SPECIAL REPORT 299:
REDUCING TRANSPORTATION GREENHOUSE GAS EMISSIONS AND
ENERGY COMSUMPTION:
A RESEARCH AGENDA

Discerning the Pathway to Implementation of a National Mileage-Based Charging System

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PREFACE

The Executive Committee of the Transportation Research Board commissioned this paper to do three things. First, develop and propose concepts for research and demonstration programs to test the technical and political feasibility of road use metering and mileage charging. Second, develop and expand upon the recommendations of TRB Special Report 285: *The Fuel Tax and Alternatives for Transportation Funding* for creating a structure to support the conduct of trials or pilot projects by individual states with federal leadership and funding aid. Third, develop cost estimates for the demonstrations and related research to design and implement the trials.

The authors present this paper in two parts. The authors intend Part One to facilitate understanding among policymakers and researchers of the decision making necessary for constructing an acceptable mileage charging system and, further, to present the mileage charging system development already accomplished and the research in progress or completed. Part Two proposes additional research to fill knowledge gaps and obtain the data and information necessary for policymakers and researchers to reach a knowledge level for the opportunity at hand sufficient to enable legislative action.

Part One assists the reader in understanding the mileage charging policy analysis in the context of completed research or underway and the resulting system possibilities. In Chapter 1, the authors lay out the necessary elements for consideration in creating mileage charge systems. In Chapter 2, the authors present the basic options for comprehensive mileage charge systems flexible enough to evolve as public policies change. The authors describe central billing, piggybacking upon existing payment systems including pay-at-the-pump and an integrated approach. The authors also describe an introductory system for electric vehicles and home fueled vehicles and a separate system for heavy commercial vehicles. In Chapter 3, the authors describe the rate structuring possibilities for mileage-based charges.

Many mileage charge system options do not enable early adoption. Therefore, the authors analyze some options for quick implementation of mileage charging in the United States in Chapter 4.

Without understanding the fundamentals of Part One, the Part Two research would be unhinged and directionless. Chapter 5 lays out various governance issues for mileage charging, including which entities should create and operate the system and the various revenue generation and allocation issues, as well as federal and state system integration issues. In Chapter 6, the authors suggest research comparing various system options and federal applications. This chapter also reviews research recently concluded or now underway on technology and systems for mileage charging, noting research gaps and proposing resolution.

Chapter 7 discusses the most critical research component for mileage charge adoption in the United States—public acceptance. Chapter 8 proposes research on the impacts of mileage-based charges to society in general as well as societal systems.

Chapter 9 proposes a national investigation of mileage-based charging, including a defined set of pilot programs that upon completion will support broad scale implementation of mileage-based charging either on a national basis or on a state by state basis. Chapter 10 provides conclusions and fundamental recommendations.

Since no one knows which governmental jurisdiction will generate the political will to implement the nation's first mileage charging system, the authors present this paper for generic application. The considerations and recommendations mentioned in this paper should apply equally to federal, individual state or multi-state applications, though some elements may only have application in a single context.

DISCLAIMER

The analysis presented in this paper goes beyond policies adopted by the Oregon Department of Transportation, the Oregon Transportation Commission and the State of Oregon. All statements, assessments, assertions, conclusions, proposals and recommendations are entirely those of the authors.

EXECUTIVE SUMMARY

This nation's ability to address some of the compelling challenges of our age– adequacy of transportation, climate change and energy independence–will depend considerably on how we finance our transportation infrastructure. Leading national policymakers now support a mileage-based charging system as necessary to our nation's transportation future.

Several questions arise. Which public policy and technical issues must policymakers consider for a mileage-based charging system? How might the nation best manage a transition from state and federal fuel taxes to mileage-based charges? How will a mileage charging system achieve public acceptance? The answers will determine the pathway forward and ultimately change how we fund and use our transportation systems. A better understanding of these issues should result in appropriate public policies, fewer unintended consequences, and greater benefits for society.

RATIONALE FOR MOVEMENT TO MILEAGE-BASED USER FEES

Long the bulwark for road funding, the fuels tax is now dying a long, slow death. Highly fuel-efficient vehicles now appear on the nation's roadways with even more efficient versions coming, including some that do not use liquid fuel at all. A mileage-based charging system can effectively address erosion of road revenue and other societal challenges such as roadway congestion and environmental protection, provided system design allows for it. Fortunately, today's computers, databases and wireless communications systems now provide the opportunity to design, develop and implement a new road system that can flexibly accommodate a variety of public policy goals.

The authors recommend a *National Investigation* as the first step to charging by the mile. While the U.S. Department of Transportation has provided funding for a few mileage charge investigations, the agency has yet to take a formal active role in policy, technology or system development for mileage-based charging. This nation requires federal leadership to develop a policy framework necessary to address national issues such as cross-border travel, system interoperability and standardization across states. The mere dependency of the Federal Highway Trust Fund on fuel taxes provides compelling justification for federal leadership. If such leadership is not forthcoming, states will have to forge ahead on their own.

A national investigation of mileage charging should include a timeline for completion of development and involve a policy oversight body and national-level interdisciplinary project teams undertaking concurrent investigations. The following research and development program would cost between $70 and $80 million:

- Determine the advisability of replacing or augmenting the fuels tax with a mileage-based charge and, if so, develop the outlines of the preferred system architecture and identify pivotal research questions and developmental activities. ($5 million)
- Make policy recommendations, finalize the recommended system architecture and determine a likely rate structure. ($7 million)

- Refine system technology to commercial viability. Conduct several pilot demonstration projects for testing system variations and filling knowledge gaps, including a broad scale pilot program in preparation for ultimate adoption. Identify transition steps. ($60 million)

These efforts should receive full funding and staffing and the regulatory freedom to proceed expeditiously. The U.S. Secretary of Transportation should have authority to impose minimum system requirements upon the automotive industry prior to completion of development. This mandate should require automakers to either install mileage charging devices meeting identified requirements or accommodate easy installation of certified after-market equipment.

KEY STRUCTURAL CONSIDERATIONS FOR MILEAGE CHARGING

Key issues for resolution before mileage-based charging can proceed to adoption:

- Minimum system requirements
- Technology choices
- Collection system design
- Cost of collection
- Accommodation of cash payers
- Privacy protection
- Transition
- System flexibility
- Rate structuring

Minimum System Requirements

A mileage-based charging system must do six things:

- Calculate miles driven (distance metering)
- Access the mileage data (communications)
- Apply mileage charge rates (data processing)
- Provide a billing to motorist (invoicing)
- Receive and ensure payment from the motorist (collections)
- Support effective deterrents and actions against evaders and delinquents (enforcement)

These minimum requirements do not imply one unique system. Electronic collection of mileage charges however, will provide the most cost effective, efficient and robust system. Over time, many different devices and systems may meet these high level requirements and obtain approval by a governing body for use.

Technology Choices

Policy, not technology, should guide system design. Nor should policymakers hamper system evolution with specific technology choices. A complete transition from fuel taxes to mileage charges may take many years. In that time, appropriate technologies will evolve and improved systems will emerge. Closed systems may not be able to adjust effectively. Open systems on the other hand, can embrace change and foster innovation. Defining minimum system and technology certification requirements could yield system flexibility that enables technology change and system evolution. Published standards would allow voluntary adoption of mileage charging equipment. Any mileage charging system must allow auditing and an ability to identify tampering.

Mandated retrofitting of vehicles with specific mileage counting equipment will prove problematic and expensive. Relying on vehicle turnover alone however, could result in a 20-year transition period. Voluntary adoption of after-market vehicle equipment may provide a faster pathway to full implementation.

Collection System Design

The nation has the opportunity to create a mileage fee collection system having the capability to evolve with changes in policy needs and technologies. Such a highly flexible and robust system must necessarily rely upon electronic technologies and contemporary communications. Contemporary technologies allow formation of *electronic zones* by latitude and longitude coordinates and time of day for isolation of a motorist's mileage traveled. The ability to create zones identified geographically and temporally offers opportunities for mileage charging on the state and local levels as well as congestion pricing.

To this point researchers have identified two basic ways to collect mileage charges: the *central billing method* and the *pay-at-the-pump method. The a*uthors present the opportunity for a third way called the *integrated systems approach* which combines the best attributes of the first two methods while minimizing the shortcomings of both.

- *Central billing.* Under the *central billing method*, an on-vehicle device wirelessly sends electronically generated mileage data to a collection center for billing. The government mails, emails or otherwise sends a monthly bill to the motorist who pays the charge. The central billing model attracts interest because of its comprehensive nature.

Several difficulties inherent within the central billing model challenge its efficacy. This system characteristically has enforcement challenges—*why would people pay the monthly bill?"*—and the difficulty of compliance for some payers, as well as high operational costs under standard billing methods for a large percentage of the population. There is also the quandary of how to provide a gas tax credit if the mileage fee's purpose is to replace the gas tax.

- *Pay-at-the-pump.* Under the *pay-at-the-pump model*, both mileage data transfer and mileage charge collection occur at the fuel pump. During refueling, an electronic reader wirelessly reads the stored mileage data allocated to each zone via short-range radio frequency. The system then automatically uploads mileage data to a revenue collection agency central computer for application of the mileage charge rates. The central computer electronically sends the billing figures back to the fueling station. The fueling station then bills the motoring consumer the mileage charges—and deducts the gas tax—along with payment for the fuel purchased. Non-equipped motorists pay the fuel tax.

The pay-at-the-pump model minimizes operational costs because of seamless integration of mileage charge payments into the existing gas tax collection system. The system assures enforcement of mileage charge payments because access to fuel can be conditioned upon payment of the charge. This system also allows motorists to easily obtain a gas tax credit when buying fuel to avoid paying both the gas tax and the mileage charge. Most importantly, the motorist does something familiar, paying a charge with the fuel bill as before. The only thing new is the type of charge paid—the mileage charge.

The pay-at-the-pump model has challenges as well. The state of Oregon first developed the pay-at-the-pump model as a *closed system* that precludes other data applications and payment methods that may emerge in the future. This makes evolution of technology and adjustments for changes in consumer behavior rather difficult. Also, the Oregon model presumed working with automakers to develop and employ a *pre-market* mileage counting device embedded into new vehicles. This limits the ability to improve capability of system technology and impedes swift implementation of a new system because of the necessity of relying on automakers' equipment development processes, which take many years. Finally, the pay-at-the-pump model cannot evolve with every vehicle choice the motorists may make in the future such as all-electric vehicles.

- *Integrated systems approach.* The optimum mileage-based charging collection system will likely have elements of both the *central billing approach* and the *pay-at-the-pump model*. Both approaches require connection with a central server/computer. System designers could integrate these two models selecting an on-vehicle technology based on an open system thus permitting new applications. This would allow organic development of vehicle locator options as well as data generation and data transfer technologies. An integrated system with such an open platform would also permit a flexible manner of payment.

The integrated approach assumes a motorist would add on-vehicle mileage-counting equipment—an *after-market* device not manufactured into the vehicle—upon obtaining ownership. The mileage data would upload wirelessly from the on-vehicle device to a central computer via various transmission possibilities. At the fuel pump, an electronic reader—similar to those operating at modern electronic toll roads—would identify the vehicle as a *mileage charge payer* by reading an automatic vehicle identification device on the vehicle. The system would connect to the central computer to obtain the vehicle's mileage data since the last fueling. The central computer would apply the mileage charge rates and send the billing information back to the fueling station's point of sale system. The motorist would pay the mileage charge as part of the fuel purchase and the gas tax would be deducted. If the motorist had already paid the mileage charge through some sort of automatic electronic payment alternative, the system would not add the mileage charge to the motorist's fuel purchase amount but *would* deduct the gas tax.

By adopting an open platform, system designers would allow payment alternatives such as automatic electronic payment variations that will evolve over time. Payers should have the option of paying a traditional way—such as with fuel purchase—or another way, such as electronic payment. In this manner, the natural payment method will organically emerge and then change with human behavior and technology. By permitting other payment options, however, the integrated system could operate more like a central billing system for vehicles not refueling or reenergizing at commercial fueling stations.

The integrated approach has the advantages of the central billing approach and the pay-at-the-pump model while minimizing the disadvantages of each. It offers a familiar traditional payment method to facilitate public acceptance and ensure a revenue flow but also offers availability to alternative fuel vehicles not fueling at commercial stations. The integrated approach would solve the *why should I pay?* problem for central billing because the motorist would have to pay the mileage charge either before or at the point of fuel purchase.

Such an open system could also reduce capital and operating costs and technological complexity at the service stations by allowing numerous options for the mileage data upload elsewhere. Further, by relying on an after-market on-vehicle device, the system application timeline would not depend upon the automakers' lengthy vehicle development period.

The integrated approach may help attain public acceptance for an electronically collected mileage fee. The open platform offers ease of use for motorists by offering multiple payment choices as well as various levels for protecting privacy. The integrated approach will also attract the public with choice of on-vehicle devices. Many people willingly embrace change when they have choices they understand.

- *Heavy commercial vehicles.* A distance charging system for heavy commercial vehicles will likely be different than for passenger vehicles because system designers must consider additional vehicle characteristics such as weight, configuration and number of axles. At least initially, this electronic weight distance charge will likely be only partially automated because of high capital costs for full automation.

Cost of Collection

Today's fuel tax system has very low collection and enforcement costs. Any mileage charging system will likely have higher initial operational costs. High administrative expense reduces net revenue—or requires a higher rate to achieve the same revenue—and as a result may face public acceptance challenges.

A stand-alone central billing system for mileage charges will likely have exceptionally high operational costs initially and for many years to follow. On the other hand, *piggybacking* invoicing and collections onto an existing collection system—such as the gas tax collection system—tends to reduce system costs.

Accommodation of Cash Payers

Any new system should accept payment by all motorists, including members of the cash economy.

Privacy Protection

A new mileage charging system must resolve privacy concerns to gain public acceptance. This paper lays out the privacy implications for various mileage charging systems and describes how a properly designed system will ensure neither the government nor anyone else can determine the location of drivers, either in real time or historically.

Transition

Handling the transition from fuel tax to mileage-based charges presents perhaps the greatest technical and policy challenges because both systems must co-exist for awhile. Transition could take more than a decade—largely dependent on political will—unless a combination of policy and technology incentive mechanisms could encourage drivers to voluntarily adopt a new system earlier.

System Flexibility

System design could provide sufficient flexibility to allow more complex mileage-based charges such as congestion pricing, environmental pricing or provide different rates for rural and urban driving. The system might accommodate low-income drivers, for example, or special purpose vehicles. Preferences on these issues will directly impact the sub-systems and system selected for implementation. Policies regarding congestion pricing, environmental pricing and subsidization of rural drivers will heavily influence the rate structure. In turn, the rate structure will heavily influence the technologies selected for the various sub-systems.

Rate Structuring

System designers can devise an electronically collected per-mile charging system flexible enough to allow rate structures that can accomplish numerous public policies. Such a system would not only raise revenue for the road system but also grant states and local jurisdictions the option of grafting onto the system. Additionally, policymakers can structure a charging rate to achieve free flow traffic conditions through peak period pricing. The rate structure can also take into account externalities such as greenhouse gas emissions. The ultimate rate structure will result from a legislative body considering various public policies and blending them to accomplish several goals.

- *A flat rate.* At the simplest level, a basic mileage charging rate can be flat but a flat rate is not a fundamental characteristic of per-mile charges. Policymakers can establish a rate structure as something other than flat, stack other rates on top of a flat rate or apply a multiplier to a flat base rate, among other possibilities.
- *A stacked rate.* An alternative to the flat rate involves stacking another rate on top of the flat rate to allow rate variability. For example, policymakers may apply a fuel inefficiency penalty to high fuel consuming vehicles in addition to the flat mileage charge rate. The structure could be built on top of a flat basic rate charged the more fuel-efficient vehicles.
- *A multiplied rate for externalities.* A second structural variation would rate each vehicle for its impact on external environmental factors. Those vehicles with the least impact could be assigned a multiplier of 1.0 and those with the greatest impact a multiplier of perhaps 6.0. When the rates for each zone are applied for mileage charge payment, a motorist’s multiplier would be applied against the base rate for that zone to determine payment. Vehicles with greater impact on external factors would pay more and those with less impact would pay less.

While all compelling policy perspectives should be taken into account when a legislative body adopts the rate structure, policymakers must recognize that valid public policy goals often conflict. The mileage charge rate structure, therefore, might *not* be the best place to accommodate every valid perspective.

AN INTERIM SYSTEM FOR QUICK IMPLEMENTATION

Researchers recently began to explore options for an interim system that would allow for quick implementation of mileage fees while providing support for the ultimate move to a robust mileage fee system over the longer term. The authors contributed to this research, a concept called the *VMT Estimate.*

The VMT Estimate

Under the VMT Estimate Concept, rather than tallying or transmitting precise mileage data, the system calculates the motorist's mileage charge at the fueling station through application of a charge rate to an estimate of the vehicle's miles traveled since the last fueling. The system calculates an estimate of VMT by dividing the amount of fuel purchased by the vehicle's fuel efficiency rating.

Under either a national or state VMT Estimate system, state DMVs would equip each resident vehicle with an automatic vehicle identification (AVI) device—perhaps embedded in the license plate, the windshield or a vehicle emissions inspection sticker—indicating the vehicle's Vehicle Identification Number (VIN). This common inexpensive device allows a mileage charge estimate to occur at the fueling station.

NECESSARY RESEARCH FOR MILEAGE CHARGING SYSTEMS

The federal government should take up the challenge of designing a mileage charging system for adoption by the federal government or any state. Among the major issues to be addressed include the following.

Governance

Development and implementation of mileage-based charges state-by-state will reveal issues of national or regional implication irresolvable by a single state. Standardization of technology and systems under a state-by-state scenario would be highly unlikely. Federal systems development may take longer than for a given state and allow less innovation because of numerous policy considerations and processes, but the Federal government can provide uniformity of technology and systems choices as well as political heft for imposing a new system on national industries. The Federal government, however, should continue to cede a healthy opportunity for innovation to the states.

Just as federal gas tax collections fit together with state gas tax collection systems, a federal mileage charge could do the same. Researchers should identify the impact of federal integration into a state-by-state implementation of mileage charge systems and how to construct a federal system that allows easy access by the states.

Allocation of mileage charge revenues among states has the potential to directly relate to travel within each state. As a result, the donor/donee revenue allocation struggle may reemerge with new evidence to support the various arguments. Researchers should study the potential impact of geographically identified mileage charges upon revenue allocations among states as compared to the existing allocation formula.

A Development Program

To enable adoption and implementation of a mileage-based charging collection system anywhere in the United States, policymakers, researchers and system designers must undertake an extensive developmental program.

Comparison of System Models

The three mileage charge collection models should undergo comparison point by point. The subject areas for comparison should include revenue sustainability, rate flexibility, system characteristics—for example, breadth of coverage, compliance burden, administrative efficiency, systems integration, enforceability, cost of operations, systemic risk, among others—feasibility for federal or state application and timeline for commencement and complete transition. All system characteristics should be measured for public acceptability.

Technology and Sub-Systems

To enable commercial implementation, necessary research must occur in the following areas.

- Protection of locational privacy
- On-board delineation of zone boundaries
- Attributes of various methods of generating vehicle miles traveled data
- Discouragement of tampering with on-vehicle devices
- Auditing
- Designing a system for updating of geographic and temporal zones
- Communication techniques for on-vehicles systems
- Integration with existing systems
- Open systems and additional applications
- Determining the most efficient and cost effective data transfer technology
- Determining the location of data transfer
- Development and application of a mileage charge system for two and three wheeled vehicles
- Integration with modern all-electronic tolling systems
- Development of a national or regional clearinghouse and revenue distribution system
- Estimates of capital and operating costs

Public Acceptance

The authors suggest three steps to public acceptance.

- **Step One**. Ensure the public understands the problem the mileage fee system is designed to address.
- **Step Two.** Ensure design of the mileage fee collection system takes into account public sensibilities.
- **Step Three.** Introduce an actual mileage charge proposal complete with privacy protections, cost projections, system impacts and a specific rate structure.

Impacts upon Societies and Societal Systems

A shift to mileage-based fees should produce positive benefits for society but there may be some negative unintended consequences as well. Mileage-based charges will have some impact on travel behavior but the degree of the impact will largely be dependent upon the rate structure and fee level. The revenue implications can be enormous, dependent upon the types of mileage-based charges involved. Economic research must be undertaken to determine the extent to which any new mileage charge system would affect existing institutions and processes from an economic and revenue perspective and how highway pricing would affect energy policy, greenhouse gas reduction and land use.

Federally Supported State Pilot Programs

This paper proposes several state-run but federally funded and directs pilot programs for testing various mileage charging systems, sub-systems and system elements.

- ***Technology refinement of closed-system pay-at-the pump model.*** Completion of system design and technology refinement for the pay-at-the-pump model.
- ***Central billing pilot program***. Test the central billing model under which an on-vehicle device generates mileage data by location then wirelessly sends that data to a collection center for billing by mail or e-mail to the vehicle owner's residence.
- ***Open system pilot program for the integrated approach***. Test an integration of the central billing approach and the pay-at-the-pump model using an open system for technology applications that allows flexibility in applying technologies for mileage data generation, data transfer, data management and payment.
- ***Electronic toll road integration pilot program***. Test integration of an electronic mileage charging system with modern all-electronic toll road systems that currently use central collection methodology.
- ***VMT estimate pilot program***. Test the potential for adoption of an interim system that estimates mileage at the fuel pump using an inexpensive AVI device.
- ***Electronic weight-distance tax pilot program for heavy trucks***. Test a separate electronic charging system for heavy trucks that accounts for factors beyond mileage, including distributed weight and configuration.

- ***Multi-state contiguous broad scale pilot program***. After research allows reading some core conclusions, the national government should sponsor a broad scale pilot program that includes several contiguous states.

FUNDAMENTAL RECOMMENDATIONS

Over the next six years, the federal government should (1) identify and complete design and development of mileage-based charging collection systems for all motor vehicles that can be implemented nationally or commonly by individual states; and (2) Engage the public through the development process to gauge public attitudes on the various mileage charge system elements so that a national consensus may form on the advisability of mileage charging in the United States and the most appropriate form for the new system. These efforts should receive full funding and staffing and the regulatory freedom to proceed aggressively and expeditiously.

PART ONE

Creating a New Road Revenue Collection System

Introduction to Part One

> *"I garaged my SUV, which I still need to haul around the dog, kids, and travel gear, and now drive a new Mini Cooper. I'm getting 31 mpg in town and close to 40 mpg out on the highway. I used to fill the SUV up every 5 days; I'm on my 3rd tank of gas since getting the MINI about 2 months ago. And I haven't diminished my driving one bit."* Citizen comment on BlueOregon Blog, early 2008.

RATIONALE FOR MILEAGE-BASED CHARGING IN THE UNITED STATES

With road revenues falling, the nation's Highway Trust Fund insolvent, congestion worsening and the general health of the road system declining, transportation policymakers across this nation now acknowledge the failure of the fuels tax to adequately fund our nation's roadway system. Long the bulwark of the entire highway system, the purchasing power of fuels tax revenues dwindles year by year because of road cost inflation, the changing nature of the vehicle fleet and loss of political support. This trend shows no signs of reversing.

The fuels tax fails in many ways. Despite the strong potential for dramatic decline of road revenues as the motoring public chooses to operate more fuel-efficient vehicles, the amount motorists use the road system—measured by vehicles miles traveled (VMT)—continues to trend upward. VMT takes a dip when the economy does and the recent drop in VMT may indicate deterioration in economic condition more than a definite move away from road travel.

Nonetheless, during times of rising fuel prices and economic tremors, the fuel efficiency of a motorist's vehicle does have an impact upon an individual motorist's VMT. The early response may be to cancel certain trips but as personal finances allow, motorists purchase fuel-efficient vehicles. Such a move increases VMT because motorists tend to drive fuel-efficient vehicles further and more often than they drive less fuel-efficient vehicles.[1] The motorist can afford to drive more while operating a fuel-efficient vehicle. Vehicle switching places greater demand on the road system than would otherwise be expected, while generating less revenue from fuel taxes. Over time, such a trend creates an unsustainable road funding system.

Owing to inherent inflexibility, the structure of the fuels tax cannot address any new policy requirements beyond highway revenue generation and modest carbon dioxide reduction. Since the nature of America's road traffic impacts several critical policy agendas for the 21st century—climate change response, energy independence, adequate road capacity and funding, environmental protection—it would be wise for our nation to develop and employ a new, highly flexible road finance system.

As road capacity improvements have not kept pace with road demand over the past 20 years and are unlikely to catch up under current circumstances, many transportation policymakers and stakeholders look to various forms of congestion pricing to reduce the amount of traffic during peak driving periods. As a per-gallon tax collected at the distributor level (and

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[1] B. Starr McMullen and Lei Zhang, *Techniques for Assessing the Social-Economic Impact of a Vehicle Mileage Fees: Final Report, June 2008, p. 14.*

reimbursed by the retailer and, in turn, by the consumer), the fuel tax collection system has no ability to vary to facilitate congestion pricing during peak driving periods.

Nor does the fuels tax functionally address the crisis of climate change or environmental impact. While the fuels tax gives marginal advantage to fuel efficient vehicles over fuel inefficient vehicles, this per-gallon tax acts only as a blunt instrument for reduction of greenhouse gases and recovery of external costs. The inherent inflexibility of the fuels tax does not permit adjustments to implement environmental strategies having greater impact upon vehicle choice. If a new source of road revenue could have enough flexibility to accomplish policy goals beyond simply raising revenue it would have the potential, should policymakers so desire, to align with other national climate change strategies such as *cap and trade* or carbon taxes.

This nation's 90-year old fuel tax collection system ought to be phased out in favor of a new system with an ability to effectively manage these problems—road revenue, congestion, climate change, dependence on foreign oil, environmental cost recovery—in a cost effective manner that accommodates the values of our nation's citizens. As this paper will demonstrate, a distance-based direct user fee, called *the mileage charge* or, alternatively, the VMT fee or tax or pricing or per-mile charge, can be structured to make substantial contributions to resolution of today's travel-related problems.

Finding a New Road Finance Mechanism

If finding a new road revenue system were an easy task, we would not be searching for one today. Policymakers have sorted through many possibilities and every one has flaws. Though beyond the scope of this paper, briefly reviewing the most mentioned possibilities may explain the growing interest in mileage charging among policymakers across the nation.

A motor fuel sales tax or indexing the fuels tax for fleet fuel efficiency improvements and inflation may seem like appealing options. When considering the lopsided burden such options might impose upon working vehicles and the less affluent drivers who tend to purchase less fuel efficient vehicles from the secondary market, any fuel based option begins to lose appeal.[2] As new vehicles become ever more fuel efficient, the stratification between the amount operators of older vehicles pay and the amount operators of newer vehicle pay may grow wider without justification based on road use. The unfairness of such a situation might be worthy cause for strong objection to fuel tax increases from these segments of society.[3] Further, an indexed gas tax does not directly relate to road use therefore having no ability to combat congestion or induce other targeted reductions in VMT.

Annual increases for registration fees or personal property taxes on vehicles may sound worthy but these options are completely divorced from road use and indeed penalize motorists that use the road infrequently. Low use motorists would subsidize high use motorists without policy justification. Moreover, since these funding options are closely associated with state operations, it may be inappropriate for the Federal government to co-opt them.

Some propose that general taxes on sales, income or real property, or perhaps a value added tax might provide sufficient additional revenue. The up and down nature of these revenue

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[2] National Surface Transportation Infrastructure Financing Commission, *Paying Our Way: A New Framework for Transportation Finance*, *2009*, p. 146.

[3] A separate analysis of this developing situation should prove helpful to policy development for road funding options.

sources will not yield reliable revenue for roads during economic downturns. Improving roads and bridges might not be a high priority under such conditions because of the intense competition for these revenues with human services and education. Moreover, these sources of revenue have no connection to road use.

Imposing high tolls on facilities with the largest amount of average daily traffic would certainly raise substantial revenue either nationally or for states with high volume toll facilities. As a general solution, however, this would not suffice as a general revenue system for the states because most states do not have high volume toll roads and motoring citizens will strongly object to tolling facilities not currently tolled. Further, since the revenue generated from the new tolls would not be associated with the facility from which they were raised, motorists could make a strong unfairness argument that would tend to dampen the ability to impose tolls for this purpose. Lastly, this option would not be an appropriate measure for federal revenue generation since the states with high volume toll roads would disproportionately bear the nation's road funding burden.

Finally, some suggest that environmental charges like a BTU tax might be the most appropriate revenue source for the road system. While such a tax may have certain environmental benefits and also cover alternative fuels, a BTU tax would have the same problem as the gas tax. With increases in vehicle fuel efficiency, revenues would drop.

The idea of a charge based on vehicle miles traveled seemed impossibly difficult not long ago. Only the availability of contemporary electronics, data processing and communications systems render the concept viable today.

A Mileage Based Road Charging System

Though long theorized as an alternative to the fuels tax, acceptance of distance-based road charging by our nation's policymakers now grows rapidly. Recently concluded investigations in Oregon and the Puget Sound area as well as the University's of Iowa's six pilot projects currently underway involve various forms of electronic metering and collection. Wary of technology, some policymakers at national and state levels look to motorist self-reporting of mileage data for mileage charges as the preferred methodology.

This nation has yet to settle on the system architecture for developing and processing mileage data and collecting mileage-based charges. For mileage-based charges to proceed rapidly to adoption and implementation, a national consensus must form around a metering and collection methodology so the nation's governments can employ a common system. To create a new revenue collection system, many interlocking policy factors must undergo consideration and preferences made and prioritized. Once policymakers make the foundational policy choices, a metering and collection system can be configured around them.

Some of the technology and sub-systems for road use metering and charging have reached the point of common agreement by various investigators in the United States while other technology and systems elements remain to be settled. Both categories require additional technological research; the first category to refine the technology to commercial application, and the second category to determine the most effective applications. A third category of technology choices will be determined not by technological capability but rather by policy choices made by this nation's policymakers and public acceptance will strongly influence the policy choices made for road use charging.

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Fundamentals

THE CHALLENGE OF COLLECTING A MILEAGE-BASED CHARGE

Assembling a collection system for a mileage-based charge, when first approached, seems like a fairly easy endeavor. Every vehicle already comes equipped with a mileage counting device that records individual distance data, an odometer. Find a way for the motorist to transfer these data, apply the charge, demand and receive payment and you have a new system. In theory, every step of this process can occur manually—the method of choice by early proponents over a decade ago—but once thinking turns to actual implementation, simplicity melts away. System designers and policymakers discover the complexity of assembling a mileage charge collection system with desirable features that also passes the test of public acceptance.

This chapter lays out the essential considerations for creating a collection system for a mileage-based charge. The interconnected factors described below can seem overwhelming at first glance. By establishing priority for various relevant public policies, however, policymakers and system designers discern the pathway to an acceptable conclusion.

STRUCTURAL CONSIDERATIONS FOR MILEAGE CHARGING

What a Mileage-Based Charging Collection System Must Do

A per-mile charging system must do six things:

1. Calculate miles driven (distance metering),
2. Access the mileage data (communications),
3. Apply mileage charge rates (data processing),
4. Provide the motorist a billing (invoicing),
5. Accept payment from the motorist (collection), and
6. Support effective deterrents and actions against evaders and delinquents (enforcement).

Each of these steps consists of one subsystem contributing to an overall revenue collection system. A legislative body could stitch together pieces of existing sub-systems to accomplish these steps but the resulting patchwork might not be optimum or preferable. In creating a new mileage-based charging system, legislators should consider numerous public polices in assembling the new collection mechanism but especially adherence to appropriate revenue generating tenets, especially acceptance by the public.

Motorist Self-Reporting of Mileage Data

In the past year, several national and state policymakers of significance have expressed support for mileage-based charging as an important component of the road revenue generation pie. Unfortunately, a few of these fresh supporters want to *keep it simple* by advocating for motorist self-reporting of mileage data directly from the vehicle odometer. When one seriously considers self-reporting in the context of the structural elements required for creation of an efficient and acceptable mileage charge collection system, support for a manual collection system withers away. (The authors will argue this more pointedly in Chapter 4.) Regarding the same structural elements, an electronic mileage charge collection system based on contemporary technology provides the potential for adoption of an efficient and acceptable revenue system.

Embracing Technology, But Not Too Tightly

The intriguing capability of the various technological gadgets available for mileage charging can overwhelm system development. Despite the mesmerizing nature of available technologies for metering, data uploading and charge collection, technology should *not* drive system design. Public policy, rather than technology, should determine the nature of any mileage charging system. If technology leads the discussion, public policy concerns will take a back seat and the possibility for public acceptance decreases commensurately.

After policymakers structure the new collection system around appropriate public policies, technology applications should support the policies chosen. When technological or systemic roadblocks emerge, policymakers may want to adjust policy decisions to ensure development of a practical system.

Nor should policymakers aggressively choose specific technologies to meet system requirements. Technologies frequently change but robust policy choices may withstand change. Rather than specifying a particular technology or implementation detail, policymakers should identify policy requirements for which a technological system can be constructed. Even so, new technologies may support policy choices better than earlier technologies and the policy choices supporting system development may well account for that. To encourage the incorporation of improved technologies, policymakers may want to choose between development of an *open system*[4] and a *closed system.* A closed system would tend to be stuck in time, anchored by the capabilities of the earliest deployed on-vehicle device. An open system built with open interfaces and open technical specifications—similar to the Internet—can allow implementations to evolve over time as the underlying technologies change. An open system encourages interoperability therefore fostering multiple competing and improved implementations, lowering costs and improving the quality of the systems themselves.

During their early years of designing mileage-based charging systems, the authors struggled with numerous fundamental factors, each described briefly below, that influence and, indeed, constrain developmental choices for a new collection system. Conducting a stand-alone analysis for each issue becomes impossible because they tend to impact and influence each other.

[4] Open systems are computer systems that provide some combination of interoperability, portability, and open software standards and can also mean specific installations that are configured to allow unrestricted access by people and/or other computers.

Policymakers and system designers must resolve all systemic issues as part of the process of system adoption. Some of these issues require value judgments by executives or legislators. Others require further engineering or social research.

Designing an entire mileage charging collection system involves the challenge of selecting one sub-system for each step mentioned at the start of this chapter over competing methods and competing technologies, determining the technical specifications for each activity or component and integrating these sub-systems into a complete system. The ability to *mix-and-match* various sub-systems and methodologies makes this effort much more complicated than it may appear at first glance.

Finally, policymakers and system designers must recognize the social, transportation and economic differences between light vehicles and heavy vehicles. The technical and policy responses to the issues below may prove quite different for heavy vehicles than for light vehicles.

Purpose for the New System

Those examining the potential of mileage-based charges tend to see their potential from distinct vantage points. Roads advocates see the potential for a revenue source not affected by motorists moving to fuel-efficient vehicles in great numbers. Those seeking traffic reductions during peak driving periods see the potential for application of *designer* congestion pricing strategies that fit the individual characteristics of metropolitan areas. Environmental advocates seeking effective climate change strategies and energy independence see the opportunity to reduce the overall amount of driving by sending motorists a *concurrent* price signal but also to encourage motorists to operate fuel-efficient, clean vehicles by providing a *strong* price signal.

Those with different perspectives peer curiously forth as well. Local governments may view the per-mile charge through the lens of an accurate revenue allocation amongst jurisdictions. Some within the trucking industry may see distance-based charges as a way to accurately collect truck travel data to satisfy requirements of the International Fuel Tax Agreement and International Registration Plan.

A properly constructed mileage-based charging system will have the ability to achieve most of these purposes. Not every possible system for collecting a per-mile charge, however, provides the flexibility necessary to achieve a given purpose. The precise system architecture naturally flows from the purpose sought.

From the revenue generation perspective, policymakers must decide whether a mileage-based charge should replace or augment the fuels tax. Replacement of the gas tax requires an understanding of how long it will take to complete implementation. If implementation must be phased in over a number of years so the two systems must operate concurrently, then those paying the per-mile charge must either receive a credit for gas tax paid or a reduction in the gasoline price by the amount of the gas tax. Augmentation of the gas tax does not generate the same issues but may have a steeper public acceptance hill to climb.

With regard to congestion management, policymakers will want to decide the degree with which urban areas should have the option of creating ever more complex congestion management strategies to conform to the ever changing confluence of road networks and driving habits. London, Stockholm and Singapore employ congestion management strategies such as toll rings by using established tolling-style equipment but this manner of congestion pricing only works well for core areas with exceptionally high travel demand. For effective application of congestion pricing to urban areas with other congestion problems, such as neighborhood-to-neighborhood or economic center-to-economic center travel, governmental jurisdictions must employ other technologies and collection methods. Issues of operations cost, privacy, traffic diversion and cross-jurisdictional impacts will surface during this analysis.

Policymakers can structure a mileage-based charge to discourage the consumption of fuels contributing to global climate change. Not only could consumption of alternative fuels involve payment of a lower charge but motorists operating fuel efficient vehicles could pay less per mile than those operating gas guzzlers. The varying nature of the charge could impose a financial burden for inefficient vehicles that mirrors the burden of the gas tax or, if policymakers want to impose a greater burden, the charge could be structured to recover the cost of externalities related to driving. Whether to impose these additional burdens will depend upon consideration of overall national energy policy and greenhouse gas reduction policy in the context of a *cap and trade* system or carbon taxes.

Some policymakers may desire to create an accurate allocation of road revenues amongst governmental jurisdictions based on the actual burden the motorists place on a given road or local network. If so, precise measurement of miles driven on each particular road or within jurisdictional boundaries appears to be possible. Application of higher technologies would be necessary to accomplish this purpose. Examination of issues relating to privacy and motorist expense would also enter the analysis.

Finally, policymakers may face strong desire to enable local governments the option of imposing additional charges on top of state or national mileage charges. Offering this option will cause policymakers to prefer on-vehicle technologies that can more easily create electronic geographic zones.

Identifying Nature of Payer and Charge

Policymakers must determine whether the mileage-based charge should be a user fee or a general tax. A general tax does not require relationship with use. A user fee should directly relate to the burden a user imposes.

Another core issue is whether motorists should pay the mileage charge on total miles driven or only on miles driven within a given jurisdiction. This issue, of course, essentially has no relevance for national mileage charges. Charging for total miles traveled will likely have the advantage of requiring less technology for system operation but would have the disadvantage of disconnecting driving from the burden a motorist places on the road system. If a state wants to charge resident motorists only for the burden they place on the state's road system, then a way to assign vehicle miles traveled by jurisdiction must be employed. Further, if policymakers want to grant governmental jurisdictions authority to impose local mileage charges or implementation of congestion pricing without an ability to track vehicles, then a way to assign VMT within geographic boundaries must be employed.

Policymakers must determine whether payment should be made pre-usage, like the fuel tax, or post-usage. Computation of projected usage can simulate pre-usage payment but less precisely than the precise post-usage method.

Policymakers may want to allow for the possibility of charging a discount for payments made pre-usage or a surcharge for payments made post-usage. Allowing for differing rates may help gain wider public acceptance.

The frequency of payment has relevance to public acceptability and revenue flow. Frequent payment, perhaps monthly or more often, will result in lower billings that are more likely to be acceptable to payers and easier for collection. Infrequent payment will likely result in greater defaults, more evasion and less public acceptance, as well as disrupted and reduced cash flow for the government. For some motorists, various prepayment options may offer ways to manage cash flow in an acceptable way.

The size of the payer base will influence the potential size of the charge per payer. The nature of the payer base might also indicate the difficulty and effectiveness of an auditing program.

Many user fees are embedded within transactions and therefore hidden. Policymakers must decide whether mileage charges should be transparent to the payer or embedded within each fuel purchase like the current gas tax. If hidden, the motorist may never know the mileage charge amount. If transparent, the motorist will know the mileage charge amount either at the time of payment or while the charge tallies during travel, depending upon the technology employed within the vehicle.

Charging out-of-state motorists invites complexity. Legally, out-of-state motorists must not drive free of charge when local residents pay the charge. Policymakers must decide whether out-of-state motorists should pay under the same system as resident motorists or whether a different system could be deployed for them. A national mileage charging system, whether deployed for a national mileage charge or merely to support state charging systems, would render the out-of-state motorist issue irrelevant.

Policymakers must decide whether the new mileage charging system should be mandatory or voluntary for motorists. A mandatory system could address policy goals immediately but must face the inherent challenge of political inertia. A voluntary system might receive greater public acceptance but must establish an incentive to ensure success. Since voluntarily opting into a mileage-based charging system would require acceptance of a payment burden, the incentives offered may have to be large or highly attractive. The authors examine a voluntary system in greater detail in Chapter 4.

Overall System Risk

Both the size and nature of the payer base affect overall collection risk for the system. A greater number of payers will lead to a greater number of delinquencies and therefore higher administrative costs. The gas tax has a small payer base—about 5,700 gasoline distributors nationally[5]—with minimal risk of short payment or nonpayment. Moving the incidence of revenue payment to the service stations—well over 100,000 nationally[6]—will result in more auditing and enforcement actions. Moving the obligation for revenue payment to the individual motorist—over 200 million nationally—would result in the need for an extremely large administrative and enforcement force to ensure payment equity and significant revenues.

Adherence to Desirable Tax Policies

Policymakers generally apply publicly acceptable tax policies for tax, fee and charging collection systems to ensure fairness, operational efficiency and effectiveness. Generally, the following

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[5] See http://www.hoovers.com/petroleum-wholesale-distribution/--ID__62--/free-ind-fr-profile-basic.xhtml (accessed July 20, 2009).

[6] See http://www.census.gov/econ/census02/data/industry/E447110.HTM (accessed July 20, 2009)

tax policies should be considered while developing the new system for collection of mileage-based charges.

- *Breadth of charge application among payers.* If policymakers prefer that the mileage charging system operate on a user pays basis, the collection system must capture a broad array of users, indeed, each user of the system must pay directly for the burden made on the road system.
- *Relative fairness among payers.* The new mileage charging system must have the perception of fairness across all user groups. Any subsidy for a particular user group must be justified.
- *Low relative capital costs for implementation.* The capital costs required to implement the new system must not overwhelm the ability to pay for the system.
- *Low relative annual operating costs.* To facilitate public acceptance, broad based taxing and fee charging systems should have low operating costs relative to the revenue generated. This condition takes on added importance if the mileage charging system replaces the gas tax as the primary road funding mechanism since the gas tax operating costs are extremely low.[7]
- *Low relative compliance burden.* The system should impose minimal burdens on payers in the context of effort, cost and complexity. If mileage charging replaces the gas tax, the method of payment may need to match the simplicity of paying the gas tax in order to garner public acceptance.
- *Minimal relative administrative burden upon the private sector.* The system should impose minimal additional costs on businesses collecting the charge and forwarding payment to the government collection agency. As an alternative, the opportunity to earn transaction processing fees may allay the burden of these additional collection costs.
- *Efficient administration.* Government administration of the mileage charging system should not result in a huge and expensive bureaucracy.
- *Effective enforceability*. Government administration should be effective enough for assurance that most motorists actually pay the appropriate mileage charges. Government auditing costs should be low relative to revenues raised, especially if policymakers want the new system to replace the gas tax.
- *Minimal evasion and avoidance.* The system should make tax evasion and tax avoidance difficult. The system must assure accurate data generation and transfer as well as appropriate civil and/or criminal penalties for tax evaders.

System Administration and Integration

To ensure system feasibility and reliability, one must consider the point of collection in terms of risk. In this respect, enforcement should be simple and easy and auditing efficient and effective. If the new system involves existing systems—such as to provide a credit for gas taxes if the purpose of mileage charge is to replace the gas tax—then the mileage charging system should integrate well with those systems. Policymakers and system developers must determine who should operate the new system, the government or private vendors. Finally, the new system

[7] James M. Whitty, *Road User Fee Task Force Report to the 72nd Oregon Legislative Assembly*, March 2003, p. AA-1.

should have the capability of integrating with national and other states' revenue collection systems.

System Reliability

If a preferred mileage charge system configuration presents significant collection risk, system designers should ensure reliability by providing a back up collection system available for substitution as necessary. An accessible back-up collection system would forestall loss of revenues, for example, should an on-vehicle device experience data transmission difficulties owing to power outages.

Managing Nonpayment

The *evasion potential* of a new system not only affects revenue levels but also the potential for shifting the burden of reaching a certain revenue level onto those not evading payment. The system must not only enforce payment efficiently and cost effectively but also discourage legal avoidance of the mileage charge.

Capital and Operating Costs

Any new revenue system will have start-up, capital, and operating costs. Capital costs include physical infrastructure (facilities, buildings) and data generation and transfer mechanisms as well as data management and billing and payment systems. Operational costs include data management, enforcement and auditing operations.

These costs can range from modest to quite substantial, depending on the system. Determinants include the following:

1. Whether the system applies to currently owned vehicles and therefore requiring retrofitting of on-vehicle technology,
2. The amount of information collected and how the system will protect privacy to levels expected by the motoring public,
3. How transmission of information occurs,
4. Data processing systems,
5. Billing processes,
6. Charge collection processes, and
7. Customer service required by system design.

Critical to political acceptability, capital and operating costs for the new system must be affordable. One's view of affordability varies with the nature of the system. The relative operating costs for privately run revenue systems—like toll roads where volunteer users accept high administrative costs for access to the facility—may not be acceptable for government revenue systems where payment for general use is mandatory. If policymakers seek to replace the gas tax rather than augment it, capital costs for a new system become particularly important because the gas tax collection system already exists. To replace the gas tax, capital and operating costs should remain as low as possible. Equally important, the administrative burden and compliance costs for the taxpayer and the private sector must be at acceptable levels.

Perspectives on affordability change when considering heavy commercial trucks. The recent implementation of Germany's heavy truck charging system indicates the capability of the motor carrier industry to absorb considerably higher system costs than anticipated for passenger vehicles. A distance charging system for a regulated industry may need more sophistication and additional charging options than for light vehicles, since vehicle configuration, weight and number of axles will likely determine the rates charged. Such a system should provide improved data and communication benefits to motor carriers as well as planners and regulators.

Technologies

Technology choices for the overall system and sub-systems, from the many possible combinations, influence most of the factors discussed in this chapter. This is particularly true for various pricing strategies, privacy protection and the collection approach selected.

Feasibility and Effectiveness

While policy and not technology should drive system design, technological realities should loop back and inform policy choices as practical limitations emerge so that policymakers can adjust preferences accordingly. In this respect, policymakers should interact with system designers to achieve outcomes that align system needs with public acceptance requirements.

The practicality of technology applications will emerge from analyses of cost and maintenance factors but also from factors related to functionality, availability, accuracy and reliability. The technology and systems employed must also reach and maintain a high degree of security. Ideally, both on-vehicle technology and the systems technology employed should interoperate with existing systems such as modern electronic toll collection systems and perhaps computer systems at DMVs. Finally, policymakers may want to consider whether a given technology application has the capabilities of expandability and upgradeability to allow swift change as new systems or needs develop in the future.

Emerging Technologies

In this age of technological revolution, technologies for road pricing rapidly improve. Scientists continually improve data transmissions and data sharing platforms. The University of Iowa launched this year a major mileage-based charge technology demonstration project. Further, the large motor vehicle manufacturers working in concert with USDOT have in process a vehicle to highway infrastructure integration (VII) initiative. While primarily focused on safety applications, VII technology may enable metering and collection of mileage-based charges.

As technology evolves, it would be advantageous for a mileage charging system to evolve to incorporate improved technology. System designers could specify the necessary data elements for collection but allow for the possibility for new methods of computation and communication. Defining minimum system and technology certification requirements could yield sufficient system flexibility to enable technology change and system evolution.

Other new technologies assisting mileage charge implementation could rapidly emerge within the next few years. Whether the underlying mileage charge system is *closed* or *open* to new technologies could determine future capability and efficiency for the system. An open system with available standards, protocols and network—something akin to the Internet—that accommodates a variety of interoperable implementations should be more readily adaptable to improved technologies. Further, an open system may create opportunities for a variety of additional commercial implementations and applications for incorporation with the mileage charge system, thus increasing the potential for public acceptance.

Gradual, staggered adoption of mileage charge systems by individual states means later adopters may employ more advanced technology than early adopters. If system designers adopt a closed system approach, the most likely result will be a collection of disparate and incompatible systems. An open approach will more likely result in interoperable systems.

While it helps for states to have some sense of how existing technology will likely evolve before implementing a new system, technologies for some sub-systems have already reached maturity. System designers and policymakers can rely upon sub-systems built around currently mature technology.

Transportation providers should anticipate and understand the implications of emerging technologies for mileage charge applications—both mature and evolving—before adopting a specific sub-system. This holds for both light and heavy vehicles.

Transition Management

Minimizing Difficulties

Transition issues can impact acceptability of a new system and complicate implementation. The principal concern involves duration of the transition to full implementation of the new system. System designers must compare the feasibility of immediate and full implementation with the practicality of phasing the new system in over a period of years. If policymakers determine that technology must be employed within vehicles to make the new system practical, system designers must assess retrofitting of all vehicles in terms of practicability, public acceptance, cost and logistics. System designers must also assess the seamless capacity of the transition.

Mandated retrofitting of every vehicle may prove unnecessary if voluntary adoption of on-vehicle devices added *after-market* become attractive to motorists. If policymakers ensure application of an open technology standard, after-market on-vehicle devices may achieve attraction naturally. Under an open system, systems designers must ensure open specifications and interfaces to ensure interoperability.

Continuing Fuel Taxes

Whether mileage-based charges replace the fuels tax or augment it, there are strong advantages to retaining fuel taxes during a mileage charge phase-in either as the underlying back-up collection system or as a part of the collection sub-system for mileage-based charges. If policymakers decide not to require retrofitting of on-vehicle devices, it will be necessary to continue fuel taxes in order to facilitate a lengthy phase-in period for the mileage charge system. If policymakers decide to retrofit on-vehicle devices, it may not be necessary to continue fuel taxes, but continuation may be desirable as a back-up method in the event of on-vehicle device or system failure.

Most heavy vehicles operate on diesel fuel. State governments generally collect taxes on diesel fuel differently than taxes on gasoline. In some circumstances, this may have some bearing on the issue of whether to continue the tax on diesel fuel.

Constitutional Constraints

New systems must comply with various provisions of the United States Constitution and related and relevant provisions of state constitutions. The authors have found relevant the Commerce Clause and Equal Protection Clause of the United States Constitution especially with regard to transition issues for congestion pricing applications.

POLICY CHOICES FOR KEY PIVOT ISSUES

System Needs Vis-a-Vis Privacy Protection

The public interest requires that every revenue collection system have certain capabilities in order to assure efficacy and fairness to the payers. While application of electronics may assist in achieving these objectives, too much government involvement can impinge upon the public's desire for a certain level of privacy protection from government intrusion. Policymakers must strike a balance between system needs and the protection of privacy.

The tension between system needs and privacy hinges on three issues; the information collected on consumer activity, the ability to audit and on-vehicle device capability. Interaction among these issues will largely define the nature of the mileage-charging system adopted.

Information Collected on Consumer Activity

Policymakers must carefully determine the degree to which a government can obtain motorists' specific movement or location information. Though a highly charged political issue, some U.S. toll roads essentially track their customers. Despite the availability of special procedures to eliminate this tracking capability, most toll road consumers ignore the opportunity for travel anonymity.[8] Nonetheless, public outreach efforts, focus groups, and polling indicate a significant and strong aversion to any government activity that appears to track the movements of individuals and their vehicles. Large segments of the public will not accept any system perceived to enable vehicle tracking.

This problem becomes particularly vexing when considering application of elements of Global Positioning System (GPS) technology. A promising candidate for mileage charging systems, GPS-based vehicle positioning cannot, by itself, enable vehicles to be tracked. Unfortunately, the media tends to portray GPS systems as tracking technology, with many articles about firms using GPS devices to track customers in their vehicles. As a result, the public has understandable concern—though not necessarily accurate—that any system using any aspect of GPS technology will enable the tracking of vehicles.

While not entirely absent, privacy protection and vehicle tracking have less political sensitivity for the motor carrier industry than for the general public. This makes sense because the government regulates the motor carrier industry as a commercial rather than personal activity. Accordingly, government agencies monitor heavy commercial trucks for size and weight enforcement purposes. Motor carriers, therefore, surrender a certain amount of anonymity

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[8] For instance, the initial operator of the California 91 Express lanes offered a special procedure for customers who wished to remain anonymous with very few takers.

to lawfully operate on the road system. As a result, many more system options are potential candidates for application to the motor carrier industry.

Ability-to-Audit and Challenge a Billing

Once a collection agency collects mileage-metering data, the system may require additional data to enable the collecting agency to verify accuracy or reasonableness and enable the mileage charge payer to verify the accuracy of the data and the charge. How much additional data the agency will require depends upon the information the public is willing to allow the government to collect, and whether there will be any sort of pricing beyond a flat VMT rate. Research may reveal that the public may prefer providing more detailed data to private sector system operators under stringent data-protection rules.

The motoring public has security concerns as well. The public worries whether the mileage-related data could be intercepted by outside parties during transmission. The public also has concerns about whether data banks can be compromised and the data stolen. Recent, high profile data-security lapses by both large firms and government agencies have challenged public confidence.

Sorting through the trade-offs between charge verification and privacy protection, it helps to recognize the natural continuum for these issues. With electronic collection of mileage data and vehicle identification, a system design can protect privacy completely on one hand—including a system with GPS elements!—or invade privacy completely on the other, depending upon technology applications and system configuration.

Oregon tested a mileage charge collection system whereby the system protected privacy by calculating mileage charges without identifying the travel of the vehicle either in real time or historical record. In Oregon's pilot program, the on-vehicle devices contained latitude and longitude coordinates identifying the geographic boundaries of particular *zones*, such as the borders of a state or city. The only data developed and transferred were the mileage totals within each geographic boundaries of each zone. A congestion charging study in Puget Sound, on the other hand, developed and retained an entire travel history of motorists participating in the study.

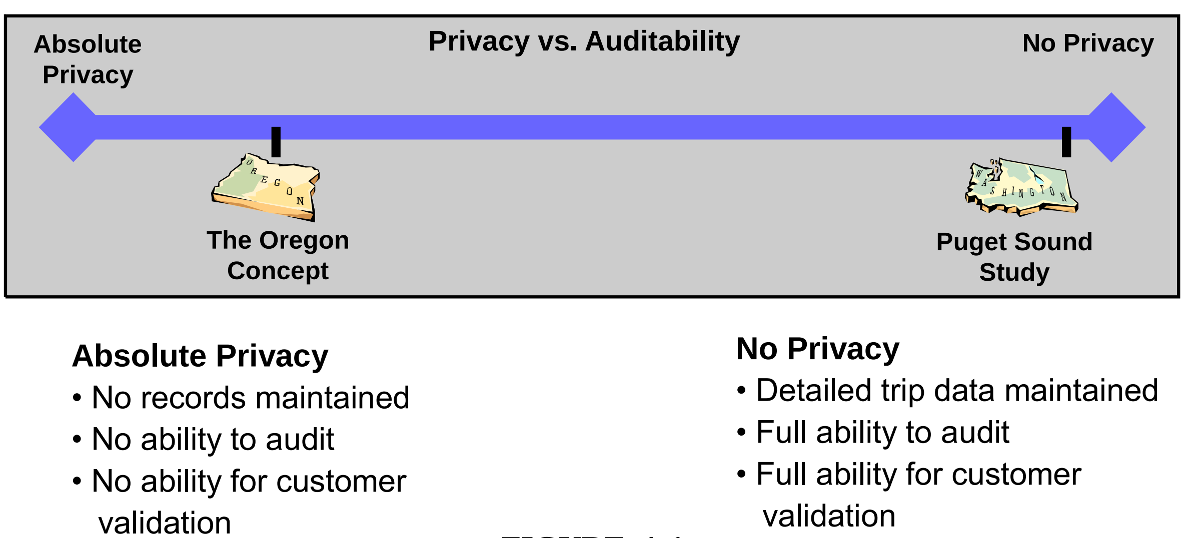

FIGURE 1-1

Depending upon the system and technology adopted, full protection of privacy may thwart the collection agency's ability to gather sufficient data to enable auditing and effectively enforce payment or allow the consumer to challenge a billing. Legislative policies placing a mileage charging system at a point on this continuum thus affects evasion prevention, collection enforcement, and security of data, as well as vehicle tracking. A legislative body may not need to precisely define how privacy will be protected. Simply adopting a policy mandating that certain data not be accessible to anyone may be enough.

Several decades of advances in modern cryptography make it possible to design more sophisticated and complicated protocols that can achieve privacy goals. These techniques may make it plausible to design fairly general protocols which function in this fashion without violating the privacy of drivers, while enabling auditing, enforcement, and allowing the consumer to challenge a billing.[9]

The Iowa mileage charge pilot project currently underway encrypts the precise travel records and communicates the aggregate charges owed, enabling the driver to open the encrypted file to challenge charges if desired.[10] Some members of the public may prefer a system unable to generate any vehicle location data, while others may find a system that develops encrypted data satisfactory in order to obtain the ability to ensure proper billing. Policymakers will have to gauge the political potency of each preference. Over time, preference for data encryption may win the day as younger citizens tend to accept new technology more quickly than older citizens and therefore may more easily find comfort with these privacy protections embedded within the technology.[11]

Legislative policymakers have options to protect privacy beyond simply negating application of certain technologies. Legislation can establish effective legal prohibitions, including criminal sanctions, to limit a collection agency's ability to compromise the privacy of motorists. A legislative body could mandate system designers to establish safeguards against interception of data during transmission from the vehicle and to create first-rate data bank security.

Departments of Transportation routinely audit motor carriers for tax purposes. Allowing a collection agency to obtain the additional information required for auditing should be much less of an issue for heavy vehicles. The commercial trucking industry should demand assurance of data bank security and safeguards against data interception to the degree required for passenger vehicles.

On-Vehicle Device Capability

The amount and type of information collected from charge payers directly determines the capability required of on-vehicle devices. On one hand, the devices must collect information sufficient to satisfy the purposes established for the mileage charging system. On the other hand,

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[9] Raluca Ada Popa, Hari Balakrishnan and Andrew Blumberg, *VPriv: Protecting Privacy in Location-Based Vehicular Services, 2009*; Andrew Blumberg and Robin Chase, *Congestion pricing that respects "driver privacy,"* a whitepaper.

[10] The National Surface Transportation Infrastructure Financing Commission, *Paying Our Way: A New Framework for Transportation Finance. February 2009, p*. 152.

[11] Ralph Gross, Alessandro Acquisti and H. John Heinz III, *Information Revelation and Privacy in Online Social Networks. ACM Workshop on Privacy in the Electronic Society (WPES), 2005,* http://portal.acm.org/citation.cfm?doid=1102199.1102214

some members of the public will reject devices capable of collecting and providing more information about individuals and the movement of their vehicles—whether encrypted or not—than they feel acceptable. Less capable devices also have the benefit of minimizing device cost. Lower device capability also directs transportation providers to lower their expectations about the kind and amount of data collected for planning purposes and limits the types of pricing techniques otherwise available with more capable devices.

The device capability issues do not change vis-à-vis heavy vehicles as opposed to light vehicles. Nevertheless, the characteristics of heavy vehicles may result in different device capabilities and different technologies than for light vehicles.

Vehicle Equipment Retrofitting Versus Long Phase-In

Policymakers often ask how quickly mileage-based charges can reach full implementation. The ability to retrofit currently operating vehicles with necessary collection technology determines how quickly mileage charges—and other policies for congestion pricing, environmental pricing, local jurisdiction charges, and revenue allocation among jurisdictions—can be applied to the entire vehicle fleet.

While several factors influence the ability for rapid implementation, cost may be determinant. Quick implementation requires retrofitting of currently operating vehicles with the necessary on-vehicle devices. Adding retrofit devices to currently operating vehicles simply costs more—mostly due to the price of labor—than having manufacturers install the devices in new vehicles only. This disparity will grow ever larger as retrofit installation costs tend to increase while device costs shrink over time.[12]

Considering cost, a gradual phase-in may be preferable. Applying the on-vehicle technology to only a portion of the vehicle fleet, however, means that mileage-based charges beyond a per-mile charge replacement for the fuels tax—for example, GPS-based congestion pricing, some forms of environmental pricing, and local-option charges—could not be applied for some years into the future. Combination with current systems may allow employment of less sophisticated versions of congestion pricing and environmental pricing sooner.

Retrofitting may also increase the difficulty of ensuring tamper resistance for on-vehicle devices. Devices added externally to a vehicle's existing electrical and operating system would seem more obvious and available for tampering than devices embedded within a vehicle by design.

Finally, completely eliminating fuel taxes as the primary road funding mechanism over a short timeframe may be much easier under a retrofitting alternative. The ability to retrofit strongly influences whether policymakers should retain fuels taxes until completion of the transition.

While the retrofitting cost issue may appear the same for heavy vehicles as for light vehicles, the cost structure of commercial carriers, the greater ability to audit payments due and the smaller number of payers imply that retrofitting heavy commercial vehicles may be easier than for light vehicles. Moreover, the regulated nature of the motor carrier industry may permit government monitoring to ensure heavy vehicles contain the required operational mileage

[12] Cost for on-vehicle devices, which are essentially computers, are subject to Moore's law while installation is a labor cost. Moore's law says that the capability of computer processors doubles every 24 months; conversely, the cost of computer processors with no change in capability decreases accordingly.

counting devices. Device security may therefore be less of an issue for heavy vehicles, depending upon system design.

Congestion Pricing Considerations

Congestion pricing has enormous potential for reducing traffic delay on the specific facilities or areas for times in which it is applied. Combined with environmental pricing, congestion pricing may allow an effective mechanism for addressing reduction of greenhouse gas emissions from the transportation sector.

Despite the potential benefits, policymakers must consider applying congestion charges to a mileage charge for a given geographic area carefully. The proof is in the application. Some congestion pricing strategies may work well for one urban area but fail in another. The congestion pricing strategy imposed for an urban area will determine whether the traffic reduction and economic impact yield success or unintended consequences leading to public rejection.

Layering a congestion charge to a mileage charge invites complexity to decision-making about which collection system to adopt. An urban government can price congestion many different ways—cordon pricing, specific facility pricing, area pricing—and theorists and researchers have examined and tested many of these variations.

The data and charge collection system selected for the basic mileage charge will constrain the congestion pricing possibilities within an urban area. Some technology choices for the underlying system—for example, not applying a vehicle location device—may severely limit the creative applications of congestion pricing and increase the cost of operations. The stand-alone, camera-based, cordon pricing systems for London and Stockholm are of this nature. Transponder-based systems for specific facilities—like those under Urban Partnership Agreements for Seattle, Miami, San Francisco and Minneapolis/St. Paul[13]—may solve congestion issues for a given facility but not for the general urban road system. Other technology choices that use vehicle location ability may offer less operations expense and more creative applications across the entire system but await inclusion of the technology into contemporary vehicles.

Adding a congestion pricing system to a mileage-based charging system will inadvertently create some undesired effects for urban areas, depending upon the congestion pricing method employed. Traffic diversion becomes a significant issue. Given a choice between a *free* facility and a tolled facility, many drivers will choose the *free* facility, even if its qualitative characteristics are not as good as those of the tolled facility. Non-tolled routes parallel to a route with a new toll may become quite congested as a direct result of the toll.

Traffic diversion creates other problems. Traffic and travel patterns heavily influence the location of development and urban form. Potentially, altered traffic routing and travel destinations could undo years of land use planning. For example, if a government tolls radial routes to a central business district, downtown businesses may lose sales to suburban competitors. Ultimately, this could lead to downtown business closures and more suburban sprawl. Additionally, while improved conditions on tolled routes tend to have a positive impact on air quality, in some circumstances congestion caused by diverted traffic traveling on other

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[13] http://www.upa.dot.gov/

roads could actually result in worse air quality overall. This applies to greenhouse gas emissions as well as traditional pollutants.

Some forms of congestion pricing will cause unacceptable traffic diversion impacts while other forms will have negligible traffic diversion impacts. Careful study can determine an appropriate congestion pricing application for a given area or whether congestion pricing may produce severe challenges. How a government addresses traffic diversion and land use implications will directly affect both public acceptance and the specific system selected for implementation.

Congestion pricing looks different from the perspective of motor carriers. The sheer size of the operating light vehicle fleet causes congestion on most roadways. Owners of heavy vehicles sometimes argue that their vehicles should not be charged to address a problem caused by other motorists. At the same time, heavy vehicles undeniably contribute to congestion and should receive greater economic benefits from reduced congestion than most motorists. New facilities built with revenue from congestion pricing will accommodate heavy vehicles. The nature of the application of congestion pricing strategies to heavy commercial vehicles will ultimately be a political decision. Governmental entities may apply congestion pricing to heavy vehicles in different ways than for light vehicles.

Public Acceptance Requirements

Without a doubt, public acceptance affects design of a mileage-based system more than any other factor. What may work for the system may not work for the public. In this respect, system designers must establish an informational feedback loop with the general public that informs policy choices as public attitudes become apparent so that policymakers may adjust policy preferences accordingly.

Efficiency of the System

The general public's fundamental focus may concern the complexity of the system and the difficulty of use. For payment of mileage-based charges, contemporary researchers propose a variety of processes, including having consumers making special trips to offices for bill paying or recharging an account, answering payment questions at a fueling station, uploading and downloading data to and from some form of *smart card* or paying yet another monthly bill. The number and difficulty of new steps a motorist must perform to transfer mileage data or pay the mileage charge, including added transaction time, will largely impact acceptability. So will the cost of compliance, whether for capital expenditures or operations. If motorists must incur significant expense to comply with new system requirements, acceptance will greatly diminish.

Confidence in the System

To garner public acceptance, motorists must also gain confidence in the system's ability to accurately generate mileage data and apply the mileage charges. Transparency of the charges will bolster regard for the system as will the motorist's ready ability to challenge a billing.

The public will also desire the option of traditional methods of payment—their choice of cash, credit and debit—rather than forced into a method of payment they do not use. Sizeable proportions of the U.S. population operate on a strictly cash-only basis and greater numbers strongly prefer cash-only transactions. For instance, 28 percent of U.S. households do not have a general-purpose credit card, 35 percent do not have home-based internet access, and nine percent do not have a transactions-oriented financial account[14]. Any charge collection system that does not allow for easy cash payment will experience extreme public acceptance challenges.

Motorists paying into the new system will want to ensure everyone pays their fair share. They will not tolerate a system that permits a substantial number of free riders. Neither will motorists tolerate an unreliable technology application nor one that offers the opportunity to tamper with the on-vehicle device so that scofflaws can alter with mileage data to their advantage.

Privacy and Fear of Technology

The general nature of the system will also be important to the public. Motorists will insist upon protection of privacy to levels they expect. This expectation has several elements. The motoring public will expect a high level of security for their mileage data. They will also not want anyone to have access to their travel locations, whether in real time or historical record, especially government agencies. The public may feel more secure if travel location data were never generated or, at least, erased or inaccessible through encryption. The level of privacy expectation may change over time because younger members of society generally have less anxiety about technology than older members.

Rate Structure and Rate Equity

Public acceptance of the mileage charge will largely depend on the structure of the applied rates. If the system relies upon computers to calculate the rate, the possibilities for various rate structures are numerous. Such a rate structure could address several public policy goals at once. Raising revenue, congestion management, roadway efficiency, the relative burden vehicles place upon the road system, fuel efficiency and ability to pay are a few factors that might be considered in creating a rate structure. Indeed, such a system could evolve as preferred public policies change or adjust to fit characteristic local needs and policies. The authors examine the possibilities for rate structuring of mileage-based charges in greater detail in Chapter 3.

Policymakers must decide whether the new system should charge for direct use or whether some users should receive subsidization. As any new system may create *winners and losers*, this issue may become a political battle as well as a policy battle. Fairness, in this case, can be found in the eye of the beholder. One person may see fairness as every vehicle operator paying the same rate for imposing the same burden on the road system while another strongly believes fairness means operators of fuel efficient vehicles should pay less and operators of inefficient vehicles should pay more.

The issue of subsidization for rural motorists and less affluent motorists will yield more opinions about fairness. One argument asserts that rural drivers—who must by necessity drive longer distances because of the unavailability of transportation alternatives—deserve a subsidy. A counterargument declares that road capacity demand, being equal among motorists, does not warrant differentiation between rural and urban motorists. Another argument contends that poorer motorists cannot afford paying by the mile. A counter argument emerges that since no

[14] U.S. Census Bureau, *Statistical Abstract of the United States: 2008*, Tables 1127, 1140, and 1158.

direct nexus exists between road funding and poverty, the new system should not bear the burden of subsidies to the poor.

Rate structuring preferences will have an effect on the technologies and system ultimately adopted. This applies to both light vehicles and heavy vehicles.

Various Forms of Pricing

Although the nation now has several examples of successful new congestion priced highway facilities in urban areas, it does not yet seem apparent that this will become a trend. Notwithstanding obvious traffic flow benefits, the general motoring public may not routinely accept congestion pricing on pre-existing urban highway facilities.

Environmental pricing may be another matter. Members of the public who drive fuel-efficient vehicles or take non-motorized forms of transportation may support an environmentally priced mileage charging system. Of course, the opposite side of the spectrum may counter with intense opposition.

Perceptions of the New System

Even though the new system may be efficient, user friendly, protective of privacy and fair, the general motoring public may still reject it because of a perception that the system creates a new large governmental bureaucracy. In this respect, prospective payers will not tolerate high administrative and collection costs as a proportion of gross revenues.[15] In most states, the administrative and collection costs of the gasoline tax consist of less than one percent of total revenue collected, with diesel tax collection costs somewhat higher. If the mileage charge replaces fuel taxes, mileage charge collection costs will be measured against the yardstick of fuel tax collection costs. Under any collection scenario, mileage charge collection costs should be greater than those of the gasoline tax, though not necessarily exorbitantly so.

Motorist Class Wars

The political and economic battles apparent in other sectors will enter mileage charging as well. The urban-rural divide surfaces as rural motorists insist upon subsidies because they assert that they travel longer distances as a matter of daily necessity. Urban motorists may counter that as a true user charge the mileage charge rate should reflect demand rather than necessity.

Motorists driving fuel-efficient vehicles may assert that a strict user charge should take into account impacts other than road use such as greenhouse gas reduction and air pollution. On the other hand, motorists driving less fuel-efficient working vehicles necessary for farm and business uses may argue the benefit they provide to the economy should override anything but their direct contribution to road needs.

These class war arguments tend to be endless and lead to no common agreement. All societal policymaking enters this conundrum, particularly development of revenue generating systems. Policymakers should not expect to find a silver bullet here either. To enact any version of mileage charging, policymakers must make value and political judgments about these kinds of issues and forge compromises that may reflect incomplete resolution.

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[15] NCHRP 19-08, *Costs of Alternative Revenue-Generation Systems*, is underway.

Reflections on Public Acceptance

Changing from, or adding, one form of revenue generation to another presents the motoring public with sweeping change. As most people strongly resist the uncertainty caused by change, the public will not accept the change to mileage-based charges without extensive dialogue, near-perfect justification and clear understanding of the personal impact upon the individual. While such a dialogue has only begun in the United States, the lengthy period required for development and implementation of a sophisticated and integrated new revenue collection system should not stall while public regard for the new system grows to critical mass. Rather, the public dialogue and system development should proceed on concurrent pathways until both reach the tipping point.

Policy Choice Conclusions

Many policy choices affect each other, public acceptance and the specific system ultimately adopted. Policymakers and system designers must address each of these issues before identifying and implementing a new mileage-based system for a governmental jurisdiction; not the other way around.

Within the issue-groups in this chapter, knowledge gaps can be found. The authors propose further technical, economic, and social research and experimentation to fill these gaps in Part Two.

2

An Evolutionary Road Revenue Collection System

CONTEXT FOR AN EVOLUTIONARY SYSTEM

The search underway to find a new road funding revenue mechanism originally assumed someone could find a silver tax collection bullet that addresses every concern or, barring that, at least something simple. Finding a complete simple solution was the authors' goal when we began our work in this field several years ago. After a few months, we abandoned the effort. Our 21st century world simply changes too quickly to lock down on one simple funding mechanism.[16] It is reasonable to assume that appropriate responses to rapid change will require the nation's road funding structure to undergo perpetual adjustments. It would be wise then to create a road revenue system flexible enough to evolve with changing conditions and policies of legislative bodies.

The authors call the proposed mileage charging system *an evolutionary system* because it relies heavily upon contemporary technology—computers, databases and wireless communications—with the capability for accommodating an evolving set of public polices and governmental applications limited only by imagination and political will. In essence, a highly flexible system can change with the times.

Evolution via Ability for Vehicle Location Within Space and Time

Contemporary technology affords ability for electronic location of a vehicle within a given geography within a specific period of time. Now common GPS-based navigations units identify specific roadways and time of travel by accessing an embedded geographic information system (GIS) map but not without difficulty within *urban canyons*. The Oregon Road User Fee Pilot Program used a receiver of satellite signals to identify whether a vehicle was in a specific geographic zone, identified by pre-determined coordinates, within a specific period of time but with no ability to identify specific travel routes. Under a closed technology platform, system designers feel compelled to choose one method over the other, of course with associated tradeoffs. Under an open platform, it may be possible to allow the most desirable features of both to emerge over time as technology and system use evolves.

The Ability to Create Zones

A mileage charging system that can isolate mileage driven within specifically identified geographic and temporal zones provides an extensive ability for application according to the particular characteristics of urban areas. Such a system must necessarily rely upon electronics.

[16] For example, in 2003, US automakers declared the electric car dead. Now that the world has changed in response to the fear of volatile fuel costs, the electric car will soon rise from the ashes of that declaration like a phoenix. Automakers now tell us of their plans for introduction of attractive all-electric vehicle models by the end of 2010 with mass marketing set for late 2012.

Indeed, for an easily useable and affordable application, the on-vehicle mileage-counting device must have an ability to identify the borders of a geographic zone according to times of day. This may mean use of a receiver that can access signals from the global positioning system but other location devices may also have viability in this respect.

The most basic electronic mileage charging system would consist of two zones: in-jurisdiction and out-of–jurisdiction. A legislative body would designate a mileage charging rate for the in-jurisdiction zone and a zero rate for the out-of-jurisdiction zone. Legislative bodies could allow creation of other zones for local jurisdiction charges or time-of-day congestion charges. Without isolating geography, any mileage charging system would necessarily be imprecise in that all mileage would be charged whether or not driven within the charging jurisdiction.

A state or local government certainly can develop and employ a simple mileage charging system based on *all mileage* generated by a motor vehicle, but charging all mileage treats motorists unfairly in that they would pay on mileage generated outside the levying jurisdiction. As such, the charge-all-mileage approach would not connect the charge directly to road use. Policymakers could not characterize the mileage charge as a direct user fee nor fair to all drivers. Therefore the new system would lose that positive attribute in the effort to win public acceptance.

For revenue generation at the national level, charging all mileage would have essentially no impact except for the limited circumstance of mileage driven in Canada and Mexico. Even so, policymakers may find it advisable to create a national mileage charging system that facilitates state adoption of mileage charges by integrating a state system upon the federal. A national system that charges all mileage without an ability to differentiate mileage by jurisdiction would presuppose state policy on the matter, something that may hamper state acceptance.

Further, the charge-all-mileage approach abandons the ability to create congestion pricing strategies specifically designed for the particular characteristics of urban areas and that are inexpensive to implement and operate. Metropolitan areas would be left with cordon congestion pricing schemes that are only effective for managing congestion in downtown core areas[17] that are expensive to implement and operate,[18] or pricing stand-alone facilities.

Finally, taxing all mileage would essentially eliminate the ability for city, county and other local jurisdictions to levy mileage-based charges because local governments could not establish local mileage charging districts. A local jurisdiction could theoretically levy a charge on all residents' mileage but garnering local political support for such a measure seems highly unlikely.[19]

The only realistic and fair way to provide local city and county option and the opportunity for effective congestion pricing in urban areas is through an ability to establish electronic zones. Some technologies and systems permit separation of local mileage from total mileage. Other systems can identify local areas, but cannot distinguish between Interstate highways, state highways, city streets and county roads. Still others can identify mileage by

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[17] See London and Stockholm.

[18] Operating costs for London's cordon pricing scheme consists of consume 49 percent of the charges paid. See Transport for London, *Central London Congestion Charging Impacts Monitoring*, sixth annual report, July 2008, Table 10.2.

[19] Some city and county governments currently charge the gas tax purchased within the jurisdiction but not elsewhere, even though the miles are driven out side the jurisdiction. Charging all mileage of residents, however, would expand the reach of the local government beyond a nexus with the local road network.

individual facility, but this capability raises the specter of vehicle tracking and invasion of privacy.

If policymakers on all levels of government want system options beyond simply generating revenue on the federal level, they must establish an electronically collected mileage-based system that affords mileage-based charging opportunities for all levels of government. Establishment of electronic zones provides those opportunities.

The Ability to Identify Specific Roadways

Through accessing a GIS map, GPS-navigation style receivers can identify vehicle locations more specifically than simply identifying a particular zone of travel. Rather, these on-vehicle units can identify specific roadways of travel, by distance and time. This creates more data for management than the zone-only approach but also requires more computing capacity and accordingly higher device cost. Alternatively, the on-vehicle device can supply the vehicle location information to a central server for application of the specific roadway identification and pricing information.

The ability to identify specific roadways through access of a GIS map may appeal to policymakers and system designers because such a system could allow designation of pricing for individual roadways. The zone-only approach has a limited ability to do that by creating small zones but not as robustly without involvement of a GIS map. It is highly doubtful that policymakers would want to price *each* roadway separately because of complexity and public acceptance unlikely. Nevertheless, the ability to identify specific roadways combined with zone creation ability could facilitate applications of congestion pricing that fit the individual characteristics of urban areas, essentially allowing for *designer congestion pricing.*

Evolution via Accessing Vehicle Characteristics

A mileage charging system that can connect with a database containing the characteristics of individual vehicles—perhaps a DMV database—has an ability to charge variable rates based on weight, engine size, drive train or fuel efficiency rating, among other factors. Thus, policymakers can develop mileage charging rate structures to accomplish policy goals beyond simply raising revenue, such as for greenhouse gas reduction. The authors discuss these possibilities in Chapter 3.

This ability to integrate mileage charging with the characteristics of vehicles will have political importance as well should legislative policymakers decide to apply mileage charging to replace the fuel tax. Replacing the fuel tax with any other revenue system will make winners and losers as the switch advantages one set of payers and disadvantages another set. The ability to charge vehicle owners varied mileage rates can help legislators design a rate structure that minimizes political strife.

BACKGROUND FOR CREATING AN EVOLUTIONARY SYSTEM

Researchers have heretofore identified two fundamental ways to create an electronic data transfer and collection system for a mileage-based charge. One involves a *central billing* system and the other involves *piggybacking* onto existing revenue payment systems. A central billing system for a mileage-based charge must be created from the ground up. The piggybacking approach, on the other hand, taps into payment systems already in place.

Both pathways have potential for creating a highly flexible system that can evolve with changing conditions and accommodate changing policies. Both approaches have features that make one preferable over the other. Policymakers and system designers should assess the strengths and weaknesses of each to design a system that is efficient, cost effective and suits the ever-changing nature of contemporary life. Ultimately a system combining elements from both may produce the best outcome. Later in this chapter the authors examine *an integrated approach.*

The Central Billing Approach

Under the central billing model, an on-vehicle device wirelessly sends electronically generated mileage data to a collection center for billing. The government mails, emails or otherwise sends a monthly bill to the motorist who pays the charge. As this model covers every type of vehicle operating on the road system no matter how it obtains energy, the search for new payment systems for emerging types of vehicles and payers would end. One system would fit all vehicles now and in the future and would only have to change with technology improvements. That's the allure of the central billing model.

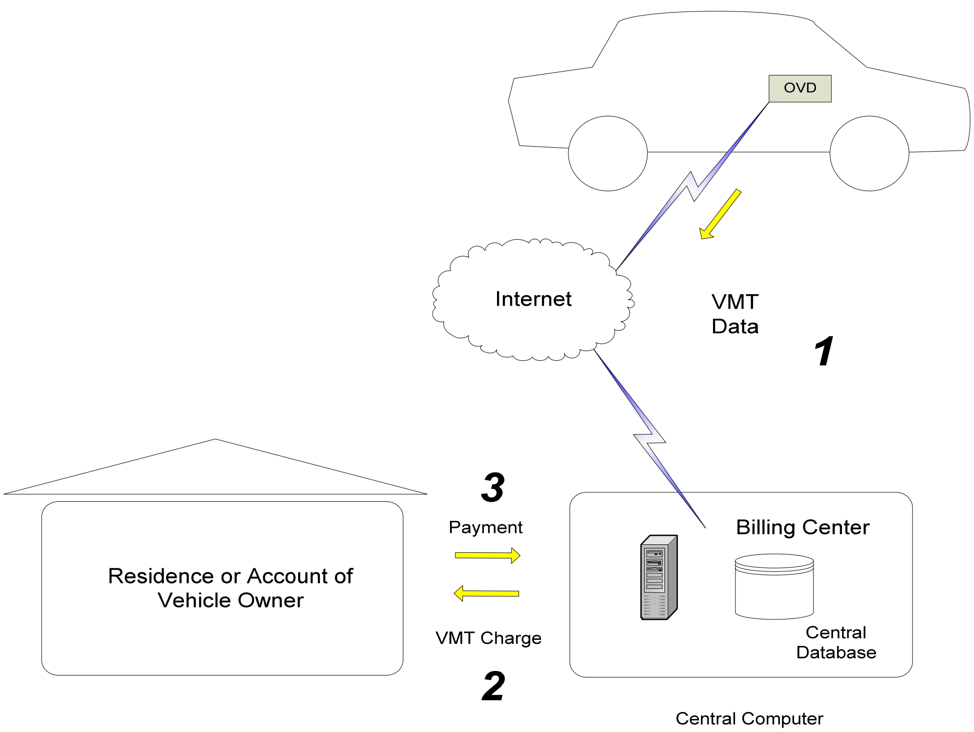

FIGURE 2-1 The central billing model.

The central billing model attracts interest because of its comprehensive nature. That characteristic alone is enough to retain status as a potentially viable option worthy of additional research. Even so, several difficulties inherent within the central billing model challenge its efficacy. They have to do with the enforcement challenges and the difficulty of compliance for some payers, as well as high operational costs under standard billing methods for a large percentage of the population.

Enforcing Payment

Some theorists opine that user fee payment under the monthly billing model could turn the road system into something akin to a public utility. The collection authority simply measures roadway usage by mile and sends a bill to the user for payment. This sounds appealing until one compares this model with how public utilities actually manage payment. With water, gas and electricity, a utility can enforce payment by the threat of turning off service. Since transportation agencies cannot shut off access to the road system,[20] the non-paying motorist has no direct and immediate incentive to pay the bill.

Without a direct and immediate consequence for nonpayment, the question emerges, "Why would a motorist receiving a mileage charge bill in the mail actually pay?" A significant percentage of motorists, in fact, would *not* pay the charge. Some have suggested that the government could enforce a penalty for nonpayment at registration of the vehicle every one or two years. While theoretically possible, this may not prove practical. A significant percentage of motorists today drive with expired tags, or move out-of-state before payment is due, and therefore would have an easy opportunity to evade the charge. Implementation of a national central billing system may eliminate payment dodging but integration with state registration systems may prove complex and somewhat difficult, adding to the cost of operations.

Faced with a significant mileage charge evasion problem, the government would have three options. Under option one, the revenue authority simply receives less revenue. Option two would shift the evaders' revenue burden to the payers. Under option three the revenue authority would engage in expensive and extensive civil collection actions to recover the evaded mileage charges. All three options seem unpalatable, especially when compared to the simplicity of the fuels tax collection mechanism. A motorist cannot buy gasoline without paying the gas tax.

In whatever way a revenue agency chooses to manage evasion, the cost of operations would grow much higher than for the gas tax. Moreover, employing the central billing model for mileage charges would increase the risk that a large percentage of those paying the gas tax today will avoid paying for road system use altogether.

The potential for an extraordinary number of tax evaders under the central billing model raises the *overall system risk* for this mode of mileage fee payment to a high level. Mandating a direct payment obligation for over 200 million motorists in this manner would require an extremely large and costly administrative and enforcement infrastructure to ensure payment equity among payers and sufficient revenue generation for the road system. An alternative strategy could reduce the administrative infrastructure and associated cost but increase the mileage fee rate accordingly to cover lost revenues from less effective auditing and enforcement

[20] It may be technologically possible to shut down use of a vehicle for nonpayment but enacting public policy allowing such enforcement activity seems highly doubtful in the United States.

practices, albeit with a cost increase and shift of the burden to honest paying motorists and no increased benefit to the road system.

Resolving the enforcement question becomes the principal question for acceptability of the central billing model. Options may emerge that could solve the nonpayment problem. For example, making the on-vehicle device attractive to motorists could mean they will not tamper with it for fear of losing access. Still, designing an on-vehicle device attractive to everyone seems exceedingly optimistic at this point. Technology applications may someday solve the nonpayment problem but until then, issues of payer fairness and enforcement cost will continue to hamper the acceptability of central billing.

Difficulty of Compliance for Some Payers

Cash payments become difficult and expensive some members of the public to manage under the central billing model. For members of the cash paying economy without access to a bank account or easy access to the Internet, regular payment of a mailed mileage charge billing adds a significant burden. While cash payers now easily pay the gas tax at the fueling station as part of their fuel bill,[21] paying a monthly billing requires traveling to the collection center or some other designated collection office or kiosk. Managing cash payments requires additional collection personnel thereby adding another layer of costs to administration. Other cash equivalent methods of payment such as cash cards may become viable options that could alleviate the added costs for administration.

High Operational Costs

In a 2002 analysis, researchers added up the cost of operating a centralized mileage charge billing system for Oregon, both as a government run and privately run system. The results were striking. Operating costs for central data processing and collection ranged from $50 million to $110 million annually.[22] Compared to the low operating costs for the gas tax—about $1 million annually in Oregon—centralized monthly billing would add administrative costs to collection of mileage charges by one or two orders of magnitude.[23]

A significant portion of the cost of operations in the 2002 analysis consisted of mailing expenses. While contemporary electronic payment methods may afford the opportunity to reduce overall mailing expenses, bill mailing will continue to be a large expense because of the many payers who do not have bank accounts or credit or, in fact, the ready availability of computers. Even among those able to pay electronically, some will prefer a paper billing to ensure accuracy or because of discomfort with technology. Further, the costs for collection of nonpayment claims will continue to be a large portion of the cost of operations for the central billing model.

Some policymakers dismiss the challenges for central billing, citing the effectiveness of all-electronic toll road collection systems. A high volume toll road may seem like a large

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[21] Actually, the gasoline distributor pays the gas tax in most states at the first point of distribution in the state. The retailer then reimburses the distributor at delivery and the motorist reimburses the fueling station retailer at fuel purchase.

[22] Whitty, *Road User Fee Task Force Report to the 72nd Oregon Legislative Assembly*, March 2003, p. X-1.

[23] Robert L. Bertini, Kerri Sullivan, Karen Karavanic, Hau Hagedorn and Dean Deeter, *Data Transmision Options for VMT Data and Fee Collection Centers (FHWA –OR-VP-03-06), (2002),* pp. 26-28.

business but compared to the size of an entire state road system or the national road system, they are mom and pop operations. Scaling up one high volume toll road's total operating costs to the size of a statewide or national road system leads to an enormous and costly administrative system that the citizenry would likely not accept. Further, because motorists choose to use toll roads, they accept the large administrative costs embedded within the tolls paid. The publicly owned road system does not have the luxury of imposing significant operating costs on motorists who have no choice on use.

Over time, the central billing model's challenges of enforcement, difficulty of use for cash payers and high operational costs may either be solved or lessened in intensity. Currently, however these challenges severely hamper acceptability for this model as a system under which *every* motorist must pay a minimum responsibility for the burden they place on the roadways. The central billing model should in no way be dismissed. Central billing may play a key role in a comprehensive mileage charge payment system. A purely electronic central billing and payment method may operate an optional payment system for those preferring electronic payment and this group may become predominant over time.

The Piggybacking Systems Approach

Piggybacking Arrangements

As an alternative to building a central billing system for mileage charges, policymakers should consider accessing tried-and-true revenue collection mechanisms currently in place. Piggybacking onto existing collection systems offers the potential to minimize capital costs, provide low operating costs and mimic the efficiency of the existing collection system. Integrating with an existing collection system also offers an already workable billing and payment system and access to existing payment methods, including cash, and familiarity to mileage charge payers.

Further, piggybacking mileage fee payment onto an existing revenue collection mechanism may well minimize overall system risk. There may be an opportunity in an integrated system to designate the existing revenue payment obligation as a proxy for a portion of the mileage fee. The new mileage-based charge system would also have access to existing refined enforcement and auditing systems that keep payment levels high and enforcement costs low.

Admittedly, piggybacking the new charge onto a tried-and-true revenue system would likely require tweaks of the existing system. System designers can minimize added expense if the existing collection mechanism relies upon a sophisticated computing system, as extensive modern collection systems generally do. The authors designed an arrangement for piggybacking the mileage charge onto the fuel tax collection system for motorists fueling up at commercial stations. The authors call this arrangement the *pay-at-the-pump model*.

Multiple Piggybacking Arrangements

While a piggybacking arrangement may offer low operating costs and user familiarity as positives, it will not necessarily cover all new types of vehicles. Currently, over 99 percent of all motor vehicles purchase fuel at commercial fueling stations. The pay-at-the-pump model will operate well for this group of vehicles for a long time. As the public moves to alternatively powered vehicles, other piggybacking arrangements will have to be found for them. A piggybacking arrangement may not be found until the refueling/recharging patterns for these newer vehicles become known. In the meantime, it will be necessary to employ an introductory mileage charge collection system (described below), temporarily employed for these new alternatively powered vehicles. Once a new vehicle type achieves critical mass, a specific collection system for that vehicle type can be identified, developed and deployed.

Oregon's Pay-at-the-Pump Model: A Mileage Charge Collection System for Passenger Vehicles Fueled at Commercial Stations

For a long time to come, substantial numbers of motorists will continue to operate vehicles obtaining fuel—whether liquid or gaseous—at commercial fueling stations. Despite the coming opportunities to purchase non-liquid or non-gaseous fueled vehicles, the capital costs for purchasing these new vehicles naturally discourage a swift and widespread changeover in the nature of the entire vehicle fleet. New vehicle types enter the marketplace slowly. Furthermore, just because a motorist purchases a new vehicle type does not mean the older car goes to the junkyard. The motorist either keeps the older vehicle for secondary use or sells it to the secondary market where other generally less affluent motorists look for functional vehicles at low capital cost.

Owing to the slow turnover of the vehicle fleet makeup, not only will motorists continue to operate liquid fuel vehicles, but liquid fuel vehicles will also comprise the predominant portion of the vehicle fleet for several decades to come. Acknowledging this, a specific mileage charge collection system for liquid fuel vehicles should integrate with the existing revenue collection for liquid fuel vehicles; in other words, piggyback onto the gas tax and use fuel tax systems. The advantages of piggybacking onto fuels tax collections include low capital and operating costs, providing a gas tax credit and, most importantly, familiarity for motorists likely to be hesitant about accepting an alternative road revenue system.

Description of Oregon's Pay-at-the-Pump System

The state of Oregon concluded a study in 2007 that tested the pay-at-the-pump model known as the Oregon Mileage Fee Concept.[24] In this study, both mileage data transfer and mileage charge collection occurred at the fuel pump.[25]

System designers of the Oregon's pay-at-the-pump system opted for an on-vehicle receiver that accesses signals from the US global positioning system (GPS) to delineate pre-defined zones.[26] This feature enables the on-vehicle device to locate itself while the vehicle moves about. The pilot program for this model tested mileage counting two ways, one by using the odometer to measure distance traveled within the zones and the other by using the GPS receiver for measuring distance.

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[24] James M. Whitty, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program: Final Report,* November 2007. http://www.oregon.gov/ODOT/HWY/RUFPP/ruftf_reports.shtml.

[25] Whitty, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program: Final Report*, November 2007, p. 9.

[26] Theoretically, existing GPS receivers provided currently by OEM suppliers could have been employed in the Oregon Road User Fee Pilot Test because the receiving technology is essentially the same. Nevertheless, whether the GPS receiver systems required for mileage charging systems access existing devices of similar nature from OEM suppliers or whether a stand alone device would be created for this purpose will largely be determined by the level of security required for the devices. Device security is part of the next round of technological investigation required for broad scale implementation of mileage charging in the USA.

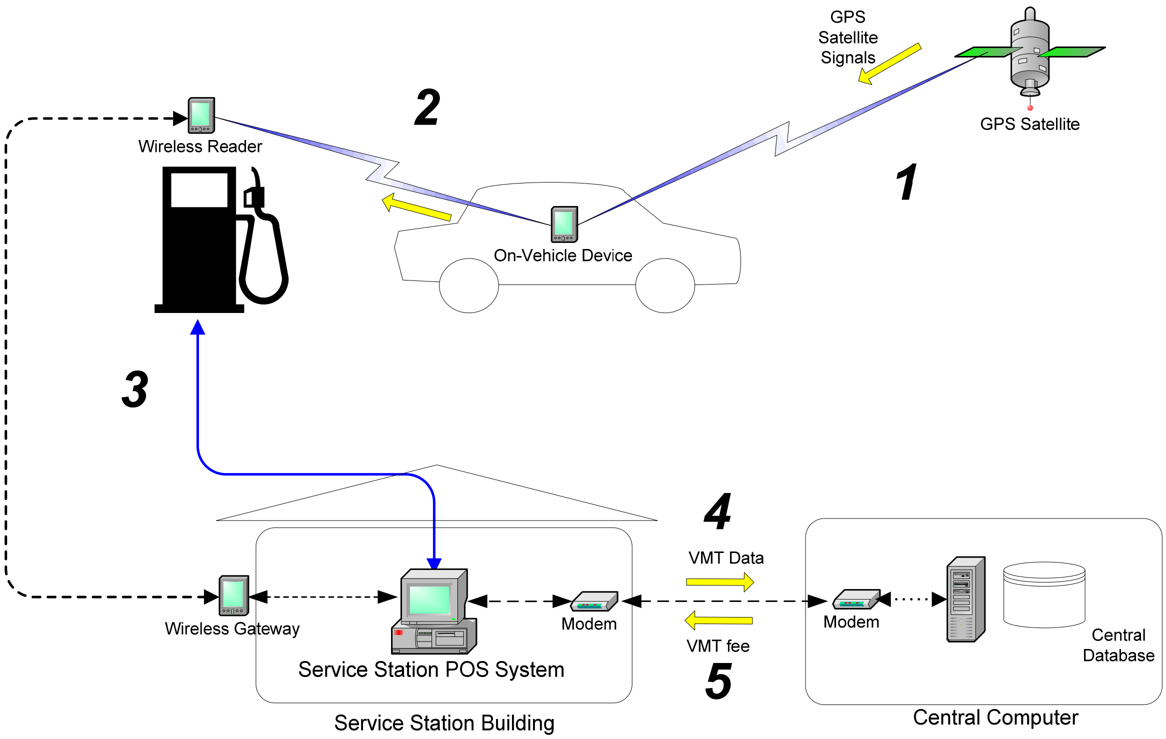

FIGURE 2-2 Pay-at-the-pump model.

During refueling an electronic reader at the fuel pump wirelessly reads the stored mileage data allocated to each zone via short-range radio frequency. The system then automatically uploads mileage data through the fueling station's point-of-sale system via digital subscriber line (DSL) to a revenue collection agency central computer for application of the mileage charge rates.[27] Once the rates are applied, the central computer sends the billing figures back to the fueling station via DSL line. The fueling station then bills the motoring consumer the mileage charges—and deducts the gas tax—along with payment for the fuel purchased. Motorists pay only for mileage driven within jurisdictional boundaries defined by the system. Non-equipped motorists pay the fuel tax.[28]

This pay-at-the-pump system treats part, or all, of the motorist's mileage charge as pre-paid by the gasoline distributor in the form of the distributor's gas tax payment to the revenue collection agency. After the consumer transaction, the fueling station retailer remits, via electronic payment, the differential between the total mileage charges paid by the consumer and the amount the fueling station reimbursed the distributor for the pre-paid gas tax, if greater. If the fueling station retailer collects less in total mileage charges than the amount of pre-paid gas taxes reimbursed to the distributor, the revenue collection agency pays the difference to the

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[27] In Oregon, the Oregon Department of Transportation is the revenue collection agency for fuel taxes and would likely be the state's collection agency for mileage charges.
[28] Heavy commercial trucks would not pay the mileage charge under the Oregon's pay-at-the-pump model because Oregon's weight-distance tax for heavy trucks would be retained. See below for a description of a concept to adapt Oregon's weight-distance tax for heavy trucks for electronic collection.

fueling station.[29] An electronic accounting mechanism manages payments of the mileage charge differential through a periodic reconciliation between the revenue collection agency and the service station retailer.[30]

If the fueling transaction involves a fuel other than gasoline and diesel, the fueling station remits the whole mileage charge received, less any allowable commission, to the revenue collection agency if this agency collects use fuel taxes directly at the fueling station level. If the use fuel distributor pre-pays use fuel taxes in a state that requires pre-payment, the payment system would operate in a manner similar to gasoline purchases.

The fueling station's transactions with the revenue collection agency minimize additional complexity and operating expense to fueling station operations. The Oregon pilot program tested the electronic payment system for determining and paying the differential between mileage charges and gas taxes to the revenue collection agency. This agency could manage payments to the fueling stations by automatic deposit. (The mileage charge payments embedded in use fuel transactions should operate much the same as for use fuel tax payments.) A fueling station could operate these systems simply and easily. The fueling stations could manage the capital costs for the new equipment and updating the stations' point-of-sale systems through a combination of government grant and loans and various tax credits and deductions.

Advantages of the Oregon Pay-at-the-Pump System

Oregon's pay-at-the-pump model successfully manages all the major requirements for a new revenue system identified in Chapter 1, including adherence to desirable tax policies. This model embeds mileage charge payments into an existing payment system for fuel purchases. As a result, the system can minimize operational costs[31] because of seamless integration of mileage charge payments into the existing gas tax collection system.[32] Additional auditing costs should

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[29] James M. Whitty and Betsy Imholt, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program: Report to the 73rd Oregon Legislative Assembly, June 2005,* pp. 35-39.

[30] A periodic reconciliation process—essentially a *truing up*—removes the burden of accounting for taxes and fees from the shoulders of employees at service stations, and instead accomplishes these tasks electronically. The truing up process requires the retailer to electronically submit the following information to account for the amount of revenue owed to the revenue collection agency or to be reimbursed to retailers by the revenue collection agency:

- Concurrent reporting of the amount of gallons of fuel purchased by customers at the station subject to mileage charges for a given period, and
- The amount of mileage charges paid by mileage charge payers during the same period.

The truing up method minimizes the involvement of retail station personnel because of reliance on real time electronic transfer of data. Service station attendants will not have to change their current behavior. The only additional burden will be for retail stations to manage either a periodic billing or a periodic reimbursement payment. Processing these transactions via electronic deposit should further mitigate any additional burden on the stations. The motoring customer experience no operational difference between paying a per-gallon charge and paying a per-mile charge, although regularly there will be slight per transaction differences in the payment amount if compared on a per-gallon equivalent.

[31] Whitty, *Road User Fee Task Force Report to the 72nd Oregon Legislative Assembly, March 2003*, p X-1. *http://www.oregon.gov/ODOT/HWY/RUFPP/ruftf_reports.shtml.*

[32] Whether the fueling station retailer receives compensation for executing a mileage charge collection transaction will be determined by a legislative body. If legislatively approved, the retailer's compensation rate should be fairly low because the fully automated pay-at-the-pump model does not involve new steps for filling station personnel, other than perhaps the bookkeeper.

only be slightly higher than for the gas tax.[33] The system can assure enforcement of mileage charge payments because access to fuel can be conditioned upon payment of the charge.

This system allows motorists to avoid paying the gas tax when paying the mileage charge, a critical requirement for a system designed to replace the gas tax. This approach also minimizes systemic risk in that the mileage charge payment system treats the bulk of the mileage charge as pre-paid by the distributors, a reliable taxpaying sector. Over time, the mileage charge differential paid by the retailer gradually gains predominance in the road revenue system.

Since the gas tax paid by the distributor acts as a surrogate for the bulk of the mileage charge, with the gasoline fueling stations only paying the mileage charge differential, the bulk of the mileage charge revenue system remains with stable fuel distributing businesses. The reliable gas tax payment system will only gradually be replaced by the mileage charge system. The long transition period allows (1) assessment of risk points and revenue leaks before mileage charge payments become the dominant portion of the revenue stream; (2) convenience to the private fuel distribution industry; and (3) appropriate compliance mechanisms to be developed for retail service station payments.

Retaining gas tax collection as the bulwark of the road revenue system will protect the new mileage charge system through application of the revenue collection agency auditing procedures and multi-state anti-evasion processes. Interstate anti-evasion processes for the mileage charge will develop over time as other states adopt and implement the mileage charge concept.

Continued payment of the gas tax at the first point of distribution—known as *the rack*—as the underlying mechanism supporting the mileage charge system provides system redundancy in the event of widespread system failure and technology tampering. In the event of extraordinary occurrences hampering the mileage charge system, the gas tax collection system will continue to operate without a hitch. The only revenue lost will be the differential between gas tax supported collection and the mileage charge payments made by retail service stations.

By paying mileage charges at the fuel pump, the motorist pays nearly contemporaneously with driving, generally no more than a few days removed for regular drivers. This offers potential for a near immediate price signal directly associated with driving. Paying a monthly billing, on the other hand, has less immediate and direct connection with driving behavior. Payment annually or with multi-year vehicle registration provides essentially no price signal that will impact driving behavior.

Most importantly, the motorist can easily use the pay-at-the-pump collection system for paying mileage charges. The motorist paying the mileage charge does something familiar, paying a charge with the fuel bill as before, either by cash, credit or debit. The only thing new for the motorist is the type of charge paid—the mileage charge.[34]

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[33] Whitty, *Road User Fee Task Force Report, 2003,* p Y-1 (Quintin Hess, *Cost of Auditing VMT Fee Collected at the Fuel Pump, October 8, 2002*); Oregon DOT Fuels Tax Group, *Cost Estimates of Oregon's Mileage Fee and Road User Fee Program with the Fuels Tax Group, January 20, 2009.*

[34] Oregon's Electronic Pay-At-The-Pump Mileage Charge Payment Process. The pay-at-the-pump model accommodates both mileage charge payers and non-mileage charge payers. When a transaction starts at a fuel pump, electronic readers automatically determine whether the vehicle at the pump contains the on-vehicle device associated with mileage fee collection. The process for completing fueling transactions and mileage charging, if applicable, occurs as follows:

1. Vehicle detection. When a fueling transaction begins, a central reader at the station detects the presence of vehicles equipped with the mileage charging technology. If no equipped vehicles are detected, the point-of-sale system charges the gas tax and no more actions are required.

Disadvantages of the Oregon Pay-at-the-Pump System

As a closed system, Oregon's version of paying the mileage charge at the fuel pump necessarily precludes other data applications and payment methods that may emerge in the future. This makes evolution of technology and adjustments for changes in consumer behavior rather difficult.

While the Oregon pilot program applied an on-vehicle device retrofitted into existing vehicles, the Oregon Mileage Fee Concept presumed working with automakers to develop and employ a *pre-market* device embedded into new vehicles. Dependence upon a pre-market device impedes this system in two ways. First, a pre-market device severely limits the ability to improve capability because it would be unworkable to replace every device deeply embedded into the mechanical workings of a multitude of vehicles. This limits system alterations for vehicle location, data flow, rate applications and payment methods.

The second impediment of requiring a pre-market device involves reliance upon the vehicle development processes of the automakers. System design for automobiles takes many years from concept through manufacturing. Assuming political resistance dissolves, reliance on the automakers' development processes will necessarily lengthen the timeline for ultimate adoption of mileage-based charging beyond an acceptable period.

Finally, the pay-at-the-pump model cannot evolve with every vehicle choice the motorists may make in the future. Piggybacking upon existing payment systems—public and private—may allow coverage of these new vehicles but there is no certainty that piggybacking will be an easy endeavor for every vehicle type.

Although the Oregon Mileage Fee Concept is a complete system that elegantly solves many system development issues, the closed system upon which it is based limits implementation viability in the short term and technological viability over the long term. System designers of a mileage-based charge paid with fuel purchase should investigate an open system

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2. Vehicle-to-pump association. If the central reader detects one or more equipped vehicles, the central reader instructs the wireless devices on each fuel pump to broadcast a message that can be detected by on-vehicle devices. The vehicle's on-vehicle device then communicates the signal strength of the broadcast message from each fuel pump device to the central reader. The software controlling the central reader uses the signal strength information to determine whether an equipped vehicle is adjacent to a fuel pump. If so, and if the fuel pump determined by the controlling software is where the transaction started, then the process continues with step 3. Otherwise, the point-of-sale system charges the gas tax and no more actions are required.
3. Read mileage data. The central reader reads mileage data from the on-vehicle device associated with the fuel pump where the transaction started. The software controlling the central reader passes this mileage information and on-vehicle device identification number to the fueling station's combined mileage charge/point-of-sale system.
4. Central database lookup. The system queries the central database, via a high-speed data connection, to determine the vehicle's last mileage reading for each zone.
5. Mileage fee calculation. The system extracts the mileage charging rates from the central database and applies them to the difference between the vehicle's last and current mileage readings to calculate the mileage fee. The mileage fee system passes the mileage fee amount to the point-of-sale system. The point-of-sale system deducts the gas tax from the fuel purchase.
6. Final receipt. The receipt presented to the motorist displays each amount involved in the mileage charge fueling transaction separately—fuel price (including gas tax), amount of gas tax deducted, and mileage charges.
7. Payment. When the point-of-sale system indicates completion of the transaction, the central database updates with the latest mileage reading, the amount of fuel purchased, and the total mileage charge assessed.

James M. Whitty, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program: Final Report*, November 2007, p. 9.

standards[35] and an open technology platform that accommodates an organic evolution of the system.

Introductory Mileage Charge Systems for Passenger Vehicles

A Temporary Collection System for Alternative Vehicles Not Fueling at Commercial Stations

As public anxiety grows with fuel prices—or even the prospect of higher fuel prices in the future—some people look for ways to become less dependent upon market forces. They seek, find and operate vehicles that can recharge or refuel at home or that can use fuel made at home or at a business. While these motorists may pay a vehicle registration fee, they pay nothing for road use since they do not pay fuel taxes.[36]

Imposing a mileage-based charge upon this power-at-home group would account for burdens their vehicles impose on the road system. Conceivably, operators of these vehicles would pay under the central billing system model. They certainly would not pay under the pay-at-the-pump model but system designers could conceivably develop a piggybacking arrangement for nearly all of them. Even so, the number of alternatively fueled vehicles, including the power-at-home group, starts out small and grows slowly.[37] It is neither cost effective nor sensible to design and develop a complex piggybacking arrangement onto an existing collection system for a vehicle type small in number.

As an alternative to designing a piggybacking arrangement for a vehicle class small in number, a collection authority might employ an introductory mileage-based charge collection system for any vehicle unable to participate in the primary collection system. At such time as the number of a particular group of alternative fuel vehicles begins to reach critical mass—perhaps one or two percent of the total vehicle fleet—then an optimal collection system for that type of vehicle could be designed, developed and employed, perhaps under an open technology platform.[38] An introductory mileage-based charge collection system would likely involve *payment at vehicle registration*.

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[35] By *open system standards* the authors mean a standard by which a standard body arrives at a mutually agreed upon and publicly available set of terms and criteria for technology that is part of a system. The authors intend that the availability and non-proprietary nature of the standards will provide the opportunity for competition in the marketplace.

[36]Some states have *use fuel taxes* that obligate even the fuel at home motorists to pay tax based on the BTU of the fuel used but many would be taxpayers are unaware of this tax payment requirement and therefore do not pay it.

[37] The rate of adoption for alternatively power vehicles can be inferred by the rate of adoption for hybrid-electric vehicles. In Oregon—often cited as the state with the highest adoption rate for hybrid electric vehicles—Oregonians registered 300 hybrid electric vehicles for operation in 1999, the first year of availability. Ten years later, approximately 30,000 hybrid electric vehicles are now registered in the state according to Oregon DMV's Vehicle Registration System. While a growing number, the total number of hybrid electric vehicles in Oregon still represents less than one percent of the statewide passenger vehicle fleet. Adoption of new vehicle types is slow relative to the total vehicle fleet.

[38] As of this writing, electric vehicles appear to be the likely dominant alternative vehicle type. Other vehicle types, however, could easily emerge, for example, home-fueled natural gas vehicles. It may be difficult for anyone to predict exactly which new vehicles will emerge or take hold in the marketplace.

Payment at Vehicle Registration

For this system, the motorist's mileage data would upload from the on-vehicle mileage-counting device at a wireless electronic reader at DMV. Alternatively, the motorist could rely upon data uploaded at another wireless electronic reader within a designated period prior to re-registration. The collection authority would impose the mileage-based charges to the transferred mileage data as a condition of re-registration of the vehicle. An introductory system would add administrative costs to the overall mileage charging system. The extent of the additional cost should be evaluated as part of the cost of the pay-at-the-pump model because the monthly billing model will likely not require an introductory system nor have to bear its additional cost.

Although feasible for small numbers of vehicles, payment-at-vehicle-registration is infeasible for broad scale implementation for three major reasons. One, payment-at-vehicle-re-registration will likely require a significant amount of human interaction with the payment system and therefore would be expensive operationally. A state DMV would necessarily require large numbers of new personnel to manage demand from hundreds of thousands of mileage charge payers monthly, resulting in potentially huge administrative costs. Two, public acceptance would likely be low—and evasion high—because of the sizable billing that would result from months or years of accumulating mileage charges. Three, the infrequency of re-registrations and the avoidance of re-registration by a significant number of motorists would negatively impact revenue levels to a substantial degree.

Collecting Mileage-Based Charges from Electric Vehicle Operators

In a couple of years, motorists in the United States will have the opportunity to purchase standard looking vehicles that will operate completely on electric batteries.[39] Obviously, these all-electric vehicles will not participate in the pay-at-the-pump method described above. System designers must develop another method for collecting mileage-based charges from operators of all-electric vehicles. As all-electric vehicles will likely not gain notable market share for many years, system designers can develop an introductory collection system with perhaps high per vehicle operating costs but small total operating costs because of the small number of vehicles involved.

The most intriguing question for electric vehicles of any kind is, "Where and how will electric vehicles get a recharge?" Plug-in electric vehicles may initially recharge at home or at the office. The coming fleet of all-electric vehicles, however, will not have long-range capability.[40] For mass adoption, all-electric vehicle operators will require ready availability of commercial stations for recharging—or possibly even switching—batteries, while away from residences or offices and in-between urban areas.

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[39] Though the authors have learned through discussion with automakers that availability of all-electric vehicles for mass marketing may begin in 2012, true battery-only electric automobiles—not neighborhood vehicles similar to golf carts nor motorcycles—should remain a relatively small proportion of the vehicle fleet through 2035. A PricewaterhouseCoopers Global Automotive Outlook Q4 2008 release forecasts battery-only-electric automobile production of 70,021 in 2015, compared to total automobile production of 84,378,203. It takes many years to ramp-up production, and it takes 20 years after that for turnover of the existing fleet.

[40] On various websites and in meetings with Oregon DOT, electric vehicle manufacturers estimate the range of new EVs for release in 2010 will approach 100 miles per charge.

Commercial Recharging Payment Option

Once a recharging network forms, the possibility will emerge for collecting a mileage-based charge at commercial recharging stations in a manner similar to the pay-at-the-pump model described above for liquid or gaseous fuel consuming vehicles. Owing to the fact that electric vehicles could recharge at home without going to a commercial station, payment-at-commercial-recharging stations alone will likely present an unreliable form of payment.

Electric Utility Meter Payment Option

Another collection option might involve uploading mileage charge data wirelessly through electric utility meters for billing via the monthly electric bill. Though electronic utility meters now operate in the marketplace, under this data collection method these smart meters would necessarily have data upload capability. It might be feasible for data upload to occur in the proximity of any electric meter or other manner under an open system platform. As part of the process, vehicle identification would direct the mileage charge to the proper account for billing. Thus, this mileage charging system would have the same operational advantages of fueling at the fuel pump—cost savings from tapping into an existing billing system and ease of use for the motorist who pays the electric bill as before but with the mileage charges added to the bill. Still, as a second piggybacking arrangement—pay-at-the-pump as the first—payment with the electric bill would add administrative costs to the overall mileage charging system. The extent of the additional cost is not yet known and should be evaluated.

Combination

Potentially, *any* mileage data reading from an electric vehicle could connect with the revenue collection agency central computer and database for application of the mileage charge rates. The billing amount would then electronically transmit to the local electric utility for inclusion in the monthly billing for electricity use. A system with multiple opportunities for uploading mileage data would guard against avoidance of payment of the mileage charge.

Pre-Payment Option

An alternative would involve pre-payment of mileage charges at the time of vehicle registration. Under this alternative, at registration of an electric vehicle, the vehicle owner would pay an additional mileage charge pre-payment for credit against future mileage-based charges. The system would address any imbalance at vehicle re-registration.

If the pre-paid amount does not cover the mileage-based charges incurred between registration and re-registration, then the vehicle owner would pay additional charges at re-registration. If the pre-paid amount exceeds the mileage charges incurred, then the system would credit the overage towards mileage charge pre-payment at vehicle re-registration. To keep administrative costs low, no refunds for unused mileage—other than credits during re-registration—should be allowed.

Most likely, DMV would collect mileage data during re-registration. This would involve the same kind of reader installed at fueling stations under the pay-at-the-pump method described above and the same kind of on-vehicle device used for liquid-fueled vehicles.

This electric vehicle pre-payment option would impact certain common DMV vehicle registration processes. For example, owners of electric vehicles could no longer re-register their vehicles by mail. Further, states with multi-year registration periods would end up charging huge prepayment charges at the time of registration. In order to keep charges manageable or to accommodate a national mileage charge, these states may change to an annual registration cycle for electric vehicles. Even so, pre-payment charges could still be quite large.

By definition, the pre-payment will be an estimated, average amount. A revenue collection agency should consider a number of factors in calculating this amount:

1. The range and charging issues for electric vehicles mean they will rarely be driven on long-distance trips. Until electric vehicle batteries allow longer travel distances, electric vehicles will have limited demand in rural areas.
2. For many years, electric vehicles will tend to be urban vehicles. At least in urban areas of less than one million people, electric vehicle travel distances should be short.
3. The short-distance nature of electric vehicle trips implies limited cross-state-border travel.
4. The urban nature of these vehicles means a greater likelihood of travel in congested places during congested times.
5. The rate level, whether mileage charges are flat replacements for fuel taxes, and whether environmental charges, congestion charges, local-option charges or other charges are imposed.

These factors indicate motorists will drive electric vehicles far fewer miles per year than traditional vehicles. Electric vehicle motorists will more likely drive these miles in urban areas during peak hours. A revenue collection agency cannot transform this information into annual pre-payment estimates until policymakers establish a rate structure and rate levels.

Plug-In Hybrid Electric Vehicles

Plug-in hybrid electric vehicles present a more difficult challenge. Plug-in hybrids may recharge at home or refuel at the pump or, perhaps more commonly, do both. By a little thought and disciplined behavior, some plug-in hybrid operators living near state borders could potentially dodge payment of state imposed mileage-based charges altogether. (Such avoidance for plug-in hybrids would likely prove impracticable, however, for a mileage-based charging system imposed on the national level.) As a revenue assurance measure, therefore, it may make strategic sense to require plug-in hybrid-owners to present a current mileage data reading as part of the vehicle re-registration process to prevent extensive avoidance.

All-Electric Heavy Vehicles

All-electric heavy vehicles intended for highway use do not appear practical for roadway use, particularly for typical Class 8 applications[41]. Even so, the mileage-based charging mechanism for heavy commercial vehicles will likely have ready application to all types of trucks.

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[41] Some electric heavy vehicles move containers on port grounds. Their range is quite limited.

THE INTEGRATED APPROACH: AN EVOLUTIONARY SYSTEM UNDER AN OPEN TECHNOLOGY PLATFORM

The optimum mileage-based charging collection system will likely have elements of both the *central billing approach* and *piggybacking approach* (otherwise known as the *pay-at-the-pump model* for commercially fueled vehicles). Since these two approaches both require connection with a central server/computer, system designers could integrate them.

System designers should not disregard aligning mileage charges with existing payment systems because they provide familiarity for payers and a reliable source of collection. The public tends not to favor being forced out of comfortable arrangements. In moving to a new road revenue system, familiarity may be a critical factor in achieving public acceptance. Accordingly, system designers could regard mileage charge payment with the fuel purchase as the primary payment option for liquid fueled vehicles, a least initially. Paying with the fuel purchase, however, may not be the only option available.

To allow the mileage charge system to evolve along with technology and human behavior, system designers might select an on-vehicle technology with an open system standard thus permitting new technology applications. This would allow organic development of vehicle locator options as well as data generation and data transfer technologies. An integrated system with such an open platform would also permit a flexible manner of payment.

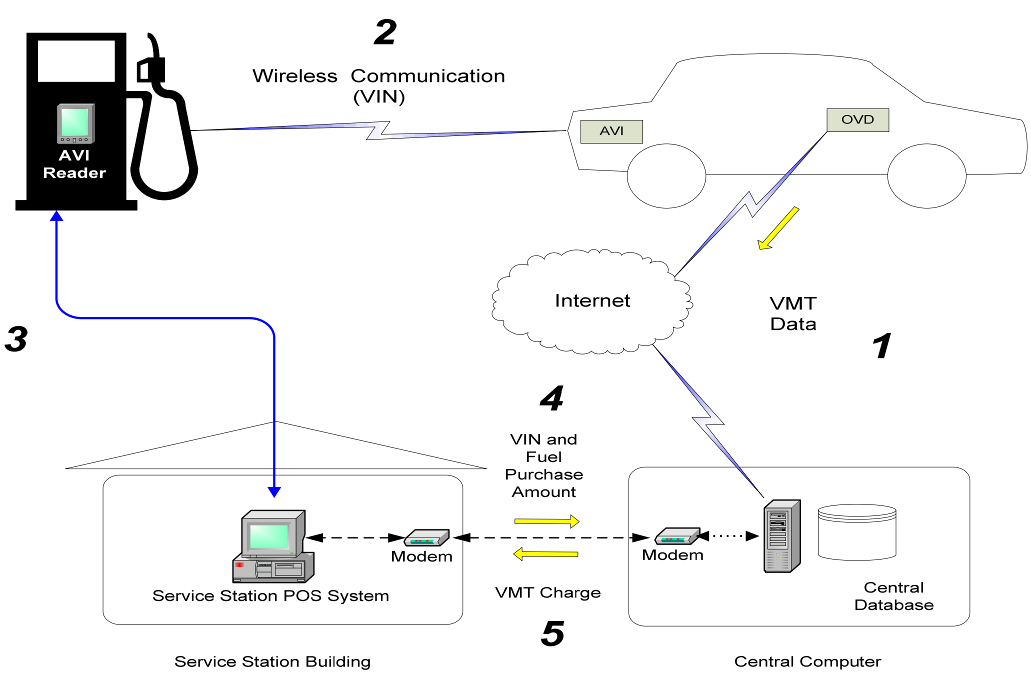

FIGURE 2-3 The integrated systems approach.

The integrated approach assumes a motorist would add on-vehicle mileage-counting equipment—an *after-market* device not manufactured into the vehicle—upon obtaining ownership. The mileage data would upload wirelessly from the on-vehicle device to a central server/computer via various transmission possibilities that meet open system standards. At the fuel pump, an electronic reader—similar to those operating at modern electronic toll roads—would identify the vehicle as a *mileage charge payer* by reading an automatic vehicle identification device (AVI) embedded within or attached to the vehicle. The system would transfer the vehicle identification plus the gallons purchased to the central computer to combine with the vehicle's mileage data since the last fueling. The central server/computer would apply the mileage charge rates and send the billing information back to the fueling station's point of sale system. The motorist would pay the mileage charge as part of the fuel purchase and the gas tax would be deducted. If the motorist had already paid the mileage charge through some sort of automatic electronic payment alternative, the system would not add the mileage charge to the motorist's fuel purchase amount but would deduct the gas tax.

By adopting an open platform, system designers would allow payment alternatives such as automatic electronic payment variations that will evolve over time. Payers should have the option of paying a traditional way—such as with fuel purchase—or another way, such as electronic payment. In this manner, the natural payment method will organically emerge and then change with human behavior and technology.

Retaining the point of collection at fuel purchase as one payment option will ensure payment by all motorists operating vehicles fueling at commercial stations. Rather than become the *only* option for payment, however, and therefore a *closed system*, payment with fuel purchase may, over time, become the fallback manner of payment as an alternative becomes available.

By permitting other payment options, the integrated system could operate more like a central billing system for vehicles not refueling or reenergizing at commercial fueling stations. If there are large numbers of a particular vehicle type, a piggybacking arrangement could be designed, developed and deployed as the principal manner of payment, or as the fallback payment method—if the central billing payment methods functioned well—to ensure each motorist with this class of vehicle pays the mileage charge obligation.

Advantages of the Integrated Approach

The integrated approach would have the advantages of both the central billing approach and the piggybacking approach (the pay-at-the-pump model for liquid fuel vehicles) while minimizing the disadvantages of each. It would offer a familiar traditional payment method to facilitate public acceptance and ensure a revenue flow but also offer availability to alternative fuel vehicles not fueling at commercial stations. The integrated approach would solve the *why should I pay?* problem for central billing because the motorist would have to pay the mileage charge either before or at the point of fuel purchase.

An open platform integrated approach could offer ease of use for motorists by offering multiple payment choices. It could offer various levels for protecting privacy to ensure individual needs are met. Such an open system could also reduce capital and operating costs and technological complexity at the service stations by allowing numerous options for the mileage data upload elsewhere.

The system would simply require service stations to install an AVI reader and a connection with the central server/computer. By relying on an after-market on-vehicle device, the system application timeline would not depend upon the automakers' lengthy vehicle development period.

Finally, with public acceptance as the top concern, an open platform integrated approach can allow accommodations for attracting the public, such as choice of on-vehicle device, with associated optional features, and various payment options. Many people willingly embrace change when they have choices they understand. If the open platform allows voluntary consumer oriented applications as they emerge, public regard for the new system may reach acceptance quickly.

AUTOMATED MILEAGE-BASED CHARGES FOR HEAVY TRUCKS

An Electronic Weight-Distance Tax

Though recently implemented in Germany, conceptualization of a system for electronically collected distance-based charges from heavy commercial vehicles has just begun in the United States. Given that only four states operate some version of a weight-distance tax, this is understandable.[42] Indeed, only the state of Oregon operates the weight-distance tax as the state's principal road tax mechanism imposed on the motor carrier industry.[43]

Designing a system for electronic generation of VMT data from heavy vehicles and providing for electronic collection of fees based on distance traveled at rates that vary according weight and axle configuration requires an underlying weight-distance tax. If the weight-distance tax bases the rates per axle/weight configuration on the cost allocated burden the vehicle places on the road system, then a government can impose a true user fee on the motor carrier industry.

The administrative costs for collecting a weight distance tax approximate those of a comparable diesel fuel taxation system from the perspective of the taxing authority. While Oregon's weight-distance tax allocates the tax burden between all classes of heavy trucks in a cost responsible way, the motor carrier industry laments that their administrative costs for collecting underlying data to report and pay the tax exceed what they might otherwise incur for a diesel fuel tax. Oregon DOT attributes this to the manual nature of compliance and reporting. Moving from manual reporting to electronic reporting in the form of an electronically collected mileage-based charge should significantly reduce the relative cost of compliance for the motor carrier industry. Government would garner additional benefits resulting from not having to deal with associated paper tax returns. An electronically collected charge would likely have the associated benefit of improving evasion rates because policing and auditing can become more effective.

Currently, under Oregon's weight-distance tax, operators of heavy vehicles manually keep track of the declared weight of each truck combination, number of axles and beginning and ending odometer readings. Monthly or quarterly, motor carriers complete and issue a mileage report calculating the weight-distance tax due and provide payment.

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[42] Oregon, Kentucky, New York and New Mexico.

[43] In this paper, the authors use the term "weight-distance taxes" generically to include every weight and distance tax systems for heavy trucks, including axle-weight distance taxes. We are not making a policy judgment when we use this generic term.

Under an initial demonstration of an electronic weight-distance charging system for heavy commercial trucks, operators would manually record in a small on-vehicle computer the declared weight[44], truck combination and number of axles at the start of each trip. After a successful demonstration project, a further deployment of such an automated system could eliminate even this manual in cab data entry requirement by instead using automated data capture technology that would automatically record weight and axle configuration data from equipment in the road bed. Manual recording of odometer readings would be a thing of the past. Instead, each truck would have a GPS receiver that counts mileage traveled within pre-identified electronic zones and assign actual routes of travel by overlaying truck movement over GIS maps. The necessity of motor carrier back office reporting staff would also fade away.

Electronic reporting would occur automatically at the end of each month when the mileage data, declared weights, number of axles and truck combinations upload wirelessly to a central repository. At the central billing center, the declared weights, truck combinations and number of axles would combine with the mileage data to characterize the nature of the miles driven. Particular configurations would have certain tax rates assigned just as for the current manual reporting weight-distance tax. A collection agency would use this information to generate a highway use tax billing. The carrier would choose whether to receive the billing statement by mail or manage payment online. Such a system would be strongly analogous to the model used by the telephone company. Nearly everyone has a phone in the residence. We use it as often as we like to make any number of local and long distance calls. We make no effort to track our minutes of use or whether or not we are making a toll call. The phone company simply sends us a bill at the end of the month for our metered use of the phone system. Highway use taxation can be managed in much the same way.

The practicalities of electronic collection of weight-distance taxes are apparent. Many trucking companies already use GPS devices and GPS-based fleet management products. Furthermore, motor carriers already record report miles traveled to comply with the requirements of the International Registration Plan and the International Fuel Tax Agreement.[45]

Electronic generation of weight-distance tax charges would minimize tax evasion. The systems employed facilitate enforcement and auditing. The system can incorporate automated checks of truck travel against weigh station records, making it easier for auditors to verify both road use and declared weights. Processing and compliance costs would lessen for motor carriers and paperwork would lessen for drivers. Accuracy and audit risk would also lessen.

The system components of an electronic weight-distance taxation system—mileage calculating software and billing systems—are deployable anywhere in the United States. States could redirect audit capabilities now used for fuel tax compliance to weight-distance tax compliance. This system should prove most effective in states with good size and weight enforcement programs and the capacity to weigh trucks and keep weigh station records for audit purposes.

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[44] Weigh station records, including weigh-in-motion records, would be centered in another repository that would feed into and draw from the central repository to allow for automated and manual auditing of the information flowing from heavy trucks.

[45] The envisioned system would collect route-specific information about trucks but this would not risk public disclosure of sensitive business information because that information may not be considered a public record, depending upon the state public records law. Under Oregon law public records law, this information would be protected from disclosure.

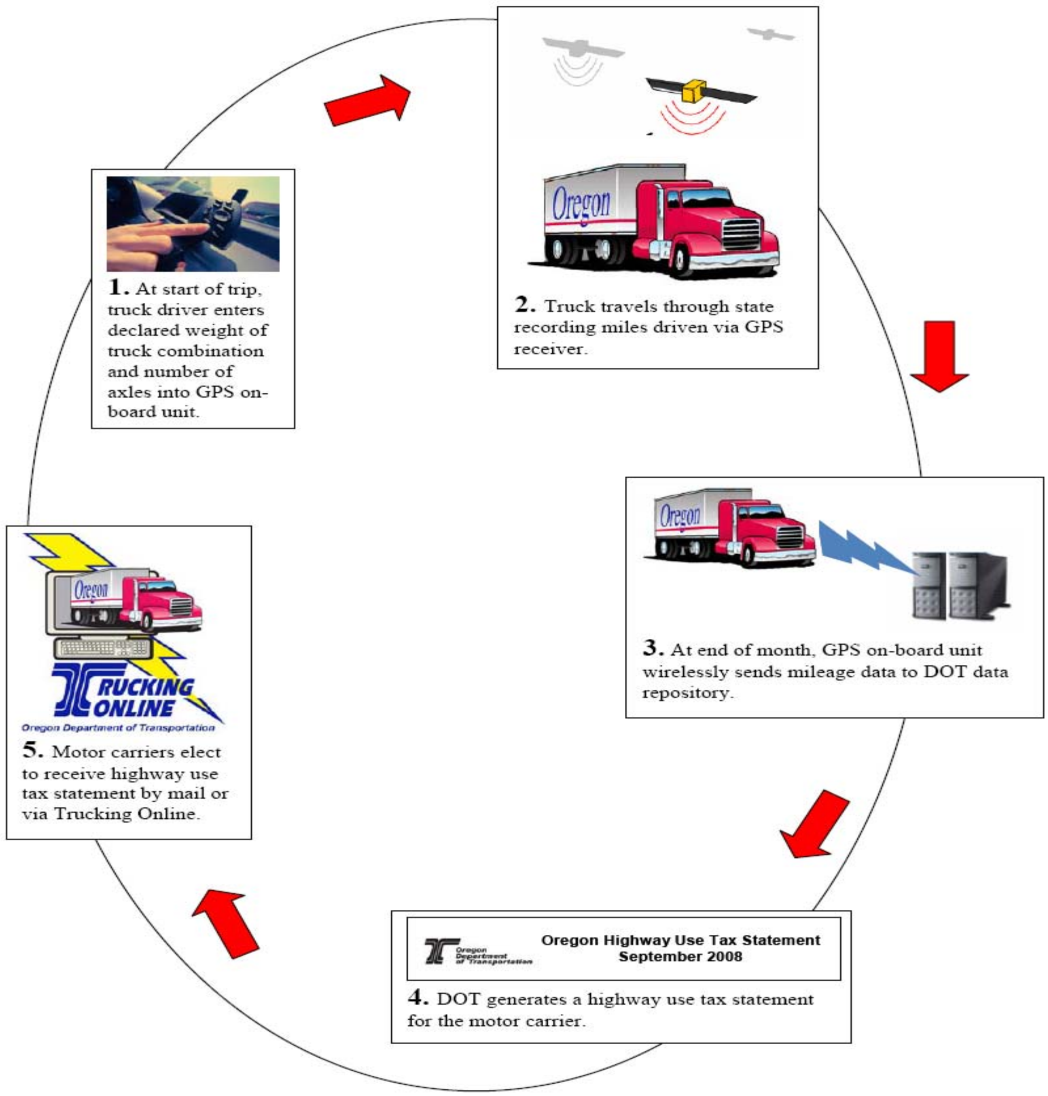

FIGURE 2-4 Electronic weight-distance tax for heavy commercial vehicles.

A national system may prove the most efficient way to transition from diesel taxes to automated weight-distance taxes across the United States. Implementation nationally would occur from scratch ensuring a common approach for the commercial trucking industry rather than a potentially fragmented state-by-state approach.

CONGESTION PRICING

Contemporary tolling systems and time-of-day congestion pricing ought to adapt easily to any of the electronic mileage-based charge approaches. Urban governments could employ any of these models to accomplish all common electronic toll payment applications, including distance tolling for specific highways, point tolling of on-ramps to limited access highways or cordon pricing (entry pricing into pre-defined geographic zones). After completing the transition to an electronic mileage-charging model, existing electronic tolling or congestion pricing systems would no longer require a separate enforcement system. Further, these models would accommodate *area pricing* where vehicles pay a higher per-mile rate for driving within a designated zone during peak period congestion.

The combination of an ability to combine area pricing with peak period pricing of specific roadways or on-ramps opens up the possibility of *designer congestion pricing* applications suitable for the unique characteristics of urban areas in the United States.

As a practical matter, until mileage counting devices are equipped in every vehicle, congestion pricing applications would likely include a combination of the mileage charging collection system and the more traditional toll collection systems currently employed. The full system advantages of an electronic mileage charging system would not become apparent until every vehicle were required to be equipped with the on-vehicle mileage counting equipment.

Dynamic Pricing

Some applications of congestion pricing for management of traffic levels involve immediate rate changes in response to traffic conditions. The pay-at-the-pump model can accommodate such dynamic pricing should that option prove desirable for a given facility or area. While reliance on GPS-receivers to create geographic zones does not facilitate immediate price changes for specific facilities, if a government added roadside message boards to the technology configuration, a government could theoretically employ dynamic pricing under the pay-at-the-pump method. Such a system could electronically forward specific traffic volume data to the ODOT central computer for immediate updating of the rate table for a given zone or a single facility. At the instant the government updates the rate table, the government would post the new price for entering the specific zone or facility on a roadside message board near the entry point and on-line. Thus, the motorist would obtain the transparency required to make an individual travel decision in advance. The system would apply the new rates for the applicable period for the given zone or facility at the next fuel purchase.

The dynamic pricing application to the pay-at-the-pump technology configuration would involve greater active charge collection involvement by service stations and require more sophisticated on-board devices than necessary for simple per-mile charge applications. Alternatively, a gantry system connected to the collection agency central computer could accomplish the same result.

A transportation agency can apply a dynamic pricing system under the pay-at-the-pump model to individual facilities but doing so may compromise public acceptance. Definite time-of-day pricing applications for specific zones or facilities create precise location data on motorist travel. At current levels of public sensitivity on the privacy issue, the ability to create precise location detail may impinge upon public preference, at least if broadly applied across the system.

Deferring Payment

Using the pay-at-the-pump model for payment of congestion pricing charges may reveal systemic difficulties. If a cash-based motorist driving a family vehicle, for example, finds a surprisingly larger charge than anticipated while refueling because others drove the vehicle during peak charging periods, the consumer may have difficulty paying the amount due. Under these circumstances, charges in excess of basic per-mile charges ought to be deferrable to a mailed billing with, of course, associated handling charges for taking that opportunity. Under an integrated approach, a motorist could pre-pay these excess charges in another manner.

MANAGEMENT OF IMPLEMENTATION

In order to implement an electronically collected mileage charge system, the authors make the following observations.

Privacy Protection

Protection of privacy is perhaps the most critical public acceptance factor to resolve prior to implementation of a mileage-based charging collection system.[46] The privacy issue appears to have more importance for owners of passenger vehicles than for owners of commercial vehicles. Truckers surrender a certain amount of privacy merely by operating in a regulated industry, although it would be inaccurate to say that privacy has no relevance to commercial vehicle operators.

An electronic mileage charging system can completely protect privacy or wholly undermine privacy, depending upon system design, as described in Chapter 1. The policies a legislative body adopts for protecting privacy will largely determine the ability of the system to protect privacy.

Privacy goals may be met in a variety of ways. Proponents of modern cryptographic methods claim it possible to design a system to protect privacy while simultaneously enabling auditing, enforcement, and allowing the consumer to challenge a billing. Apparently, these methods can also help detect tampering with an on-vehicle device, reducing the need to make on-vehicle devices extremely tamper-proof.

In the Oregon Road User Fee Pilot Program, the authors researched a collection system that provided the maximum privacy protection for motorists within the context of audit-ability. At this level of protected privacy, the system did not require transmission of vehicle travel locations, either in *real time* or of travel history. Accordingly, it was unnecessary to store travel location points within the on-vehicle device nor transmit them elsewhere. A system involving technology unable to do these things means it would be impossible for anyone to *track* vehicle movements because the on-vehicle hardware could not function that way.[47] Depending upon public attitudes regarding encryption of mileage data, non-generation of precise travel data may be necessary for public acceptance over the course of the next decade or longer. At some point, perhaps soon, the public may accept encrypted data once they understand that cryptographic technology can preserve the privacy of precise travel data.

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[46] Not all researchers agree on the need for privacy protection of mileage data. This is why some research efforts have not included privacy protection as fundamental to their studies.

[47] The Oregon Road User Fee Pilot Program employed a *passive* receiver that could locate itself by accessing signals from satellites but was unable to transmit a signal outward for anyone to access for purposes of following the on-vehicle device as it travels. The designers eliminated from the hardware the possibility of a strong signal outward from the on-vehicle device in order to protect location privacy. The designers also eliminated the device's ability to generate a travel history. For most participating vehicles, the odometer counted the miles within pre-established zones identified by latitude and longitude coordinates. For another small group of participating vehicles, the satellite signal receiving device counted the miles.

Miles related data transfer would occur by secure wireless communication at the time of fueling. Pilot programs in the United States have tested several methods to do this, including use of commercial cellular systems and various other wireless technologies.

As a further protection, a legislative body could develop legal safeguards to prevent anyone other than the vehicle owner/operator from knowing the vehicle's movements without the vehicle owner/operator's consent.

Under a system designed to protect privacy to high level, there would be no need for a collection agency to get involved in developing, installing, maintaining or having any access to the on-vehicle devices except, perhaps, to investigate potential tampering in an effort to evade the mileage charge.

Enforcement and Auditing

A mileage-base charge collection system must have an ability to enforce mileage charge payments for obligated payers. For passenger vehicles, the obligation for payment at the pump allows enforcement activities similar to those for the gas tax. Refusal to pay the mileage charge assessment at the pump would render the motorist unable to obtain fuel. If a motorist finds a way to successfully thwart transfer of mileage data, the system would identify the motorist as a payer of fuel taxes with perhaps only marginal benefit but with the added risk of criminal prosecution.

To facilitate auditing of transactions for enforcement purposes and consumer challenge of billing assessments, the collection agency would acquire certain data at the time of fueling. The collection agency would learn the identity of the vehicle at the fuel pump, the amount of fuel purchased and the fueling station. Combined with the total miles driven in each zone, this limited amount of information enables a collection agency to search for anomalies in charge paying patterns for purposes of auditing.

The ability to audit becomes more difficult under the introductory system because a collection agency would not receive information on fuel purchase amounts. Payment under an electronic weight-distance tax, however, may actually facilitate more accurate auditing than for the existing weight-distance tax systems.

Enforcement may become even easier with additional technology research. By embedding a tamper detection system within the on-vehicle technology and/or the cryptographic protocols, the system may be able to notify the collection agency of tampering with the on-vehicle equipment.

Phasing Transition to Full Implementation

Achieving full implementation of a mileage-based charge collection system—meaning every licensed vehicle participates—might take many years if the necessary on-vehicle technology must be manufactured into new vehicles, essentially a *pre-market* application. If the motorist adds the on-vehicle equipment upon obtaining ownership of the vehicle—an *after-market* device—then full implementation may take much less time.

Mandating retrofitting older vehicles with pre-market on-vehicle devices can be problematic. Vehicles do not yet come with standardized ports or powering systems, making plug-and-play devices difficult to deploy. Even if older vehicles could accept a retrofit on-vehicle device, the integrity of the device might be jeopardized because it would likely be readily accessible to *tinkerers.*

Mandating retrofitting of pre-market on-vehicle devices would also present the challenge of obtaining the cooperation of every vehicle owner. Even if widespread acceptance of the system prevailed, a minority of the motoring population will always resist giving someone access to their vehicle to attach a government required gadget to it. Retrofitting also adds installation costs to on-vehicle device deployment, indeed a challenge to public acceptance.

Under an open technology platform, after-market devices chosen by motorists would be desirable and therefore unlikely to involve widespread tampering because device removal or tampering may well involve system interruption for desired service and products provided by the device. Indeed, an operable tamper detection system embedded within the on-vehicle device, and/or with cryptographic protocols, should discourage all but an emboldened few motorists to undertake the risk of tampering.

Under either a pre-market or after-market on-vehicle device application, completing implementation may take longer than a decade. Pre-market installations only in new vehicles may 20 years or more, as long as it takes for the entire passenger vehicle fleet to turn over. Post-market applications may take considerably less time to reach full penetration—perhaps seven to ten years—provided the device applications become desirable enough to *attract* motorists. Otherwise, after-market applications will take as long as pre-market installations.

During a long transition, two basic road revenue systems for passenger vehicles would operate at the same time, one for payers of gas taxes and the other for payers of mileage charges. A basic mileage charge would apply to new, fully equipped vehicles or—if mileage charging begins on a state-by-state rather than national basis—newly registered vehicles entering a state for the first time that have the capability for either manufacture or post-manufacture application of the necessary technology.

During transition, the system must accommodate payers of both the gas tax and mileage charge, and perhaps beyond for anything but a national adoption because out-of-state vehicles may not contain the necessary technology when fueling in a mileage charging state. Consequentially, older vehicle operators and out-of-state visiting vehicle operators would continue to pay the state fuel tax until the vehicles were retired from use or until retrofitting becomes practical. Notwithstanding a future opportunity for full application of mileage charging technology within all licensed vehicles, it makes policy sense to maintain integration with the gas tax collection system to guard against equipment tampering and provide system redundancy.

RATE STRUCTURING UNDER AN EVOLUTIONARY SYSTEM

With adoption of technology applications capable of creating numerous geographic and temporal zones and connecting with databases that house the characteristics of individual motor vehicles, the mileage-based charge rate structure can evolve as public policy requirements evolve. The various possibilities for rate structuring under such an evolutionary system are nearly unlimited. Some basic options that illuminate the possibilities for rate structuring are outlined in Chapter 3.

3

Rate Structuring Under an Evolutionary System

Setting a rate structure for mileage charging presents political challenges as critical as the initial policy decision to move forward with mileage-based charging. The issues involved include the following.

1. The rate level for particular vehicles,
2. The rate level for particular behavior,
3. Transparency for calculation of the rates, and
4. How well the rates and revenue generated satisfy program goals.

Failure to carefully consider the political realities of these issues and adjust accordingly could easily reverse a decision to move forward with mileage charging.

RATE STRUCTURING OPTIONS

At the simplest level, a basic mileage charging rate can be flat, and most people assume a flat rate when first introduced to the concept. A flat rate, however, is not a fundamental characteristic of per-mile charges. Policymakers can establish a rate structure as something other than flat, stack other rates on top of a flat rate or apply a multiplier to a flat base rate, among other possibilities.

System designers can devise an electronically collected per-mile charging system flexible enough to allow rate structures that can accomplish numerous public policies. Such a system would not only raise revenue for the road system but also grant states and local jurisdictions the option of grafting onto the system. Additionally, policymakers can structure a charging rate to achieve free flow traffic conditions through peak period pricing. The rate structure can also take into account externalities such as greenhouse gas emissions.

A flexible electronically collected mileage charging system offers essentially a blank slate upon which a society through its legislative body can pursue whatever outcomes it prefers. The ultimate rate structure, therefore, will result from a legislative body considering various public policies and blending them to accomplish several goals.

A Flat Basic Rate

Some people object to a flat rate. Three arguments lie beneath their objection.

Vehicle Weight

One argument declares that operators of the heaviest passenger vehicles should pay higher mileage charges because heavy vehicles do the most damage to the pavement. Considering all vehicle classes, including the heaviest trucks, it is true that the heaviest passenger vehicles do the most damage to the entire roadway. When viewed from the standpoint of cost recovery, however, the actual damage caused by all passenger vehicle classes has minimal variance with no difference at all to the underlying road infrastructure, the most expensive part of a roadway to repair.

Heavy commercial vehicles cause the most significant damage to the roadways, the largest weighing an order of magnitude greater than the heaviest passenger vehicle. The weight of passenger vehicles of any size has minimal impact upon roadway depreciation. Passenger vehicles affect highway costs primarily by the shear number of miles motorists drive upon them. Passenger vehicles as a group demand a highway system with large capacity. Without sufficient roadway capacity, passenger vehicles can create significant traffic congestion.[48]

Impact On Vehicle Choice

The second argument against a flat rate assumes that people consider the fee and tax cost in choosing whether to buy a fuel-efficient vehicle. Proponents of this argument say shifting from a fuel tax to a flat rate mileage charge removes the incentive for motorists owning gas guzzling vehicles to trade up to fuel-efficient vehicles. Looking at this issue solely from the perspective of environmental motivation, this point has validity. Looking at the issue from only the

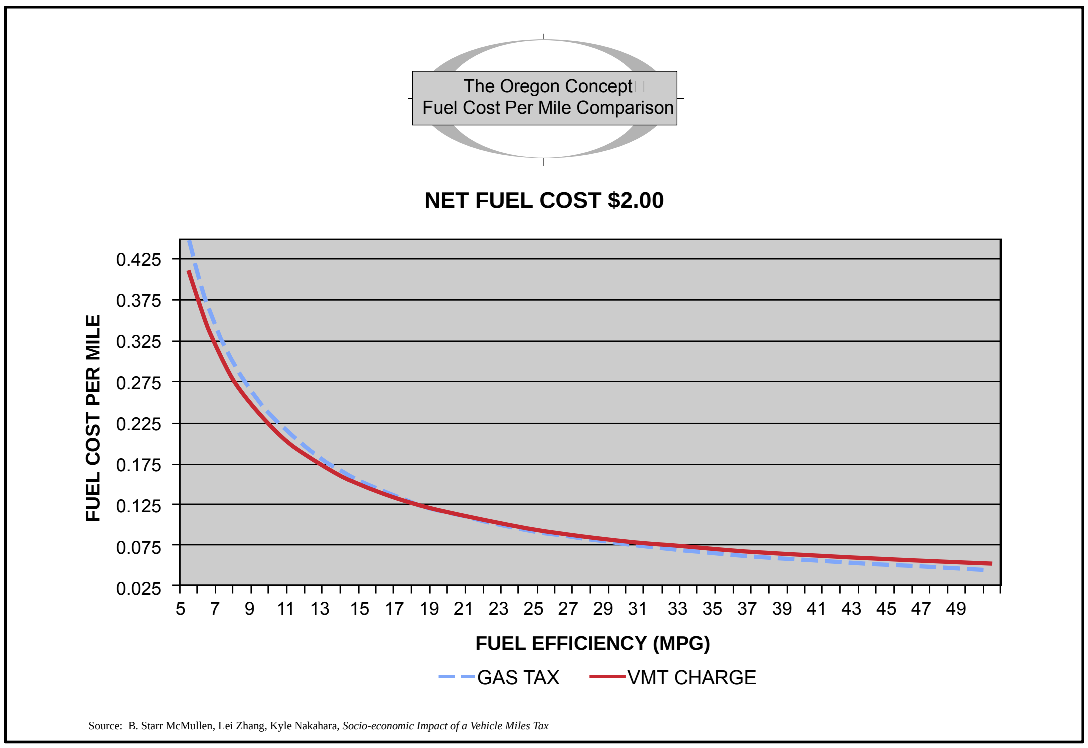

FIGURE 3-1

[48] John Merriss, *Increasing Light Vehicle Weights and Cost Responsibility, Policy Notes, Oregon Department of Transportation, Policy Unit, 2004*, p.2.

perspective of economic motivation, however, alters one's conclusion. Road charges imposed on vehicles—whether fuel taxes or mileage charges—consist of only a small portion of total operating fuel costs for passenger vehicles. Research reveals that a flat mileage charge rate would have only a slight impact on vehicle choices based on the cost per mile driven.[49]

Owing to the fact that current fuel taxes are a small percentage of total fuel cost per mile, the impact of shifting to a mileage-based charge should be minor. As the above graph indicates and the OSU research study concludes, "Vehicle choice and usage will depend on overall gas prices,"[50] rather than the amount of taxes or fees embedded in the price, at least at current levels of taxation. People buy vehicles for greater fuel efficiency primarily because of fuel cost, not government imposed charges.

Accommodation of Non-Road Policies

The third argument against a flat rate presents other policy considerations in determining the appropriate mileage charge rate structure, such as greenhouse gas reduction, energy independence and traffic demand management. Considering only roadway needs, however, the flat rate seems reasonable because every passenger vehicle makes similar demands upon entering the road system. A legislative body desiring application of other public policies may seek more complex rate structures.

Winners and Losers Under a Flat Rate Structure

Notwithstanding the three opposition arguments to a flat rate, many motorists may simply object to who will win and who will lose when compared to payment obligations under the existing gas tax. Figure 3-2 demonstrates that under a flat rate the winners are motorists driving less fuel efficient vehicles and the losers are those driving more fuel efficient vehicles. A large number of motorists instinctively regard such a rate structure as unfair, notwithstanding the class of vehicle they drive.

Alternative Rate Structures

An appropriately tailored mileage charging system can accommodate additional policy considerations into a rate structure because such a system can identify not only numerous geographic and temporal zones but also the particular characteristics of each vehicle traveling along the roadway. Among the public policy goals for consideration include controlling greenhouse gas emissions, air quality control, energy use efficiency, congestion management, land use planning, and, of course, fairness in paying for road capacity expansion. Whether a legislative body adopts a flat charge rate or a structured rate relates to the policies considered at the time. Depending on the nature of the technology and collection system chosen, a legislative body can continually revise the rate structure to accomplish other public policy goals as circumstances warrant.

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[49] McMullen and Zhang, *Techniques for Assessing the Social-Economic Impact of a Vehicle Mileage Fees: Final Report, June 2008, pp. 7-8.*

[50] McMullen and Zhang, *Techniques for Assessing the Social-Economic Impact of a Vehicle Mileage Fees: Final Report, June 2008,* p. 6.

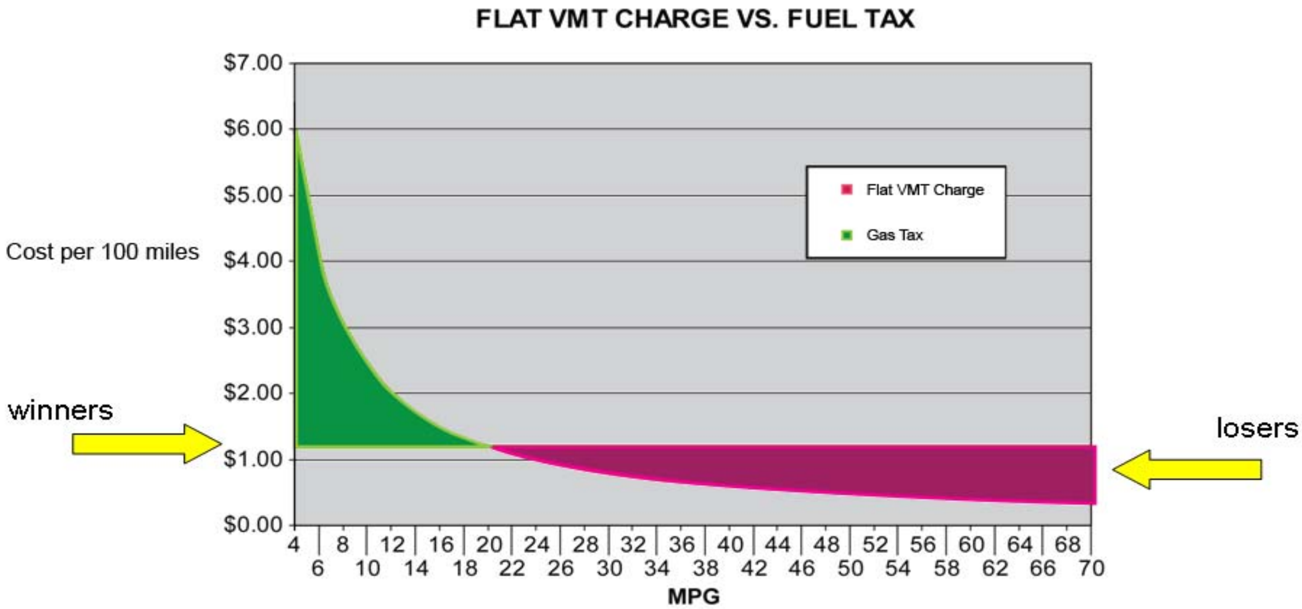

FIGURE 3-2

Congestion Pricing

To encourage free flow road conditions on busy roadways, a policymaking body could employ different time-of-day rate structures to discourage travel during certain peak periods. Policymakers might employ numerous congestion pricing strategies under the electronic mileage charging platforms identified in Chapter 2. These include distance tolling of specific highways, point tolling of on-ramps to limited access highways or entry pricing into pre-defined geographic zones—known as *cordon pricing*—all without the need for a photographic enforcement system or separate transponders. These electronic platforms also accommodate *area pricing* under which vehicles pay a higher per-mile rate for driving within a designated congestion zone during periods of high congestion.

The electronic mileage charging platforms identified in Chapter 2 can adapt as public attitudes and objectives change to allow comprehensive congestion pricing strategies that have the ability to meet the unique, urban travel needs of metropolitan areas. Such an electronic platform might, for example, facilitate a *road mileage allowance,* essentially a limit on mileage driven in urban areas beyond which a penalty would be imposed.

Environmental Charging

Since the electronics-based mileage charging platforms described in Chapter 2 can identify the individual characteristics of vehicles, policymakers could structure rates to advantage use of certain vehicle models while disadvantaging use of other models, perhaps on a greenhouse gas emissions basis. Depending upon the rate structure adopted, the addition of an environmental charge to a mileage charge could range from quite simple to much more complex than a congestion pricing application.

An environmental charging structure may either charge all vehicles by the amount of emissions specific to each vehicle or by fuel type, or perhaps some combination. Presumably, policymakers would intend environmental charges to change consumer behavior in some way—for example, less VMT or greater fuel economy—and by some amount. Effectiveness at changing consumer behavior, complexity, revenue generation, and public acceptance will affect whether and precisely how to implement an environmental charge.[51]

A flat rate per-mile charge may have only a small affect on reducing greenhouse gas emissions because the system charges the motorist based on distance but not on fuel efficiency. Vehicles driven during peak period congestion emit quantities of extra greenhouse gases beyond amounts they would emit under free flow conditions. Combining congestion pricing with varied rates based on greenhouse gas emissions may allow for creation of an effective overall strategy to reduce greenhouse gases from the passenger vehicle sector. Motorists would pay additional cost not only for driving generally fuel inefficient vehicles but also for driving these vehicles during peak periods of congestion.

Application of environmental charges could take many forms. Among the variations are stacking a second rate on top of a flat base rate, applying a multiplier rate against a flat base rate or retention of the fuel tax only for gas guzzling vehicles. Others may conceive of additional rate structure variations for consideration. Rate structure alterations may have application not only to environmental policy goals but perhaps other public policy goals as well.

Heavy and light vehicles are quite different by their nature and purpose and political dynamics. Any environmental charges imposed will likely differ between the two groups.

A Stacked Rate

Policymakers may consider several rate structure alternatives to the flat rate for encouraging various public policies. One alternative involves stacking another rate on top of the flat rate to allow rate variability. For example, policymakers may apply a fuel inefficiency penalty to high fuel consuming vehicles in addition to the flat mileage charge rate. The structure could be built on top of a flat basic rate charged the more fuel-efficient vehicles. Figure 3-3 illustrates this graphically.

An Externality Multiplier

A second structural variation would rate each vehicle for its impact on external environmental factors. Those vehicles with the least impact could be assigned a multiplier of 1.0 and those with the greatest impact a multiplier of perhaps 6.0. When the rates for each zone are applied for mileage charge payment, a motorist's multiplier would be applied against the base rate for that zone to determine payment. Vehicles with greater impact on external factors would pay more and those with less impact would pay less. Figure 3-4 illustrates this graphically.

The multiplier could apply to all base rates, including local jurisdiction charges and congestion pricing. While Figure 3-4 applies the externality multiplier based on a fuel efficiency

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[51] A Resources for the Future discussion paper, *Marginal Social Cost Pricing on a Transportation Network: A Comparison of Second Best Policies*, 2007, begins to address these issues.

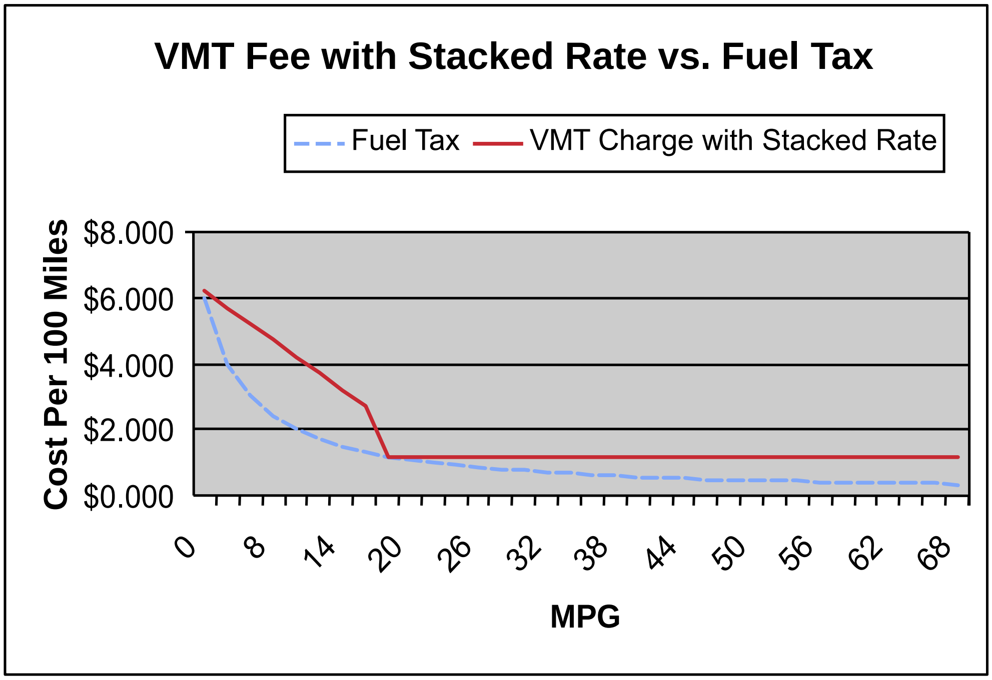

FIGURE 3-3

MPG	*Multiplier*
42+	*1.0*
34	*1.2*
26	*1.5*
22	*2.0*
18	*2.5*
15	*3.0*
10	*4.0*
6	*6.0*

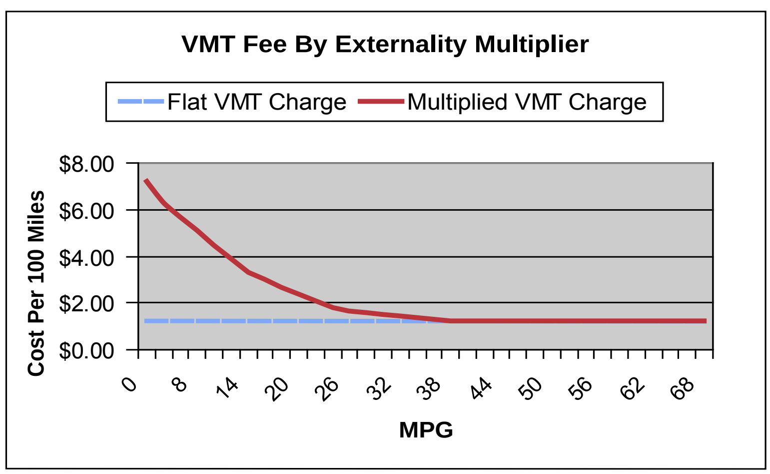

FIGURE 3-4

factor, other factors such as actual emissions might be included in assigning the multiplier to a given vehicle. Such a system would encourage those operating gas guzzlers to change to more fuel-efficient vehicles and especially discourage operating gas guzzlers during peak driving periods when they are more emitting even more greenhouse gases while moving slowly or not at all. In effect, the mileage charge could be structured as a progressive carbon tax.

Retention of Fuel Tax for Gas Guzzlers

Another rate structuring variation would apply the mileage charge to high fuel economy vehicles while maintaining the gas tax for low fuel economy vehicles. This application would apply even though the gas guzzling vehicle contains the necessary on-vehicle mileage charging equipment. Figure 3-5 illustrates this graphically.

Inflation Escalator

Inflation Indexing

Policymakers should consider whether the basic mileage charge should be fixed or subject to an annualized escalator for inflation. As mileage charges naturally account for fuel efficiency improvements while volume-based fuel taxes do not, the addition of an inflation factor to the rate structure could make the mileage charge perhaps the optimum charging mechanism for the road system, depending, of course, on how a legislative body constructs the inflation escalator.

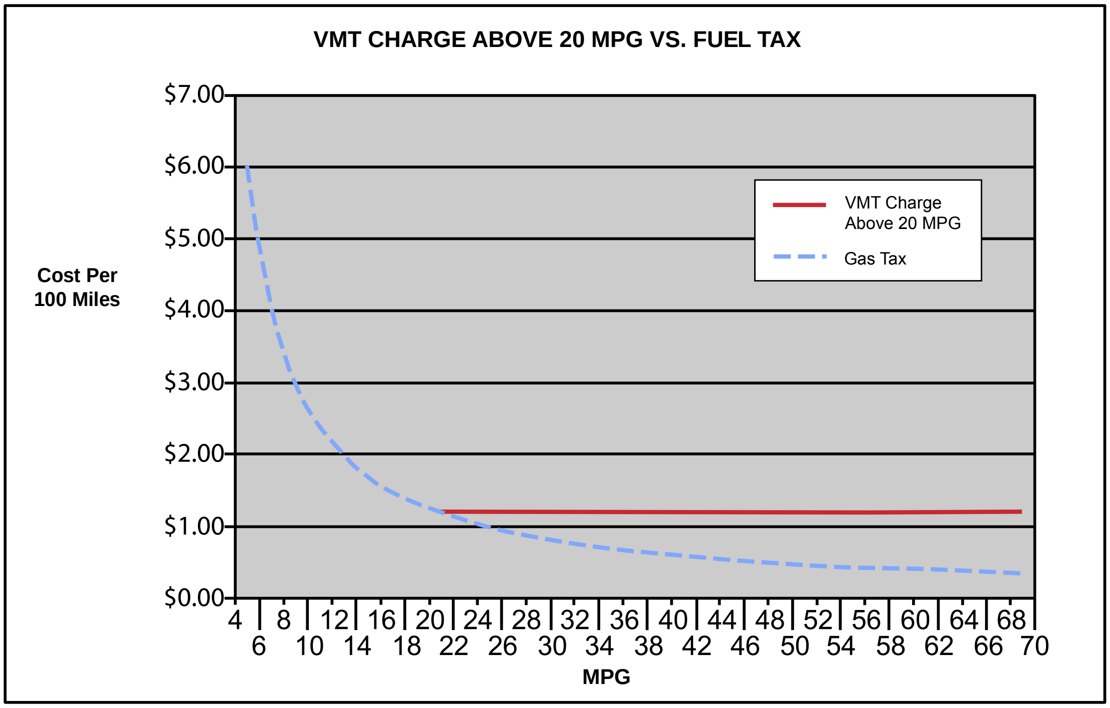

FIGURE 3-5

RATE FAIRNESS

When structuring rates to accomplish various public policy goals, policymakers will consider the issue of subsidization. The gas tax is an indirect user fee. Since the amount of gas tax revenues raised relies on the volume of gasoline consumed, the gas tax subsidizes vehicles that consume less gasoline while the overwhelming bulk of the passenger vehicle fleet places nearly an identical burden on the road system. A flat rate mileage charge would operate as a direct user fee. Policymakers might consider whether certain segments of society deserve subsidization to accomplish certain policy goals and structure the mileage charging rates accordingly.

Fuel-Efficient Vehicles

Motorists operating fuel-efficient vehicles tend to be the most vociferous in opposing a flat mileage charge rate. This group argues that because they operate vehicles that burden the environment less, they should be favored relative to those operating vehicles with a larger environmental impact. While this point has validity with the environment as the *only* policy factor, when one considers that each vehicle operator has an identical interest in roadway availability, then an equal responsibility to pay for the system emerges. Such is the justification for a user pays system.

Rural Drivers

Rural motorists advocate for more favorable treatment than urban motorists. They claim that rural residents tend to drive more than urban motorists for ordinary services and have few transportation alternatives. They say rural motorists should either not pay a per-mile charge or deserve a subsidy. This view opposes the notion that road funding should occur on a user pays basis.

By itself, driving more miles alone does not justify a subsidized rate for rural motorists. Many urban motorists also drive many miles. Further, lack of transit alternatives is relevant only when one considers non-road public polices. From the perspective of road funding alone, those motorists burdening the road system should pay for that relative burden. Nevertheless, the lower cost to maintain rural roads may warrant consideration of a lower rate for driving on those roads, although motorists driving on certain types of city streets may successfully make a similar argument.

Should policymakers decide to subsidize rural driving, legislative bodies could impose lower mileage charge rates in specially identified rural zones. Establishing the boundaries of these lower-priced rural zones will be rather challenging as policymakers consider whether to include certain small towns within the zone even though few local residents have long distance commutes. Alternatively, legislative bodies could establish certain rural highways as lower-price facilities.

Less Affluent Drivers

Whether the shift to a distance-based charge will positively or negatively affect the poorer element of society depends on the rate structure adopted and the type of vehicle operated. An Oregon State University study reports that a large portion of the lowest income group tends not to be affected by road taxes and fees because they do not operate motor vehicles. For the poor who do drive, they tend to drive older and less fuel-efficient vehicles in times of increasing fuel prices because new fuel-efficient models tend to be more expensive than less fuel-efficient models sold on the secondary market.[52] The poorer motorist would generally pay more per mile under the fuel tax than they would under a comparable flat rate mileage charge. The gas tax therefore would be more regressive to poorer motorists than a flat rate mileage charge. Graduated, stacked, multiplied or other non-flat mileage charge rate structures will yield different outcomes.

Difficulty of Accommodating All Valid Policy Perspectives

The above discussion reveals that policymakers can structure the mileage charge in a myriad of ways. While all compelling policy perspectives should be taken into account when a legislative body adopts the rate structure, policymakers must recognize that valid public policy goals often conflict. The mileage charge rate structure, therefore, might *not* be the best place to accommodate every valid policy perspective. A legislative body may choose to address the road funding concern in the mileage charge rate structure while addressing environmental policy goals, or other policy goals, in other tax or fee structures that do not directly relate to road funding; whereupon, viewing the whole, all relevant public policies are accommodated.

Whatever the legislative preferences, policymakers should understand the initial motivation for development of the per-mile charge was to prepare for the day when all new vehicles contain a high degree of fuel efficiency built into their systems, fuel prices regularly increase over time and motorists continually trade up to vehicles with greater fuel efficiency. This understanding may lead to a rate structure where at least the leading edge of fuel-efficient vehicles pay on a flat rate basis to ensure no revenue erosion from constant vehicle fuel efficiency improvements.

[52] McMullen and Zhang, *Techniques for Assessing the Social-Economic Impact of a Vehicle Mileage Fees: Final Report, June 2008*, p. 5.

4

An Interim System for Quick Implementation

As political acceptance of mileage-based charging grows in this nation and policymakers become aware of the lengthy period required for development and implementation of an electronic collection system, the question arises, "Is there an interim collection system we can employ quickly while the optimum system completes development?" Indeed, viable interim concepts do exist and do not involve motorist self-reporting of mileage data.

WHY MOTORIST REPORTING OF MILEAGE DATA WILL NOT WORK

Some policymakers leap to the view that *paper and pencil* reporting of mileage data directly from the odometer offers the quickest way to implement mileage charge collection. Under a motorist self-reporting system, vehicle owners report their accumulated mileage in written format on some periodic basis and receive a billing annually or biennially based on that reported mileage. Enforcement would likely involve the threat of withholding vehicle registration.

Despite the illusion of simplicity, human data gathering in this manner reveals significant implementation problems and numerous systemic difficulties. These challenges make a non-technology based mileage charging system simply not viable on a large scale.[53]

Start-up alone might stall the entire effort as many motorists decline cooperation amidst legal quandaries concerning requirements for uniformity of taxation and phase-out of fuel taxes. DOT's would likely receive an annual or biennial payment rather than monthly fuel tax payments, playing havoc with both start-up period and on-going cash flow.

Operating costs would escalate as DMV staffing grows to meet demand for direct public contact. Administrative costs would likely end up one or two orders of magnitude higher than the low operating cost fuel tax collection system. For those interested in comparisons with electronic mileage charge collection models, these costs should be calculated and compared.

Already common, odometer fraud would likely grow rampant. Moreover, without legions of enforcement staff and an expensive mileage verification program, the relative ease of under reporting of mileage could lead to huge losses in revenue relative to fuel tax collections or higher rates for honest payers.

An implementing DMV would face likely irresolvable systemic quandaries. Vehicle owners could sell their vehicles midyear before the mileage charge payment due date thereby raising apportionment issues. Accordingly, timing for out-of-state moves could change to just before the due date. New residents may delay registering their vehicles. Vehicle owners would pay based on mileage driven out-of-state even while paying other states' fuel taxes. Less affluent motorists may have trouble assembling a large payment every year or two rather than periodic small payments made now under the fuel tax payment system. If policymakers intend

[53] New Zealand operates a manual odometer inspection program on a small scale, simply for the small number of vehicle operators who do not pay fuel taxes.

that mileage charges replace fuel taxes, the self-reporting system lacks a way to directly and accurately credit the motorist for fuel tax payments made on mileage charged.

Implementation nationally may face even greater difficulties than those of an individual state because of the necessity of piggybacking on to existing non-standardized DMV registration systems. Indeed, a national self-reporting mileage system may require a mandate for state vehicle registration processes, including duration of registration, payment processes and enforcement requirements.

Finally, a self-reporting system inherently lacks an ability to establish geographic and temporal zones, an important element for a flexible and robust road revenue system that allows time-of-day congestion pricing and participation by local governmental jurisdictions.

NEAR TERM ELECTRONIC COLLECTION OPTIONS

Researchers have recently turned focus towards possibilities for implementation of an electronic mileage-based charging collection mechanism in the near term with hopes of finding an interim method that could offer support for the ultimate move to a robust mileage charging system over the longer term. A report recently prepared for the National Cooperative Highway Research Program of the Transportation Research Board describes several potential approaches in this regard.[54] The report declares the following as the three *most promising* options.

- *The Coarse-Resolution GPS-Based Mileage Metering* employed in *Oregon's Road User Fee Pilot Program*, but with an *after-market* on-vehicle metering device.[55]
- *The On-Board Diagnostics Port/Cellular-Based Mileage Metering* concept contributed by the University of Minnesota's Intelligent Transportation Systems Institute.[56]
- *The Fuel Consumption-Based Mileage Estimate concept* contributed by the authors and described in detail below as the *VMT Estimate Concept*.

THE VMT ESTIMATE CONCEPT

Though many policymakers generally recognize electronic mileage charging can resolve all problems associated with self-reporting via the pencil and paper method, they also express concern about the practicality of near term implement-ability of a technology-based system. Dissolving these worries, a fairly simple electronic mileage charging system—the *VMT Estimate Concept*—can meet most system objectives, if not quite all. As an interim mode of collection, however, the VMT Estimate Concept may prove acceptable.

The authors conceived the slightly less accurate but more easily implemented VMT Estimate Concept for mileage charging in 2002.[57] Under this concept, resident motorists pay a

[54] Paul Sorenson, *Implementable Strategies for Shifting to Direct Usage-Based Charges for Transportation Funding: Final Report*, June 2009 Draft, prepared as part of NCHRP Project 20-24(69)
[55] See pages 44 through 49.
[56] Max Donath, Alec Gorjestani, Craig Shankwitz, Richard Hoglund, Eddie Arpin, PiMing Cheng, Arvind Menon, and Bryan Newstrom, *Technology Enabling Near-Term Nationwide Implementation of Distance Based Road User Fees*, Intelligent Transportation Systems Institute, University of Minnesota, June 2009
[57] Whitty, *Road User Fee Task Force Report to the 72nd Oregon Legislative Assembly*, March 2003, p M-1 (Scenario 4)

mileage charge based on an estimate of vehicle miles traveled (VMT). The system does not tally or transmit precise mileage data. Rather, the system calculates the motorist's mileage charge at the fueling station through application of a charge rate to an estimate of the vehicle's miles traveled since the last fueling. The system calculates an estimate of VMT by dividing the amount of fuel purchased by the vehicle's fuel efficiency rating. If implemented in a single state, out-of-state motorists would continue paying the fuel tax. The out-of-state motorist would disappear as a concern under a national mileage charging system.

Under either a national or state VMT Estimate system, state DMVs would outfit each resident vehicle with an automatic vehicle identification (AVI) device—perhaps embedded in the license plate,[58] the windshield or combined with a vehicle emissions inspection sticker—that indicates the vehicle's Vehicle Identification Number (VIN). This common inexpensive device allows a mileage charge estimate to occur at the fueling station. The system can accomplish the mileage data estimate and the mileage charge collection under either of two system options.

System Option #1. When a vehicle refuels, an electronic reader at the fuel pump wirelessly reads the AVI device to identify the vehicle's VIN. The system forwards the vehicle identification plus fuel purchase amount via direct service line to a collection agency central computer where the vehicle's fuel efficiency rating is multiplied by the amount of fuel purchased to calculate the VMT estimate. The central computer applies the charge rate to the VMT estimate and forwards the VMT charge amount to the fueling station's point-of-sale system. The station's point-of-sale system combines the VMT charge with the fuel purchase price and provides an invoice to the motorist. The mileage charge calculations would occur within the central computer. This *reading* of the vehicle identification and the interaction with the central computer would occur in a manner similar to contemporary all-electronic tolling systems and the data reporting and charge collection mechanism demonstrated during Oregon's Road User Fee Pilot Program.[59]

System Option #2. When a vehicle refuels, an electronic reader at the fuel pump wirelessly reads the AVI device to identify the vehicle's VIN and the vehicle model's assigned fuel efficiency rating embedded in the AVI device. The system forwards the vehicle identification and fuel efficiency rating plus fuel purchase amount to the station's point-of-sale system where the vehicle's fuel efficiency rating is multiplied by the amount of fuel purchased to calculate the VMT estimate. The station's point-of-sale system applies the charge rate to the VMT estimate, combines the VMT charge with the fuel purchase price and provides an invoice to the motorist. The calculations would occur within the point-of-sale systems at the fueling stations in the same manner as occurred during Oregon's Road User Fee Pilot Program, but under option #2 central processing to determine the VMT estimate would not take place. The *reading* of the vehicle identification would occur in a manner similar to contemporary all-electronic tolling systems. The data reporting and charge collection mechanism was demonstrated during the Road User Fee Pilot Program. Under this option, the collection agency's only role in the collection process would be to receive the mileage charge revenue from the fueling stations.

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[58] Through meetings with industry suppliers, the authors learned that versions of this license plate currently exist in the marketplace.

[59] Whitty, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program: Final Report*, November 2007.

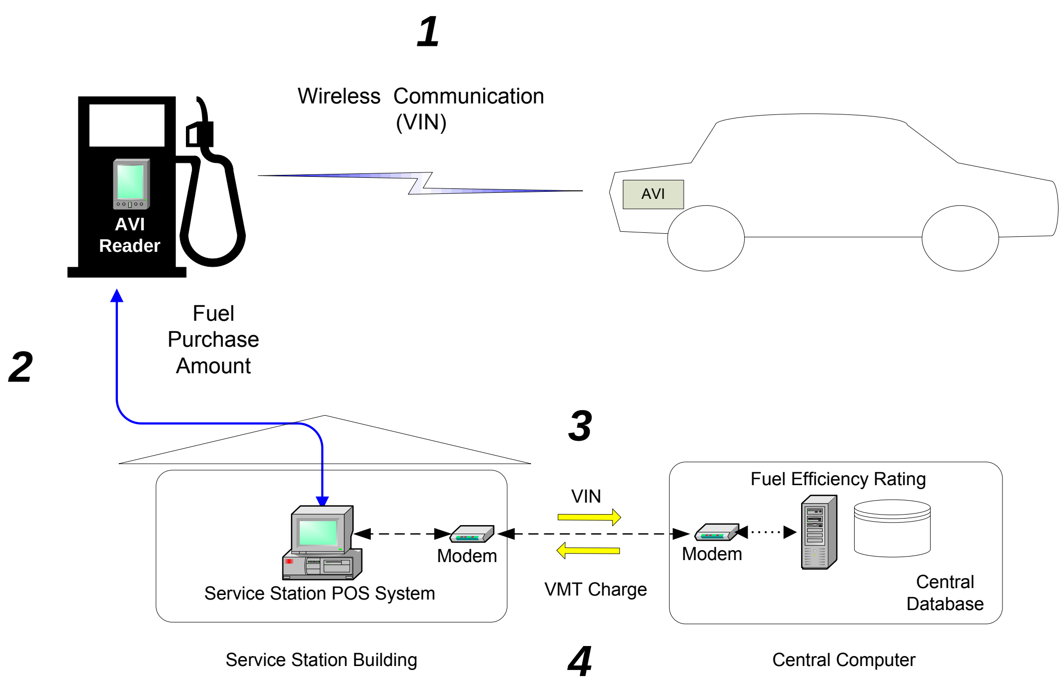

FIGURE 4-1 VMT estimate System Option #1.

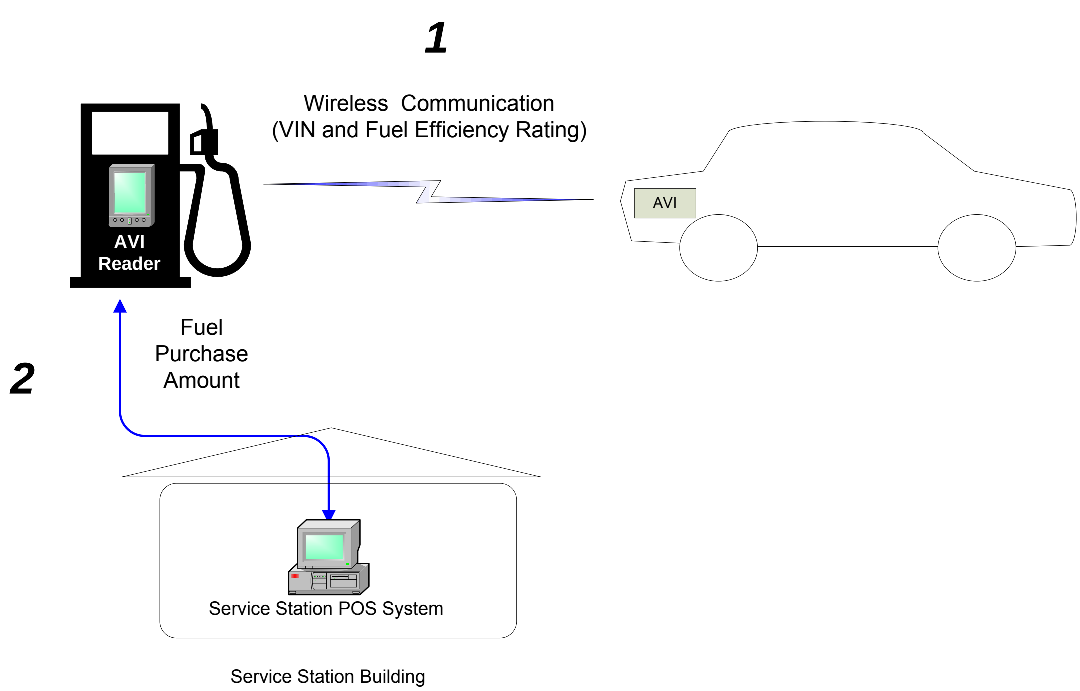

FIGURE 4-2 VMT estimate System Option #2.

VMT Estimate as Replacement for Fuel Taxes

If policymakers prefer to adopt the VMT estimate system to replace the fuel tax, then at the point of invoicing, the system would deduct the fuel tax amount from the fuel purchase price. The motorist would pay the VMT estimate charge and the price for the fuel less fuel taxes.

How the retailers remit the mileage charges to the collection agency will depend upon whether the retailer sells gasoline, diesel or other fuels. Since in most states the gasoline retailer reimburses the distributor for gas taxes paid at the rack, the gasoline retailer would pay to the collection agency the difference between the total mileage charges collected and the gas taxes paid by the retailer on the gasoline purchased for a given period, if greater. If the total mileage charges collected totals less than the gas taxes paid on the fuel purchased, the collection agency would pay the gasoline retailer a reimbursement payment. Retailers selling diesel or other fuels and paying a the use fuel tax directly to the collection agency would also pay the mileage charges collected from customers directly to the collection agency.

VMT Estimate Rate Structuring Limitations

The VMT estimate system has limited ability for creation of alternative rate structures to accomplish public policy goals other than revenue generation. This system cannot create electronic zones either geographically or temporally. As a result, the mileage charge covers all miles traveled on an estimated basis. Thus, this system cannot accommodate public policies that require identification of specific geographic areas for congestion pricing, land use management or revenue allocations among governmental jurisdictions. Nor would this system permit adoption of local mileage charging by county or city jurisdictions.

Under system option #1, the VMT estimate system can access the characteristics of individual vehicles because of the involvement of a state central computer connected to a DMV database. Thus, system option #1 would allow a rate structure to accommodate public policies related to greenhouse gas reduction[60] and energy independence as well as revenue generation. System option #2 would not have this ability without extensive reworking of fueling station's point of sale systems, perhaps at great expense.

VMT Estimate Charge as Augmentation of Fuel Tax Revenues

If policymakers prefer to add additional revenues by augmenting fuel tax revenues, all motorists would pay a flat mileage charge—or a mileage charge adjusted for public policy factors such as fuel efficiency, vehicle weight or vehicle emissions rating—rather than integrating with fuel tax collections in order to stop road revenue erosion. Although the VMT estimate system would piggyback on the sale of fuel, mileage charge collection would be independent and not integrate with the fuel tax collection.

VMT Estimate Charge as Hybrid Between Replacement and Augmentation of Fuel Tax Revenues

Policymakers may prefer to retain the fuel tax for fuel inefficient vehicles while charging fuel efficient vehicle operators the mileage charge as a flat rate in order to combine sustainable

[60] See Figure 3-3.

revenue generation requirements with a greenhouse gas reduction strategy. Under this rate structure, motorists would only pay the greater of the mileage charge or the fuel tax when refueling. Gasoline retailers would remit to the collection agency only the mileage charge differential above the gas tax paid at the pump. This system would raise more revenue than the current gas tax system. How much would depend upon the level of the mileage charge rate set.

Tampering Consequences

Ultimately, tampering to disable the AVI device would result in a *no read* of the VIN. Motorists in a no-read situation might have the highest fuel efficiency rating applied to the fuel amount purchased. This would calculate more miles and therefore act as a penalty for tampering and an incentive to repair the device in a timely manner. Until all resident vehicles contain the AVI device, however, a *no read* could not trigger such a penalty. Prior to statewide application, a *no read* for a resident vehicle would cause the motorist to default to the payment of the gas tax. Out-of-state motorists would continue to pay fuel taxes except under a national system.

Privacy

Public perceptions about privacy invasion would calm under system option #1 because precise mileage data would not be tallied. Only the time and location of refueling would be provided to the collection agency as well as the amount of fuel purchased.

Public concern about privacy might dissolve under system option #2 because precise mileage data would not be tallied and the collection agency would not have direct access to the time and location of vehicle refueling. Further, there would be no need for data transfer of fuel purchase amount to the collection agency because determination of the VMT estimate data would occur at the fueling station.

Implementation

Policymakers would require fueling station participation through a mandate upon all retail fueling stations to install the necessary technology. The mandate could involve adequate compensation for the station owners.

Capital Costs

Capital costs for the technology required at the fueling stations under system option #1 should be lower than for the pay-at-the-pump method described in Chapter 2 (because only AVI technology would be required). System option #2 requires no centralized computer system. Under either option, secure AVI devices for a medium size state would cost approximately $250 million and fueling station equipment would cost $50 million.[61] If the AVI devices were embedded only into *new* license plates, perhaps under the license sticker, or combined with a

[61] This cost figure assumes five million vehicles, $50 for purchase and a secure installation of each device, 3,000 fueling stations and an average equipment cost of $15,000 per station. The state would also establish an electronic link to fueling stations to enable monthly reconciliation to occur. Under system option #1, the added cost of the collection agency central computer would be required.

vehicle inspection sticker, capital costs for installation should drop to nothing for the on-vehicle application, leaving only the capital cost of the fueling station equipment.

Operating Costs

Collection agency operating costs should prove minimal under either system option. Essentially, operations would include an auditing function and computer maintenance.

Impact on Private Sector

Under system option #1, fueling station operations—installation of AVI reading equipment and DSL lines, synchronizing with existing point-of-sale systems and cost—would likely not vary from the pay-at-the-pump system described in Chapter 2. In contrast, system option #2 would eliminate costs associated with data transfers to a collection agency central computer.

Timeline for Implementation

Implementation of the VMT estimate system would require minimal technology development and testing. The marketplace already avails AVI device technology embedded in license plates. The Road User Fee Pilot Program already tested a similar data management system.[62] Implementation of this system should require only one six-month test. The remaining steps for implementation would include the following.

1. Commence production of the AVI license plates and installation as replacement license plates commencing within the first year after legislative adoption. Alternatively, commence production of a combined AVI vehicle emissions inspection sticker.
2. A legislative body mandates fueling stations to (1) add AVI reading equipment to their fueling stations, (2) upgrade their point of sale systems in accord with specifications provided by a governmental entity, and (3) add DSL line connection to a collection agency central computer. Compliance with this mandate should occur within two years of governmental adoption of specifications.
3. If system option #1 selected, the governmental entity develops central computer system, including necessary redundancy, and prepares for deployment.
4. Switch on system for vehicles containing the necessary technology within four years of the effective date of legislative enactment.
5. The VMT Estimate system could become *fully operational* for the entire vehicle fleet *within three or four years* of the formal starting point, depending upon how quickly the governmental entity adds AVI devices to all resident vehicles.

Advantages of VMT Estimate Concept

1. *Protection of privacy*. No involvement with GPS system, therefore largely reduced perceptions of privacy invasion.
2. *Integration with fuel tax collection system*. Provides credit for fuel taxes paid.

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[62] Whitty, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program: Final Report*, November 2007. pp. 9 and 19.

3. *Elimination of on-vehicle counting device*. No engagement of automobile manufacturers required. No need to manufacture on-vehicle device into vehicles or add them prior to first sale.

4. *Retrofitting*. System allows for easy retrofitting of existing vehicles without the difficulty of integration with their technology systems.

5. *If central computer eliminated,*
   - Fueling stations would have a transaction with fewer steps than under the pay-at-the-pump system identified in Chapter 2.
   - System would provide a complete buffer against government intrusion but there would be no ability to audit motorist payments, making it difficult to audit fueling station receipts.

6. *Compared to the manual self-reporting method,*
   - No revenue disruption during start-up.
   - No issues involving uniformity of taxation.
   - Only a modest increase in operating costs relative to fuel tax collections.
   - Much more limited fraud, evasion and avoidance potential.
   - The fuels tax collection system could remain in place as a back-up system for redundancy.
   - Would enable environmental pricing for greenhouse gas emissions control.
   - Regular periodic payment with fuel purchase makes the charge visible and thus more likely to impact travel behavior than an annual or biennial payment made with registration.
   - Universal AVI device may facilitate development of congestion pricing applications albeit not as sophisticated as under the pay-at-the-pump system described in Chapter 2.

Disadvantages of VMT Estimate Concept

1. Approximation of VMT would generate an imprecise mileage charge and therefore may negatively impact motorist regard of this system.

2. The system would charge motorists for vehicle miles traveled out-of- state but this would not be an issue for a national implementation.)

3. Since zones could not be established, this collection method would not facilitate area-wide congestion pricing.

4. Without zones, local adoption by cities and counties could not avail of this system nor would the system allow precise revenue allocations among governmental jurisdictions.

5. The collection agency must obtain the cooperation of unwilling motorists to allow installation of AVI devices. Obtaining motorist cooperation may prove easier for AVI devices embedded in new license plates or vehicle emissions inspection stickers.

6. While operating costs may be even lower than the pay-at-the-pump system described in Chapter 2, capital costs for retrofitting all vehicles should be much more expensive. Start-up costs for a medium size state would run approximately $300 million if every motor vehicle were required to obtain the AVI devices, or $50 million if only newly issued plates contained the AVI devices.

Remaining Issues for VMT Estimate

1. *Length of phase-in period*. Researchers must determine how to install secure AVI devices on vehicles and the length of the period required for doing so. Alternatively, researchers must determine whether embedding AVI devices into license plates, vehicle emissions stickers or windshields can be made secure and the length of the period required for installation of the AVI device for all existing resident passenger vehicles.
2. *Non-compliance penalty*. Motorists not identified with an AVI device should default to the highest fuel efficiency rating for purposes of the VMT Estimate calculation. Researchers must determine how this would affect non-resident motorists. If a state were to charge out-of-state motorists the same mileage charge rate as resident non-compliant motorists without a way for them to pay the mileage charge based on their vehicle rating, the US Commerce Clause may be violated. The state may have to provide out-of-state motorists a way to obtain the AVI device upon entering the state.
3. *Place of VMT Estimate calculation*. Researchers must determine whether it would be better to have the vehicle fuel efficiency rating embedded in the AVI device (system option #2) or added via central computer (system option #1).
4. Researchers should measure the relative benefits of the VMT estimate model against the added costs of implementing an interim system intended for abandonment once the primary system becomes ready for operation. While the costs can be easily tallied, the benefits may be somewhat ethereal, including assisting development of public comfort with mileage charging and reduced perceptions concerning invasion of privacy invasion. Further, some may consider the VT estimate as a worthy gamble in the event a more robust mileage charging system never launches.

INTERIM SYSTEM FOR ELECTRIC VEHICLES

Mileage-based charging at electric vehicle charging stations might become feasible in a manner similar to the VMT estimate method described above. With the option of recharging at home or the office or somewhere other than a commercial electric charging station, the challenge may be that motorists could avoid payment of the mileage charge under such a system. Until mileage charging for electric vehicles becomes feasible through the electric utility meter, it may be necessary for mileage data upload and mileage charge payment to occur under the introductory method described in Chapter 2 or to encourage voluntary adoption of a mileage charge system through incentives.

VOLUNTARY ADOPTION OF MILEAGE CHARGING

Motorists may more willingly accept the shift to mileage-based charges if they have the option to choose the on-vehicle device from among several options. It may be even easier to obtain public acceptance for mileage charges if motorists would have the opportunity to *voluntarily* install an on-vehicle device to pay the mileage charge as a substitute for the gas tax. Either way, motorist choice would necessarily involve a motorist adding an *after-market* on-vehicle device to the vehicle under an open technology platform under which numerous and evolving choices become available.

Without additional services connected with the on-vehicle device, one cannot imagine a motorist opting into a new charging regime. Without something more, no motorist will opt for the mileage charge unless the amount paid is less than the fuel tax they pay. Since most transportation policymakers cite sustainable revenue generation as the principal purpose for enacting a mileage charge, voluntary adoption under this scenario will not achieve the desired result.

For voluntary adoption to make economic sense, the motorist must perceive an economic benefit for opting into a mileage-charging regime. If the on-vehicle device required for mileage charging also offers additional services to the motorist, then motorists may choose to pay by the mile rather than by the gallon. Additional services might include some currently available such as navigation and pay-as-you-drive insurance but also others such as automatic payment of parking charges without feeding the meter, automatic vehicle emissions testing, traffic information (best routes and identifying bottlenecks in real time) and traffic management tools (actual mileage per gallon per trip or route), electronic safety features and car sharing. Adoption of an open system technology for an-after-market on-vehicle device could facilitate development of additional applications desired by the motoring public. An alternative to added services would be to raise the fuel tax to high levels and provide a reduced mileage charge rate for early adopters, perhaps a politically difficult strategy to accomplish.

Motorist acceptance of an after-market on-vehicle device coupled additional features and services may depend upon whether the motorist or the vendor finances the on-vehicle device. If the motorist perceives high value for the available services or features, the motorist may pay for the device. If the vendor can extract sufficient value from applications, then the vendor may finance the device.

Some features and services associated with the on-vehicle device may be enough to excite widespread acceptance of the device despite the *price* of accepting mileage-based charges. Even so, the more the motoring public fears exposure to complex mileage charging strategies such as congestion pricing, the less likely voluntary adoption will succeed. Therefore, combining a legislative mandate for mileage charges with motorist choice of on-vehicle device may offer the most realistic opportunity for ultimate application of a robust mileage-based charge system.

CONCLUSION OF PART ONE

With sufficient political will, the VMT estimate system could become fully operational within four years of a formal starting point. While this system would introduce the motoring public to the concept of mileage charging and provide an effective transition to a more sophisticated system, it can serve as only a partial bridge to best technology and robust user charge systems. The more robust systems require adding on-vehicle devices though the fueling station equipment, central computer processes and databases may be similar. Nonetheless, once a more robust system becomes viable for implementation, the ultimate system and the VMT estimate system do have the ability to operate together while the more sophisticated system phases in.

PART TWO

Research Requirements for a New Road Revenue Collection System

Introduction to Part Two

> *"… the unfamiliar, the vaguely perceived, the mysterious, the hidden, the unexpected are all apt to be threatening. One way of rendering them familiar, predictable, manageable, controllable, i.e., unfrightening, and harmless, is to know them and to understand them."* Abraham H. Maslow, *Toward a Psychology of Being*.

Members of the general public often show strong concern about the idea of charging by the mile because the details are unknown. They do not know how the government would impose the charges nor do they know the effects they would have on daily life or society in general. The only way proponents of mileage charging can resolve these concerns and obtain public consent for change is through development of a specific mileage charging system and researching the likely effects of that system on our nation. In other words, we must make the unknown known.

While several mileage charge studies recently concluded or now underway provide much of the necessary research framework for eventual adoption of a mileage-based charge system, no consensus has yet formed around which mileage charge collection approach should be adopted. Part Two suggests research to provide more clarity for making this decision.

Part Two suggests research in several areas before national or state-by-state adoption of a mileage charge system. The authors suggest a developmental program to understand *governance* issues, federal and state systems integration issues and the *necessary technology and systems* development required to ensure a viable collection system. Many technology elements for a mileage charge system have reached the point of maturity but many more might dramatically improve with future development. Impacts of a mileage charge system on *economics and revenue*, *energy policy* and *greenhouse gas reduction* as well as *governance* are also explored.

As the most critical concern before the nation, *public acceptance* requires understanding of public attitudes and needs to assist system design. Part Two recommends a vigorous communications program to ensure the public understands how system design meets their needs.

Mileage charges imposed nationally or by individual states will have *impacts upon our society and our societal systems*. Part Two proposes research on impacts relating to travel behavior, revenue, energy and environmental policy and land use.

Finally, Part Two suggests a national investigation to complete development of a mileage charge system for the nation rather than state-by-state development. The national investigation should include a timeline for completing development, a national policy oversight body, national-level project teams, concurrent investigations and several pilot programs. Part Two concludes with fundamental recommendations.

Once the nation completes development, knowledge should reach a level sufficient to enable Congress or any state legislature to adopt a mileage charge system.

5

Governance

Transportation policy emerges from a confluence of market-based needs and non-market-based needs. For the past century, our nation's legislative bodies have charged government—with a few exceptions, such as freight rail—with the responsibility of advancing surface transportation policies. Government, therefore, plays the key role in development and management of the nation's transportation system. The private sector plays a key role as contractor for certain developmental aspects and construction of facilities. In recent years, the private sector has emerged as owner/operator for certain facilities procured as public private partnerships.

Adoption and application of mileage-based charges create the potential for fierce policy debates among governmental entities and intergovernmental squabbles over cross-jurisdictional effects on traffic and land use. Legislative bodies should anticipate these policy disagreements and associated trans-jurisdictional effects when enacting a mileage-based charging system for a state or the national government.

WHO SHOULD DESIGN, ORGANIZE AND IMPLEMENT THE SYSTEM?

To this point, states, local MPOs and universities have assumed charge of analyzing and experimenting with mileage-based charge systems in the United States. The Federal government funded the bulk of these experiments, either through USDOT grants or direct congressional appropriations, with the remainder funded through local match. Federal support to the states for mileage charge development yielded definite gains fairly quickly but without national policy direction nor significant assessment of governance issues such as responsibility for system design, implementation and operation, as well as revenue allocation and cross-jurisdictional effects.

This developmental tension represents the polarity of state versus federal control. On one hand, the Federal government provides a global view of development while slowed by the numerous interlocking factors essential for consideration. On the other hand, the states can think creatively and act more rapidly but without federal clout and the necessarily complex national perspective. Ideally, system design and organizational development will involve both a federal role and a role for the states.

State-by-State Development

As incubators of change, state mileage charge development efforts can reveal helpful system innovations quickly and easily. Mileage charge implementation on a state level tends to stall, however, when confronted with the impact of large-scale adoption and national issues and concerns. For example, working with prototype technology for a pilot test occurs easily locally but broad scale implementation of a mileage charging system requires refining the technology to commercial viability, a relatively expensive proposition for all but the largest states. Further, implementation of mileage charging on a state level requires the involvement of major industries such as automobile manufacturers and fuel retailers/distributors, a perhaps insurmountable political challenge for all but the largest states.

Development and implementation of mileage-based charges state-by-state will reveal issues of national or regional implication irresolvable by a single state. State-by-state adoption will take a long time to produce mileage charges systems that blanket the nation. As a result, standardization of technology and systems under a state-by-state scenario would be highly unlikely. Different policy goal priorities and the technology changes will create large differences among state systems. If one state adopts a collection system and technology that does not integrate and interoperate with a nearby state's collection system and technology, administrative costs for both systems may prove larger than necessary. Moreover, multiple state systems will likely subject motorists driving between states to more difficult mechanisms to capture out-of-state user fees than if the systems integrated well.

If one state replaces the gas tax with a mileage charge and the neighbor state does not, cross-border effects might cause inadvertent revenue impacts. In such a scenario, resident drivers would tend to fuel in the home state for lower gasoline prices[63] and ensure a credit against the gas tax paid. At borders, this could change current fuel purchasing patterns for potential customers living nearby. If mileage charges augment the gas tax, resident motorists living near the border may attempt to avoid payment by fueling in the other state.

The rate structure of a state's mileage charge will have greater impact on state-by-state revenue flow than the mere adoption of a mileage-based charging system. Flat mileage charges may yield jurisdictional pricing advantages for some motorists but not others. Mileage-based environmental pricing, on the other hand, may yield an opposite result. Before enacting mileage-based charges, governmental jurisdictions should learn how a given price structure may impact traffic and revenue flow within the jurisdiction and also in neighboring jurisdictions.

Perceived external revenue, traffic and land use impacts upon neighboring jurisdictions will raise the specter of veto rights, national preemption and imposition of standard practices and limitations. The extent to which policymakers can know these impacts prior to enactment of mileage-based charges may result in adjustments that alleviate them. Managing interstate impacts of mileage charge rate structures may prove infeasible through a nationwide compact. Rather, states may have to negotiate rate agreements on a corridor-by-corridor basis.

Nonetheless, in the absence of federal involvement, the states could develop national standards—working through a multi-state consortium or AASHTO—for adoption of mileage-based charging systems, including determination of best practices and system guidelines. At minimum, these standards/guidelines should include a common collection system or at least collection systems that use interoperable technology and databases that can communicate with each other. A multi-state consortium could also lessen the sting of expensive system and technology refinement efforts. Leaving national standard setting to the states, however, would also face the necessity of enactment in all 50 state legislatures for a national system to emerge, a rather challenging endeavor for certainly the short term.

[63] The gasoline price would not include the state gasoline tax for motorists paying the mileage charge, resulting in a likely lower price for gasoline when compared with a neighboring state.

Federal Development

In Germany and The Netherlands, the federal governments lead development of mileage-based charging systems, both from a policy perspective and technology and systems perspective. In order for positive direction and rapid action, the federal governments established aggressive timelines for development and implementation. Germany succeeded in this manner and The Netherlands appears to be making headway. The United States government should learn from these experiences and seriously consider an aggressive timeline as well.

Federal systems development may take longer than for a given state and allow less innovation because of numerous policy considerations and processes, but, on the positive side, the Federal government can provide uniformity of technology and systems choices as well as political heft for imposing a new system on national industries. Lending these positive qualities to the developmental process appears essential for completion of preparation for implementation. The Federal government, however, should continue to cede a healthy opportunity for innovation to the states.

REVENUE GENERATION AND ALLOCATION

Just as federal gas tax collections fit together with state gas tax collection systems, a federal mileage charge could do the same. On the other hand, gas tax collection systems among states are fairly similar, though not identical, but mileage charging systems designed and operated by states have the potential for wide divergence, making federal alignment potentially difficult. This potential provides argument for development of a national mileage charging system upon which states can piggyback their own systems. Researchers should identify the impact of federal integration into a state-by-state implementation of mileage charge systems and how to construct a federal system that allows easy access by the states.

The nature of the revenue generated will impact revenue allocations. The principal generators of gas tax revenue—the states and the Federal government—will be the principal generators of revenue from a basic, or flat, mileage charge. Additional mileage-based charges and alternative rate structures may generate more revenue but also more complexity by establishing charges beyond those of the principal generators and requiring additional revenue allocation formulas.

Congestion Pricing

Mileage-based congestion pricing for urban areas will require approvals from multiple governmental jurisdictions with authority over the roadways involved: state for state highways, local governments for local streets, boulevards and roads, as well as federal for constraints on federal-aid highway uses and operations. One should expect urban planning agencies to also exercise approval authority and air quality agencies to express concerns.

With approval authority tends to go revenue allocation authority or, in other words, *a say* in allocating pieces of the revenue pie. If the congestion pricing schemes of London and Stockholm are valid indicators, public attitudes will shape revenue allocation as well. It should be reasonable to assume the motoring public will want transportation alternatives when congestion pricing discourages peak period roadway travel. On the other hand, the motorists continuing to drive on congested roads may want the congestion charge revenue to pay for road improvements. Advocates for social equity will step forward for subsidies relating to the additional financial burden congestion pricing places on less affluent motorists. Nearby governmental jurisdictions may attempt to force revenue allocation outside the pricing area to offset unintended consequences and account for the travel of their residents through the congested area. Policy analysts should consider proposing a national policy directive for allocation of congestion pricing revenues that aligns with national policy directives.

Without a national policy directive on congestion pricing revenue allocation, state and local politics will decide the nature of congestion pricing revenue allocations. Critical to urban congestion pricing, decision-making at local and state levels may be appropriate for obtaining public consent. A literature review may reveal the likely range of potential revenue allocations and degree of local control necessary to enable congestion pricing strategies for urban areas in the United States.

Environmental Pricing

Imposition of environmental pricing over a basic flat rate may not, by itself, result in revenue allocation issues, depending upon the level of the underlying flat rate. If the flat mileage charge rate relates to the gas tax rate for a vehicle with average fuel efficiency, then adding environmental pricing would yield greater revenue than under the gas tax. Advocates for environmental polices may argue that legislative bodies should allocate amounts raised above the flat rate to environmental programs or environmental mitigation and adaptation strategies. They may also argue for an allocation to alternative modes of transportation as a VMT reduction opportunity. Road transportation advocates may argue that user-based charges should be allocated to roadway development. Both arguments have a nexus with revenues resulting from environmental pricing. Policy analysts should investigate the nature of each nexus and propose a structure for the appropriate allocation of revenues to state and federal agencies.

Road Revenue Allocation Formulas

With a national system able to identify the particular states in which travel occurred, allocation of mileage charge revenues among states has the potential to directly relate to travel within each state. As a result, the donor/donee revenue allocation struggle may reemerge with new evidence to support the various arguments. In this context, researchers should study the potential impact of geographically identified mileage charges upon revenue allocations among states as compared to the existing allocation formula.

If system technology could identify specific facilities for travel, the mileage charge revenue allocations could become even more granular. Under this scenario, the system might generate precise VMT data for specific federal-aid facilities with the potential for facility-based revenue allocations. Researchers should examine the likelihood and effect of this possibility.

If development of mileage-based charging systems devolves completely to the states, the state legislatures will determine which jurisdictions will have the authority to generate mileage charging revenue and the allocations thereof. These impacts should receive the attention of researchers as well.

The possibility that mileage-based charges could upset current road revenue allocations among governmental jurisdictions may be facilitated by the level of mileage travel data developed which, in turn, depends upon the technologies employed, data retained and policies adopted. While precise VMT estimates could form a basis for revisiting revenue allocations, these data would not necessarily compel reallocation. Support will continue for other revenue allocation policies related to supporting industrial, agricultural and marine commerce, tourism and other economic development.

DEVELOPMENT AND OPERATIONS UNDER PUBLIC PRIVATE PARTNERSHIPS

The authors note that some members of the motoring public struggle with government use of technology for revenue generation, even with assurances for the protection of privacy. Some analysts believe private operation of the mileage charging collection system would alleviate these concerns provided the arrangement protects privacy. Survey research may reveal whether this is true.

Private design, development and operation of a mileage charge collection system could yield technological and operational advantages over a government design and operation. Even so, a government may want to separate these functions to ensure optimum design and efficient operations and protect against conflicting interests. For example, if the designer will not operate the system, they can put a structure in place to encourage innovation by supporting multiple vendors rather than a sole source. Under this arrangement, the government would have no involvement in selecting a non-vehicle device.

Under a public private partnership for design, implementation or operation of a mileage charging system to generate revenue for the Federal-aid highway system, a state highway or local roads and streets, the government could shift the risk of technology difficulties and mileage charge collection to the private partner. Assuming this risk will result in a higher rate of return for the private partner and thus higher administrative costs for the system. On the other hand, the government will receive assurances of an agreed upon level of revenue and operational efficiency. Private sector involvement will also afford opportunities for creative solutions.

Road Pricing Plans

Recent public opinion research indicates that some members of motoring public prefer to pay the gas tax over a mileage charge even though the gas tax acts somewhat like a per mile charge; albeit a poorly structured one. This research also indicates motorists prefer road tolls to either the gas tax or mileage charges. The authors suspect this aversion to distance-based user charging has to do with perceptions of motorist control.

A motorist who currently pays a toll or the gas tax when buying fuel in effect purchases a pricing plan for a period of time. In essence, they purchase a contract to use the roads for a specific duration. A motorist paying the mileage charge does the opposite; the motorist pays the mileage charge *after* driving has happened with total exposure to the charge after the fact. Motorists may regard congestion charging even more poorly because of fear they would have no control over road travel costs, and therefore less control over how they live.

Consumers may reject direct user charges because of the open-ended nature of the payment obligation. Consumers may prefer an advanced payment that *locks in* the payment obligation at an agreed rate. This preference seems to hold true no matter the size of the transaction. After all, road charges are relatively small when considered on a weekly or even monthly basis.

A potential solution to this natural aversion to user charges would provide the motorist an option for advance payment of a mileage-based charge to lock-in the travel price and guarantee control over road travel costs. This option would involve purchasing a *road pricing plan* in which the motorist could purchase a contract guaranteeing a road travel price in advance of a travel period (such as a month, quarter or year). These pricing plans would mimic those used for mobile phone service to obtain access to the telephonic infrastructure. Private sector actuaries have figured out how to gain revenue with mobile phone plans and they should be able to figure out how to do the same for roads.

With a road pricing plan contract, a motorist would buy a certain amount of access to the road infrastructure. The pre-determined charges would incorporate and reflect high rates during peak hours and low rates during off-peak hours. If a motorist with a pricing plan exceeded the VMT amount allotted for a given time slot, that person would pay more than they would have otherwise. This would dampen travel during peak periods and therefore act as a voluntary traffic management tool.

To facilitate implementation of a road pricing plan system for the motoring public, a transportation agency would likely contract with the private sector to develop and manage the pricing plan system as well as collect revenue for the governmental entity.

Federal Oversight

The extent to which the Federal government relies upon state mileage charge collection structures for mileage charge revenues or the extent to which there are concerns of Commerce Clause implications for state structures, Congress may want to impose restrictions on mileage charge rate structures or applications and on the involvement of private sector operators.

6

A Developmental Program

To enable adoption and implementation of a mileage-based charging collection system anywhere in the United States, policymakers, researchers and system designers must undertake an extensive developmental program to take the system to the point of application. Although investigators have completed significant research and development for key elements of mileage charge systems, including efforts by the Puget Sound Regional Council, the State of Oregon, the 15-state consortium led by the University of Iowa and the Federal Republic of Germany, more work needs to be done for implementation in the United States. Among the subject areas requiring extensive research and development include economics and revenue, energy policy and greenhouse gas reduction, land use impacts, governance, administrative and capital costs and technology and systems.

COMPARISON OF SYSTEM MODELS

The nation has yet to settle on a specific collection system for mileage-based charges. To enable swift development of mileage charges in the United States, the three basic collection models described in Chapter 2—monthly billing, piggybacking arrangements and the integrated approach—should undergo comparison point by point. This comparison should also include interim collection models such as the motorist self-reporting and the VMT estimate. Among the criteria for comparison include the following.

- Revenue Sustainability
  - Precision as a user charge
  - Protects against fuel efficiency improvements
  - Adaptability for an inflation escalator
- Rate Flexibility
  - Adaptability for local jurisdiction charges
  - Adaptability for congestion charging
  - Adaptability for environmental pricing
- System Characteristics
  - Breadth of coverage
  - Compliance burden
  - Privacy protection
  - Transparency and the ability to send a price signal to motorists
  - Administrative efficiency
  - Integration with existing systems (such as the gas tax)
  - Opportunities for evasion and avoidance
  - Effective enforceability
  - Operating costs

    - Capital costs
    - Technology platform: open or closed
    - Systemic risk
    - System adaptability
- Federal Application
- State Application
- Timeline to Commencement of System Application
- Timeline to Complete System Application

All of these characteristics and the system generally must be measured for public acceptability.

Researchers may have to make some assumptions about application of certain technologies while making these comparisons. In some cases, researchers may have to assume more than one variation.

FEDERAL APPLICATIONS

Some federal mileage charging system applications will require building a completely new system from the ground up while others will require piggybacking onto existing state revenue or other systems. Issues of cost, complexity, systems integration and mandates upon states will heavily influence the ultimate system chosen for the national government.

Mileage charge collection models that will not require direct reliance upon state systems include the monthly billing model for passenger vehicles and, generally, an automated weight-distance tax system for heavy commercial vehicles. Other than four states with weight-distance taxes, neither model relies upon a state system. As such, the federal government will find both models expensive to develop, implement and operate. Despite this independence, federal development will require integration with certain indirect state systems. For example, a federal monthly billing model application must integrate with the state fuel tax system in order to grant motorist fuel tax credits if the purpose of federal mileage charging will be to replace federal or state gas taxes. Researchers, policy analysts and system designers must investigate the various issues for designing an entirely new federal system for mileage charging, including efficiency, cost, systems integration and accommodation of state applications.

Federal policymakers may prefer piggybacking mileage charges onto existing state systems, such as Oregon's pay-at-the-pump model. For complete application, however, the federal government would have to either institute a mandate to the states or wait until all of the states implement the particular model. The integrated approach described in Chapter 2 may offer the opportunity for federal government to implement a central billing option for some states and a piggybacking/pay-at-the-pump model for other states. For federal applications that would involve state DMV agencies—motorist self-reporting, VMT Estimate, introductory systems—federal integration with non-standard DMV systems may prove problematic, leading to certain system mandates upon states to ensure compatibility. Researchers, policy analysts and system designers should examine the necessary federal and state system components and likely mandates for integrability, efficiency, cost and state resistance.

TECHNOLOGY AND SUB-SYSTEMS

Status of Research for Passenger Vehicle Charging

Although the concept of broad-based distance-based charging emerged decades ago,[64] the cumbersome nature of gathering data by means of manual reporting —the only possible charging process at the time—frustrated serious consideration of adopting and implementing this alternative road charging possibility. Distance-based charges reemerged as worthy of consideration for road funding only when computing, wireless data transfer systems, AVI technology and global positioning systems reached sufficient capability and maturity to feasibly enable electronic generation of data and revenue collection.

Accordingly, the emerging consensus among investigators of mileage-based charging systems in the United States prefers *electronic data generation* for distance traveled. Electronics allows for greater accuracy and speed, ease of use and less cost for operations than manual data gathering. Electronic data gathering also affords an ability to create precise geographic and temporal zones for segregation of mileage driven so that various governmental jurisdictions can charge separate rates.

There are numerous options for *electronic data transfer* and no consensus on the best method. There are also several options for *payment* of the charge and while investigators have identified efficient payment systems for vehicles fueling at commercial distribution stations,[65] a consensus has also not yet formed on a mileage charge payment system.

As for *data management*, the developing consensus among US investigators leans toward managing and storing mileage data through interaction with a central computer.[66] Despite this general agreement, these identified systems have yet to be refined to levels required for commercial implementation.

Electronic Mileage Charging Investigations in the United States

Serious investigation into electronic collection systems for mileage-based charges began slightly over a decade ago in the United States. The State of Oregon concluded a six-year initial systems study in 2007 that successfully field-tested the Pay-at-the-pump model known as the Oregon Mileage Fee Concept.[67] The University of Iowa Public Policy Center and the University Of Minnesota Department Of Mechanical Engineering led a 15-state consortium,[68] and the Federal Highway Administration of the United States Department of Transportation, in development of a

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[64] Minnesota Department of Transportation, *Road Pricing Study*, 1997; California Department of Transportation, *Vehicle Miles Traveled Measurement and Assessment, 1997, and* Oregon Governor John Kitzhaber's "kitz-o-meter" *proposal in 1996.*

[65] See Chapter 2.

[66] While the capability exists for storing and processing mileage data on-board the vehicle, issues concerning system integrity and management tend to dismiss the on-board option as not viable.

[67] Whitty, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program: Final Report*, November 2007. http://www.oregon.gov/ODOT/HWY/RUFPP/ruftf_reports.shtml.

[68] California, Connecticut, Iowa, Kansas, Michigan, Minnesota, Missouri, North Dakota, Ohio, Texas, South Carolina, Utah, Washington and Wisconsin.

national investigation into mileage-charging systems beginning in 2000.[69] This work resulted in the multi-city/region[70] mileage charging field studies currently underway for testing various components of the central billing approach for public acceptability but does not actually invoice a mileage charge.[71]

The Oregon and Iowa investigators selected an on-vehicle device that receives signals from the US global positioning system (GPS) to locate itself geographically while the vehicle is operating. This ability allows creation of pre-defined electronic zones described by latitude and longitude coordinates. Both studies access the vehicle's odometer as the primary method for tabulating the number of miles driven within each zone. The Oregon field test yielded positive results for both purposes. Oregon's Road User Fee Pilot Program also successfully employed a GPS receiver-based system for mileage counting functions on certain models of vehicles in which the preferred odometer-accessing devices could not be integrated.

The Oregon and current Iowa electronic collection models differ in the nature of the mileage data upload from the vehicle, billing processes and motorist payment of the charge. As described in Chapter 2, Oregon's test of the pay-at-the-pump system successfully uploaded mileage data via wireless transfer at a fueling station to a central data management and billing center. The motorist pays the mileage charge while at the fuel pump along with the charge for fuel. The Iowa model, in contrast, uploads mileage data from the vehicle directly to a billing and dispersal center via periodic cellular transmission. The center would invoice the owner of the vehicle by mailing a billing statement or debiting an account. The vehicle owner would pay the charges to the billing center. The center would then remit the receipts to the appropriate taxing authority.

The Puget Sound Traffic Choices Study's two-year field test of congestion pricing, concluding in 2007, successfully tested a GPS receiver-based congestion pricing system to delineate routes and count miles by time-of-day.[72] This system uploaded location point data from the vehicle directly to a billing and collection center via periodic cellular transmission. The center invoiced the owner of the vehicle by mailing a billing statement and debiting an account. The center would then remit the receipts to the appropriate taxing authority.

The amount and nature of the mileage data generated by on-vehicle devices allows ever more detailed congestion pricing applications. Policymakers may want to apply congestion pricing to individual facilities or to specific location points such as on-ramps. If the mileage counting on-vehicle device contains a geographic information system (GIS) map, miles traveled can associate with specific roadways but also allow generation of detailed travel data. With no GIS map within the on-vehicle device, coordinates to identify geographic zones would indicate the zone for tallying miles but generally no detailed travel data.

Even so, the smaller the zone the greater likelihood that the system can identify specific points of travel. The number and nature of the zones created and the ability to re-define and

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[69] Max Donath, Pi-Meng Cheng, Shashi Shekhar, Xiaobin Ma, *A New Approach to Assessing Road User Charges: Evaluation of Core Technologies (Final Report),* September 2003; David J. Forkenbrock and Jon G. Kuhl, *A New Approach to Assessing Road User Charges*, 2002,

[70] San Diego, CA, Austin, TX, Baltimore, MD, Boise, ID, the Research Triangle in North Carolina and Eastern Iowa.

[71] Jon G. Kuhl, *in the University of Iowa Road User Charge Study: Project Overview, 2007, p. 2.* http://ppc.uiowa.edu/dnn4/TransportationbrPolicyResearch/RoadUserChargeStudy/tabid/65/Default.aspx (accessed January 5, 2008)

[72] Puget Sound Regional Council, *Traffic Choices Study – Summary Report*, April 2008.

adjust them over time will largely depend upon the capability of the mileage counting device employed within vehicles. Whether the on-vehicle device contains a GIS map or not, the greater the capability of the device, the greater the ability to identify detailed travel and the greater the cost, although device cost tends to decrease over time as noted by Moore's law.

Device capability also raises the issue of whether data storage and data processing should take place on vehicles or in another location, or both. This fundamental system issue affects the capacity, complexity and expense of the on-vehicle device and the technologies selected (for example, whether the device must adapt to changes in functionality, algorithms, geographic zone definitions and the like over time or if simpler on-vehicle tasks would suffice). Device capability also affects a revenue agency's ability-to-audit. Recent research efforts tend to focus on off-vehicle options, but this is not completely settled. Emerging technologies could reverse this trend. Settling this issue would help narrow the options for developing and adopting a fully specified system. Several technology experts believe that technology design can *collapse* the privacy continuum (see Figure 2-1), thus allowing complete protection of privacy while providing a complete ability to audit or challenge a billing.[73] Researchers should confirm the validity of this claim. This would have the advantage of enabling an enforcement mechanism that can detect a variety of driver misbehaviors ranging from simply disabling the in-vehicle device to more sophisticated attempts to forge inaccurate data.

The Netherlands Road Charging System Development

Though still without a field test underway, the Netherlands federal government has committed to implementation of a GPS-based mileage charging system in 2011, beginning with commercial vehicles followed by passenger vehicles in 2014.

Status of Research For Heavy Commercial Vehicle Charging

Research into electronic distance charging technology and systems for heavy commercial vehicles has just begun in the United States. Although Oregon has considered concepts for a heavy vehicle electronic mileage charging system,[74] preparation for testing has not begun. Potential investigators can source this lack of development to the very mode of taxation common for heavy commercial vehicles in the United States. As noted in Chapter 2, very few states have weight-distance taxes upon which policymakers and system designers can build an electronic weight and distance charging system.

Fortunately, other nations have forged ahead with development of heavy truck distance charging systems. Indeed, after some false starts, the Federal Republic of Germany launched an electronic distance-based collection system for heavy commercial vehicles in 2005 that continues to operate successfully.

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[73] Blumberg and Chase, *Congestion pricing that respects "driver privacy,"* Popa, Balakrishnan and Blumberg, "VPriv: Protecting Privacy in Location-Based Vehicular Services," 2009. IBM's Naveen Lamba concurred in a speech delivered to the National Governors Association Center for Best Practices' *State Summit on Innovative Transportation Funding & Financing,* Washington DC, June 24, 2008.

[74] See Chapter 2.

Germany's Electronic Truck Toll System[75]

The German federal government, through private sector contract, developed and implemented an electronic satellite-based charging system for heavy commercial vehicles to calculate and collect a road use toll charge based on distance traveled and other characteristic factors. The system covers all heavy commercial vehicles and vehicle combinations weighing at least 12 tons traveling on the 12,000 kilometers of the German autobahn and some major truck roads.

Applied to both German and foreign users, the German system allows an automatic log-on option and a manual log-on option. The automatic log-on option requires retrofit installation of an on-board unit within the vehicle to access GPS satellite signals and other positioning sensors for identifying the toll routes traveled, including time of travel, and enforcement. The on-board GPS-based receiving unit records precise truck travel data by reference to a digital map to automatically determine the number of kilometers driven on a charged route. (The odometer, or tachograph, acts as a back-up mileage counting system.) The on-board unit then calculates the charge based on charging rate information officially entered within the device and transmits this information to a computer center for data processing. Drivers may pay in advance via the Internet. The manual log-on option requires significantly more effort on behalf of the driver.

The German system applies varied charging rates depending upon axle class and emissions category. The system invoices users on a monthly basis and allows numerous methods for payment, including cash and various forms of credit and debit. The toll charge ranges between 9 and 14 cents per kilometer. Strategically located toll checker gantries combined with mobile patrols that scan and monitor trucks in motion ensure payment of the toll charges.

Mature Versus Evolving Technology

As noted in Chapter 1, the maturity of the technology applications for mileage-based charging strongly affects not only selection of the collection system but also the speed of development. Some technology applications available for electronic metering and mileage-based charging systems have reached the point of maturity so that policymakers and system designers can rely upon them without concern that the technology employed will *go out of date*. Other technology applications are still undergoing developmental evolution that may affect the applications employed in mileage-based charging systems. Critical to mileage charging system development, technology researchers must assess which potentially applied technologies have reached the point of maturity and which still evolve.

Necessary Research to Enable Commercial Implementation

Protecting Personal Location Privacy

Methods of protecting personal location privacy while meeting the demands of a mileage charging system require further investigation. Researchers and system designers should examine practical implementations to eliminate the need for the public to accept the *trusted third parties*

[75] http://www.toll-collect.de/frontend/HomepageVP.do;jsessionid=E82BB9F30659A9C210D811CCBAEC93D3 (accessed December 6, 2008)

model—because it may prove difficult to obtain public acceptance of this model for mileage charges—and the options available for enforcement, audit-ability, and the ability to challenge charges.

On-Board Delineation of Zone Boundaries

On-board devices containing receivers of satellite signals from the Global Positioning System (GPS) can be designed for use in a way that electronically marks the borders of geographic and temporal zones for efficient and generally accurate counting and allocation of mileage data while protecting location privacy for motorists. This provides a simple way to mark the boundaries of any jurisdiction implementing mileage charging. Researchers should determine whether on-board delineation of zone boundaries can meet the demands of a fine-grained mileage charging system—statewide zones, county or municipality and congestion zones, facilities—while protecting personal location privacy.

Despite the high capability of GPS receivers, it must be acknowledged that most of the general public associates the acronym *GPS* with terms like *tracking* and *monitoring* of vehicle movements. While GPS receivers cannot by themselves track or monitor vehicle movement, it may facilitate public acceptance of electronic mileage charging if another location device could be found that could efficiently delineate zones and generate data in an accurate and cost effective way.

Generation of Vehicle Miles Traveled Data

Investigators in the United States have tested mileage data generation using both the GPS receiver and the odometer. Trials with GPS receivers reveal higher accuracy in generating mileage data but not without error because of occasional signal blockage.[76] Further, odometer readings are not always perfect. One can expect a difference of two or three percent from actual distance traveled and the odometer-measured distance from normal tire wear or simply from improperly inflated tires. Researchers should determine the relative merits of different methods of mileage data generation.

Discouraging Tampering with On-Vehicle Devices

Motorists desiring to act on an economic incentive to disable an on-vehicle device must encounter resistant engineering and an enforcement procedure discouraging device tampering or other manipulation of zone delineation, data generation or data transfer.[77] If the manufacturer incorporates the device into the vehicle, the motorist must find the receiver difficult to remove without great expense, the mileage-calculating process inaccessible and blockage of data transfer impractical. The motorist may find it easier to disable an after-market device, especially if self installed. Alternatively, system design may supply the motorist with an economic reason not to

[76] Whitty, *Oregon's Mileage Fee Concept and Road User Fee Pilot Program: Final Report*, November 2007, p. 35. http://www.oregon.gov/ODOT/HWY/RUFPP/ruftf_reports.shtml.

[77] For example, some system designers propose that illegal entry into an on-vehicle device would trigger an exception that would notify enforcement authorities. In the system proposed by Popa, Balakrishnan and Blumberg, an enforcement mechanism built into the protocol can detect a variety of tampering behaviors. See footnote 9.

block the signal or tamper with the device, such as suffering an economic disadvantage or losing a desired tax status. Another possibility is development of a program for voluntary adoption of mileage charges in lieu of fuel tax payment. Researchers should determine the methods by which on-vehicle device tampering can be detected and discouraged.

Auditing

Researchers should determine the need for audit-ability of the mileage charging system, both from the point of view of the state and the vehicle owner. The state must have the ability to verify accurate charging of all vehicle operators and ensure appropriate payment. The vehicle operator has a similar need but may want the availability of a detailed breakdown of charges. Researchers should investigate public tolerances for trading-off location privacy against the ability for an itemized bill.

Designing a System for Updating of Geographic and Temporal Zones

Mileage charging system design requires an ability to update for zone boundary changes and rate table adjustments. System designers must determine whether to maintain the zone and rate table information on a central server or, alternatively, within the on-vehicle devices.[78] The flexibility and nimbleness afforded a central server architecture makes updating simple when compared with updating widely distributed on-vehicle devices. Further, maintaining a full history of all of the changes to zones and rates would be much more practical with central server architecture.

Though a regular occurrence for central servers, researchers have demonstrated the feasibility of updating on-vehicle devices only on a small scale in the United States. A 2008 electronic updating of the German heavy vehicle charging system indicates feasibility for this functionality. If system designers choose to maintain the zone and/or rate table information within an on-vehicle device, a confirming test would be necessary for a US system.

Communication Techniques for On-Vehicle Devices

On-vehicle devices can use a variety of techniques to exchange information necessary to compute mileage charges. Researchers should determine the tradeoffs between traditional infrastructure-based networks such as cellular and alternative infrastructure-less networks such as mobile ad-hoc wireless.

Integration with Existing Systems

Any mileage charging system must integrate with current national and international agreements for sharing travel and tax data as well as revenue allocation. These agreements include the International Fuels Tax Agreement and the International Registration Plan. Researchers must identify similar agreements and determine the factors necessary for systemic integration.

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[78] Oregon's Road User Fee Pilot Program tested a model that maintained the geographic zone information within the on-vehicle device and the rate table at the central server. System designers chose this model to keep the duration of the data upload at the fuel pump within acceptable industry standards for credit card transactions.

Open Systems and Additional Applications

Researchers should explore the use of an open platform available for building other applications. Making available other compelling consumer services and applications would make the mileage charging system more attractive to a vehicle owner.

Advisable Research for Mileage Charging Implementation

Retrofitting On-Vehicle Devices

Today's motor vehicles do not have standardized ports and powering systems required for retrofitting of on-vehicle devices. For broad application of a mileage charge system over a short duration, researchers must find an effective way to either create an on-vehicle device that can retrofit into currently owned vehicles without inviting tampering or create an economic system whereby motorists would voluntarily place an on-vehicle device within their vehicles that could collect and transfer mileage data.

Eliminating Mileage Charging for Travel on Private Property

While the gas tax system uses an honor system reimbursement method for gas tax paid for travel on private property, a mileage charge payment system could be enabled to use the electronic means for delineating zones to create *zero rate* zones for private property. Whether this can be accomplished on a landowner-by-landowner basis or whether this must be accomplished system-wide must be researched and tested.

Optional Research for Congestion Charging Implementation

Application of Dynamic Congestion Pricing

Although Oregon and Florida investigators jointly discussed a potentially feasible system for use of GPS receivers for dynamic congestion pricing, such a system has yet to be tested.

Enforcement, Auditing and Challenging a Congestion Charge

Some have suggested that adding congestion charges could make a simple mileage charge auditing system and billing challenges more difficult because charging anomalies would not be as readily determinable. While this may be true for the congestion charge portion, the underlying base mileage charge would remain available for auditing and bill challenging. It seems difficult to imagine that tampering with the congestion charge mileage tabulation will not also affect the underlying basic mileage charge. Prior to using the mileage charging system for congestion pricing, researchers should determine if the base mileage charging system will prove sufficient to guard against tampering for the congestion charge. Alternatively, researchers might determine whether greater location information should be stored within the on-vehicle device to provide a travel history sufficient to ensure proper congestion charging. Generation and retention of greater detail on travel history will affect public acceptability of congestion charging.

Technology and Systems Choices Not Yet Settled

Despite agreement by the principal investigators heretofore in the United States on various system elements for electronic collection of mileage-based charges, several mileage charging areas require additional research to ensure selection of the most appropriate electronic means of zone delineation (as needed), route identification (if necessary), data gathering, data transfer, billing and payment.

Emerging Technologies

Technology in this area evolves rapidly. Technology researchers have projects underway that seek to refine existing technology for better applications. The large motor vehicle manufacturers and FHWA are working on a vehicle-highway infrastructure-integration (V-I-I) initiative. Other new technologies assisting electronic mileage charging implementation may rapidly materialize. Policymakers and system designers must understand the implications of these emerging technologies for mileage charge applications.

Determining the Most Efficient and Cost Effective Data Transfer Technology

Various investigators in the United States have examined several methods for uploading mileage data—regular cellular, periodic cellular, smart cards and short-range radio frequency—but other data transfer methods may prove more efficient and cost effective. For example, mobile ad-hoc wireless networks may require very little infrastructure as the communication nodes themselves form the network. This affords an attractive possibility of using the on-vehicle devices themselves to create their own communications network as an alternative to the considerable investment needed for fixed and inflexible roadside hardware installation. These newer data transfer methods should be identified, thoroughly examined and the most appropriate tested.

Location of Data Transfer

The location at which the mileage data uploads partially depends upon the data transfer technology selected. Options include at home, a DMV office, a fueling station, at commercial locations or while traveling on the highway, perhaps multiple ways to accommodate the motorist. As communication technology evolves, these mechanisms will change. The desirability and feasibility of a given place for data upload will largely depend upon the requirements of the system design, and vice versa.

Determining a Specific Payment Method for Vehicles Powered Either by Non-Liquid and Non-Gaseous Fuel or Home-Fueled

While the mileage charge payment-at-the-fuel-pump method may be the most efficient payment method for liquid and gaseous fuel vehicles, another method must be devised for the vehicles operating purely from an electric charge or operating on energy not purchased from a commercial supplier.

Conception and Application of a Mileage Charge System for Motorcycles And Motorbikes

On-vehicle technology has yet to be tested for two/three-wheel motorized vehicles. Rate table differentiation between these vehicles and four-wheel vehicles has also yet to be undertaken.

Integration with Modern All-Electronic Tolling Systems

A new system of charging by the mile based on modern electronics may present synergies with modern all-electronic tolling systems. A relatively small figure on a national basis, toll road mileage should not be a major factor in selecting a mileage charging system. Nevertheless, the various mileage charging systems developed by investigators in the United States should be able to integrate with modern all electronic tolling systems in some manner. A field test of such systems integration has yet to occur.

Development of a National or Regional Clearinghouse and Revenue Distribution System

An electronic clearinghouse and revenue distribution system would allocate federal, state and municipal mileage and congestion charge revenues. The location and number of central databases and how they would coordinate has yet to be conceptualized and tested.

Additional Technical Issues

Trailers and Boats

The pay-at-the-pump model accommodates motorized vehicles but trailers burden the road system as well, as do boats. To ensure a complete mileage charging system, researchers must undertake analysis of adding or embedding mileage-counting devices into these vehicles as well.

Buses and Light Commercial Vehicles

Trucks having gross registered weights between 10,000 and 26,001 pounds and buses are often taxed differently than either light vehicles or trucks having gross weights over 26,000 pounds. Policy-makers should decide whether buses and *medium weight* trucks should be charged as light vehicles, as heavy vehicles or in separate categories.

Border Jumping

States of large size and states isolated by geography can practically rely on a pay-at-the-pump mileage-based charging system for passenger vehicles with minimal lost revenue through tax avoidance refueling tactics at borders. The pay-at-the-pump model may also prove practical for individual small states to implement without regional cooperation or a national system. Before a state considers implementation of a mileage-based charging system alone, border jumping avoidance tactics must undergo analysis to reveal effects on revenue generation. For a national implementation, jumping international borders would likely prove an impractical avoidance tactic for motorists.

Transition Issues

If policymakers determine that a fuel tax collection system should remain in place either as a primary payment system or as a back-up collection system, or simply during the transition, policymakers and system designers must determine how a mileage charging system will integrate with fuel tax collections. The technology and systems must interoperate and integrate systemically and financially and the applied technology must facilitate this.

For governments implementing an interim mileage charge collection system prior to implementation of a preferred primary model, due consideration must be given to how the two systems would operate together during a transition from one to the other. The authors have determined that transition from a VMT Estimate model to the more comprehensive pay-at-the-pump model would occur without difficulty because both systems can operate simultaneously.

Estimates of Capital and Operating Costs

Primary, Introductory and Interim Systems

Calculating start-up, capital and operating costs will be critical not only for selection of any mileage charging collection system but also for an ability to implement the system. Policymakers should insist upon a complete cost analysis prior to system selection and preparation for implementation. Fortunately, research of cost comparisons for alternative revenue generating systems has begun.[79]

[79] NCHRP Project 19-08, *Cost of Alternative Revenue-Generation Systems.*

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Public Acceptance

Adding a new form of taxation, or replacement of one form of revenue generation for another, imposes major changes on the public. Policymakers should expect most people to struggle with recognition that a long-standing, acceptable and understandable system for funding our roads—the fuel tax—is dying a slow but inevitable death.

People generally do not like the circumstances that require change—in this case, a crumbling and crowded road system with dwindling available revenues during a time of economic crisis—and therefore go through the stages of grief when presented with the inevitability of change: shock, denial, pain, anger, bargaining, depression, and finally acceptance. No one should expect the change to a mileage charging system for roads to undergo any different process.

THREE STEPS TO PUBLIC ACCEPTANCE

Taking the first critical step to achieving public acceptance requires making certain the public understands the problem addressed. The public will never accept a solution for a problem they do not perceive. With many motorists shifting to fuel-efficient vehicles in recent years, a growing yet still small segment of the public now perceives the eventual failure of the gas tax.

While public acceptance of our nation's road revenue dilemma may not be too far off, acceptance of mileage charges for addressing greenhouse gas reduction or congestion relief may be a tougher sell. These policy applications have the potential for impacting how motorists live their daily lives.

The second critical step involves designing a new revenue collection system that takes into account public sensibilities. The motoring public will reject a costly system or one with significant compliance burdens. The system must treat motorists fairly and not unduly compromise privacy. It would help if the new system had the feel of familiarity. The authors identify these concerns in greater detail in Chapter 1.

Even a new road revenue collection mechanism that accommodates every concern of the motoring public will meet skepticism and resistance. That's the nature of the change process. For example, Oregon's Mileage Fee Concept—specifically designed to *make it easy on the motorist*—received intense rancor from many angles when first proposed. Despite careful design to protect privacy, keep capital and operating costs low, integrate well with gas tax collections and keep data transfer and payment simple for the motorist, the proposal in the early years attracted only negative comments, most based on inaccurate assumptions. The authors note that during periods of societal stress the negative comments become more intense than usual.

The third critical step to public acceptance may require introduction of an actual mileage charge proposal complete with privacy protections, cost projections, system impacts on the motorists and a specific rate structure. This way, motorists will understand how the new system affects them personally, particularly the extent of their financial exposure. The general public will not support change to a new road revenue system without knowing how the new system will impact them. Until they understand the impacts of a proposed system, members of the public will project their fears of the unknown into knowledge gaps. They will oppose the change not for what the system does but for what they think it does. Clear communication of an actual proposal may be necessary for public acceptance.

WILL AN "OPT OUT" OPTION PRODUCE GREATER PUBLIC ACCEPTANCE?

The authors' perceive the underlying discomfort many members of the public have with mileage charging relates to a government mandate for a technologically driven system. While much of the fear comes from inaccurate assumptions regarding the mileage charge tests accomplished to date as well as future plans, this discomfort may be difficult to allay for many years unless motorists have a choice whether or how to participate. Conceivably, in order to facilitate acceptance of a mileage charging mandate for new vehicles, motorists having discomfort with participating in an electronic mileage charging system could elect to self-report their travel data manually to a DMV on a periodic basis. Payment in this manner would likely bear the greater cost of administration necessary for this method. The Minnesota Department of Transportation is currently preparing an approach for opting-out of an electronically metered and collected mileage charge in favor of a default option involving manual odometer reading and a flat per mile rate paid with vehicle registration.[80]

While certainly not preferable for a large segment of the motoring population, the option to *opt out* of an electronic mileage charging system may quell the fear of the most intense opponents. For this to be workable, only a small group of motorists could elect this option with most motorists accepting the electronic payment method. Researchers should determine whether this option would improve the chances and timeline for public acceptance. Researchers should also determine feasibility in terms of the extent to which motorists would elect this option as well as the impact on the electronic mileage charge collection system.

A COMMUNICATIONS PROGRAM

After more than seven years of direct contact with the motoring public about mileage charging as a replacement for the gas tax, the authors note that many people have visceral reactions in opposition to mileage charging. Their opposition stems not from the nature of the pilot tests conducted to date nor research plans for the future, but because with so many unknowns about the ultimate mileage charging structure the public fills in details that tend to be highly inaccurate. These *filled-in details* come from erroneous assumptions. Most people simply do not understand the problems mileage charging attempts to solve nor how a mileage charging system actually would work or impact their daily lives.

The authors find that dialogue converts most people to accept the necessity of finding an alternative to fuel taxes. With even more dialogue to unravel the erroneous assumptions, objections soften enough to reveal that public acceptance of a mileage charging system can be

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[80] Ray Starr, in a presentation entitled, "Technology Integration Strategies for Minnesota," at the Symposium for Mileage-Based User Fees in Austin, Texas, April 14, 2009.

achieved. Effective communications, therefore, provides the pathway to public acceptance of mileage-based charging.

A communications program designed for honest and effective dialogue with the public must have a public outreach component and an education component. The program should strive to accomplish public understanding of the problem seeking resolution and the solution proposed.

The communications effort should have three stages, one to explain the problem and focus attention on it, a second at the beginning of policy development and design to identify the public's system requirements, and a third following design of the new system to educate the public about how the system impacts their individual lives. Each stage should employ traditional communication methods, such as surveys, focus groups and interviews, to learn the precise concerns underlying objections to a change from fuel taxes to mileage-based charges. During the first two stages, this research may yield certain policy and systems adjustments necessary for acceptance of a mileage charging system. During the third stage, after policymakers and designers settle on the preferred collection methodology, extensive education may prove necessary to overcome common misunderstandings about certain system elements.

The education process will require specific targeted research on certain key issues. Researchers must determine the nature of the compliance burden the public will accept. They must also determine public expectations for the level of privacy protection required for the technology employed for data generation, transfer and management, and invoicing and payment and how these issues are managed under the new system. This question must be handled carefully as it interrelates with other factors such as the burden of compliance and administrative cost.

With regard to mileage charge rate setting, researchers must evaluate public acceptance and understanding of the opportunities for rate structuring under various policy applications, how the rates affect equity and fairness among motorist classes and whether the general public accepts allowance of subsidies for certain classes such as rural drivers and poorer drivers.

Research must determine the public's ability to gain confidence in the new system. In this regard, the new system must demonstrate an ability to operate efficiently for all charge payers and avoid requiring a large and expensive government bureaucracy to manage it.

A demographic study should reveal the differences within the motoring public regarding the technology applications for the new system. While older drivers tend to fear technology, younger drivers tend to embrace it. Over time, the number of drivers who will accept the technology applications for mileage charging should grow as a percentage of the total motoring public. At the same time, the number of drivers who fear technology will shrink as a percentage of the total motoring public. As a matter of course, any objections to mileage-based charges simply based on discomfort with technology should wane significantly over the next decade and beyond.

Extensive studies should ascertain the socio-economic effects and implications of either continuing the fuels tax system or moving to a mileage charging system. These studies should determine whether the burden shifts from one segment of society to another under either scenario as well as under the various scenarios for policy applications under a mileage-based charging system.

Ultimately, it may well serve policymakers to authorize a public information campaign to ensure public understanding of the new system prior to implementation. This may involve testing of public fears, attitudes and understanding of the proposal, deployment of education techniques designed to correct misunderstandings and inaccurate assumptions and retesting to measure the effectiveness of messages. This process would not involve manipulation of the public but would ensure correct understanding of the nature of a new collection system designed with strict regard for public concerns.

SUMMARY OF NEEDED RESEARCH ON PUBLIC ACCEPTABILITY AND COMMUNICATION

1. Evaluate public understanding and acceptability of the burden imposed for motorist compliance with a new system.
2. Ascertain public expectations for the level of privacy protection required in the context of the technology employed for data generation, transfer and management as well as invoicing and payment and how these issues are managed under the new system.
3. Assess public understanding and acceptance of the opportunities for rate structuring under various policy applications, how the rates affect equity and fairness amongst motorist classes and whether the general public accepts allowance of subsidies for certain classes such as rural drivers and poorer drivers.
4. Undertake a demographic study of the differences within the motoring public regarding the technology applications for the new system.
5. Appraise public confidence in the new system's ability to operate efficiently for all charge payers and avoid requiring a large expensive government bureaucracy to manage it.
6. Assess the socio-economic effects and implications of moving from charging per gallon to charging by mile under whatever policy applications are under analysis, as suggested in Chapter 7.
7. Structure an effective public outreach program.
8. Design an effective public education program.
9. Design a targeted public information campaign for the new system ultimately selected by policymakers.
10. Research should determine whether permitting a voluntary *opt out* from an electronic mileage charge system in favor of motorist self-reporting of mileage data would improve the chances and timeline for public acceptance and the extent to which motorists would opt out of the primary mileage charge collection system and the impact upon that system.

8

Impacts upon Societies and Societal Systems

ECONOMICS AND REVENUE

Behavior

The act of traveling involves considerable expense, involving choice among modes, fuels, base locations, destinations, activities and time-of-day, and reduces remaining income. In addition, all of these factors are subject to rapid change. Finally, independent of these factors, consumers' tastes and preferences constantly change.

In popular lexicon, the term *travel demand* refers to the amount of travel consumed under generalized circumstances (but with consideration of specific time periods). To economists, terms referring to *demand* have a technical meaning. Research involving the analysis of questions concerning the allocation and consumption of resources related to transportation (for example, investment dollars, highway capacity, transit capacity, trip cost, fuel consumption), requires *travel demand* to take on a meaning that considers consumption under many different circumstances. Conceptually, this enables economists to develop demand equations that enable analysis of many different issues.

Clearly, mileage-based charges will have some impact on travel behavior. The impact may be small to quite large depending upon the rate structure. The key to predicting travel behavior is developing demand equations based on empirical data. A fair amount of data is already available from MPO-based simulations and pilot tests.[81] However, these have not yet been synthesized (1) to indicate where data gaps are, and (2) to estimate and validate demand equations for all forms of mileage charges based on MPO data for national application.

Once the appropriate demand equations have been developed, behavioral change as a result of changes to the structure of road user charges can be modeled. While the demand equations themselves focus on travel behavior under different price structures and levels, the process of developing them from a variety of MPO research efforts should also provide the information necessary to enable the equations to vary depending upon other factors such as availability of other modes, patterns of land use, demography and geography, household income, economic structure, etc. Just as there are many factors beyond price that affect travel, there are several very different potential forms of mileage-based charging. The models need to be able to handle these as well.

All of this would enable the effects of mileage-based charges on travel to reflect local conditions or hypothetical conditions resulting from local policy changes. For example, models of this sort enable the status quo to be compared to the effect of a specified form of congestion pricing at current levels of transit service to be compared to the effect of that form of congestion pricing accompanied by improvements in transit service. Comparisons could involve different

[81] See for instance, the Puget Sound Regional Council's *Traffic Choices Study*, the Oregon Department of Transportation's *Oregon Mileage Fee Concept and Road User Fee Pilot Program Final Report*, Resources for the Future's *Marginal Social Cost Pricing on a Transportation Network*, the European cordon pricing projects, the HOT lane projects in the United States, and the various studies produced by FHWA's Value Pricing Pilot Program.

pricing structures, different prices, different modes, and different community characteristics (for example, population density).

Actual model development can occur on either a national basis or an MPO basis. As there are several hundred MPOs, a significant role for central development and refinement coordination seems appropriate. In addition, this sort of modeling can provide insight for policy-making on a national basis—which also argues for a central model analysis capability.

Revenue

The elimination of fuel taxes and the imposition of a variety of mileage-based charges has small to enormous revenue implications, depending on the types of mileage-based charges involved. Such revenues can be estimated from the behavior modeling research outlined above. However, the policy issues related to revenue generation are very different and just as important, and so require separate consideration.

Forecasts of revenue generated by mileage-based charges consistent with forecasts of travel behavior will be based on empirical data, demand equations and models developed through the research suggested above. It is the form of the demand equations (or curves) that determines quantity of travel, by mode (solved simultaneously), for a given price structure (including the price of alternatives to single occupancy vehicles (SOVs). Quantity and price determine gross revenue for each mode.

The cost of collecting mileage-based charges is expected to be significantly greater than the cost of collecting fuel taxes. Consideration of revenue in a social welfare context and in terms of how much can be purchased or reinvested requires calculation of revenues net of collection costs. The need for research on collection costs is discussed elsewhere and is already underway[82]. The point is there may be a very large difference between gross revenue and net revenue, and it is net revenue that matters.

The manner in which net revenue is allocated will be a key consideration of any shift to mileage-based charges. Net revenue from highway user charges has been constrained to highway construction only, used for public transit capital, public transit operations, bicycle and pedestrian programs, and Transportation Enhancements, as well as general governmental purposes. Economic theory indicates net revenues should be invested where they would maximize future net revenues after depreciation and operating expenses under competitive conditions. Unfortunately, theory and reality are not always consistent with each other.

A number of details are extremely important for considering how to use net revenue. The net revenue from a mileage charge only intended to replace fuel taxes is likely to only be used for infrastructure preservation. If this is combined with a charge for environmental damage, the additional net revenue is a payment to all of society for the harm done to it. Theory allows the additional revenue to be used for any purpose, but since it comes from transportation, transportation stakeholders generally argue that it should be used for transportation purposes.

The net revenue from additional congestion charges presents several conundrums. First, congestion pricing is a method of rationing scarce highway capacity. When applied to existing roads, the direct benefits to system users of reduced congestion alone are rarely, if ever, sufficient to make up for the losses suffered by those who have changed behavior or are paying higher charges. This means for users of highways before pricing to be better-off as a result of a

[82] NCHRP Project 19-08, *Costs of Alternative Revenue-Generation Systems*, is underway.

new congestion charge, they need the revenues from congestion pricing to be expended in ways that benefit them[83]. There is no clear process for determining what these are.

Second, while congestion has broad indirect effects, the direct effects of congestion are strictly internal to highway users using highways during peak periods. Any net revenue from congestion charges on highway users used to address the congestion problem should be allocated on the basis of how effectively it solves or partially solves the problem. First order effects indicate these will generally be highway-based, but this is not an absolute.

Third, in this day and age, surface transportation is largely the responsibility of government. Even when government attempts to implement market-based policies, transportation decision-making will be influenced by many non-market issues.

Finally, systems of highways rarely have competitors. Monopolists have an incentive not to invest in additional capacity. This allows both demand and price to increase over time, providing a large boost in revenue at no cost. A government monopolist may be tempted to use a system of congestion pricing as a cash cow for other governmental purposes.

Ultimately, the critical factor for implementation of congestion pricing is public acceptance. Anecdotal evidence from actual experience in Western Europe and New York City's attempt at implementation may be instructive. Cities that can be characterized as *auto-dependent* tend to use the revenue from congestion pricing for highway improvements. Cities that can be characterized as *transit-dependent* tend to use that revenue for transit improvements. It is not clear whether these observations are the result of transportation analysis or political expediency.

One of the major constraints on implementation of congestion pricing is the issue of what to do with the revenue generated. Clearly, there is a need for a framework to be developed that integrates economic theory, potential transportation solutions, and political decision-making. Such a framework could enable our institutions to consider these issues in a coherent manner.

A final set of issues involved with revenue generation concern equity. Equity issues include issues related to income distribution, resource consumption, and household or business location. A small but growing body of research exists that has examined fuel taxes, general taxes, various forms of congestion pricing, and mileage charges and their potential impacts on these equity issues. As with data on mileage-based pricing and travel, these studies have not yet been synthesized into a unified whole.

Unintended Consequences

All change has consequences. A shift to mileage-based charges should produce positive benefits for society. Even so, there will likely be some negative consequences to such a large change. Several of these have already been identified, and stem from potential rate structures and potential rate levels. By understanding them, policymakers can mitigate their effects or at least partially address them.

The most widely noted negative consequence results from shifting the charge basis from quantity of fuel to number of miles traveled. In concept, this eliminates an incentive to conserve fuel and gives a break to operation of vehicles that *guzzle* fuel. In reality, fuel taxes are only a small part of the price of fuel. As a result, a shift to mileage-based charges will have only a small effect on fuel consumption. In addition, a shift to mileage-based charges creates the opportunity

[83] This was conceptualized by Gomez-Ibanez in *The Political Economy of Highway Tolls and Congestion Pricing*, Transportation Quarterly, (July 1992), and confirmed by the findings of the Puget Sound Regional Council in its recent congestion pricing experiment.

to impose other *green* fees such as congestion pricing and environmental charges based on vehicle characteristics. These either cannot be imposed or are difficult to impose through fuel taxes.

The effects congestion pricing will have on traffic patterns—and the resulting side-effects[84]—are not widely understood. One reason is simply a lack of experience. Another is that the information available has not been widely disseminated or publicized. Yet another is the quantity of many different forms of congestion pricing that could be implemented (for example, cordon pricing (with and without time-of-day components), HOT lanes (new and converted), single facility pricing, motorway network pricing, network pricing that varies by segment, queue-jumping fees, Oregon's concept for area pricing). The specific impacts of each are very different, leading to confusion. A synthesis of expected traffic diversion as a result of different types of congestion pricing would be quite useful.

Many congestion pricing structures envision charging different fees for similar facilities in different parts of an urbanized region. Regardless of the economic logic behind the rate structure, highway users of higher priced routes will strongly object to paying higher fees for similar facilities. This is a social-political issue that needs to be recognized and addressed during the rate structure development process. Potential concepts and compromises for dealing with this kind of problem need to be developed.

The current focus on greenhouse gas emissions and other environment concerns implies mileage-based charges may be used to address these issues. Such charges would discourage low-value travel and establish a new source of revenue. They could also have some effect on long-term patterns of land use. What is not clear is the point at which these charges begin to discourage relatively high-value trips or begin to discourage trade, and therefore begin to noticeably affect economic growth. Examination of mileage response to 2008's wild fluctuations in fuel price combined with other modeling efforts[85] could provide some insight into this issue.

The replacement of fuel taxes with mileage-based charges would be a major change. Major changes are often accompanied by unintended consequences. As indicated by the discussion above, transportation practitioners have been working to anticipate as many unintended consequences as possible. Change of this scope, however, will likely have consequences that remain unanticipated. These can be minimized through pilot testing and serious examination of new issues as they arise.

Summary of Needed Research on Economics and Revenue

1. Synthesize the data available from pilot tests and MPO simulations on mileage-based pricing and its affect on travel. Develop demand equations or curves applicable to all forms of mileage-based pricing for national discussion and identify any remaining gaps in the data.
2. Develop a central model analysis capability with a specific focus on transportation pricing.
3. Develop a framework for decision-makers about the allocation of net revenues from congestion pricing. The framework should integrate economic theory, potential transportation solutions, and political reality into a decision-making process.

[84] These include congestion on parallel facilities, additional traffic through neighborhoods, negative air quality impacts, negative or unintended land use impacts, and incorrect revenue forecasts.

[85] See for instance, Safirova, E., et al. "*Marginal Social Cost Pricing on a Transportation Network: A Comparison of Second-Best Policies*," Resources for the Future, 2007.

4. Synthesize the findings of reports that have studied the equity effects of mechanisms that have been used to generate revenue for transportation purposes.
5. Synthesize the effects various forms of congestion pricing will have on traffic diversion and patterns of VMT, and identify the resulting consequences.
6. Develop a toolbox for dealing with the public's objections to charging different congestion prices for similar facilities in different locations.
7. Research the points at which high prices and reduced VMT begin to have a significant impact on economic growth and development.
8. Develop peer-reviewed, long-range, national projections of both VMT and petroleum-based fuel consumption for light and heavy vehicles.

HIGHWAY PRICING, ENERGY POLICY AND GREENHOUSE GAS REDUCTION

It is a fundamental principle of economics that the higher the price of something, the less of it we consume, all else equal. The ability to impose increased prices can be a powerful tool for controlling consumption. As the highway system is primarily in public ownership, units of government have the ability to set prices for its use. However, pricing can easily have multiple effects, including unintended consequences.

For instance, an energy tax placed on all fuels would reduce the use of renewable and carbon-neutral fuels as well as traditional fuels. If the intent is to reduce carbon dioxide emissions, a much more effective tax would leave renewable and carbon-neutral fuels tax-exempt, thus providing an option and incentive to use more of these fuels. The end result would be a much greater reduction in carbon dioxide emissions on a total system basis.

The key to avoiding unintended consequences is to begin with specific policy goals. There are likely to be several, and they will often have aspects that conflict with each other[86]. Once the policy goals are defined, appropriate alternatives for meeting those goals can be identified. At that point, the central problem becomes how to deal with multiple objectives, multiple pricing options, and multiple effects that are sometimes in conflict with one another. This is the problem we are facing in the policy nexus among transportation funding, energy dependence, alternative fuel, and greenhouse gas emissions goals.

Oregon developed a solution that allowed different types of pricing, designed to address different policy goals, to be layered, one upon another. It enables a flat mileage charge in support of highway programs to be overlaid by a congestion charge, to be overlaid by a gas guzzler charge, to be overlaid by a VMT reduction charge, to be overlaid by a local-option charge. These can be analyzed separately for their effects on the targeted policy goals, and jointly when necessary.

Other approaches may be possible. These remain to be identified and tested. A survey of highway pricing techniques and how they may be used to implement different policy goals may be of some use[87]. However, the fundamental problem in this area is adopting pricing techniques that best reflect policy goals. This is primarily an exercise in reasoning; it is not research.

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[86] These may include but are not limited to; paying for highway programs, reducing highway congestion, reducing total VMT, reducing energy intensity of the economy, reducing petroleum consumption, reducing coal consumption, reducing greenhouse gas emissions, optimizing use of electric power generation and distribution systems, etc.
[87] The need for research on the effect different forms of pricing and different price levels have on behavior was covered in a previous section.

PRICING AND LAND USE

The cost and price of transportation has strong effects on where and how land is developed and used. The directions of these effects are well understood, but for road user pricing, the effects have not been widely quantified. In addition, the work that has been done in this area has not been considered in a unified manner for type of pricing, level of pricing, specific structure of pricing, or local characteristics (for example, existing pattern of land use, availability of alternatives, demographics). The most important of these are discussed below.

Flat Charge Price

While flat charges merely intended to replace fuel taxes will modestly cause some households to pay more and some to pay less, the overall effect will be about neutral. As a result, such flat charges should not have any discernable effects on patterns of land use.

Environmental Pricing

Broadly, environmental pricing can be imposed in two basic ways. The simplest is a flat charge reflecting the typical or average environmental impacts of travel, during all hours of every day. This kind of charge would significantly raise the cost of travel for every automobile traveler. It would encourage centralization and discourage sprawl. As many other factors influence business and household location decisions, the land use effects of higher transportation costs should be noticeable but relatively modest. MPOs have modeled these effects on an ad hoc basis. Actual data for urbanized areas in the United States does not exist.

A much more complicated environmental pricing system would consider the environmental impacts of each vehicle as it travels. Pricing of distance traveled by each vehicle could reflect each vehicle's noise, traditional emissions, greenhouse gas emissions, weight, or other characteristics. Vehicles with a large environmental impact would be heavily charged, while those with a small environmental impact may be charged very little. This means owners of environmentally friendly vehicles would have little or no incentive to change locations. Owners of vehicles with a large environmental impact would have an incentive to change locations, but have the ability to eliminate this incentive by replacing an environmentally unfriendly vehicle with an environmentally friendly vehicle. The end result should likely be a very small effect on the pattern of land use. To the authors' knowledge, no one has demonstrated or modeled this sort of pricing in the United States nor its impacts on land use.

Congestion Pricing

Congestion pricing has the potential to induce greater land use changes than environmental pricing, but many of these changes will be perceived as negative unintended consequences. Generally and with exceptions[88], congestion pricing typically penalizes travel to some locations while leaving travel to other locations uncharged. This means the other locations become more likely destinations, while travel to the original locations becomes less likely. This affects housing location, geographical size of labor markets, and manufacturing plant location, as well as retail competitiveness and location.

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[88] These may include conversion of HOV lanes to HOT lanes and Oregon's area pricing concept.

There are many different potential forms and modified forms of congestion pricing. Each of these forms may have very different impacts, in terms of scope and level, on the resulting changes in land use. They should be analyzed individually on an application-by-application basis. A previous section indicated a research need to better understand the effects various forms of congestion pricing will have on traffic diversion. This discussion highlights the importance of understanding how much diverted traffic, resulting from congestion pricing, causes land use to change.

Existing Patterns of Land Use

The long-term magnitude of the effect of transportation pricing on any given pattern of land use will likely depend on the centralization and density characteristics of the existing pattern. An already dense, already centralized pattern of land use will be less affected by increased transportation cost than a less dense, scattered pattern of land use. Any analysis of how transportation pricing affects land use should consider the influence of the existing pattern of land use. Modeling on this subject has been area-specific, and should be studied to quantify the influence of existing patterns on the pricing-land use relationship across many different areas.

Availability of Alternatives

Not only do other modes of transportation serve as alternatives to automobile travel, they serve as alternatives to location change. Their availability will serve to dampen the effects highway pricing would have on land use. The potential for modes of travel to substitute for one another is reasonably well understood in MPO areas. Even so, this is another factor that needs to be considered when examining the effects congestion or environmental pricing have on land use change (see above).

Needed Model Improvements

The models MPOs use to forecast transportation use are mentioned several times above. Transportation modeling is outside the authors' expertise. It seems clear, however, that these models need to be improved to handle the effects of transportation pricing on land use.

Summary of Needed Research on Pricing and Land Use

1. Synthesize the conclusions built into existing MPO models concerning the relationship between transportation cost and *existing* land use density and centralization.
2. Develop models of the impact flat environmental charges will have on land use.
3. Expand these models to reflect environmental pricing on a vehicle-specific basis.
4. Expand the synthesis study on congestion pricing and traffic diversion recommended in the Economics and Revenue section to describe the land use change that occurs as a result of diverted traffic.
5. Support efforts to improve modeling of the effects of transportation pricing on patterns of land use. This may be folded into the central model analysis capability of USDOT.

A National Investigation

STATE VERSUS NATIONAL IMPLEMENTATION

As several states undertake investigations into mileage charging systems, and political acceptance of mileage charging begins to build, the question arises about the best way for the future system to emerge. Though surely the incubators of change, having the states pursue and implement individual mileage charging systems on their own could yield a hodgepodge of disconnected systems that will foil the potential for national adoption or even widespread adoption among states. The national interest calls for a single system that individual states can access and upon which states can build policies.

State by state implementation of mileage charging systems would prove remarkably more difficult than national implementation. Interoperability may become unachievable as states choose different collection methodologies, technologies and policy goals.

Single state implementation would require the cooperation of motor vehicle manufacturers. With the possible exceptions of California or a group of large states working together, an isolated state would likely face tremendous resistance in imposing equipment standards on vehicle manufacturers.

Implementation by an individual state or group of states would require special systems, potentially cumbersome, for charging out-of-state vehicles.[89] For states wanting to allow congestion pricing, environmental charging or local-option charges, charging out-of-state vehicles becomes exceedingly cumbersome and impractical when considering legal requirements.

National implementation resolves the difficulties described above or renders them much less problematic. Nonetheless, though difficult to resolve, individual states can surmount these problems. Even if Congress does not mandate national implementation, the Federal government could play a vital coordination role for these states.

A system for collection of mileage-based charges from heavy commercial vehicle operators will likely differ from a system that collects mileage-based charges from light vehicles. As a result, Congress may adopt a system of mileage-based charges for one set of users and not the other, or that significantly differs from the other.

In any event, moving to an alternative road revenue system should be more compelling for the Federal government than for state governments. Though heavily reliant upon gas tax revenues, most states have substantial additional revenue sources contributing to state highway funds. Since about 90 percent of the Federal Highway Trust Fund consists of fuel tax revenue, the Federal government has the most at stake in finding and implementing a suitable gas tax alternative as soon as possible. Further, a federal mileage charge may be more difficult to impose if the states adopt widely differing collection systems. A national collection system, on

[89] Oregon's pay-at-the-pump model manages out-of-state drivers rather simply. If the mileage reading system does not identify the motorist as a mileage charge paying vehicle, the operator pays the fuel tax. Applying congestion pricing charges under this system, however, will require special, cumbersome systems for out-of-state motorists.

the other hand, can be designed to accommodate state applications. It therefore becomes incumbent upon the Federal government to take charge of mileage charge development and proceed with due haste.

APPROACH FOR A NATIONAL INVESTIGATION

Timeline for Completion of Development and Implementation

The Federal government should establish a short, demanding timeline for completion of preparation for implementation of a federally supported mileage-charge system. The goal would be for any state or the Federal government to have the option of immediate implementation of a mileage-based charging system upon completion of preparation.

The authors recommend a development timeline of six years from Congressional enactment of the 2009 National Surface Transportation Authorization legislation. This period should include testing of viable concepts through several pilot programs. Though a six-year development period may seem extraordinarily aggressive, with enough commitment, leadership, staffing, funding and freedom from administrative restrictions, the Federal government can accomplish a six-year development period provided development efforts proceed concurrently rather than consecutively. Following the development period, national consensus building leading to implementation should occur during the next six-year period.

Our national government has completed development of extensive technical programs under short timelines in the past.[90] Commitment to a short development timeline relates directly to the perceived nature of the crisis at hand. Our nation's current road funding crisis will grow in intensity over the next decade. Rather than act from the current severity, our nation's policymakers should recognize future conditions and act accordingly.

Policy Oversight Body

An independent policy oversight body should direct policy and system development of a national mileage-based charging system according to policy guidelines provided by Congress. The form and structure of the policy oversight body should ensure the ability to operate swiftly and efficiently. The national commission model should receive due consideration because of its historical familiarity and effectiveness. Members should include representation from the states, metropolitan planning organizations, federal agencies, the business community, including automobile and trucking industries, non-governmental organizations, the National Academy of Sciences, the American Association of State Highway & Transportation Officials, among other stakeholders.

Constructed to build national consensus, the policy oversight body would provide leadership over the project teams and oversee the entire development effort, including the distribution of research and development funding. The policy oversight body should assume the critical role of understanding public perceptions and educating the public during the developmental period but also into the implementation period in order to assist in development of a national consensus on mileage charging in the United States.

[90] The Manhattan Project and the 1969 lunar landing come to mind, among others.

National-Level Project Teams

The Federal government should establish two technical project teams to undertake development work for the following investigatory subject areas:

- *Passenger vehicle project team*, for coordinating work on implementation of mileage-based charges for passenger vehicles.
- *Motor carrier project team*, for coordinating work on design and implementation of an electronic weight and mileage-based charging system for heavy commercial vehicles that could replace existing diesel taxes and truck fees.

Each team should be interdisciplinary, including economists, policy analysts, systems analysts, data transfer specialists, data management specialists, and experts on fuels tax collections and auditing, computing technology, communication systems and vehicle technology.

The two teams should coordinate with each other and consult with interested parties. The passenger vehicle project team would consult with automobile manufacturers and the fuel and electricity distribution industries, among others. The motor carrier project team would consult with the trucking industry and other affected stakeholders.

The project teams should commence work with high-level policy oversight, perhaps the Secretary of Transportation. Each project team should immediately begin to develop specifications for a secure on-vehicle mileage-counting device so this technology could be available for broad deployment at the earliest date possible. The project teams should also immediately begin review and development of technology and systems for transmitting mileage data from vehicles to charge collection systems.

Reports to Congress

The policy oversight body should prepare three reports to Congress during the development period.

Phase One Report to Congress

Within 12 months of enactment of the authorizing legislation, the policy oversight body would review and analyze relevant prior work completed or underway within the United States and internationally and issue a Phase One Report to USDOT and Congress on various issues related to implementation of a mileage-based charging system. This report would include the following issues relating to the fundamentals described in Chapter 1.

- Feasibility of implementation
  - Identification of potential collection mechanisms
  - Capital costs
  - System operations costs
  - Systemic risk and redundancy
  - Integration with other tax collection systems
  - Seamlessness of transition
  - Technological reliability and security and mitigation of component failures

  - Retrofitting vehicles
- Evasion and avoidance risks
- Collection and enforcement effectiveness
- Privacy protection and audit ability
- Ease of use by the motoring public
- Breadth of payer base
- Transparency and ability to send a price signal
- Adaptability for congestion pricing
- Adaptability for environmental pricing and recovery of externalities, including acting as a carbon tax surrogate
- Potential for inclusion of an option for adoption by local government jurisdictions
- Benefit/cost analysis of mileage charging system alternatives, including comparisons of alternatives that are integrated with existing state, local and private sector operating systems, all within the context of likely vehicle market acceptance factors, likely policy choices and public acceptability
- Optimum system architecture
- Equipment specifications
- Integration with VII
- Possible phase-in schedule

This Phase One Report should recommend the advisability of replacing or augmenting the fuels tax with a mileage-based charge. If the policy oversight body recommends replacement of the fuels tax with a mileage-based charge, this report would develop the outlines of the preferred system architecture and identify key *pivot issues* for decision through additional analysis and research and development activities.

Phase One Report cost: $5 million

Phase Two Report to Congress

Within 18 months of issuance of the Phase One Report, the policy oversight body would issue a Phase Two Report that provides a determination of the feasibility of transitioning to a mileage-based charging system. This report would:

- Make policy recommendations on the key pivot issues that determine system design and public acceptance;
- Define an evolutionary system addressing the issues raised in Chapter 2;
- Determine a likely rate structure, as discussed in Chapter 3;
- Address the specific research needs identified in Chapters 5 through 8; and
- Finalize recommendations on system architecture for permanent, introductory, and interim systems, as needed.

Phase Two Report cost: $7 million

Concurrent Investigations

Given the urgency of this nation's road funding crisis, research and development efforts for a new funding mechanism should proceed concurrently rather than consecutively. This means some tasks should begin before completion of other tasks that may affect them. It also means many of the activities under phase two should begin while phase one is still underway. The authors recognize the risk in this approach. Researchers and developers will by necessity have to make certain assumptions about findings and policy decisions prior to official determinations. As a result, assessment mistakes might lead to proceeding down blind alleys and abandoned approaches. Well known to private sector technology companies, USDOT staff and Congress must accept the added risk of concurrent development as the necessary price for rapid development.

Phase Three Report to Congress

Within 42 months of issuance of the Phase Two Report, the policy oversight body would issue a Phase Three Report that provides results and conclusions from activities undertaken by Phase Three:

- Statewide pilot programs for testing, public outreach and Congressional education
- A broad scale pilot program in preparation for ultimate adoption, building from the statewide pilot program research efforts
- Refinement of system technology to commercial viability, including setting final technology component specifications and database requirements
- Identification of transition issues and required steps
- Development of a full implementation timeline
- Development of data to enable congressional staff to advance statements of fiscal impact for directly related legislation in 2015

Phase Three Report cost: $60 million

Technology Test and Pilot Programs

As part of Phase Three, the policy oversight body should direct several technology tests and pilot programs that prepare the nation for implementation of the preferred mileage-based charging system, and perhaps an interim system as well.

Potential Pilot Programs

The Federal government should identify several states willing to conduct pilot programs to advance specific aspects of the research agenda. In order to assure timely completion, USDOT should grant appropriate relief from administrative regulations for research efforts under these pilot programs. The authors suggest the following directed pilot studies:

- *Technology Refinement Pilot Program for the Closed System Pay-at-the-pump Model*. This study would select and commercially refine the optimum technologies for the pay-at-the-pump model and include integration of equipment in vehicle manufacturing and fueling station processes and anti-tampering strategies. This study would develop a timeline for commencement of deployment through full implementation and complete capital and operating costs estimates.

- *Central Billing Pilot Program.* This study would complete system development for the central billing approach and test the central billing system operationally. This study would develop a timeline for commencement of deployment through full implementation and complete capital and operating costs estimates.
- *Open System Pilot Program for the Integrated Approach*. This study would integrate the pay-at-the-pump model with elements of the central billing model under an open system that is cryptographically secure with after-market on-vehicle devices, addressing privacy, enforcement, and auditing issues. This study would test voluntary adoption of this mileage charging system. This study would develop a timeline for commencement of deployment through full implementation and complete capital and operating costs estimates.
- *Electronic Toll Road Integration Pilot Program.* This study would examine and test integration of mileage charging systems with modern electronic tolling technology and toll roads.
- *VMT Estimate Pilot Program.* This study would complete development and prove implementation viability for this interim mileage charging collection system.
- *Electronic Weight-Distance Tax Pilot Program for Heavy Commercial Vehicles.* This study would identify and deploy the technology and systems necessary for imposition of an electronic weight-distance tax for the motor carrier fleet applied either in one state or in several contiguous states. This study would develop a timeline for commencement of deployment through full implementation and complete capital and operating costs estimates.
- *Multi-State Contiguous Broad Scale Pilot Program.* In preparation for commencement of implementation of a mileage charging system nationally, it will be necessary to conduct a multi-state pilot program for contiguous states that tests on a broad-scale the preferred mileage charging collection system identified by the policy oversight body. This study will test the preferred system, including its interstate data and charge collection and distribution elements. Such a test might be conducted by contiguous member states of the I-95 Corridor Coalition or the West Coast Corridor Coalition.

These pilot programs should be conducted by states currently taking concrete steps toward electronic mileage charging system development such as Massachusetts, Minnesota, Oregon and Texas. Consideration should also be given to other states showing interest such as Florida, New York, Pennsylvania, Ohio, California, Washington, Nevada and Colorado.

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Conclusions and Recommendations

CONCLUSIONS

A general consensus has formed around recognition that the United States must transition from the fuel tax as the primary way we fund our road system. The intriguing possibility of replacing or augmenting the fuels tax with a mileage-based charging system continues to garner support. Organizations such as the American Association of State Highway & Transportation Officials, the U.S. Chamber of Commerce Foundation, the National Conference of State Legislatures and the American Road Transportation Builders Association all support transitioning to mileage-based charges. Further, two congressionally created national commissions advise making a paradigm shift to mileage charging, the National Surface Transportation Policy and Revenue Study Commission and the National Surface Transportation Infrastructure Financing Commission.

Despite growing support for transitioning to per-mile charging, a consensus has yet to form around how to collect mileage charges. Some seek a simple system, like a tax based on self-reporting of annual mileage data. Not really all that simple, consideration of practical implementation requirements for the self-reporting method reveals deep flaws.

In this paper the authors propose an evolutionary mileage charging system and strategy that can employ effective available solutions for our current and near future vehicles while continually adjusting for policy needs and creating the future systems needed for emerging travel alternatives. In an era of great change, we must become accustomed to constant motion and adjustments.

To obtain efficiency and adaptability, the new mileage charging system must necessarily rely heavily rely upon electronics. The fundamental question will be whether the new system will be open or closed. A closed system may yield certain outcomes yet a long timeline to full implementation. An open system may provide greater public acceptance yet is an unknown pathway.

This paper poses the proposition that electronic mileage-based charging is not only feasible for both passenger vehicles and heavy commercial vehicles but that the nation ought to confirm this through a national investigation. The authors propose an intensive preparatory program and timeline for implementation of a mileage charging system.

The suggested mileage charging system and associated strategies have the ability to not only fund our road system but also to accommodate policies related to other driving-associated problems of our age: congestion management, greenhouse gas reduction and attaining energy independence.

FUNDAMENTAL RECOMMENDATIONS

Our national government should do the following within the next six years:

- Identify and complete development of mileage-based charging collection systems for motorists fueling at commercial stations and those fueling or recharging elsewhere that can be implemented nationally or commonly by individual states.
- Design and complete system development for an electronic weight-distance tax for heavy commercial trucks for adoption nationally or by individual states.
- Engage the public throughout the development process in order to gauge public attitudes on various mileage charging system elements, including education and communication on all elements, so that a national consensus may form on the advisability of mileage charging in the United States and the most appropriate form for the new system.

These efforts should receive full funding and staffing and the regulatory freedom to proceed aggressively and expeditiously.

The Secretary of Transportation should have the authority to impose system technology requirements upon the automotive industry, particularly mandating that automakers design for installation of on-vehicle mileage charging technology, whether on a closed or open system basis, commencing before the end of the mileage charging system development period. This will facilitate adoption of a mileage charging system following completion of development by any state or the Federal government.

Appendix A

MILEAGE CHARGE SYSTEMS COMPARISON CHART

	Revenue Sustainability			Rate Flexibility			System Characteristics				Timeline		
	Precision as User Charge	Fuel Efficiency Protection	Inflation Escalator	Local Jurisdiction Charges	Enables Congestion Pricing	Environmental Pricing	Ease of Motorist Use	Privacy Protection	Operating Cost of Collection	System Capital Costs	Technology Platform	Time to Commencement of System Application	Estimated Timeline for Full System Application
Pay at the Pump	Yes	Yes	Allows	Allows	Yes	Allows	High	Allows	Low	Moderate	Closed	8 years*	25 to 30 years **
Pay Monthly Billing	Yes	Yes	Allows	Allows	Yes	Allows	Moderate	Allows	High	Moderate to High	Flexible	8 years*	25 to 30 years **
Integrated Approach	Yes	Yes	Allows	Allows	Yes	Allows	Very High	Allows	Variable	Moderate	Open	5 or 6 years***	12 to 15 years**
Annual Read and Pay at DMV	Yes	Yes	Allows	Allows	Yes	Allows	Low	Allows	High	Low to Moderate	Closed	8 years*	25 to 30 years **
VMT Estimate	Moderate	Yes	Allows	No	Somewhat	Allows	High	Yes	Low	Low* to High**	Closed	4 years***	4 to 8 years ***
Fuel Taxes	Low-Moderate^	No	Poor Track Record	Allows	No	Somewhat	High	Yes	Low	N/A	N/A	N/A	N/A

^ Depends upon the vehicle
^^ Depends upon open platform viability

Positive (green)
Neutral (yellow)
Negative (pink)

* Applied only to new cars
** Applied to every car
*** Applied either to new cars or every car
N/A Not Applicable