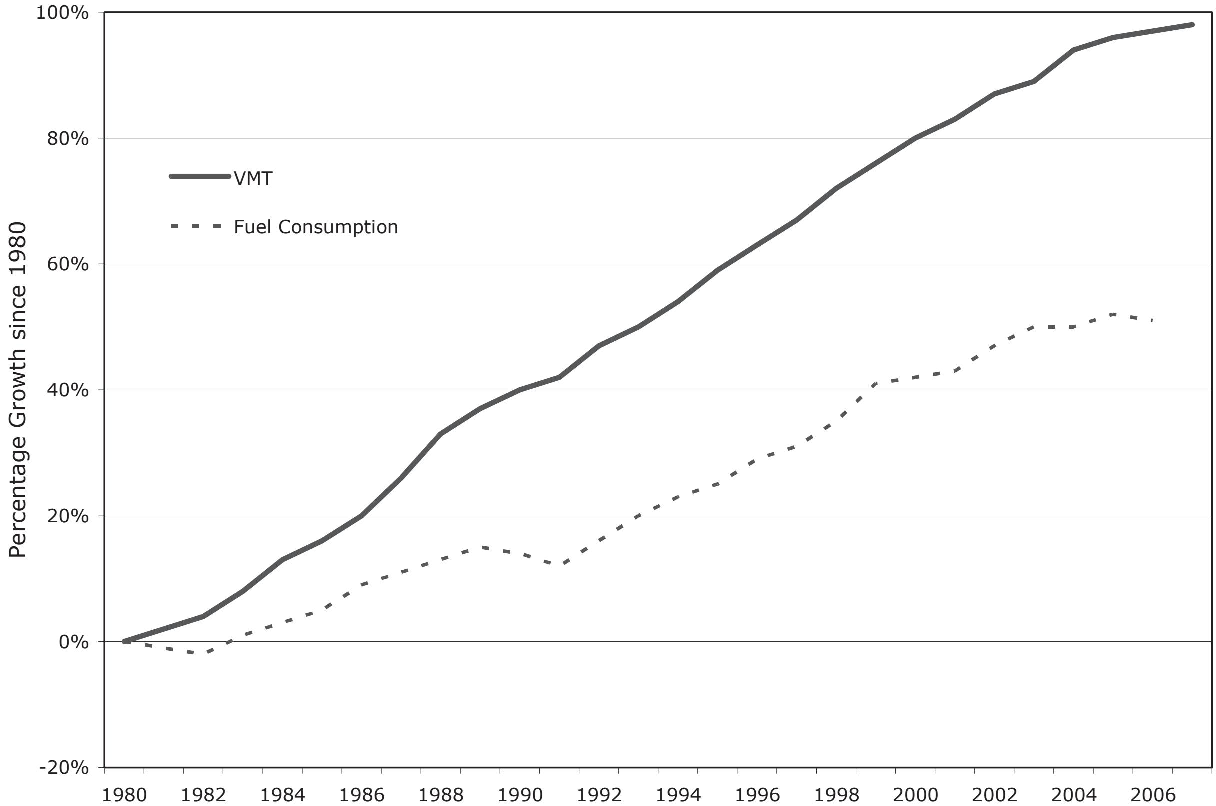
If one potential benefit of making a transition to VMT fees is maintaining and increasing revenues to support transportation, an essential first step to identifying VMT-fee options is considering the levels of revenue to be raised. As will be shown in this chapter, the growth of national VMT levels has outpaced growth in fuel consumption over the past several decades. Generally speaking, the amount of fuel-tax revenue raised per mile of travel has declined over time. To forecast future trends, the research team considered factors that may influence future VMT, available VMT-forecast data sources, and methods that states might use to forecast VMT-fee revenue. A forecast of the future revenue stream resulting from an initially revenue-neutral replacement of federal fuel taxes with VMT fees beginning in 2015 illustrates such a method.

2.1. Past Trends in VMT and Fuel Consumption

Over the past several decades, as population, incomes, and the number of cars in the United States have increased, so too has fuel consumption risen. VMT, however, has grown at a much faster rate. This is due, in large part, to federally mandated corporate average fuel economy (CAFE) standards, first enacted in 1975, which have required gradual increases in the average fuel economy of cars and trucks sold in the United States (BEES 2002). As the average fuel economy of vehicles on the road has increased, the fuel tax revenue per mile of travel has decreased correspondingly. This is not the only factor to undermine fuel taxes – inflation is the other main culprit – but its effects are significant.

Figure 2.1 illustrates the percentage growth in VMT and fuel consumption from 1980 to the present. As the figure demonstrates, fuel consumption has increased by about 50 percent over this period, while VMT has almost doubled. Should this trend continue, as many expect that it will, the efficacy of fuel taxes for raising sufficient transportation revenue will continue to decline in the coming years.

Figure 2.1. Historical Growth in VMT and Fuel Consumption



Sources: FHWA (2007 Table 5.2.1), ORNL (2008 Table 2.7)

2.2. Factors Influencing Future VMT

Forecasting future VMT, and in turn VMT fee revenue, is inherently difficult. Aggregate travel is affected by a broad range of factors, including the health of the economy, the size of the population, the price of fuel, the average fuel economy of the fleet, and the supply of roadways (which in turn relates to the level of congestion on the roads). Some of these factors can be predicted with relative confidence; for example, population trends are relatively stable and are not subject to major sudden swings. On the other hand, oil prices are notoriously difficult to predict, and have historically fluctuated greatly over short time periods. This makes it quite challenging to accurately forecast future VMT.

Forecasting VMT is further complicated because the relative importance of these factors may vary depending on the type of travel. For example, passenger VMT may be more sensitive to changes in the price of fuel, while truck VMT may be more sensitive to changes in the economy. Commute trips may be less elastic than shopping trips, because people have less leeway to forego trips to work even if gas prices rise considerably. Since not all VMT reacts in the same way to changes in the underlying factors, it can be hard to predict the overall impact.

Finally, there could be major paradigm shifts over the longer-term future that change these relationships in ways that would be difficult to predict. For years it was almost an article of faith that VMT rose annually—until 2008, when oil prices spiked and VMT declined for the first time since records have been kept. This added new data to our understanding of the relationship between fuel prices and VMT, which has historically been relatively inelastic. Similarly, while most retired people drive considerably less than when they worked, the Baby Boom generation is the first to grow up with widespread dependence on automobiles, and they are living longer and healthier lives than their predecessors Predicting their behavior based on that of previous generations may thus prove misleading. The imposition of VMT fees—or, alternatively, more aggressive pricing of carbon emissions—would also change the cost of travel, in turn producing an entirely new variable that would affect VMT. The degree of the effect would depend on the specific rate structure—a policy decision rather than an independent factor. It is well beyond the scope of this research to assess such potential paradigm shifts, but these examples imply that forecasts based on previous experience are uncertain at best.

The preceding points suggest three important considerations relevant to the forecasting of future VMT-fee revenue.

- First, the base VMT estimates should account for, among other possible factors, changes in population, in the economy, in fuel efficiency, and in the price of fuel.
- Second, given inherent uncertainty in the underlying factors that influence VMT, reliance on point estimates of future VMT is not advisable. Rather, it would be helpful to examine alternate future scenarios to understand the potential range of future VMT, and in turn the range of revenue.
- Third, for any given forecast of future VMT, it is important to include a feedback mechanism to understand how the imposition of VMT fees may change the cost of travel, and in turn total VMT. This may be less crucial for a simple per-mile charge set to replace fuel taxes on a revenue-neutral basis, but it could have a considerable effect, for example, if mileage-based congestion tolls were widely applied (these could significantly alter the cost of travel, and in turn VMT and revenue).

2.3. VMT Forecast Data Sources

This research does not develop VMT forecasts, but rather analyzes existing forecasts. Two federal agencies prepare national forecasts of VMT: the Federal Highway Administration (FHWA) and the Energy Information Administration (EIA). As discussed above, long-term forecasting is risky and there is no guarantee that these VMT forecasts, used in this research to develop estimates of future VMT-fee revenue, will prove to be accurate. But these represent the most authoritative VMT forecasts available, and the federal government currently relies on these forecasts to support policy decisions and revenue projections.

FHWA VMT Forecasts. FHWA develops 20-year VMT forecasts based on data from the Highway Performance Monitoring System (HPMS), which samples traffic flow on about 116,000 road segments throughout the country. States are responsible for reporting sampled data on the segments within their jurisdiction and forecasting how the traffic flows on those segments will change in future years. FHWA then integrates current and future flow predictions on the segments and uses the information to forecast future VMT across the entire road network. The most recent forecasts from FHWA, available in the 2006 Conditions and Performance Report (FHWA 2006), are several years out of date. While FHWA typically provides its forecasts aggregated for over all vehicles at the national scale, it has in the past provided estimates broken down by state and classified by urban and rural roads (GAO 2002).

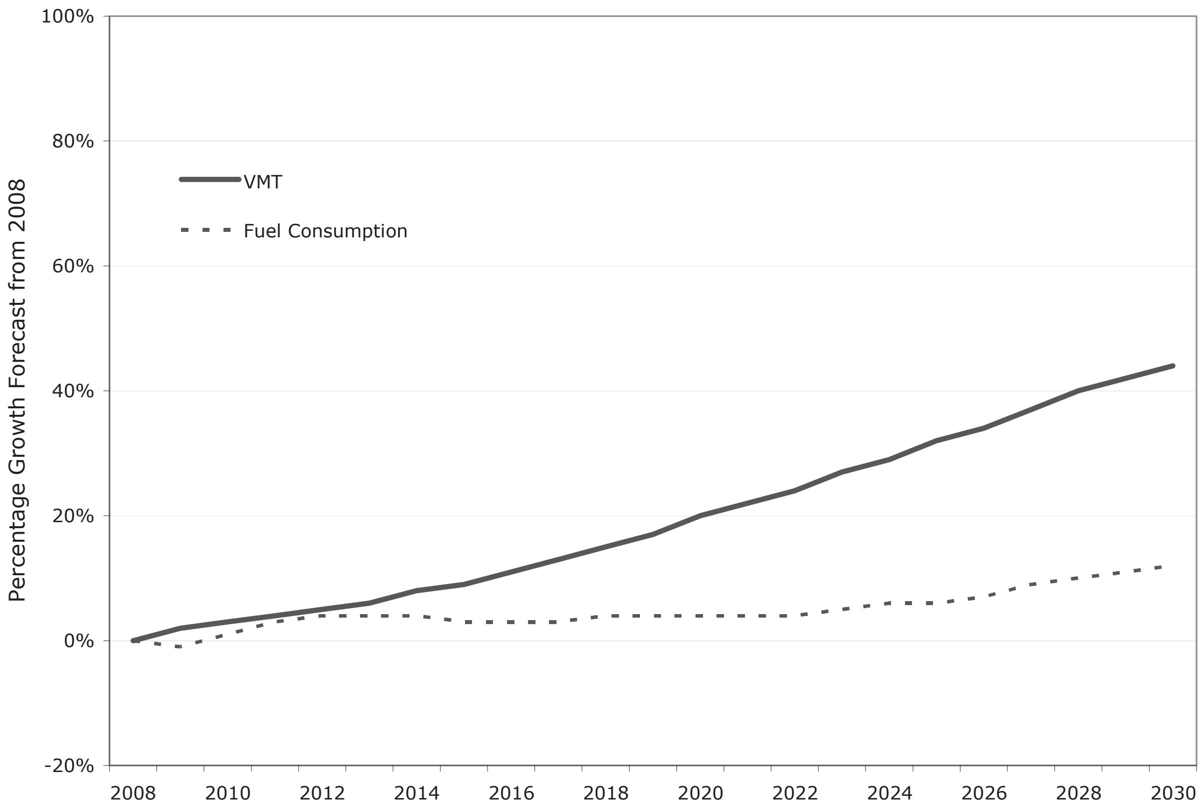
When considering the rigor of FHWA VMT forecasts, there are several important points to make. First, the road segments included in HPMS may not constitute a representative sampling of all roads. While the segments remain constant, sample bias can creep in over time if traffic volumes on some segments increase or decrease more rapidly than the average. States are supposed to update samples if they are not capturing a stratified random sample of functional classes and traffic volume. There is thus some difficulty in interpolating between travel on the sampled segments and travel across the entire road network. Second, FHWA does not provide strict guidance to the states in terms of the methodology for forecasting future travel on the road segments, except to state that they "should come from a technically supportable State procedure or data from MPOs or other local sources [and that] HPMS forecasts for urbanized areas should be consistent with those developed by the MPO at the functional system and urbanized area level" (FHWA 2005, p. IV-38). While some states may develop sophisticated models that incorporate predicted changes in population, the economy, fuel prices, and fuel economy, others may simply perform linear extrapolation based on recent trends. These issues make it difficult to suggest, as a general rule, that all states could rely on HPMS data to develop accurate statewide VMT forecasts.

EIA VMT Forecasts. EIA also develops VMT forecasts, as part of an integrated suite of models (the National Energy Modeling System, or NEMS) aimed at predicting future energy consumption and prices. EIA's forecasts are informed by FHWA numbers, but also take into consideration predicted trends in population, the economy, fuel prices, and fleet-wide fuel economy. Moreover, the influence of these factors within the models is allowed to vary for different types of vehicles (e.g., trucks vs. passenger cars), as theory would suggest.

Despite this rigor, there are two challenges to the use of EIA's VMT predictions within the context of forecasting VMT revenue at the state level. First, though EIA's VMT forecasts are broken down by different vehicle classes (light-duty household vehicles, fleet vehicles and freight trucks), they are not disaggregated to the state level; rather, they are only available at the national level. Second, although EIA may evaluate different modeling scenarios during the analysis stage, they routinely publish point estimates for future VMT rather than ranges (EIA 2009).

In addition to VMT forecasts, NEMS is also used to forecast fuel consumption. Figure 2.2 graphs EIA's NEMS forecasted growth for both VMT and fuel consumption in percentage terms from a base year of 2008. Note that despite the distinctions in methodology, FHWA's HPMS-based VMT forecasts are roughly similar to those of EIA. A key distinction, however, is that the most recently published FHWA data are several years out of date and thus do not account for the recent downturn in fuel consumption resulting from the spike in fuel prices followed by the severe economic recession. As a result, FHWA VMT forecasts are slightly higher than EIA VMT forecasts, though they follow a parallel trajectory. Figure 2.2 shows only the EIA forecasts, as they are more recent.

Figure 2.2. EIA Forecasted Growth in VMT and Fuel Consumption



Sources: EIA (2009 Tables 45, 60, 65, and 67)

Comparing the two forecasts in Figure 2.2, one can see that growth in VMT is expected to continue to outpace growth in fuel consumption over the forecast horizon. This reflects the expectation that more fuel-efficient conventional vehicles, along with alternative fuel options, will achieve greater market penetration in the years to come.

2.4. Options for Forecasting State VMT-Fee Revenue

The process of forecasting VMT-fee revenue can be broken down into two stages: forecasting VMT, then applying a VMT-fee rate (which may in turn influence VMT). The research team first considered several options for developing state VMT forecasts using the data sources discussed above, and then applied VMT fees to forecast revenue.

Leveraging the above data sources, there are several methodologies that states could pursue to forecast VMT at the state level. The forecasting methodology should, if possible, account for the range of factors that may influence VMT, and also allow for the generation of multiple future scenarios to reflect uncertainty.

- **HPMS-based forecasts.** States with sophisticated modeling capacity could utilize HPMS data as a basis for developing their own VMT forecasts. Currently, states are required to forecast VMT on the specific sampling segments within the HPMS system, not for the road network as a whole, so this would constitute an extension of current practice. Though representing a significant amount of work, an advantage here is that states would be able to perform multiple modeling runs to examine whatever scenarios they would like to consider.

- **Extrapolation from national EIA forecasts.** The idea here would be to begin with EIA national forecasts and then extrapolate state forecasts based on the current percent of national VMT that occurs within each state. The current breakdown of VMT by state can be found in Table VM-2 of the Highway Statistics Series (FHWA 2007). As an example, 2007 data indicate that of 3.049 trillion VMT nationwide, Alabama accounted for 61.41 billion VMT, or 2.03 percent of the national total. To derive future VMT forecasts in Alabama, then, the state would simply multiply EIA's national forecasts by 2.03 percent for each year over the forecast horizon. To enable states to consider alternate future scenarios, EIA could publish multiple forecasts based on different assumptions about future changes in population, the economy, fuel prices, and fleet-wide fuel efficiency. If this is not possible, states could simply make upward or downward adjustments by, say, 10 percent to examine the revenue implications. Note that inherent in this approach is the assumption that the share of national VMT for a given state will remain roughly constant in the coming years. If states have reason to believe that their share of VMT will either increase or decline relative to the nation as a whole, they could choose to examine either more optimistic (from a revenue perspective) or pessimistic VMT forecast scenarios.
- **Forecasting state VMT through use of EIA models.** A final option that might be considered would be for EIA to share its modeling structure with states so that they could perform their own analyses at the state level. (The research team did not explore whether this would be possible). The models are complex, so this would require considerable investment on the part of states; on the other hand, this would also provide states with significant modeling flexibility and rigor.

Once VMT forecasts have been generated, the next step is to predict future VMT-fee revenue. This must account for two factors: (a) how the VMT fee will be structured, and in turn how that will influence the cost of driving, and (b) how VMT will be affected by changes in the cost of driving. The latter can be determined by examining the *elasticity* of travel demand with respect to changes in the cost of driving. Considerable research on this question has been conducted; see, for example, the reviews presented by Litman (2008) and Goodwin, Dargay, and Hanly (2004). One useful measure is the elasticity of VMT with respect to changes in the price of fuel, which may be used to evaluate, for instance, the effect on VMT that would result from increasing or decreasing fuel taxes (see, for example, Sorensen 2006). In similar fashion, the effect of replacing fuel taxes with VMT fees could be approximated as a change in the price of fuel.

Based on our calculations (described in more detail at the end of this chapter), it appears that an initially revenue-neutral replacement of fuel taxes with flat VMT fees would have very little dampening effect on VMT over the forecast horizon, even though VMT is expected to grow faster than fuel consumption during this period. This is because changes in the price of fuel have only a modest effect on changes in VMT (our review of the research suggests that the expected elasticity is about -0.29 over the long term), and fuel taxes only account for a small share of the price of fuel. On the other hand, if the VMT fee structure included some form of congestion pricing, this could increase the cost of travel significantly, and the effect on VMT would likely be much more dramatic. Calculating such impacts would have required much more detailed modeling, beyond the scope of the current research project.

2.5. A Simple Illustration of VMT Revenue Forecasting

To illustrate the potential effects of replacing fuel taxes with VMT fees, the research team developed several forecasts of federal VMT-fee revenue and compared them to forecasted motor fuel tax revenue. The work began with setting the VMT fee for the first year, 2015 (the near-term transition year envisioned in this research) to a level that would generate revenues for that year equal to those forecast for motor-fuel tax revenues. Based on EIA fuel-consumption forecasts for 2015, federal revenue from motor fuel taxes of 18.4 cents per gallon for gasoline and 24.4 cents per gallon for diesel would total about $35.7 billion in 2015. (All dollar values in this section are in unadjusted 2009 dollars.) Assuming that all vehicles would pay the same per-mile rate under a system of VMT fees, the fee would need to be set at 1.1 cents per mile ($35.7 billion divided by 3.23 trillion VMT in 2015) to be initially revenue neutral. Forecasts of future VMT revenues were then made under four scenarios:

- VMT fees remain at 1.1 cents per mile.
- VMT fees remain at 1.1 cents per mile, but VMT grows at a rate 10 percent lower than projected by EIA.
- VMT fees remain at 1.1 cents per mile, but VMT grows at a rate 10 percent higher than projected by EIA.
- VMT fees are set at 0.8 cents for cars and 3.4 cents for trucks, reflecting the differences in current contributions to fuel tax revenues.

Obviously, many more scenarios would be possible. For example, the base per-mile rate might be increased in future years, or additional forms of pricing – varying the per mile rate by time and location, or varying the rate for trucks based on vehicle weight – might be introduced. Such scenarios would, however, have required much more complex modeling beyond the scope of the study. The research team therefore focused on VMT-fee scenarios with a simple rate structure that remains constant over time.

EIA fuel consumption forecasts were also used to project motor fuel tax revenues. Here two scenarios were created:

- Fuel taxes remain at current levels over the entire forecast period
- Fuel taxes are increased by five cents per gallon (for both gasoline and diesel) in 2015 and then remain constant over the forecast period (note that the value of five cents was selected, after some trial and error calculations, to achieve roughly the same revenue as a 1.1-cents-per-mile VMT fee by 2030).

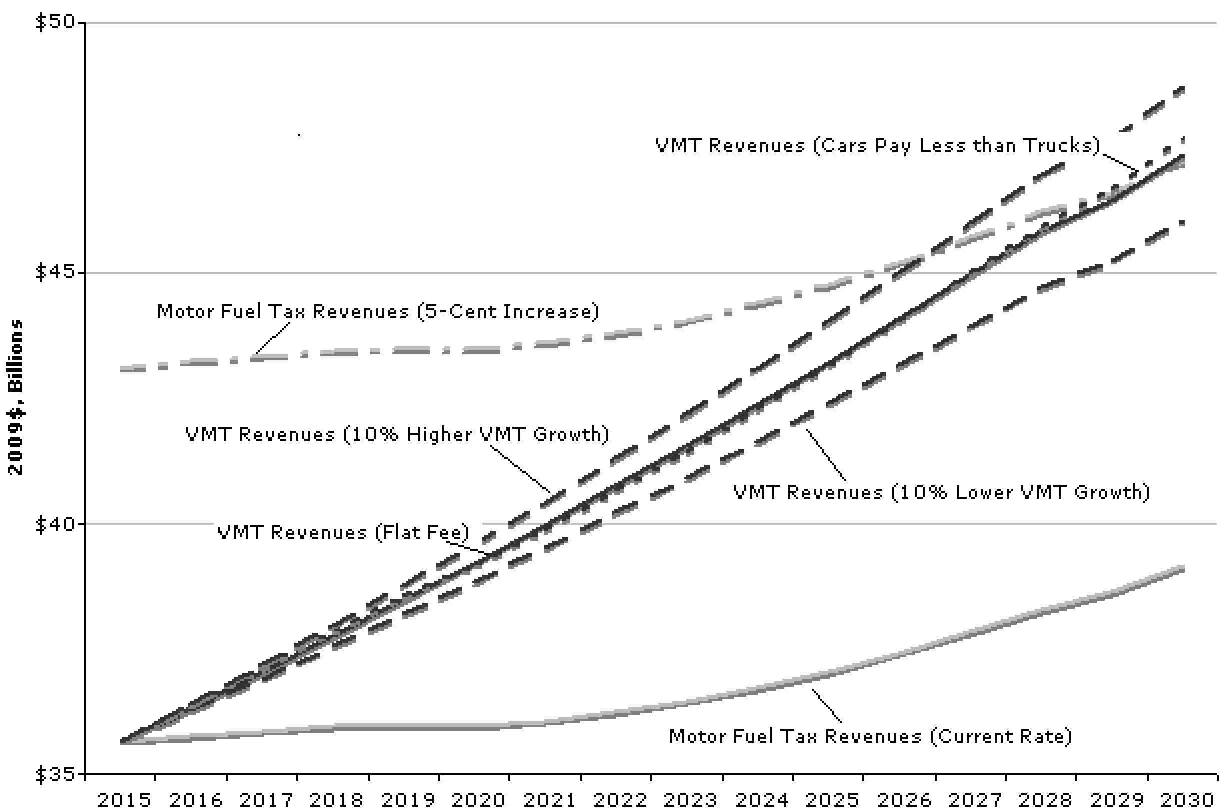
Comparisons of the four VMT fee and two fuel tax revenue forecasts are provided in Table 2.1 and Figure 2.3. The analysis shows that in the absence of a fuel tax increase, an initially revenue-neutral switch to VMT fees will likely produce approximately 20 percent more revenue by 2030, even if growth in VMT is 10 percent lower than the median projected. Increasing fuel taxes by five cents per gallon (to 23.4 cents for gasoline and 29.4 cents for diesel) could produce revenue in 2030 similar to that forecast for VMT fees.

Table 2.1. Illustrative National VMT-Fee Revenue Forecasts

Scenario	2015 Revenue (2009 $B)	2030 Revenue (2009 $B)	Growth 2015 - 2030
Motor fuel taxes at current rates	$35.7	$39.2	10%
Motor fuel taxes with five-cent increase	$43.1	$47.2	10%
VMT fees (flat fee, 1.1 cents)	$35.7	$47.4	33%
VMT fees (flat fee, 10% lower VMT)	$35.7	$46.1	29%
VMT fees (flat fee, 10% higher VMT)	$35.7	$48.7	37%
VMT Revenues (cars less than trucks)	$35.7	$47.7	34%

Sources: Computed by authors based on data from EIA (2009 Tables 45, 60, 65, and 67)

Figure 2.3. National VMT Fee Revenue Forecasts



Sources: Computed by authors based on data from EIA (2009 Tables 45, 60, 65, and 67)

As Figure 2.3 shows, a 1.1-cent VMT fee would results in approximately $7 to $9 billion in additional revenue in 2030, without adjusting for inflation. It is beyond the scope of this paper to project future expenditures, so it is difficult to say whether this would be sufficient to meet the country's transportation needs. However, given that the needs may well be greater, and that VMT may decline due to any number of factors as discussed above, it is entirely possible that instituting a revenue-neutral shift from fuel taxes to VMT fees will not prove sufficient to meet future needs. Fees may therefore need to be raised in the future, presenting the same political challenges as raising fuel taxes. Alternatively, VMT fees could be varied – for instance, charging a higher rate for driving more heavily polluting vehicles or for driving in congested areas during peak periods – to raise additional revenue while simultaneously addressing other policy goals.

The research team also calculated an additional adjustment to EIA's forecasted VMT to account for the fact that over time, driving would become more expensive with a VMT fee than with a gas or diesel tax. VMT would most likely decrease slightly, all things being equal, as driving becomes more expensive. The calculation began with AAA's estimate of the average fuel price in late 2008 of $2.30 per gallon. Of this, 18.4 cents, or roughly 8 percent, corresponds to the federal fuel tax (note that EIA's fuel price forecasts suggest that this will increase only slightly – by a few cents per gallon – over the forecast horizon). To account for how the replacement of the federal fuel tax with VMT fees would affect that cost over time, 18.4 cents was subtracted out the of federal fuel taxes and added back the cost of the VMT fee, expressed in per-gallon terms given expected fleet fuel economy. This led to what might be viewed, in effect, as a slight increase in the cost of gas (more precisely, a change in the cost of gas minus federal fuel taxes plus federal VMT fees). Finally, a long run elasticity of -0.29 was applied, suggested by the studies examined by Litman (2008), to account for the degree to which this effective change in the cost of fuel would reduce VMT. In aggregate, the effect was negligible, dampening VMT and in turn VMT-fee revenue by only about 0.2 percent by 2030. Given that this change was so small, it is not incorporated into the VMT-fee revenue estimates in Table 4.1 and Figure 4.1.

3. RELEVANT PROGRAMS, PROPOSALS, AND STUDIES

The concept of distance-based user fees has received considerable attention over the past decade, with examples spanning the range from preliminary research and pilot projects to planning and full-scale implementation. At least three factors have motivated a heightened level of interest. First, the challenges associated with declining state and federal fuel tax revenue have grown acute, motivating a willingness on the part of decision makers to consider innovative funding options (note that while transportation funding regimes are different in other countries, many face comparable funding shortfalls). Second, technological advances have enabled a broad range of electronic tolling options offering the potential to develop new forms of road pricing not possible in decades past. Third, as the problems associated with auto-dependency – traffic congestion, sprawling patterns of development, dependence on foreign sources of oil, and the threat of climate change – have become more severe, decision makers and analysts have grappled with a wide range of strategies for reducing auto use and promoting less energy-intensive transportation alternatives. There now appears to be a growing recognition that the means of financing transportation can have significant influence over such outcomes.

To elaborate on this last point, if drivers are charged more for traveling during the peak hours, many will choose to shift their travel times or travel by some other mode, thus helping to reduce traffic congestion. In a similar vein, if drivers are charged for the level of harmful pollutants that their vehicles emit, there will be a strong financial incentive to purchase more environmentally-benign vehicles, thus helping to improve air quality. As a final example, many automotive costs that are currently fixed – such as insurance and leasing costs – could be charged on a per-mile basis instead. This would provide additional incentive for reducing automotive travel (or, to be more precise, to limit automotive travel to an economically rational level).

Taking stock of planning efforts, pilot tests, and programs implemented in recent years, one can discern three broad categories of distance-based pricing concepts that may offer insights in the technical and administrative design of a VMT-based system for road use charges. The examples within these categories may also yield important insights into a range of technical, political, administrative, and legal obstacles that would need to be overcome in order to implement distance-based road use fees. The three categories are as follows:

- **General-purpose distance-based road use charges.** Examples in this category involve the application of distance-based road-use charges that would apply to all light-duty vehicles (e.g., passenger cars), and potentially apply to trucks as well.

- **Weight-distance truck tolls.** Conceptually similar to the previous category, the key distinctions here are that (a) the charges only apply to heavy trucks, and (b) the per-mile rate varies by some measure of vehicle weight to account for road wear.

- **Pay-as-you-drive (PAYD) insurance/leasing.** Automobile insurance and leasing costs are often fixed, structured as a set price for a fixed period of time (e.g., $1000 per year for insurance). The idea behind PAYD insurance and leasing is to vary these costs on a per-mile basis such that the less one drives, the less one owes.

The remainder of this chapter looks at each of these categories in greater detail, listing for each some of the best known examples and discuss policy goals, pricing structure (as a function of policy goals), technical implementation options, enforcement approaches, administrative structures, and public acceptance concerns. Note that Appendix A provides brief summaries for many of the cases referenced in this chapter; for additional discussion, see Sorensen and Taylor (2005, 2006).

At the end of the chapter is a summary of several high-level findings that emerge from the review of existing programs, proposals, and studies. More detailed insights regarding specific technical and administrative design issues are deferred to subsequent chapters that focus on those topics.

3.1. General-Purpose Distance-Based Road Use Charges

Distance-based systems for levying road use charges that would apply to all vehicles on the road have yet to be implemented, but more limited systems do exist. In New Zealand, for example, a system of distance-based road use charges that applies to passenger vehicles that do not pay fuel taxes (principally diesel-powered vehicles) as well as vehicles weighing in excess of 3.5 tons has already been instituted (Land Transport NZ 2008). The idea of developing more robust and flexible distance-based road-use charging systems, however, has received considerable attention in recent years.

Examples. Well-known examples in this category include:

- Oregon Department of Transportation Road User Fee Pilot Program (Whitty 2003, Whitty 2007, Whitty 2008)
- Puget Sound Regional Council Traffic Choices Study (PSRC 2008)
- University of Iowa Mileage-Based Road User Charge study (Forkenbrock and Kuhl 2002, Forkenbrock 2006, Kuhl 2007, Kuhl 2009a)
- Georgia Tech “Commute Atlanta” study and trials (Guensler and Ogle 2004)
- The Netherlands proposal (Alternative Payment for Mobility Project Team 2008)
- The New Zealand road user charge (Land Transport NZ 2008, New Zealand Ministry of Transport undated)

Policy Motivations. One of the central motivations underlying this idea is to develop an eventual replacement for motor fuel taxes that would provide more stable and sustainable revenue over time. A second motivation stems from the observation that by varying the per-mile charge according to certain vehicle characteristics (e.g., axle weight or emissions class) and travel characteristics (e.g., time and location of travel), it would be possible to create a set of financial incentives that would support a broad range of policy goals such as reducing traffic congestion, road wear, and harmful emissions (Forkenbrock and Kuhl 2002, Whitty 2003). In the New Zealand program, the goal is simply to capture road use charges for vehicles that do not pay fuel taxes (Land Transport NZ 2008).

Pricing Variations. At a minimum, proposals and programs in this category involve levying road use charges on the basis of distance traveled. Depending on the program or proposal, the specific rate could vary with such factors as vehicle weight, vehicle emissions class, vehicle fuel-economy, jurisdiction of travel (enabling different jurisdictions to set their own rates), or specific time and location of travel (to charge more for peak hour travel on congested routes).

Technical Implementation Options. The most sophisticated proposals and trials make use of in-vehicle units (also known as on-board units, or OBUs) equipped with global positioning system (GPS) receivers and digital maps to enable charge rates that vary with such factors as jurisdiction, route, and/or time of travel. Because a GPS signal is not always available (e.g., in a tunnel or in an area with many tall buildings), such systems often rely on a redundant means of metering mileage (e.g., a connection to the on-board diagnostic port or the odometer feed) and then use the GPS signal principally to determine the location of the mileage. Several electronic options for communicating billing data have been considered, including the use of "smart cards" (data cards that could be removed from the OBU and then used to upload billing data via the internet or via conveniently located card-reader stations), short-range wireless communications (e.g., communications with an electronic reader device at the fuel pump), and longer-range wireless communications (e.g., cellular communications with a central billing agency). The New Zealand program stands as an outlier with respect to technical complexity; because the sole goal is to account for miles traveled and only a subset of vehicles must pay the charge, the billing system relies on manual inspections (odometers for passenger vehicles, hub-odometers fitted to vehicle tires for trucks).

Verification and Enforcement Options. Common to the more sophisticated technical configurations is the idea of ensuring that the OBU is tamper-resistant – i.e., that it can't (at least not easily) be temporarily disabled to avoid charges. At the more extreme end, one could wire the system such that the vehicle would not be operational unless the OBU is also operational. Such an approach, however, could lead to a range of unintended consequences (e.g., disabling a vehicle if the device breaks down or is accidentally dislodged). The more common approach, therefore, is to design the OBU with a certification seal affixed during the installation process and ensure that the device cannot be disabled without breaking the seal. Enforcement then becomes a matter of verifying that the seal has not been broken through periodic inspections. Beyond the tamper-resistant OBU concept, additional options include manually verifying that the mileage count on the OBU aligns with a vehicle's odometer reading and setting up road-side or overhead communications devices that electronically query a vehicle's OBU to ensure that it is functional. In the New Zealand example, the approach is again much simpler. Vehicle owners subject to distance-based road use fees are required to pre-purchase blocks of mileage, and law enforcement officers can stop drivers and verify that the current odometer reading does not exceed the miles that have been purchased.

Administrative Options. Two broad administrative options have been considered. The first is to expand or modify existing revenue channels. In the approach developed by Oregon, for example, road use fees would be added, and fuel taxes subtracted, with the purchase of fuel (vehicles not yet equipped with mileage metering devices would continue to pay fuel taxes). Funds would then flow through existing administrative channels, though some additional complexity would be required to reconcile the amount of fuel taxes paid at the point of wholesale with fuel taxes debited at the retail level (Whitty 2003). The second option is to create a new entity that would collect and distribute revenues. This option becomes especially appealing, perhaps necessary, if the program is intended to span multiple states or apply on a nation-wide basis. In principal, the entity could be structured as a public agency, a non-profit organization (perhaps involving a compact among states, similar to IRP and IFTA), or a private firm. Some have argued that allowing the function to be fulfilled by a private or non-profit entity could (a) improve the efficiency of collecting and distributing funds across multiple jurisdictions, and (b) allay to some extent privacy-related concerns regarding government access to detailed information about the driving patterns of individuals.

User Acceptance Concerns. Several user acceptance concerns arise with proposals to institute mileage-based user fees. First, with the use of GPS, there is concern that the government would be able to monitor and track the location of individual drivers, a perception often reinforced by poorly-informed press accounts. In fact, existing technical proposals have incorporated strategies to protect private data (for instance, transmitting information about the total bill owed but not data about the time or location of travel – see Forkenbrock and Kuhl 2002), but it appears that further public education and outreach efforts would be needed to convey this fact. Second, environmental advocates have argued that a flat per-mile fee, in comparison to existing fuel taxes, would reduce the incentive to purchase more fuel-efficient vehicles. This, of course, could be addressed by varying the per-mile fee based on vehicle characteristics such as weight or fuel-economy. More generally, it is not clear that a significant portion of the electorate understands the motivations for switching from fuel taxes to a mileage-based system of fees, making the political prospects for such proposals less promising absent considerable outreach efforts. For example, there is little evidence to suggest that the public recognizes any shortcomings of the gas tax as an adequate mechanism for funding transportation. It may be necessary to present to the public generally a better developed analysis of why the gas tax will not work in the future before a shift to an alternative funding system would be acceptable.

3.2. Weight-Distance Truck Tolls

Weight-distance truck tolls are not a new concept, and many states have in the past instituted this form of road-use charges. Previous programs were implemented through cumbersome manual means, however, and only four states currently levy weight-distance road use fees. Within the past decade, though, several European nations have successfully implemented weight-distance truck charges through the use of electronic tolling technology, and this has stimulated a renewed interest in the concept.

Examples. Well-known examples in this category include:

- The Austrian GO program (Schwarz-Herda 2004)
- The Swiss Heavy Goods Vehicle Fee (HVF) program (Balmer 2004, Werder 2004)
- The German Toll Collect program (Kossak 2003, Rothengatter 2004, Rothengatter and Doll 2002, Ruidisch 2004)
- The United Kingdom proposal (Worsley 2004)

- The Oregon concept (Whitty and Svadlenak 2009)

Policy Motivations. A principal motivation for the application of weight-distance road use charges is to capture and allocate the maintenance costs associated with heavy truck travel (Rothengatter and Doll 2002). Additional motivations include automating (streamlining) the collection of road use charges for trucks (apparent for example with Oregon's proposal to convert its manually-implemented weight-distance truck toll to an automated program leveraging current electronic tolling technology), ensuring that foreign trucks pay the same road use charges as domestic trucks (Worsley 2004)), stimulating a freight mode shift from trucks to rail (Werder 2004), and providing an incentive for adopting less-polluting trucks (Rothengatter and Doll 2002).

Pricing Variations. At minimum, weight-distance truck tolling programs account for the distance of travel as well as some measure of weight (although axle-weight may be the most appropriate measure in this regard, most existing programs employ such surrogates as total laden weight or number of axles). Only vehicles above a certain weight must pay the charges (in Switzerland, for example, the lower limit is 3.5 tons; in Germany, the lower limit is 12 tons). Beyond weight class, these programs may also vary the per-mile charge on the basis of such factors as vehicle emissions class or the type of road on which travel is taking place. Note that some programs only price travel on the main highway network (Schwarz-Herder 2004), while others encompass the entire road network (Werder 2004). The German program initially priced travel just on the highway network, but has subsequently priced travel on some adjacent surface streets to eliminate the incentive for trucks to divert to local roads so as to avoid tolls.

Technical Implementation Options. At the simpler end of the spectrum, the Austrian program employs an in-vehicle transponder that communicates with overhead gantries on the highway network to register the charges owed (Schwarz-Herder 2004). This approach works from a cost perspective because only the highway network is subject to tolls; if the program applied to all roads in Austria, it would be prohibitively expensive to install the required infrastructure. The more technically sophisticated implementations rely on GPS. In the Swiss case, the odometer is used to measure mileage, while GPS is used to determine whether or not the travel occurs within Swiss borders (the fees are not differentiated by road type, so greater precision is not required – see Werder 2004). In the German case – by far the most sophisticated – GPS is used to distinguish the specific route of travel, as some roads are tolled and others are not (Rothengatter 2004). The German program also relies on cellular communications for uploading billing data. Note that all of the European examples also have paper-based alternatives that can be used to assess tolls for trucks lacking the necessary in-vehicle equipment (this typically applies to foreign trucks that don't frequently travel in the country where the charge is applied).

Verification and Enforcement Options. Two common approaches have been employed to verify compliance with weight distance truck tolls. The first is to set up gantries with devices that query, via dedicated short range communications (DSRC), passing trucks to verify that their in-vehicle equipment is functioning properly. Non-compliant vehicles can either be pulled over and cited by law enforcement agents, if available, or electronically identified via automated number plate recognition (ANPR) systems (cameras and software capable of reading license plates) and subsequently cited by mail. The second is to ensure that the in-vehicle devices are tamper-resistant – that is, that a driver will not be able to temporarily disable the device without being caught in a subsequent inspection (inspections might be performed during random roadside checks or on a periodic basis, e.g. once per year).

Administrative Options. Existing weight-distance truck tolls have been developed with both public and private administration strategies. In the Swiss case, the HVF program is administered by the Swiss Customs Agency, with enforcement support from the Swiss Cantons. The Oregon proposal is another case in which administrative functions would likely be supported by a public agency. In both the Austrian and German cases, in contrast, a private firm (or consortium of firms) performs, for a fee, the operational aspects of program administration.

User Acceptance Concerns. Generally speaking, the application of weight-distance truck tolls has resulted in higher road use charges for trucks. To succeed politically, it has therefore been necessary to ensure that the trucking industry also sees some benefits from the program. In the Swiss case, trucks were allowed to carry heavier loads over the Swiss Alps in order to facilitate more efficient goods movement operations (Balmer 2004). In the German case, revenues were dedicated to maintenance and enhancement of the highway network, and rates were structured such that truckers could reduce the charge by up to 50 percent by upgrading to the least polluting vehicles (Rothengatter 2004). With the U.K. proposal, one of the pre-existing concerns for domestic truckers was that their foreign counterparts could purchase fuel in other countries with lower fuel taxes and then conduct business in the United Kingdom, gaining a cost advantage. By developing a weight-distance truck toll that would apply to both domestic and foreign truckers operating in the United Kingdom, the playing field would be leveled (Worsley 2004). It is noteworthy that even though GPS components are used in several of the existing weight-distance truck tolls, privacy issues have not emerged as a significant concern, in part because the trucking agency is already subject to a stricter regulatory regime than passenger vehicles.

3.3. Pay-As-You-Drive (PAYD) Insurance / Leasing

The PAYD insurance concept appears to be gaining significant traction, with many companies in the United States and abroad either offering or experimenting with this concept. Note that some examples are more aptly described as mileage-based discounts, in which the rates depend, for example, on whether a vehicle travels between 0 and 2,500 miles in a year, between 2,500 and 5,000 miles in a year, between 5,000 and 7,500 miles in a year, etc. Even in such cases, however, it is still necessary to meter miles of travel. Though PAYD leasing – that is, varying the lease payment on the basis of miles traveled – has also been explored, to our knowledge this related concept has yet to be implemented.

Examples. Implemented programs in this category include:

- Massachusetts, multiple companies offering mileage-based insurance discounts (Bingham 2009, Boston Consumer's Checkbook undated)
- GMAC, offering mileage-based discounts for OnStar customers in 34 states (OnStar 2007)
- MileMeter, offering PAYD insurance in Texas (MileMeter undated)

- Progressive Insurance, offering PAYD insurance in nine states (Donohue 2008, Progressive Insurance undated)
- Aviva, offering PAYD insurance in Canada (Bettencourt 2005, Insurance-Canada 2005)
- CoverBox, offering PAYD insurance in England (CoverBox undated).
- Hollard Insurance, offering PAYD insurance in South Africa (Hollard Insurance undated)
- Nedbank, offering PAYD insurance in South Africa (Nedbank undated)
- Real Insurance, offering PAYD insurance in Australia (Pay As You Drive undated)

There are additional companies offering PAYD insurance in Austria (Uniqa), Belgium (Corona Direct), Germany (DVB Winterthur, Swiss Re, and WGV), Israel (Aryeh), Italy (SARA), Japan (Aioi), Netherlands (STOK and Polis Direct), and Spain (MAPFRE), though the research team was unable to gather much information in English about these programs. There are also many examples of deploying in-vehicle equipment to monitor driver risk factors (e.g., speed); if these did not also encompass a pay-as-you-drive feature, they were not included in the review.

Policy Motivations. Programs in this vein are privately operated, and the decision to offer PAYD insurance is, at root, a market-based decision. One can infer, then, that insurance firms believe that an appreciable number of drivers may value the opportunity to lower their insurance bill in return for driving fewer miles. It is also the case, however, that PAYD insurance programs can yield important public benefits (e.g., reducing traffic congestion and pollutant emissions by creating a financial incentive to drive less), so this concept has enjoyed support from the public sector as well. In California, for example, legislation was recently enacted to allow insurance firms operating within the state to offer PAYD insurance options.

Pricing Variations. PAYD insurance programs, at minimum, vary the cost of insurance on the basis of distance traveled (with PAYD insurance, the rate is structured on a per-mile basis; with mileage-based discounts, distance is measured in more aggregate terms). It is also typically the case that rates will vary based upon demographic characteristics of the insured driver such as age, gender, and residential location. In a number of programs, rates vary by the time of travel as well. For instance, the per-mile rate may be higher when driving during rush hour or late at night than when driving during off-peak daytime hours. In relatively few cases, the rates also vary based on such additional risk related factors as the speed of travel.

Technical Implementation Options. All of the programs reviewed in this study appear to rely on one of three options: the odometer, an OBU connected to the on-board diagnostics (OBD-II) port, or an OBU equipped with a GPS receiver. Programs in which the rate varies solely by driver characteristics and miles traveled tend to rely on the odometer, as this is the cheapest option (in terms of equipment costs) to deploy. If the rate also varies with such factors as time of day or speed of travel, it becomes necessary to make use of an OBU equipped with either OBD-II connection or a GPS receiver. As the latter involves more expensive equipment, programs employing GPS-equipped devices often leverage the technology to offer additional value-added services such as pinpointing location for road-side assistance or tracking stolen vehicles. With regard to collecting mileage data, the odometer-based systems rely on periodic (e.g., once per year) checks of the odometer. More sophisticated systems often employ cellular communications to automatically upload mileage data to the insurance provider, facilitating a monthly billing cycle.

Verification and Enforcement Options. Odometer-based systems do not generally involve verification and enforcement activities beyond periodic odometer checks. For more technically complex programs involving in-vehicle equipment, efforts are made to ensure that the device cannot be temporarily disabled (e.g., through the use of a certification seal which, if broken, would indicate that the equipment has been tampered with).

Administrative Options. All of these programs are implemented and administered privately. In terms of how payments are structured, three main options exist: (1) monthly payment depending on the amount of usage, similar to a utility bill; (2) standard scheduled payments (monthly, quarterly, etc.) with adjustments based on mileage; and (3) pre-payment of a fixed number of miles or for a certain period of time.

User Acceptance Concerns. Because enrollment in PAYD insurance programs is optional, there are no major user acceptance concerns. It is noteworthy, however, that many of the programs rely on GPS equipment, suggesting that the privacy-related concerns often associated with such technology may be lessened (at least for some drivers) by the knowledge that more detailed travel information is being monitored by a private firm rather than by the government. Another potential explanation is that even if privacy concerns persist, motorists are willing to set aside those concerns for the chance to save money on their insurance bill.

3.4. Summary of Observations

Reviewing the existing program, studies, and proposals in the areas of general-purpose distance-based road use fees, weight-distance truck tolls, and PAYD insurance, several high-level observations emerge:

- **A broad array of metering mechanisms are feasible.** Options range from simple odometer readings to sophisticated in-vehicle equipment featuring GPS to determine the time and location of travel. All of the options have been demonstrated as feasible, either in existing programs or trial tests.
- **Metering capabilities vary considerably across the options.** Simpler metering mechanisms are only capable of metering total miles, while more sophisticated options can determine the time of travel, the jurisdiction in which travel occurs, and even the specific route of travel.
- **Desired policy goals influence technology choice.** Intended policy goals imply a minimal set of metering capabilities (e.g., to levy congestion tolls, it is necessary to meter the time and location of travel). The choice of technology, therefore, will inevitably be based, at least in part, by the policy goals that underlie the program.
- **There are no "low cost" options that can be easily verified and enforced.** The only low cost option observed in this study involves self-reported odometer readings, and this mechanism is difficult to verify or enforce. Other options require either official odometer

inspections (entailing high operational costs) or sophisticated in-vehicle equipment (entailing high capital cost).

- **Concerns over privacy remain a significant barrier to the use of GPS equipment to support general-purpose VMT fees.** Existing proposals and trials have taken significant steps to ensure that the privacy of travel data can be protected (Forkenbrock and Kuhl 2002, Whitty 2003), but the perception that GPS will be used to track and monitor travel remains a potent public concern. Beyond education and outreach, factors that may help overcome privacy concerns include (a) providing the opportunity to save money through use of the equipment (e.g., with pay-as-you-drive insurance), and (b) using the GPS technology to provide additional user features (e.g., navigation, real-time route-specific traveler information).
- **For weight-distance truck tolls, industry concerns center on the distribution of costs and benefits.** In many cases, trucking costs would rise with weight-distance truck tolls. To forestall strong stakeholder resistance, existing weight-distance truck tolls have been structured with additional features that benefit the trucking industry – for example, allowing larger truck loads in certain corridors (Balmer 2004), leveling the playing field with foreign competition (Worsley 2004), and dedicating the resulting revenue to highway investments that will benefit truckers (Ruidisch 2004).
- **Drivers respond to price signals.** Existing trials and programs demonstrate that drivers do respond to price signals embedded in the rate structure. Charging more for peak hour travel in busy corridors, for instance, will encourage drivers to shift their travel to other times or routes of travel (PSRC 2008, Whitty 2007), while charging a higher rate for more polluting vehicles will stimulate more rapid adoption of less polluting vehicles (Ruidisch 2004). The implication is that the concept of leveraging a system of VMT fees to achieve other policy goals has merit.

4. STATE PERSPECTIVES

As indicated in the prior chapter, many potential mechanisms could be employed to develop a national system of VMT fees. Some, however, would likely require significant support from the states. For example, to levy VMT fees based on odometer readings, states might be called upon to perform odometer inspections and collect VMT charges on behalf of the federal government.

It is not clear, however, that all states would be eager to support efforts to levy VMT fees. To gain greater insight on state perspectives and concerns as well as state-level implementation issues, the research team interviewed officials in four states: Texas, Minnesota, South Carolina, and Vermont (note that the research plan initially called for interviewing five states; however, officials in one state department declined to be interviewed, and it did not prove possible to set up interviews with an alternate state within the available time). The goal in selecting these states was to achieve diversity with respect to geography, size, international borders, and institutional arrangements for the departments that register motor vehicles. The researchers also obtained written responses to our set of questions from project panel members representing four additional states: Oregon, California, Virginia, and New York. The list of questions, provided in Appendix B, addressed such issues as current vehicle registration processes, vehicle inspections, license plate production, methods for collecting fuel taxes, and attitudes and concerns about VMT fee implementation.

For additional insight on possible models of state support for federal road use revenue programs, the questionnaire addressed state procedures to verify motor carrier payment of the federal Heavy Vehicle Use Tax (HVUT). The research team also asked about state experiences with the International Registration Plan (IRP) and the International Fuel Tax Agreement (IFTA), programs with an institutional structure that might serve as a model for the collection and apportionment of VMT fees among states. Both IRP and IFTA are compacts administered by non-profit entities to deal with fees and taxes paid by motor carriers. Motor carriers pay registration fees in a base state, where the vehicle is registered, and pay fuel taxes in the states where they purchase fuel. The states and Canadian provinces who are members of IRP and IFTA have agreed that the revenues collected should be apportioned among all states in which the vehicles operate, based on records submitted by motor carriers of their mileage driven by state. Otherwise, the concern is that trucks would register and buy fuel where rates are lowest and higher-tax states would incur costs related to truck damage of roadways without sufficient revenues to address those issues.

IRP and IFTA share a basic institutional structure: individual states and provinces are members, and they make up the boards that govern the organizations. States also pay membership dues to IRP and IFTA. While the federal government has encouraged states to join these organizations, there is no federal involvement in their operations. The main difference in their operations is that IRP operates a clearinghouse whose function is to apportion the revenues accurately among states. Instead of each state making individual payments to other states, states pay into a centralized clearinghouse that calculates payments. IFTA does not have an equivalent system operating, although the New York State DOT provides a similar service called the Regional

Processing Center to 16 member states. In order to understand these organizations better, the interviews also included an Indiana state official who serves as the current chair of IRP.

4.1. Summary of State Agency Responsibilities

Table 4.1 summarizes the organization of different revenue collection and enforcement functions in the states included in the interviews. For passenger vehicles, the table lists the agencies responsible for administering fuel taxes, vehicle registrations, and vehicle inspections for safety and emissions (note that not all states conduct inspections). For motor carriers, this section provides brief descriptions of how the states currently deal with IFTA, IRP, and HVUT.

Table 4.1. Organization of State Revenue and Enforcement Functions

State	Passenger Vehicles			Motor Carrier Vehicles		
	Fuel tax	Vehicle Registration	Vehicle Inspection	IFTA	IRP	HVUT
MN	Revenue	DVS (Public Safety)	none	DVS (Public Safety)	DVS (Public Safety)	DVS (Public Safety)
TX	Comptroller	VTR (DOT)	DEQ/Public Safety	Comptroller	VTR (DOT)	VTR (DOT)
VT	DMV (VTrans)	DMV (VTrans)	DMV (VTrans)	DMV (VTrans)	DMV (VTrans)	DMV (VTrans)
SC	Revenue	DMV (Ind Agency)	none	DMV (Ind Agency)/DOT	DMV (Ind Agency)/DOT	DMV (Ind Agency)
OR	DOT	DMV (DOT)	DEQ	DOT	DOT	NA
CA	BOE	DMV (BTH)	BAR	BOE	DMV	DMV
VA	DMV (Ind Agency)	DMV (Ind Agency)	DEQ/State Police	DMV (Ind Agency)	DMV (Ind Agency)	DMV (Ind Agency)
NY	Tax Deot	DMV (Ind Agency)	DMV (Ind Agency)	Tax Deot	DMV (Ind Agency)	DMV (Ind Agency)

Notes:
An agency in (parentheses) is the parent agency. A slash indicates shared responsibility of some type. "Department of" is implied.

Abbreviations:
BAR = Bureau of Automotive Repair
BOE = Board of Equalization
BTH = Business, Housing, and Transportation
DVS = Driver and Vehicle Services
Ind Agency = Independent Agency (stand-alone)
VTR = Vehicle Titles and Registration
DEQ = Dept of Environmental Quality
VTrans = Vermont Agency of Transportation
NA = not available

As the table shows, these responsibilities are divided differently in each state. Vehicle registration is consistently handled by a department of motor vehicles, which may be an independent agency or housed within another state agency.

4.2. Overview of State Interview Results

This section discusses key findings from interviews with individual states. The following section distills key themes and issues that arise based on all of the interviews conducted.

Minnesota. Minnesota collects fuel tax revenues through the Department of Revenue but IFTA is handled by the Driver and Vehicle Services (DVS) Division of the Department of Public Safety. DVS also collects passenger and truck registrations. While this is a state function, 173 entities throughout the state, both public and private, are designated "deputy registrars," meaning that they can collect passenger vehicle registration fees. They are allowed to keep the $4.50 processing fee, which the state adopted in the 2004-05 fiscal year based on an analysis of collection costs. Almost three-quarters of registration payments to DVS are made through such deputy registrars.

The passenger vehicle registration system was described as "fragile," and expensive and difficult to re-program when fees change. It dates back to the 1980s and cannot communicate electronically with other computer databases. Running queries to obtain data from the system requires programming, which raises the concern that the entire system will crash. DVS is in the first of a four-year project to update this system.

In contrast, the IRP database is web-based and takes in about 40 percent of its transactions online. It is run by a third party contractor (the system has been contracted since 1990) and they are satisfied with the arrangement. Over 3000 user IDs have been issued, many to the agents that handle IRP filings for the carriers.

Texas. Texas' Vehicle Titles and Registration (VTR) Division is part of the Texas DOT. Unlike many DMVs, they work only on the vehicle side and do not issue drivers' licenses. The counties are responsible for collecting all passenger vehicle registration fees, some of which they are allowed to retain for their own transportation funding needs. The counties have the option to levy some additional fees for child safety, roads and bridges, and insurance verification, but these fees are all under $10 (the state legislature limits the amounts that counties can charge). The system of county retention of fees is convoluted but evolved to allow some county retention of funding.

The current passenger registration system is old and has several limitations: it is difficult to add new fields, transactions are processed in batches, and it is difficult to locate a record without a vehicle identification number (VIN). VTR does not have enforcement authority if owners fail to register their vehicles, but they conduct outreach to encourage registration.

All counties have a safety inspection but only 17 counties conduct emissions inspections. Odometer readings are recorded and entered in a database called TAVIS that the Department of Public Safety implemented in August 2007. However, they are not linked with the VTR vehicle registration database.

The Texas IRP, a server-client based system, was implemented in November 2006. This database is much more "user-friendly" and can easily accommodate changes in fees. Just over half of truck registrations are processed online. The database can also track audits and verify HVUT payments. IFTA processing, which is handled by the Comptroller's office, is contracted out to the Regional Processing Center (RPC) operated by New York State. Texas still processes applications, billings, and so forth, but RPC handles the funds netting.

Vermont. Vermont's Department of Motor Vehicles (DMV) is housed at the Vermont Agency of Transportation. DMV is responsible for all fuel tax collections and vehicle registrations for both passenger and motor carriers, as well as vehicle inspections. For passenger vehicles, registration is largely a state function but some town clerks are authorized to process renewals and retain a fee for doing so. Passenger vehicle registrations vary by fuel type (gas, diesel, and other), with "other" fuels types costing nearly double ($104.25 for other fuel, $60 for gas, and $20 for diesel).

The DMV described their 38-year-old passenger vehicle registration system, as "antiquated," relaying on batch processing and a mainframe system. A new online system, called V-Drive, is expected to begin operations in 2010. That project required 3.5 years and an outside consultant's review of DMV's business processes to implement.

DMV conducts annual vehicle inspections in a decentralized system, with 1,600 authorized stations. Odometer readings are collected by the mechanics but the system is still paper-based, so they are noted in a paper log and on the registration sticker. They are not tracked in the registration database or made available to third parties.

While it has not considered RFID technology for license plates, DMV in February 2009 began issuing drivers' licenses with an RFID chip. Drivers may choose this option (it is not mandatory) so that they can use their driver's license as a border-crossing card with Canada.

South Carolina. The South Carolina Department of Motor Vehicles is a separate state agency. Vehicles owners pay two types of fees: a state DMV flat vehicle registration fee (generally $24 for cars) and a county ad valorem tax based on the value of the vehicle, determined by age and mileage. Counties determine the taxes and send the annual tax bills, on which the bi-annual registration fees are included. All counties can collect the registration fee, which is returned to the state; 22 of 46 counties can issue the renewal decal to the vehicle owner for an additional $1 fee, which the county retains. Vehicles are renewed every two years.

The DMV implemented a new passenger vehicle registration system in 2002, after a business process re-engineering. The new server-client system was described as flexible and able to process transactions in real-time. The DMV is also beginning to discuss tracking alternative fuel vehicles, more for statistical purposes in looking at safety issues. They are also planning to implement a new system for IRP in 2010 that will be integrated with the title/registration system as well as the IRP Clearinghouse; currently, these transactions are still processed manually.

Oregon. Oregon's DMV collects bi-annual registration fees, with new vehicle registrations good for four years. Vehicle registrations are recorded on a mainframe computer, which is difficult and costly to reprogram. Registration fees are low ($108 for the first four years), so there is a continuing problem with residents of neighboring states trying to register vehicles in Oregon.

Oregon is the only state in the country to have a weight-distance tax for motor carriers instead of a tax on diesel fuel. Oregon participates in IFTA, to ensure that carriers based on Oregon pay the proper amount of fuel taxes to other states in which they operate.

Oregon's Department of Environmental Quality operates an emissions inspection program, but only in certain counties.

California. California's DMV, part of a larger agency that also includes the California Department of Transportation, collects a number of fees in addition to the registration fee: an ad valorem tax (temporarily raised to 1.15% in May 2009 from the previous 0.65%) and various miscellaneous fees for special programs. New car dealers, AAA, and other private entities also collect fees. The state has two "front-end" systems to collect fees, depending on the channel, and a "back-end" system that tracks fee collections and assigns revenues to the various agencies. While functional, these applications are over 20 years old and "cumbersome" to change.

In terms of enforcement, DMV transfers both passenger vehicle and motor carrier cases to the Franchise Tax Board (FTB) for collections. Also, DMV no longer issues Temporary Registration Authority to carriers unless IRP fees are paid. The Board of Equalization staff also cooperates with the California Highway Patrol on enforcement of tax payments, staffing inspection facilities at entry points to the state, including the Mexican border.

California has a biannual emissions inspection. While odometer readings are collected, they are not transferred to DMV or shared with other parties.

The DMV replaced its legacy IRP system with a new system in August 2008, which allowed the state to join the IRP Clearinghouse. The new system represents a "major improvement."

Virginia. Virginia collects a base registration fee in addition to several special fees ranging from 25 cents to $4. One city has a local vehicle registration fee as well, which DMV collects. Fees are annual, and vehicle owners can renew for one to three years. DMV commissions some agents as "DMV Selects" to perform some transactions. In some cases these DMV Selects process the transactions, while in others they simply collect fees.

The computer system is called the Citizen Services System (CSS) and it dates to 1993, after design work began in the 1980s. While it has good accounting controls, it does not encompass all DMV functions or meet its reporting needs. DMV is in the middle of redesigning the system. Changes to CSS are "cumbersome, difficult and costly."

Virginia contracts out its passenger fuel tax collections, along with IRP and IFTA, to a private contractor. This process is working well.

The annual inspections process is carried out by the State Police. Odometer readings are collected manually, but not entered into any central database.

New York. The New York DMV collects weight-based registration fees as well as plate fees, title fees, and vehicle use tax. Vehicles are registered for two years. Counties are authorized to collect fees on behalf of the state and can retain 12.7 percent of most transactions.

The DMV has eight different systems used to collect, track, or transmit vehicle registration fees. While all work "reasonably well," six of the eight were described as "moderately" or "very" difficult to change, for reasons ranging from multiple versions to limited staff support. The DMV uses a number of channels to collect fees but has not calculated the cost of collection. The systems used to support IRP and IFTA both work well. New York State also operates the Regional Processing Center, which processes IFTA transactions for 16 states. Since 2002, users have been able to use "IFTA e-file," a web-based application.

Gasoline and diesel taxes are both collected by the state's Tax Department. Fuel taxes are collected monthly from distributors upon importation into the state. New York has a weight-distance tax on heavy vehicles, but the state has not discussed the possibility of extending this to passenger vehicles.

New York has an annual state-wide inspections program. The DMV certifies private repair shops to perform the inspection. They collect odometer readings manually, which are sent to the DMV, but not maintained as part of the registration record.

4.3. Insights from State Interviews Relevant to the Development of a Nationwide System of VMT-Based Road Use Fees

A number of potentially relevant themes and issues became apparent during the course of the interviews. For organizational clarity, these are grouped in the following categories: current systems for passenger vehicles, current systems for IRP and IFTA, enforcement and evasion issues, attitudes toward VMT fees, and barriers and potential solutions.

Current Systems for Passenger Vehicles

- **Many passenger vehicle registration systems are antiquated and difficult to change.** Six states reported that their databases were several decades old and the technology did not function well. They are difficult to re-program when new fields need to be added or registration rates are changed. It can also be difficult to extract needed information; one DMV representative asserted that they need to write a program for every query they want to run. Another noted that their system is 38 years old. The third noted that their system is more vehicle-centric than driver-centric; it would be difficult to look up a record by name, but easy with a VIN. Most systems have an added component to allow online renewal by owners, but rates of online renewal tend to be around 5 to 10%. (While interviewers did not ask specifically about the use of each payment channel, one state reported 20%, saying that they thought the usual rate was 5-10%, while another state cited a figure of 8%.)
- **New systems are under development.** Four states reported they were in the process of developing new systems, generally a multi-year process. Desired capabilities include being web-based, having the ability to process transactions in real time (current systems generally rely on batch processing), and being able to connect electronically with other systems (such

as the IRP database). Vermont seems to be the furthest in development, with a new "V-Drive" system slated to become operational in 2010. South Carolina's new system was implemented in 2003, and they reported a high level of satisfaction with it.

- **Passenger vehicle registration fees are collected by a variety of entities, even in state-based systems.** Texas has a county-based system in which their 254 counties have the primary responsibility for fee collection. These counties can retain some of the collected fees either permanently (for their own road maintenance) or temporarily (to earn interest), although the formulas are somewhat complex. Texas counties can also subcontract fee collection to private companies. In South Carolina, all counties can collect registration fees for the state DMV, although only about half can process the full registration renewal. Counties in South Carolina also levy their own property taxes on vehicles, which are generally higher than the registration fees. In Minnesota, 173 entities (a mixture of local government and private businesses) serve as "deputy registrars," who can retain the processing fee but cannot charge additional fees. In Vermont, town clerks can process vehicle renewals. County DMV offices collect registration fees in New York. Virginia also deputizes 50-some "DMV Selects," or entities (mostly local governments, but some private businesses) to collect fees. Most states have automobile dealerships collect fees on newly sold vehicles.
- **Passenger vehicle registration evasion is not a particular problem.** Only California flagged in-state evasion as a concern, saying that their Highway Patrol reacts to citizen complaints and that the DMV refers delinquent fees to the Franchise Tax Board. South Carolina noted that many newcomers resist registering their vehicles, because the county property taxes are high, but enforcement is left to the counties. Oregon noted that they have some problem with non-residents registering their vehicles because their fees are low.
- **All states can identify alternative fueled vehicles, but some can do so more easily than others.** New York and Vermont both track this information directly; Vermont charges higher registration fees to alternative fueled vehicles, while New York does not. Both Texas and Minnesota said that if needed, they can identify alternative fueled vehicles registered in their states based on the VIN, even though there is no separate field to track fuel type. Minnesota said that programming to extract such data is complicated and that if they needed such information they would use a contractor. South Carolina is considering adding such information.
- **The per-transaction cost of collection varies.** Minnesota studied their costs of vehicle registration and determined that it costs $4.50 (averaged across all channels). The state currently has a $4.50 processing fee, based on this study. Virginia found an average of $13 for new registrations and $5 for renewals (also averaged); Virginia has been encouraging the use of less expensive channels. Vermont was able to provide very detailed information: $7.22 for a new registration, $3.22 for a counter renewal, $1.93 for online renewal, and $0.62 for their "lock-box" system, in which owners can send a check to a bank for deposit in the state's account. California and Oregon track these costs but did not provide figures. Texas, South Carolina, and New York do not track collection costs.
- **Odometer readings were not considered a viable option for VMT fees at the present time.** State officials noted several reasons for this. First, odometer information collection is influenced by the federal Truth in Mileage Act (TIMA). TIMA requires the collection of

odometer readings during title transfer, but only for vehicles less than 10 years old. So in some states, if an 11-year-old vehicle is purchased out of state, the state may never have an odometer reading for it. Second, the states interviewed either do not collect odometer readings on a regular basis, or if they do, the information is not electronically stored or readily available. Odometer readings are generally collected during vehicle inspections. The two states with inspections reported that the readings are not uploaded to the passenger vehicle database. However, it is possible that with new databases, the ability to collect, store and track odometer readings would be much improved. Third, some states with high through traffic were worried that odometer readings would not be able to distinguish in-state from out-of-state travel and would make a poor basis for developing a system to apportion revenue to states.

- **Vehicle inspection programs vary across states.** According to the Equipment and Tool Institute's 2007 National I&M Overview, 33 states have some type of vehicle inspection program. Six of the states interviewed had such programs, while South Carolina and Minnesota did not (both states had programs that were subsequently discontinued). Some inspections program are strictly for emissions, some for safety, and some both; programs can be centralized, decentralized, or a combination; programs can be annual or biannual; programs can cover the whole state or just specified areas.
- **License plate processes are mixed.** Seven states obtain license plates through some type of prison industry. Oregon indicated that they use a third party producer. Minnesota, Texas, Vermont, Oregon, Virginia, and New York are two plate states; South Carolina has one plate, and California issues two plates for most vehicles and one plate for large commercial vehicles and motorcycles. Minnesota replaces plates every seven years (state mandated), Texas every eight years (mandated in both rule and statute), and South Carolina every six years (state mandated) Vermont, Oregon, California and Virginia have no set schedule; owners replace them voluntarily. New York does not have a set schedule but is planning for a replacement cycle in April 2010. Only Texas could quote a total replacement cost: $24 million to produce 16 million plates (production costs, not administrative). South Carolina reported that it costs about $4 to produce and provide a plate; Virginia provided a figure of $4.70, and California $3.65. No state had studied the possibility of embedding an RFID chip in a license plate, although Texas may study this in the coming year. Several states noted that the addition of an RFID would require legislation, and California noted that it would be "controversial." Most states produce an embossed (raised letters and numbers) or flat plate; only Vermont has a debossed plate (depressed letters and numbers). It was not clear whether these production processes might allow for the embedding of an RFID chip.

<u>Current Systems for IRP and IFTA</u>

- **The databases to handle IRP and IFTA are generally more modern.** Minnesota, Vermont, and Virginia outsource their handling of IRP and IFTA to contractors, and reported that this has worked well. Texas has a web-based database that was considered very effective. Users can easily query it for information, and it serves as a repository of audit information. California replaced its IRP system in August 2008. South Carolina anticipates replacing its IRP system in 2010 with one that is linked electronically to their passenger database. New York operates the IFTA Regional Processing Center, which it described as "user friendly."

- **IRP and the IRP Clearinghouse received good reviews.** Three states were strong supporters, saying IRP (and IFTA) have eliminated a lot of unnecessary paperwork and generally function very smoothly. They believed this state-run structure would serve as a good model for an institutional structure. The IRP Clearinghouse currently does the "funds netting," or reconciliation of funds to be allocated between the member states for those members who participate. The Clearinghouse was called an "excellent time-saving enhancement" and "so very efficient." (According to the IRP web site, 51 of 59 member jurisdictions belong to the IRP Clearinghouse. South Carolina still processes IRP manually, and California's new mCarrrier system allows participation in the Clearinghouse.) The states still vary in their registration processes. According to the chair of the IRP Board, some states have registration processes so smooth that new trucks can be registered and "on the road" in less than an hour, while in other states the process takes six weeks.
- **IFTA reviews were more mixed.** Unlike IRP, there is not yet a national IFTA Clearinghouse to handle fund netting among the states, although one is under development. New York operates a Regional Processing Center, which fills some of this role for those 16 jurisdictions that participate. Texas, which participates, noted that the states still have to collect data to participate, but that RPC handles the funds netting. In two cases the DOT was skeptical about IFTA overall, although those same states' DMVs did not report complaints. One DOT official expressed concern that the IFTA monthly receipts were inconsistent and the system generally not very transparent. That state's DMV officials indicated that they understand the inconsistencies and do not find them problematic. Another DOT official complained about the cost, approximately $1 million, of processing IFTA, especially since that state sends out more funds than it receives. DMV officials in that state said they thought the cost was typical of other states, and the largest component is the mandatory audits.

Enforcement and Evasion Issues

- **Tax evasion and underreporting remains a problem with commercial motor carriers.** Two states mentioned in some form that they have continuing problems with inaccurate carrier mileage. As one state pointed out, the "cost of compliance" (i.e., having trained staff to ensure that documentation is accurate) is often lower than the cost of being caught with incorrect figures. The low audit rate (IRP and IFTA require that three percent of carriers be audited annually) means that many carriers take their chances with getting caught. Even when the inaccuracy in mileage reporting is not deliberate, mistakes are frequent, and one state reported that most audits find something wrong. While it is possible to file a fraud case against a carrier, it is a long and drawn-out process. No states reported any particular problems with respect to confirming the payment of the Heavy Vehicle Use Tax.
- **Diesel fuel tax collection is problematic in some states.** Two states discussed diesel fuel tax evasion as a major problem. Untaxed fuel for off-road use is dyed red so that it can be easily distinguished from taxed fuel. One state's enforcement allows their commercial vehicle inspectors to stop vehicles anywhere in the state and sample their fuel. They reported that they have collected "substantial" fines for diesel fuel tax evasion. Another state reported that they had recently decided to increase the number of inspections that their Highway

Patrol conducts because of a perception that their previous inspection rate was not sufficient. South Carolina mentioned that when they moved from collecting taxes form distributors to from terminals, they reduced the number of taxpayers from 2000 to 45, and increased collections by $20 million annually due to fewer opportunities for "slippage." However, no state mentioned passenger fuel tax evasion as a particular concern.

Attitudes Towards VMT Fees

- **VMT fees are seen as highly desirable, even inevitable, due to declines in fuel tax revenues.** Three states reported that there was legislative interest, or in one case interest from the governor, in VMT fee implementation. Texas said their revenues are down 2 percent, amounting to a shortfall of $90M to $120M. Minnesota said their fuel tax revenues, which had been rising at about 1.5 to 2 percent annually, have flattened out and even begun declining, despite a recent five-cent fuel tax increase. For their elected officials, this was the key factor in their VMT fee interest. For transportation professionals other potential system benefits, such as emissions reduction and congestion management, are important as well. Several states noted that it is difficult to raise the gas tax, and even difficult to pass legislation that indexes it.
- **State DOTs have been following the Oregon pilot program with interest.** Minnesota, which is currently preparing an RFP for a pilot project for summer 2009, thought that the pay-at-the-pump feature was very desirable. In part this was due to ease of implementation from the drivers' point of view, and in part because it would represent a similar cash flow model to the gas tax. They see their own pilot program as trying to go a "step beyond" what the Oregon pilot has already demonstrated, although they are still determining the parameters of their pilot program. Vermont liked the fact that urban and rural miles were charged at different amounts, and they thought a GPS system was the most realistic possibility. State DMVs in general were less familiar with the concept of VMT fees and offered fewer opinions about them.
- **States are waiting for the federal government to take the lead.** Four states said they assumed that implementing a VMT fee would have to be done at the federal level. Any changes involving technology to be built into new vehicles or anything involving roadway changes, would clearly need to be federal (the only alternative mentioned was that California might have the ability to set standards, the way it can set its emission standards separately from the federal ones). A state that decides to implement VMT fees on its own would "soon regret" that path, because of the potential for fraud (such as driving miles on one state but claiming them in another) if just one state adopts the fee. No state was interested in being the first to implement a VMT fee; they were interested in joining a larger system. One state objected to the concept of collecting a federally mandated fee, stating that it would require "significant" changes to existing processes, but others said they would find a way to comply. Most states expressed definite interest in being able to levy state fees as well.
- **States vary in their assessments of the necessary characteristics of a VMT fee system.** In one state, officials felt strongly that it would not be worth switching to a VMT-based fee unless it could track mileage by time of day, to implement some type of congestion pricing. They thought that the technological and political effort of changing systems to a flat fee was simply not worth it. A rural state reported that they were relatively unconcerned with

congestion, since it was not a major issue for them, but that the ability to measure whether travel was in- or out-of-state was of critical importance, since many of their drivers cross state borders daily. A third state also mentioned border issues, particularly since they have an international border.

- **A VMT fee should be mandatory, and co-exist with a gasoline tax.** One state mentioned that if drivers could make calculations about whether it would be cheaper for them to pay a gas tax or a VMT fee, they would naturally choose whichever is lower for them. Allowing this decision might lead to lower revenue collections overall, and possibly decisions by drivers to purchase lower-mileage vehicles, since such vehicles might result in lower VMT fees being paid. Therefore when a VMT fee is implemented it should be mandatory. However, gas taxes should still be collected, since there are a number of uses for gasoline that are not tied to road use (such as marine uses), and many states allot portions of gas tax collections to environmental quality purposes.
- **Appropriate technologies already exist.** Minnesota talked about its PAYD insurance experiment, which could serve as an interim step towards a VMT fee. Another official mentioned that his own OnStar-equipped car had extremely advanced capabilities.
- **Self-reporting of odometer readings or other data is probably not a good idea.** Several states noted their concern with errors and fraud if drivers are asked to report their own mileage, and said that the auditing required to ensure compliance would be extensive and burdensome. Others noted that the public might object strongly to a system that places a heavier burden on them. While taxpayers self-report under IRP and IFTA, this type of record-keeping is much less onerous for a business than an individual.
- **Alternative fueled vehicles are not a major issue now, but eventually they will be.** One state said that they often point to the use of electric vehicles as a reason for looking to VMT fees, even though such vehicles are still a very small part of the overall fleet. Another noted that such numbers can grow rapidly, and they must be accounted for in any new system.

<u>Barriers and Potential Solutions</u>

- **Privacy and legislative issues are the main barriers.** Almost all states asserted that privacy was a key concern for the public. One state mentioned that they had heard privacy concerns raised with red light cameras and highway information cameras, even the 911 telephone system. They were certain that once VMT fees were discussed in their state, privacy would be raised as a top concern. After privacy, legislative resistance was considered the most significant barrier, due to various factors such as existing bans on tolling and general opposition to any new taxes.
- **Privacy concerns might be addressed by third-party management of the collected data.** A state with a private contractor operating a HOT lane said that all data related to vehicle location remained with the contractor, even as revenues from tolling flowed to the state's account. These state officials noted that it might be possible to reduce public concerns about government access to personal data by having a private operator run the system. They noted that most people are not concerned with "Google or Amazon" having access to their personal data. However, an official at another toll road state said that the problem was the fear of data

being sold, which could be an issue regardless of whether it is held by the public or private sector.

- **Payment options may influence support.** Several states mentioned the issue of a lump-sum annual payment (for example, at the time of registration renewal) vs. periodic payments, such as at the pump. The consensus was that the public would be more opposed to a lump-sum payment, because it would be expensive and visible. A pay-at-the-pump system, like existing gas taxes, would be more palatable because it is paid in small increments. As one official noted, VMT fees will create a different set of winners and losers than the gas tax does, but drivers now don't know whether they are winners or losers because people do not know how much they pay in gas taxes every year.
- **Public education will be needed to develop support.** One state mentioned that an online article in the city's main newspaper, which only mentioned VMT fees, drew 300 "vitriolic" comments, mostly on the assumption that a VMT would charge Hummer drives the same as Prius drivers. That state is embarking on a major survey effort to see if providing educational materials on VMT fees will make any difference in public acceptance, when compared to a control group without such information. They felt that FHWA's surveys of pilot program participants were insufficient to measure public support.

5. EVALUATION FRAMEWORK

Several criteria will be helpful when evaluating the strengths and weaknesses of alternate options for implementing VMT fees. The development of this evaluation framework draws upon (a) the review of existing programs and proposals discussed in Chapter 3; (b) the interviews conducted with state DOT, DMV, MVA, and revenue agency officials discussed in Chapter 4; (c) and feedback and suggestions offered by the project panel and participants in the expert workshop conducted for this project. In the chapters that follow, this framework is applied in examining the different mechanisms for supporting VMT fees. (Note, however, that in the scope of this project, it has not been possible to provide a rigorous assessment for each criterion across all of the implementation mechanism; rather, the framework serves mainly as a helpful tool for guiding and organizing the assessment of strengths and weaknesses for each option.)

To set the stage for discussion of the evaluation framework, it is helpful to note that a simple VMT-fee system in which all vehicles are charged the same flat per-mile rate could serve the goal of raising sufficient revenue, provided that the per-mile charge is set high enough. To implement such a system, it would be necessary to measure or estimate the number of miles that each vehicle travels, but little additional information would be required.

In tandem with the goal of raising revenue, it would be possible to pursue additional policy goals by varying the per-mile charge based on certain vehicle attributes or travel characteristics. For example, the per-mile charge could be increased for more heavily polluting vehicles to provide a financial incentive for the purchase of less polluting ones. Likewise, the per-mile fee could be increased for peak-hour travel in congested corridors to provide an incentive for traveling at alternate times or by alternate modes in order to reduce congestion. Broadly speaking, the inclusion of additional policy goals leads to more sophisticated mileage metering requirements, so it is useful to classify potential VMT-fee implementation options with respect to their technical capabilities.

Beyond the question of technical capabilities, there are additional criteria by which to judge the advantages and drawbacks of alternate VMT-fee mechanisms. For instance, how much would the system cost to implement? Does the system allow for effective enforcement? Could the system be administered through existing agencies or would new institutions need to be developed? By assessing such criteria, it becomes possible to understand relative merits of alternate VMT-fee mechanisms that, from a technical perspective, are equally capable with respect to the metering requirements for a particular set of policy goals.

The remainder of this chapter first discusses the range of policy goals that a system of VMT-based road use charges might be designed to accomplish. Specific road-use metering capabilities that would be needed to support certain policy aims are then enumerated. The chapter concludes with a discussion of additional factors to be considered for understanding the relative strengths and weaknesses of alternate VMT-fee implementation options.

5.1. Policy Goals for Mileage-Based Road Use Pricing Structures

Road use pricing structures (e.g., a flat per-mile rate vs. a per-mile rate that varies by vehicle type vs. a per-mile rate that varies by time and location of travel) can be designed to foster a variety of policy goals. At a conceptual level, these can be grouped into three broad categories: raising revenue, apportioning road use costs among different user groups, and capturing externalities.

Note that the demarcations between these categories are not entirely sharp. For instance, pricing certain existing externalities will certainly boost revenue, and may also be helpful in apportioning road use costs among different user groups. Even so, this categorization is useful in helping to clarify the discussion. The potential policy aims falling under each of these categories are as follows.

Raising Revenue

- **Preserving or augmenting road use revenue.** Failure to raise motor fuel taxes with sufficient regularity to keep pace with inflation and fuel economy gains over the past several decades has led to growing shortfalls in transportation funding at the federal and state level (TRB 2005). The prospects for higher fuel prices, more fuel-efficient conventional vehicles, and the mass-marketing of alternate-fuel vehicles in the coming years will likely exacerbate the current funding crisis (Whitty 2003). At minimum, the goal would thus be to prevent further erosion in road use revenue, but ideally the hope would be to close the current funding gap.
- **Accurately apportioning road use revenue.** The goal here can be described as geographic equity; that is, ensuring that each state, and potentially each local jurisdiction, would be appropriately compensated for travel that occurs within its boundaries (or, alternatively, that any formula for allocating revenue among jurisdictions could at least incorporate an accurate accounting of mileage by jurisdiction). Absent accurate apportionment, it would be difficult to avoid the situation in which some states become "donors" (receiving less funding proportionate to the national total than they account for in revenue production) while others become "donees" (receiving more than their proportionate share).

Apportioning Maintenance Costs Among Different User Groups

- **Accurately capturing maintenance costs.** The amount of roadway damage caused by a vehicle depends on the weight of the vehicle (specifically, the axle-weight) as well as the engineering design standards of the road (generally speaking, freeways are designed to accommodate heavier loads than many surface streets). So, for example, a light passenger car traveling on a freeway imposes relatively little road wear, while a heavily laden truck with few axles traveling on a lightly-engineered surface street could do considerable damage. While the current system of motor fuel taxes leads to higher charges for heavier vehicles based on their lower fuel economy, there are still cross subsidies among different road user groups – between passenger cars and trucks, for instance, and between lighter trucks with more axles and heavier trucks with fewer axles (Small et al. 1989). The intent within this policy goal would be to account more precisely for the level of road damages caused by different vehicles and then structure the per-mile road use charges accordingly.

Capturing Externalities

- **Reducing congestion delays.** When roads become overcrowded, each additional vehicle imposes congestion costs on other travelers, leading to wasted time and wasted fuel. Failure to charge motorists for the delays imposed on others leads to grossly inefficient use of existing capacity, in turn artificially boosting the "need" for new roadway supply (Downs 2004). The intent of this policy goal would be to raise the per-mile cost of peak hour travel in crowded corridors to capture the cost of delays imposed on others. By creating a financial incentive for drivers to shift their travel patterns where possible, this could significantly reduce traffic congestion. It could also enable our existing roads to carry far more vehicles per lane per hour during peak periods (see, for example, Obenberger 2004), effectively shortening the length of rush hour traffic periods and reducing the perceived need for roadway expansion. As one member of the project panel pointed out, for congestion pricing to work motorists must be aware of the variable rates when they make their travel decisions. This could be achieved through several mechanisms – for example, posting current road use prices on variable message signs preceding facility entrance points, or displaying current prices on the in-vehicle equipment used to support VMT fees. Fees could even vary in real time with the level of congestion.
- **Reducing criteria pollutant emissions.** Motor vehicles account for a significant share of the so-called criteria air pollutants regulated by the Environmental Protection Agency under the Clean Air Act, most notably fine particulate matter, carbon monoxide, and ozone precursors such as nitrogen oxides and volatile organic compounds (Bae 2004). Criteria pollutants are known to harm human health as well as the environment. The idea in this potential policy goal would be to raise the per-mile cost of travel for vehicles with higher pollutant emissions as a means of encouraging more rapid adoption of vehicles with lower levels of emissions.
- **Reducing greenhouse gas emissions.** Motor vehicles also account for a sizable percentage of anthropogenic greenhouse gas emissions, although the quantity of emissions is tied more closely to the amount and type of fuel consumed than to the number of miles traveled. Even so, per-mile fees could be increased for vehicles with lower fuel efficiency in order to stimulate the demand for more fuel-efficient vehicles. In effect, this would be similar in nature to the current system of motor fuel taxes, which likewise increase the incentive to buy more efficient vehicles.

5.2. Road-Use Metering Capabilities to Support Policy Goals

The potential policy goals that a VMT-based system of road use fees might be designed to address require varying degrees of specificity with regard to vehicle characteristics and the amount, time, and location of travel (Sorensen and Taylor 2006). Key factors to consider include:

Base Mileage Metering Capabilities

- **Accurate mileage counts.** Given an intent to consider possible designs for a VMT-based system of road use charge, an ability to at least estimate mileage with reasonable accuracy must be presumed. Being able to calculate mileage with greater precision, while clearly desirable in general terms, is only judged necessary for policy goals under which the rates would vary by location, thus requiring accurate mileage counts by location. This would include the policy goals of accurately apportioning road use revenue (requires information about jurisdiction of travel), accurately capturing maintenance costs (requires information about the type of road on which travel occurs), and reducing congestion delays (requires information about the specific route or area of travel).
- **Full road network coverage.** Some system designs might be capable of measuring miles of travel on just a subset of all roads, such as the access-controlled highway network, while others would be able to measure mileage across the entire network. While generally desirable, full network coverage is particularly important for the policy goal of accurately capturing maintenance costs, where the damage done by a heavy truck will tend to be greatest on the road segments least likely to be included in a partial network – i.e., lightly engineered minor arterials and residential streets. On the other hand, full network coverage is not needed for the application of congestion tolls, given that the vast majority of traffic congestion occurs on a relatively small percentage of highways and major arterials.

<u>Specific Travel Characteristics</u>

- **Jurisdiction of travel.** To accurately apportion revenue it is necessary to capture mileage by jurisdiction – by state at minimum, and possibly by city or county depending on the structure of the program. Absent such information it is still possible to generate estimates of miles by jurisdiction and apportion revenue accordingly (consider, for example, the estimates of mileage by state in the HTF allocation formula), but the estimates will not be as accurate.
- **Type of road traveled.** The type of road traveled – particularly, its engineering characteristics – is a key determinant of the degree of road wear caused by a given vehicle, and is thus required for the goal of accurately capturing maintenance costs. Note that the most likely approach to the determination of road type would be to first identify the link on which travel is occurring and then ascertain the corresponding road type. From a technical perspective, then, determining the type of road traveled is just as difficult as determining the specific route traveled.
- **Route or location of travel.** Traffic congestion varies by location, so a system would need to be able to account for either the specific route or general location of travel to incorporate congestion-based per-mile fee offsets. Note that identifying the route of travel would enable facility-specific fee offsets, while identifying the broader area of travel (e.g., travel within a central business district, or CBD) would facilitate cordon pricing concepts similar to the programs in Singapore (Goh 2002), London (Santos and Shaffer 2004), and Stockholm (although these existing programs simply charge a fee on entering or exiting the cordon area; a VMT-based system could instead charge an elevated per-mile rate when traveling within the cordon area).

- **Time of travel.** Traffic congestion also varies by time, so this travel characteristic is also judged as a requirement for the policy goal of reducing congestion delays by charging higher per-mile fees for congested travel.

Specific Vehicle Characteristics

- **Vehicle fuel efficiency.** As noted earlier, greenhouse gas emissions vary directly with the amount and type of fuel consumed, and this in turn depends on factors such as the speed and flow of travel (for instance, unimpeded freeway travel is generally more fuel-efficient than stop-and-go city travel, although the reverse is true for hybrid vehicles with regenerative breaking). Based on a vehicle's fuel economy rating, however, one can develop per-mile fee offsets to roughly account for the externality of greenhouse gas emissions. If existing fuel taxes were entirely replaced by a system of VMT-based fees, then knowledge of the vehicle's fuel type and fuel efficiency would be required to support the policy goal of reducing greenhouse gas emissions.
- **Vehicle emissions class.** Criteria pollutant emissions vary based on a range of travel characteristics, including how many times an engine is started and stopped, whether the engine is hot or cold when it is started, and the speed and flow characteristics of travel. That said, vehicles can be classified according to their expected level of pollutant emissions (e.g., low emissions vehicles, or LEVs, and super ultra low emissions vehicles, or SULEVs), and such classifications can serve as a basis for adjusting the per-mile fee to approximate the social and environmental costs of criteria pollutant emissions. The ability to incorporate information about a vehicle's emissions class is therefore judged as a requirement for the goal of reducing criteria pollutant emissions.
- **Vehicle weight.** Damage to the roadbed depends on the type of road, as noted earlier, as well as the weight of the vehicle (specifically, the laden axle weight). Including this information within the structure of per-mile fees would therefore be required to pursue the policy goal of accurately capturing road maintenance costs.

Table 5.1 maps the policy goals presented earlier with specific metering requirements. As discussed in Chapter 7, different VMT fee implementation mechanisms differ considerably in their metering capabilities; therefore, the selection of a particular set of policy goals (beyond simply preserving revenue) limits the number of mechanisms that could be used to implement the system of mileage-based fees.

Table 5.1: Linking VMT-Fee Policy Goals to Road Use Metering Capabilities

Metering Capabilities	Policy Goals					
	Preserving or Augmenting Road Use Revenue	Accurately Apportioning Road Use Revenue	Accurately Capturing Maintenance Costs	Reducing Congestion Delays	Reducing Criteria Pollutant Emissions	Reducing Greenhouse Gas Emissions
Base Mileage Metering Capabilities						
Accurate Mileage Counts	Desirable	**Required**	**Required**	**Required**	Desirable	Desirable
Full Road Network Coverage	Desirable	Desirable	**Required**		Desirable	Desirable
Specific Travel Characteristics						
Jurisdiction of Travel		**Required**				
Type of Road Traveled			**Required**			
Route/Location of Travel				**Required**		
Time of Travel				**Required**		
Specific Vehicle Characteristics						
Vehicle Fuel Efficiency						**Required**
Vehicle Emissions Class					**Required**	
Vehicle Weight			**Required**			

5.3. VMT-Fee System Evaluation Criteria

Beyond the technical capabilities of a system for metering road use, which govern the feasibility of pursuing alternate policy goals, there are additional criteria that can be used to assess the relative merits of alternate VMT-fee implementation mechanisms intended to accomplish the same set of goals. Broadly, the issues of interest include the implementation costs, functional considerations, institutional considerations, and acceptability among users. Specific evaluation criteria include:

Implementation Costs

- **In-vehicle technology cost.** This describes the cost of any equipment that needs to be added to the vehicle to enable metering – including the equipment itself as well as the cost of installing the equipment (which is greater for certain technical configurations than others). This can generally be viewed as a start-up or capital cost rather than an ongoing cost, although it will be required each time a new vehicle enters the fleet.
- **Supporting infrastructure cost.** This refers to the cost of any additional infrastructure required to support metering efforts. Examples include electronic readers mounted on gantries over the road network or installed in fueling stations to communicate with the on-board metering equipment in cars. This can also be viewed as an initial capital cost.
- **Collections cost.** This encompasses the cost of transmitting mileage data, issuing bills, and receiving payment. At least some component of this cost will be ongoing.
- **Enforcement cost.** This refers to any additional cost above and beyond collections that is required to verify and enforce payment of mileage fees. At least some component of this cost will be ongoing.

Functional Considerations

- **Technology risk.** Many of the technical configurations considered in this report have been proven in existing programs or recent trials. A few, however, have yet to be demonstrated. This factor should be weighed when selecting a particular implementation mechanism – if it has not yet been proven, sufficient time and resources should be devoted to develop the technology to an implementation-ready level.
- **Ease of enforcement.** Some technical configurations would be easier to enforce, while others would be much more difficult. Lack of effective enforcement would create two significant problems. First, it would reduce the revenue stream, a key motivation for making the transition to VMT fees. Second, the perception that others might be able to cheat the system could lead to significant resentment among law-abiding citizens, dimming in turn the political prospects for adopting the system in the first place (Short 2004).
- **Flexibility/extensibility.** If the sole goal of a VMT-fee system is to preserve revenue, the technical approach can be simple (for example, reading a vehicle's odometer on an annual basis). If additional policy aims are intended or envisioned as possible future extensions, the system will require additional complexity. The purpose of this criterion is to consider

whether the system can support, if desired, more complex pricing structures in the future. If not, it may be necessary to upgrade the entire system at some future date – a costly and complex undertaking.

- **Accounting for all vehicle types.** Certain VMT-fee implementation mechanisms would not apply to all vehicles. For example, paying mileage fees at fueling stations would not account for electric cars, while in-vehicle technology requiring a connection to the OBD-II port would not work for vehicles produced prior to 1996. From a revenue perspective, charging all vehicles may not be strictly necessary, provided that the percentage of vehicles not covered by the system is small. Over time, however, it would be viewed as inequitable to charge some vehicle owners and not others. In practical terms, then, adopting a particular mechanism for levying VMT fees that does not accommodate all vehicle types would necessitate the development of parallel payment options for vehicles not covered by the primary system. This, in turn, would increase both costs and administrative burden.
- **Accounting for foreign vehicles.** The question of interest here is how difficult it would be to levy some form of road use charges for foreign vehicles traveling within the United States. The underlying assumption is that while a national system of VMT fees might require some type of in-vehicle equipment, foreign cars and trucks would not necessarily have that same equipment on board. If other countries – primarily Canada and Mexico – instituted the same form of VMT fees, this issue would be resolved.

<u>Institutional Considerations</u>

- **Administrative complexity.** This criterion focuses on the administrative difficulty to set up and operate the VMT fee system, including such factors as whether current agencies would need to be expanded or whether new institutions would need to be developed. A key issue here is the relative role of the states and the federal government. Broadly speaking, system designs that can be implemented at the national level (e.g., a central billing agency) may be easier to accomplish than system designs requiring a high level of support from all states (e.g. annual odometer readings as part of the vehicle registration process). The latter would involve processes that would need to be replicated 50 times, and some states may have difficulty passing any required legislation. Should a federal system of VMT fees be developed, some states would likely choose to make use of the system to levy their own VMT fees, while other states would decline this option. Any implementation option that requires the support and participation of states – whether or not they choose to levy state-level VMT fees – is therefore likely to prove problematic.
- **Legal barriers.** The purpose of this criterion is to assess whether there are particular legal issues that would make certain VMT fee mechanisms more difficult to implement. Options requiring enabling or conforming legislation in all states would likely prove more difficult to adopt.

<u>User Acceptability</u>

- **Burden on users.** The existing system of fuel taxes places minimal burden on users, as the taxes are simply added to the purchase price for fuel. Any new system that significantly increases the burden on users (e.g., requiring that users visit an authorized station for periodic odometer readings) would likely increase political resistance to the application of VMT-based user charges. This criterion then is critically important for all of the policy goals.

- **Audit trail.** For users to trust the system, they must be able to (a) understand how the charges are being applied, and (b) verify that they are not being over-charged.
- **Privacy concerns.** The importance of privacy concerns depends on the specific travel characteristics that would need to be metered, and that in turn depends on the policy goals embedded in the VMT-fee rate structure. For raising revenue and capturing criteria pollutant and greenhouse gas emissions externalities, all that is needed is information about the type of vehicle and the total number of miles traveled, so privacy concerns are relatively less important (or less relevant). More detailed information is needed for accurately apportioning revenue or accurately reflecting road maintenance costs, including travel by jurisdiction and travel by road type, so here privacy concerns are judged as being very important. Finally, the most detailed information – travel by time and by specific location or route – is required for the goal of levying congestion charges, and as a result privacy concerns may be of critical importance.

  In contrast to many existing forms of electronic tolling in the United States, which can be viewed as optional (i.e., a motorist can choose to an acquire an electronic toll tag, to pay manually, or to not use the tolled lanes or tolled facility at all), a nationwide system of VMT-based road-use fees would eventually become mandatory, and this heightens privacy-related concerns. Accordingly, many researchers have stressed the importance of addressing the privacy concerns associated with electronic road pricing in a satisfactory manner to gain greater public acceptance (Ogden 2001, Forkenbrock and Kuhl 2002, Whitty 2003).

  Briggs and Walton (2000) have outlined the types of privacy concerns that may arise with the application of intelligent transportation systems (ITS); many of these would apply for electronically-implemented VMT-based road-use fee systems as well. First, it is possible that the data may be shared for secondary purposes (e.g., marketing) that have no relation to road pricing. This issue is exacerbated by the fact that many entities operating in the United States (e.g., financial institutions) have the legal authority to share private data unless customers make an explicit request to keep their data confidential. Second, law enforcement may be able to make use of stored travel data to support traffic enforcement activities, such as the detection of speed limit violations. Third, detailed travel data may be used against a driver in the case of litigation; toll road operators have reported, for instance, that customer records are often subpoenaed in marital disputes. Fourth, it is possible that travel data may be linked with additional customer information (e.g. shopping and other expenditure habits) to develop much more detailed profiles of individuals and households. Fifth, there is concern that the data will not be stored in a secure manner and thus subject to security breaches.

  While not all citizens are especially concerned about these issues, many are. For example, Riley (2008) shows that the rate of FasTrak adoption in the San Francisco Bay Area has been lower than one would otherwise expect because at least some drivers place a higher value on privacy than on the convenience electronic toll payment. Based on survey results, ITS America (1998) reports that roughly 20 percent of Americans can be described as “privacy insensitive;” they do not think that technology threatens their own privacy, and in fact are more concerned that technological progress will be hampered by the privacy sensitivities of others. Another 55 percent can be categorized as “privacy pragmatists;” while they desire the benefits that information technology creates, they are also concerned about the potential harm from unauthorized and unexpected information use. Finally, 25 percent can be viewed as “privacy fundamentalists;” this group is concerned about all forms of information storage and gathering and believes that it should be kept to an absolute minimum. Given the fact that a reasonably large minority of the population appears to hold strong views regarding privacy, and that a distance-based road-use fee system would (at least eventually) be mandatory rather than optional, finding a way to protect private travel data may well prove necessary to gain sufficient political support for a transition from fuel taxes to VMT fees.

- **System security.** Closely related to privacy concerns is the issue of system security – preventing unauthorized parties from accessing for nefarious purposes (e.g., via hacking) private travel information or other data tracked by the system. Generally speaking, some implementation mechanisms (e.g., those involving wireless communications) may be more difficult to secure than others (e.g., those involving manual odometer readings conducted in person). That said, using best available practices such as firewalls and data encryption it should be possible to provide an acceptable level of security for any of the system designs discussed in this report. Should the decision be made to implement a national system of VMT fees, the overall system design should certainly include appropriate security safeguards. Given that such safeguards should be possible for any of the implementation mechanisms, this analysis focuses on the issue of privacy protection generally rather than the relative strengths or limitations of different options regarding security.

5.4. Additional Criteria Not Considered

In closing, it is worth highlighting several evaluation criteria that have been excluded from this list because they relate to the overall structure of a VMT-based system of road use fees rather than to the particular mechanism used to implement the fees. The first of these is the sustainability of revenue under a system of VMT fees. This depends not on the technology adopted for measuring mileage, but rather on the per-mile rate structure and whether it is allowed to vary over time (e.g., to increase with inflation or declining VMT). In addition, specific user group concerns may arise depending on which policy goals the VMT-fee system is designed to support. Truckers, for instance, would likely face higher fees if the system is intended to fully capture maintenance costs, while advocates for lower income travelers, owing to the potential financial hardships imposed on their constituents, would likely be among the parties voicing strong objections to a system in which the per-mile fees are higher when traveling in congested conditions. While such issues are clearly important, they are a function of overall system design rather than specific technical strategies, and thus less relevant when assessing alternate VMT-fee implementation mechanisms that could be put in place in the near term.

6. ELEMENTS OF A VMT-FEE SYSTEM

This chapter begins by considering the key functions – metering, billing, and enforcement – that must be supported within a VMT system. Next there is a brief consideration of the relevant technologies that may play a role in supporting these functions. This is followed by discussion principal options for each function: metering mileage, transmitting billing data and collecting revenue, and enforcing system compliance. The chapter closes by considering the potential roles that public, quasi-public, and private entities might play in supporting the various elements required in a national system of VMT fees.

The next chapter considers how these elements may be combined with one another to form a fully integrated system. At that point it becomes possible to consider the relative strengths and weaknesses of the alternate configurations with greater specificity.

6.1. Core Functions in a VMT-Fee System

VMT-fee systems are complex, and different authors have offered alternate categorizations of the key functional elements (see, for example, Whitty and Svadlenak 2009). Within the context of evaluating implementation mechanisms for this report, it is convenient to discuss three broad functional elements:

- **Metering.** This function encompasses the determination of miles traveled as well as any additional data (e.g., weight of vehicle or time and location of travel) that may influence either the fees owed or the allocation of the revenue among different jurisdictions.
- **Billing.** This function includes the communications of either mileage data or fees owed as well as a mechanism for issuing a bill and collecting the revenue.
- **Enforcement.** This function focuses on ensuring that all motorists are being charged the correct amount and have paid the fees owed.

6.2. Enabling Technologies

There are, not surprisingly, many technologies that could support different functions in a VMT-fee system. The following list defines those that appear to offer the greatest promise over the next several years.

ANPR (Automated Number Plate Recognition). Combining digital cameras with optical character recognition software, this technology makes it possible to identify vehicles that pass a particular location based on their license plate numbers.

AVI (Automated Vehicle Identification). This term describes technology that supports wireless identification of a particular vehicle (e.g., a vehicle passing by a particular checkpoint). Radio-frequency identification (RFID) tags are the most common example of this technology, but there are other methods as well.

Cellular communications. Cellular is often considered as an option to support necessary communications. It can also be used, however, to provide location information (by triangulating between nearby cell phone towers or simply identifying the closest cell phone tower). This potential role for cellular, not explored in prior road-pricing programs or trials, is discussed in recent concept paper developed by Max Donath and colleagues at the University of Minnesota (Donath et al. 2009). When discussing cellular technology, it is also commenting on “smart phones” – that is, phones designed with additional computation power and extra features such as GPS receivers, which account for a growing share of the mobile phone market. In principal, the capabilities of smart phones could provide many of the capabilities needed for an in-vehicle metering device. Even so, smart phones would not represent an ideal choice for a base metering technology configuration. To begin with, they provide far more computing power than would be needed, and thus do not represent the most cost-effective option. Additionally, despite their gain in market share, not everyone owns a smart phone, nor will over the relatively short timeframe considered in this study. Finally, to make use of a smart phone it would likely be necessary to plug it in to an onboard metering device; this creates additional enforcement challenges to ensure that the device is properly connected whenever the vehicle is operated, and may also be viewed as an inconvenience to users.

Debit cards. In-vehicle metering equipment could be configured to accept pre-paid debit cards. As mileage fees are accrued, the fees would simply be deducted from the card; the user would then periodically add more money to the card (this approached is used in the Singapore road pricing program, and users can purchase or recharge their debit cards at such locations as banks and convenience stores – see Goh 2002). To allow for a smaller in-vehicle device, such debit cards would probably be smaller than ATM-style magnetic stripe cards and thus not interoperable with existing bank-issued cards.

Digital maps. A GPS receiver (see below) can be used to determine the current latitude and longitude of a vehicle. These coordinates can then be checked against a digital map to determine, for example, the jurisdiction in which travel is occurring, or even the specific route of travel. For the latter, the digital road network maps must be quite precise to distinguish, for instance, between travel on a freeway and travel on an adjacent frontage road.

DSRC (Dedicated Short Range Communications). DSRC enables wireless communication between AVI-equipped vehicles (e.g., vehicles with an RFID tag) and external infrastructure equipped with electronic readers. Using DSRC, it would be possible for a vehicle to communicate, for example, with readers mounted on overhead gantries when traveling on a particular facility or with readers installed at the pump when making fuel purchases. Note that term DSRC tends to be used differently in Europe than in the United States. In Europe, DSRC typically refers specifically to vehicle-to-infrastructure communications in support of electronic tolling; in the United States, DSRC also may describe vehicle-to-vehicle communications in support of intelligent transportation systems. Use the term “DSRC tolling” subsequently in this report refers to the European understanding of vehicle-to-infrastructure communication in support of electronic road pricing.

GPS (Global Positioning System) receivers. GPS receivers triangulate between dedicated satellites to determine current latitude and longitude coordinates. Within the context of road use metering systems, GPS can be used to ascertain the location, or even the specific route, of travel. Note that GPS technology is available in different grades of accuracy, ranging from errors on the order of several meters to errors on the order of several centimeters. From the perspective of designing a system of road use fees, it is sufficient to distinguish between coarse-resolution GPS (offering less than one-to-two meter accuracy) and high-resolution (or differential) GPS (offering greater than one-to-two meter accuracy); either could determine the area or jurisdiction of travel, while only the latter (paired with highly accurate digital road network maps) could determine the specific route of travel. Higher-resolution GPS equipment is also more expensive.

Odometer. The odometer, available on all vehicles, provides accurate mileage data. It does not, obviously, provide information about the time or location of travel.

OBD II (On-Board Diagnostics, 2nd generation) port. Vehicles produced in 1996 or later are equipped with an OBD-II port that indicates, along with other information, vehicle speed. This can be integrated over time to estimate travel distance.

OBU (on-board unit). More complex technical configurations will typically be integrated within a device that can be mounted in the vehicle. This is often referred to as an on-board unit, or OBU.

RFID (radio-frequency identification). RFID technology is a common option for implementing AVI, as described above, and is often used to support DSRC applications. Costing just a few cents per unit, RFID tags could be embedded in license plates or even registration stickers. Though RFID tags do not require power, it is possible to integrate RFID tags with a small battery to increase their communication range; this leads to a modest increase in cost, however.

"Smart cards" (small data storage chips): Smart cards allow for the transfer of electronic data between one computational device and another. One potential option for transmitting billing data (suggested in the initial University of Iowa study – see Forkenbrock and Kuhl 2002) would be to store road use data on a smart card inserted into an OBU; periodically, users would remove the smart card from the OBU and insert it in a home computer or other reader station (e.g., located at gas stations or convenience stores) connected to the internet to transfer payment information to a central billing agency.

6.3. Principle Metering Options

To set up a nationwide system of VMT fees, several core metering options are possible. Following are brief descriptions of how each option would work. The next chapter discusses their strengths and limitations in greater detail.

Odometer option. With this option, mileage data would be determined based on periodic readings of the odometer, and this would serve as the basis for issuing mileage fees. If desired, vehicle characteristics – weight, emissions class, fuel economy – could be factored in to the per-mile rate. This option would not provide information about either the time or location of travel, so these factors could not be included.

Fuel-consumption option. The concept here is to combine fuel consumption with information about a vehicle's fuel economy (based on make and model) to estimate mileage (see Whitty and Svadlenak 2009). For instance, if a vehicle's expected fuel economy is 25 mile per gallon, then the purchase of 10 gallons of gas should translate to about 250 miles of travel. In determining the per-mile rate, here again it would be possible to factor in relevant vehicle traits. There would be no way, however, to determine either the time or location of travel.

OBD II option. This option, used in many taxi meters as well as some PAYD programs, would involve the use of an OBU connected to the OBD II port. The device would read travel speed information from the port and then integrate that information over time to estimate travel distance. Here again, the per-mile rate might vary with vehicle characteristics, which could be stored in the OBU when the device is installed, but it would not be possible to meter travel by location. Note that the main advantage of this option, in comparison to simple odometer readings, is that the OBU could be equipped with wireless communications technologies (DSRC or cellular) to automate the billing function.

OBD II/cellular option. For this metering option, discussed by Donath et al. (2009), the OBU would integrate a connection to the OBD II port with cellular communications. Mileage would be determined based on the speed signal from the OBD II port, while the cellular service would be used to determine the approximate location of travel (the information would be accurate enough to determine the jurisdiction or area of travel, but not the specific route of travel). The per-mile rate could also vary to account for relevant vehicle characteristics stored on the OBU. Note that this configuration has not been demonstrated in practice, but from a theoretical perspective it appears quite promising.

Coarse-resolution GPS option. This option, used in the Oregon trial program discussed in Chapter 3, involves the installation of an OBU equipped with a coarse-resolution GPS receiver that would determine both the time and the area or jurisdiction of travel. It would also be possible, by interpolating between subsequent location points, to use the GPS data to determine travel distance. Because the GPS signal is not always available (it may be lost, for example, when traveling in canyons or between high buildings), the OBU may also be connected to the OBD II port to provide a redundant source of data for computing distance. In terms of metering, this offers the same options as the OBD II/cellular combination.

High-resolution GPS option. This option is similar to the prior approach, but would rely on a differential GPS receiver connected to the OBU for sufficient accuracy (i.e., accurate within one to two meters) to determine the specific route of travel (again, travel distance could be measured either by GPS or via a connection to the OBD II port). This would enable the greatest flexibility in pricing; per-mile rates could vary by vehicle characteristics, by jurisdiction, by area within jurisdictions, by route, and by time. The ability to meter by route may be most useful for heavy trucks, in that the damage caused by truck travel varies considerably depending on the engineering quality of the road. It would also make it possible, however, to develop facility-based congestion tolls for all vehicles without needing to install gantries. (i.e., accurate within one to two meters).

DSRC tolling on a partial road network. With this option, all vehicles would be equipped with an AVI device (likely using an RFID tag) and gantries would be set up along the most heavily traveled segments of the road network to support facility-based tolls – either flat tolls or tolls that vary by time and location. This approach would not support tolling across the entire road network, as it would not be practical, let alone cost effective, to install gantries on lightly traveled road segments. On the other hand, this approach could be used to extend the metering capabilities for any of the options above that include either AVI or an OBU (which could be configured to include an AVI component). For instance, the OBD II / cellular combination could be used to meter mileage by jurisdiction, and the addition of gantries would then enable the addition of facility congestion tolls.

Table 6.1 summarizes the metering capabilities offered by each of the options, and in turn the policy goals that they would be able to support. Note that all (save DSRC tolling) can meter by total mileage as well as vehicle characteristics. Key differences involve the ability to meter by location and time of travel, a requisite for several of the policy goals.

Table 6.1. Policy Goals Supported by Core Metering Options

Supported Metering Capabilities and Policy Goals	Core Metering Options						
	Odometer	Fuel-Consumption	OBD II	OBD II / Cellular	Coarse Resolution GPS	High Resolution GPS	DSRC for Partial Road Network
Metering Capabilities							
Accurate mileage	X		X	X	X	X	
Full road network coverage	X	X	X	X	X	X	
Jurisdiction or area				X	X	X	
Route or type of road						X	X
Time of travel				X	X	X	X
Fuel efficiency	X		X	X	X	X	
Emissions	X		X	X	X	X	
Weight	X		X	X	X	X	
Policy Goals							
Preserve / augment revenue	X	X	X	X	X	X	
Accurately apportion revenue				X	X	X	
Capture maintenance costs						X	
Reduce congestion delays				X	X	X	X
Reduce criteria pollutants	X	X	X	X	X	X	
Reduce greenhouse gases	X	X	X	X	X	X	

6.4. Billing and Collections Options

From a review of existing programs and proposals, there emerge four main options for assessing and collecting VMT fees. Two of these – pay with registration and pay at the pump – would involve modifying or expanding existing revenue systems. The other two – a central billing agency and debit cards – would require the development of new institutions. While there are potential economies that may result from the use of existing revenue collection systems, particularly in the near term, each of the four options has its own advantages and limitations.

Pay with registration. With this option, mileage fees would be tacked on to annual vehicle registration fees. This most obvious application of this approach would be for odometer-based metering. Each year, motorists would be required to report annual mileage (either self-reported or based on an authorized odometer inspection) to the state DMV or MVA, and the registration fee would be augmented accordingly. States would then pass along the revenue (minus, perhaps, an administrative fee) to the federal government. In evaluating this option, it is crucial to observe that all states would need to participate for a successful national program. Based on interviews with state officials, discussed in Chapter 4, as well as comments from some project panel members, it is quite clear that not all states would welcome such a requirement or be able to implement it quickly.

Pay at the pump. For this mechanism, applied in the Oregon trials and further discussed by Whitty and Svadlenak (2009), mileage fees would be added, and fuel taxes subtracted, when motorists make fuel purchases. To accomplish this, fuel stations would be equipped with electronic readers at each pump to communicate with in-vehicle equipment. For the option of estimating mileage based on fuel consumption, the readers would communicate with the AVI device to determine the vehicle's identification and, in turn, its fuel economy rating; mileage estimates and corresponding fees would then be computed based on the quantity of fuel purchased. For options involving more sophisticated in-vehicle metering equipment (the OBD II, OBD II/cellular, and coarse- and high-resolution GPS options), the OBU would transmit current mileage fee information to the readers so that it could be included in the bill. Note that at the expert workshop conducted for this project, concerns were raised that the process of reconciling VMT fees and fuel taxes at the retail station level could prove administratively cumbersome for tax collection agencies; while this did not prove to be a problem in the Oregon trials, that experiment involved only two stations and a few hundred vehicles.

Central billing agency. Under this model, a new nationwide central billing agency would be established to collect fees from users and distribute the revenue to participating jurisdictions (at minimum, for a national system, the federal government, but possibly including states or even local areas that choose to opt in to the system and levy their own mileage-based fees). This would be a suitable billing and collections model for any of the options that involve an OBU. Although different communication channels would be possible, the most likely approach would be to include cellular service within the OBU. On a periodic basis, the OBU would communicate with the central billing agency to record fees owed; motorists might then be issued a monthly billing, which could be paid manually or – for greater efficiency – via automated some form of automated payment.

Debit cards. This approach, used in the Singapore electronic road pricing program (Goh 2002), would also be applicable for metering approaches involving the use of an OBU. Motorists would purchase pre-loaded debit cards that could be inserted into the OBU, and road use charges would then be subtracted from the debit card balance as mileage accrues. As the existing balance nears zero, motorists would need to add more money to the card balance; in the Singapore example, this can be done at banks, convenience stores, fueling stations, and the like. Within the context of developing a nationwide system of road use charges for the United States, it is not clear that debit cards would be a sensible choice as the *sole* means of paying for road use, as this would result in an increased burden on the user (i.e., the need to periodically purchase or refresh debit cards). A stronger case can be made, however, for considering pre-paid debit cards as an *option* for paying road use charges. If a pre-paid debit card were inserted into the metering equipment, there would be no need to store such information as time or location of travel for future billing because the corresponding charges could be immediately debited from the card. This could be viewed as a valuable option for those with heightened concerns regarding privacy. Note that to support the goal of accurate apportionment of revenue while preserving privacy, the in-vehicle technology could be configured to report, for any user relying on debit card payment, the breakdown of miles by jurisdiction on an anonymous basis; funds would then be distributed accordingly from the pool of revenue received from all debit card purchases.

6.5. Enforcement Options

As with billing and collection mechanisms, suitable verification and enforcement options are heavily dependent on the metering approach adopted. It is useful, in particular, to distinguish between enforcement for odometer-based metering, for estimates based on fuel consumption, and for metering that involves an OBU.

Enforcement options for the odometer. For odometer-based metering, the only option for enforcement is a certified odometer inspection (this may also be the way that odometer data is collected, though self-reporting is also possible). This is inherently problematic in that the odometer provides the *only* record of mileage – no redundancy checks are possible – and odometer fraud is already a non-trivial problem (NHTSA 2002). States without existing inspection programs would have to develop mechanisms for odometer inspections, and most states do not currently store vehicle odometer readings in their registration databases.

Enforcement options for mileage estimates based on fuel consumption. Enforcement is not a significant challenge for this metering option (Whitty and Svadlenak 2009). If the AVI device on a vehicle is not functioning, the driver will simply be charged fuel taxes instead of mileage fees, so revenue will still be collected. For highly fuel-efficient vehicles, of course, fuel taxes could be considerably lower than mileage fees, so there still might be an incentive to disable the AVI. If this proves to be a problem over time, the fuel tax could be raised high enough to discourage efforts to avoid mileage charges (at that point, most domestic vehicles would have properly functioning AVI devices and pay mileage fees rather than fuel taxes; the fuel taxes would be left in place largely as a means for collecting road use revenue from foreign cars).

Enforcement options for OBU metering devices. For metering approaches involving the use of an OBU, the key challenge is to make sure that drivers do not disable, even temporarily, the in-vehicle equipment to avoid road use charges. Several distinct, and potentially complementary, approaches have been proposed to date, and the best option is not yet clear. It is likely, in fact, that a VMT-fee system reliant on an OBU would employ several redundant verification and enforcement strategies.

- **Redundancy checks.** The idea here would be to check mileage counts from the OBU against some other measure of travel and ensure that they are consistent. A simple option would be to compare the OBU with the odometer. This could be performed for all vehicles on an annual basis (obviously entailing high ongoing labor costs), or perhaps performed via random checks. Another option, possible with the pay-at-the-pump collection model, would be to keep an ongoing record of both mileage fees and fuel purchases for each vehicle and verify, through some sort of automated audit check, that they are roughly consistent.
- **Tamper-resistant OBU.** A second approach is to design the OBU in such a manner that it would be difficult for a motorist to temporarily disable the device to avoid mileage fees without this being subsequently detected. One option would be to use some type of seal, affixed when the unit is installed, designed such that the unit could not be disabled without breaking the seal. The seal could then be periodically inspected to ensure that the device has not been tampered with. Another potential option would be to design the OBU to send out a wireless alert to the central billing agency or enforcement authority if the unit detects that it has been disconnected.
- **External OBU checks.** Yet another approach is to rely on external infrastructure to query the OBU and verify that it is functioning as intended. This could be achieved by setting up check points combining DSRC and ANPR technology – either in fixed or random positions – across the road network. The DSRC device would send a signal to the OBU to confirm that it is functioning; if it is unable to communicate with the OBU, then ANPR would be used to capture the vehicle’s license plate number, which would trigger further enforcement action (e.g., mailing the owner a summons to bring the vehicle in for manual inspection). A second option would be for the central billing agency to periodically query, via cellular transmission, the OBU. If multiple queries fail, the owner would again be requested to bring the vehicle in for a manual inspection.

6.6. Public and Private Roles

Developing, operating, and administering a VMT fee system will require a broad range of tasks. Some are ideally suited to public entities, while others clearly fall in the private domain. Finally, some activities could be led by either the public or private sector. This section considers the suitability of public and private actors for different aspects of a VMT-fee system, beginning with several high-level observations regarding public and private participation and then focus more specifically on relevant roles in the areas of technology procurement, system integration, system operations, billing and collections, enforcement, and oversight.

Public administration issues. For public sector administration, there are two important questions to consider. First, should responsibility for the operational administration of a national system of VMT fees reside at the federal level or instead be distributed among the states? While the latter may be more complex from the perspective of intergovernmental interactions, it is also the case that most existing transportation revenue mechanisms are currently implemented at the state (or local) level.

Second, how do the new administrative requirements relate to the functions of existing agencies? The answer may lead to one of four approaches: (1) tapping an agency that already operates a similar revenue program (e.g., collecting vehicle registration fees or fuel taxes) to administer the mileage fees; (2) significantly expanding the duties of an existing agency (e.g., a department of transportation) that does not currently perform similar duties; (3) creating a new agency; or (4) creating some type of intergovernmental joint-powers authority. The strongest case for public administration can be made for the first of these alternatives, where only minor modifications to existing procedures need to be made. In the latter three cases, the potential for private rather than public administration merits consideration.

Private administration issues. An argument commonly offered in favor of private administration is that the private sector is capable of delivering services faster and more efficiently. Debate over this issue is rife with ideological overtones, and this research is not meant either to support or dispute the argument. The programmatic implementation and administration of a system of VMT-based road-use fees will require a range of tasks and duties, and it does seem reasonable to expect that private actors may be well-suited (if not exclusively so) to accomplish some of the necessary activities. It has also been argued that the privacy concerns associated with metering road use (most prevalent when GPS is involved) can be mitigated to some extent if the data is transmitted to private firms rather than the government. Given that individuals routinely entrust, for example, cell phone providers and credit card companies with sensitive private data, the argument may have merit. On the other hand, data in those instances is exchanged in a market where consumers have other options; a cell phone provider can lose customers if it does not respect their privacy. If program administration is contracted to a single firm or consortium, this potential advantage would be diminished.

Several potential options exist for private participation in developing and administering a system of distance-based road use fees. First, a private, not-for-profit entity could be created to administer a particular function. Such an entity might be governed by a combination of public stakeholders, e.g. states, in which case it might instead be viewed as a quasi-public institution. Examples of this may be seen with IRP and IFTA. As another alternative, the entity could be governed by some combination of public and private actors.

Second, an individual for-profit firm (or consortium of firms) could compete to be the sole provider of a service. The consortium that developed and operates the Toll Collect weight-distance truck toll program in Germany is an example of this arrangement.

Third, multiple firms could simultaneously provide a service, competing for customers (motorists) on the basis of price and/or added functionality. This could be the approach taken, for example, if developing a network of certified stations to perform annual odometer checks to serve as a basis for implementing mileage fees.

Procuring in-vehicle technology. The private sector is best positioned to fulfill the technology development role. Two models are possible. First, the government could create a set of specifications for the in-vehicle equipment that providers would need to meet to be certified. Providers could then offer additional “value-added” features (e.g., in-vehicle navigation or roadside assistance) and compete for customers on the basis of price and functionality. This is the approach envisioned in the current Netherlands proposal. A key advantage here would be the function of competition in driving down costs. Second, the government could contract with a sole provider to develop the technology for all vehicles, as was the case in the German Toll Collect program. The principal argument for this arrangement is that it ensures that the technology will in fact be developed (under the multi-firm option, it is possible that no firms would choose to compete in the sector). As illustrated by the delay in launching the Toll Collect program, however, there is no guarantee that the sole provider will deliver the technology according to schedule or within a pre-determined budget.

System integration. This category includes development and integration of the technical components (hardware and software) that facilitate such functions as data communications and billing. Here again, the private sector offers the greatest expertise. The logical option here would be to let firms (or consortiums) bid to be the sole provider of this service.

System operations. The precise nature of the operations function depends on the metering strategy employed, but this category generally includes such tasks as installing and maintaining equipment or inspecting odometers. These tasks could be performed by public agencies, by a non-profit entity, by an individual private firm (or consortium), or by multiple private firms in competition with one another.

Billing and collections. Billing and collecting, and in turn disbursing, road use revenue is a centralized function. It thus makes the most sense that this be managed by a single entity, although that entity could be public, non-profit, or private.

Enforcement. Private industry could participate in enforcement, for instance by certifying that OBUs have not been tampered with. Ultimately, though, this function requires the ability to issue and enforce fines or other penalties, so the involvement of law enforcement is a requisite.

Oversight. Roads in the United States, with few exceptions, are publicly provided and maintained, and transportation finance is a matter of public policy. Accordingly, it can be argued that the oversight function – e.g., setting fare policy, determining appropriate allocation of revenue, etc. – falls squarely within the public domain.

Table 6.2 summarizes the potential public and private roles for various system development and administrative functions, as just discussed.

Table 6.2. Potential Public and Private Roles in System Development and Administration

System Development and Administrative Functions	Public / Private Options			
	Public Sector	Not-for-Profit Entity	Private Firm or Consortium	Multiple Competing Firms
In-vehicle Technology			X	X
System Integration			X	
System Operations	X	X	X	X
Billing and Collections	X	X	X	
Enforcement	X			
Oversight	X			

7. PRELIMINARY ASSESSMENT OF VMT-FEE OPTIONS

The prior chapter briefly outlined the functional requirements of a VMT-fee system and described the core options for metering mileage, collecting revenue, and verifying compliance. This chapter considers the likely ways in which these individual components might be combined within a national system for VMT fees and evaluate, at a high level, the relative strengths and limitations of the alternate configurations. The goal is to screen for the most promising options, which are then examined in greater detail in the next chapter.

While there are numerous ways to configure a VMT system, some are more promising than others. Rather than examining exhaustively every possible combination of technologies, this research was focused on nine basic configurations that (a) have already been implemented or studied, (b) have been suggested as potential options by elected officials interested as possible ways to implement VMT fees, or (c) have emerged as promising candidates based on our research. The nine options are as follows:

- Self-reported odometer readings
- Periodic odometer inspections
- Assumed annual mileage with odometer inspection option
- Mileage fees based on fuel consumption
- OBD II metering device
- OBD II / cellular metering device
- Coarse-resolution GPS metering device
- High-resolution GSP metering device
- DSRC-based tolling on a partial road network

Note that there is some flexibility within these options; for instance, multiple collection mechanisms would be possible for any of the latter four options – those involving an OBU.

Each of these options is examined more closely below. The following discussion briefly describes how the system might work, identifies key strengths and limitations, and comments upon challenging tasks required for implementation. Based on this high level assessment, the research team judged whether (a) the option is worthy of further consideration as a primary means of levying national VMT fees in the near term, (b) the option might serve as a parallel fee mechanism for vehicles not covered by the primary system, (c) the option could be added to extend the capabilities of the primary system, or (d) the option might serve the goal of providing a more robust and sustainable VMT-based revenue system over the longer term – i.e., a system with very flexible metering capabilities to accommodate a range of pricing and policy options. The following criteria were considered in assessing the potential utility as a primary near-term metering mechanism:

- **Full road network metering.** The explicit goal of this project is to identify options for levying fees based on VMT. To capture all VMT, the system must meter mileage across the entire road network.

- **Cost vs. metering capabilities.** Given that a principal goal of the envisioned transition to VMT fees is to preserve or enhance revenue, any system that offers only limited metering capabilities should also be relatively inexpensive to implement and operate. Otherwise, the per-mile fees would need to be much higher in proportion to existing fuel taxes to simply maintain existing revenue. By the same token, any system that entails higher costs should provide flexible pricing options (e.g., varying the rate by time and location of travel) that would make it possible to increase total revenue without significantly increasing the base per-mile rate.
- **Enforceability.** For a host of reasons, ranging from revenue goals to perceptions of equity among law abiding citizens (Short 2004), the system must allow for at least reasonably effective enforcement activities.
- **Minimal required state support.** Based on the state interviews reported in Chapter 4, it was evident that not all states would be eager or willing to exert significant administrative effort to support the transition to a national system of VMT fees. Any option that requires (as opposed to allows) concerted effort on the part of states, therefore, is unlikely to succeed, at least in the near term.
- **Minimal burden on users.** Gaining public acceptance for the transition from fuel taxes to VMT fees will likely be difficult in its own right. Increasing the burden on users – for instance, by requiring regular odometer inspections – will make this even more difficult.

7.1. Self-Reported Odometer Readings

For this option, drivers would report their current mileage each year as part of the annual registration process. The state DMV or MVA would then assess a corresponding mileage fee, which would be added to the base vehicle registration fee (if paying the full amount in a lump sum proved to be burdensome for some drivers, an option of paying the fee in twelve monthly installments could be provided). The state would then pass along the mileage fee component, minus some administrative charge, to the federal government.

Key Strengths. There are several strengths to this approach. First and foremost, it would be very low cost, with no in-vehicle equipment requirements and relatively low collections cost. Another benefit is that this option would not create privacy concerns.

Key Weaknesses. The main drawback of this approach is that it would be extremely difficult to provide effective enforcement unless routine odometer inspections were required (Whitty and Svadlenak 2009). A driver might, for instance, repeatedly underreport mileage over a period of some years and then scrap the vehicle at the end of that period – this would be very difficult to prevent. This option would also require that all states track vehicle odometer data – many do not currently store this information in their registration systems – and update their billing systems. One of the observations arising from our interviews with state officials, discussed in Chapter 4, was that many state registration databases can be described as “fragile” legacy systems for which even simple changes to data fields or billing processes may be difficult to achieve. Also, many states allow multi-year registration options, meaning that either they would have to change their processes to incorporate annual readings or drivers would be asked to pay several years’ worth of mileage in a lump sum. Finally, this option offers limited metering capabilities; rates might vary by relevant vehicle characteristics, but not by time or location of travel.

Implementation Challenges. The most significant implementation task would be for states to update their vehicle registration and billing systems. All states would need to participate.

Summary Assessment. Because this option would pose difficult and likely intractable enforcement challenges, it is not suggested for further consideration.

7.2. Annual Odometer Inspections

Similar to the prior option, the key distinction here is that drivers would submit to periodic (likely annual) odometer readings at certified stations as the basis for assessing mileage fees. The odometer readings could be conducted either by a public agency, such as a state DMV or MVA, or contracted to authorized private stations. Here again, fees would be added to the base registration charge, and states would then remit the federal share of VMT fees to the Treasury Department.

Key Strengths. The principle advantage of this option is that no additional in-vehicle equipment would be required. Additionally, this option does not raise privacy concerns.

Key Weaknesses. This option faces a number of limitations. The most important of these is the significant operational cost that would be required to conduct odometer readings. To employ this option and preserve existing revenue, the per-mile fee would need to be proportionately much higher than existing fuel taxes. It would also require that all states develop a network (publicly or privately operated) of odometer check stations. Although about two-thirds of the states already have such infrastructure in place (e.g., to check emissions equipment), the inspections are often conducted less frequently than once per year. Additionally, state vehicle registration databases would again need to be updated to track and bill for mileage. The pricing flexibility under this option (i.e., the ability to account for time or location of travel) remains limited, and it would not be possible to precisely allocate revenue by jurisdiction. The need to conduct periodic odometer readings would increase the burden on many road users. Finally, though enforcement would be easier than under the self-reporting model, it is still possible that vehicle owners could find ways to tamper with their odometers.

Implementation Challenges. The most significant near term tasks would be for states that do not currently conduct vehicle inspections to develop and deploy the necessary infrastructure and for all states to adapt their registration processes as needed. Here again, all states would need to participate, and some may be reluctant to take on these tasks.

Summary Assessment. This option is not suggested as the principal metering platform for three reasons: (a) it would be expensive to operate while offering limited metering capabilities, (b) it would require significant state involvement, and (c) it would increase the burden on users. This option could, however, be considered as a parallel fee system for vehicle classes not covered by the main metering approach, provided that the numbers of such vehicles are small (e.g., in a pay-at-the-pump system, electric vehicles might be required to pay fees based on odometer readings).

7.3. Assumed Annual Mileage with Optional Odometer Checks

With this approach, road users would be assessed an annual VMT fee based on the estimated mileage for the vehicle class (e.g., passenger vehicles vs. commercial trucks). Road users that travel significantly less than the assumed amount could submit to annual odometer readings to qualify for a reduced fee based on actual miles of travel, while users that travel more would simply choose to pay the estimated mileage charge. As with the previous option involving odometer inspections, states would still need to provide the infrastructure for road users that choose to have their odometers read, and they would likewise need to modify their vehicle registration systems to accommodate this new form of charging. VMT fees, once collected, would be remitted to the federal government.

Key Strengths. Here again, no additional in-vehicle equipment would be required, and this mechanism would not raise privacy concerns. Additionally, the cost of administration would be less than under the prior odometer option since many users would choose simply to pay the estimated mileage charge rather than having their odometer checked each year.

Key Limitations. This option also faces a range of limitations and concerns. As with the prior odometer option, the pricing flexibility is limited to mileage and vehicle characteristics, and it is not possible to apportion revenue among jurisdictions with a high degree of accuracy. States would still need to develop a network of odometer reading stations for those users wishing to qualify for lower feed based on reduced mileage, and they would need to update their vehicle registration databases and billing systems as well. The potential for odometer fraud would remain as a concern as well. It is also worth noting that any drivers wishing to qualify for a reduced rate would need to have their odometers checked both before and after the year in question. Unique to this odometer option, there could be equity concerns as well. Specifically, while vehicle owners that travel less than the assumed amount would likely have their odometers read to qualify for a reduced total fee, they would still end up paying the assumed base rate on a per-mile basis. In contrast, drivers that travel far in excess of the assumed annual mileage would simply choose to pay the fixed total fee, resulting in a much lower charge on a per-mile basis. In other words, those who drive less would tend to subsidize those who drive more. Given our understanding of the factors that influence travel behavior, this would tend to benefit wealthier drivers at the expense of poorer drivers, and suburban and rural drivers at the expense of urban drivers (Pisarski, 2006).

Implementation Challenges. The obstacles here are the same as for the prior odometer-based option: the need for states that do not currently conduct vehicle inspections to develop and deploy the necessary infrastructure and for all states to adapt their registration processes as needed.

Summary Assessment. This option is likewise not suggested as the main metering approach. Though not all drivers would choose to have their odometers read – lowering both administrative costs and user burdens – all states would still need to set up the necessary infrastructure for odometer stations. Additionally, this option raises equity concerns in that high-mileage drivers would end up paying lower per-mile rates than low mileage drivers. That said, this option could be considered as a parallel fee system for vehicle classes not covered by the main metering mechanism, as the number of such vehicles would presumably be quite small.

7.4. Fuel Consumption-Based Mileage Estimates

Under this approach, as described in the prior chapter, fuel consumption would serve as the basis for estimating travel distance. All vehicles would be equipped with some form of AVI (likely an RFID tag embedded in the license plate or registration sticker). When a vehicle visits a gas station to purchase fuel, electronic readers installed at the pump would detect the vehicle ID and use this information to determine the vehicle's fuel-economy rating (and, optionally, other characteristics such as weight or emissions class) based on the make and model. The expected mileage could then be estimated based on the number of gallons purchased. The corresponding charge could then be added to the fuel purchase price, while fuel taxes (already paid at the wholesaler level and therefore built into the retail price) would be subtracted. Vehicles not yet equipped with an AVI device (including foreign vehicles) would continue to pay the existing fuel taxes rather than mileage charges. The administration for this option would involve expanding the existing fuel tax collection system to include fuel retailers along with wholesalers. Specifically, it would be necessary to account for the difference between fuel taxes (paid at the wholesale level) and mileage fees (collected at the retail level) and interact with fuel retailers to either collect or refund the difference.

Key Strengths. There are several important advantages to this approach. First, administration should be less demanding than for many other options, requiring interaction with fuel retailers (numbering in the hundreds of thousands) as opposed to vehicle owners (numbering in the hundreds of millions). Second, the cost of equipping vehicles with electronic identifiers could be quite low (RFID tags can cost on the order of a few cents per unit). Third, vehicles that are not equipped with the required identifier can simply continue to pay the existing fuel tax. This means that (a) the system can be phased in over time, (b) foreign vehicles can continue to pay their share of road use costs via the gas tax, and (c) enforcement should not be a major concern – vehicles, when refueling, must either pay mileage charges or gas taxes.

Key Limitations. There are several limitations for this approach as well. The mileage estimates may be inaccurate depending on travel conditions (e.g., vehicles stuck in traffic will experience reduced fuel economy). Pricing flexibility is rather limited, and there is no way to accurately apportion revenue among jurisdictions. It would also be necessary to determine to find the right avenue for equipping all vehicles with the AVI device. One of the project panel members noted, for instance, that enabling state legislation would be required to include an RFID tag within a license plate or registration sticker. There may also be some privacy concerns associated with the use of RFID or other AVI options. Additionally, vehicles that do not require conventional fuel (e.g., electric cars) would require a parallel mechanism for assessing VMT fees, and the share of such vehicles is expected to grow in the coming years. Considering that there are about 160,000 retail fueling stations in the country (National Petroleum News 2008), the cost of installing the needed equipment to detect vehicle identification would be significant, and it is likely that some station owners would not welcome this imposition. Depending on the configuration of the station equipment, there may also be challenges for rural stations that lack internet connectivity. Finally, the current system for administering fuel tax collections would need to be expanded to encompass all retailers, a non-trivial endeavor.

Implementation Challenges. The three main challenges include equipping all vehicles with some form of electronic identification, equipping all retail fuel stations with the necessary devices to detect vehicle identification and adjust the mileage fee added to the fuel bill accordingly, and adapting the current fuel tax collection system to accommodate retail stations. Given that RFID tags are inexpensive, the second of these is likely to account for the largest share of capital costs, while the third represents a moderately difficult administrative task.

Summary Assessment. This option is suggested for further consideration as a core mechanism for implementing VMT fees over the near term. Not withstanding its limitations, the advantages of this approach are significant – most notably the very low costs for vehicle equipment, the need to administer a much smaller number of entities (all fuel stations vs. all vehicle owners), and the ability to continue to apply existing fuel taxes to vehicles lacking the necessary electronic identification (e.g., foreign vehicles). This option could also serve as a parallel payment mechanism. For instance, if the OBD II option were selected as the principal mechanism for implementing VMT fees, the fuel-consumption based option could serve as a parallel charge mechanism for pre-1996 cars (which lack the OBD II port). While this would seem to involve a significant cost to handle a small (by 2015) and shrinking share of vehicles on the road, equipping all fuel stations with the necessary communications equipment could make it possible to (a) allow conventionally-fueled vehicles with the OBD II port device to communicate mileage data and pay charges at the pump, (b) allow pre-1996 vehicles to pay estimated mileage charges at the pump based on their fuel economy, and (c) detect vehicles lacking electronic identification and levy fuel taxes instead of mileage charges.

7.5. OBD II-Based Mileage Metering

For this approach, vehicles would be equipped with an on-board unit connected to the OBD II port, providing data on vehicle speed that can be used to compute travel distance. The per-mile fee could be modified, if desired, by vehicle characteristics such as weight, fuel economy, or emissions class. Fees could be collected either through the pay-at-the-pump model or via a central billing agency (while debit cards would also be possible, this option does not present the same privacy concerns that might motivate drivers to prefer this option).

Key Strengths. One advantage of this approach is that the per-vehicle costs, though more expensive than simple RFID tags, should be low. In comparison to GPS-based systems, retrofitting existing vehicles with the technology is relatively easy, requiring a simple connection to the OBD II port. Some pay-as-you-drive insurance programs already utilize this approach, so the technology can be viewed as "proven" and off-the-shelf devices are available. In comparison to the fuel consumption approach, the mileage estimates, though still the result of a calculation, should be more accurate.

Key Limitations. Here again the pricing flexibility is relatively limited, and it is not possible to accurately apportion miles by jurisdiction. Because the OBD II port is only available on vehicles manufactured after 1996, it would be necessary to establish a parallel charging mechanism for older vehicles (although by 2015 the share of such vehicles should be relatively small and will decline over time). Either of the options for collecting fees will entail at least moderate administrative cost and complexity. It will also be necessary to employ one or more options to ensure that drivers do not disable the OBU to avoid mileage charges (a recurrent theme for the options that involve an OBU).

Implementation Challenges. Several significant tasks would need to be accomplished for implementation. These include procuring the technology and retrofitting existing vehicles, either adapting an existing or developing a new administrative system for collecting and allocating the revenue, and deploying any additional infrastructure (e.g., vehicle check stations) to support system enforcement activities. Within the near term, these can be viewed as possible but challenging.

Summary Assessment. From a cost perspective, this option would be similar (slightly cheaper, but roughly comparable) to the OBD II / cellular combination, while offering significantly reduced metering capability (no ability to determine the location of travel). It is thus not suggested for further consideration.

7.6. OBD II / Cellular-Based Mileage Metering

Like the previous approach, this would rely on an on-board unit connected to the OBD II port to meter mileage. The OBU would also be equipped with cellular communications, and this would make it possible to determine the location of travel with enough accuracy to place the vehicle in a specific jurisdiction or zone (but not on a specific route). This configuration would thus make it possible to vary rates by vehicle characteristics, by jurisdiction, or by smaller geographic area (e.g., area-based congestion tolls in a dense urban district). The location data would also make it possible to accurately allocate mileage fees among multiple jurisdictions. To collect fees, it would be possible to set up the pay-at-the-pump model, develop a central billing agency, or develop a debit card system (for users concerned with privacy, as this approach meters travel by time and location).

Key Strengths. Owing to the addition of cellular communications to the OBU, this option would be more expensive than the previous configuration. On the other hand, the cellular component would be used both to support communications and determine location. In comparison to the GPS options, this would result in fewer required components on the device and lower overall cost. Another strength is that this configuration would make it possible to determine the location of travel with enough accuracy to enable flexible pricing options, yet may not raise the same degree of privacy concerns that the public associates with GPS (the majority of citizens already own cell phones and carry them on a routine basis). However, without further study of public opinion it is difficult to know if this option would assuage privacy concerns.

Key Limitations. The application of cellular technology for providing information about the location of travel remains to be demonstrated in practical field trials, so there is some technical risk with this option. The addition of cellular communications would also require a service contract, and this would add to the ongoing operational cost. Additionally, because the OBD II port is only available on vehicles manufactured after 1996, it would be necessary to establish a parallel charging mechanism for older vehicles. Any of the available options for transmitting and billing for mileage will entail at least moderate administrative complexity. Finally, here again it will be necessary to develop strategies for ensuring that a vehicle owner cannot disable the OBU to avoid mileage charges.

Implementation Challenges. The first step under this option would be to conduct research and development activities to ensure that the technology can function as envisioned. Assuming that the tests prove successful, it would then be necessary to procure the technology and retrofit the existing fleet, either adapt an existing or develop a new administrative system for collecting and allocating the revenue, and deploy any additional infrastructure needed to support enforcement activities.

Summary Assessment. This option provides highly flexible pricing options. The per-vehicle cost would likely be lower than with GPS-enabled equipment, while public concerns over privacy may be reduced. This option is therefore suggested for further assessment, though further development efforts would be required to verify that the technical configuration works as expected (Donath et al. 2009). Should the option of paying VMT fees based on fuel consumption be implemented as the primary VMT system, this option could serve as a parallel payment mechanism for vehicles that do not run on conventional fuels (e.g., electric vehicles). Note that the metering capabilities are sufficiently flexible that this configuration could serve as both a short- and longer-term solution, perhaps obviating the need for a longer-term transition.

7.7. Coarse-Resolution GPS-Based Mileage Metering

From the perspective of metering capabilities, this option, employed in the Oregon trials, is identical to the previous approach. The only difference is that the OBU would rely on a coarse-resolution GPS receiver, rather than cellular communications, to identify the jurisdiction or area of travel (GPS could also be used to measure travel distance – by interpolating between subsequent location points – or the OBU could include a connection to the OBD II port for this purpose). This configuration would also enable similar payment mechanisms, including the pay-at-the-pump model, cellular transmission of mileage data to a central billing agency, and pre-paid debit cards inserted into the OBU.

Key Strengths. Like the prior option, this provides extremely flexible metering capabilities, enabling all but the determination of travel on specific routes. Depending on the adopted payment strategy (pay at the pump vs. central billing agency), it may be possible to omit cellular technology from the OBU, reducing the cost of the equipment and eliminating ongoing cellular service costs. A coarser-resolution GPS receiver would also be cheaper than higher-resolution GPS (e.g., national differential GPS). If GPS (rather than the OBD II port connection) were used to meter mileage, the equipment could work for all vehicles on the road. Finally, the inclusion of GPS would make “add-on” services such as in-vehicle navigation or emergency location possible, and this could increase the attractiveness of the in-vehicle equipment from the perspective of end users.

Key Limitations. Because GPS requires connection to a power source as well as line-of-sight access to the sky (the device must either be mounted on the dash or include an antenna), the cost of installing the equipment will be higher than with the OBD-II port option. It is also not clear that the public appreciates the distinction between lower- and higher-resolution GPS, so the perception of privacy concerns may be difficult to overcome. It should be stressed that, from a technical perspective, it is absolutely possible to protect private data. It is just that convincing the public and press of this has thus far been difficult –it is impossible, from the perspective of drivers, to prove that private data is not being stored without their knowledge. Finally, here again it will be necessary to develop strategies for ensuring that a vehicle owner cannot disable the OBU to avoid mileage charges.

Implementation Challenges. The viability of this technology has already been demonstrated in the Oregon trials. Needed steps would therefore include procuring the technology and retrofitting the existing fleet, adapting an existing or developing a new administrative system for collecting and allocating the revenue, and deploying any additional infrastructure needed to support enforcement activities. Given current privacy concerns associated with GPS, it is clear that education and outreach to overcome this resistance would be imperative.

Summary Assessment. This option provides flexible metering capabilities similar to the combination of an OBD II port connection and cellular communications. While the start up costs might be higher (due to potentially higher equipment costs and more challenging installation requirements), the ongoing operation costs could prove to be lower (given the potential of omitting cellular service for vehicles that pay at the pump). The main disadvantage with this option is the public perception that use of GPS will create the potential for privacy invasion. Even so, this option merits further consideration as a core metering mechanism, as there are a number of promising "opt-in" strategies that could overcome privacy concerns. It could also provide a parallel payment option for any vehicles not covered by the primary mechanism (e.g., electric vehicles in the pay-at-the-pump model). Here again, the metering capabilities are sufficiently flexible that this configuration could serve as both a short- and longer-term solution, perhaps obviating the need for a longer term transition.

7.8. High-Resolution GPS-Based Mileage Metering

This option is similar to the prior approach, but would rely on differential GPS for sufficient accuracy (i.e., accurate within one to two meters) to determine the specific route of travel (again, travel distance could be measured either by GPS or via a connection to the OBD II port). This would enable the greatest flexibility in pricing; per-mile rates could vary by vehicle characteristics, by jurisdiction, by area within jurisdictions, by route, and by time. The ability to meter by route may be most useful for heavy trucks, in that the damage caused by truck travel varies considerably depending on the engineering quality of the road. It would also make it possible, however, to develop facility-based congestion tolls for all vehicles without needing to install gantries. Similar payment options would be possible: paying at the pump, transmitting mileage data wirelessly to a central billing agency, or making use of pre-paid debit cards inserted into the OBU.

Key Strengths. This option provides the greatest flexibility in pricing. Also, if an RFID-based pay-at-the-pump model were adopted, it would be possible to omit cellular technology from the technical configuration (at least for conventionally-fueled vehicles). If GPS (rather than the OBD II port connection) were used to meter mileage, the equipment could work for all vehicles on the road. Here again, the inclusion of GPS would make "add-on" services such as in-vehicle navigation or emergency location possible, and this could increase the attractiveness of the in-vehicle equipment from the perspective of end users.

Key Limitations. High-resolution GPS is more expensive than the coarser-resolution variety, with differential GPS receivers costing hundreds of dollars. One would envision that the cost would come down considerably if scaled to several hundred million drivers, but this would still be the most expensive configuration on a per-vehicle basis. As with the previous GPS option, installation requirements would be manually intensive, and this would also boost the per-vehicle cost. It would also be necessary to develop more precise digital road network maps to take advantage of the higher-accuracy GPS, likely entailing at least some expense. Privacy concerns would be acute, and considerable outreach would likely be necessary to ensure the public that their private travel data is sufficiently protected. Finally, it would again be necessary to develop strategies to prevent or dissuade users from tampering with the OBU.

Implementation Challenges. Perhaps the two greatest obstacles to the near-term implementation of this approach are the high cost of retrofitting the existing fleet with the needed technology and overcoming current public concerns regarding privacy. Assuming that these can be accomplished, additional steps include procuring the technology and retrofitting the existing fleet, adapting an existing or developing a new administrative system for collecting and allocating the revenue, developing more accurate digital road network maps, and deploying any additional infrastructure needed to support enforcement activities.

Summary Assessment. The additional metering flexibility of this option – determining location by route of travel – is likely, in the near term, to prove most useful for weight-distance truck tolling applications in which the per-mile rate would very by type of road (over the longer term, it would enable ubiquitous facility-based congestion tolls, applicable to all vehicles, but the public is unlikely to accept such a radical policy shift soon). Moreover, the cost structure of trucking operations would make it easier to amortize the required in-vehicle equipment, while the privacy concerns are less acute in an industry already subject to significant government regulation. This option is thus not suggested as a near-term platform for general purpose VMT fees, but rather as a near-term extension (for trucks) and possible longer-term transition for all other vehicles.

7.9. DSRC-Based Tolling on a Partial Road Network

With this option, all vehicles would be equipped with AVI and gantries would be set up along the most heavily traveled segments of the road network to support facility-based tolls – either flat tolls or tolls that vary by time and location. This approach would not support tolling across the entire road network, as it would not be practical, let alone cost effective, to install gantries on lightly traveled road segments. As such, this would likely be used to augment, rather than replace, fuel tax revenue. The two most likely options for collecting payments would be to set up a central billing agency or use pre-paid debit cards inserted into the in-vehicle equipment.

Key Strengths. The costs of in-vehicle equipment with this option would be low. Additionally, this would allow congestion tolling on the most heavily traveled corridors, which could raise considerable revenue.

Key Limitations. Within the context of this study, the most important limitation is that this option would not support tolling on the entire road network, and thus would not constitute a true VMT fee. Additionally, the cost of installing a significant portion of the road network with gantries to detect vehicles and read their AVI devices would be considerable. It also appears unlikely that the public is ready to embrace full scale congestion pricing, which – from a revenue perspective – would be a key rationale for this approach. Because this approach would need to register the passage of vehicles at specific points on the road network, privacy concerns would likely arise (though these could be overcome through the use of pre-paid debit cards or some form of "anonymous" accounts made available to road users concerned with privacy). There could also be problems caused by traffic diverting from tolled routes to un-tolled routes. Finally, if this option were implemented by the federal government, if gantries were only installed on heavily traveled corridors, and if the resulting revenue were distributed among the states based on the current Highway Trust Fund allocation formula, predominantly urban states would end up subsidizing predominantly rural states.

Implementation Challenges. Building the political support for tolling on a partial road network would be one of the main obstacles, particularly if the tolling would involve some form of congestion pricing. Beyond that, it would be necessary install to AVI devices on all vehicles, equip some portion of the road network with gantries, and develop a central billing agency to collect tolls (this could be done individually in each state, or at the national level). This could be possible in the short term, but certainly challenging.

Summary Assessment. Given the limitations of this option – most importantly the fact that it would not meter mileage across the entire network – it is not suggested for further analysis as a core mechanism for implementing VMT fees over the near term. On the other hand, this approach could be used to extend the capabilities of alternate metering mechanisms. Specifically, for any approach that relies on AVI or an OBU to meter total VMT, gantries could be added at strategic locations to enable, for example, facility congestion tolls or cordon congestion tolls.

7.10. Summary of VMT-Fee Mechanism Assessments

Table 7.1 summarizes our assessments regarding the potential suitability of each of the mechanisms as (a) a core metering option, (b) a parallel metering option for certain classes of vehicles, (c) a means of extending the metering capabilities of the core mechanism, and (d) a longer-term transition option.

Table 7.1. Summary Assessment of VMT-Fee Mechanisms

Metering Option	Core Metering Option	Parallel Metering Option	Extended Metering Capabilities	Longer-Term Transition
Self-reported odometer				
Annual odometer inspection		X		
Optional odometer inspection		X		
Fuel-consumption estimates	X	X		
OBD II				
OBD II / cellular	X	X		X
Coarse-resolution GPS	X	X		X
High-resolution GPS			X	X
DSRC tolling			X	

8. ANALYSIS OF MOST PROMISING VMT-FEE OPTIONS

This chapter provides further analysis of the three VMT-fee options judged most promising for near-term implementation – mileage estimates based on fuel consumption, OBD II / cellular in-vehicle equipment, and coarse-resolution GPS in-vehicle equipment. For each option, the following sections present more detailed consideration of metering capabilities, costs to implement and operate (note, however, that rigorous cost estimates are beyond the scope of this project), administrative options, enforcement options, parallel charging mechanisms for certain classes of domestic vehicles, parallel charging mechanisms for foreign vehicles, legal barriers, user burdens, privacy concerns, ability to audit charges, near-term flexibility, and support for the transition to a more robust and sustainable system of VMT fees over the longer term (note that with the exception of cost and user-acceptance criteria, the OBD II / cellular and GPS options are quite similar). The chapter summarizes relevant strengths, weaknesses, uncertainties, and key design decisions for each option and notes obstacles that all of the options will face.

While any of the three options could be applied to trucks as well as cars, it may be desirable to instead develop a more sophisticated approach based on high-resolution GPS to implement weight-distance truck tolls capable of metering road use by specific route. Discussion at the end of the chapter comments briefly on the strengths and limitations of this concept.

8.1. Fuel-Consumption-Based Mileage Estimates

Core metering capabilities. With this option, per-mile fees could be levied on the basis of estimated mileage as a function of (a) the expected fuel economy for the vehicle's make and model and (b) the amount of fuel purchased at the pump. If desired from a policy perspective, the per-mile fee could also vary according to such vehicle characteristics as weight, greenhouse gas emissions, or criteria pollutant emissions. Under the core configuration, it would not be possible to achieve policy goals or pricing variations keyed to the time or location of travel. This rules out accurate apportionment of mileage revenue among jurisdictions, accurate assessment of road damages caused by heavy trucks on the basis of axle-weight and specific route of travel, and any forms of congestion pricing (although, as described below, extensions to the core configuration would enable some of these options).

Cost. There are two main up front costs required to implement this strategy. The first is to equip all stations with the necessary electronic gear – including an AVI reader for each pump (located in such a manner that it is possible to clearly distinguish between the vehicle located at one pump and the vehicle located at another), a service station point-of-sale system for calculating and tracking VMT fees and fuel tax rebates, and, optionally, an internet-based connection to a central data repository. Whitty and Svadlenak (2009) have estimated that this equipment would cost approximately $15,000 per station. Our research indicates that there are approximately 160,000 retail fueling stations across the United States, resulting in a total cost of roughly $2.4 billion.

The other main capital cost would be for equipping all vehicles with the necessary AVI device, likely involving an RFID tag. This could be affixed to the windshield, embedded in a license plate, or even embedded in an annual registration or emissions sticker. Whitty and Svadlenak

(2009) have estimated an upper bound price of $50 per unit to manufacture and install a reasonably tamper-resistant AVI on existing vehicles; with approximately 250 million vehicles in the United States, this would entail a total cost of $12.5 billion. This should be viewed, though, as a worst case cost scenario. RFID tags are themselves cheap, on the order of a few cents per tag. Depending on the specific deployment strategy (e.g., embedding RFID tags within annual registration stickers), the cost could be considerably lower, perhaps negligible.

The cost of administration must also be considered. Because this option would involve the expansion of an existing revenue system rather than the development of an entirely new system, administrative costs should (in theory) be lower. The key modification to the fuel tax collection system (described in more detail below) will be to provide a mechanism for resolving the difference between the amount of fuel taxes paid by the retail station, which is already included in the cost of fuel purchased from distributors, and the amount of VMT fees collected by the retail station. Depending on whether the balance is positive or negative, fuel station owners would either receive a credit or pay additional revenue to the fuel tax collection agency. In their exploration of this concept for the state of Oregon, Whitty and Svadlenak estimated that this additional administrative effort would cost about $1 million per year, roughly equal to what the state currently pays to collect fuel tax revenue. In other words, this approach would likely double the current administrative costs associated with fuel taxes. Given that fuel tax administration is quite efficient, with costs typically less than one percent of revenues, this should be viewed as a key advantage of this proposed approach. Note, however, that some participants in the project's expert panel expressed the opinion that administrative costs could be much higher. This assessment is therefore judged as uncertain and merits further analysis.

Administration. Since 1994, the IRS has collected federal fuel excise taxes at the terminal rack, the point at which fuel is transferred from barges, ships, or pipelines to tanker trucks. The "position holder" – the entity that owns the fuel as it passes through the rack – is liable for the tax. As of 2003, there were about 1,400 terminal racks in the United States, and each must register with the IRS. State revenue agencies vary in their practices for collecting excise taxes; some, like the IRS, collect at the terminal rack, others collect from the distributor who purchases fuel at the rack, and still others collect at the point when the fuel first enters the state. Diesel fuel taxes, which apply to on-road vehicles but not off-road vehicles (e.g., farm equipment), may be collected by states at subsequent stages in the distribution chain.

Under the proposal for levying VMT fees at the fuel pump, the IRS and comparable revenue agencies at the state level would need to interact directly with retail fuel stations to reconcile the difference between existing fuel taxes added to the price of fuel earlier in the distribution chain and VMT fees collected at the pump. If VMT fees collected exceed the amount of rebated fuel taxes, then the station would need to remit the difference to the IRS or the state collection agency. If, on the other hand, the amount of fuel taxes rebated to the customer exceeds the amount of VMT fees collected, then the fuel station would need to be reimbursed by the revenue agency (though given that the intent of VMT fees is to raise revenue, this outcome is less likely).

A key point here is that the number of parties with which the revenue agency must interact could increase considerably, from a relatively small number of wholesalers and distributors to a much larger number of retailers. The IRS and state revenue agencies routinely interact with millions of income tax payers each year, so the additional complexity of interacting directly with retail stations would seem to be well within their capabilities. However, one reason from moving fuel tax collection to the rack was to increase compliance, and some workshop participants expressed concern that moving the point of collection further "downstream" may increase the opportunities for tax evasion. It is possible that both the IRS and states will oppose this scenario on the grounds that it both complicates their existing collection mechanisms and opens the door to increased evasion.

An open question regarding administration is whether both the IRS and state revenue agencies would need to interact with retailers. One could envision, for example, the federal government collecting VMT fees from retailers and then reimbursing any states that choose to opt in to the system by levying their own VMT fees. In either case, the interaction with tax authorities may constitute an additional burden to fuel station owners, who do not currently participate directly in the collection of fuel taxes.

Enforcement. This approach performs especially well with regard to enforcement. If a vehicle is equipped with the required AVI device when refueling, mileage fees will be substituted for fuel taxes. If the vehicle does not have the AVI equipment, or if the AVI device is not working for some reason (including deliberate tampering), the vehicle will instead pay fuel taxes. In other words, there is no way for a vehicle to avoid paying road use charges, either through VMT fees or through fuel taxes, when refueling.

One could envision that this approach might be phased in over some period of time, such as with vehicle purchases or ownership transfers or with the routine re-issuance of license plate tags. During the transition period, vehicles not yet equipped with the device would continue to pay fuel taxes as before. When the transition is complete, the AVI device would be required for all (domestic) vehicles. At this point, the fuel tax might be raised considerably to discourage efforts to tamper with the AVI device, as this would result in a higher charge than simply paying the mileage fees.

Parallel charging mechanisms for domestic vehicles. The proposed approach would work well for conventionally-fueled vehicles, which currently account for more than 99 percent of the on-road vehicle fleet (Whitty and Svadlenak, 2009). It would not, however, account for vehicles that do not need to purchase fuel at a gas station. While recent developments suggest that electric vehicles may be the first in this category to reach the stage of mass marketing, future years may witness the introduction of natural gas- and hydrogen-powered vehicles with home-fueling options as well. Pluggable hybrids present another challenge. Though such vehicles will still purchase fuel as needed, their fuel economy – the basis for estimating mileage charges – will vary highly depending on the frequency with which they recharge their batteries.

In short, the pay-at-the-pump model will not handle all vehicles currently on the road, and the percentage of vehicles not covered under this model will likely increase in the coming years. This makes it necessary to consider strategies for levying VMT fees for non-conventionally fueled vehicles (likely including pluggable hybrids). Several options may be considered:

- **No charges levied.** Policymakers may wish to create incentives to encourage more rapid adoption of alternative-fuel vehicles. Allowing owners to forego road use charges might be viewed as such an incentive. From a revenue perspective, this would not be problematic until alternative fuel vehicles begin to achieve significant market share (say, greater than two percent of the fleet, although EIA (2009) forecasts that this will occur by 2011). There are, however, equity implications to consider. In the early years, alternative-fuel vehicles, given their more limited production, will tend to be more expensive than conventional vehicles. As a result, early adopters are more likely to those with higher incomes. Allowing such owners to forego road use fees will therefore result in a marginal shift of the burden of the tax burden from upper- to middle- and lower income groups.
- **Fixed VMT fee.** Another option would be to simply add a fixed "mileage fee" to the annual registration fee for alternative-fuel vehicles. Assume, for instance, that the base per-mile fee for conventional vehicles is set to 1.1 cents per mile (a roughly revenue-neutral replacement for current federal fuel taxes), and that the average car is driven 15,000 miles per year. This would result in an annual mileage surcharge, paid with registration, of $165 for alternative-fuel vehicles. Though not sensitive to actual miles of travel, the advantage of this approach would be the relative ease of administration – simply adding to the annual registration fee for a small subset of all vehicles.
- **Fixed VMT fee with odometer-based appeal.** This would be similar to the last option, with the exception that vehicle owners that travel significantly less than the assumed mileage would have the option of submitting to annual odometer readings to qualify for a reduction in total mileage fees. Though this would likely be viewed as a more equitable arrangement, it would lead to a considerable increase in administrative complexity. States that do not currently conduct vehicle inspections would need to develop the infrastructure to perform odometer readings, and many states would also need to augment their vehicle registration databases to track annual odometer readings.
- **Odometer-based VMT fees.** With this option, all alternative vehicles would submit to annual odometer readings, resulting in a more accurate assessment of VMT fees for this class of vehicles. Like the previous option, this would create additional administrative complexity for states in terms of the need to collect, track, and bill for odometer readings.
- **Wireless communications with central billing agency.** One of the assumptions underlying this project is that the near-term options for implementing VMT fees considered in the study may evolve to (or be replaced by) a more robust system that offers greater pricing flexibility (e.g., the ability to meter miles by time and location) over the longer term. The longer term approach may involve in-vehicle equipment that communicates wirelessly (e.g., via cellular communications) with a central billing agency. The idea with this option would be to develop the option for wireless communications to a central billing agency in the near term and apply the option solely to alternative-fuel vehicles (all such vehicles might be required to adopt this approach, or alternatively it could be provided as a more convenient option for vehicle owners not wishing to submit to annual odometer readings). Because the percentage share of such vehicles will remain low for some years, this could present the opportunity to develop and deploy the central billing system in a low-volume and low risk (in terms of total transactions and share of total revenue, respectively) environment. This will provide

operational experience that could guide the scaling and refinement of the central billing option, should the decision ultimately be made to apply this mechanism for all vehicles.

Parallel charging mechanisms for foreign vehicles. Another important advantage of the pay-at-the-pump model is that it would still be possible to charge foreign vehicles for their use of the road. Unless Canada and/or Mexico also adopted a similar charging scheme, foreign vehicles would lack the necessary AVI equipment to estimate VMT fees on the basis of fuel economy. In this case, however, the drivers would simply pay applicable fuel taxes instead of mileage fees.

Legal barriers. This approach would certainly require enabling federal, and potentially state legislation. One of the project panel members noted, for instance, that his state would require legislation to affix an AVI device for the purpose of federal road use fee collection to state-issued equipment such as a license plate or registration sticker. Beyond that, the authors are not aware of specific legal barriers that would prevent this form of charging.

User burden. The user burden under this option would be low. Depending on the configuration of the AVI device, it might be necessary for owners to visit a station where the device would be installed, though even that would not be necessary if the choice were made to embed an RFID tag in replacement license plates or annual registration stickers. Once the device is installed, there would be no further burden for the owners of conventionally-fueled vehicles. They would simply pay mileage charges at the pump, similar to fuel taxes. Depending on the strategy used to levy mileage charges for alternative-fuel vehicles, there may be a modest burden on the owners of such vehicles (e.g., the need to have the odometer inspected on an annual basis). In the near term, though, such vehicles will likely remain a small percentage of the total fleet.

Ability to audit. Auditing VMT fees should be straightforward with this option. When purchasing fuel, the receipt that it printed out could be designed to include (a) vehicle identification information, (b) rated fuel-economy for make and model, (c) corresponding mileage fee per gallon of gas, (d) gallons purchased, and (e) total mileage charge.

Privacy concerns. Equipping all vehicles with some form of AVI might lead to privacy concerns. Yet the level of concern should be much less than with a system featuring GPS, since the fuel-consumption-based model will not have the capability to track either time or location of travel. Should the system be extended to include gantries that would monitor the passage of vehicles on specific routes or within specific areas to facilitate certain forms of congestion tolling (see below), privacy concerns would likely increase.

Near-term flexibility. The core technical configuration under this option permits, as noted, VMT fees based on estimated mileage that may vary with such vehicle characteristics as weight and emissions class – but not with the time or location of travel. The fact that all vehicles would be equipped with AVI devices, however, creates several additional pricing options that could be pursued if desired. By adding gantries equipped with DSRC readers along heavily traveled routes, for instance, it would be possible to levy facility-based congestion tolls, as has been done with current HOT lane implementations in the United States. By placing gantries at all entrances to a crowded urban core, it would likewise be possible to implement a cordon congestion charge similar, from a technology perspective, to the Singapore program.

Several caveats should be mentioned. First, the installation of DSRC-equipped gantries is not inexpensive (in addition to the RFID reader, the gantry must also include a sensor to detect that a vehicle is approaching; otherwise it would not be possible to flag vehicles that lack the needed AVI device). On the other hand, congestion tolls would create a considerable revenue stream, so it should not prove difficult to recoup the infrastructure cost in a short period. Second, adding this form of road pricing would require a parallel payment mechanism. With only a simple AVI device (e.g., an RFID tag), the in-vehicle equipment would not be capable of storing congestion tolls accrued throughout the road network that could subsequently be paid at the pump. Rather, the readers attached to the gantries would need to communicate the charges owed by each passing vehicle to a central data repository such that the motorist could be subsequently billed. Third, the cost of the required AVI technology would likely increase. Standard RFID tags can be reliably read within a distance of 5 to 10 feet – sufficient for a stationary vehicle parked next to a fuel pump but not necessarily adequate for a vehicle passing under a gantry at 60 miles per hour. To increase the range, the strength of the RFID signal can be boosted through the inclusion of a small battery. This would obviously increase the cost of the AVI technology, though the added cost should not be major.

Support for longer-term transition. This option should support, rather than hinder, any efforts to transition to a more robust system of VMT fees over the longer term. First, it would introduce motorists to the concept of mileage-based user fees, but in a non-threatening way. The payment mechanism would remain the same, and the privacy concerns associated with tracking the location of travel, e.g., via GPS, would not be relevant. Second, the approach leverages the existing fuel tax collection system. This should keep current administrative costs low – an important advantage – but it also obviates the need to make considerable investments in a new collection system before the optimal configuration of the longer-term system has been determined. Third, even when a robust system featuring more advanced in-vehicle technology has been implemented over the longer term, it will still be necessary to assess road use fees for foreign cars. The electronic equipment installed at gas stations, used in the near term to read vehicle identification information, can later be used to distinguish between domestic vehicles equipped with metering technology and foreign vehicles lacking the necessary metering equipment. The latter group would pay fuel taxes, while the former would pay mileage charges. Finally, though other payment options might be provided in the longer term system, many motorists will continue to purchase fuel at filling stations, and some may prefer the option of continuing to pay their mileage charges at the pump.

Summary. The strengths, limitations, uncertainties, and key planning decisions for metering based on fuel-consumption can be summarized as follows:

<u>Strengths</u>

- Likely low in-vehicle equipment costs for AVI
- Potentially low administrative costs
- Effective and low-cost enforcement
- Addition of gantries enables additional forms of pricing

- Easily accommodates foreign users
- Low user burden
- Straightforward audit trail
- Minimal privacy concerns

<u>Weaknesses</u>

- Core pricing flexibility is limited
- Inaccurate mileage estimates
- Not possible to accurately apportion revenue by jurisdiction
- High cost to equip fuel stations with electronic readers
- Share of vehicles requiring parallel payment mechanism increases over time

<u>Uncertainties</u>

- Cost and configuration of AVI device
- Cost of equipping fuel stations with electronic readers
- Cost of modifying fuel tax collection system to interact with retail fuel stations
- Compliance with tax remissions

<u>Planning and Design Issues</u>

- State vs. federal roles in revenue collection
- Payment mechanism for alternative-fuel vehicles
- Whether to augment metering capabilities with DSRC tolling

8.2. OBD II Port Connection Combined with Cellular Communications

Core metering capabilities. By integrating vehicle speed information collected through the OBD II port over time, this approach should allow for more accurate mileage estimates than the fuel-consumption-based model. The on-board unit can also store information about the vehicle's make and model, making it possible to vary the per-mile rate according to such factors as weight and emissions class. Additionally, the inclusion of cellular communications makes it possible to determine the area or zone of travel. This permits relatively accurate apportionment of mileage revenue among different jurisdictions and also facilitates area-based forms of pricing (e.g., paying different mileage fees in different jurisdictions or paying higher per-mile fees when driving in a particular metropolitan area during peak hours). In short, this option offers a high degree of pricing flexibility. The main capability not provided is metering travel by specific route of travel, which would be most important for weight-distance truck tolls.

Cost. There are several important cost components for this option. The first is the cost of the in-vehicle equipment. On-board devices featuring an OBD II port connection along with cellular communications are available on the market today (they are used in some pay-as-you-drive insurance programs, as well as in other applications). Inquiries with equipment manufacturers and insurance firms suggest that these devices currently cost about $50 per unit. It should be noted, however, that the current market penetration can be measured in the tens of thousands. Expanded to a user base of hundreds of millions of vehicles, the per-unit cost would surely decrease. Assuming a worst case scenario of $50 per unit, however, would lead to a total cost of about $12.5 billion to equip 250 million cars. Additionally, it would likely be necessary to have the units installed at a certified shop, another important start up cost (although the installation of a device connected to the OBD II port is much simpler than installing GPS equipment, discussed later).

To make use of the cellular technology to determine the location of travel, it would likely be necessary to set up a cellular service agreement with one or more service providers, and the associated cost would be required on an ongoing basis. Depending on the structure of the service contract, the transmission of data (e.g., to a central billing agency) could entail additional costs. In preliminary analysis of the cost of developing and operating a central VMT fee billing agency for the state of Oregon, Bertini et al. (2002) estimated the cost of air time for data transmission at $.05 per minute. Allowing for inflation, and assuming that mileage data would be transmitted on a monthly basis and that each transmission could be accomplished within a minute, the cost would be roughly $1 per vehicle per year, or roughly $250 million annually. It should be noted, of course, that the cost of wireless transmission has decreased in the intervening years, and sending text data is even cheaper than voice communications, so the cost may well be substantially less. Given the ongoing nature of this charge, further research to update this cost estimate would be merited.

A final cost to consider involves setting up and operating a central billing agency with which the on-board equipment would communicate. Note that the scale of central billing operations would depend on the selected strategy for collecting mileage data and assessing fees. One possibility would be to set up electronic readers at fuel stations, as with the previous fuel-consumption-based metering option, such that conventionally-fueled vehicles could pay mileage fees at the pump. Only alternative-fuel vehicles would then need to communicate wirelessly with a central billing agency, which could be scaled accordingly. As another option, the system could be set up such that all vehicles would communicate mileage data through the same central billing office, and this would increase the cost.

Prior work by Bertini et al. (2002) provides insight into the potential magnitude of the costs of setting up a central billing agency to collect mileage data wirelessly and issue bills. As part of the initial Oregon VMT fee study, Bertini and his colleagues developed estimates for the initial capital and ongoing operational costs for a central billing agency to support Oregon's three million drivers. For the scenario under which vehicles would transmit mileage data on a monthly basis, initial capital costs were estimated at $1 million, while operational costs were estimated at about $50 million annually. To put these numbers in context, the state of Oregon currently spends about $1 million each year collecting fuel taxes (Whitty and Svadlenak, 2009), so this would represent a substantial increase in administrative costs. It should be noted that a significant share – about $18 million per year – of the estimated operational costs were based on the assumption that paper bills would be generated and sent to motorists on a monthly basis. As electronic billing systems become more widespread, this cost component would likely decrease considerably. Additionally, there would likely be some economies of scale when developing a central billing system to accommodate all motorists across the U.S. Even so, it is apparent that both the capital and operational costs of such a system would be high.

Administration. The previous approach of metering mileage based on fuel consumption dovetails well with the existing system for administering fuel taxes. With this option, in contrast, there are at least three options worthy of consideration. One possibility, similar to the previous approach, would be to equip fueling stations with electronic readers capable of communicating with in-vehicle metering equipment (in this case, however, the devices would communicate mileage fees directly, as opposed to vehicle information used to estimate mileage). While requiring a higher initial capital investment to equip the stations, this could substantially reduce administrative costs. Again, however, it would be necessary to develop parallel collection mechanisms for alternative-fuel vehicles.

The second option, facilitated by the use of cellular communications on the in-vehicle device, would be to establish a central billing agency that communicates with the device via wireless transmissions. As noted above, this would likely lead to higher operational costs. On the positive side, because this could handle all vehicles, it might eventually eliminate the need for parallel collection mechanisms. Additionally, it is anticipated that a greater share of alternative-fuel vehicles will enter the marketplace in the coming years, and these may need to rely on central billing.

Should it prove necessary or desirable to pursue the central billing agency, the next question that arises is how to administer the billing center. Several possibilities exist, including federal administration, contracting the service out to a private firm or consortium, or developing some type of non-profit agency or joint-powers authority governed by representatives of the states. Further research to examine the strengths and weaknesses of these options is merited.

The third option would be to develop debit cards that could be inserted into the OBU to pay mileage fees. This would obviate the need to report mileage data to a central billing agency, thereby reducing potential privacy concerns that might arise due to the use of cellular to meter the location of travel. Because this would increase the burden on users – who would need to purchase and periodically recharge the debit card – this would not likely be selected as the sole means of payment; rather, it would be an option for those particularly concerned with privacy. Developing this additional option would increase the costs of administration, but further research would be needed to specify the magnitude of the increase. Research would also be needed to determine the best model for producing and vending debit cards and allowing users to recharge them as needed.

Enforcement. The enforcement challenge is more difficult with this option than with the approach based on fuel consumption. The key issue here is to ensure that the motorist does not accidentally or deliberately disable the in-vehicle metering device so as to reduce the number of miles recorded. There are several approaches, depending on the adopted mechanism for transmitting mileage data.

Under the pay-at-the-pump model, a disabled metering device would lead to a failure when the reader at the station attempts to communicate with the in-vehicle equipment. In this case, the vehicle would instead be required to pay fuel taxes. This would not help, however, with the case in which a device is disabled while driving and then re-enabled prior to purchasing fuel. An option here, described by Whitty and Svadlenak (2009), would be for the fueling station to transmit data to a central computer system on mileage fees as well as the quantity of fuel purchased for each transaction. This data could then be audited to scan for gross inconsistencies between mileage and fuel consumption, which could trigger a subsequent audit.

For the approach in which mileage data are wirelessly transmitted to a central billing agency, it becomes necessary to ensure that the on-board unit is highly resistant to tampering (this would be advisable as well for the pay-at-the-pump model). Perhaps the simplest model would be to design the devices such that they could not be disabled without breaking a certification seal affixed to the device at the time of installation. The seals could then be inspected each year to ensure that no tampering had occurred. This, however, would greatly increase administrative costs. Another option would be to randomly inspect a smaller share of vehicles each year, setting the penalty high enough such that a rational actor would choose not to intentionally disable the in-vehicle equipment (similar in concept to the honor system for transit fares). Yet another possibility would be to allow police cars that stop vehicles for other reasons to check the odometer and compare that to the mileage data provided via OBU, with citations issued in the case of a gross mismatch. With all of these cases, it would be desirable to ensure that any driver that accidentally disables the device would be aware of the problem such that they could have it fixed promptly to avoid penalties. For example, the device might be designed to blink with a bright red light if it is not operating properly. As another possibility, the central billing agency could periodically send wireless queries to the on-board equipment; after a sequence of failed queries, the system could then generate an audit request. Alternatively, if the on-board device detects that it has been disabled, it could send a wireless alert to the billing agency which would likewise trigger a compliance audit. Finally, if gantries are set up throughout the network (for instance, to levy facility-specific tolls on top of the base per-mile fee), then the gantries could query the on-board unit on each passing vehicle to verify that it is functioning properly.

In short, there are a range of potential enforcement options, and it may prove useful to combine several for the sake of redundancy. Further research to determine the most effective, and cost-effective, approaches would be beneficial.

Parallel charging mechanisms for domestic vehicles. The OBD II port did not become standard equipment until 1996. As a result, this metering approach would not work for vehicles produced prior to that year. Fortunately, the share of such vehicles still on the road by 2015 will be small, and it will continue to decline as the years pass. Even so, it is necessary to consider parallel mechanisms for charging such vehicles for road use. There are several possibilities.

- **No charges levied.** As with the prior approach, it would be possible to allow older vehicles to travel without paying for road use. Unlike with alternative-fuel vehicles, it is difficult to make a compelling policy argument for this choice (ease of administration aside). Older vehicles tend to be the least fuel efficient and most polluting, after all, so creating an incentive to keep such vehicles on the road even longer would undermine environmental goals.

- **Fixed VMT fee.** Another option would be to simply add a fixed “mileage fee” for older vehicles. This would be inexpensive to administer, and concerns over the relative inequity between higher-mileage drivers and lower mileage drivers would diminish as the share of such vehicles on the road declines with time.
- **Fixed VMT fee with odometer-based appeal.** This would provide lower-mileage drivers with the opportunity to reduce their annual charge if they are willing to submit to annual odometer readings. On the negative side, this would also require that states develop the infrastructure to conduct odometer readings and handle mileage appeals. It may be difficult to justify such investment given that the share of pre-1996 vehicles on the road will decline with time.
- **Odometer-based VMT fees.** Under this option, all pre-1996 vehicles would submit to annual odometer readings, resulting in a more accurate assessment of VMT fees. Here again, the required administrative investment on the part of states may be difficult to justify from a cost-recovery perspective.
- **Fuel taxes.** If the pay-at-the-pump collections model is developed, it would be possible to distinguish between newer vehicles with the necessary metering equipment and older vehicles lacking the equipment. In this case, pre-1996 vehicles could simply continue to pay fuel taxes, while newer vehicles with the required metering device would pay mileage fees instead. If, in contrast, the central billing model facilitated by wireless transmissions were developed for all cars, then this option becomes more difficult, though not impossible. Under a concept put forward by Donath et al. (2009), vehicle owners with metering equipment installed in their cars would pay fuel taxes at the pump and then subsequently receive a rebate for fuel taxes paid (to record the amount of fuel taxes paid, a driver’s credit card could be linked to vehicle information; drivers who prefer to pay cash might instead be issued some type of special purpose refueling card that would indicate the vehicle identification). Vehicles lacking in-vehicle metering equipment would simply pay fuel taxes that would not be rebated. The advantage of this concept is that it would not be necessary to equip all fueling stations with DSRC readers, although it would still be necessary to upgrade the electronic payment system to link fuel tax payments with vehicle identification. On the other hand, this would lead to additional administrative costs to set up and operate the necessary bookkeeping and fuel tax rebate system, and it would also increase, to some extent, the burden on users.
- **GPS-based metering equipment.** A final option would be to install more advanced devices equipped with GPS in older vehicles. Rather than relying on the OBD II port connection to determine mileage, the device would instead rely on successive GPS readings to estimate travel distance. Though technically feasible, this application of GPS may increase the perception of privacy concerns among some owners of older vehicles.

Parallel charging mechanisms for foreign vehicles. If the pay-at-the-pump model were adopted, the reading equipment at gas stations would be able to distinguish between vehicles with mileage metering devices and those without. The former would have mileage fees added to the fuel purchase and fuel taxes subtracted, while the latter – including foreign vehicles – would simply pay fuel taxes.

If, instead, the central billing agency option were adopted as the sole collection mechanism such that gas stations did not need to be equipped with electronic readers, and if the fuel-tax rebate system described above were not developed, then fuel taxes would presumably be phased out once the system is in place. This would make the proposition of charging foreign vehicles much more complicated. The following options, all of which face certain weaknesses, might be considered:

- **Flat fee.** With this approach, a flat fee would be assessed for all vehicles entering the country. It could be viewed as grossly inequitable in that it would not distinguish between, for example, a vehicle that crosses the border for a short day trip and one that enters for an extended several week trip. It would also increase the cost and complexity of administering border check points.
- **Flat fee with odometer-based appeal.** This would enable those that cross into the country for just a short trip to qualify for a reduced fee by checking the odometer upon entering and existing the country. This would further add to the administrative cost and complexity of operating border checkpoints.
- **Odometer-based fees.** This approach would require that all foreign vehicles have their odometers checked on entering and exiting the country and pay the corresponding road use charge. This would entail even greater expense for operating border checkpoints.
- **On-vehicle equipment for frequent visitors.** With this approach, frequent foreign visitors, such as trucks, would install the same metering equipment as domestic vehicles, thus automating the collection of road use fees and reducing administrative costs at the borders. Infrequent visitors, however, might still need to pay road use fees manually.

Legal barriers. This approach would also require enabling federal, and potentially state, legislation. Beyond that, the authors are not aware of additional legal barriers that would prevent this form of charging.

User burden. For this approach, the user burden depends on several technical and programmatic design issues. When the program is first initiated, users would likely need to visit a certified shop to have the in-vehicle equipment installed. Under the pay-at-the-pump model, motorists would then pay mileage fees with fuel purchases, requiring no additional burden. Under the central billing option, motorists would need to pay fees on a periodic basis, likely monthly. This would add some burden, though the process could be automated through electronic payment systems for motorists who desire this option. A final issue – and this could be significant – depends on the approach for verifying that the in-vehicle equipment has not been tampered with. If the adopted approach relies on annual inspections, the additional user burden (along with administrative cost and complexity) would be considerable. If it proves possible to develop effective enforcement strategies not reliant on periodic equipment inspections, the user burden would be much reduced.

Privacy concerns. This approach would allow mileage metering by time of travel and by area or jurisdiction. The privacy concerns are thus higher with this option than with estimating miles based on fuel consumption. The level of concern, however, may be less than with a GPS-based system. In part due to inaccurate or inflammatory press coverage, the mere mention of GPS often conjures imagery of "big brother watching," and this perception may be sufficiently strong as to render a GPS-based approach politically infeasible. Deriving the location of travel based on cellular communications provides accuracy on par with lower-resolution GPS receivers, but it may not create the same stigma in the public eye.

Ability to audit. With any OBU that meters location information, there is a desire to both protect privacy and provide enough data to enable the motorist to verify that charges have been correctly applied (Whitty and Svadlenak, 2009). While it was noted at the workshop that a system could be designed with high degrees of both privacy protection and auditability, the trade-off is that the system would become much more expensive. This is an issue that could benefit from further research attention.

Near-term flexibility. A key advantage of this approach is that it offers very flexible pricing options. The in-vehicle equipment enables accurate metering of mileage by jurisdiction or area, making it possible to vary charges by vehicle characteristics, by jurisdiction, or by time and area of travel (e.g., area-based congestion tolls). By adding gantries at strategic points throughout the road network, it would also be possible to levy facility-based or cordon congestion tolls. Each time a vehicle passed a gantry, the in-vehicle equipment would store the relevant charge, and that would be added to base mileage when computing the fees owed. As noted earlier, gantries could also query to verify than on-board units are functioning properly, thus supporting the enforcement function.

Support for longer-term transition. Under the assumption that gantries are added to enable facility-based or cordon congestion tolls, this configuration allows for almost any conceivable pricing option. The sole exception would be fees that vary by specific route across the entire road network. This latter capability, however, would be mainly relevant for weight-distance truck tolls intended to capture the greater damage imposed by heavily laden trucks traveling on lightly-engineered surface streets. For all other vehicles, this approach could be implemented in the near term and could also support a robust and sustainable system of VMT fees over the longer term. The longer-term task, then, would not be one of transition, but rather one of evolution and refinement (for example, finding ways to make the on-board device even more tamper-resistant over time).

Summary assessment. The strengths, limitations, uncertainties, and key planning decisions for the OBD II / cellular option can be summarized as follows

<u>Strengths</u>

- Core configuration offers flexible pricing
- Addition of gantries enables additional forms of pricing
- Allows for accurate apportionment of fees by jurisdiction

- Comparatively low in-vehicle installation costs
- Percentage of vehicles requiring parallel payment mechanism declines over time
- Can support longer-term sustainable revenue system; no transition required

Weaknesses

- Use of cellular to meter location unproven in road pricing applications
- Higher costs for in-vehicle equipment
- Potentially higher administrative cost if central billing agency used to collect fees
- Difficult to charge foreign users unless pay-at-the-pump collection model employed
- Enforcement more difficult, perhaps more costly
- Potentially higher user burden depending on enforcement strategies
- Greater privacy concerns given cellular metering of location

Uncertainties

- Practical feasibility of metering location via cellular service
- Cost of in-vehicle equipment manufactured at scale
- Ongoing cost of cellular service
- Costs associated with pay-at-the-pump system, if implemented
- Costs associated with central billing agency system
- Costs associated with debit card payment option
- Cost and effectiveness of alternate enforcement options
- Whether cellular location will raise privacy concerns comparable to GPS
- How to enable billing audits while protecting privacy

Planning and Design Issues

- Strategy for procuring technology (see next chapter)
- Method(s) for collecting revenue – pay at the pump, central billing, and/or debit cards
- Public vs. private administration of central billing agency
- Strategies to enforce compliance
- Parallel payment system for vehicles manufactured prior to 1996
- Method for charging foreign vehicles, if fuel taxes phased out
- Whether to augment metering capabilities with DSRC gantries

8.3. Coarse-Resolution GPS Option

Core Metering Capabilities. The metering capabilities of this option are identical to that of the OBD II / cellular combination, and can likewise be extended through the addition of DSRC gantries at strategic points throughout the road network. The only capability not possible under this configuration is metering by specific route across the entire road network. Note that because the GPS signal may not be available in some areas (e.g., in tunnels or in urban canyons), it may still be necessary to include a connection to the OBD II port to ensure accurate mileage metering at all times.

Cost. Relative to the OBD II / cellular OBU configuration, this option would likely cost more on a per-unit basis due to the need to include a GPS receiver (although depending on the selected method for collecting fees, it may be possible to omit the cellular component). A cursory review of currently available consumer GPS applications (e.g., personal navigation devices) suggests that the per-unit cost should not exceed one or two hundred dollars. Additionally, because GPS requires connection to a power source (likely the vehicle's battery), the initial installation costs for this option are likely to be higher as well.

It is important to stress, however, that there are factors that could result, over the next five years, in much lower cost. First, the per-unit cost should come down considerably if production is scaled to hundreds of millions of units, as would occur with a national system. Second, many vehicle manufacturers are beginning to include GPS as standard equipment on their models. Provided that the OBU could be designed to plug into the vehicle's GPS signal, this would reduce the cost of the OBU (which would no longer require a separate GPS receiver) as well as the cost of installing the OBU (which would no longer require a battery connection).

This technology configuration would present the same payment options as with the OBD II / cellular device, so the cost of collecting revenue would be comparable.

Administration. The same administrative options possible with the OBD II / cellular device – pay at the pump, central billing, and debit cards – are also relevant for this configuration. The relative advantages and limitations of these three options also remain the same.

Enforcement. This option also presents the same enforcement challenges as the OBD II / cellular device – namely, finding a way to make sure that the motorist is unable to temporarily disable the OBU to avoid applicable mileage fees. The same core options, including use of the odometer as a redundancy check, tamper-resistant OBU design, and external verification that the OBU is functioning properly, are possible.

Parallel Charging Mechanisms – Domestic Vehicles. One key advantage of this option is the technology can be configured to work with any vehicle. Thus it is not strictly necessary to create a parallel charging mechanism (although one might choose to do so to allow a technology phase-in period).

Parallel Charging Mechanisms – Foreign Vehicles. Unless foreign vehicles are equipped with the same in-vehicle metering equipment, it will be necessary to determine a method for charging those vehicles for road use. The same options available for the OBD II / cellular platform would again be relevant here. If current fuel taxes were left in place, foreign vehicles would simply pay the fuel taxes when refueling. This would be the case if (a) the pay-at-the-pump collection mechanism were implemented, or (b) the central billing agency approach were designed with a mechanism for tracking and rebating fuel taxes paid.

If, on the other hand, fuel taxes were phased out, then it would be necessary to employ a more cumbersome approach for charging foreign vehicles for travel in the U.S. The options, as described under the OBD II / cellular approach, include a flat fee, a flat fee with optional odometer reading, odometer-based fees, and the installation of in-vehicle equipment for frequent foreign visitors.

Legal Barriers. Federal and state legislation required for this option would be similar to that for the OBD II / cellular configuration.

User Burden. The burden on users would be comparable to that for the OBD II / cellular combination, including the initial time required to install the device and, possibly, paying bills on a periodic basis (or setting up automated bill payment) if the central billing agency approach is pursued.

Privacy Concerns. Privacy concerns are likely to be considerable with this option (Forkenbrock and Kuhl 2002, Whitty 2003). Though it would not meter location at a greater level of precision than the OBD II / cellular option, the use of GPS appears to be clearly linked with privacy concerns in the public debate. To achieve a minimum level of public acceptability, it will be imperative to employ one or more strategies to ease privacy concerns.

Ability to Audit. This faces similar challenges as the OBD II / cellular option with regard to the issues of protecting privacy and allowing motorists to audit their charges. Further research on this topic would be beneficial.

Near-Term Flexibility. The flexibility of this approach is comparable to the OBD II / cellular option. The in-vehicle equipment enables accurate metering of mileage by jurisdiction or area, making it possible to vary charges by vehicle characteristics, by jurisdiction, or by time and area of travel (e.g., area-based congestion tolls). By adding gantries at strategic points throughout the road network, it would also be possible to levy facility-based or cordon congestion tolls.

Support for Longer-Term Transition. As with the OBD II / cellular combination, this configuration allows for almost any conceivable pricing option. The sole exception would be fees that vary by specific route across the entire road network, applicable mainly for weight-distance truck tolls. Thus it would not be necessary to transition to a more robust VMT-based revenue system over the longer term; this platform would provide all required capabilities.

Summary. The strengths, limitations, uncertainties, and key planning decisions for the coarse-resolution GPS option can be summarized as follows:

<u>Strengths</u>

- Core configuration offers flexible pricing

- Addition of gantries enables additional forms of pricing
- Allows for accurate apportionment of fees by jurisdiction
- Potential ongoing cost savings if cellular service not required
- Accommodates all vehicle types; no parallel payment mechanism required
- Can support longer-term sustainable revenue system; no transition required

Weaknesses

- Likely the highest costs for in-vehicle equipment
- Likely the highest costs for equipment installation
- Potentially higher administrative cost if central billing agency used to collect fees
- Difficult to charge foreign users unless pay-at-the-pump collection model employed
- Enforcement more difficult, perhaps more costly
- Potentially higher user burden depending on enforcement strategies
- Highest level of privacy concerns

Uncertainties

- Cost of in-vehicle equipment manufactured at scale
- Cost implications if GPS becomes standard vehicle equipment
- Costs associated with pay-at-the-pump system, if implemented
- Costs associated with central billing agency system
- Costs associated with debit card payment option
- Cost and effectiveness of alternate enforcement options
- Whether privacy concerns associated with GPS can be overcome
- How to enable billing audits while protecting privacy

Key planning decisions

- Strategy for procuring technology (see next chapter)
- Method(s) for collecting revenue – pay at the pump, central billing, and/or debit cards
- Public vs. private administration of central billing agency
- Strategies to enforce compliance
- Method for charging foreign vehicles, if fuel taxes phased out
- Strategies to enforce compliance
- Whether to augment metering capabilities with DSRC gantries

8.4. Shared Obstacles

Despite their promise, the three VMT fee options discussed in this chapter share several important limitations to consider – most notably increased cost and administrative complexity. Evidence to date suggests that any of the options will involve higher – likely much higher – collection costs than current fuel taxes. At the same time, moving the point of collection from a relatively small number of entities (fuel wholesalers) to a much larger number (either retail fuel stations or individual motorists) raises the possibility of increased tax evasion. All three would also be far more complex administratively; depending on the specific option, it may be necessary to develop or secure new tax collection channels; a new national agency or expanded state powers; cooperation from entities not currently involved with fuel tax collection, such as cellular providers and retail fuel stations; participation of the IRS; national technological specifications and a system for certifying compliance; and enabling or conforming state legislation. Finally, while VMT is projected to grow more quickly than fuel consumption, it would still be necessary to either index VMT fees or institute periodic raises to offset the effects of inflation. This would likely engender the same level of political resistance as the prospect of raising fuel taxes does today. These factors should receive due consideration in the debate over whether, and at what pace, to pursue a transition from fuel taxes to VMT fees.

8.5. GPS-Based Weight-Distance Truck Tolls

The three metering concepts explored in this chapter could apply to trucks as well as cars. Given, however, that a key issue in charging trucks for road use pertains to the maintenance costs they impose, and that this in turn depends on their weight as well as their specific routes of travel, it could be beneficial to develop a separate system for implementing VMT-based fees for trucks. For the required level of locational specificity, such a system would need to rely on precise GPS receivers as well as digital road maps more accurate than those currently available. To properly account for wear and tear imposed on the roadway, the rate structure would also include some measure of the vehicle's weight (i.e., the per-mile rate would be higher for heavier trucks than for lighter trucks).

The current research is intended to focus on near-term options for general-purpose VMT fees, and so excluded a comparable depth of consideration for a GPS-based charging mechanism specifically for trucks. It is nonetheless useful to consider briefly the potential advantages and drawbacks of near-term implementation of electronic weight-distance truck tolls reliant on GPS-enabled equipment.

Advantages. There are several advantages – some significant – worth mentioning. These can be summarized as follows.

- ***Near-term feasibility.*** One of the principal motivations for this project stems from concern that it would not be possible to implement a flexible, general-purpose system for levying VMT fees reliant on GPS technology in the near term (although, as indicated by our inclusion of the coarse-resolution GPS option above, our research suggests that this option merits further consideration). Limiting factors include the cost of retrofitting the existing fleet of vehicles as well as public concerns over potential privacy issues. While not entirely absent, these two concerns are much less relevant for the trucking industry. First, in comparison to passenger vehicles, trucks would face higher per-mile fees based on their weight, and they travel many more miles each year. Thus the cost of the in-vehicle equipment could be amortized much more quickly. Additionally, the trucking industry, as a commercial enterprise, is already subject to a much stricter regulatory regime than other motorists. This reduces the privacy concerns associated with metering travel by time and location.

- ***Higher revenue.*** With respect to road maintenance, the current system of fuel taxes creates a cross subsidy between lighter passenger vehicles and heavier trucks. That is, the percentage of road damage attributable to trucking, particularly on lightly engineered surface streets, exceeds the share of fuel taxes paid by trucks. Developing a weight-distance truck tolling system that adequately captures road damages would therefore likely lead to an overall increase in revenue from this segment of road users (Small et al., 1989).
- ***Reduced road damages.*** Establishing a weight-distance truck toll could also lead to a reduction in road damages. If structured on the basis of axle-weight, the fees would create an incentive for truckers to adopt rig configurations with more axles to reduce road use fees. This in turn would lead to a reduction in actual road damages (Small et al., 1989).

Disadvantages. There are several disadvantages that should also be considered.

- ***In-vehicle equipment cost.*** To meter travel by specific route, relatively precise GPS receivers would be required, likely entailing a cost of several hundred dollars per unit. As noted above, however, even this higher cost could be recouped quickly.
- ***Cost of developing accurate digital road maps.*** Work by researchers at the University of Minnesota (e.g., Trach et al., 2005) demonstrates that currently available digital road network maps are not sufficiently accurate to enable the detection of route-specific travel. It would therefore be necessary to develop (and maintain over time) a more accurate digital road map for the entire United States – entailing a considerable expense.
- ***Resistance among the trucking industry.*** To the extent that weight-distance truck tolls place a greater financial burden to truckers, the trucking industry can be expected to resist this concept. To gain greater buy-in, it will likely prove necessary to ensure that the program also creates benefits for the trucking industry. Allocation of revenue will be key. For example, revenue could be allocated to relieve congestion along important trucking corridors or to create new truck-only lanes. The potential of automated weight-distance truck tolls to reduce the burden of regulatory compliance among trucking firms should also be highlighted. For instance, electronically-enabled weight-distance truck tolling systems could automate the collection and reporting of data under IRP and IFTA. They would also reduce the effort associated with the current, manually implemented weight-distance truck tolls in Oregon, Kentucky, New York, and New Mexico.
- ***Privacy concerns.*** Because the trucking industry is already subject to significant federal and state regulations, privacy concerns may not be as high as with general passenger traffic. On the other hand, the specific pattern of truck pickups, routes, and drop offs may be viewed as proprietary information that supports a firm's competitive advantage. Firms will therefore want to ensure that the privacy of such information is maintained.

9. IMPLEMENTATION STEPS AND STRATEGIES

As indicated in the preceding chapter, each of the three most promising options for the near-term implementation of VMT fees presents its own set of strengths and limitations. Moreover, there are key uncertainties regarding the likely costs and capabilities of certain administrative and technical components. This makes it difficult, absent additional targeted research, to specify with precision the optimal configuration for implementation by 2015. That said, prior work conducted in this arena does not provide a sufficient basis for outlining a set of planning and development steps that accommodates the near-term implementation goal yet offers enough flexibility to manage the risk surrounding remaining uncertainties. This chapter begins by laying out an approach that builds toward the near-term implementation of national VMT fees.

Even if implementation commences in 2015, it may take time to phase in the required equipment for the entire fleet – particularly if the metering involves the use of an OBU. Two issues that will affect the duration of the transition include the cost of retrofitting existing vehicles and the level of privacy concerns surrounding metering based on vehicle location. As discussed in several recent proposals, it may be possible to mitigate both of these obstacles by developing a system in which users are not immediately required to install more sophisticated equipment, but rather are given the choice of choosing to opt in. It is thus useful to comment on possible incentives that could be used to encourage more rapid adoption.

The chapter next discusses the potential advantages of an "open systems" approach to the development of the required in-vehicle technology. Broadly consistent with the opt-in transition strategy, the basic idea is that a national, minimal set of road use metering requirements would be developed. Technology vendors would compete for market share on the basis of price and add-on features (e.g., personal navigation or real-time travel information).

Expanding on this discussion, the chapter considers the alternate roles that might be performed by public and private parties in the development, operation, and enforcement of a national system of VMT fees.

9.1. Managing Risk on the Path to Implementation

Each of the implementation mechanisms discussed in the prior chapter offers compelling advantages, yet each suffers key limitations as well. Broadly speaking, the fuel-consumption-based mechanism offers more limited pricing flexibility, but it would also be much cheaper to implement and administer. The two options involving an OBU – including the OBD II / cellular device and the GPS device – offer much greater pricing flexibility, but at the cost of more expensive in-vehicle equipment and potentially more complex enforcement and administrative requirements. Additionally, acute privacy concerns may constrain the acceptance of either of the OBU mechanisms. If, however, the decision is made to implement VMT fees by 2015, then concerted efforts must begin shortly. Based on evidence from past studies and trials, the following planning and development steps may facilitate progress towards implementation by 2015 while helping to manage the risk associated with remaining uncertainty.

Implement Pay-At-The-Pump Collections. This payment option – requisite for the fuel-consumption-based estimates and optional with either of the OBU metering configurations – offers several significant advantages. The payment mechanism is already familiar to drivers, and it offers a means of charging for road use for vehicles lacking the necessary metering equipment, including foreign vehicles as well as older domestic cars. Though requiring an upfront cost to equip all fuel stations with electronic readers and an added burden on retail fuel stations, the option should none-the-less result in relatively low collection costs given that it involves the expansion of an existing revenue channel rather than the development of an entirely new collection apparatus. The pay-at-the-pump model also minimizes the risk associated with the transition to a new revenue system. Specifically, it provides a fallback revenue source – existing fuel taxes – should any element of the new system fail (Whitty 2008).

Develop a Central Billing Agency that Supports Wireless Data Transmission. Regardless of the specific metering approach adopted, alternative-fuel vehicles will not be able to pay mileage fees at the pump. While such vehicles could pay based on periodic odometer readings, it may prove advantageous to develop a central billing agency with wireless data transmission capability. For one thing, this would reduce user burden, and it may well prove less expensive to implement than manual odometer inspections. Additionally, while the share of alternative-fuel vehicles is still low, it looks likely to grow in the coming years, and wireless communications to a central billing agency may prove the most flexible collections option for such vehicles. Implementing a central billing agency at the outset would provide the opportunity to explore alternate protocols and administrative arrangements while the volume of users is still low, hence lowering the risk should unanticipated problems arise. Any lessons learned in this process could be applied as the system is scaled up over time to accommodate more users.

Resolve Uncertainties Surrounding In-Vehicle Equipment Options. Through targeted research, it should be possible to resolve remaining uncertainties surrounding the alternate technology configurations over the next several years and thus support a more informed decision regarding the most cost-effective metering platform.

For the AVI device to support estimates based on fuel consumption, key issues include:

- Cost and configuration of AVI device
- Method of installing AVI device
- Whether, and what form of, state support will be required

For the OBD II / cellular OBU option, key issues include:

- Whether the cellular location concept works in practice
- Anticipated cost of device produced at scale
- Anticipated cost of installing equipment in vehicles
- Anticipated cost of ongoing cellular service
- Methods for, and anticipated cost of, ensuring that users do not disable the OBU
- Whether cellular location stimulates the same level of privacy concerns as with GPS

For the GPS option, key issues include:

- Anticipated cost of device produced at scale
- Anticipated cost of installing equipment in vehicles
- Accuracy of metering while traveling in areas where the GPS signal may be weak or unavailable
- Whether cost may decrease if GPS becomes standard vehicle equipment
- Methods for, and anticipated cost of, ensuring that users do not disable the OBU
- Whether, and by what means, current privacy concerns can be mitigated

Proceed Based on Research Results. Depending on the research results, implementation could proceed in one of several directions:

- If the two OBU options prove infeasible – from either a technology or cost perspective – vehicles could be equipped with a simple AVI device to enable mileage estimates based on fuel consumption. Because the AVI device should be inexpensive, a rapid transition period should be possible.
- If it can be demonstrated that the OBD II / cellular OBU configuration works as expected and does not raise significant privacy concerns, the implementation effort could focus on this option. Given the higher equipment and installation costs, the transition may require a longer phase-in period.
- If the expected equipment and installation cost for a GPS-equipped OBU can be reduced and current privacy concerns can be overcome, this option could be selected as the preferred configuration. Here again, the costs of retrofitting the existing fleet may motivate a longer phase-in period.

9.2. An “Opt-In” Strategy to Speed the Transition Period

An assumption common to earlier VMT-fee concepts (Forkenbrock and Kuhl 2002, Whitty 2003) is that retrofitting existing vehicles with the required metering equipment would prove to be an extremely costly and cumbersome undertaking. To minimize start up costs, these earlier proposals suggested phasing in the equipment with new vehicle purchases, entailing a transition period of perhaps 15 to 20 years as the existing vehicle fleet turns over.

If additional research demonstrates that the option of metering mileage based on fuel consumption represents the best near-term option, the expense of the required AVI device should be minimal, allowing for a much faster transition period. If, on the other hand, the decision is made to pursue either of the more flexible OBU-based metering mechanisms from the outset, then the issue of retrofitting existing vehicles must still be addressed. Recent proposals, however, have considered options for encouraging users to adopt the metering technology on a voluntary basis – to “opt in” to the system – so as to speed the transition period (at some juncture, of course, it may be necessary to require that all remaining vehicles adopt the equipment).

The discussion of opt-in strategies has identified at least three factors that could encourage more rapid adoption on a voluntary basis: lower costs, greater convenience, and access to desirable add-on functionality.

Lower costs. Minnesota is currently planning to implement a VMT-fee trial that will incorporate a cost incentive to encourage voluntary adoption (Starr, 2009). Under the Minnesota concept, all drivers would be required to submit to periodic odometer readings as the basis for assessing VMT-based road use charges. Drivers willing to accept in-vehicle metering equipment, however, would qualify for a reduced per-mile rate when traveling in rural areas or at off-peak times, while drivers without the equipment would pay the undiscounted rate for all miles traveled.

Applying this concept to the mechanisms under consideration here, all conventionally-fueled vehicles might be equipped with a simple AVI device by 2015 to meter estimated mileage based on fuel consumption, with a moderately high per-mile charge. Vehicle owners willing to voluntarily adopt an OBU, however, would qualify for lower rates for rural or off-peak mileage, though they perhaps might also be required to pay higher rates for peak-hour travel in congested periods. The potential to reduce fees should encourage at least some drivers to adopt the equipment sooner rather than later. Another option would be to raise fuel taxes during the transition period such that adopting VMT fees would be cheaper than continuing to pay fuel taxes.

Greater convenience. By allowing for automated payment, in-vehicle equipment may be viewed as an opportunity to increase the convenience of paying road use charges. Imagine, for example, that conventional vehicles are provided the opportunity to pay fees at the pump. Owners of alternative-fuel vehicles might then be provided the option of either (a) submitting to annual odometer inspections as a means of levying VMT fees, or (b) adopting the in-vehicle metering equipment to automate the process. Many might view the latter option as being the more desirable.

Access to desirable functionality. Whitty and Svadlenak (2009), along with other researchers, have made the observation that an OBU capable of determining the location of travel (e.g., via GPS) can be extended to offer many additional features that a driver might find desirable. In-vehicle navigation is the most obvious example, but many other possibilities exist, particularly when one considers ongoing advances in intelligent transportation systems technologies. The equipment might, for example, provide real-time traffic advisories specific to the current route of travel, estimate travel time to the intended destination given current traffic conditions, or identify available parking spaces in the nearby vicinity. Such features may further increase the number of vehicle owners willing to adopt an in-vehicle metering device. However, the programming associated with multiple functions can also increase security risks in data transmission, and further research in this area is likely warranted.

9.3. An "Open Systems" Approach

Consistent with the "opt-in" approach, Whitty and Svadlenak (2009) also recommend consideration of an "open systems" approach in which the government publishes a set of standards that dictate minimum required metering capabilities and interface specifications for the OBU. Vendors would then be able to introduce their own products and compete for market share on the basis of (a) price, and (b) the provision of additional features that motorists find desirable (note that each product would need to be certified as meeting the required metering capabilities).

This concept is appealing in several regards. First, by harnessing market forces, it should help to increase the quality of the devices while simultaneously driving down cost. Second, it opens the door to the incorporation of new technologies as they emerge in future years. There would not be a single design that every driver uses; rather, vendors could continue to modify and improve their offerings as technology allows.

10. PREPARING FOR IMPLEMENTATION BY 2015

From the past several chapters, one may infer that the task of preparing to implement a national VMT fee system by 2015 will be complex and demanding. Yet with focused effort and attention, this goal should nonetheless be possible. To bolster the prospects for success, however, it would be extremely beneficial – likely necessary – to undertake a coordinated set of preparatory activities, spanning the areas of planning, research, technology development, larger-scale trials, and education and outreach. This chapter considers specific investments in each of domains that would support the goal of implementing VMT fees by 2015.

10.1. Planning Investments

Planning, developing, and implementing a national system of VMT fees will be a massive effort, involving far too many planning and oversight activities to enumerate in this document. What is clear, however, is that the effort will require a designated entity, granted the requisite level of authority. Likely responsibilities would include overseeing research efforts, interpreting results, making programmatic design decisions, formalizing technical and functional system requirements, identifying legislative and administrative actions needed at the federal and state levels, and interfacing with private sector participants. While several administrative forms might prove possible – a commission, a committee, a joint powers authority, or an expanded role for an existing agency – it would be advisable for the entity to include representation for a broad range of stakeholders, including U.S. DOT and Treasury, congressional staff, the states, relevant advocacy groups (e.g., road user groups and environmental organizations), subject matter experts within the research community, and the private sector (with care taken to avoid potential conflicts of interest). The entity would also require funding sufficient to accomplish its tasks.

10.2. Analytic Studies

As noted in Chapters 8 and 9, there are remaining uncertainties surrounding many of the possible implementation options that might be pursued. To better understand the likely costs and benefits of alternate system design options, the following targeted analytic studies would be beneficial:

- Study the behavioral response to alternate forms of pricing
- Develop revenue projections for alternate forms of pricing
- Estimate the cost of alternate in-vehicle equipment configurations produced at scale
- Estimate the installation costs for alternate in-vehicle equipment configurations
- Estimate the likely market penetration of in-vehicle GPS-based navigation systems which could be used to support mileage metering
- Estimate the cost of equipping fueling stations with electronic readers
- Estimate the cost of collecting revenue via the pay-at-the-pump model
- Estimate the per-vehicle cost of cellular service in support of VMT fees

- Estimate the cost of developing and operating a central billing agency
- Estimate the cost of developing and operating a debit card payment option

10.3. Technical Research and Development

Though many of the potentially relevant implementation technologies have already been proven in real-world trials and are well understood, further research and development efforts on the following components would help ensure feasibility of VMT-fee options.

- Develop and demonstrate the use of cellular equipment to meter travel by location
- Evaluate AVI configurations for pay at the pump and tolling via DSRC gantries
- Develop effective, low cost enforcement options to prevent OBU tampering

10.4. VMT-Fee System Trials

Several significant VMT-fee system trials – in Oregon, in Puget Sound, at the University of Iowa, and at the Georgia Institute of Technology – have already been completed or were underway as this research was being conducted. While these efforts offer valuable insights and information, it would be beneficial to invest in additional VMT-fee trials on the path to implementation in 2015. To gain greater insight on what would be most helpful in these trials, research team members spoke with James Whitty (2009) and Jon Kuhl (2009b), the two individuals responsible, respectively, for the Oregon and University of Iowa pilot programs. Several key themes and suggestions emerged from this interaction:

- **Shift from exploratory pilot programs to directed research trials.** Prior trials have demonstrated that several implementation options are feasible and provided a rough understanding of the relative advantages and limitations of the alternatives. Additional trials should be specifically targeted to provide greater clarity on design and implementation issues central to the development of an effective and efficient national-scale VMT-fee system. Some of the most important questions include the cost of alternate collection channels, the effectiveness of different enforcement strategies, and the robustness of alternate technical configurations.
- **Develop set of baseline technical specifications to support VMT fees along with an "open system" architecture.** The idea here would be to establish, based on what has already been learned through prior research and trials, a minimum set of technical requirements for the in-vehicle equipment designed to support a national system of VMT fees. The exact set of specifications would depend on policy goals but might include, for example, a requirement that any in-vehicle devices used in the trials would be able to meter mileage by state to allow for accurate apportionment of fees. Note that with this approach it would still be possible to examine and test different technical designs for the in-vehicle equipment provided that they met the basic technical specifications, thus allowing for continued innovation and improvement.
- **Pursue a large-scale national trial of the baseline VMT-fee functionality.** This suggestion involves a trial program that includes a much larger number of participants than in prior pilot studies – perhaps on the order of 20,000 to 50,000 – as well as more states. Organized at the

national level, states would have the opportunity (rather than a requirement) to participate in the trial, in which case they would receive the resources needed to fund their efforts. The large-scale trial would focus principally on the functionality called for within the minimum technical specifications described above.

- **Make the large-scale trial as realistic as possible.** The large-scale trial should involve the collection and apportionment of actual VMT fees to test certain system attributes, such as the costs of alternate collection mechanisms and the effectiveness of different enforcement strategies (to avoid double-taxation, participants would of course need to be reimbursed for any fuel taxes incurred during the trial).
- **Fund additional smaller-scale trials to test extensions to the baseline functionality.** Trials in this vein would focus on "value-added" features for the base VMT fee system used in the larger national trial. Such trials might, for instance, explore more flexible pricing capabilities, such as varying the fee by time, by location, or by specific route of travel. Alternately, the trials might involve the provision of additional services to users such as route guidance based on real-time conditions or pay-by-the-minute parking. Both states and private firms should have the opportunity to compete for grants to perform such trials.

The feedback from Whitty (2009) and Kuhl (2009b), along with other insights gained during the research and analysis conducted for this project, suggests the following tasks for future VMT fee system trials:

- Develop agreement, in the form of a baseline technical specification for in-vehicle metering equipment, on the pricing functionality to be supported by a national system of VMT fees.
- Fund a large-scale, multi-state trial to test the baseline pricing configuration. Use this trial to gain greater clarity regarding key system design issues – including alternate technical configurations for in-vehicle equipment, alternate revenue collection avenues, and alternate enforcement strategies. To fully exercise all system components, make the trial as realistic as possible, including the collection and apportionment of actual VMT-fee revenue.
- If a national system of weight-distance truck tolls is envisioned, include trucks within the trial program (or, alternately, develop a separate weight-distance truck tolling trial).
- Fund additional, smaller-scale trials to test additional functionality that might be used to augment the baseline VMT-fee system configuration, including more sophisticated forms of road pricing along with value-added user features.

10.5. Public Education and Outreach

In considering the public acceptability of VMT fees, experts contacted by the research team offered two salient observations. First, there is little public understanding of the current challenges in transportation finance, and in turn the motivations for a transition to VMT fees. Second, the privacy concerns associated with GPS remain a potent obstacle to the acceptance of sophisticated in-vehicle metering equipment. To bolster the political prospects for transitioning to a VMT-fee system, concerted public education and outreach will likely be imperative. It is not clear, however, what may be the best avenues along which to pursue this effort. Participants in the expert panel suggested the idea of a "grass tops" approach, in which initial education and outreach would focus on state and local elected officials, who in turn would be able to build support among their own constituencies. It was also suggested that educating the press will be valuable, but this might occur at a later stage. Responsibility for leading education and outreach efforts would presumably be assigned to the designated entity planning, developing, and implementing a national system of VMT charges, but that entity might delegate responsibility to others.

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Abbreviations

BEES	Board on Energy and Environmental Systems
EIA	Energy Information Agency
FHWA	Federal Highway Administration
GAO	Government Accountability Office
NHTSA	National Highway Traffic Safety Administration
NSTIFC	National Surface Transportation Infrastructure Financing Commission
ORNL	Oak Ridge National Laboratory
PSRC	Puget Sound Regional Council
TRB	Transportation Research Board.

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APPENDIX A. EXISTING PROGRAMS AND PROPOSALS

This appendix provides brief descriptions of the existing and proposed distance-based charging systems discussed in Chapter 3. They are divided into three categories: general-purpose distance-based road use charges, weight-distance truck tolls, and pay-as-you-drive (PAYD) insurance.

A.1. General-Purpose Distance-Based Road Use Charges

Oregon Department of Transportation's Road User Fee Pilot Program. Under a mandate from the State Legislature, the Oregon Department of Transportation planned and conducted a pilot study of mileage-based user fees and area-wide congestion tolls. The 12-month pilot project took place from 2006 to 2007 and included 285 vehicles, 299 drivers, and two gas stations. On-board units combined GPS receivers to identify whether vehicles were driving in one of two zones, and mileage was measured with the odometer. Mileage data was communicated wirelessly to the participating gas station, which then calculated the difference between the gas tax that would have been paid and the mileage fee. The gas stations' point-of-sale systems also had to be reconfigured to participate. After an initial phase in which all drivers paid the regular gas tax, drivers were divided into two groups to test various pricing concepts: some paid a flat fee of 1.2 cents per mile in one zone, while others paid 10 cents per mile during peak hours in the "congestion zone," but only 0.43 cents for other travel. Drivers did not pay the new fees at the pump, but they received credits in a endowment account that was paid out at the end of the study. Both groups reduced their overall VMT during the study, and the technology functioned well. For more information, see Whitty (2003, 2007, 2008).

Puget Sound Regional Council's Traffic Choice Study. The Puget Sound Regional Council, the MPO for the Seattle area, conducted a study of network-wide congestion tolls from 2005 to 2006. Approximately 275 households participated; their 500 vehicles were equipped with an on-board unit, complete with cellular communications and a GPS receiver. The study was designed to test responses to areas-wide congestion tolls; tolls were levied on freeways and major arterials, with per-mile rates ranging from zero to 40 cents depending on the link and the time of day (however, tolls did not vary dynamically). The on-board unit detected when the vehicle traveled on a link subject to congestion tolls, calculated the charge, and periodically uploaded the data to a central computer center. The GPS display showed drivers the current cost per mile as well as the cumulative cost for the trip; drivers also received a mock invoice at the end of every month. Drivers had a financial incentive to reduce their travel, since a "travel budget" was maintained by the study, and if drivers reduced their VMT they received the balance at the end (if their behavior was unchanged, they did not lose money). Analysis of study results found that many drivers did change their travel behavior and that the equipment functioned well. For more information, see PSRC (2008).

University of Iowa Mileage-Based Road User Charge study. The University of Iowa is in the middle of conducting the second phase of a study on mileage-based fees. Trials are taking place in 12 locations around the country and will ultimately include about 2,700 vehicles. The first round of trials took place in Baltimore, San Diego, Austin, the Research Triangle in North Carolina, Boise, and Eastern Iowa; the second round begins this year in Chicago, Billings, Albuquerque, Wichita, Portland (Maine), and Miami. Vehicles are outfitted with an on-board unit that combines GPS with an OBD port connection; the GPS unit determines location, while vehicle speed data from the OBD port is used to compute travel distance. Charges vary with two criteria – the fuel economy profile of the vehicle and the jurisdiction. Per-miles rates vary from 0.36 cents (for vehicles in the 48 - 53 miles per gallon range) to 1.99 cents (for vehicles in the 8.8 - 9.7 miles per gallon range). Per-mile rates may also vary across states if current fuel taxes also vary. Within each jurisdiction, however, all miles driven by a vehicle are charged the same rate; neither time nor specific location is considered. Pricing is set to be revenue-neutral overall. Data from the instrumented vehicles are transmitted wirelessly to a "back office" operated by the University, which then sends mock invoices to the drivers in all six regions on a monthly basis. Drivers continue to pay normal gas taxes, though; the invoices only demonstrate how much they would have paid if the system were fully operational. For further information, see Forkenbrock and Kuhl (2002), Forkenbrock (2005), and Kuhl (2007).

Georgia Tech Commute Atlanta study. The Georgia Institute of Technology conducted a study called Commute Atlanta to examine the effects of converting fuel taxes, registration fees, and insurance costs to variable costs. The first phase of the project collected baseline data from 475 vehicles in 273 households in 13 counties. In addition to conventional travel diaries, data were collected via GT Trip Data Collectors that were installed in the vehicles. These GPS devices collected data on vehicle location, speed, and acceleration every second. The second phase of the project studied travel behavior with a mileage-based incentive simulation. Participating households received rebates on travel costs based on their miles traveled in the preceding year; that is, if they drove fewer miles, they earned a certain number of cents per every miles not driven (the number started at 5 cents per mile and increased to 15 cents). (Phase II study results are not yet available to the public.) A third phase, to study the impacts of congestion tolls, was not funded. For further information, see Guensler and Ogle (2004).

The Netherlands proposal. The Netherlands has an ambitious proposal to move all vehicles to a distance-based system by 2018. While full details have not yet been worked out, recent reports have suggested that vehicles will pay different rates based on their emissions profile, and that some but not all roads will have congestion tolls as well. The exact payment system has yet to be determined. In keeping with an European Union directive, the system will be GPS-based with an element of mobile communications. Multiple equipment providers will be allowed, and will compete for customers based on additional features. For further information, see Alternative Payment for Mobility Project Team (2008).

New Zealand. Since the late 1970s, New Zealand has had a weight-distance fee system in place for vehicles whose fuel is not taxed at the source (mostly diesel) or that are over 3.5 tonnes. The fees vary by vehicle weight and the number of axles. Driver purchase licenses for a specific distance in 1000-km increments and display them in the vehicle. Trucks required to pay the road-user charge must be outfitted with a hubodometer, which measures distance by the rotation of the wheels. There is discussion of moving to electronic collection, but specific recommendations have not yet been made. For further information, see Land Transport NZ (2008) and New Zealand Ministry of Transport (undated).

A.2. Weight-Distance Truck Tolls

The Austrian GO program. Successfully launched on time and within budget in January 2004, the Austrian GO truck-tolling program is managed by Europpass, a subsidiary of the Italian firm Autostrade. The GO program applies distance charges on the motorway for all vehicles whose maximum admissible weight exceeds 3.5 tons, with specific fee levels that depend on the weight class and the number of axles. From a technical perspective, the GO program is the simplest of the recently implemented or proposed truck tolling schemes reviewed here. To participate in the GO program (and thus avoid the inconvenience of paying tolls manually), each vehicle is equipped with an on-board unit featuring DSRC. These units communicate with overhead gantries located on different links throughout highway system. Each time a vehicle passes one of the 420 gantries distributed throughout the network, a distance charge for the link in question is applied. If the gantry fails to detect an on-board receiver, the vehicle will be flagged for investigation of possible toll evasion. One notable feature of the GO system is interoperability with the Swiss tolling program; by inserting a simple chip within their "Tripon" on-board units, Swiss drivers traveling in Austria can pay their tolls automatically as well. For further information, Schwarz-Herda (2004).

The Swiss Heavy Goods Vehicle Fee (HVF) program. Following a lengthy political acceptance process, Switzerland successfully launched its heavy goods vehicle fee (HVF) on time and within budget in January of 2001. The HVF applies to all vehicles with a maximum laden weight in excess of 3.5 tons. The fee is calculated based on the distance driven (on all Swiss roads, not just the highways) as well as the maximum laden weight and the emissions class of the vehicle. The price structure is designed to account for both direct and external costs of trucking to encourage a freight mode shift from road to rail. The supporting technology includes an on-board unit (mandatory for all Swiss vehicles and optional, though encouraged, for foreign vehicles) featuring GPS and DSRC, as well as a connection to the vehicle's tachometer (including odometer information). DSRC signals from overhead gantries at border crossings (in the case of primary arteries) and/or the GPS position signals (in the case of smaller roads without DSRC gantries) are used to set the status of the OBU (within Switzerland or traveling abroad), and odometer information is used to register miles driven on Swiss roads. DSRC stations mounted throughout the network are also used to verify the correct functioning of passing trucks as a means to prevent toll evasion. For further information, see Balmer (2004) and Werder (2004).

The German Toll Collect program. The German Toll Collect truck toll system was initially targeted for implementation in the fall of 2003, but due to technical and contractual difficulties the launch was delayed until January of 2005. Per European Union directive, the fee system applies only to vehicles over 12 tons and principally to use of motorways (some adjacent surface streets are tolled to prevent truck diversion). The price varies by distance traveled, by the number of axles (as a surrogate for weight), and by the emissions class of the vehicle. The overall fee structure is designed to recoup direct capital and operating costs to the motorway system imposed by truck traffic. The technology supporting Toll Collect involves an on-board unit equipped with GPS (to determine both entry to and exit from the motorway network and distance traveled) and cellular communications (to transmit billing data to the central computer system). Toll Collect is administered by a private consortium that collects the tolls on behalf of the German government. The government then spends most of the revenue on road maintenance and improvement projects that reflect government priorities. For further information, see Kossak (2003), Rothengatter (2004), Rothengatter & Doll (2002), and Ruidisch (2004).

The United Kingdom proposal. Several years ago the United Kingdom planned to develop a weight-distance truck tolling program, though to date it has not been implemented. The plan called for varying fees according to distance traveled, type of vehicle (weight, number of axles, and emissions class), and type of road. In subsequent years, the fee basis would be expanded to include time of day (to reflect congestion costs) and geographic area (to reflect, for example, the high costs that trucks can impose on residential areas) as well. The technology to support the toll would be based on an on-board unit that includes GPS (to determine both distance and road type), cellular (to communicate with the central billing authority), and a link to the vehicle's tachograph (to provide a backup check on distance traveled). The motivation for the fee was to ensure that foreign haulers who purchase their fuel abroad before arriving in the UK are forced to pay their share for road use. Because the focus of the new program was not on increasing fees on domestic truckers, but rather leveling the playing field, the proposal reportedly enjoyed a significant degree of political popularity in the U.K. For further information, see Worsley (2004).

The Oregon electronic weight-distance truck toll payment concept. Oregon is currently the only state to rely exclusively on weight-distance tolls for trucks (the three other states with weight-distance fees also levy diesel fuel taxes). Oregon has looked at a concept in which trucks would be outfitted with GPS systems that capture information about mileage traveled within pre-identified zones based on GIS maps. At the end of each month, data would upload wirelessly to a central billing center. Truck weights and number of axles would be factored in with the mileage data to determine road use charges, as with the current manual reporting system. Trucking companies could either receive a paper statement or manage payment online. For more information, see Witty and Svadlenak (2009).

A.3. Pay-As-You-Drive Insurance

Massachusetts. Massachusetts introduced competitively priced auto insurance in April 2008; previously, rates had been set by the state. Insurance companies can now offer discounts for low mileage: 10 percent discount for driving between 0 and 5,000 miles annually, and a 5 percent discount for mileage between 5,000 and 7,500. Mileage is verified by the Massachusetts Registry of Motor Vehicles. For more information, see Bingham (2009) and Boston Consumer's Checkbook (undated).

GMAC. In 34 states, drivers of GM vehicles equipped with OnStar GPS systems can sign up for mileage-based discounts. Discounts are based on mileage bands; for example, drivers who drive 5,000 to 7,500 miles per year receive a 34 percent discount over the standard premium they would otherwise pay, while those who drive 7,500 to 10,000 miles could receive a 26 percent discount. The mileage is calculated by the vehicle diagnostics system; location of driving is not used to calculate the premium. For more information, see OnStar (2007).

MileMeter. This Texas firm offers PAYD with the cost per mile based on the driver's age, vehicle, and location. All miles driven carry the same cost. The driver purchases a six-month policy for a specific number of miles from 1,000 to 6,000; the policy ends when either the six-month mark is reached or the driver has driven the number of miles purchased. MileMeter does not track the number of miles driven; if a claim is filed, it is matched against the policy validity, and the policy is not valid if the odometer reads over the specified number. For more information, see MileMeter (undated).

Progressive Insurance. Progressive offers PAYD in ten states, under a program called MyRate. Pricing is based on distance driven but also takes into account the time of day (miles driven during peak hours and after midnight are more expensive than at other times of day) and sudden starts and stops. Drivers receive a discount on their next policy renewal. Discounts currently go up to 25 percent; drivers are also subject to a nine-percent surcharge if they are deemed more risky based on their driving habits. Mileage, time of day, and driving habits are tracked with an ODB device that transmits data wirelessly to Progressive at the end of each trip. For more information, see Donohue (2008) and Progressive Insurance (undated).

Aviva (Canada). Aviva has a pilot program called Autograph offering PAYD insurance in the province of Ontario. Much like Progressive Insurance, from whom it licenses the technology, Aviva offers discounts based on distance driven, time of day, and speed; distance is the most important in terms of calculating the discount. While the maximum discount possible is 35 percent, and the lowest 5 percent (Aviva does not raise rates based on high mileage), the average discount is around 20 percent. The OBD II device that records the data requires the driver to take the device out, upload the data to a computer, and send it to Aviva. Aviva plans to move to wireless transmittal of data in the future. For more information, see Bettencourt (2005) and Insurance-Canada (2005). Note that Aviva also offers PAYD in France and Turkey, but further information was not readily available in English.

Coverbox (United Kingdom). Coverbox (owned by Wunelli Limited) offers PAYD insurance with costs based on distance and time of day driven (off-peak, peak, and "super-peak" periods). The per-kilometer cost is calculated for each driver; as Coverbox functions as a broker, drives can choose between quotes. Drivers estimate when they take out a policy the number of kilometers they think they will drive. They can either pay monthly, like a utility bill, or pay the whole premium up front and be credited or debited at the end of the premium period for any difference from their estimate. Kilometers are tracked by the Coverbox, a GPS unit produced by Cobra that must be professionally installed and offers anti-theft protection. For more information, see CoverBox (undated).

Hollard Insurance (South Africa). As with the Real Insurance program in Australia, Hollard offers PAYD insurance with a two-part fee, fixed and variable. However, the customer receives a monthly bill for the number of kilometers driven, much like a utility bill. The variable fee is applied for monthly distances driven between 417 and 3,200 km (259 to 1,988 miles) per month. All kilometers are charged at a flat rate, which is calculated separately for each driver. Kilometers are measured by a GPS device called Skytrax, produced by the firm Tracker and professionally installed. Skytrax offers roadside assistance and theft tracking. For more information, see Hollard Insurance (undated).

Nedbank (South Africa). Hollard Insurance also underwrites an insurance policy called "Pay per K." Drivers pay on a monthly basis with a flat fee per kilometer driven. Distance is measured based on odometer readings, which are captured with a NedFleet card that drivers use to purchase fuel. For more information, see NedBank (undated).

Real Insurance (Australia). Real Insurance's PAYD program operates with a two-part fee. Drivers pay a fixed fee per month (legal liability coverage) and a variable fee based on distance driven (comprehensive coverage). The initial purchase must cover at least 5,000 km, which can be rolled to the following period if the driver travels fewer kilometers. All miles are charged at the same rate. Real Insurance verifies mileage when claims are filed, and a claim can be refused if the odometer shows more kilometers than last purchased. The liability coverage remains in place even if the comprehensive coverage has run out. For more information, see Pay As You Drive (undated).

APPENDIX B. STATE INTERVIEWS AND QUESTIONS

B.1. List of Agencies and Persons Interviewed

To gain greater insight into state perspectives regarding a potential transition to VMT fees, the research team interviewed the following state officials. All interviews were conducted by telephone by Liisa Ecola. If multiple persons are listed at an agency, they were part of the same interview.

Minnesota Driver and Vehicle Services Division (March 13, 2009)
Patricia McCormack, Director
Marge Noll, Program Supervisor for IRP and IFTA
Roxanne LaDoucer, Interim Vehicle Service Program Director
Linda Long, Support Service Program Director (registration tax)

Minnesota Department of Revenue (March 11, 2009)
Bob Overturf, State Program Administrator Senior, Petroleum Unit, Special Taxes Division

Minnesota Department of Transportation (March 16, 2009)
Bernie Arseneau, Division Director, Policy, Safety, & Strategic Initiatives Division
Ken Buckeye, Program Manager
Norm Foster, Finance Director

South Carolina Department of Motor Vehicles (March 23, 2009)
Jimmy Earley, Chief of Staff to Executive Director
Lottie Devlin, Deputy Director for Vehicle Services

South Carolina Department of Transportation (March 20, 2009)
Michael Covington, Director of Administration
Susan Johnson, Director of Engineering Outreach

Texas Department of Transportation (March 17, 2009)
Steven Simmons, Deputy Executive Director

Texas DOT, Vehicles Titles and Registration Division (March 12, 2009)
Rebecca Davio, Director
Mike Craig, Deputy Division Director
Marianne Chapman, Branch Manager Communications Analysis and Planning
Bobby Johnson, Director of Production Management
Linda Kirksey, Chief of Registration

Texas Department of Public Safety (March 13, 2009)
JoJo Jeselmeyer, Manager of Vehicle Inspections

Texas State Comptroller of Public Accounts (March 18, 2009)

Kirk Davenport, Systems Analyst/Tax Specialist for Fuels Taxes

Vermont Department of Motor Vehicles (March 18, 2009)
Bonnie Rutledge, Commissioner
Glen Button, Director of Enforcement and Safety
Linda Schnieder, Director of Operations
Donna Earl, Chief of Fuel Taxes

Vermont Department of Transportation (March 17, 2009)
Thomas Daniel, Director of Finance and Administration
Costa Pappis, Planning Coordinator
Mel Adams, Director of Planning

B.2. Interview Questions for States

The following pages present, in sequence, the background material and questions presented in advance to interview participants.

NCHRP 20-24 (69)
Implementable Strategies for Shifting to Direct Usage-Based Charges for Transportation Funding

Questions for State DOTs, DMVs/MVAs, and other state agencies

Thank you for your potential interest in being interviewed for this project. This Transportation Research Board (TRB) project is looking at possible implementation strategies for vehicle miles traveled (VMT) fees and what could be accomplished over the next five years if this fee collection concept were to be implemented. With your assistance, we would like to better understand your state's current fee collection systems and your vehicle registration systems to consider what challenges and/or obstacles might arise with a VMT fee.

We assume that some of the questions below will be more appropriate for a DOT than a DMV, and vice versa. We have provided all the questions in a single document so that you will understand the full range of the topics that will be considered, and so that you would also be able to pass questions along to the appropriate state agency.

Please see the last page of this document for more information on VMT fees and background of this project.

Interview Questions

Current Systems – Passenger Vehicles

What types of passenger vehicle registration fees do you (or other entities) collect? Straight registration fees, personal property tax (ad valorum tax-based on the value of the vehicle), clean air/emissions fees, other?

How often are fees collected?

What agency(ies) is/are responsible for collecting vehicle registration fees for passenger vehicles? Is your agency the sole agency or entity responsible for collecting vehicle registration fees for passenger vehicles? If not, what other entities are responsible? Do you use private entities (such as AAA)? Do car dealers collect fees? Do counties have a registration/fee collection role? What percentage of fees do you collect versus other entities?

What transactional systems are in place to collect, track, and transmit fees? How well do they operate? Are they easily changed? Is it difficult or costly to change them? Why?

What collection channels do you use? Mail, counter, phone, internet?

Have you determined the cost of collecting vehicle registration fees? What is the cost of vehicle fee collection? Is this considered high, low, or acceptable? Is lowering this cost a high priority? Do you assess the cost of fee collection on a per-vehicle or other basis? How do you make that determination?

Are there any specific enforcement issues with regard to vehicle registration fees, such as in-state evasion, out-of-state registration, running on temporary tags indefinitely, not formally registering, or other? If in your state the counties collect registration fees, do you know their average cost for vehicle fee collection? Do they keep a percentage of the fee collected? If so, what percentage?

Do you have a different registration fee (sales tax or property tax) for alternative fuel vehicles? Can you distinguish different vehicle types in your registration system (e.g., SUV, hybrid, passenger vehicle, alternative fuel)?

What agency(ies) is/are responsible for collecting and receiving fuel taxes for passenger vehicles?

What systems are in place to collect, track, and transmit fuel taxes? How well do they operate?

Does your state incur any additional costs associated with enforcement or fraud?

Please describe briefly your vehicle inspection process with regards to the following: Frequency of inspections; centralized, decentralized, or a combination/hybrid; who conducts the inspections; does it cover the whole state or only certain counties?

Do you collect odometer readings as part of an inspection process? Are those readings transmitted from service stations or inspection stations to the DMV? Are they connected to the vehicle record, i.e. put into the system at each inspection? Do you share them with third parties (for example, Carfax or insurance companies)? Do you collect odometer readings for any other transactions? Are they made part of the vehicle record?

Please provide some background on your license plate production process. Does your state issue one plate or two plates? Are they produced by the prison, other state entity, or third party producer? Is there a required replacement cycle? If so, what is the replacement cycle? Have there been any changes to the replacement cycle? Is it legislated/mandated in law? What is the estimated cost to complete a plate replacement program for your state? Are any planned? Could a device, such an RFID, be embedded in the license plate as it is currently produced? Would this type of action require legislation? What would the issues be?

Current Systems – Trucks

Which agency(ies) is/are responsible for collecting registration fees for trucks under the IRP?

Which agency(ies) is/are responsible for collecting fuel taxes for trucks under the IFTA?

What systems are in place to collect, track, and transmit these fees (IRP/IFTA)? How well do they operate? What are the issues and benefits of these systems? What changes have been put in place to improve collection and transmission?

What is your overall assessment of the IRP and IFTA systems, including the IRP Clearinghouse? Have your audits found many problems? What kinds of problems? Is registration evasion an issue? Is reporting less mileage than traveled an issue?

Are there any specific enforcement issues with regard to IRP and IFTA? If so, how are they addressed?

What is the cost of IRP and IFTA collection? Is this considered high, low, or acceptable? Is lowering this cost a high priority? Do you assess the cost of IRP and IFTA collection on a per-vehicle or other basis? How do you make that determination?

Which agency is responsible for confirming payment of the Heavy Vehicle Use Tax? What is the process for payment confirmation?

Are there any specific enforcement issues with regard to HVUT?

Potential Systems for VMT Fees

Would there be interest in your state in moving towards a system of VMT fees, either to supplement or replace the gas tax? If not, why not? If yes: describe the anticipated benefits associated with your state's planned system of VMT fees. Comment on the applicability of such potential benefits as increased equity, consumer savings, affordability, economic efficiency, reduced vehicle travel, safety, impact on other modes of travel (e.g., public transit) and potential emissions reductions.

If there were to be a VMT tax in your state, what role would you envision for the DOT, DMV, and/or other state agencies? Do you see a role for any other entities outside of state government (e.g., county clerks, insurance industry, consumer groups, public safety organizations)? If so, what would their role be?

What state-level barriers exist with regards to implementing a VMT fee? These might include legislative issues, political opposition, problems arising at state borders or with other jurisdictions, other institutional barriers, technological issues, and privacy concerns.

Are your current systems capable of implementing a VMT fee using odometer readings (which might be supplied by customers or inspection stations or through the registration process)?

Currently your state collects the federal fuel tax for the federal government. Would there be any issues with your state collecting a federally imposed VMT tax at the time of vehicle registration or by using odometer readings?

What are your thoughts on viable technologies or other operational systems to implement a VMT fee? Describe these technologies and systems relative to equipment costs, operating costs, user convenience, effectiveness in meeting VMT goals.

If your state is exploring VMT fees already, describe some best practices your state has developed or considered in evaluating implementation of a system of VMT fees.

Are the IFTA and IRP models potential models to consider for implementing VMT fees? Why or why not?

Background: VMT Fees

The RAND Corporation is leading a project (NCHRP 20-24, Task 69) to identify and evaluate options for a near-term (5 years) transition to vehicle-miles traveled (VMT) fees. Such fees would shift the main burden of taxes to pay for roads and other transportation from a per-gallon fuel tax to a per-mile fee for every mile driver by a motorist. VMT fees have been piloted in several states but not implemented on a permanent basis.

VMT fees could be calculated and collected in a variety of ways: via odometer readings, transponders, GPS systems, radio frequency identification (RFID) chips, and several other technologies. Depending on the technological flexibility of the system, it might be possible to assess fees that vary with vehicle type (for example, a low-emissions vehicle could pay a lower per-mile rate than a high-emissions one), with time of day or real-time congestion level (so as to manage congestion by charging more to drive during peak hours), or other factors.

VMT fees would overcome some of the revenue challenges faced by fuel taxes while simultaneously providing a means for addressing several other important policy goals. Most existing proposals suggest phasing in a VMT-fee system gradually, over a period of perhaps 15-20 years, as consumers purchase new vehicles equipped with more advanced technology such as on-board computers equipped with GPS receivers. Yet the challenges motivating a switch to VMT fees are urgent, and there is keen interest in determining whether it might be possible to develop a simpler system for VMT fees that could be implemented much more rapidly.

The goals of this project are to identify, evaluate, and recommend mechanisms for near-term implementation of VMT fees, considering a broad range of technical, political, administrative, and legal factors, and to outline the steps needed to put such a system in place by 2015. The project will also consider how a simple system for VMT fees might transition to a more technically sophisticated system over the longer term. We will be assessing a number of technologies and payment systems against criteria such as revenue generation, administrative costs, privacy and other public concerns, and policy flexibility. Your responses to the questions on the previous pages will help us assess issues with regard to existing state systems and identify potential problems or opportunities.

See the project's Web page for more information:
http://www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=2626.

APPENDIX C. EXPERT PANEL WORKSHOP

As part of the process for gathering expert input on user-based fee mechanisms, the project team held a day-long workshop on April 23, 2009 at AASHTO headquarters in Washington, DC. The purpose was to elicit opinions and suggestions on earlier phases of the research from a variety of stakeholders, as well as understand other concerns. Comments from the workshop are summarized by theme below; however, these comments should be considered in the wider context of this report. A list of the workshop participants is provided at the end of the appendix.

C.1. Workshop Themes

Responses to Proposed Approach

- The two most important policy goals for the short-term are to preserve overall revenue and ensure accurate apportionment of revenue by state. The other goals are not unimportant, but they could be implemented later. It is also important to build flexibility (of both technology and privacy options) into any system.
- The two suggested options (OBD/cellular and pay at the pump) in the near term are considered the most promising, but GPS should not automatically be ruled out as a possible strategy in the near term for some choice users.

Why Change to VMT Fee

- Gas taxes will not work well in a situation of increasing differentials of fuel efficiency.
- VMT fee would likely keep better pace with inflation.

Technology

- It is important to have an open system, to avoid getting locked in to one particular option.
- Consumer acceptance may be spurred by having devices that provide additional benefits to drivers: for example, the ability to get an insurance discount through PAYD insurance, to know where a free parking space is, or to know how bad congestion will be if they leave at a certain time.
- However, while this was not discussed in detail at the workshop, there is an inverse relationship between the number of applications and the security of the system. The more applications are added, the more difficult it is to ensure "hacker-proof" communications.
- PAYD insurance will likely become more popular; the current low penetration rates (one insurance industry representative thought there were perhaps 50,000 policies in the U.S.) is probably not a predictor of future use. The main obstacle is the cost of technology.
- It would be a good idea to have federal technology standards, primarily to ensure interoperability. But it is too early to create such standards at this point.
- There are ways to provide in-vehicle information to drivers so that they know how much they are paying for a trip.

- The available technologies are sufficiently flexible that they can be deployed to meet specific policy objectives.
- Debit cards could be made to work with any option. They could be removable and drivers could re-load them with additional money.
- Since it would not be practical to have a car stop in the middle of the road when the payment runs out, enforcement would need to be linked to registration.
- Systems that are simple for users to understand are preferable to those that are complex.
- At some point all vehicles will be equipped with GPS.
- While OBD ports are not entirely standardized, for the purposes of implementing an OBD-based system the standardization is probably sufficient.

Privacy

- Privacy is the top public acceptance concern.
- GPS is *not* synonymous with privacy concerns. Privacy can be a concern with any technology that seems intrusive or can determine drivers' location to a certain degree of specificity.
- The higher the resolution of location information (being able to place a driver on a certain road or at a certain intersections), the greater the privacy concern.
- Full privacy and full auditability are possible in the same system, but building in both capabilities will be expensive.
- There is probably no way to fully convince the public that their privacy will be protected. Acceptance has to come through personal experience—as people sign up for the system and do not experience any violation of privacy, they will become more accepting. EZPass and the Western Hemisphere Travel Initiative are good examples of this—they are both voluntary.
- Private companies have an incentive to protect consumer privacy because consumers can take their business elsewhere if they feel their privacy has been violated. But this may not be relevant if there is only one contractor for the system.
- It is important to provide opt-in and opt-out provisions. While "opt-out" was not precisely defined at the workshop, it suggested that drivers could pay fees through a paper-based system, or continue to pay the gas tax.
- Even if only a few people choose the opt-out provision, it may "take the wind out of the sails" regarding opposition based on privacy concerns.
- There are different ideas about privacy: privacy by design, privacy by policy, and provisions to opt-in or opt-out.
- It may be advisable to consult with a privacy expert.

Obstacles

- State legislation will be required for almost any system. The willingness of state legislatures to pass such legislation may vary from state to state.
- Although an increase in VMT is predicted, AASHTO has been pursuing policies to reduce VMT growth. If they are successful, VMT may grow more slowly.
- Capital and operating cost estimates are not well-enough developed to make decisions or do benefit-cost analysis. It may be helpful to present ranges of costs, since there is a high degree of uncertainty.
- In particular, there was disagreement about how expensive the pay-at-the-pump system would be. The Treasury representative thought that the reconciliation between the IRS and fuel retailers would be cumbersome and expensive, and more open to fraud, but the Oregon trials seemed to suggest this was not a major obstacle.
- Nobody was aware of reliable cost studies that might throw more light on this subject. States do not always know what it costs them to collect fuel taxes, but one participant said his state had measured costs at about 1% of total collections.
- Past experience with emissions testing programs has shown that cost estimates can be far too low for equipment and consumer pricing.
- Any costs borne by retailers (service stations) will likely be passed on to customers.
- Since current GPS devices are removable from vehicles and easy to turn on and off, it is necessary to have an enforcement mechanism that ensures that drivers keep them in continuous operation.

Phase-In/Implementation

- There are major trade-offs with regard to short-term implementation. Even if it were possible to adopt a system right now—like the flat VMT fee with an odometer-based adjustment—there are serious concerns that it might "poison the well" for future attempts at more sophisticated options, if a selected technology and billing plan do not work as well as promised.
- If there is a major need for short-term revenue, it is not clear how implementing a poorly thought-out VMT fee is superior to raising the gas tax. There is a lot of room to raise the gas tax without affecting behavior, and best time to have done so would have been when gas was much more expensive (since it would have constituted a small percentage increase). However, Congress seems very focused on what they can do besides raise the gas tax, such as implement a flat VMT fee based on average mileage.
- Another short-term option is the "pseudo-VMT tax." This would increase the gas tax annually based on the amount of VMT, so that gas tax revenues keep pace with VMT increases.
- It is not a good idea to change systems with each reauthorization bill.

Large-scale Trials

- The group favored several trial programs, to be operated in different states. The best type would be a full-scale trial, of perhaps tens of thousands of vehicles, that incorporates real-world issues of revenue collection, police enforcement, multi-state boundaries, and various partnerships. The number of vehicles should be based on some percentage of the vehicles within a metropolitan area, county, or state to be meaningful.
- Some trials should incorporate incentives to cheat so that detection and enforcement mechanisms can be tested. Other trials might incorporate financial incentive to comply, to determine what type of incentive drivers need to switch from a gas-tax based system to a VMT-fee based one.
- Trials could test various concepts of operations, with different policies and degrees of privacy.
- One participant thought these trials would cost $100 million/year.
- The U.S. should conduct its own trials, not rely on developments in other countries. However, U. S. policy makers should monitor what other countries are doing. For example, Singapore is moving to "ERP 2" (a second generation of electronic road pricing)
- IBM is conducting some trials in Europe in support of the Netherlands project. The University of Iowa trials are about half completed. These will eventually include 2,700 vehicles at six sites. They have a specific focus on user attitudes and acceptance. Interest in participating was high; they had 40,000 applicants for 1,200 initial slots, mostly recruited through media campaigns.
- It is probably not possible to combine the Intellidrive trial with a VMT trial, even though there is some overlap in the technology. The two avenues have different goals (Intellidrive is focused on safety and requires a considerable amount of roadside infrastructure.)
- A federal commission could be created with this reauthorization that could oversee the trials and make recommendations for the next reauthorization. These trials should be more focused than those from the value pricing program.
- The trucking industry might support a trial if revenues were directed to specific corridors (such as I-95).
- Trials could be conducted with fleet vehicles (such as rental cars or government fleets), since it would be easy to instrument them with the technology being tested. However, this would not yield good information about driver behavior since it is not capturing average drivers using their own vehicles.
- It is probably not a good idea to start with electric vehicles, as there are other policy reasons to encourage wider adoption of them.

Program Administration

- States are very concerned with program administration, particularly with which agencies will be responsible for fee collection and enforcement. These issues need to be resolved for successful implementation.

- States require the option of implementing their own fees on top of any federal fee. It is important to remember that some states have additional taxes on fuel besides the per-gallon excise tax.
- There could be one payment mechanism that both the federal governments and states utilize. This could be based on the IRP/IFTA model, which has been quite effective and has won states' trust.
- If the point of tax collection is moved from the terminal rack to individual drivers it will be important that efforts be made to minimize opportunities for fraud. (The terminal rack is the point at which fuel is transferred from pipelines to tanker trucks for distribution.) IRS tax collection was moved to the rack for this reason, and it was successful in increasing collections.
- IRS would probably not condone the use of a private entity collecting taxes, even though this has been implemented in other countries. This issue is that whoever is liable for the tax interacts directly with the IRS. (Many taxes are passed on to consumers, even when another entity is responsible for the tax; for example, retail stores are liable for sales taxes, even though they pass them on to consumers.)
- Minnesota uses a private contractor, Cofiroute, to administer its MnPASS program, but participation is voluntary. Driver can use the HOT lane only if they have a credit card.
- There may need to be provisions for low-income drivers for whom in-vehicle equipment is prohibitively expensive. (Not mentioned at workshop: statistics suggest that 10% of adults do not have a bank account, and about 20% of households do not have a credit card (Parkany, 2005). This must be factored in to any collection mechanism.)
- There are no good data on the percentage of gasoline sold to, and therefore fuel tax pad by, foreign vehicles.
- It might be necessary to raise the gas tax to convince people to adopt VMT fees, if the system allows this as a choice.

<u>Outreach and Education</u>

- State legislatures may be a good starting point for outreach. Many are interested in the topic and can help constituents better understand the concept.
- It is important for elected officials and staff to have basic information before they are targeted by opponents of VMT fees.
- Elected officials may be more receptive to language about "preserving revenue" than "increasing revenue."
- Support and opposition is not divided along party lines.
- It may be helpful to tie the VMT fee to specific spending measures, rather than just saying, "the system needs more money." This has been effective with regards to the California county sales taxes that provide revenue for transportation.
- The public tends to oppose taxes on the grounds that current revenues are spent wastefully.

- People generally do not know how much they pay in gas taxes (on average about $10 per month). Many guess the number is much higher.
- The general public tends to know only a few things about VMT fees, and makes assumptions about the other details. Criticisms tend to be focused on those assumptions. It may be important to have the details in place before beginning a public outreach campaign.
- Some members of the public will react strongly (negatively) to a flat VMT fee, because of the perceived disconnect from other environmental initiatives.
- On the other hand, rural areas may be opposed on the grounds that they have few alternatives to long trips.
- Language comparing the highway system to other public utilities, which charge users for the amount they use, has been effective in convincing people that VMT fees are acceptable.
- AAA does not yet have a position on this, but is contemplating doing focus groups with members to better understand public's concerns.
- It is a difficult topic to convey accurately in a one-page article.
- There might be some opportunity in converting other fixed fees to variable VMT fees as well.

- ***C.2. List of Workshop Participants and Affiliations***

Project Team:

Paul Sorensen, Martin Wachs, and Liisa Ecola, RAND Corporation
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Betty Serian, Betty Serian Associates

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Andrew Lemer, NCHRP/TRB
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James Whitty, Oregon DOT
Roberta Broeker, Missouri DOT
Lynn Weiskopf, New York State DOT
Joung Lee, Tony Kane, and Jack Basso, AASHTO
Patrick Harrison, Virginia DMV
Ralph Davis, Deputy Secretary of Transportation, Virginia

Expert Invitees/Participants:

Jon Kuhl, University of Iowa
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Shelley Row, US DOT, Research and Innovative Technology Administration
Jill Ingrassia, American Automobile Association (National)
Tim Lynch, American Trucking Association
David Huber, California State Automobile Association
Jim March, US DOT, Federal Highway Administration
Allen Greenberg, US DOT, Federal Highway Administration
Susan Binder, Senate Environment and Public Works Committee
Anne Teigen, Nick Farber, National Conference of State Legislatures
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Steve Lockwood, Parsons Brinckerhoff
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