



INFRASTRUCTURE, SAFETY, AND ENVIRONMENT

THE ARTS
CHILD POLICY
CIVIL JUSTICE
EDUCATION
ENERGY AND ENVIRONMENT
HEALTH AND HEALTH CARE
INTERNATIONAL AFFAIRS
NATIONAL SECURITY
POPULATION AND AGING
PUBLIC SAFETY
SCIENCE AND TECHNOLOGY
SUBSTANCE ABUSE
TERRORISM AND
HOMELAND SECURITY
TRANSPORTATION AND
INFRASTRUCTURE
WORKFORCE AND WORKPLACE

This PDF document was made available from www.rand.org as a public service of the RAND Corporation.

[Jump down to document](#) ▼

The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world.

Support RAND

[Browse Books & Publications](#)

[Make a charitable contribution](#)

For More Information

Visit RAND at www.rand.org

Explore [RAND Infrastructure, Safety, and Environment](#)

View [document details](#)

This product is part of the RAND Corporation reprint series. RAND reprints present previously published journal articles, book chapters, and reports with the permission of the publisher. RAND reprints have been formally reviewed in accordance with the publisher's editorial policy, and are compliant with RAND's rigorous quality assurance standards for quality and objectivity.



NCHRP

Web-Only Document 143:

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

Paul Sorensen
Liisa Ecola
Martin Wachs
The RAND Corporation
Santa Monica, CA

Max Donath
Lee Munnich
University of Minnesota
Minneapolis, MN

Betty Serian
Betty Serian Associates
Harrisburg, PA

Under Subcontract to
ICF International
Fairfax, VA

Contractor's Final Task Report for NCHRP Project 20-24(69)
Submitted June 2009

National Cooperative Highway Research Program

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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

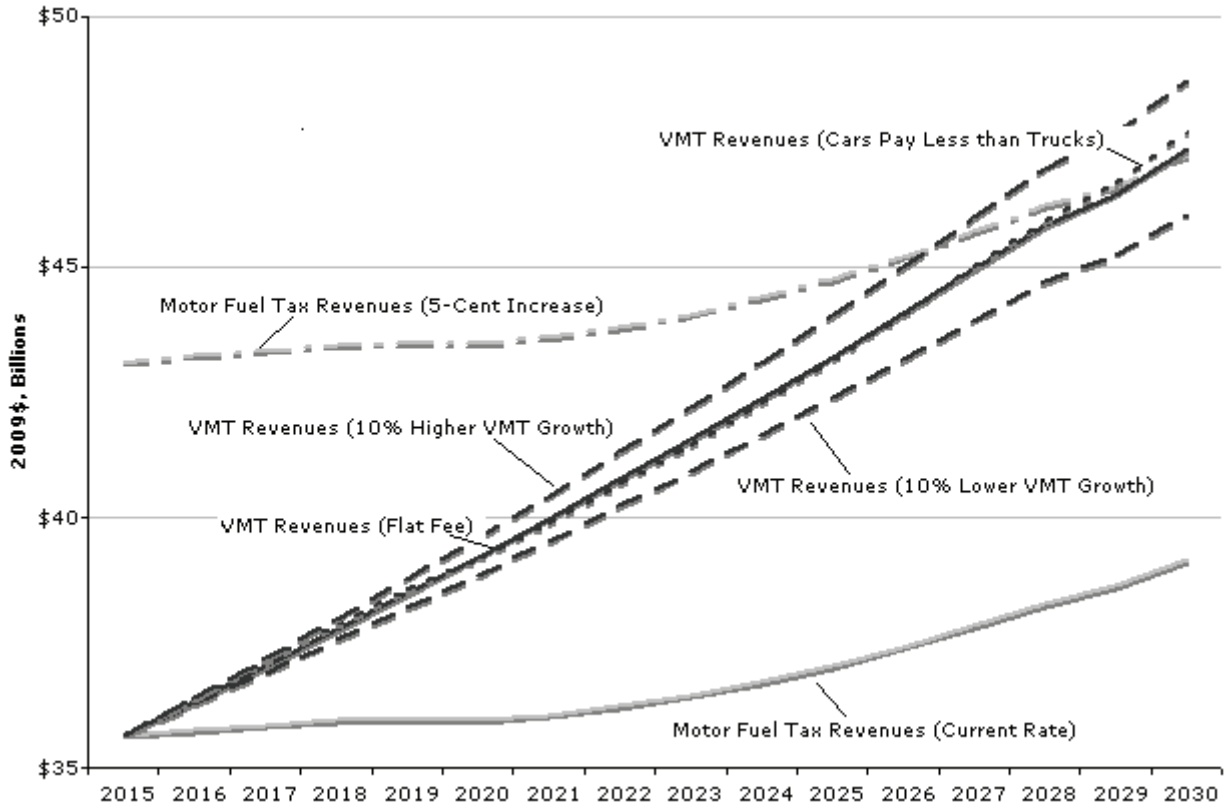
The analysis conducted by the research team, in concert with feedback from the project panel and other subject matter experts, leads to the following principal findings:

- 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.