



NEVADA DEPARTMENT OF TRANSPORTATION

NEVADA
VEHICLE MILES TRAVELED (VMT)
FEE STUDY - Phase 1



December 2010



**State of Nevada
Department of Transportation**



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EXECUTIVE SUMMARY

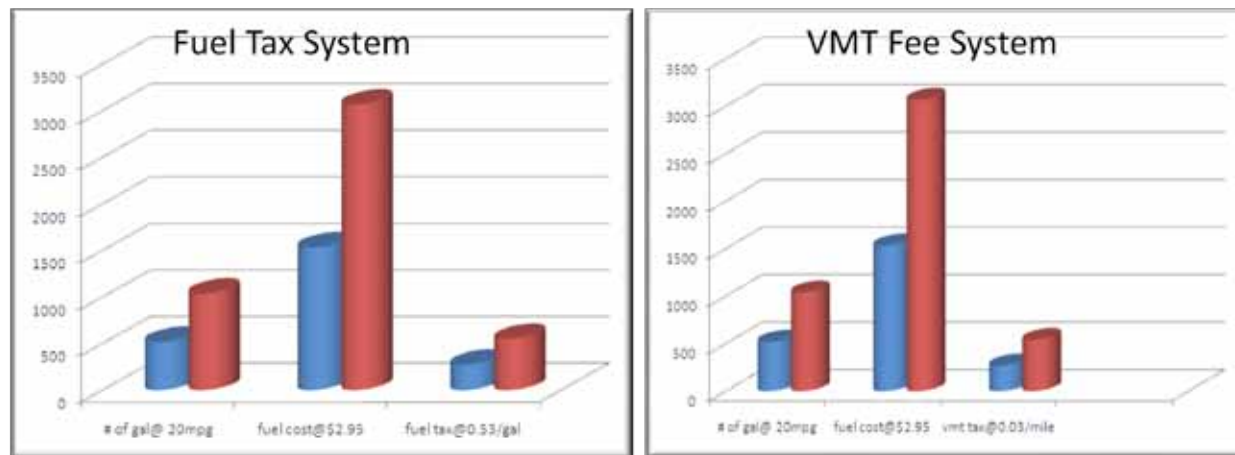
The Nevada Department of Transportation (NDOT) in collaboration with the University of Nevada Reno and University of Nevada Las Vegas initiated a “Vehicle Miles Traveled (VMT) fee” research study in 2009 to assess and evaluate the feasibility and workability of an alternative, sustainable, easy-to-use, equitable, cost-effective, and future-oriented viable transportation funding mechanism that will potentially replace the current fuel tax funding mechanism and that will adequately meet the future transportation needs of the State of Nevada. The primary objectives of this research project are to: a) assess and evaluate the feasibility of a VMT fee collection and payment mechanism specific to the State of Nevada, b) conduct proactive public outreach and education effort to educate the public, elected officials, various stakeholders, and decision makers about the critical future funding shortfalls and limitations of the current fuel tax system, c) identify and address the significant elements associated with the concept of a VMT fee and, d) design a VMT Fee Pilot Program for Nevada. The Nevada VMT Fee Study consists of three phases as listed below:

Phase I of the study was initiated in 2009 and completed in 2010. The major components of Phase I of the study include: 1) conduct comprehensive literature review of VMT fee studies evaluated by other States to avoid duplication of efforts and to only focus on the areas that have not been adequately identified and answered in the other studies, 2) conduct comprehensive public outreach and education through public meetings, workshops, newspaper editorials, newsletters, opinion surveys in the rural and urban areas, videos, and presentations to solicit input, identify concerns and answer questions from the various stakeholders, the public, and decision makers, 3) assess and evaluate any potential privacy impacts of a VMT fee payment mechanism, 4) analyze institutional, policy, legislative, and legal aspects of a VMT fee payment mechanism, 5) develop economic models to assess and recommend equitable VMT fee for different vehicle sizes and types, and 6) design a pilot program protocol that will be used in a future VMT Pilot Program to study the feasibility of a VMT fee mechanism in Nevada.

Phase II of the study began in November 2010 and will be completed in June 2011. It will include conducting a field test to assess the feasibility and workability of implementing the new payment mechanism on a small scale. Approximately 40 volunteer vehicles will participate in the field test. The emphasis of the field test will be on a simple and user friendly at-the-pump payment and collection mechanism that will minimize privacy concerns. The pump sensor will read the vehicle odometer miles each time the vehicle goes to the pump to purchase fuel. The sensor will then apply an established rate and calculate the fee. Other components of Phase II include: identifying and defining the initial costs and operation and maintenance costs, defining the administrative structure, conducting public outreach, assessing the legal and policy aspects of a VMT program, identifying the auditing capabilities, analyzing the privacy aspects of the VMT Fee program, and developing the at-the-pump payment mechanism.

Phase III of the study will include conducting a VMT Fee Pilot Program in which a few hundred volunteer vehicles will participate to assess, evaluate and analyze the major components of a future VMT fee collection and payment mechanism, and to develop recommendations based on the pilot program data.

It is a general and common misconception that rural residents and people who have longer commute will pay more under a VMT Fee system. As shown in the figures below, the more we drive the more we pay in fuel cost and fuel taxes under the current fuel tax system. This will not be any different in the VMT Fee system; the more we drive the more we will pay in VMT fees.



Usage	miles/yr	Fuel Consumption @ 25mpg	Existing fuel tax system fuel tax@\$0.53/gal	VMT payment system VMT fee @\$0.021/mile
40 mile/day	10400	520 gal	\$ 275	\$ 275
80 miles/day	20800	1040 gal	\$ 551	\$ 541

Figure 1. Irrespective of the fuel taxes or the VMT fees; the more we drive the more we pay

Example 1 Under the Fuel Tax system

1. A person drives 40 miles a day – 10400/yr @ 25 mpg, 416 gals @\$2.9, fuel taxes @ 53 cents/gal = \$220

Under the VMT payment system

1. A person drives 40 miles a day- 10400/yr @25mpg, 416 gals@\$2.37, VMT fee @ 2.1 cents/mile = \$220

Example 2:

Under the Fuel Tax system

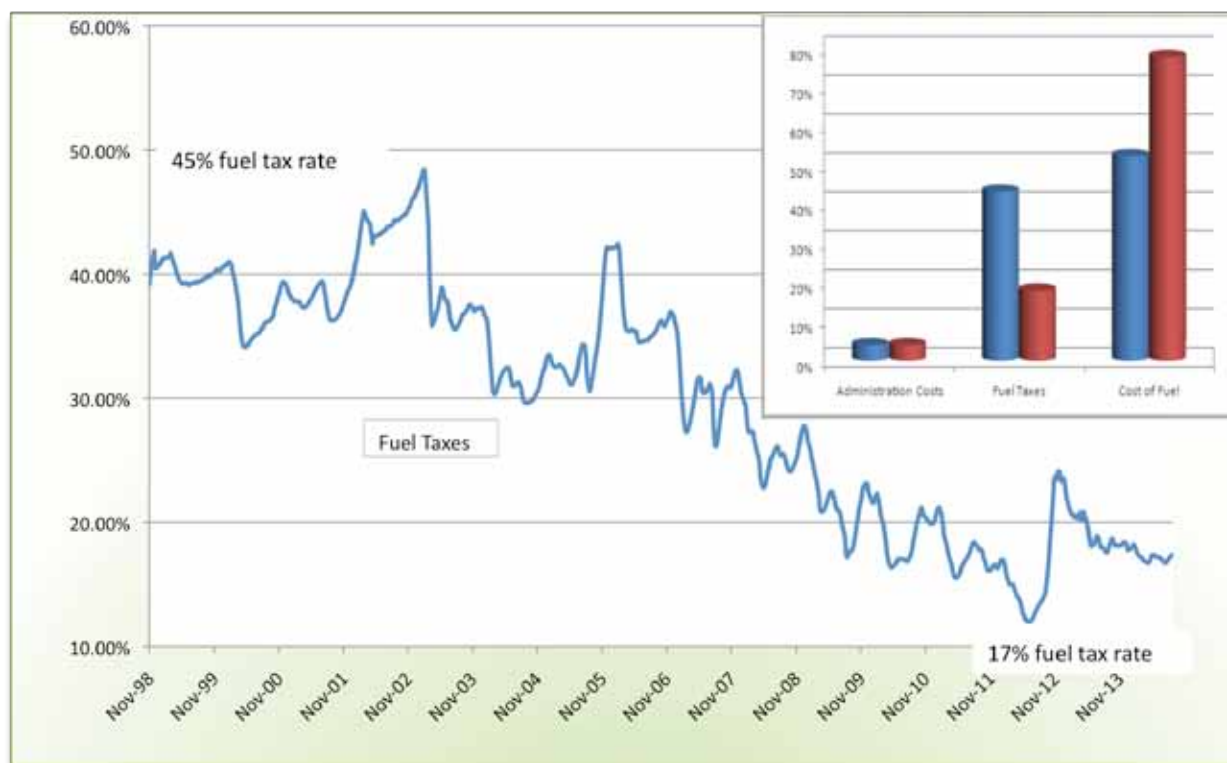
2. A person drives 70 miles a day – 18200/yr @ 25 mpg, 728 gals @\$2.9, fuel taxes @ 53 cents/gal = \$386

Under the VMT payment system

2. A person drives 70 miles a day – 18200/yr @ 25 mpg, 728 gals @\$2.37, VMT fee @ 2.1 cents/mile = \$386

In 1993, the pump price of a gallon of fuel was about \$1.22 and the fuel tax per gallon was about 53 cents in Nevada, meaning that the effective fuel tax rate (ratio of fuel tax to fuel price per gallon) was about 43%. In 2009 the price of a gallon of fuel raised to about \$3.10 per gallon, yet the fuel tax per gallon stayed the same - 53 cents per gallon, meaning that the effective fuel tax

rate dropped to about 17%. As shown in the figure below, the price of fuel has increased significantly, whereas the fuel tax rate has consistently decreased and today we are only paying about 17% in fuel taxes, which means the effective fuel tax rate has reduced by almost one third compared to 1993. At the same time, the cost of construction and inflation increased multifold, further limiting the ability to construct, operate, and maintain the transportation system.



Year	Fuel Price per Gallon at Pump	Administration Costs	Fuel Taxes	Cost of Fuel
1993	\$1.22	\$0.05 - 4%	\$0.53 - 43%	\$0.64 - 53%
2010	\$2.95	\$0.12 - 4%	\$0.53 - 18%	\$2.30 - 78%

Figure 2. The effective fuel tax rate* per gallon has declined from 43% in 1993 to 18% in 2010

* Effective fuel tax rate is the ratio of fuel tax to the total fuel price per gallon in a given year.

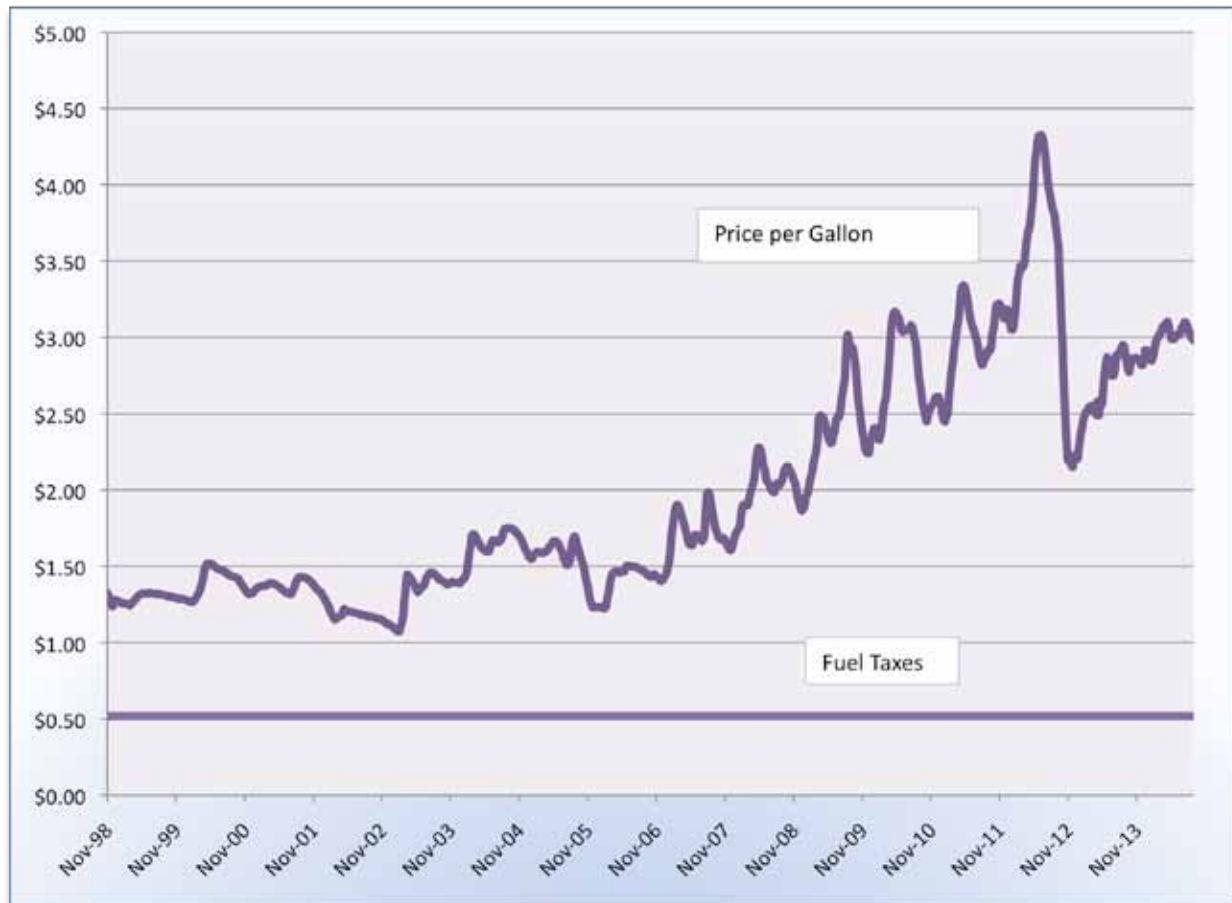


Figure 3. Price of Fuel per gallon has increased; whereas Fuel Taxes have remained flat

In conclusion, it should be noted that:

- Transitioning to other payment and collection mechanisms will probably take a decade or more but the process of exploring the options must start now.
- Public understanding and acceptance of any new payment and collection mechanism is the key to success.
- The new payment and collection mechanism will need to be phased-in to account for the older vehicles.
- The new payment and collection mechanism will need to be a collaborative effort of many States across the nation, and will need to be implemented at the national level.

This report is organized into eight major sections. Executive summaries from each section are included as follows:

1. LITERATURE REVIEW

This section provides a review of studies related to VMT fee programs in the U.S. and throughout the world. The following are the major findings of the literature review;

The current fuel tax has several advantages that include: a) provides substantial income, b) administration is easy and inexpensive; c) has low fraud potential; d) protects consumers' privacy.

However, the current fuel tax mechanism also has several disadvantages including: a) it is generally not indexed for inflation; b) it is lower in the U.S. than other developed countries; c) it decreases as the number of fuel efficient vehicles increase; d) it is not reducing the gap between revenue and transportation needs; e) it will not be a sustainable source of revenue in the future.

The five main issues for implementing a VMT Fee Pilot Program are technology, pricing policy, privacy protection, public acceptance, and institutional relationships.

The technology issues reported in previous studies mainly focused on the following: a) determining location and time of travel, b) measuring the distance traveled, c) transmitting billing data, d) maintaining privacy, and e) eliminating fraud and evasion. Most of the studies proposed a phase-in strategy. Existing vehicles would have the option of paying through the current fuel tax system until the general vehicle fleet transitions to new vehicles with VMT technology.

Generally, the application of a VMT fee pricing policy includes congestion pricing and cost based on time of day and roadway functional classification. In addition, vehicle weights can be incorporated into the VMT fee pricing policy. The results of one congestion pricing study indicated reductions in three travel parameters: 7% of all vehicle trips, 8% of vehicle travel time, and 13% of miles traveled on busy freeways.

On the issue of privacy, one study revealed that no matter how clearly the privacy protection strategies were explained; there were still people who were against the idea of using GPS technology for charging mileage user fees.

Public acceptance, and subsequent political support, is essential for implementing VMT fee programs. Two critical issues for public acceptance were pricing equity and privacy.

The major institutional issues include a framework for VMT fee collection and the revenue distribution among several jurisdictions. Any institutional mechanism that could replace the fuel tax will likely cost much more than the current cost (i.e., 2% of the revenue).

2. PUBLIC OUTREACH AND EDUCATION

This section contains information on the VMT fee study public outreach and education, including workshops and public meetings conducted in Reno and Las Vegas. The major objective of this effort was to conduct comprehensive public outreach and education through public meetings, workshops, newspaper editorials, newsletters, opinion surveys in the rural and urban areas, videos, and presentations to solicit input, identify concerns and answer questions from the various stakeholders, the public, elected officials, and transportation decision makers.

WORKSHOPS

The Reno workshop was conducted on May 9, 2009 and the Las Vegas workshop was conducted on August 19, 2009. Both workshops were conducted from 8:00 AM to 12:00 PM and approximately twenty invitees attended each workshop. In addition to the invitees, a number of project team members were present to make presentations or facilitate the discussions.

The most important activities at the workshops were the breakout sessions, where the attendees were divided into four groups providing feedback on the most important VMT fee issues dealing with policy, administrative, privacy, and technology concerns. Policy and privacy issues were ranked as the first and second most significant issues in both workshops. Attendees at the Reno workshop ranked technology related issues as third and administrative issues as fourth. The Las Vegas attendees ranked the administrative issues higher than the technology related issues. Reno attendees did not want the VMT fee data to be collected by a private firm and showed more trust in a public body in charge of the program. Las Vegas attendees suggested that “social benefits should prevail over individual privacy concerns.” However, the Las Vegas attendees also emphasized the need to protect privacy and making sure that the system is reliable and secure.

The discussions in both workshops suggest the need to properly define the concept of the equity in the fee collection system. As a matter of policy, an equitable system will need to be properly defined and presented to the public for their understanding and acceptance in the upcoming public meetings.

In lieu of the immediate funding shortfalls and since the implementation of a possible VMT fee system is at least a decade away, there is a need for more immediate actions. In other words, an intermediate funding solution is needed to bridge the current fuel tax system with a future VMT fee mechanism. The workshop attendees commented that this issue will need to be addressed by NDOT and RTCs prior to any upcoming public meeting. The workshop attendees emphasized the need to educate the public of the funding shortfalls. They also recommended that through an outreach program, such as the upcoming public meetings, inform the public on the reasons for pursuing alternatives to the current fuel tax system.

PUBLIC MEETINGS

In addition to the workshops, two public meetings were held. The first public meeting was held on Tuesday, March 30, 2010 from 4:00 PM to 7:00 PM at the Reno Sparks Convention Center with 75 people in attendance. The second public meeting was held on Thursday, April 29, 2010

from 4:00 PM to 7:00 PM at the Clark County Government Building with 45 people in attendance.

At the public meetings a series of stations were set up and covered by the research team to discuss various aspects of the VMT Fee Study including reasons for the study, other studies in the U.S., technology, privacy, and policy issues. An exit survey was provided to the attendees to obtain further input from the public.

Both public meetings were successfully conducted however there were some issues. Neither public meeting had a large turnout (i.e., 75 attendees in Reno, 45 in Las Vegas). The lower turnout in Las Vegas may have to do with location of the meeting and traveling during PM rush hour period. Both public meetings had media in attendance. The media did not interfere with the researchers' presentations and discussions.

The public was generally satisfied with the public meetings, indicating that the public meeting addressed their concerns, and that they learned new information, based on the exit survey results. They also stated that the visual aids and handouts were clear and concise. Privacy and policy were listed as items that need additional explanation. This is similar to our workshops findings where privacy and policy issues were ranked as the most important issues.

Approximately half the attendees who responded to the survey indicated that they may be willing to participate in the Pilot Program but over half of them indicated that they are not willing to have VMT technology in their vehicles for the Pilot Program. Many public meetings attendees also found the information presented discouraging. As the research continues to progress and more findings become available, we will be able to provide more concise information on the VMT and Pilot Program technology and hopefully alleviate some of the concerns.

Over seventy percent of attendees who responded to the survey questions were either very satisfied or satisfied with the public meetings held in Reno and Las Vegas.

3. INSTITUTIONAL ASPECTS

A successful Pilot Program will require a well established program management structure and adequate funding. This section discusses the management of the Pilot Program including identifying and addressing the institutional issues. The institutional issues have been separated into the following categories: a) administrative, b) cost, c) funding, d) outreach, e) hardware & software, f) VMT fee structures, g) billing and collection and h) participants. Prior to implementing the Pilot Program, the administrative issues must be addressed. The administrative areas include: purpose and objectives, organization, duties and responsibilities, processes and procedures, and final deliverables. Cost is a major institutional issue that needs to be determined. This section discusses the costs associated with startup, operation, maintenance, enforcement, and auditing of the Pilot Program activities. The Pilot Program potential funding sources include United States Department of Transportation (USDOT), Federal Highway Administration (FHWA), NDOT, regional and local entities, and private organizations. The hardware and software issues identified are availability, accuracy, reliability, security, privacy, expandability, and integration. This section discusses various VMT fee structures including a

break-even rate, variable fee rate, and a flat fee rate. Finally, recruitment, qualifications, screening, and training of potential Pilot Program participants are discussed. In summary, a successful Pilot Program will require a comprehensive set of protocols that cover all the institutional issues discussed in this section.

4. PRIVACY ASPECTS

The purpose of this section is to address privacy and security aspects. In this section, a set of policies are presented for greater public acceptance of data collection for a VMT fee program in the future.

For the most part, other pilot programs have focused on two aspects of data security – technological feasibility and participant’s willingness to disclose information. The VII Privacy Policies Framework provides nine principles that are critical in guiding development of specific privacy policies linked to VMT fee collection. However, even those nine principles leave considerable leeway for interpretation of what might constitute appropriate types of information for collection, adequate notice, or even what data might be shared and under what circumstances. The Pilot Program must go beyond a focus on information security and fully address the range of privacy concerns articulated in the VII principles. A field test must be matched with extensive governmental outreach activities that simulate as much as possible, real-life road pricing situations, information gathering regimens and administrative practices that will ultimately be part of a VMT fee system. The importance of field testing the various administrative elements is as critical as testing and verifying technology. For a statewide VMT fee to be implemented, legislative authorization will be required – not only for the collection of fees and authorization of a program budget, but also to insure that basic elements of individual privacy protection are provided. Such privacy protections, as noted in the VII, are likely to protect privacy at a level higher than that required by the Fourth Amendment. This will require action by the legislature and will greatly influence subsequent implementation by whatever entity is designated to oversee a VMT fee system. It is therefore prudent that field tests provide a range of administrative recommendations that can be forwarded with some range of confidence to legislative leaders. The field tests of such administrative measures should be developed from the VII principles and through shared experience with other pilot programs. If these tests are done with full reporting to the public – as the pilot program progresses – public acceptance is likely to be enhanced. As the VII argues, privacy concerns must be a “first priority” for VMT fee implementation and this first priority should be incorporated into the Pilot Program.

5. ECONOMIC MODELS

The primary objective of this section was to develop optional VMT fee structures. First, the section discusses the current fuel tax system. It states that the current system faces challenges including a loss of purchasing power, a decreasing tax base, and lack of incorporating indirect user travel costs. Second, the section examines historical patterns of VMT, fuel efficiency, and gasoline sales in the U.S. and Nevada. It finds that gasoline sales have not kept pace with VMT mainly due to the improved fuel efficiency. Third, the section introduces six VMT fee structures and discusses their advantages and disadvantages. Considering fairness and data availability, and assuming the VMT fee is accepted by the public, it is recommended that a variable fee

model that charges fees for different vehicle types be utilized for the short term. In the long run, the section argues for a full cost model because it makes travelers pay their full cost including both direct and indirect user costs.

6. PARTICIPANTS SELECTION

The Pilot Program requires the selection of volunteer participants. In the Pilot Program, a simple onboard device will read the mileage information directly from the vehicle odometer fee to calculate the vehicle miles traveled based fee. The success of the Pilot Program relies substantially on properly selecting and addressing the payment mechanism, economic model, and social elements. This section discusses the key issues in choosing participants for the Pilot Program, recruiting participants, and a recommended sampling methodology. The key issues can be divided into a few general categories: vehicle type, transportation behavior, demographic considerations, and social and political attitudes.

The first step in the volunteer participant's selection is to determine the policy target population. In the case of Pilot Program, there are several target populations, to include the following: a) residential drivers – drivers who primarily travel locally within their relative communities; b) traditional commuters – drivers who commute to and from work during peak periods of the day; c) intrastate drivers – drivers who engage in regional travel; and d) interstate travelers – drivers who travel for recreation and tourism purposes, while a larger portion are commercial (large trucks) travelers. Additionally, to evaluate the potential of widespread application of a VMT Fee, the participants will need to include a mixture of vehicles – gasoline and diesel, small and large - and both male and female drivers.

Recruitment will be done through web posting, invitation, and public service announcements. Prospective participants should have the following qualifications: valid driver's license, willingness to abide by Pilot Program terms, particular vehicle type, and acceptable participant demographics.

After the prospective participants meet basic qualifications, they will go through a screening process to further refine the pool of participants. All individuals, who have indicated that they wish to participate in the Pilot Program, will have to sign a informed consent form indicating that if they are chosen from the pool of participants, they agree to participate in the study. Next, the participant training will be conducted consisting of informational sessions, hands on practice with hardware and software, and discussion of protocols for reporting errors or malfunctions.

In order to effectively educate and inform the public about the Pilot Program, there must be publicity, engagement, and a period of assessment. The public outreach must be extensive to create a broad understanding of the current funding problem, the Pilot Program, the method of implementation, and the anticipated impact on individual system users. The outreach will include newspaper, radio, TV, interviews, website, providing speakers, public service announcements and press releases, etc. Additionally, an advisory group of stakeholders is recommended to meet regularly to review the Pilot Program activities and offer comments to the contractor and Management Group.

7. PILOT PROGRAM PROTOCOL DESIGN

A successful Pilot Program requires an effective management structure and adequate funding.

The purpose of the Pilot Program will be to study the feasibility and workability of implementing a VMT fee system in Nevada.

The Pilot Program will be conducted by private contractor. The advantages of having a private contractor conduct the Pilot Program include cost effectiveness, clear roles and responsibilities, and timely deliverables. The Pilot Program will be overseen by Pilot Program Management Group, which consists of dedicated personnel from (NDOT) technical experts from private industry and universities, affected state and local agencies, and others as required by NDOT. The Pilot Program Management Group will need the necessary support in staffing and budget to successfully oversee the Pilot Program.

The following costs are discussed in this section: start up, operations, maintenance, evasion enforcement, and auditing. At this time, the costs have not been estimated for a Pilot Program. During Phase 2 of this study, cost estimates for the Pilot Program will be developed for the contract for Phase 3 – conducting the Pilot Program.

For the Pilot Program, potential funding sources include the USDOT, FHWA, NDOT, local and regional entities, and private organizations. In order to approach these groups, the following activities are recommended: documenting current work, public outreach, distributing informational materials at “proper” locations, use networking, holding workshops / public meetings, and being transparent with funding sources.

An important part of the Pilot Program is evaluating whether the goals and objectives of the Pilot Program have been met. Evaluation includes the analysis and comparison of actual progress versus prior plans, oriented toward improving plans for future implementation. It is recommended that a separate contractor (e.g., academic research team) be selected for the evaluation to avoid the appearance of any conflict of interest.

1. LITERATURE REVIEW

1.1 INTRODUCTION

The vehicle fuel tax, which is based on the tax per gallon, has been the main source of collection road revenues in Nevada since 1923. The Federal Government began collecting gas taxes in 1932, but did not dedicate the gas taxes to highways until 1956. Today fuel taxes collected by the federal, state and many local governments are used to fund the planning, design, construction, maintenance and operation of our roadways, and to support public transit systems. The fuel tax, in essence, is the road user fee. Currently, the Federal tax is 18.4 cents/gallon for gasoline and 24.4 cents/gallon for diesel. In the State of Nevada, these tax rates are 18.455 cents/gallon and 27.5 cents/gallon, respectively. In Washoe County there is local and Regional Transportation Commission gasoline taxes totaling 17.53 cents/gallon that is indexed to inflation, but there is no local tax on Diesel. The fact that it worked well for many decades proves that the fuel tax policy has its advantages, thus many people believe that it will remain the mainstay of highway finance for many years. However, many researchers have stated that the fuel tax in the United States is too low (1,2); thus, the current fuel taxes need to increase. Others have stated that in the future, fuel taxes will become less reliable because of emerging alternative means for energy. The use of hybrid gasoline/electric, electric, natural gas and other means of vehicle propulsion is diminishing the use of gasoline and diesel, and subsequently reducing the fuel tax revenues. Consequently, it is clear that the current gas tax must be replaced by a different revenue collection method. Following the concept of road users paying for the roadway system, a new revenue mechanism is needed that can directly relate to the cost of road usage. The distance-based road user fee is considered an effective solution to this dilemma. According to this new concept, road users are charged by the amount of roadway travel instead of how much gas they consume.

The primary objective of this study is to design a pilot project for implementing and testing a VMT Fee Study program in Nevada. The pilot project, if successful in addressing the major concerns, hopefully will eventually be implemented state-wide. This section provides a comprehensive review of similar studies found in the literature.

1.2 CURRENT FUEL-TAX SYSTEM

1.2.1 ADVANTAGES

There are several advantages associated with the current fuel-tax system as described below:

- It has generated substantial revenues for many decades.
- It is easy to collect and administer. The tax is directly collected from a small number of gasoline wholesale distributors or refineries. Retail stations reimburse the gasoline distributors, and the motorists, in the end, reimburse the retail stations.
- It involves a low administrative cost. According to Martin Wachs's study (1), the way of collecting fuel taxes (i.e., collecting from whole sellers and refineries instead of the

public) generate less administering cost. He also compared the cost of administering between fuel taxes and the traditional manual toll collection, and stated that the traditional manual toll collection costs twenty to twenty-five percent of the revenue, while the fuel tax only takes one or two percent of the revenue (1).

- It has less fraud potential. The fuel tax is paid directly by the distributors which reduces the possibility of fraud. Wachs stated that a certain kind of dye is added to the taxed fuel to change its color, thus it is easy to identify if the fuel has been taxed or not (1).
- It ensures the consumers' privacy. Consumers pay fuel tax while paying for the fuel at the pumps, anonymously by cash if desired.

1.2.2 DISADVANTAGES

The disadvantages of the current fuel-tax system are summarized below:

FUEL TAXES ARE GENERALLY NOT INDEXED FOR INFLATION.

Currently, the fuel tax is levied by volume rather than price, thus it does not increase automatically with the inflation. As a result, the revenue loses purchase power of time. For example, the state of Nevada collects 18.4 cents, Clark County 15.35 cent and Washoe County 17.53 cents in fuel taxes per gallon of gasoline. The state tax rate has not been changed since 1992; however, the local portion is indexed to inflation. In addition, the last increase in Federal fuel taxes was in 1993. Meanwhile, many other forms of taxes, for example sales, property, and income taxes, have successfully kept up with the inflation. Since the last increase in state and federal fuel taxes, there has been a significant reduction, about 50%, in purchase power.

FUEL TAXES IN THE U.S. ARE LOW COMPARED WITH OTHER DEVELOPED COUNTRIES.

Ian and Kenneth (2) stated that an ideal scheme of gas taxation should include pollution caused by vehicle emission, transportation congestion during peak hours, and the probability of causing accidents. They stated that Britain has the highest fuel tax rate among industrial countries and the United States is the lowest. The high fuel tax in Britain is due to several important "external costs of driving." These are: "1) penalize gasoline consumption because of pollution, such as the greenhouse gas, hydrocarbon, nitrous oxides, etc.; 2) raise the cost of driving and, therefore, indirectly reduce traffic congestion and traffic-related accidents; 3) provide significant government revenue (3)." According to their analysis, the gasoline tax in the United States should be \$1.01/gal which is more than double the current rate.

INCREASING NUMBER OF FUEL EFFICIENT VEHICLES TENDS TO REDUCE THE FUEL TAX REVENUE.

According to some statistics on vehicle fuel economy, new cars improved from 14.2 miles per gallon (MPG) in 1974 to 28.6 MPG in 1997 (4). This means that with the same amount of gas tax, newer vehicles could travel more than twice the distance compared with new vehicles two decades earlier. Besides, Hagquist stated that "the 2007 Corporate Average Fuel Economy (CAFE) standard for the fuel efficiency of new vehicles is 11.7 kilometers per liter, km/l (27.5 miles per gallon, mi/gal) for cars and 9.4 km/l (22.2 mi/gal) for light trucks. Some commercial hybrid vehicles already on the road attain double those figures (5)." These statistics show that even without considering inflation, the fuel tax revenue erodes by the increased purchase of fuel

efficient vehicles. Furthermore, whenever, there is an increase in fuel prices, people are more willing to purchase more fuel efficient vehicles. This, of course reduces the gas tax revenue to the government. Therefore, the gap between road revenues and roadway infrastructure construction and maintenance cost will increase. Many researchers believe that in the near future due to new vehicle technology, road users will no longer be paying enough fuel taxes to support their roadway system.

REVENUE-NEED GAP IS GROWING BETWEEN FUEL TAXES AND TRANSPORTATION PROJECTS.

It is well known the purchasing power of money is reduced by inflation. Any transportation project requires expenditure for right-of-way, labor, and materials; however, due to the impact of inflation, these all cost more than before. As stated earlier, the current fuel-tax policy does not generally include inflation. In addition, the cost of highway projects has increased beyond the general rate of inflation. As a result, the purchasing power of the fuel tax revenue reduces even more (6). For example in Nevada, the state's 18.4-cent per gallon fuel tax has not increased since 1992. Meanwhile, highway construction prices rose 99.7 percent nationally. Furthermore, according to the Blue Ribbon Task Force (2006) "Nevada's per capita highway travel has increased 6.8 percent and per capita fuel use has declined 8.3 percent since the state's fuel taxes were last raised in 1992. Ultimately, Nevada's highways are being traveled more heavily, using less fuel per capita, and at a tax rate that does not account for 14 years of inflation (7)." In addition, "from 2003 to 2005, the Consumer Price Index increased just 6.1 percent, while the Federal-Aid Highway Construction Price Index rose 40.2 percent. At the federal level, the Highway Trust Fund is projected to go into deficit by 2010 if current spending levels continue without additional revenues. Future reliance on federal funding to address Nevada's shortfall is not realistic (8)."

1.2.3 NEW REVENUE ALTERNATIVES

If we maintain the current fuel tax structure, the fuel-tax revenues will keep declining. In addition, due to increase in vehicle mile traveled (VMT), there is an increasing demand for highway system expansion. However, raising the fuel tax is not the solution to this problem since it is not a politically popular decision. To provide better roadway revenue stream, the current revenue mechanism must be replaced by a method, which is not dependent on the quantity of fuel sold. The new revenue scheme should have a more "equitable" fee structure, which will require motorists paying in proportion to their travel and to the costs they impose on the roadway. Considering this concept, the mileage-based user fee is proposed as an alternative road financing method. This concept has been given different names and scopes by different studies, but is commonly referred to as "mileage-based user fee (mileage fee)" or "distance-user fee."

In 2006, the Transportation Research Board (TRB) published a special report on the fuel tax and other alternatives for transportation funding (9). They reported that charging the road users by vehicle miles (VMT) has many advantages. If fuel taxes are substituted by mileage fees, the revenue will not be influenced by the vehicle fuel efficiency, in other words, the innovations in vehicle technology and alternative fuels will not endanger the roadway revenues. The TRB report also stated that "if the use of all roads were monitored and charged for, local governments

could readily fund their streets and roads with revenues from the user fees, as the states do now, rather than relying on more general revenue sources. More importantly, the benefits of the system to travelers and the public could be substantially increased, since travelers would have incentives to use roads more efficiently and road authorities would have better information to guide investment decisions (10).”

Besides the mileage fee, many other kinds of road pricing applications are investigated to achieve various objectives including “facility congestion tolls, cordon (or area) congestion tolls, weight-distance truck tolls, and distance-based price variabilization (11)”. “For facility tolls, users pay a fee to use transportation facilities, like a bridge, tunnel, or specified section of highway, the level of which depends on the ambient level congestion. Usually, these programs are to ensure free-flowing traffic, thus maximizing capacity. For cordon congestion tolls, users are charged to enter a specified charging zone during peak hours, which usually surrounds a congested urban area. This type of program is mostly to reduce demand, therefore easing congestion and pollution. For weight-distance truck tolls, trucks need to pay the fee to use the road system based on their weight and distance traveled. Depending on the specific program, the measurement of weight may be based on actual weight, maximum laden weight, or axle configuration. As we know, heavy vehicles cause most of damage to roads; therefore, such tolls are designed to recover the costs caused by the heavy vehicles on the road network. In distance-base price variabilization, variable prices based on mileage traveled are used to substitute the currently fixed charge of vehicle ownership and usage, such as registration fees, leasing fees, and insurance (11)”. Based on a VMT Fee Study, motorists could save money by traveling less, which might result in a decrease in VMT, thereby ease problems related to congestion and environmental pollution. These road pricing applications can be used to serve many objectives, such as collecting the road revenue, charging equitable costs, reducing traffic congestion, improving safety and efficiency protecting environment, and diminishing pavement damage (12). Even though these programs may not have the same objectives as the mileage user fee program, the lessons learned about techniques, pricing policy, institutional issues, and public acceptance will contribute know to any mileage user fee program.

1.3 OVERVIEW OF PREVIOUS STUDIES

Since 1980’s, many countries have invested hundreds of millions of dollars annually to study various Intelligent Transportation System (ITS) technologies (13). Many of these investments have been directed toward toll and road pricing systems. This literature review contains both international and domestic studies.

1.3.1 INTERNATIONAL STUDIES

Sorensen and Taylor (14) provided a comprehensive review of the international studies on different fuel tax and user charging methods. The majority of these studies were conducted in European countries.

The European Commission conducted a study between 2000 and 2004, “Pricing Road Use for Greater Responsibility, Efficiency, and Sustainability in Cities (PRoGRESS) (15)”. The overall objective of PRoGRESS was to “demonstrate and evaluate the effectiveness and acceptance of

integrated urban transportation pricing schemes to achieve the operational goals and, at the same time, raise roadway revenue (16).” The project was conducted in eight European cities: Bristol, Copenhagen, Edinburgh, Genoa, Gothenburg, Helsinki, Rome, and Trondheim. Seven of these eight cities (excluding Helsinki), have implemented various methods of road pricing schemes by charging fee using cordons, areas, zones and distance. Different technologies, including Dedicated Short Range Communication, Automatic Number Plate Recognition, and Global Positioning System (GPS) were adopted by these cities. The work in Helsinki focused on modeling the effects of different road pricing schemes. According to their findings, a road pricing program would get more public support if the program could reduce congestion and eventually improve transportation systems. Also, a successful delivery of road pricing objectives can help eliminate opposition. In addition, the trials from two locations (Copenhagen and Gothenburg) showed that “surveillance was not a big issue for the participants (17)”.

In 2001, the “MobiMiles” Program was proposed by the Dutch Ministry of Transport, Public Works, and Water Management as part of the Dutch National Traffic and Transport Plan (18). The program was intended to introduce a new road pricing system which charges user fee based on the vehicle location, time of the day, and the impact to environment caused by the vehicle. By doing this, the new method integrated how much drivers needed to pay with how much road facilities they actual used. Therefore, the influence on drivers’ behavior due to the new pricing scheme would also be studies. The ultimate objectives of this program were to improve the transportation system, reduce congestion, and protect environment. Even though, according to Pieper’s study, “the MobiMiles Proposal has received extremely broad support both within the market and amongst political parties and activist groups (19)” and “the GSM standard development process has showed that Europe can successfully work together on technical issues (20)”, the program was cancelled in 2002 after “the election of a new, more conservative government (21)”.

In the United Kingdom, the new charging mechanism of road user fee was studied to solve issues, such as the congestion due to saturation of vehicle ownership, and the foreign heavy vehicles using the British roadway for free. Blythe et al. from University of Newcastle (22), summarized the projects from previous studies, which are the first cordon toll at Durham and the congestion charge in central London, which were designed to reduce traffic demand, and also the “field-trials” in Leeds. Those cases all achieved their goals. According to Blythe et al., the technology issues would not be the obstacle of the implementation of those programs; however, the different objectives of the programs, such as “local hypothecated charges” and “national tax-raising measures” may confuse the public and make them hard to be implemented.

In 2003, the European Commission proposed that all vehicles in Europe should pay road tolls electronically. In the same year, the European Space Agency conducted a project entitled ‘Active Road Management Assisted by Satellite’ (ARMAS) (23). The objectives of this project are to improve safety, increase dynamic traffic management capabilities, and provide electronic fee collection mechanisms. Phase I of this project studied the technological feasibility, privacy issue and liability issue, and also provided a “rough prototype” for institutional, legal, and safety issues. In the following year, Phase II was conducted to show the capability of ARMAS program in traffic safety, traffic management and “virtual tolling” by “demonstrating the functionalities in tolling based on using satellite positioning on highways and urban areas (Zone

Tolling), warning provision, and SOS request (23).” In that phase, some critical issues, such as positioning accuracy and fraud detection were studied by several countries including Great Britain, Portugal, Ireland, and Netherlands. Phase III took place from August 2006 to December 2007 to “bring the ARMAS ‘product’ close to market (24)” and “develop the common platform which is interoperable with multiple scheme/application types and which can be tailored to the requirements of local solutions (24).” A final ARMAS workshop was scheduled on September 26th, 2008, which was intended to present the key findings achieved during Phase III. However, the detailed information of this workshop has not been found by the authors of this literature review.

In 2005, a new road user fee system, called LKW-MAUT, was introduced for German autobahns for all trucks weighing 12 tons or more (25). This new toll system is capable of performing automatic tax collection from all heavy vehicles using German autobahns based on the distance driven, with the consideration of vehicle characteristics, such as the number of axles and exhaust emissions. There are three methods of paying the user fees: 1) for vehicles equipped with On-Board-Units which are featured by GPS and, user fees are paid via wireless transaction; 2) for vehicles without, it needs to pay at “toll payment terminals at motorway service stations or rest areas” by “entering the details of their journey and pay the toll in advance (25)”; 3) taxes can be also paid via internet for people who are willing to pay it in advance. In this program, the average charge is €0.135 per kilometer and it raises sufficient road user revenue around €2.4 billion per year. The toll system was constructed and administered by a private company called Toll Collect. The road user fee revenue is used by the government to maintain existing roads and construct new ones.

1.3.2 DOMESTIC STUDIES

In the United States, several studies and possible legislations have been initiated for VMT Fee studies. This is to address the serious shortfalls of roadway revenue based on the current fuel tax schemes.

1.3.2.1 OREGON STUDY

Mileage fee is not a new concept for Oregon. This idea has been used in truck toll for many years. The State of Oregon has experience with truck mileage fee program for several years. According to the FHWA statistics of 2007, the mileage fee of ton-mileage tax in Oregon produces \$191 million. This is the highest revenue among the nine states with similar programs (26). Oregon rates are from \$0.04 to \$0.185 per mile depending on the truck’s registered weight and number of axles. Trucks are subjected only to the weight-distance tax and not the state fuel tax.

Since 2001, the Oregon Legislature established the Road User Fee Task Force to identify new road user revenue strategies (27). Eventually, the task force recommended to the Oregon Legislature and the Oregon Department of Transportation (ODOT) the test of a new revenue concept based on mileage and congestion costs.

In 2006 ODOT launched a 12-month pilot program, with 299 volunteer motorists and two service stations in Portland. Overall, the pilot program found that the mileage fee program is feasible by using existing technologies, and the new concept was largely supported by a majority of participants in the trial. The Pilot Program also demonstrated that the privacy can be protected with certain technology.

TECHNOLOGY ISSUE

In Oregon's mileage fee final report (29), detailed information about technological adoption and application was provided. On-vehicle devices were installed onto the participating vehicles. The device included a dashboard display, a GPS receiver and an antenna to track the miles driven in pre-defined zones and the time of travel, a mileage counter unit, and a short-range radio frequency antenna. Travel information including mileage traveled, time of day, vehicle appearance in specific zones was transmitted by on-vehicle devices to wireless readers installed at the service stations via "2.45 GHz radio frequency communication (28)", thus appropriate fees were calculated and collected at the gas pumps. The "OBDII device" (similar to vehicle odometer) and the "GPS-only device" were the two optional devices for mileage counting. Both devices obtain the mileage from the odometers. However, it required retro-fitting the vehicles with the on-board devices that to connect the odometer. In addition, for the purpose of collecting mileage fee and congestion fee, the technology applied needed to identify vehicle travel during specific time and within designated areas. There were three options to fulfill this goal: 1) using GPS to differentiate the geographic zones, days of the week, and times of the day 2) using Automatic Vehicle Identification (AVI) when there are boundary crossings; 3) using cellular technology rather than GPS receivers. However "the infrastructure required for ubiquitous coverage currently does not exist (30)". GPS was adopted in the end, considering accuracy, cost and functionality. When vehicles were at the gas station to be refueled, the pump recognized vehicles and charged vehicles with a mileage-base fee instead of gas tax. At the beginning stages of the program, two optional manual methods were considered. Those methods require participants to either use scanners to scan bar codes provided to participating vehicles in advance, or swipe a card at the pump. Under the principle of causing participants less trouble, the pilot program adopted a wireless connection to achieve vehicle-to-pump communication. The wireless signal was sent out by the on-vehicle devices to the pump so that the participating vehicles were recognized and were not charged the conventional gas tax. This technology proved viable because of motorists' privacy, operation costs, and convenience to motorists and service station operations. Mileage traveled needed to be stored for charging the mileage user fee. Two options for data collection and storage were discussed: "central storage" and "on-vehicle storage." In the pilot program, mileage data were stored in the data center which provided data to calculate road user fees for the vehicles between refueling stops.

PUBLIC ACCEPTANCE ISSUE

According to Oregon's experience, effective communication with the motoring public is the key to gain public consent. By communicating with motoring public for six years, ODOT realized that "public policymakers must adequately address before public consent for a mileage fee system can be achieved (31)."

The public attention on this program was mainly focusing on five aspects, which were privacy protection, rate equity, fairness, technology reliability, and costs to vehicle owners.

1. Privacy Protection

The Oregon pilot program designed a system which only collected necessary data for mileage fee application. The on-vehicle device that ODOT designed did not send an identifying signal out to denote vehicle's real time travel. Thus, a vehicle's movements were not tracked by anyone. Also, the on-vehicle device did not retain any travel history. "No one, therefore, with a search warrant or court order could obtain that travel history because no travel history exists (32)."

"The only compromise to privacy for the Oregon Concept involves ODOT obtaining the identification of the vehicle, the gasoline amount purchased and mileage totals in each zone during refueling. There are ways to design a mileage fee collection system at the pump without providing any of this data but severe compromises to ODOT's ability to enforce fee payment would have to be made. Still, a legislative body could make this choice (32)."

According to Oregon's experience, no matter how clearly they explained their privacy protection strategies; there were still people who were against the idea of using GPS technology for charging mileage user fee. Those people misunderstand the GPS technology and may resist accepting any other techniques for electronic collection of mileage fee. Oregon study suggested that the concerns of this group of people should not be reason to discard electronic collection of mileage fee. However, their concerns should not be ignored.

2. Rate Equity

In the Oregon's pilot program, a flat mileage fee rate was tested, which was questioned by many as not being equitable. Some arguments were based on an incorrect assumption that "the variance in the weight of passenger vehicles creates a variance in the damages done to the road with the heaviest passenger vehicles doing the most damage (33)". According to those people, the heavier a passenger vehicle, the higher the mileage fee rates should be. However, researchers in Oregon stated, "on a microscopic physical level, this may be true; on a cost recovery basis the damage passenger vehicles do to pavement has little variability with no difference at all to the underlying road infrastructure (and the most expensive part of a road to repair) (34)." According to their experience, the only difference of road damage made by vehicles exists between heavy trucks and passenger vehicles; therefore, the difference in fee was only between these two types of vehicle. In contrast, the flat mileage fee rate in the pilot program, at certain level, tends to discourage people from using more fuel efficient vehicles. Consequently, ODOT developed another fee structure to encourage fuel efficiency.

3. Fairness

The public concern of fairness mainly focused on two issues. First, some people thought vehicles that generated less impact on environment should pay lower fees. Considering only the environment, this argument was true. However, when the use of the road by each

motorist was taken into consideration, it was more important that motorists pay for the proportion of roadway capacity they occupy. Second, some people worried about system security and potential for cheating. According to the Oregon’s pilot study, the current security features were not sufficient for statewide implementation.

4. Technology Reliability

According to the Oregon mileage fee project final report, the reliability, accuracy and security were three issues that most people were concerned about. These issues were also raised by the task force and ODOT. According to the report (27), since ODOT requests “the highest level of assurance of technological reliability and accuracy”, ODOT engaged world class technology firms to develop the technology proposed for the Oregon Concept to the point of commercial viability (35).”

5. Cost

Some people were concerned about the cost of implementation and operation. “Actually, cost control was one of the central goals in developing the Oregon Concept. ODOT developed the collection at the fuel pump method to avoid the massive capital and operational costs associated with centralized mileage fee collection. Operations costs—essentially for auditing—would be about the same as for the gas tax. The Oregon Mileage Fee Concept could be implemented and operated statewide affordably (35).”

1.3.2.2 IOWA STUDY

Starting from 1999, the University of Iowa has been conducting a national evaluation of a distance-based gas tax system (36). This study is funded by the Federal Highway Administration (FHWA) and fifteen departments of transportation serving California, Connecticut, Iowa, Kansas, Michigan, Minnesota, Missouri, North Carolina, Ohio, Oregon, South Carolina, Texas, Utah, Washington, and Wisconsin. The study is examining the public policy, privacy, institutional, and technical issues related to a new road user fee mechanism. One of the conclusions of the study thus far, is that the best method for assessing road user charges is the actual miles traveled, called a vehicle miles of travel (VMT) user charge.

The project is in its second phase - a four-year field testing and evaluation phase. Six sites were chosen for the field test, including 1) Austin, Texas; 2) Baltimore, Maryland; 3) Boise, Idaho; 4) Eastern Iowa; 5) the Research Triangle Region of North Carolina; and 6) San Diego, California. It is anticipated that this methodology will be ready for broad implementation after the project is completed.

PRIVACY ISSUE

In the Iowa study, researchers investigated the “legal foundations of privacy and concluded that even if extensive data were collected, the new approach would not constitute a legal infringement of user’s privacy (38).” “Two features are keys to maximizing public acceptance of the new approach. First, the data on road use stored on board the vehicle and transmitted to the collection center should be as non-specific as possible (i.e., should not reveal which roads were traveled or when). Second, the collection center at which the data are processed should be operated by a private firm working under a stringent series of controls. Under no circumstances

should these data be used for any purpose other than assessing road user charges (38).” The storage of only user fee data is considered as a measure of privacy protection, thus, the public will feel more comfortable with this storage strategy.

1.3.2.3 PUGET SOUND (WASHINGTON) TRAFFIC CHOICES STUDY

As early as 1995, the Puget Sound Region Council, which is the regional transportation, economic and growth planning agency for the central Puget Sound region in the State of Washington, created a Transportation Pricing Task Force to find ways for road pricing for the Puget Sound Region (39). In 2002, they received a grant from FHWA to conduct a pilot project to study drivers’ behavior changes due to variable roadway tolling. The Traffic Choices Study had three objectives: “(i) analyze road user’s choice and behavior under a broad and sustained tolling experiment, (ii) understand the key policy variables and requirements related to the implementation of road tolling, and (iii) test an integrated system of technical solutions to the problem of tolling a large network of roads without installing substantial physical hardware on the roadside. The Traffic Choices Study is the most comprehensive study of demand response to network tolling in existence (40).”

In this study, the driving behavior of 450 volunteer drivers with vehicles from over 275 households was monitored for approximately 18 months. A baseline “before-tolling” driving routine was first established, and then volunteers were charged a toll for accessing selected roadway facilities at particular time periods during the day. However, they did not lose money. “They were given an account (their travel budget, or endowment account) from which tolls were deducted. If their driving patterns remained unchanged over the experiment, they would “spend” their account balance by the time the experiment concluded. If they changed their driving patterns to reduce the amount of driving on ‘toll roads’, they would keep the difference. This method held participants financially harmless, yet offered them the incentive of keeping their leftover budget if they changed their driving patterns. In this way, the study introduced real price incentives of a toll system, and measured whether and how much participants responded to those incentives (41).”

This study concluded that 1) the program might reduce traffic congestion and raise road revenues; 2) the core technology is mature and reliable in field implementation; 3) “a large-scale U.S. deployment of a GPS-based road tolling program will depend on proven systems, a viable business model, and public acceptance of underlying concepts (42).”

PRICING ISSUE

In this program, the congestion fee varied according to three different time periods. There was no charge for off-peak hours. For the period between off-peak and peak hours, which they called shoulder hours, moderate congestion charges were applied. During the peak hours, full congestion charges were applied. In the study conducted by Sorensen et al., they summarized that “Congestion fee calculation is based on (i) the physical characteristics of the road segments (e.g., length, design capacity, etc.) and (ii) the average peak loads on that link, as estimated by a regional transportation model. That is to say, congestion charges increase as the length of links and the level of congestion increases (43).”

1.3.2.4 (A) MINNESOTA PAY-AS-YOU-DRIVE STUDY

The Minnesota Department of Transportation (Mn/DOT) conducted a pay-as-you-drive (PAYD) study (44). The objectives of this study were to “(a) simulate the replacement of the fixed costs of vehicle ownership and operation with variable costs that give drivers explicit price signals about travel decisions and alternatives; (b) develop the best possible understanding of transportation price elasticity and how they vary by vehicle ownership/lease arrangement, income, location, annual mileage driven, and other factors; (c) develop an understanding about driver acceptance of use-based fees and appropriate price signals necessary to affect travel behavior changes; and (d) identify strategies and recommendations that might be employed to mainstream or institutionalize policies or techniques learned from the demonstration(45).” The study also discussed whether there would be a reduction in mileage traveled by vehicles due to the mileage-based pricing scheme and concluded that fee rate has an impact on the changes of mileage traveled; however, due to the sample size, the difference was not statistically significant. According to this paper (44), Minnesota PAYD project also conducted a field test, in which 130 households from Minneapolis/St. Paul metropolitan area volunteered. The electronic devices called “CarChips” were distributed to participant households to install in their vehicles, in order to record information needed for calculating user fees. CarChips are required to collect and send data periodically.

PRICING POLICY

The following description of the PAYD pricing policy was quoted from a paper written by Abou-Zeid et al. (44). They stated that “the experiment was conducted by giving each participant household a monetary budget and a rate for each mile driven. Mileage budgets were set based on the number of miles driven during the first month of travel with the CarChip when all vehicles were in a control period. Any money left in the budget at the end of the experiment was theirs to keep. Pricing protocols were assigned randomly and ranged from \$0.05 to \$0.25 per mile. Pricing for some households was varied for peak and off-peak travel. Ten households were charged a flat fee of \$0.05 per mile; 22 households were charged a fee of \$0.10 per mile; 11 households were charged a fee of \$0.15 per mile; 10 were charged a fee of \$0.20 per mile. The remainders of households were charged higher rates in the peak period than in the off-peak periods (46).” The pricing policy provided motorists an incentive for deducing or changing their travel patterns.

1.3.2.4 (B) MINNESOTA ROAD USER STUDY

In addition to PAYD program, Minnesota conducted other study related to road pricing. In 2003, researchers from the University of Minnesota Department of Mechanical Engineering evaluated the core technologies of the road user charges (47) for a project, entitled “A New Approach to Assessing Road User Charges.” The University of Minnesota and the Minnesota DOT developed and tested a road user charging system, which involved an onboard computer system that would use a differential GPS receiver, digital road maps, and map-matching software for computing the charges (48). “The charges could be calculated in real time and on a basis of mileage, time period, road jurisdiction, different fee structure, and road type. Researchers found out that GPS receivers that are commonly used by automotive navigation systems do not have sufficient accuracy for road user charging applications. However, the GPS-determined positions can be made more accurate, using publicly and privately available wireless signals, namely,

using D(differential)GPS. In short, only certain DGPS receivers are capable of achieving the needed accuracy (48).” It was also found that the existing digital maps of the time were not accurate enough to be used for road user charging. In order to design a road user charging system with high geographical resolution, and high accuracy digital maps which are used for vehicle safety applications need to be utilized.

In 2004, the Department of Applied Economics of the University of Minnesota reported that “substituting travel-dependent taxed for fixed or hidden charges could improve the tax system efficiency, and potentially distribute the road tax burden more fairly (49).”

Although the technology proved feasible for road charges, a follow-up opinion survey revealed some major concerns about the program (50). The survey was conducted among a selected 12 experts in the field of mileage user fee and 84 participants from 10 different groups featured by different traveling characteristics, such as high miles, high/low fuel efficient vehicles, peak commuters, and environmentalists. According to this study (50), the VMT Fee Study program was neither necessary nor feasible for at least 10 more years, and it should be used as a supplement, rather than a substitute to the current gas tax system. While participants were willing to pay their “fair share” based on how much they used the road, some of them believed that congestion fee is not fair for people who have to commute during the peak hours. Participants also raised concerns on potential privacy violation and the additional expenses for installing and maintaining the onboard units.

PRIVACY ISSUE

The program contains automatic monitoring of road use which is often challenged as an invasion of privacy. The program is owned and controlled by the private sector while all the monitored data is subscribed by the motorists. Monitored data could only be released with the authorization of motorists.

Based on this review of road pricing programs from both international and domestic studies, the common issues identified are technology feasibility, pricing, policy [what policy] and politics (e.g., privacy protection), and institutional collaboration. Those common issues will be discussed next. However, when dealing with a specific program, each state and local agencies will have to address specific local issues and needs. A successful program in one state does not guarantee success in another state. Additionally, mileage fee studies need to address not only technical issues but also administrative and political problems which are often more important than the technical aspects (13). These include: (a) gaining public acceptance of a financing scheme that will likely influence driver behavior and raise concerns about privacy, (b) providing a smooth transition from present highway funding scheme to a new one, and (c) learning how to determine fees so that the potential economic benefits of the new funding scheme are realized.

The next section will summarize these issues based on the lessons learned from the previously discussed studies.

1.4 RELATED ISSUES OF DISTANCE-BASED FEE COLLECTION PROGRAMS

MILEAGE COUNTING

Distance traveled by the vehicles needs to be recorded, which is the basic information for user fee calculation. Several different devices have been developed and are available to measure the travel distance traveled.

1. Odometer
Odometer alone can be used to measure distance. Odometer readings were used to measure distance in both the Minnesota's (54) and Iowa's (55) studies.
2. Dedicated Short-Range Communication
Dedicated short-range communication can not only provide the location of a vehicle, it can also measure the distance traveled on specific links or in pre-established geographical zones.

PROTECT PRIVACY

Privacy issues of the vehicle mileage fee programs have been studied since those programs were first proposed. Researchers stated that by appropriately designing the programs, motorists' privacy could be maintained. "Two approaches are proposed. First, the onboard unit is capable of analyzing travel data and calculating fees, and only the fees owed will be transmitted. Second, raw travel data are transferred to and analyzed by an authorized data analysis center under some legal or contract agreement that ensures the data will not be abused in other purposes or shared with the third party(57)." Iowa and Oregon studies adopted the former method, and Puget Sound and C-WARUM employed the latter one.

ENFORCEMENT

The evolving technology makes the enforcement of VMT Fee Study programs much easier than earlier technology. For example, fee evasion could be avoided by two techniques. "First, the onboard unit which is used to record travel history can be designed to be unable to be tampered or disabled. Second, vehicles can be observed from fixed or mobile check points, which ensure the charges are being recorded. (58)"

Sorensen and Taylor (59) summarized the detailed techniques to fulfill these two methods as follows:

1. "Strategies proposed to prevent tampering with the onboard unit include the following:
 - a. Disabling the engine unless the on-board unit also is activated;
 - b. Ensuring that the components of the onboard unit can be accessed only by certified professionals; and
 - c. Checking the onboard unit's distance monitoring records against the odometer reading each time the unit is turned on, and flagging any discrepancies.
2. Strategies for observing the vehicle from fixed or mobile checkpoints, in turn, can be based on either dedicated short-range communication or ANPR:

- a. Dedicated short-range communication can be used to transmit queries to passing vehicles to ensure that their on-board units are operating as expected.
- b. ANPR can identify vehicles that have passed a given check point; this information can later be cross-referenced against billing records to ensure all identified vehicles did in fact pay the corresponding tolls.”

In addition, according to Oregon’s concept, a successful program must be an integrated administrative process. Oregon study concluded that the administrative procedure must be a process that “(a) applies a mileage fee only to miles driven since the last fee paid, (b) may apply different fee rates for mileage driven in different geographic areas and time periods, (c) deducts the gas tax from gas purchases associated with a mileage fee paying vehicle, (d) integrates with the gas tax collection system where gas taxes are prepaid by gasoline distributors, and (e) retains sufficient data for auditing and resolving consumer challenges of mileage fees paid (60)”. Also, the collection process needs to be affordable.

1.4.2 INSTITUTIONAL ISSUES

Most of the studies reviewed in this section were designed for a single jurisdiction. The road pricing procedure calculates the user fee based on the distance vehicles traveled in one specific geographic area. For example, the VMT Fee Study pilot program in Oregon was structured to measure mileage within that state alone. Unlike this program, Iowa is conducting a national evaluation of a distance-based gas tax system for fifteen states. The road pricing system that can calculate user fees from several jurisdictions can be characterized as multi or meta-jurisdictional programs. Sorensen and Taylor (61) predicted that over the longer term, it is very possible that many single jurisdiction programs will evolve to include multiple jurisdictions. They also stated that from the technical standpoint, there is not much difference between single and multiple jurisdictions. An integrated system should be capable of calculating and collecting the revenues, and then distributing the appropriate amounts to the different jurisdictions involved.

1.4.3 PRICING ISSUES

According to the Oregon study objectives, road pricing programs chose different travel characteristics to price, which included, for example, charging for distance (VMT Fee Study), charging for travelling within a specific area or roadway segment (congestion fee), and charging for using a specific facility (i.e. bridge toll). Many pricing strategies contain other pricing factors, such as time of travel and characteristics of vehicles.

Fee rate, fee structure, and use of revenue are three major problems which are dealt with in pricing study. The fee rate is the amount of money charged for a unit (one mile) of travel. For example, the fee rate for Oregon was calculated by dividing the 24 cents (current gas tax rate) by the current average fuel efficiency of passenger vehicles of 20 miles per gallon, which calculated at 1.2 cent per mile (62). In addition, the mileage fee structure could be designed as a flat rate, or others, graduated rate, or special fee rate due to specific policy objectives. Also, the fee structure needs to consider the social equity, by considering issues previously mentioned, such as driver income, type of vehicle, and commute during peak hour.

As for the use of revenues collected by the road pricing system, there are mainly four uses for revenues (63). These are “(a) maintaining and improving the road network, (b) subsidizing alternate models of travel, (c) augmenting the general fund, and (d) returning the funds to various groups to offset equity concerns (63).” The studies we reviewed in this section mainly focused on the first two uses.

1.4.4 IMPLEMENTATION ISSUES

According to Sorensen’s study (14), implementation issues include participation requirement and rollout strategies. For most of the user-fee programs we reviewed above, whenever the purpose is to raise road revenue, participation needs to be mandatory. This is for motorists who live or work within the pre-defined jurisdictions. Also, the phase-in implementation mode is recommended by many researchers. During the phase-in period, both fuel taxes and mileage fee will be in place. A smooth transition period can ensure that no motorist would be responsible for paying both, but no road user would evade paying either of these two fees. Also, this phase-in period can save money on retrofitting which is very costly. For Oregon’s concept (64), no vehicle currently in use will be retrofitted so they will still pay fuel taxes. Only the new vehicles will be equipped with the necessary technology will pay the mileage fee. Iowa (53) study also suggested the phase-in strategy. The opposite way to implement mileage fee program is the immediate rollout, which has been used in some truck toll programs.

1.4.5 PUBLIC ACCEPTANCE ISSUES

As we all know, the successful implementation of a road pricing program requires public acceptance. Extensive communication is the most effective mean in obtaining acceptance of the public. The general public will need to understand the problems and the elements of any road pricing program before they will accept it. Additionally, they must understand how privacy could be protected and how fairness will be reflected in the fee structure.

Equity and privacy are two concerns of the motoring public. Concern for equity varies from one program to another, depending on user demographics and program design. For example, “the equity of congestion fee are often challenged by people, who think that wealthy people could buy their way out of congestion, while less wealthy drivers remain stuck in the congested free lanes. Unlike congestion fee where equity is of concern; equity issues are not usually raised with regard to weight-distance truck tolls, VMT Fee Studies, or variabilized insurance (65).”

The level of concern on privacy also varies by the different road pricing programs. Truck tolling is the last one to be challenged due to its commercial nature. However, for VMT Fee Study programs, privacy is a major issue. This is because onboard equipment needs to be installed in private vehicles and motorists’ driving patterns need to be recorded to some extent. Some researchers believe that the public concern over privacy issues may be over-estimated. For example, people accept credit cards and cell phones, and they have to share plenty of detailed information about their personal behaviors with those service providers. However, when people evaluate the benefits and costs of using them, they will make the best choice for themselves. The VMT Fee Study program is similar. Besides, the advanced technologies ensure that a VMT Fee Study program could protect people’s privacy.

1.5 SUMMARY & CONCLUSIONS

This section provides a review of studies related to road pricing programs in the U.S. and throughout the world. The VMT Fee Study approach has been introduced as a rational and effective substitution for fuel tax. A series of road pricing programs related to the VMT Fee Study concept were reviewed. The paper identified five main issues that need to be addressed for a successful implementation of a VMT Fee Study system. Those issues are technology capability, pricing policy, privacy protection, institutional relationships, and public acceptance.

According to the studies that were reviewed, there were three primary applications of road pricing programs. First was the use VMT Fee Study to replace conventional fuel tax. Second was to study driver behavior in response to congestion pricing. Third was to observe driver behavioral responses to distance-based pricing which replaces the currently fixed costs (such as registration fees, leasing fees, and insurance fees). In general, the goal of developing road pricing processes is to provide sufficient, sustainable, and viable revenue for the transportation system and improve traffic operations.

The technology issues discussed in previous studies mainly focused on five aspects: 1) determining location and time of travel, 2) measuring the distance traveled, 3) transmitting billing data, 4) maintaining privacy, and 5) enforcement. GPS is the most popular technology to determine location and count mileage. Chip card was an inexpensive way to solve data transmission problems. The technology does not track motorists and the necessary data will only be used for mileage-fee programs. That is to say, the mileage-fee system could protect individual privacy.

The institutional framework in the studies reviewed was based on either a multi-jurisdiction or single jurisdiction. However, a single jurisdictional program should have the ability to be updated to become multi-jurisdictional.

During the implementation, it would be very costly to take a one-time rollout strategy for private vehicles. Therefore, most of the studies proposed a phase-in strategy, which means new vehicles come pre-installed with the technology, while the existing vehicles have the option of paying through the current fuel tax system or converting to the new system.

Two critical issues needing political and public acceptance were equity and privacy. The literature review revealed that communication with the public, and carefully designed technology and fee structure were essential for political and public acceptance.

In general, pricing issues focused on two types of questions: (a) what will the charge be based on and (b) where will the revenue go to. There are two pricing strategies: (a) charge by distance traveled with/without consideration of vehicle classification, or (b) charge by travelling within specific zones during specific time periods.

The revenue collected by the road pricing programs was usually used in the following four ways:

1. "Augmenting the general fund
2. Maintaining and improving the road network, e.g. Oregon, Iowa
3. Subsidizing alternate models of travel (e.g. transit or rail freight)
4. Returning the funds to various groups to offset equity concerns (63)"

The literature review also indicated that, when dealing with a specific program, state and local agencies will have to address specific local issues and needs. .

The following figure shows the other States and agencies that have been involved with either implementing VMT Fee studies or are considering such studies,

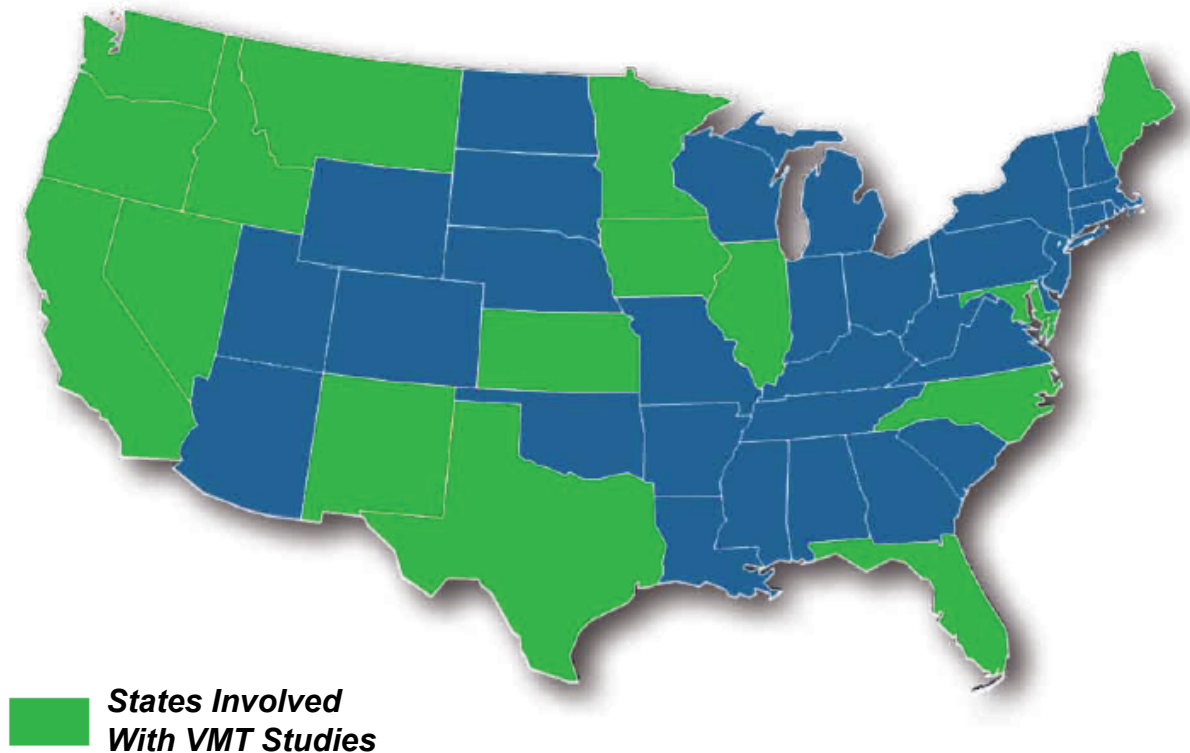


Figure 1-1. States involved with VMT

2. WORKSHOPS & PUBLIC MEETINGS

2.1 WORKSHOPS

As part of this study, a workshop was developed to seek the thoughts and ideas of various local and regional entities including citizens, privacy, and environmental groups; the trucking industry; taxpayer organizations; and public and elected officials. A number of research areas such as defining issues and possible solutions, likely technologies, privacy, policy, and administrative structure were covered.

The first workshop was conducted on Saturday, May 9, 2009 from 8:00 AM to 12:00 PM at the University of Nevada, Reno. The second workshop was conducted on Wednesday, August 19, 2009 from 8:00 AM to 12:00 PM at the Las Vegas Valley Water District facility in Las Vegas, Nevada. The remainder of this section discusses the events that occurred at each workshop and our recommendations at the time of submittal.

2.1.1 WORKSHOP INVITATIONS

2.1.1.1 INVITATIONS FOR RENO WORKSHOP ON MAY 9, 2009

Prior to the workshop, the research team worked closely with the research panel on planning and conducting the workshop. Workshop agenda and presentations were thoroughly discussed at panel meetings occurring on March 3, 2009, April 1, 2009, and April 24, 2009.

The workshop invitations included the following items:

- Invitation letters
- Preliminary workshop agenda
- Map and directions to Joe Crowley Student Union at University of Nevada, Reno
- Self-stamped RSVP card

The workshop invitations were sent out to about 130 stakeholders and organizations during the week of April 12, 2009. Thirty-two (32) people responded (25%) with a breakdown of nineteen (19) responding “yes” and thirteen (13) responding “no.” There were a total of eighteen (18) workshop attendees. In addition, a number of project researchers and panel members attended the workshop to facilitate the discussions and make presentations.

2.1.1.2 INVITATIONS FOR LAS VEGAS WORKSHOP ON AUGUST 19, 2009

Prior to the workshop, the research team worked closely with the research panel on planning and conducting the workshop. Workshop agenda and presentations were thoroughly discussed at panel meetings occurring on July 30, 2009 and August 12, 2009.

The workshop invitations included the following items:

- Invitation letters
- Preliminary workshop agenda
- Map and directions to Las Vegas Valley Water District
- Self-stamped RSVP card

The workshop invitations were sent out to 113 stakeholders and organizations during the week of July 20, 2009. Twenty-four (24) people responded (21%) with a breakdown of twenty (20) responding “yes” and four (4) responding “no.” There were a total of twenty-two (22) workshop attendees. In addition, a number of project researchers and panel members attended the workshop to facilitate the discussions and make presentations.

2.1.2 WORKSHOP PRESENTATIONS

2.1.2.1 PRESENTATIONS FOR RENO WORKSHOP ON MAY 9, 2009

Project overview presentation was provided by Ms. Susan Martinovich, P.E., Director of NDOT and Derek Morse, Interim Executive Director of RTC of Washoe County and the project research team presentation was provided by Sirous Alavi, Ph.D., P.E. of Sierra Transportation Engineers, Inc. and Eric Herzik, Ph.D., of University of Nevada, Reno.

2.1.2.2 PRESENTATIONS FOR LAS VEGAS WORKSHOP ON AUGUST 19, 2009

An overview presentation similar to the workshop presentation in Reno was presented by Mr. Rawlins of NDOT and Fred Ohene, Ph.D., P.E., Assistant General Manager of RTC Southern Nevada and the project research team presentation provided by Dr. Alavi of Sierra Transportation Engineers, Inc. and Dr. Herzik and Dr. Chris Simon of University of Nevada, Reno. Mr. Jacob Snow of RTC of Southern Nevada also made introductory comments about the goals and objectives of the VMT User Fee Study.

2.1.3 BREAKOUT SESSION FORMAT

The most important activities at the workshops were the breakout sessions. At each corner of the conference room, an easel with paper was provided for a member of the project research team (i.e., breakout session moderator) to write down the attendees’ thoughts and ideas regarding a VMT user fee system.

The comments were grouped in the areas of technical, administrative, policy, and privacy. In addition, the attendees were asked to “rank” all comments.

2.1.4 BREAKOUT SESSION RESULTS

Appendix A and Appendix B contain the unedited comments received by attendees from the Reno and Las Vegas workshops, respectively. The comments were separated for each session into four categories, namely; technical, administrative, policy and privacy issues.

2.1.4.1 RANKING OF CATEGORIES

As discussed earlier, every attendee was provided eight stickers to rank the most critical issues by placing as many stickers as desired next to an issue. Table 2-1 represents the ranking of each category according to the total number of stickers used in each category. Policy issues were ranked first followed by privacy issues for both Reno and Las Vegas workshops.

Table 2-1. Ranking of Categories by Workshop Attendees.

Ranking	Reno Workshop	Las Vegas Workshop
1	Policy Issues	Policy Issues
2	Privacy Issues	Privacy Issues
3	Technical Issues	Administrative Issues
4	Administrative Issues	Technical Issues

2.1.4.2 TOP RANKED ISSUES

Table 2-2 shows the most important issues identified by the attendees in the Reno and Las Vegas workshops.

Table 2-2. Top Ranked Issues by Workshop Attendees.

Reno Workshop	Las Vegas Workshop
<ul style="list-style-type: none"> • Funds collected should be used for all transportation needs (including capacity & mass transit) • Different state systems must be compatible • Don't tie personal ID with user data collected, only tie to miles driven • Data used only for VMT • Data will not be collected by private entity (no contractor) • There should be a uniform tax rate – national rate • If implemented, VMT should promote equity • VMT should be seamlessly integrated following a national policy • The funds collected from VMT should only be used for maintenance only • Provide an opt out (flat fee) option 	<ul style="list-style-type: none"> • VMT rates tied to vehicle classification • Societal benefits should prevail over individual privacy concerns • Government credibility is so low public won't believe data security / privacy guarantees • System must account for urban and rural differences • There may be a need of a blended system focusing on VMT as augment gas, public transportation fees • Technology must be secure • Pricing for businesses versus private vehicle owners • Tiered system for different vehicles based upon efficiency • Use existing system and add odometer readings to registration fees • Pay at pump infrastructure in place could be adapted • Data collected only for specific purpose

2.1.5 WORKSHOP CONCLUSIONS

Both workshops were well received. The attendees were very active in the discussions and breakout sessions. This is indicated by the large number of comments received from workshops attendees as shown in Appendices A and B.

The initial concern by the Reno attendees was whether there were any special interest groups behind the research. In Reno, the most common feedback topics were about system equity, uniformity, security, and reliability. It was also interesting to note that attendees were more

comfortable with public administration of a new system as compared to a private entity managing and operating the data and revenue collection. There also seemed to be consensus on a tiered system with options and flexibility on how much information a road user is willing to provide to receive better rates. The Reno attendees also recognized the need for compatible regional and national policies and rates for the new revenue system.

The Las Vegas attendees also emphasized the need for system equity, uniformity, security and reliability. Similar to the Reno workshop, issues with policy and privacy were ranked as most important by the Las Vegas attendees. The issue of tying the VMT rate to vehicle classification was ranked as the number one issue in Las Vegas.

A surprising outcome of the Las Vegas workshop has to do with the following second ranked issue, “Social benefits should prevail over individual privacy concerns.” Even though this statement tends to show support for a VMT user fee system, the attendees also shared their expectation that the system will need to be secure, reliable, and privacy concerns will need to be properly addressed. The Las Vegas attendees also discussed the possibility of a tiered system with various rates for private, public, and commercial vehicles. They suggested that the system can be tiered such that the rate will increase as one surpasses a certain number of miles driven (i.e., similar to the variable rate on our water bills). The Las Vegas attendees emphasized the need to educate the public by telling them the exact nature of the problem at hand. They stated that with all the ongoing road construction activities, it is difficult to portray the existing system as cash poor and in immediate need of additional funding. There needs to be a very good effort in convincing the public that there is a problem. The discussions at the Las Vegas workshop led to an understanding by the attendees that the funding shortfalls are imminent and immediate. The attendees were also told that the VMT user fee system is currently in a research stage and the State of Nevada is at least a decade away from any possible implementation of a VMT user fee system. The Las Vegas attendees were interested to know the intermediate solution (or step) between the current fuel tax system and any future VMT user fee system. If the State of Nevada is running out funds and the VMT user fee system is a decade away, the State of Nevada needs to have a system in place to raise the additional funds during the meantime. The Las Vegas attendees felt that this issue will need to be addressed during the upcoming public meetings.

As stated earlier, policy issues were ranked as most important in both the Reno and also the Las Vegas workshops. Of utmost importance was the issue of equity. It was stated that an equitable system can mean differently to different people and sectors of the society. As a matter of policy, an equitable system will need to be properly defined and presented to public for their understanding and acceptance.

2.2 PUBLIC MEETINGS

In addition to the workshops, two public meetings were held. The first public meeting was held on Tuesday, March 30, 2010 from 4:00 PM to 7:00 PM at the Reno Sparks Convention Center with approximately 75 people in attendance. Figure 2-1 presents attendees and the research team at the Reno public meeting. The second public meeting was held on Thursday, April 29, 2010 from 4:00 PM to 7:00 PM at the Clark County Government Building with approximately 45 people in attendance. The number of attendees was an approximation because some attendees

elected to not sign in. The remainder of this section discusses the events that occurred at each public meeting and our recommendations at the time of submittal.

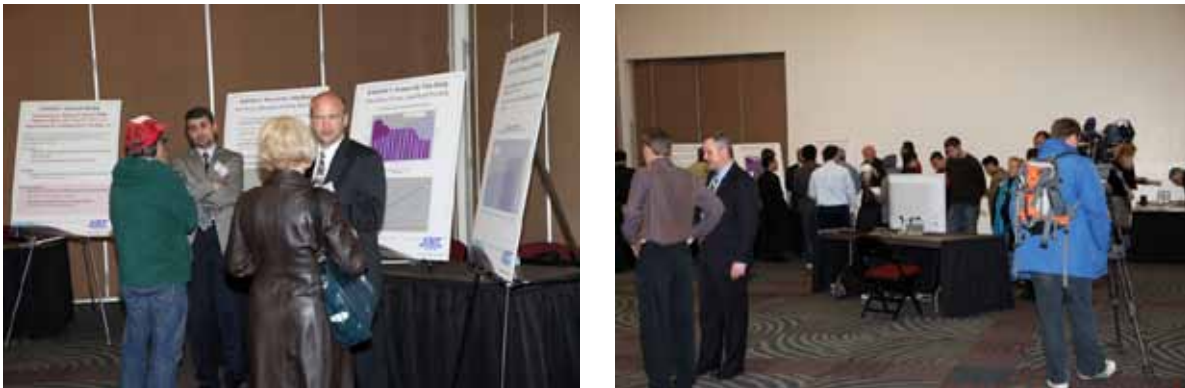


Figure 2-1. Attendees & Research Team at Reno Public Meeting.

2.2.1 PUBLIC OUTREACH

Approximately one to two weeks before the public meetings, NDOT sent out a press release to the media and posted it on the NDOT website. In addition to the press release, NDOT sent out an opinion-editorial piece to local newspapers regarding the public meeting and the VMT Fee Study.

2.2.2 PRESENTATION BOARDS

The research team provided material (i.e., text and graphics) to NDOT to create the presentation boards for the public meetings.

2.2.3 EXIT SURVEY

An exit survey was provided to the public at each public meeting.

2.2.3.1 SURVEY RESULTS FROM RENO PUBLIC MEETING

Thirty five (35) individuals responded to various portions of the exit survey. In some instances not all questions were answered or the respondent replied with more than one answer. Figures 2-2 to 2-10 provide the results of the exit survey for questions 1 to 9. The number of respondents per question and percentage of respondents with respect to the total per question are provided on each graph. Item 10 asked for respondent identification. Item 11 provided space for respondents to provide additional comments.

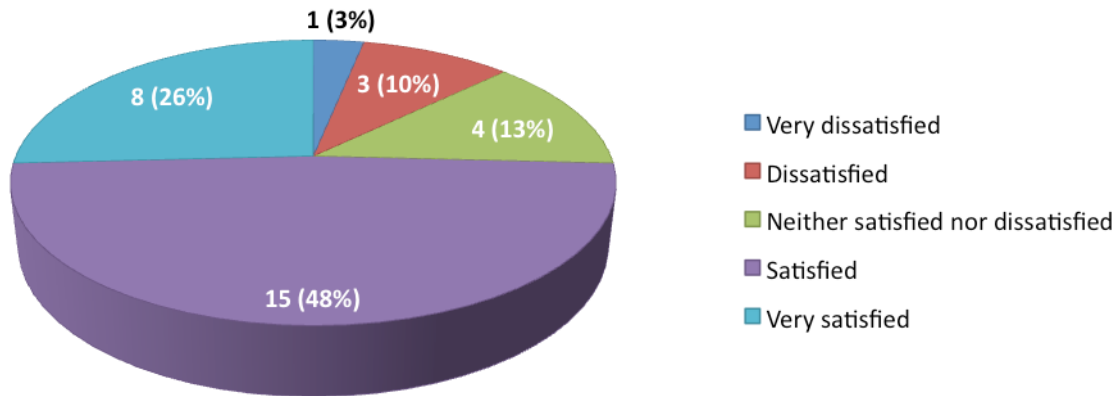


Figure 2-2. Question 1: Overall Satisfaction With Reno Public Meeting.

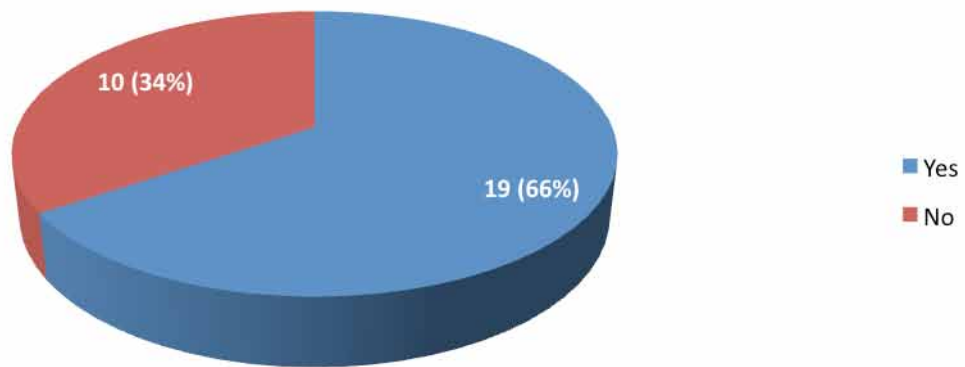


Figure 2-3. Question 2: Did Reno Public Meeting Help Address Your Concerns?

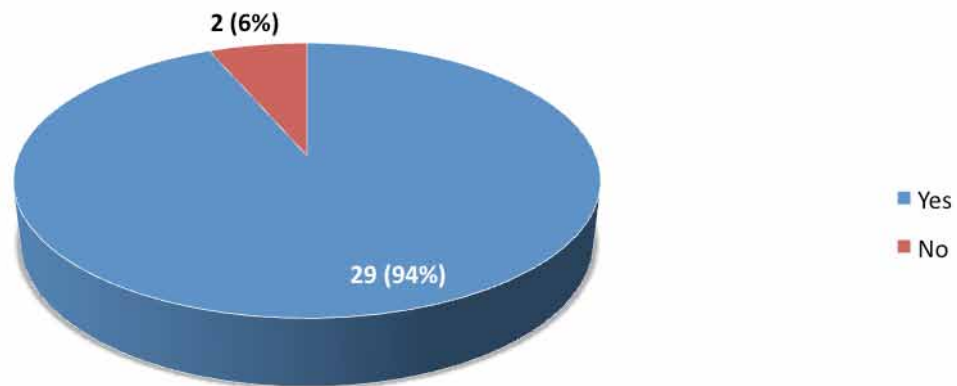


Figure 2-4. Question 3: Did You Learn Any New Information?

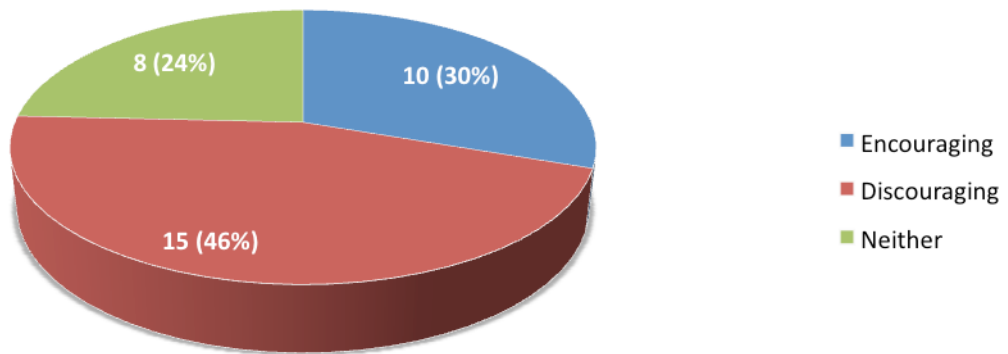


Figure 2-5. Question 4: Was Information Encouraging, Discouraging, Or Neither?

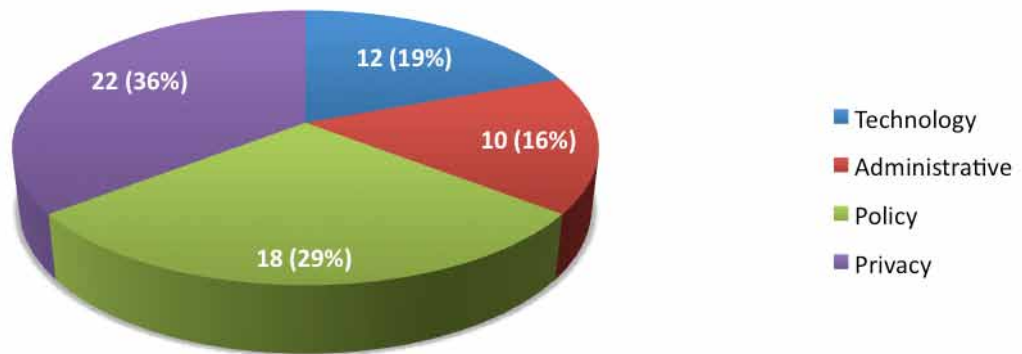


Figure 2-6. Question 5: Which Topic Areas Need Additional Explanation?

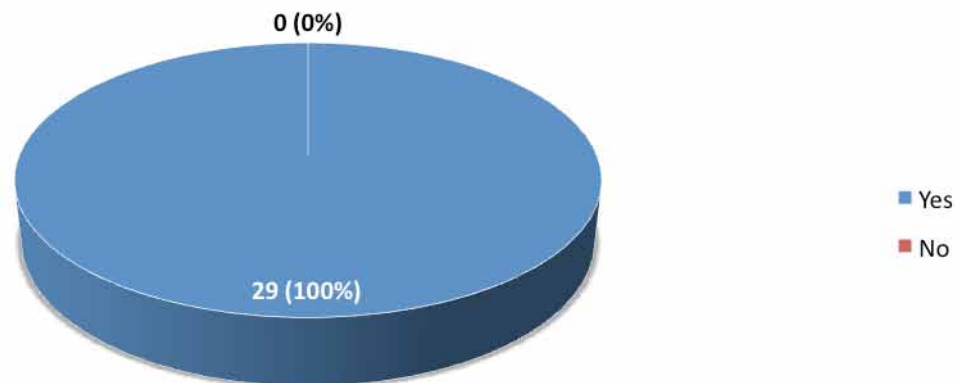


Figure 2-7. Question 6: Were Visual Aids And Handouts Clear And Concise?

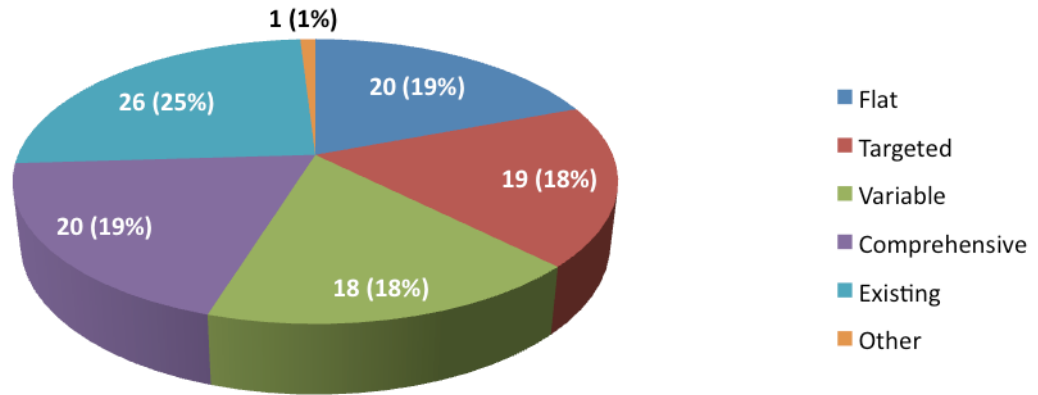


Figure 2-8. Question 7: What Type Of VMT Fee Structure Could You Accept?

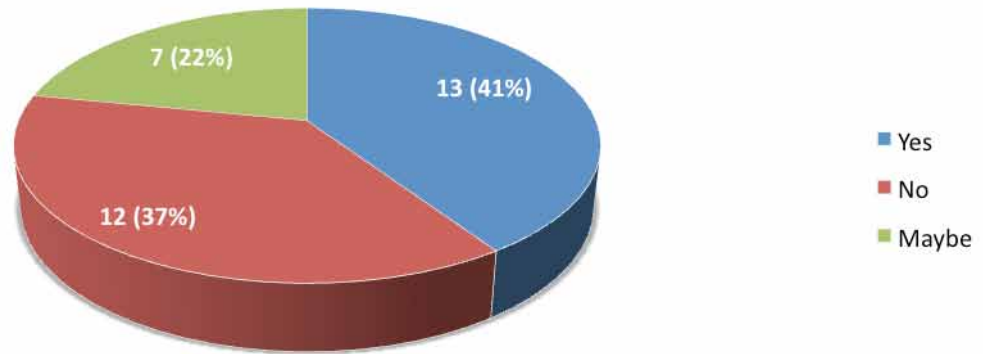


Figure 2-9. Question 8: Would You Be Willing To Participate In Pilot Program?

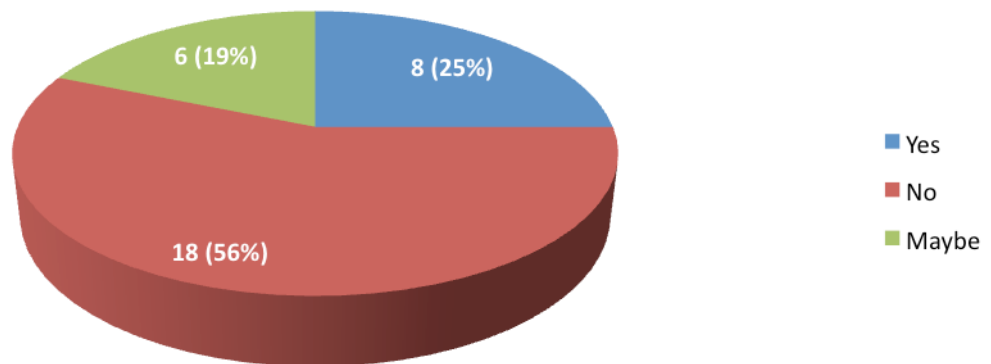


Figure 2-10. Question 9: Would You Be Willing To Have VMT Technology In Your Vehicle For Pilot Program?

2.2.3.2 SURVEY RESULTS FROM LAS VEGAS PUBLIC MEETING

Twelve (12) individuals responded to portions of the exit survey. In some instances not all questions were answered or the respondent replied with more than one answer. Figures 2-11 to 2-19 provide the results of the exit survey for questions 1 to 9. The number of respondents per question and percentage of respondents with respect to the total per question are provided on each graph. Item 10 asked for respondent identification. Item 11 provided space for respondents to provide additional comments.

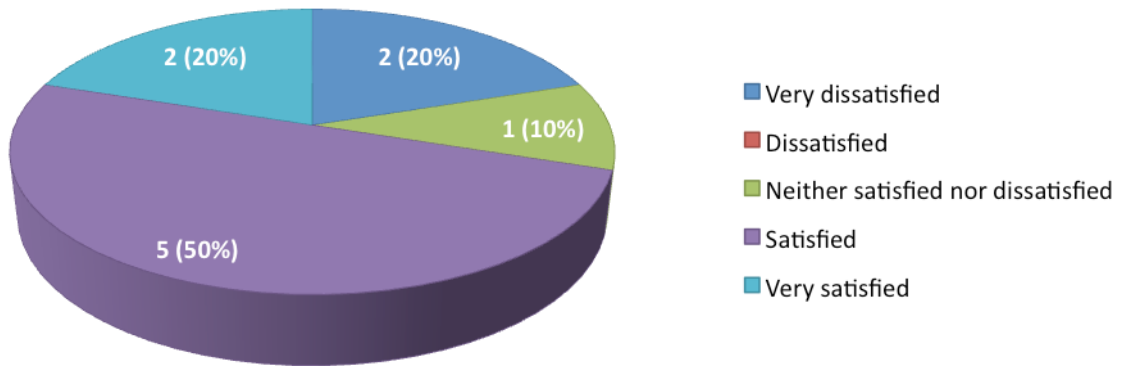


Figure 2-11. Question 1: Overall Satisfaction With Las Vegas Public Meeting.

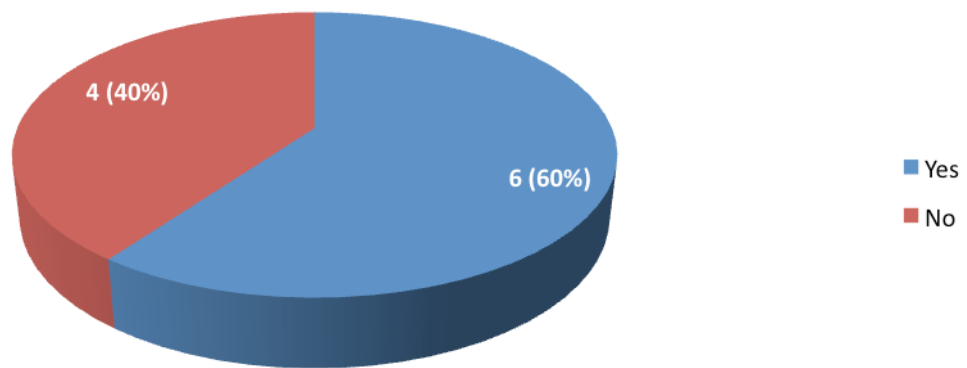


Figure 2-12. Question 2: Did Las Vegas Public Meeting Help Address Your Concerns?

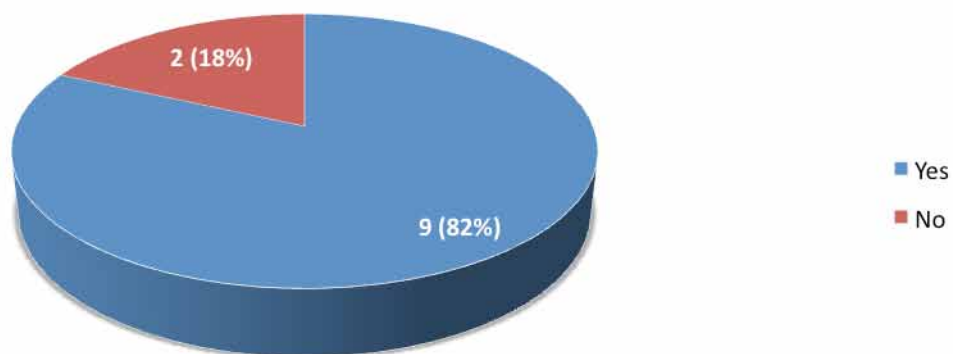


Figure 2-13. Question 3: Did You Learn Any New Information?

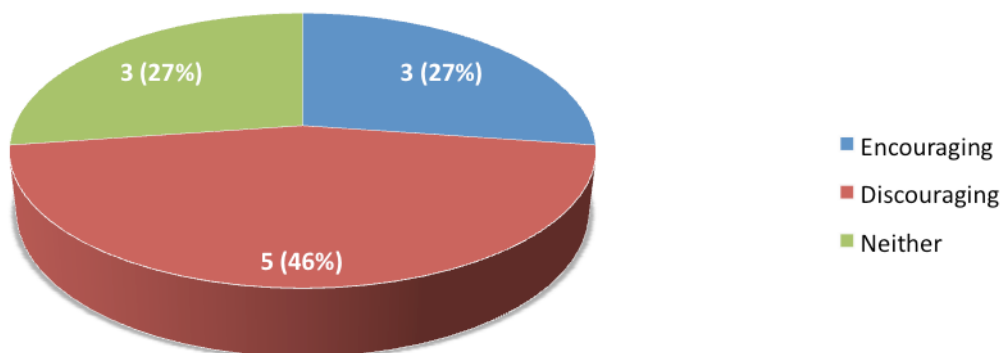


Figure 2-14. Question 4: Was Information Encouraging, Discouraging, Or Neither?

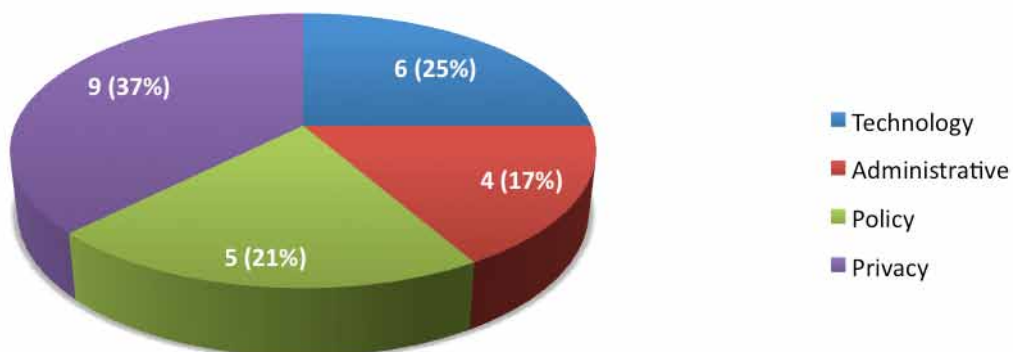


Figure 2-15. Question 5: Which Topic Areas Need Additional Explanation?

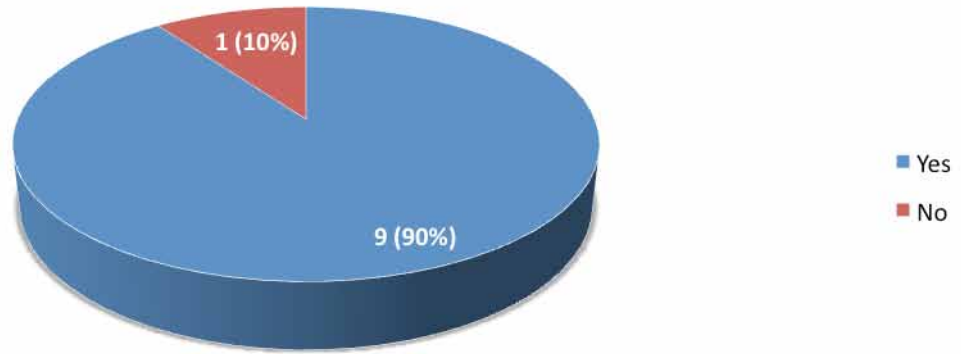


Figure 2-16. Question 6: Were Visual Aids And Handouts Clear And Concise?

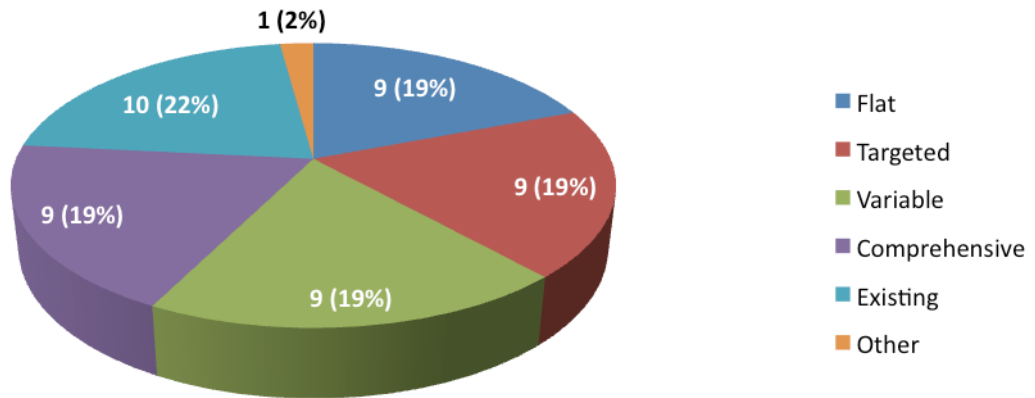


Figure 2-17. Question 7: What Type Of VMT Fee Structure Could You Accept?

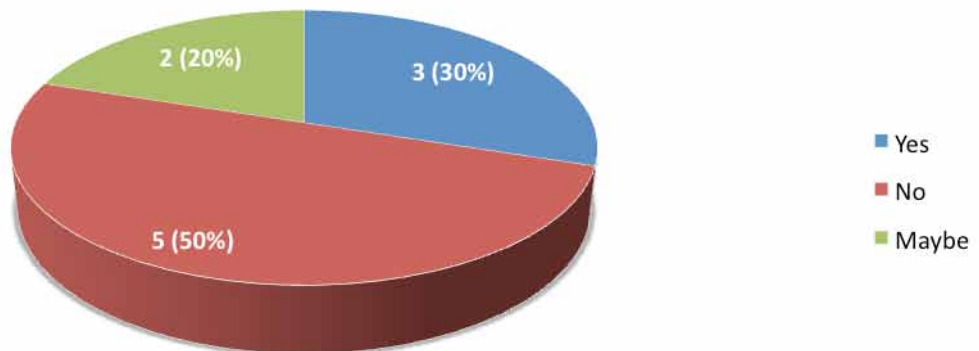


Figure 2-18. Question 8: Would You Be Willing To Participate In Pilot Program?

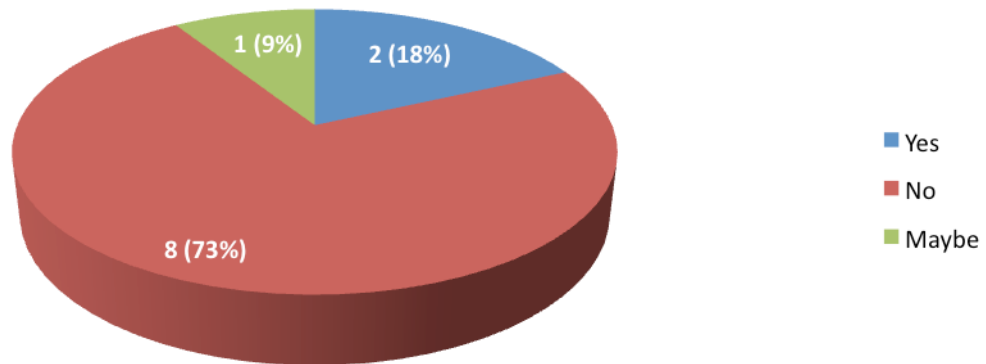


Figure 2-19. Question 9: Would You Be Willing To Have VMT Technology In Your Vehicle For Pilot Program?

2.2.4 PUBLIC MEETING CONCLUSIONS

Both public meetings were successfully conducted; however, there were some issues. Neither public meeting had a large turnout (i.e., 75 attendees in Reno, 45 in Las Vegas). The lower turnout in Las Vegas may have to do with location of the meeting and traveling during PM peak period. Both public meetings had media in attendance. The media did not interfere with the researchers' presentations and discussions.

In Reno and Las Vegas, the number of respondents to the exit survey was 12 and 35, respectively. Based on the exit survey results, the public was generally satisfied with the public meetings, indicating that the public meeting addressed their concerns, and that they learned new information. They also felt that the visual aids and handouts were clear and concise. Privacy and policy were listed as items that need additional explanation. This is similar to our workshops findings, where privacy and policy issues were ranked as the most important issues.

Approximately half the attendees, who responded to the survey, indicated that they may be willing to participate in the Pilot Program but over half of them indicated that they are not willing to have VMT technology in their vehicles for the Pilot Program. Many public meetings attendees also found the information presented discouraging. As the research continues to progress and more findings become available, we will be able to provide more concise information on the VMT and Pilot Program technology and hopefully alleviate some of the concerns.

Over seventy percent of attendees, who responded to the survey questions, were either very satisfied or satisfied with the public meetings held in Reno and Las Vegas. However, there were a few attendees at each public meeting that do not want a VMT fee under any conditions.

4. INSTITUTIONAL ISSUES

4.1 INTRODUCTION

For nearly a century fuel tax provided a good income stream to plan, construct, and maintain roadways in Nevada. However, there are some trends that are a cause for significant concern. First, the fuel efficiency of vehicles is expected to rise and, second, electric vehicles are being introduced. These trends will result in a decline of future highway revenue. Consequently, the Nevada Department of Transportation (NDOT), in collaboration with University of Nevada Reno, and University of Nevada Las Vegas has initiated a “vehicle miles traveled (VMT) fee study” to evaluate the possible replacement to the current fuel tax revenue system, which is the primary revenue source for our roads, bridges, and transit systems.

Under this task, a framework for the management of the Pilot Program has been developed including identifying and addressing the institutional issues. The remainder of this section discusses our recommendations at the time of submittal.

4.2 INSTITUTIONAL ISSUES CATEGORIZATION

Based on the literature review and the first workshop held May 9, 2009 at UNR, the project research team organized the institutional issues into the following categories:

- Administrative
- Cost
- Funding
- Outreach
- Hardware & Software
- VMT Fee Models
- Participants

These categories represent the framework of the Pilot Program that will likely be deployed in 2010. It is also recognized that any future VMT fee collection will require the approval of the appropriate entities (e.g., State legislature).

4.2.1 ADMINISTRATIVE

Prior to implementing the Pilot Program, the administrative issues must be addressed. As shown in Figure 4-1, the administrative areas that should be systematically defined are:

- Purpose and Objectives – Develop a statement of the purpose of the Pilot Program and delineate clear objectives for its accomplishment.
- Organization – Develop an organization for the Pilot Program.
- Duties and Responsibilities – Provide a description of the duties and responsibilities for project execution.

- Processes and Procedures – Provide a general description of plans to adapt, adopt, or create written processes and procedures for Pilot Program activities.
- Deliverables – Provide a general description of the deliverables for the project and the delineation of responsible parties.

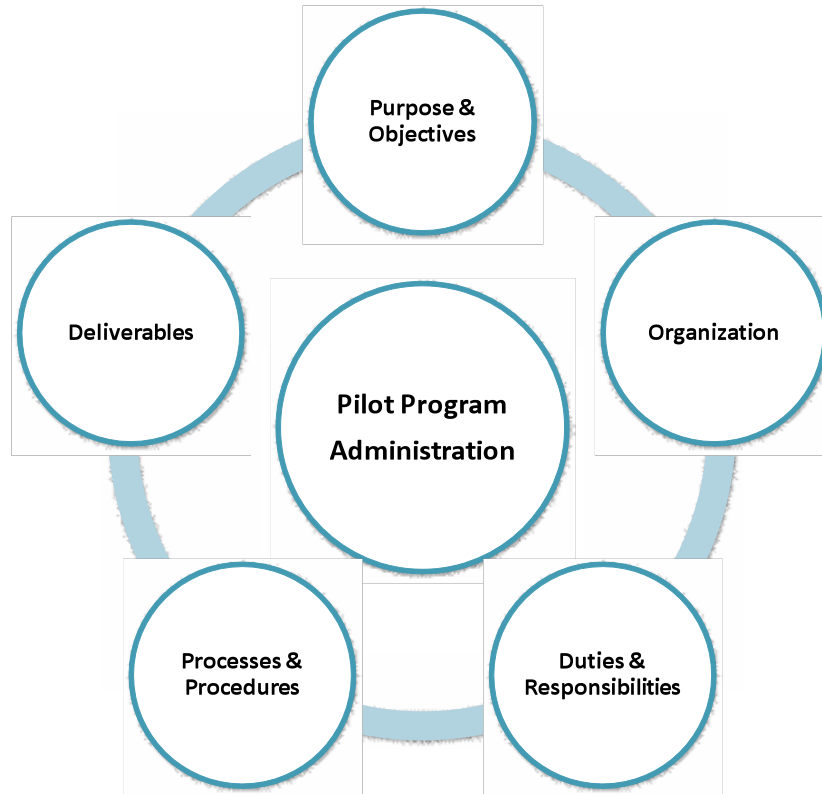


Figure 4-1. Administrative Areas of the Pilot Program.

4.2.1.1 PURPOSE & OBJECTIVES

At the conclusion of this study, the research team will develop a broad statement of purpose and clearly identify the objectives for the Pilot Program. As stated previously, the VMT fee study was initiated to evaluate its feasibility in Nevada, address issues related to the program, and develop a protocol for implementation and testing the VMT fee.

Some guiding principles that could be implemented in the future VMT fee system are encouraging an efficient transportation system investment, incorporating equity considerations, promoting broad energy policies such as energy independence, encouraging low system operating costs by “piggybacking” onto other established systems (e.g., hardware and software on infrastructure such as toll facilities, pay-at-the-pump facilities), and enhancing the mobility for all transportation system users.

4.2.1.2 ORGANIZATION

For the successful completion of any program, there should be one group who conducts the work and one group that oversees the work. Program management may involve an existing organization that already has an inherent support structure or may require the formation of a

completely new organizational element, requiring the hiring and/or reassignment of needed personnel.

Based on the literature review findings, it was anticipated that a private firm would be retained to conduct the Pilot Program. However and surprisingly at the first workshop, several attendees stated that private firms should not be allowed to collect the data for the future statewide program. Even though this is just the Pilot Program, the public may not accept a private firm's results. In addition, a private firm may have a vested interest in the VMT fee study succeeding or failing. On the other hand, the advantages of having a private consulting firm conducting the Pilot Program include cost effectiveness, clear roles and responsibilities, and timely deliverables. The research panel will need to decide on whether a Pilot Program implementation will be done by the agencies or a private consulting firm.

A Pilot Program Management Group should be established for the Pilot Program. This group would be, for instance, the project panel. It should have dedicated personnel with technical and administrative expertise. It should have resources to be able to conduct its oversight. The Pilot Program Management Group could potentially partner with centers at the UNR and UNLV. Experts from outside academia could include technical experts from private industry, politicians, civic groups, etc.

4.2.1.3 DUTIES & RESPONSIBILITIES

Once the organization of the Pilot Program is decided, a description of duties and responsibilities for project execution must be completed. The duties and responsibilities should be clear and delineated. For example, a Pilot Program Management Group oversees the Pilot Program. This group is the authority regarding business affairs, interpretation of the contract requirements, and mediates issues regarding priorities, project scope, and project execution. There should be some mechanism to monitor and assess the objectives of the Pilot Program.

The Project Manager of private firm or group conducting the Pilot Program should be responsible and accountable for project execution and all deliverables. This Project Manager is generally responsible for the day-to-day administration of the project. Other members of the private firm or group conducting the Pilot Program should also be defined.

4.2.1.4 DELIVERABLES

Based on the stated purpose and desired objectives of the Pilot Program, a series of deliverables will be defined. The team conducting the Pilot Program will complete a number of defined tasks. Deliverables will include an assessment of the different processes such as administration, cost, public outreach, technical, and VMT fee models.

4.2.2 COST

The Pilot Program capital costs are unknown at this time because the final objectives are still being developed by the project team. Depending on the final objectives, the size and scale of the

Pilot Program can be determined. Based on the size and scale, costs can be estimated for the Pilot Program.

4.2.2.1 START UP

Pilot Program start up costs would include hardware and software, VMT fee payment technology (e.g., radio frequency identification (RFID), and administration.

4.2.2.2 OPERATION

Operational cost is basically the cost associated with conducting the Pilot Program and includes administration, enforcement, and auditing. In addition, depending on the desired objectives and how the VMT fee payment technology is designed, operational cost could include communications (e.g., dedicated RFID, dedicated short range communications, internet).

4.2.2.3 MAINTENANCE

Maintenance costs are basically costs associated with maintaining data collection, equipment, and troubleshooting problems that occur during the Pilot Program.

4.2.2.4 ENFORCEMENT

As part of the Pilot Program, enforcement costs could be evaluated. The future VMT fee system should be developed with effective deterrents and actions against people, who evade payment or are delinquent in payment by hardware and software or institutional policies. Enforcement could include 1) stationary equipment placed on current infrastructure that identifies the vehicle by Vehicle Identification Number (VIN) or license plate and 2) mobile enforcement.

4.2.2.5 AUDITING

Auditing costs depend on the amount of data that will be collected and maintained. More data typically means more auditing costs. Depending on the complexity of the VMT fee system and the public's acceptable level of privacy intrusion, "audit-ability" of the VMT fee system must be explored. The audit-ability of the VMT fee system is required to verify accuracy and reasonableness of the system and provide the road user the means to challenge a billing if necessary.

4.2.3 FUNDING

For the Pilot Program, potential funding sources include the United States Department of Transportation (USDOT), Federal Highway Administration (FHWA), NDOT, Local Governments, and Private Entities (e.g., Industry firms). In order to approach these groups, the project team recommends the following:

- Documenting Current Work
- Public Outreach
- Distributing Informational Materials at "Proper" Locations

- Use Networking
- Hold Workshops / Public Meetings
- Be Transparent with Funding Sources

One caveat to the funding issue is that funds may include conditions or restrictions. For example, in order for an agency to participate, it may request that vehicle weight data be included in the Pilot Program; thus adding complexities to the initial Pilot Program objectives.

4.2.4 PUBLIC OUTREACH AND EDUCATION

In order to effectively engage in a dialogue, and educate and inform the public about the Pilot Program and a future VMT fee system, there must be effective public outreach and education, and a period of assessment. The public outreach must be extensive to create a broad understanding of the current funding problem, the future funding problem, the proposed solution, the intended method of implementation, and the anticipated impact on individual system users. The project team believes the public outreach should include the following elements:

- Proactively engage in a dialogue as many stakeholders as possible such as local clubs (e.g., Sierra Club), business associations, and government (e.g., policy makers).
- Provide presentations at local, regional, state and national levels.
- Provide information to local print, broadcast, and electronic media groups.
- Recruit as many stakeholders as possible such as local clubs (e.g., Sierra Club), business associations, and government (e.g., policy makers) to be advocates for the Pilot Program and future VMT fee system.
- After a period, assess how the public outreach has performed and what modifications may be needed to explain current problem better.

4.2.5 VMT FEE MODELS

For the Pilot Program, the hardware and software will collect the full spectrum of data and the Pilot Program project team will model various VMT fee models. Depending on the desired objectives of a future VMT fee system, models could include targeted, flat, variable, and comprehensive fees. Targeted fee models would likely be based on policy decisions. For example, a targeted fee structure could be developed to make trucks or less fuel efficient vehicles pay an increased rate. Flat fee models would be a flat fee for miles traveled. Although this would be straightforward, it would also reduce the incentive for people to buy more fuel efficient vehicles. Variable fee models could entail different models for different groups, different fees at different times of day, etc. Comprehensive fee models would likely have elements of congestion pricing, roadway functional class, time of day, different geographic areas, and possibly vehicle weight and size. From correspondence with the research panel, the following areas should be addressed in the Pilot Program:

- User fee rate for break-even revenue with the current gas tax policy
- Variable fee rates that take into consideration of the time, space, and fuel efficiency vehicles

- Issue of miles driven outside of the program boundary
- Distribution of the revenue among local jurisdictions

4.2.6 PARTICIPANTS SELECTION

As shown in Figure 4-2, the research team believes that protocols must be established for recruiting participants, qualifications for participants, screening the participants, and training the participants.

4.2.7.1 RECRUITMENT

As part of the public outreach, Pilot Program participants should be identified. In addition, incentives such as financial rewards may be needed. Depending on the desired complexity of the Pilot Program, a large group may be required to evaluate different variables such as vehicle types.

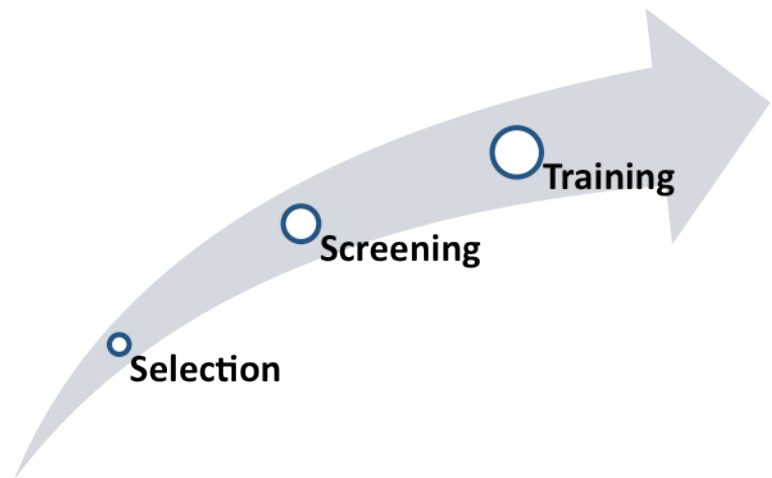


Figure 4-2. Potential Participant Protocols for the Pilot Program.

4.2.7.3 SCREENING

After recruiting for the Pilot Program, the participants should go through a screening process. The screening can be performed through online, telephone, in person surveys. The Pilot Program project team would provide background information and the basic framework of the Pilot Program.

4.2.7.4 TRAINING

After participants have been recruited and vetted, training is required. The training could include informational sessions, hands on practice with hardware and software, and discuss protocols for reporting errors or malfunctions.

5. PRIVACY POLICIES

5.1 INTRODUCTION

The construction, maintenance and operation of roadways in the United States have traditionally depended on the revenues generated from fuel taxes, with secondary funding from an assortment of registration fees and taxes. While vehicle mile travel (VMT) and road construction costs have generally increased, fuel taxes rarely match such increases in demand and expenditure. Indeed, as fuel taxes are often set and then ignored for years, and with the addition of more fuel efficient automobiles, fuel tax revenue may actually decline in relation to VMT. Nevada is an excellent example of such a gap. The current Nevada fuel tax was set in 1992. Since that time, VMT has increased by 6.8 percent per capita while fuel use per capita has declined by 8.3 percent. These diverging demand and revenue statistics place the future of Nevada's transportation system at risk.

Shifting revenue generation to a program linked to VMT is an alternative that may provide Nevada with a more stable source of transportation funding. A VMT fee system could generate revenue that is more proportionate to actual roadway use. In more advanced forms, a VMT fee system might also provide incentives for drivers to make more efficient use of roadways – and their own time. Data collected from an advanced VMT fee monitoring system can also be incorporated into transportation system planning.

Nevada has taken the lead, with a handful of other states, in pursuing development of a VMT user fee system. The Nevada pilot program shares many of the same approaches as found in other states. Depending on both the technical sophistication and goals of the program, a wide range of data may be collected from any vehicle in the program. For example, a simple at-the-pump collection payment and collection mechanism will read the odometer miles from the vehicle. The miles can then be assessed a fee. In more sophisticated programs, differential pricing might be assessed to both capture additional costs linked to congestion (congestion pricing) and the type of roadway being used. If such information is then given to drivers there may be an effort by drivers to modify their driving behavior to limit individual costs. This feedback pricing mechanism was a key component of the Puget Sound Study (80).

The purpose of this section is to address privacy and security concerns. We will also develop a set of policies that need to be considered for action to insure greater public acceptance of a VMT fee system.

5.2 ADDRESSING PRIVACY CONCERNS

Nearly every VMT fee pilot program has recognized the importance of privacy concerns. However, few have directly addressed the more specific contours of these concerns and most have equated privacy with information security. For example, the draft report from the Minnesota Pilot Program focused almost exclusively on technical dimensions of GPS and

mapping systems noting multiple measures of technical feasibility (81). The multi-state Iowa Study (82,83) also spent the bulk of their report discussing the technical feasibility of various ways to accurately track and measure VMT, but did go farther assessing privacy concerns. The Iowa Study utilized an on-board “smart card” data recording system. Recognizing privacy concerns linked to public acceptance, the Iowa Study stresses that road use information transmitted to the collection center should be as non-specific as possible. To insure the non-specific nature of data, a two-stage data entry system was developed where participants upload basic miles travelled, but then must separately login to a system to upload more extensive personal data. The miles driven are thus unlinked from other personal data to insure anonymity of the data. Whether there is greater acceptance of this two-stage data entry system is not known, but the Iowa researchers recognize that addressing privacy concerns are paramount in advancing VMT fee systems. Interestingly, the Iowa Study recommends that data should be processed and stored by a private firm under a stringent series of controls. No particular reasoning for the private firm recommendation is given except that there may be strong distrust of government by program participants. The same theme of participant distrust in government linked to privacy is also discussed in the Oregon study (84) The Oregon Study did not utilize an on-vehicle GPS tracking system to record VMT. Instead, the Oregon pilot program recorded VMT by altering gasoline pumps. Oregon collected miles driven in particular zones (during refueling) and collected no data concerning records of a vehicle’s travel history. Even with this design, a segment (not measured) of the population believes privacy is “at risk.”

The focus on technology in the initial pilot programs is certainly understandable. Before a VMT fee program can be pursued there must be confidence that VMT can be accurately and reliably measured. Yet in all prior studies, once technology issues are addressed, the research emphasizes the need for public acceptance. The greatest barrier to public acceptance is recognized as insuring driver privacy to the greatest extent allowed by available technology. However, none of the pilot studies conducted in the United States have developed a comprehensive set of privacy guidelines.

5.3 DISTINGUISHING PRIVACY & SECURITY

While there is overlap between the terms privacy and security, they are fairly distinct concepts and are addressed with very different sets of protection protocols. Data security is the protection of information assets from loss, theft, and unauthorized access. Data security is the less personal of the two areas and is largely accomplished with technology and specific administrative practices. The goal is primarily to prevent a breach to the data collection system.

The second element is privacy, which is the protection of information that includes personal identifiers from exposure that would cause embarrassment or danger to its owners, including physical or financial harm. Privacy also considers what data is collected, how it is to be used and who may have access to the data. Where physical security might best be described in technological terms, privacy protections are more the result of distinct policy choices. In both cases, though, the purpose is to insure individuals are confident that data collected remains private or at least confined within a specified domain of use. Without such confidence, public acceptance of a VMT fee system will be extremely difficult to achieve and maintain.

5.4 DEFINING A PRIVACY SYSTEM

While previous VMT fee studies have devoted relatively little attention to privacy issues, the National VII Coalition produced a preliminary overview document, “Vehicle Infrastructure Integration Privacy Policies Framework, Version 1.0.2” (hereafter referred to VII). The VII stresses that any data collected should be anonymous and, as much as possible, be linked to vehicles rather than individuals. The statement of policy is clear: “The essence of anonymous information is that it cannot be linked with an identifiable individual” (85). However, the VII recognizes that at some point vehicle information data can become linked to individuals. In the most obvious case, vehicle miles travelled must ultimately be linked to an individual for billing purposes. It is arguable that simply linking a vehicle to the registered owner still insures anonymity as the routes and person driving the miles to be billed are not identified. Indeed, information regarding only vehicles (as opposed to people) “is not usually considered personal information in the United States” (86). However, this is a matter of indeterminate legal status. As the PPF describes:

“In a National VII Program, there may be instances where impersonal VII data is linked by an identifier to other data that is personal information. In such a situation, what had been anonymous information in the form of impersonal vehicle data could become personal information regarding an identifiable individual. The Drivers Privacy Protection Act, 18 U.S.C. @ 2721 et seq. reflects such concerns about linking otherwise anonymous vehicle information with other information that can be used to identify a particular individual” (87)

To address and define boundaries for a comprehensive privacy policy, the VII outlines nine accountability principles for which policies should be developed. The nine principles are described briefly below.

5.4.1 RESPECT FOR PRIVACY & PERSONAL INFORMATION PRINCIPLE

Commitment to respect for individual privacy emphasizes that “personal information should be acquired, retained, disclosed, and used only in ways that protect the privacy of individuals. Personal information users should collect, retain and use only anonymous information whenever possible (88).” This fundamental first principle further strengthens privacy protections noting, “The concept of reasonable expectation of privacy under these VII Privacy Principles is not limited by what counts as a reasonable expectation of privacy under the Fourth Amendment of the United States Constitution. In many instances, society has deemed it reasonable to protect privacy at a level higher than that required by the Fourth Amendment. See, e.g., Electronic Communications Privacy Act, 18 U.S.C. § 2701 (1988); Right to Financial Privacy Act, 12 U.S.C. § 3401 (1988); Privacy Act, 5 U.S.C. § 552a (1988); Drivers Privacy Protection Act, 18 U.S.C. §§ 2721-2725; and Federal Communications Law and Regulations protecting wireless communications under 47 U.S.C. § 222 (89)” Any governmental entity thus anticipating development of a VMT fee system employing any sort of remote mileage collection system must be prepared to adopt legislation creating this higher order of privacy protection.

5.4.2 INFORMATION PURPOSES PRINCIPLE

“A personal information user should acquire, use, disclose and retain personal information only for valid purposes, consistent with the goals of a National VII Program (89).” This principle emphasizes that any participants in a VMT system should be informed about the purposes for which personal information will be collected, used or disclosed. Any information collected should be retained and stored only so long as it serves a valid purpose linked to the specific purposes for which it was collected. Interestingly, though, the VII Privacy Protocols allow the disclosure to and use by third parties “for valid purposes about which the information subject has been informed (89).” This allows some leeway, if suitably announced in advance, for a more expansive use of information by parties not specifically linked to direct delivery of a VMT system.

5.4.3 ACQUISITION PRINCIPLE

Before acquiring personal information, personal information users should assess the potential impact of such information collection on privacy. Personal information collection should be “limited to that reasonably expected to support currently planned activities that have been explained in advance to the personal information subjects who will provide personal information.” Mere possibility of future use for an undefined potential project would not be a sufficient “planned activity” under this principle (90).” The emphasis of this third principle is that privacy must be a first priority of any VMT system using any sort of remote information collection as “once privacy is lost, it can rarely be restored (91).” This principle also places the burden of advance determination of data needs on the information collection agency. Any personal information collected must be linked – in advance – to a specified and justified program objective.

5.4.4 NOTICE PRINCIPLE

The Notice Principle “insists that appropriate prior notice be given to personal information subjects so that information subjects know in advance about personal information collection and how that personal information will be used. Such knowledge allows personal information subjects to make informed choices about the use of information collected (92).” While seemingly overlapping with both principles 2 and 3 above, the Notice Principle further emphasizes that participants have advance knowledge of how information will be used and gives participants options in whether they will participate in more advanced aspects of information gathering. This “participant option” element of the Notice Principle is essential in designing any form of opt-in or opt-out systems where participants might be able to not only provide greater information but also use such information (such as congestion pricing data, or even payment options) to modify their own driving behavior on a voluntary basis.

5.4.5 FAIR INFORMATION USE PRINCIPLE

Any personal information collected must only be used “in ways that are compatible with the personal information subject’s understanding of and agreement to how it will be used (93).” The important point here is that any use of personal information is “predicated on advance notice of

planned uses being provided by a personal information user (93).” The advance notice and limitations on fair use apply to both the collecting agency and any third party users (see Section 5.4.2).

5.4.6 INFORMATION PROTECTION & RETENTION PRINCIPLE

Principle six emphasizes establishment of both technical and administrative protections of any personal information collected as part of a Vehicle Infrastructure Integration System. “Personal information users and information administrators should use technical, physical and administrative measures (emphasis added) to protect the confidentiality and integrity of personal information. The VII System should be designed so as to limit the potential for problems regarding information quality and security. For example, strong encryption of personal information transmitted through the VII System will greatly reduce risk of unauthorized access, as well as disclosure, alteration, or destruction of personal information (94).” Preparations to react quickly and effectively in the event of a security breach should be evaluated in advance. In addition, to avoid potential breaches of information, personal information should not be retained any longer than necessary and should be deleted as promptly as possible linked to the purposes of the information collected as authorized by both the individual providing the information and the entity using the information. “Personal information users should adopt time-limits on storage of personal information, inform personal information subjects about such time limits, and abide by them in actual operations (95).”

5.4.7 OPENNESS PRINCIPLE

The Openness Principle addresses “the need for transparency in a National VII Program. Personal information users, information administrators, and personal information subjects need to be able to make informed decisions regarding what personal information is collected and used, and how it will be protected...Openness is intended to encourage personal information users and information administrators to adopt coherent privacy protection processes and policies that users have articulated both internally and in communications to personal information subjects who participate in a National VII Program. In doing so, personal information users should seek current, reliable information about potential privacy issues and the best ways to maintain the privacy of personal information (96).” To advance openness, operators are encouraged to help information subjects “understand personal information practices” with internet privacy “help” sites and published privacy compliance guidelines. Comprehensive marketing and publicity campaigns should provide clear explanations how personal information will be collected, used and protected from unauthorized use.

5.4.8 PARTICIPATION PRINCIPLE

Subjects should participate in the protection of their own privacy. “That means that a personal information subject needs to be given notice of personal information collected from or about him or her (see Section 5.4.7), as well as access to the information subject’s personal information held by a personal information user. A personal information subject should also be able to correct his or her personal information to the extent that it is demonstrated to be inaccurate. A

personal information subject should also have the opportunity to object to improper or unfair use of his or her personal information (97).”

5.4.9 ACCOUNTABILITY PRINCIPLE

“Personal information users should provide appropriate means for personal information subjects to raise privacy issues and to make complaints regarding interference with privacy interests. A personal information user should respond to inquiries and complaints about interference with privacy interests or misuse of personal information, including use of personal information in ways that are incompatible with notice provided to information subjects (see Section 5.4.4) (98).” It is incumbent on personal information users to develop formal procedures to consider and resolve any disputes raised concerning the collection, use and protection of personal information.

5.5 APPLYING PRIVACY PRINCIPLES

While each of these principles has distinct attributes, they in many cases overlap. The thrust of the VII Principles is that data should be as secure as possible and that users be given multiple options for advance notice of what information will be collected and how such information will be used. A key component is that all personal information should be as anonymous as possible and, once collected, must be safeguarded with an identifiable individual agency accountable for establishing and maintaining these safeguards.

Implementation of privacy principles requires creation of specific policies – established by the relevant governing body (in the current case, the State of Nevada) – that address technological and administrative aspects related to the collection, use and safeguarding of personal information. Fortunately such policies are not unique. Governments at all levels have experience in drafting privacy information policies. Perhaps the best known policy in this regard is the federal government’s Health Insurance Portability and Accountability Act of 1996 (HIPPA). Besides addressing the titled issue of health insurance portability, HIPPA includes a complex set of rules covering patient privacy. HIPPA protection includes any information health care providers collect in an individual’s medical records, but also extends to information in an insurer’s data system and such third party entities as billing agencies. Amendments to HIPPA have strengthened rights of “prior consent” before information can be collected or disclosed. Patients have the right to review and obtain a copy of their health records; have corrections added to health records; to receive notice telling in advance how health records will be used and requiring advance notice for any disclosure of health records to third parties; and requires a report be sent if individual health information was shared. In addition to these protections, HIPPA creates a system where complaints can be filed and reviewed.

While HIPPA covers much of the same ground as found in the VII principles covered above, it is not an ideal analogy for collection of personal information linked to a VMT fee program. Health information is collected upon initiation of the individual. The individual has far more incentive for extensive information to be collected and has multiple possibilities (i.e. going from a general practitioner to a series of specialists) for sharing information.

A more cogent comparative policy framework is the Nevada Security of Personal Information Law (NSPI). NSPI is directed primarily at credit card issuers to insure the security of personal information and is covered in NRS section 603. The emphasis of the NSPI is the security of data. Encryption systems are mandated, as are the maintenance of “reasonable security measures” (NRS 603A.210). Disclosure of security breaches is required as is the destruction of records that pose a security breach hazard. A strength of the law is that it applies to entities holding personal information, regardless of whether the controlling entity got the information directly from a consumer or from a third party. The weakness of the law, however, is that records subject to protection and destruction are not specifically defined. The duration for holding information is also left to the discretion of the organization holding the record.

The initial action creating a VMT fee privacy policy must come from legislative authorization (similar to the NRS provisions created by the NSPI.) The policy needs to be fully informed by the nine principles from the VII (covered above). In particular, legislative action must designate a responsible state agency that is held fully accountable for development of specific protocols protecting individual privacy. Such privacy concerns must come prior to or simultaneously with any authorization of a VMT fee system. While specific aspects of technological protection are likely not the subject of NRS code, requirement for information security must be a priority and legally mandated aspect of policy. The mandate is not only for protection provided by an accountable agency, but should extend to any third party users of information. Security policies should also include severe penalties for unauthorized use or access into the information system and, as much as practicable, limit the use of information beyond specified uses. In addition, protocols for public consent and notice must be codified into law. Without such codification there is little chance for public acceptance.

Once an administrative entity is designated, specific policies for information use must be developed through open public meetings (linking to the transparency concerns in the openness principle in Section 5.4.7). This will require the responsible agency to clearly articulate in advance the types of personal information that might be collected linked to a specific project purpose. At the present time such specification is likely impossible as pilot programs have yet to even be tested. However, before implementation of a VMT fee system, this level of specificity must be in place and protocols for informing all drivers must be established (linking to principles in Section 5.4.2 through Section 5.4.5). In developing information gathering and use protocols, the responsible agency should examine methods creating opt-in and opt-out programs that allow individuals to provide differing levels of information with corresponding differing levels of personal and/or public benefit. For example, if individuals desired to only provide basic mileage data (opting out of more extensive information that could inform the individual of driver behavior) then the information collection device might be so restricted. For drivers wishing to provide more information (opting in) incentives could be established linked to differential mileage rates for designated types of road (day, time, type of roadway) driving.

Data security will also fall upon the designated administrative entity. As noted above, data security has a distinct technological dimension that will likely change as technology develops in anticipation of a VMT fee system. But information security also has a distinct administrative component, and the responsible agency must develop policies of limited access to and limited time storage for collected personal information (Section 5.4.6). Creation of a public oversight

board for developing policy guidelines should be considered, enhancing the elements of Section 5.4.7 above. There must also be clearly stated (and publicly available) policies allowing individuals access to data collected about them and held by a personal information user. Policies must also be established that allows individual to both correct and challenge the accuracy of information collected (Section 5.4.8).

5.6 SUMMARY

Specific privacy protocols have yet to be developed in any of the pilot VMT projects conducted to date. For the most part, these pilot programs have focused on two aspects of data security – technological feasibility and participant willingness to disclose information. Very little discussion has occurred concerning administrative control and use of personal information. This is not surprising as no VMT fee system has yet been enacted in the United States. The VII Privacy Policies Framework provides nine principles that are critical in guiding development of specific privacy policies linked to a VMT fee system. However, even these nine principles leave considerable leeway for interpretation of what might constitute appropriate types of information for collection, adequate notice, or even what data might be shared and under what circumstances. As the Nevada Pilot Program continues, program design should attempt to as realistically as possible develop different methodologies and test policies that address the specific administrative policies that will ultimately support a VMT fee system. The pilot program must go beyond a focus on information security and fully address the range of privacy concerns articulated in the VII principles. A field operational test must be matched with intensive governmental outreach activities that simulate as much as possible, real-life road pricing situations, information gathering regimens and administrative practices that will ultimately be part of a VMT fee system.

The importance of field testing various administrative elements is as critical as testing and verifying technology. For a VMT fee program to progress, legislative authorization will be required – not only for the collection of fees and authorization of a program budget, but also to insure basic elements of individual privacy protections. Such privacy protections, as noted in the VII, are likely to protect privacy at a level higher than that required by the Fourth Amendment. This will require action by the legislature and will greatly influence subsequent implementation by whatever entity is designated to oversee a VMT fee system. It is therefore prudent that field tests provide a range of administrative recommendations that can be forwarded with some range of confidence to legislative leaders. The field tests of such administrative measures can be developed from the VII principles and through shared experience with other pilot programs. If these tests are done with full reporting to the public – as the pilot program progresses – public acceptance is likely to be enhanced. As the VII argues, privacy concerns must be a “first priority” for a VMT fee system and this first priority should be incorporated into the pilot program.

6. ECONOMIC MODELS

6.1 INTRODUCTION

Since 1923, the motor fuel tax, based on a rate per gallon purchased, has been the main manner of collecting road revenues in Nevada. The Federal Government began collecting gas taxes in 1932 but did not dedicate the gas taxes to highways until 1956. Today fuel taxes collected by the federal, state and many local governments are used to fund the planning, design, construction, maintenance and operation of our roadways, and to support public transit systems. The fuel tax, in essence, is the road user fee. Currently, the Federal tax is 18.4 cents/gallon for gasoline and 24.4 cents/gallon for diesel. The Nevada state tax rates are 18.455 cents/gallon for gasoline and 27.5 cents/gallon for diesel, respectively. In Washoe County there are local and Regional Transportation Commission gasoline taxes totaling 17.53 cents/gallon that is indexed to inflation, but there is no local tax on diesel. The fact that it worked well for many decades proves that the fuel tax policy has its advantages, which is why many people believe that it will remain the mainstay of highway finance for many years. However, there are researchers who have stated that the fuel tax in the United States is too low (99,100); thus, the current fuel taxes need to increase. Others have stated, that in the future, fuel taxes will become less reliable because of the emerging alternative transportation energy sources. The use of hybrid (gasoline/electric), electric, natural gas and other means of vehicle propulsion is diminishing the use of gasoline and diesel, and subsequently reducing the fuel tax revenues. Consequently, it is clear that the current gas tax must eventually be replaced by a different revenue collection method. Following the concept of road users paying for roadway system, a new revenue mechanism is needed that can directly relate to the cost of road usage. The distance-based road user fee is considered an effective solution to this dilemma. According to this new concept, road users are charged by the amount of roadway traveled instead of how much gas they consumed.

The primary objective of this paper is to design a VMT (vehicle miles traveled) user fee structure to replace the current Nevada fuel tax system. It includes the following sections. After the Introduction, Section 6.2 discusses the advantages and disadvantages of the current fuel-tax system and reviews previous studies related to VMT user fee programs. Section 6.3 discusses historical patterns of VMT, fuel efficiency, and gasoline sales in the USA and Nevada. Section 6.4 proposes several VMT fee structures and discusses their advantages and disadvantages. The last section summarizes the report and provided helpful conclusions.

6.2 CURRENT FUEL-TAX SYSTEM

This section discusses the advantages and disadvantages of the current fuel-tax system. It also makes comments on new revenue alternatives.

6.2.1 ADVANTAGES

There are several advantages associated with the current fuel-tax system as described below:

- It has generated substantial revenues for many decades. It is reported that 51.74 percent of all highway-user revenues comes from state and federal motor-fuel and vehicle taxes in 2007 (101).
- It is easy to collect and administer. The tax is directly collected from a small number of gasoline wholesale distributors or refineries. Retail stations reimburse the gasoline distributors, and the motorists, in the end, reimburse the retail stations. It involves a low administrative cost. According to the Martin Wachs' study (99), the way of collecting fuel taxes (i.e., collecting from whole sellers and refineries instead of the public) incurs less administering cost. He also compared the cost of administering between fuel taxes and the traditional manual toll collection, and stated that the traditional manual toll collection costs 20 to 25 percent of the revenue, while the fuel tax only takes one or two percent of the revenue (99).
- It has less fraud potential. The fuel tax is paid directly by the distributors, which reduces the possibility of a fraud. Wachs stated that a certain kind of dye is added to the taxed fuel to change its color, making it easy to identify if the fuel has been taxed or not (99).
- It ensures the consumers' privacy because consumers pay fuel tax when they purchase gasoline at the pumps, anonymously by cash if desired.

6.2.2 DISADVANTAGES

The disadvantages of the current fuel tax system are summarized below:

- Fuel taxes are generally not indexed for inflation. Currently, the fuel tax is levied in a manner that the tax rate does not increase automatically with the change of oil price at the gas station. Instead, it remains constant and hence does not keep up with the inflation. As a result, the fuel tax revenue loses purchasing power with time. Because it is not adjusted for inflation, the federal gas tax has experienced a cumulative loss in purchasing power of 33 percent since 1993 (102). For gasoline, Nevada collects 18.455 cents state tax, 6.35 cents county mandatory tax, and up to 9 cents county optional tax (103). Only the county mandatory tax and optional tax are indexed to inflation in Washoe County since 2003. Same as the federal gas tax, there has been a significant reduction in the purchasing power of the state and most local fuel taxes.
- Fuel taxes in the U.S. are low compared with other developed countries. Parry and Small (100) stated that an ideal scheme of gas taxation should include pollution costs caused by vehicle emission, transportation congestion during peak hours, and the probability of causing accidents. They stated that Britain has the highest fuel tax rate among industrial countries (\$2.80 per gallon in 2000) and the United States the lowest at about \$0.40 in 2000. They argue for higher fuel tax to 1) penalize gasoline consumption because of pollution, such as greenhouse gases, hydrocarbons, and nitrous oxides, 2) raise the cost of driving to reduce vehicular travel and, therefore, indirectly reduce traffic congestion and traffic-related accidents, and 3) provide significant government revenue. According to their analysis, the gasoline tax in the U.S. should be \$1.01/gal which is about double the current average rate.
- The increasing number of fuel efficient vehicles tends to reduce the fuel tax revenue. According to some statistics on vehicle fuel economy, new cars have seen their gas

mileage improved from 14.2 miles per gallon (MPG) in 1974 to 28.6 MPG in 1997 (104). This means that with the same amount of gas tax, newer vehicles could travel more than twice the distance than the new vehicles two decades ago. Besides, Hagquist (105) stated that “the 2007 Corporate Average Fuel Economy (CAFE) standard for the fuel efficiency of new vehicles is 11.7 kilometers per liter, km/l (27.5 miles per gallon, mpg) for cars and 9.4 km/l (22.2 mpg) for light trucks. Some commercial hybrid vehicles already on the road attain double those figures.” These statistics show that even without considering inflation, the fuel tax revenue erodes with the increased purchase of fuel efficient vehicles. Furthermore, whenever there is an increase in fuel prices, people are more inclined to purchase more fuel efficient vehicles. This, of course reduces the gas tax revenue to the government, thus widening the gap between road revenues and roadway infrastructure construction and maintenance cost. Many researchers believe that in the near future, due to newer vehicle technologies, road users will no longer be paying enough fuel taxes to support their roadway systems.

- The revenue-need gap is growing between fuel taxes and transportation projects. As we all know, the purchasing power of money is reduced by inflation. Any transportation project requires expenditure for right-of-way, labor, and materials; however, due to the impact of inflation, they all cost more than before. As stated earlier, the current fuel-tax policy does not generally include inflation. In addition, the cost of highway projects has increased beyond the general rate of inflation. As a result, the purchasing power of the fuel tax revenue reduces even more (106). For example in Nevada, the state’s 18.445-cent per gallon fuel tax has not been increased since 1992. Over the same period of time, highway construction prices rose 99.7 percent nationally. Furthermore, according to the Blue Ribbon Task Force (107) “Nevada’s per capita highway travel has increased 6.8 percent and per capita fuel use has declined 8.3 percent since the state’s fuel taxes were last raised in 1992. Ultimately, Nevada’s highways are being traveled more heavily, using less fuel per capita, and at a tax rate that does not account for 14 years of inflation.” In addition, “from 2003 to 2005, the Consumer Price Index increased just 6.1 percent, while the Federal-Aid Highway Construction Price Index rose 40.2 percent. At the federal level, the Highway Trust Fund is projected to go into deficit by 2010 if current spending levels continue without additional revenues. Future reliance on federal funding to address Nevada’s shortfall is not realistic (108).”

6.2.3 NEW REVENUE ALTERNATIVES

With the current fuel tax rate and mechanism, the fuel-tax revenues will keep declining. In addition, due to an increase in the VMT, there is an increasing demand for highway system expansion. However, raising the fuel tax might not be a good solution to this problem since it is not a politically popular decision. More importantly, a revenue mechanism solely based on fuel tax will inherit all the potential problems as described in Section 6.2.2. To provide a better roadway revenue stream, the current revenue mechanism must be replaced by a method which is not dependent on the quantity of fuel sold. The new revenue scheme, which is also a policy issue, could have a more “equitable” fee structure which requires motorists to pay in proportion to their travel and to the costs they incur on the roadway. With this concept, the mileage-based user fee is under consideration in several locations as an alternative road financing method. This

concept has been given different names and scopes by different studies but is commonly referred to as “mileage-based user fee (mileage fee)” or “distance-user fee.”

In 2006, the Transportation Research Board published a special report on the fuel tax and other alternatives for transportation funding. It reported that charging the road users by vehicle miles of travel has many advantages. If fuel taxes are substituted by mileage fees, the revenue will not be influenced by the vehicle fuel efficiency; in other words, the innovations in vehicle technology and alternative fuels will not endanger the roadway revenues. The TRB report also stated that “if the use of all roads were monitored and charged for, local governments could readily fund their streets and roads with revenues from the user fees, as the states do now, rather than relying on more general revenue sources. More importantly, the benefits of the roadway system to travelers and the public could be substantially increased, since travelers would have incentives to use roads more efficiently and road authorities would have better information to guide investment decisions (109).”

Besides the mileage fee, many other kinds of road pricing applications are investigated to achieve various objectives including facility congestion tolls, cordon (or area) congestion tolls, weight-distance truck tolls, and distance-based pricing (110). “For facility tolls, users pay a fee to use transportation facilities, like a bridge, tunnel, or specified section of highway, the level of which depends on the ambient level congestion. Usually, these programs are to ensure free-flowing traffic, thus maximizing capacity. For cordon congestion tolls, users are charged to enter a specified charging zone during peak hours, which usually surrounds a congested urban area. This type of program is mostly to reduce demand, therefore easing congestion and pollution. For weight-distance truck tolls, trucks need to pay the fee to use the road system based on their weight and distance traveled. Depending on the specific program, the measurement of weight may be based on actual weight, maximum laden weight, or axle configuration. As we know, heavy vehicles do most of the damage to roads; therefore, such tolls are designed to recover the costs caused by the heavy vehicles on the road network. In distance-based price variabilization, variable prices based on mileage traveled are used to substitute the currently fixed charge of vehicle ownership and usage, such as registration fees, leasing fees, and insurance (111)”. With a distance-based user fee, motorists could save money by traveling less, which might result in a decrease in VMT, thereby easing problems related to congestion and environmental pollution. These road pricing applications can be used to serve many objectives, such as collecting road revenue, charging equitable costs, reducing traffic congestion, improving safety and efficiency, protecting environment, and lowering pavement damage. Even though these programs may not have the same objectives as the mileage user fee program, the lessons learned about techniques, pricing policy, institutional issues, and public acceptance will contribute to any mileage user fee program.

6.3 HISTORICAL TRENDS OF FUEL CONSUMPTION & VMT

Should Nevada consider replacing fuel taxes with VMT fees? The answer depends on the sustainability of the current fuel-tax system. If fuel tax revenue can meet the future transportation demand, there are no reasons to create a new funding system like a VMT fee scheme which will certainly cause many challenges and concerns such as privacy issues, equity concerns, and enforcement challenges. Unfortunately, as discussed above, the fuel-tax revenue

will be unable to meet the future transportation needs. Mathematically, tax revenue equals the product of tax rate and tax base. For revenue to keep up with the increase in transportation needs (and costs), either (both) the tax rate or (and) tax base should increase. However, the federal and state fuel tax rates have not seen an increase since 1993. Only a small proportion of the fuel tax (Washoe County) is indexed with inflation. No doubt, fuel tax rates have remained unchanged for a very long time. Unless the tax rate could be raised, which is extremely unpopular among the general public, the only way to keep tax revenue with the increasing demand is to change the tax base. This section analyzes the historical patterns of fuel consumption and VMT in the USA and Nevada. Here, fuel consumption is regarded as the current tax base, while VMT represents the demand for transportation services. If VMT increases faster than fuel consumption, given the constant fuel tax rate, we conclude that fuel tax revenue is unable to meet the transportation demand, suggesting the government needs to change the tax base, which could be a VMT fee system.

6.3.1 US VMT AND FUEL CONSUMPTION TRENDS

Table 6-1 shows the nation’s growth rates of VMT of passenger cars, VMT of other 2-axle-4-tire vehicles (light trucks), and fuel consumed by the two categories between 1990 and 2006 (112,113,114). Light trucks include vans, pickup trucks, and sport utility vehicles. Based on the regression results, given the high significance level, the results clearly show that the annual VMT increases faster than the fuel consumption, for both passenger cars and light trucks. For instance, between 1990 and 2006, the volume of passenger car VMT increased about 1.6 percent annually, comparing with one percent of growth rate for passenger car fuel consumption. The same conclusion is revealed in Figure 6-1 (115). This suggests that VMT also increases faster than tax revenue, because fuel tax rate has virtually remained the same since 1993.

Table 6-1. Annual Growth Rates of VMT & Fuel Consumption between 1990 and 2006.

Variable	Growth Rate (%)	t-stat	Observations	Adj-R ²
Passenger car VMT	1.604	16.494	17	0.944
Light truck VMT	3.385	16.833	17	0.946
Passenger car fuel consumption	1.017	9.398	17	0.845
Light truck fuel consumption	3.267	17.666	17	0.951

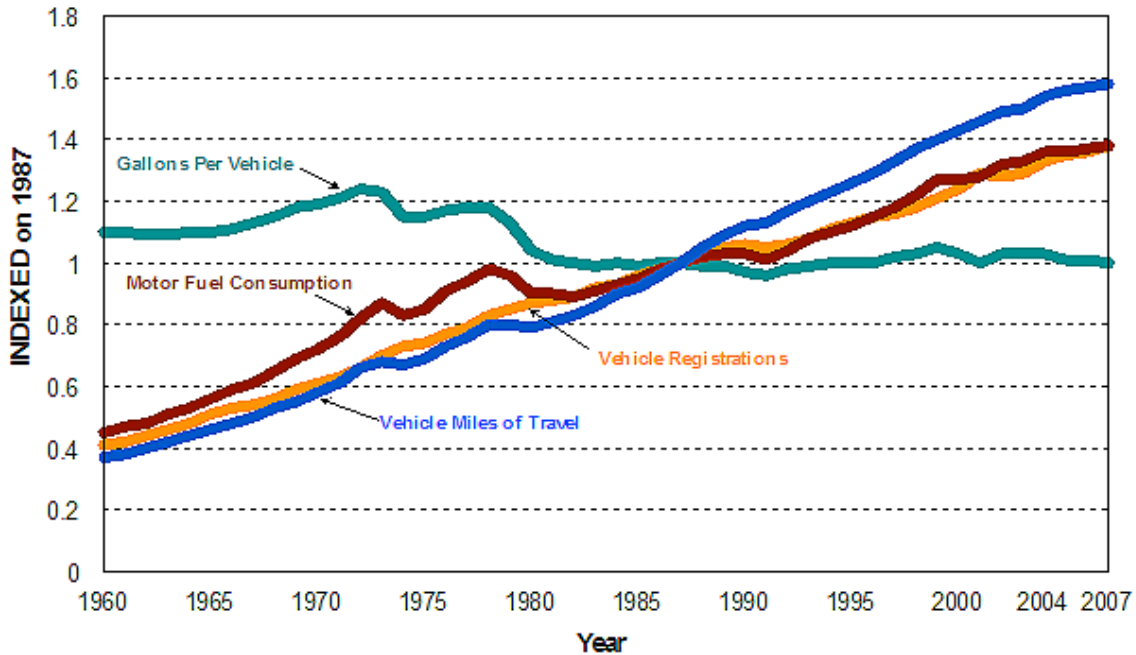
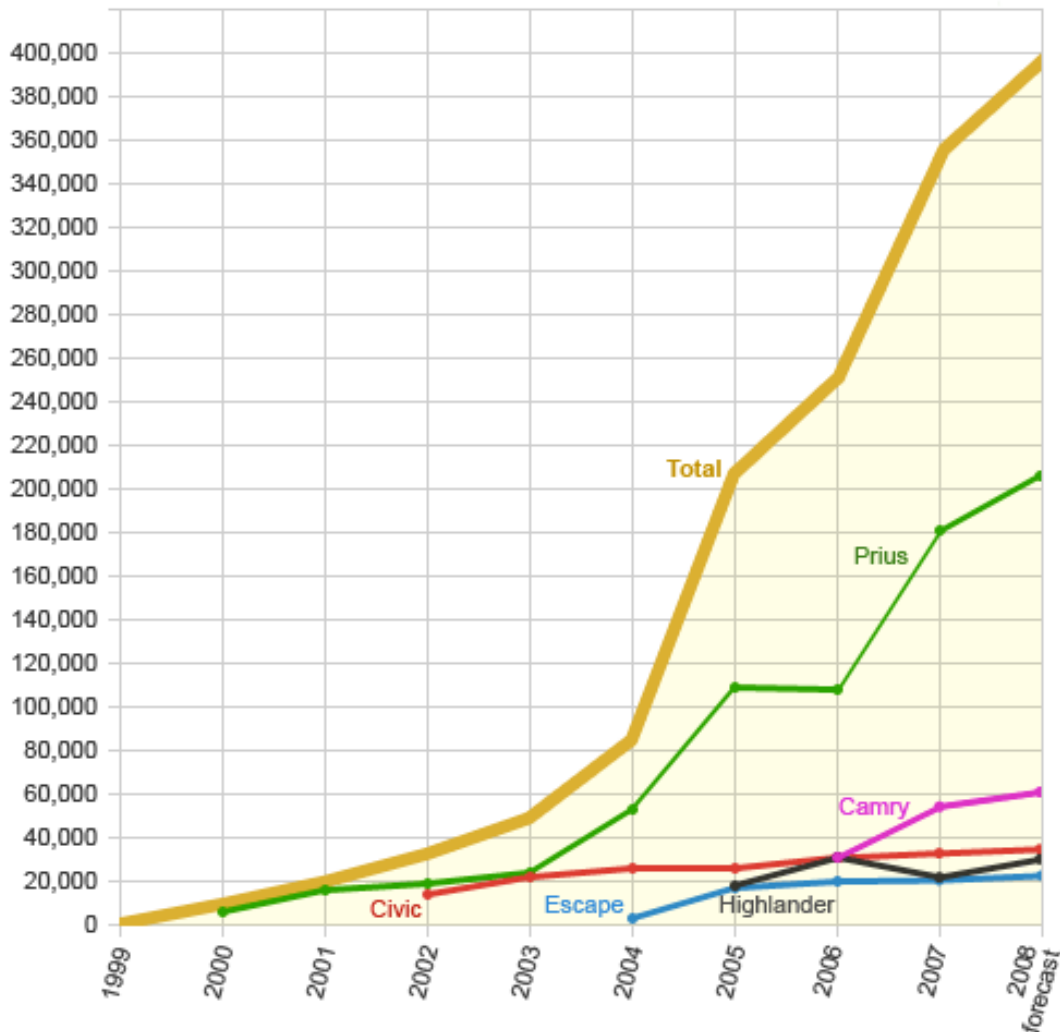


Figure 6-1. Vehicle Registrations, Fuel Consumption, & Vehicle Miles of Travel as Indices.

Two main reasons explain why VMT increases faster than fuel consumption. One is the improvement in fuel efficiency. Between 1978 and 2008, for passenger cars, the gas efficiency increased from 18 MPG to 27.5 MPG (101). During the same period, for light trucks, the number increased from 17. MPG to 22.5 MPG. The other main reason is the increasing number of hybrid vehicles (Figure 6-3). The sales of hybrid vehicles increased from 9,000 in 2000 to 352,000 in 2007 (116).

U.S. hybrid market historical sales (1999 - 2007 with 2008 forecast)



<http://www.hybridcars.com/market-dashboard/april-2008-hybrids-defy-recession.html>

Figure 6-2. Hybrid Vehicles Sold (in 1,000s).

6.3.2 NEVADA VMT AND FUEL CONSUMPTION TRENDS

Nevada experienced a similar trend as the data indicates. Between 1998 and 2007, based on linear [or nonlinear] regression results, the total VMT in Nevada increased at an average annual rate of 3.32% with a standard deviation of 0.11%, while the amount of gasoline sales increased at an average annual rate of 2.97% with a standard deviation of 0.25%. No doubt, VMT increases faster than gasoline sales, suggesting that VMT also increases faster than the gas tax revenue.

The following figures show the time patterns of VMT and the gasoline sales for Washoe County and Clark County (117,118,119). For both counties, the linear uprising pattern for VMT is quite obvious, more dramatic for Clark County (Figure 6-3). However, gasoline sales decreased in

recent years, starting 2003 for Washoe and 2007 for Clark, respectively (Figure 6-4). On a per capita basis, VMT did not show a decreasing pattern for both Washoe and Clark counties (Figure 6-5). It is interesting to notice that the per capita VMT was consistently higher for Washoe County than for Clark County, while the gap of gas consumption became smaller in more recent years. This is probably because congestion deteriorated faster in Las Vegas than in the Reno/Sparks area. In 2007, the average gas mileage was 18.71 MPG for Washoe County. It was 17.93 MPG for Clark County.

VMT directly measures the use of Nevada roads. Hence, it links to the cost of transportation services, which include road construction and maintenance. However, because of increase in the number of hybrid vehicles and the improvement in gas efficiency, the relationship between gas sales (and thus tax revenue) and transportation services (and thus cost) has become weaker. Given no change of the federal gas tax since 1993 and little change on the local gas taxes, the fact that VMT grows faster than gasoline sales suggests that transportation cost increases much faster than gas tax revenue. With the current financing system, transportation deficit appears and will become bigger. Therefore, it is necessary to seek other alternatives to better finance future transportation systems in the state.

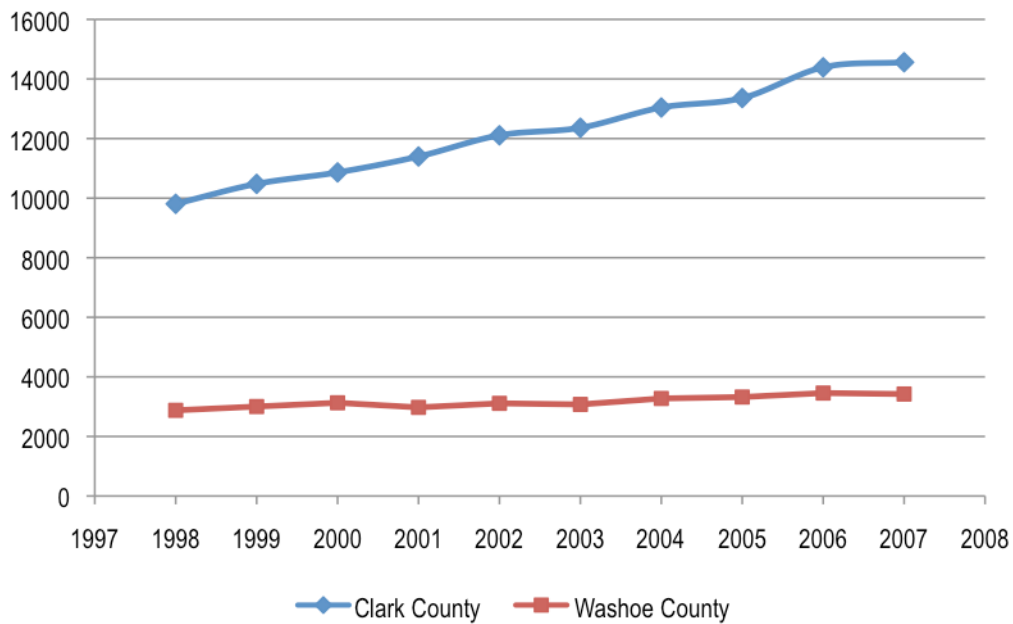


Figure 6-3. Annual VMT in Washoe County & Clark County (in million miles).

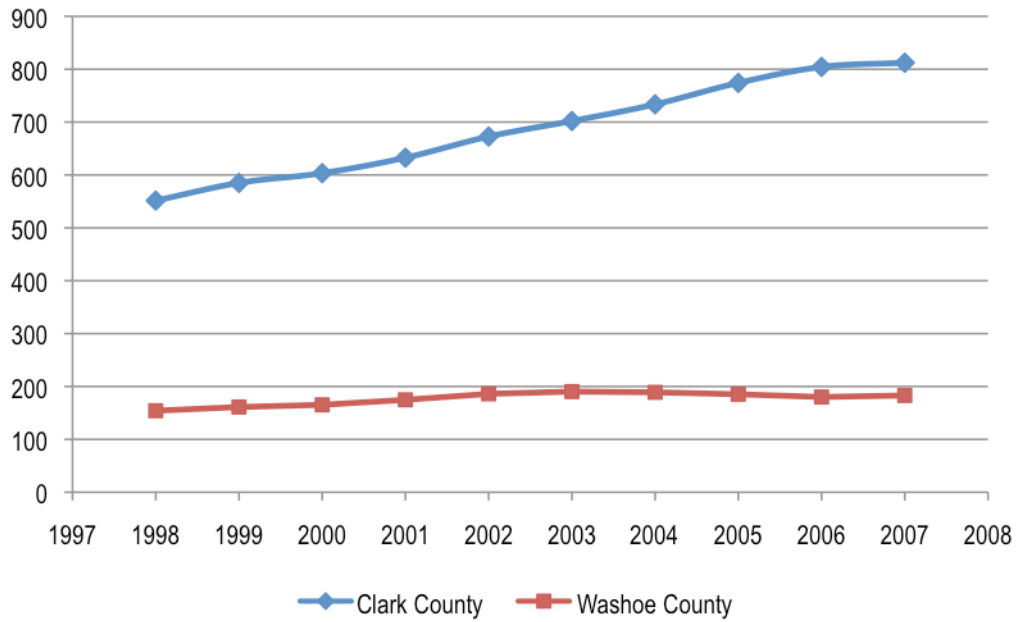


Figure 6-4. Annual Gasoline Sales in Washoe County & Clark County (in million gallons).

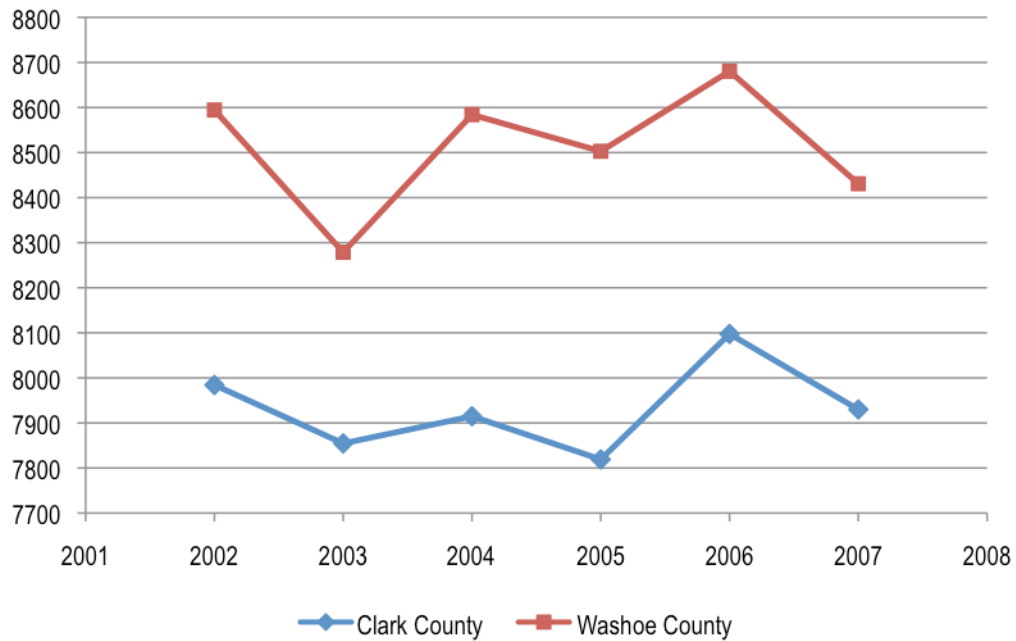


Figure 6-5. Annual Per Capita VMT in Washoe County & Clark County (miles/person).

6.4 VMT FEE STRUCTURE: SOME PROPOSALS

Given the magnitude of the revenue involved and the potential resistance to a change among the public, a VMT fee system would need to be carefully designed. Regarding a VMT fee structure, the study done by Kuhl (120) identified the following key attributes: (1) a stable revenue stream, (2) an ability to assess higher charges for users who incur higher costs, (3) an ability to offer incentives for users to travel on appropriate roads and to spread their trips across different time periods, and (4) an ability to accurately apportion user fees to different jurisdictions. In another study, Whitty suggests the following criteria for a VMT fee system: (1) users pay in proportion to road use; (2) VMT fee generates sufficient revenues to replace fuels tax; (3) funding source supports the entire road and highway system; and (4) program is perceived as fair and acceptable to the public. The study has estimated that the appropriate revenue neutral road pricing for distance (as a replacement for the fuel tax) would be approximately 1.22 cents per mile in the 2002 cost. It also argues that a VMT fee program needs to index fees for inflation, increase the fees beyond revenue neutrality, consider congestion pricing for heavily used urban road networks, and provide incentive for fuel efficient vehicles.

In this section of the paper, six optional VMT fee systems are compared and contrasted. The first four systems emphasize the idea of replacing gas taxes with VMT fees, basically on a revenue break-even basis. The fifth system is a pay-as-you-go scheme, basically an ad valorem tax, with a VMT fee determined by an estimated budget of providing transportation services. In the last system, we add indirect costs into the VMT fee, making drivers pay the total cost of traveling. In our current analyses, commercial trucks are excluded. The 5-axle combinations will be included in our future analysis to provide some context and comparisons.

6.4.1 SINGLE FEE SYSTEM

If a VMT fee is accepted by the general public to replace the current fuel tax, one possible scheme is a single fee system. This system would charge a uniform flat fee per mile regardless of vehicle categories (excluding trucks), location of travel, and time of travel. A uniform flat VMT fee would be determined on a revenue-neutral basis, i.e., a VMT fee could replace the current fuel tax so that the total revenue will remain the same.

Let R be the current fuel tax revenue and $TVMT$ the total annual vehicle miles traveled. A uniform VMT user fee, f , will be charged to all classes of vehicles, no matter where and when they travel. It can be determined by,

$$f = \frac{R}{TVMT} \quad \text{Eq. 6-1}$$

Data on both R and $TVMT$ are available from local government agencies, such as DMV. Accordingly, a uniform VMT fee can be determined by using the above formula.

Alternatively, a uniform VMT fee can be determined by

$$f = \frac{R}{TVMT} = \frac{T * TFS}{TVMT} = \frac{T}{AFE} \quad \text{Eq. 6-2}$$

where T is fuel tax rate, TFS the total fuel sales, and AFE the average fuel efficiency. To determine the VMT fee under this system, we need information on the fuel tax rate and the overall average fuel efficiency. Tax rate is readily available. The overall fuel efficiency can be obtained as the ratio of the overall VMT to fuel sales. Equation 6-2 can incorporate vehicles that use diesel. To do so, we sum the tax revenues from gasoline and diesel sales, find the total VMTs for gas-vehicles and diesel-vehicles, calculated the weighted average fuel efficiency, and determine the rate of VMT fee. It is a matter of data collection.

This ratio, however, may either underestimate or overestimate the average gas mileage, depending on the relative share of fuel purchased for commercial trucks and the relative share of VMT by hybrid vehicles. Currently, and in the near future, the probable impact of fuel used by trucks is greater than the contribution of VMT by hybrid vehicles, suggesting that the overall fuel efficiency is more likely underestimated, which leads to a higher VMT fee rate.

According to NDOT (103), the current gasoline tax is 52.205 cents per gallon, which includes federal tax of 18.4 cents, state tax of 18.455 cents, county mandatory tax of 6.35 cents, and county optional tax (9 cents for most counties such as Clark and Washoe [adjusts tax for inflation]). The 2007 average gas mileage is 18.92 per gallon (dividing the total annual VMT by total annual gasoline sales and this number is 18.71 for Washoe County and 17.93 for Clark County, respectively). Using the above formula, we calculated a uniform VMT fee of 2.76 cents per mile for the state on average, 2.79 cents per mile for Washoe County, and 2.91 cents per mile for Clark County. It is worth mentioning that charging different fees for Washoe and Clark Counties could be a political challenge. In a Clark County dominated legislature, any system where Clark County pays more is likely to be poorly received. Yet, a jurisdiction-based fee structure deserves considerations.

The advantages of a single VMT fee include: (1) it would be easy to determine and adjust the rate and (2) every driver pays the same. If VMT is measured by vehicle odometer readings, an annual uniform VMT fee can be applied even without a GPS system, which helps to deal with the concerns about privacy issues. However, a single VMT fee system could be unfair because the fee does not change with vehicle categories. Drivers pay the same fee regardless what types of vehicles they drive (gas efficient cars vs. inefficient ones), when they drive (rush hours vs. off-peak hours), and where they drive (rural roads vs. urban roads).

It is worth mentioning that this section only considers fuel tax revenue and VMT in Nevada. However, a proportion of fuel purchased in Nevada is consumed outstate and a proportion of miles driven in Nevada uses fuel purchased in other states. If the first proportion is relatively higher, Nevada receives more fuel tax revenue than the VMT occurred in the state. In this case, using the revenue-neutral principle would overcharge a VMT fee. If the second proportion is higher, meaning many drivers pump gas out state but drive in Nevada, they are using Nevada roads without paying it. In this case, the revenue-neutral principle would undercharge a VMT fee. Nevada is considered as a bridge state, where more likely than not, people drive a lot in Nevada but do not pump gas and pay gas tax enough. Hence, the revenue-neutral principle tends to undercharge a VMT fee. This resulting unfair situation calls for a national policy on VMT fee.

6.4.2 DUAL-FEE SYSTEM

A dual-fee system is to charge two different VMT fees for passenger cars and light trucks. If the 5-axle combination is also included, the following analysis can be generalized by adding another terms representing the 5-axle combination, and the scheme becomes a triple-fee system. No qualitative conclusions will be changed. Let GC_{PC} and GC_{LT} be the gas consumption of passenger cars and light trucks, respectively, VMT_{PC} and VMT_{LT} the total vehicle miles traveled, GE_{PC} and GE_{LT} the gas efficiency, and T the tax rate. We have,

$$R = GC_{PC}T + GC_{LT}T = \frac{VMT_{PC}}{GE_{PC}} + \frac{VMT_{LT}}{GE_{LT}} T = VMT_{PC} \frac{T}{GE_{PC}} + VMT_{LT} \frac{T}{GE_{LT}}$$

$$= VMT_{PC}f_{PC} + VMT_{LT}f_{LT} \quad . 6-3$$

Therefore, user fees of f_{PC} and f_{LT} will be charged to passenger cars and light trucks, respectively. To determine the VMT fee under this system, similar to the uniform fee system, we need information on the fuel tax rate and the overall average fuel efficiency for both passenger cars and light trucks.

To determine VMT fee rates for Nevada travelers, we need data on gas efficiency of passenger cars and light trucks. So far, we are unsuccessful in getting such data. For our current analysis, we assume gas efficiency the same for Nevada and the USA, which is 22.4 miles per gallon for passenger cars and 18.0 miles for light trucks (101). Using the current gasoline tax rate of 52.205 cents per gallon, VMT fee should be 2.33 cents per mile for passenger cars and 2.90 cents per mile for light trucks.

The dual fee system charges would be different VMT fees for passenger cars and light trucks. Light trucks would be charged higher because they consume more gasoline, take more road space, and cause (slightly) more pavement damage. Hence, VMT fees become fair relative to the one charged by a uniform VMT fee system, helping to increase public acceptance. Because of a lower VMT fee for passenger cars, the system may also encourage people to buy and drive smaller vehicles, making commuting less dependent on gasoline. One obvious disadvantage of the dual fee system is an increased administration cost since different fees will be charged to different vehicle categories. Also, like the uniform VMT fee system, drivers pay the same fee regardless when they drive (rush hours vs. off-peak hours) and where they drive (rural roads vs. urban roads).

6.4.3 MULTIPLE-FEES SYSTEM

The multiple-fees system generalizes the dual-fees system by grouping vehicles according to their makes and models as well as the years they were produced. Hence, fees are different from various vehicle detailed classifications. For vehicle group i , let GC_i be the gas consumption, VMT_i the total vehicle miles traveled, GE_i the gas efficiency, and T the tax rate. We have,

$$R = \sum_{i=1}^N GC_i T = \sum_{i=1}^N \frac{VMT_i}{GE_i} T = \sum_{i=1}^N VMT_i \frac{T}{GE_i} = \sum_{i=1}^N VMT_i f_i \quad \text{Eq. 6-4}$$

Therefore, for each vehicle category, a VMT user fee is determined by the ratio of gas tax rate (T) and gas efficiency (GE). The following website <http://www.fueleconomy.gov/Feg/findacar.htm> provides fuel efficiency information for all types of vehicles from 1985 to 2010. For most vehicle categories, information on gas mileage is also available for urban and highway conditions. For example, for 2009 Acura TL 2WD, the combined MPG (miles per gallon) is 21, with MPG of 18 for city roads and 26 for highways. Using 21 MPG and gas tax rate of 52.205 cents per gallon, a VMT fee of 2.49 cents per mile would be applied to 2009 Acura TL 2WD. For 2009 Acura MDX 4WD, the combined MPG (miles per gallon) is 17, with MPG of 15 for city roads and 20 for highways. Using 17 MPG and gas tax rate of 52.205 cents per gallon, a VMT fee of 3.07 cents per mile would be applied to 2009 Acura MDX 4WD. For 2009 Bently Azure, the combined MPG is 11, with city MPG 9 and highway MPG 15. Respectively, it would have a VMT fee of 4.75, 5.80, and 3.48 cents per mile. In principle, this system allows different VMT fees for highways (and rural roads) and city roads, using different MPGs.

One obvious advantage of the variable-fee system is its strong link between VMT fee and gas efficiency of various vehicle classifications. In this regard, public perception could be a lot more favorable. Interestingly, in the VMT workshop held in Las Vegas, August 19, 2009, the rank #1 statement by all participants is “VMT rates need to be tied to vehicle classification.” However, there are additional costs to implement the various-user-fee system because data on gas efficiency have to be obtained for all makes and models. Data on the gas efficiency for some vehicle categories could be challenging to obtain, such as on those vehicles made before 1985. Also, drivers pay the same fee regardless when they drive (rush hours vs. off-peak hours) and where they drive (rural roads vs. urban roads).

6.4.4 GENERALIZED USER-FEES SYSTEM

The first three systems charge a VMT fee per mile that does not depend on when and where traveling occurs. However, good efficiency is also a function of driving conditions, which in turn, depends on the time of day and where traveling occurs (such as rural, urban, highway, etc.), meaning fuel efficiency not only depends on vehicle type but also the roadway operating conditions. For vehicle i , let GC_i be the gas consumption, VMT_i the vehicle miles traveled, GE_i the gas efficiency affected by the road conditions and time of the day, and T the tax rate. We have,

$$R = \sum_{i=1}^N GC_i T = \sum_{i=1}^N \frac{VMT_i}{GE_i(x)} T = \sum_{i=1}^N VMT_i \frac{T}{GE_i(x)} = \sum_{i=1}^N \int_0^{VMT_i} f_i(X) dVMT_i$$

Eq. 6-5

where X is a vector of variables including road conditions and congestion levels. A flexible VMT fee, $f_i(X)$, is a function of vehicle make and model, road conditions, and traffic levels. Mathematically, each term inside the summation should be an integral with respect to VMT.

In the modified system, VMT fee is determined based on not only vehicle classifications but also roadway classification and traffic conditions. The system charges different fees for rural road, urban road, highway, rush hours, and off-peak hours, in addition to various vehicle types. Therefore, the fee best reflects fuel efficiency under different conditions for different vehicles.

Because of this strong relationship, drivers would pay about the same amount of tax to the government through fuel taxes or VMT user fees. Hence, for individual drivers, a VMT fee replaces the fuel taxes. One challenge of the modified system is to determine fuel efficiency for various vehicle models and under different road and traffic conditions. For this, some quantitative analyses (such as regression) have to be done to examine how fuel efficiency is related to vehicles, speed, and road conditions. To implement this system, for each vehicle, GPS needs to provide information on location and time, which will be used to analyze road conditions and traffic level, predict fuel efficiency, and determine the variable rate of VMT fees.

6.4.5 PAY-AS-YOU-GO FEE SYSTEM

The above systems are proposed based on a revenue neutral principle, i.e., the rate of user fee is determined so that the total amount of VMT fee revenue equals to the current total amount of fuel tax revenue. Given the fact that VMT grows faster than fuel consumption and thus fuel tax revenue, it is expected that the deficit will become smaller, compared to the current gas tax system. Still, on one hand, transportation deficit may continue or even become bigger in an absolute term if cost increases faster than revenue. On the other hand, if VMT and thus VMT revenue increase faster than transportation spending, surplus may be generated in the future.

One way to avoid such a deficit or a surplus is to create a pay-as-you-go user fee system. Under this system, a rate of user fee is determined to balance the predicted fee revenue and spending. To a large degree, the system is similar to the property tax system. Hence, it is an ad valorem tax. The following shows the procedure of fee determination:

1. For a given fiscal year, estimate costs of transportation, by purposes and by organizations. Add all the costs to obtain a total.
2. For the same fiscal year, predict the total VMT in an area.
3. An average user fee is determined by balancing revenue and costs. This rate can be treated as T in the above analysis, like the flat fuel tax rate. Similar to the average rate, an individual rate can also be determined for each category of transportation costs, such as administration, construction, and maintenance.
4. One of the systems proposed above (A-D) could be used to determine the VMT fee rate.
5. Adjust the VMT rate based on future costs and VMT.
6. Set up a cap on the fee to control cost from skyrocketing, on the growth rate or the level of VMT rate.

6.4.6 FULL COST FEE SYSTEM

The above proposed VMT fee structures emphasize the idea of replacing the current fuel tax with a future VMT fee. In principle, based on fuel efficiency, the proposed structures attempt to set up a VMT fee so that drivers would pay the same amount of money with either a fuel tax or a VMT fee, especially under the generalized variable-fee system. For the uniform-fee model, it is the overall averages that are the same. For the dual-fee model, light trucks and passenger cars pay different fees, and the fees are determined without considering road space taken and pavement damage caused by light trucks and passenger cars. For the multiple-fee model, a VMT fee is determined based on vehicle's fuel efficiency. Hence, because of better fuel efficiency,

new vehicles pay less than their older counterparts, and hybrid and electric vehicles pay a much lower VMT fee than other passenger cars, even though they take the same road space and cause the same pavement damage. Therefore, the above fuel-efficiency-based VMT fee proposals are not fair from the user cost of point view as they do not fairly capture the true user cost of transportation infrastructure. A better VMT fee system makes drivers pay the full cost of their traveling. Otherwise, cost will not be fully reflected in decision-making and resources will be misallocated, causing a net loss to the society.

When people are driving on roads, in addition to the costs to themselves such as travel time and vehicle depreciation, drivers also generate costs to the local society, including road damage, emission, accidents, and traffic delays. Using a VMT fee mechanism, as argued in Sorensen and Taylor (120), charges can be collected based on the total social cost. From a technical standpoint, it is relatively straightforward to layer on the congestion tolls that would apply within crowded urban areas during periods of peak travel for the purposes of optimizing road capacity or managing demand and encouraging mode shift. It is also possible to charge fees based on axle weight or emission class in order to encourage users to purchase and operate vehicles that impose less damage on roadways or the environment. Further, a fee could be collected to internalize the external accident cost. Let f be the VMT user fee per mile, following Murphy and Delucchi (121) and Parry and Small (100), we have,

$$f = UC^I + EC^P + EC^N + EC^C + EC^A \quad \text{Eq. 6-6}$$

where UC^I measures the direct user cost of transportation infrastructure, which also includes road damage, EC^P , EC^N , EC^C , and EC^A are indirect costs of pollution, noise, congestion, and accidents.

Parry and Small (100) simulated a VMT tax, which more directly addresses the distance-related externalities. For each route, let V be the traffic volume and AC be the average commuting cost (largely, it is the average commuting time). This gives the total commuting cost $AC * V$ and the following marginal social cost,

$$MSC = \frac{d(AC * V)}{dV} = AC + V \frac{dAC}{dV} = AC + EC \quad \text{Eq. 6-7}$$

where EC is the externality cost ($V \frac{dAC}{dV}$).

If the average commuting cost (such as time) increases with the number of commuters, like the case on congested urban roads, EC is positive and the marginal social cost (MSC) will be higher than the private average cost (AC). Consequently, the equilibrium travel volume (V_E) will be larger than the social optimal traffic volume (V_O), i.e., too many commuters are on the roads. The former is determined based on the private average cost while the latter is calculated based on the marginal social cost, as shown in Figure 6-6. If the average commuting cost decreases with the number of commuters, like the case of public transit, EC is negative and the social marginal cost (MSC) will be lower than the private average cost (AC). Consequently, the equilibrium travel volume (V_E) will be less than the social optimal traffic volume (V_O), i.e., too few

passengers are using public transit. If the number of commuters does not affect the average commuting cost (like in the midnight), no congestion exists and externality disappears.

To reach social optimization, externality should be internalized. In the case of congested urban

roads, this suggests a toll of $V \frac{dAC}{dV}$ be charged on commuters. Because $V \frac{dAC}{dV}$ depends on traffic volume, the toll should be higher for more congested roads or periods than for less congested roads or periods. The optimal toll revenue equals to $V^2 \frac{dAC}{dV}$ and is determined at V_0 .

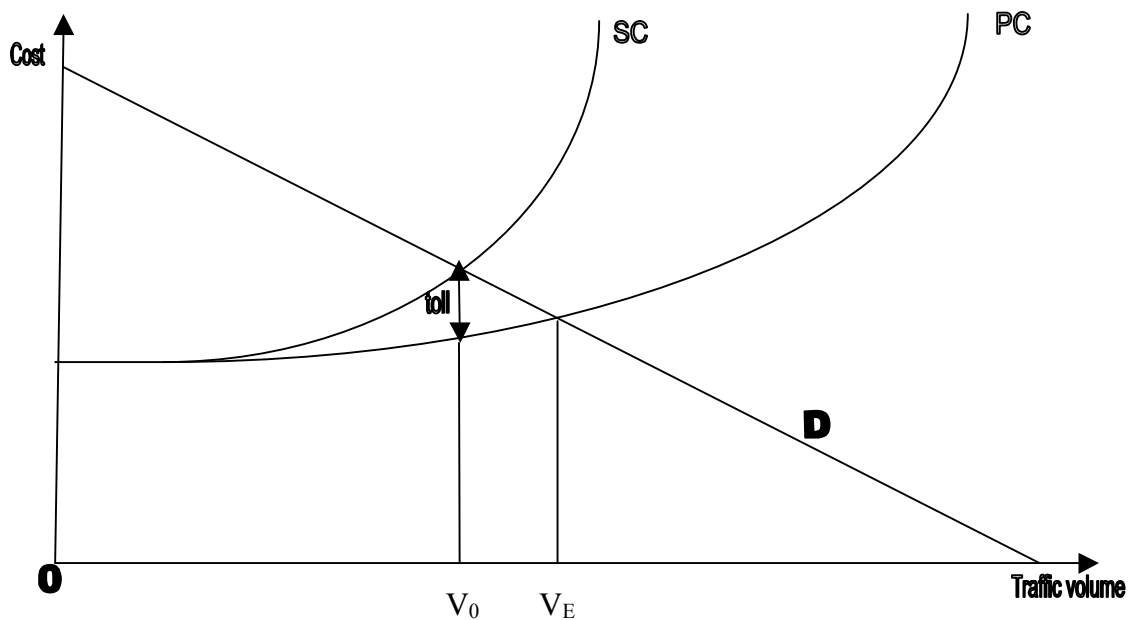


Figure 6-6. Economics of Congestion Pricing.

Many studies have discussed the theory and practice of congestion pricing. Evans (122) examined when congestion pricing is a good policy. Giuliano (123) assessed the political acceptability of congestion pricing. Small (124,125) investigated toll revenues and spending. Often, the public perceives toll simply as a tax and commuters dislike it. Congestion pricing thus is considered as an economists' dream but politicians' nightmare.

However, in recent years, congestion pricing is becoming more popular in practice and has been receiving more public support. It also has been implemented in many cities in different countries. The best-known example of a successful congestion pricing program is the Area Licensing Scheme in Singapore where vehicles that wish to enter the central business district during peak hours must purchase a license (126,127,128). In Spring 1998, the city shifted to a fully automated electronic charging system, with in-vehicle devices allowing payment by smart card and enforcement using cameras and license plate reading equipment. The system has reduced traffic by 13 percent and increased vehicle speed by 22 percent. On February 17, 2003, London implemented a plan for using road pricing to combat congestion in central London. The scheme involves a standard per-day charge for vehicles traveling within a zone bounded by an

inner ring road. The congestion charge, together with improvements in public transit financed with revenues from the charging system, led to a 15 percent reduction in traffic in central London. Travel delays have been reduced by 30 percent. Average traffic speed increased 37 percent. Excess waiting time on buses has fallen by around one-third (128,129). In the first half year of 2006, Stockholm took a trial on congestion pricing, which resulted in 22 percent drop in vehicle trips and 9 percent increase in ridership on inner-city bus routes. Traffic accidents involving injuries fell by 5 to 10 percent. Exhaust emissions decreased by 14 percent in the inner-city. Residents of the City of Stockholm voted for continuation of the system in a referendum on September 17, 2006. The system was reinstated in 2007 (128). Congestion pricing also has been implemented in the USA. Examples include the HOT lanes on I-15 in San Diego, California and the bridge pricing in Lee County, Florida, both started in 1998. A better known example is the four variably-priced express lanes in the median of the State Route 91 Freeway in Southern California. Opened in December 1995, priced express lanes each carry almost twice as many vehicles per lane than the free lanes during peak hours, because of the severe congestion in the free lanes (130, 128).

They found an optimized VMT tax of 14.0 cents per mile, equivalent to \$2.48 per gallon. This VMT rate is high, which includes pollution damage of 0.4-5.4 cents per mile for automobiles typical of the year-2000 fleet, external congestion cost of 3.5 cents per mile, and external accident cost of 3.0 cents per mile. The equal-revenue VMT tax rate would be 2.25 cents per mile.

Table 6-2 summarizes the different VMT fee systems proposed above. Please note for terms used in formulae, please refer to the above sections. The short-run and long-run rankings are authors' preliminary assessment based on technical feasibility, political acceptance, and economic efficiency. For each system, once a VMT fee is determined, revenue will go with the VMT trend. This will probably help the transportation financing in the future, given the reality that fuel consumption moves behind the VMT trend. In the short run, the variable-fee model could be most desirable. It can charge various fees for different vehicle classifications, depending on vehicle fuel efficiency. Therefore, the general public might consider it fair and become less skeptical about replacing fuel tax with VMT fees. Also, the variable-fee model better reflects the direct user cost of the transportation infrastructure, because it relates VMT fee with vehicle models and thus their weight and space. Furthermore, the system allows a lower fee for VMT on highways and rural roads than that on city roads, mitigating opposition from travelers who live in suburban areas. Relative to the uniform and dual fee systems, there are additional costs to implement the variable-user-fee system. However, such additional costs could be relatively small, because data on gas efficiency are available online for all makes and models since 1985, which should compose the vast majority of the vehicle fleet on roads. For vehicles built before 1985, some estimates can be used. Regarding the GPS device installation, the cost should be about the same. In the long run, making travelers pay the full cost should be fair and economically efficient. Therefore, the full-cost model could be economically efficient and socially equitable.

Table 6-2. Summary of Proposed VMT Fee Systems.

System	Description	Formulae	Data Needed	Estimated VMT Fee (cents per mile)	Short-run ranking	Long-run ranking
Uniform Fee	VMT fee is the same for all vehicles, location, and time of the day	$f = \frac{T}{AFE}$	Tax rate, total VMT and fuel sales	2.76 on average for Nevada, 2.79 for Washoe, and 2.91 for Clark	4	5
Dual Fees	Lower for passenger cars, higher for light trucks, but fees don't change with location and time of the day	$f_{PC} = \frac{T}{AFE_{PC}}$ $f_{LT} = \frac{T}{AFE_{LT}}$	Tax rate, average fuel efficiency for passenger cars and light trucks	2.33 for passenger cars and 2.90 for light trucks	2	3
Multiple Fees	Fee depends on vehicle classifications but not on time of the day.	$f_i = \frac{T}{GE_i}$	Tax rate, and efficiency for vehicle models, for highway/rural roads and city roads	2.49 for 2009 Acura TL 2WD and 3.07 for 2009 Acura MDX 4WD, for example	1	2
Generalized Fees	VMT fee depends on vehicles, location, and time of the day	$f = f(X)$	Tax rate, fuel efficiency depending on road conditions, congestion levels, and vehicles	Need further analysis	3	3
Pay-As-You-Go Fee	VMT fee is to balance the tax revenue and expenditure	One of the above formulae, constrained with revenue=cost	Forecasted total VMT, revenue, and cost	Need further analysis	6	6
Full Cost Fee	VMT fee includes both direct and indirect costs	$f = UC^I + EC^P + EC^N + EC^C + EC^A$	Direct user cost and estimates of indirect costs	14.0 Parry and Small (100), for example	5	1

6.5 SUMMARY & CONCLUSIONS

In addition to its substantial contribution to transportation financing, the fuel-tax system has a number of advantages: (1) It is easy to collect and administer, because tax is collected from a small number of gasoline wholesale distributors or refineries; (2) It involves a low administrative cost, taking less than two percent of the revenue; (3) It has low fraud potential. Given fuel tax is paid directly by the distributors, it is easy to determine whether the fuel has been taxed; (4) It ensures the consumers' privacy.

However, the fuel-tax system faces many challenges to sustain such as (1) Fuel taxes are generally not indexed for inflation. The federal gas tax rate has remained at 18.4 cents per gallon since 1993. Naturally, the fuel tax revenue loses purchasing power with time. For instance, the

federal gas tax has experienced a cumulative loss in purchasing power of 33 percent since 1993; (2) Fuel taxes in the U.S. are low compared with other developed countries. Some previous studies recommend an optimal gas tax be doubled, to \$1.01 per gallon, which reflects indirect costs of congestion, accidents, and air pollution, as well as the appropriate balance between exercise taxes and labor taxes in financing the government's transportation budget; (3) Both the improvement of fuel efficiency and the increasing number of hybrid vehicles reduce the fuel tax base. Without significantly increasing the fuel tax rate, fuel tax revenue is expected to decline in the coming years; (4) The gap is widening between road revenues and roadway infrastructure construction and maintenance costs. On one hand, fuel tax revenue is losing its purchasing power because tax rates are not indexed with inflation; on the other hand, costs of transportation projects have increased at a much faster rate than inflation. According to the Blue Ribbon Task Force (131), from 2003 to 2005, the CPI increased just 6.1 percent, while the Federal-Aid Highway Construction Price Index rose 40.2 percent. While this 40.2% is not typical of the Construction Price Index, the CPI is not necessarily the best indicator.

This paper also examined the historical patterns of vehicle-miles traveled (VMT), fuel efficiency, and gasoline sales in the USA and Nevada. It found that gasoline sales fall behind VMT due to the increased fuel efficiency and the number of hybrid vehicles. Because VMT directly measures the use of Nevada roads, it directly links to the cost of transportation services, which include road construction and maintenance. Faster growth of VMT than gasoline sales suggests that transportation cost increases faster than gas tax revenue. To provide a better roadway revenue stream, the current revenue mechanism should be replaced by a method that has a more equitable fee structure and requires motorists to pay in proportion to their travel and to the costs they impose on the roadway.

Six VMT fee systems were proposed: uniform VMT fee, dual fee, variable-fee, generalized variable-fee, pay-as-you-go fee, and full-cost fee systems. Each has its own advantages and disadvantages. The uniform fee system is to charge a flat fee per mile regardless of vehicle categories, location of travel, and time of travel. To be revenue-neutral, a uniform VMT fee can be determined as the ratio of current tax rate to the overall average fuel efficiency. The dual fee system is to charge a lower VMT fee for passenger cars than for light trucks, with fee rates being determined by the average fuel efficiency of passenger cars and light trucks, respectively. The variable-fee system is to charge VMT fees according to vehicle classifications. This system also allows different VMT fees for highways (and rural roads) and city roads, using different MPGs for these two general types of roads. The generalized variable-fee system charges a VMT fee that is determined by not only a vehicle's average fuel efficiency but also road conditions and time of day. The pay-as-you-go fee system, basically an ad valorem tax system, is to charge a VMT fee by balancing the predicted fee revenue and forecasted transportation budget. Hence, the VMT fee rate will change from year to year. The last VMT fee system is to make travelers pay the full cost they incur, including the direct user cost to the transportation infrastructure and the indirect costs of pollution, noise, congestion, and accidents. Therefore, the full-cost fee system is economically efficient. It also allows future implementation of congestion pricing, which is considered as economists' dream but politicians' nightmare. However, this full cost should be compared with the full benefits of the travel.

In the short run, if the VMT fee concept could be accepted by the general public, the variable-fee model could be the most desirable (to whom?). It charges various fees for different vehicle classifications and thus better reflects the direct user costs of the transportation infrastructure. Also, the system allows a lower fee for VMT on highways and rural roads than that on city roads, mitigating opposition from travelers who live in suburban and rural areas. Furthermore, the implementation costs of this system should be about the same as those for the uniform fee and dual fee systems, because data on gas efficiency are available online for all makes and models since 1985, which should compose the vast majority of the vehicle fleet on the road. In the long run, the full-cost model could be most efficient from a pure economical context.

Commercial trucks are excluded from our analysis. For trucks, the damage and thus the cost they incur to the transportation system are far more than the fuel tax they pay. Hence, the rate of VMT fee for trucks should not be determined by applying the neutral-revenue principle. However, there are a couple of ways to implement a VMT fee to commercial trucks. First, like the uniform fee system discussed in Section 6.4.1, a rate can be determined as the ratio of the current total truck tax revenue to the total truck VMT. For this calculation, we need data on the total tax revenue from all trucks and the miles driven by all trucks. Second, the full-cost VMT fee system could be implemented, as discussed in Section 6.4.6. In this case, we need to determine truckers' user cost to the transportation infrastructure and such indirect costs as those of pollution, noise, congestion, and accidents. In short, a VMT fee could be applied to trucks either by using the uniform fee or the full-cost fee system.

One may argue that charging a VMT fee to commercial trucks will increase business costs, thus hurting local businesses and consumers. Consumers will be hurt because they have to pay a higher price caused by the transfer of the VMT fee into a product price. Such arguments, however, ignore the economic theory that price should truly reflect the cost; otherwise, resources will get misallocated, resulting economic inefficiencies. If trucks do not pay the full cost they incur, someone else have to pick up the tab. Cost itself will not go away. To be fair and to better reveal the true cost, whoever costs the transportation network should pay the cost. Because Nevada is a 'bridge' state, about 60% of any increase in taxes on interstate trucks will be born by residents in other states.

Another caution needs to be taken; this paper only considers fuel tax revenue and VMT in Nevada. However, a proportion of fuel purchased in Nevada is consumed outstate and a proportion of miles driven in Nevada uses fuel purchased in other states. For example, some auto drivers will fill up in UT when headed to NV because the fuel is cheaper in UT, but some drivers in CA will wait to reach NV because the CA fuel is more expensive. If the first proportion is relatively higher, Nevada receives more fuel tax revenue than the VMT occurred in the state. In this case, using revenue-neutral principle would overcharge a VMT fee. If the second proportion is higher, meaning many drivers pump gas out state but drive in Nevada, they are using Nevada roads without paying it. In this case, the revenue-neutral principle would undercharge a VMT fee. Either case would call for a national policy on VMT fee.

7. PARTICIPANTS SELECTION

7.1 INTRODUCTION

The Nevada Vehicle Miles Traveled (VMT) User Fee Pilot Program requires the recruitment of citizen participants. In the pilot program, an onboard device for calculating mileage based transportation taxation will be placed on participant vehicles to measure the miles traveled and calculate a vehicle mileage-based tax. The success of the pilot program relies substantially on the technological, economic and social.

- Technological feasibility is assessing the feasibility of equipment in accurately calculating vehicle miles traveled in Las Vegas and Reno areas within the State of Nevada.
- Economic feasibility is being assessed two ways. First, the technology team members will assess the relative benefit/cost analysis associated with different equipment types. Second, the economic team members will determine an equitable tax rate that meets the tax “neutral” goals of the Pilot Program—namely, meeting the tax revenue needs for transportation infrastructure renewal and construction funding.
- Social feasibility is assessed through feedback provided by attendees at public meetings held in Reno and Las Vegas—the sites chosen for the pilot program implementation—attended by citizen stakeholders and representatives of citizen and private industry groups. Feasibility is also assessed through the feedback provided by pilot program volunteer participants, who must be carefully chosen so as to better assess all three areas of feasibility: technological, economic, and social feasibility.

7.2 KEY ISSUES IN CHOOSING PARTICIPANTS FOR PILOT PROGRAM

Key issues can be divided into a few general categories: participant vehicle type, participant transportation behavior, participant demographic considerations, and participant social and political attitudes. The following is an overview of pertinent literature on the subject.

In a seminal, Nobel Prize winning economist, Daniel McFadden (132) concluded that individual attitudes and behaviors play a substantial role in transportation policy and must be included in policy formulation and implementation if policy outcomes are to effectively meet policy goals

In the Iowa study of mileage-based user fees, program participant selection was based primarily on (133):

- Age
- Gender
- Education level
- Vehicle-type

Other variables considered, but that did not play a significant role in selection were:

- Annual miles driven
- Work commute length
- Social and political attitudes
- Importance of personal privacy
- Level of road finance

In recent years, the transportation policy literature has offered a variety of pertinent indicators that should be considered in participant selection methodology; in this case, in a study of mileage-based user fee policy innovation.

Reviewing a Helsinki study of road pricing policy, De Palma et al. (134) concluded that transportation policy innovations must match target population characteristics. In their study, they included the following measures:

- Workplace location
- Residential location
- Auto ownership
- Travel mode
- Route taken

In the VMT User Fee study of technological, economic, and social feasibility of a VMT policy innovation in Nevada, auto ownership will probably not be a relevant characteristic in the analysis because of the high rate of auto ownership. Nevertheless, it would be important to consider the other measures from the Helsinki study to determine if distance between workplace and residence shapes choices as well as impacting route choices. Finally, in the current study, it is important to consider so-called “surface-street” versus freeway driving to determine how VMT policy and rates might impact road congestion and accident rates.

Beyond the Helsinki study, DePalma et al. (134) analyzed cases studies that had used multiple transportation and transportation-related taxation schemes implemented in four major European cities to determine which mix of schemes would yield the highest social welfare gains for society. The policies included:

- Distance based road taxation
- Flat toll fees
- Parking fees
- Travel time taxes
- Public transportation fees

While travel time taxes, to be implemented in Paris in 2012, were estimated to yield the highest social welfare gains, the study pointed to the fact that multiple fee schemes might (or can) be an important consideration when attempting to balance social welfare with the need for transportation revenue.

Studies of congestion charge taxes have focused on the impact of such charges on shopping behavior and externalities impacting local businesses in terms of gross sales. In Schomocker et al. (135), the researchers identified the following key variables in their study of the impact of congestion charges taxes on shopping frequency:

- Gender
- Age
- Frequency of shopping in core business district (in this case, central London)
- Driving to central London for work
- Employment status,
- Customer type
- Change in frequency of shopping in core business district
- Attitude toward congestion pricing innovation
- Perception of improved driving conditions due to innovation
- Trust in government
- Car use prior to/following innovation
- Public transportation use prior to/following innovation
- Walking/cycling prior to/following innovation
- Taxi use prior to/following innovation

Several of the indicators reported here might be important to consider in choosing participants for the current study as it would give the researchers and sponsoring agencies a better sense of how VMT taxation might have impacts beyond driving behavior. Participants might move towards other forms of transportation and might choose to drive less frequently to shopping areas. Albert and Mahalel (136) used a more limited number of variables in choosing participants in their study of congestion pricing, focusing mainly on travel time, tax rate, gender, and driving behavior.

Quddus et al. (137) offer further evidence of the need to understand consumer driving behavior—in the case of the current study, if VMT taxation results in reductions in local retail store revenue, then it is likely that sales tax revenue will be negatively impacted. Setting VMT rates such that they have no adverse impact on other tax revenue sources might be an important consideration in analyzing the benefit to implementing VMT taxation. Understanding consumer behavior when choosing participants would help in better understanding elasticity in consumer demand (138) associated with shopping preferences tied to major retailers (e.g., consumer shopping at a big retail outlet such as Scheel's™ in Sparks, NV). In Quddus et al. (137), major retailers in the central business district were estimated to have lost up to 8.21% in weekly sales volume as a result of a congestion pricing innovation.

The VMT taxation policy innovation pilot program might also be used to determine if participants switch their mode of private transportation towards increased use of public transportation (in the case of the current study, the participant would likely be saving the resources made available to them for use in the VMT pilot study). Therefore, it would important to choose participants in terms of attitudes towards and motivations for their private auto use as well as access to alternative sources of transportation, such as public transportation (see 139).

Consumer reluctance to participate in the pilot program or reluctance to adopt a VMT taxation approach, particularly one focused on congestion pricing, must be carefully documented. Clearly, individuals might be resistant due to lack of trust in government institutions or resistance to new or different tax policies—McFadden (132) pointed out that drivers tend to be resistant to any change—but there might be other reasons. For example, child care arrangements might impact driving habits and limit flexibility in driving time for women (140). Variable gender-related impacts should be considered when identifying participants (141). Also, social welfare recipients might be negatively impacted in terms of their ability to use transportation to access employment and social services (142). Studying the impact of VMT taxation in relation to consumer reluctance might be an important part of understanding potential for unequal outcomes and various social costs.

7.3 RECRUITING CITIZEN PARTICIPANTS FOR PILOT PROGRAM

The first step in recruiting volunteer participants for participation in policy experiment studies is to determine the policy target population(s). In the case of VMT policy experimentation, there are several target populations, to include the following:

- Residential drivers – drivers who primarily travel locally within their relative communities. These drivers will likely be retired individuals who generally travel short distances and do not commute to work. Other drivers in this category might include tele-commuters—individuals who work part or full-time from their homes (also, parents and teenage drivers involved in school, shopping and recreation trips).
- Traditional Commuters – drivers who commute to and from work during peak periods of the day.
- Intrastate Drivers – drivers who engage regional travel long distances on an intrastate basis and will include service, sales and other intrastate business enterprises.
- Interstate Travelers – drivers who travel for recreation and tourism purposes, while a larger portion are commercial (large trucks) travelers.

In reviewing the methodology from the Iowa mileage-based taxation pilot study as well as United States Department of Transportation (USDOT) guidelines, it is recommended that obtaining a large and diverse sample of drivers is desirable. The sample does not necessarily have to be entirely random. A convenience sampling technique is acceptable if the sampling justification is focused on specific target populations whose reaction to the technology and taxation scheme is of importance to the research team.

7.4 RECOMMENDED SAMPLING METHODOLOGY

There are three methods recommended to select the sampling of target populations for the Nevada VMT User Fee Pilot Program to be conducted in Reno and Las Vegas areas. They are:

- Web postings inviting individuals to participate in the pilot study
- Randomly chosen invitation letters mailed to Nevada licensed drivers and/or owners of motor vehicles

- Public service announcements on radio, TV, and print media

7.4.1 WEB-POSTING RECRUITMENT

It is recommend that a link be placed on the State of Nevada, NDOT, Nevada Department of Taxation webpages, inviting viewers to voluntarily participate in the study. When the link is clicked-on, the viewer will be provided with a full explanation of the methods, purposes, and expected costs and benefits to the individual participant and the society as a whole. The on-line recruiting document will, therefore, cover all information necessary to obtain “informed consent” from prospective participants. The online recruitment webpage will include a short survey to determine general demographics, transportation behavior, and attitudinal characteristics of prospective participants.

7.4.2 INVITED PARTICIPANTS

Invited participants are individuals who receive a letter of invitation. The selection process should be made using a stratified random sample. Stratification should be based on aggregate demographic characteristics of neighborhoods in the Las Vegas and Reno areas as well as intrastate business entities that regularly travel on Nevada roads.

Aggregate data should be analyzed at the census block level in terms of distance from central business districts in Reno, Sparks, Las Vegas, North Las Vegas and Henderson, Nevada and should include suburban, rural and urban fringe participants. It is recommended that for selection of participants using stratified random sampling, sponsoring agencies and the Herzik/Simon portion of the VMT team consult census demographic data from U.S. Census and Nevada Small Development Center for the greater Reno-Sparks area, the greater Carson City area, and the greater Las Vegas area. Selection should be sensitive to the geographic location relative to central business districts, distance from major shopping areas, household income level, and traffic counts for regional areas within sub-regional boundaries.

7.4.3 PUBLIC SERVICE ANNOUNCEMENTS

Sponsoring agencies should coordinate public service announcements inviting listeners and viewers to participate in the pilot program, provide contact information (a toll-free telephone number and a web-address and email contact). Individuals who call the toll-free number or access the web-address should complete a telephone survey or online survey asking their name, contact information, basic socioeconomic information, as well as responses to a brief attitudinal survey. The information could be quickly tabulated electronically.

7.4.4 INFORMED CONSENT: RECRUITMENT STAGE

Prospective participants will be told on multiple occasions that their participation is voluntary and confidential. There are two stages to selection for participation in the pilot program. The first stage is recruitment. During this stage, full disclosure of information regarding the consent progress, the voluntary and confidential aspects of the program should occur.

The prospective participant will be told in the online recruiting documentation, invited participation letter, and in any public service announcements (to include related phone or online contacted) that they can, at any time, end their participation in the policy experiment without any penalty to themselves. Additionally, any economic incentive to participation should be explicitly referenced in any and all recruitment documentation for online, telephone, or general public service announcements, so that the prospective participant can make a rational choice regarding their decision to volunteer for participation. The manner in which any data associated with the pilot program are collected and the time period it will be retained should be discussed at this time. As per federal recommendations, any data collected during this study should be discarded at the completion of the pilot program—the prospective participant should be informed of the data collection, retention, and disposal protocols for the pilot program. There might be a need to ask the participant if there is any chance that an underage driver will be using the vehicle because handling data collected during the time a minor is operating the vehicle might impact methodology and protection of human subjects.

7.4.5 INFORMED CONSENT: PARTICIPANT SELECTION

From the group of individuals who have indicated interest in participating in the study, a sample of participants will be chosen using the demographic and attitudinal data collected in the first stage of the participant selection process.

All individuals who have indicated that they wish to participate in the pilot program should be asked to download informed consent documentation from a secure website. They should read the documentation, which should include a letter from representatives of sponsoring agencies indicating the purpose of the study and the collection, use, and disposal of data associated with the study, how sponsoring agencies will protect participant privacy, and the use of the data collected by sponsoring agencies and its subcontractors involved in the pilot study.

The prospective study participant will have to sign the informed consent form indicating that if they are chosen from the pool of potential participants, they agree to participate in the study, with the proviso that they will remain anonymous and their personal information will be held in strict confidence. The participants should be informed that they are free to exit participation at any time. And, the minor-driver issue must be considered as well in the signed informed consent form—the agreement to participate in the study. The signed forms should be mailed to sponsoring agencies and will be stored in a secure location by designated representatives of the study team or sponsoring agencies.

It is important to also make all recruiting and informed consent-related information available in both English and Spanish. If other language needs are required for other potential participants, this policy must be considered and therefore broadened to be as inclusive as possible.

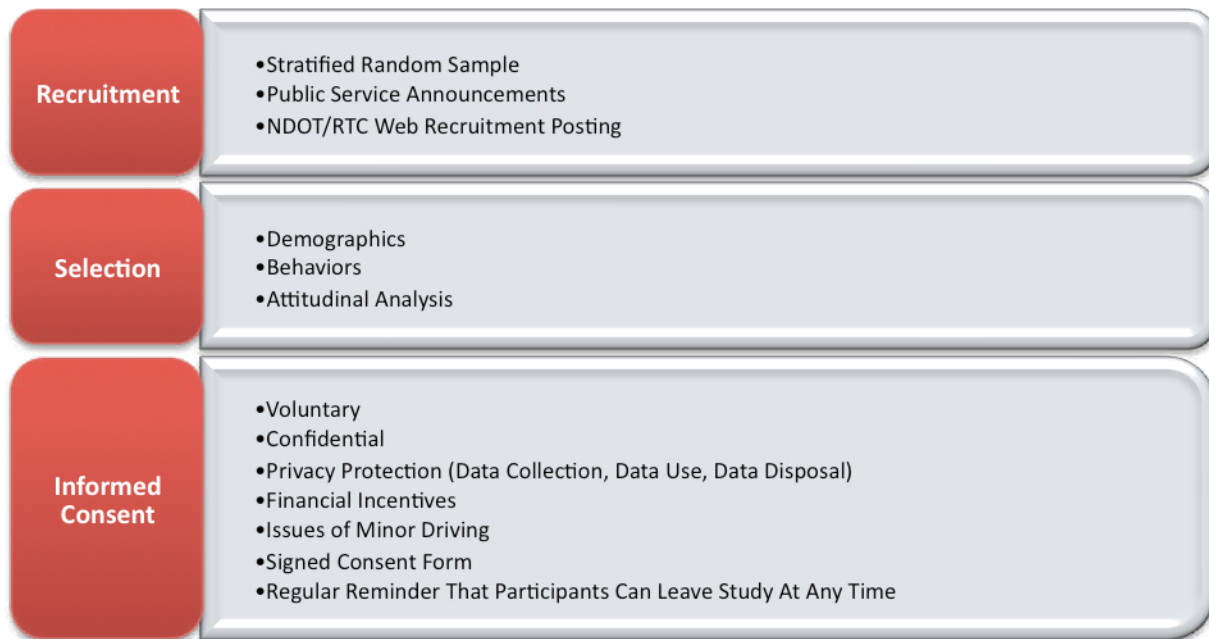


Figure 7-1. Proposed Methodology for Participant Selection.

8. PILOT PROGRAM PROTOCOL

8.1 INTRODUCTION

A successful Pilot Program will require an effective management structure and adequate funding. The purpose of this task was to develop a protocol for the Pilot Program, which includes administration, costs, outreach, technology, fee models, participants, and evaluation criteria. The remainder of this section discusses our recommendations at the time of submittal.

8.2 ADMINISTRATION

Based on the framework developed in Section 4 on institutional issues, the following administrative concepts are presented for the Pilot Program.

8.2.1 PURPOSE & OBJECTIVES

The purpose of the Pilot Program is to study the feasibility and workability of implementing a VMT fee system in Nevada.

The objectives of the Pilot Program include testing the payment and collection mechanism, addressing economic, policy, and privacy issues related to a VMT fee system, and developing a protocol for future implementation.

8.2.2 ORGANIZATION

The Pilot Program will be overseen by Pilot Program Management Group, which consists of dedicated personnel from funding agencies (i.e., NDOT, and technical experts from private industry, politicians, civic groups, universities, etc. The Pilot Program Management Group should have a support structure to successfully oversee the Pilot Program.

8.2.4 PROCEDURES

Systematic and logical procedures for the Pilot Program will need to be developed. Those procedures cover Pilot Program activities from administration to data collection. Those procedures will need to be developed in Phase 2 based on the experience gained from the limited testing. The private firm that conducts the Pilot Program should develop flow charts for their internal project activities (e.g., contractor management, quality control/quality assurance, deliverables schedule etc.).

8.3 PARTICIPANTS

The Pilot Program requires the recruitment of participants. Protocols have been established for size, recruiting participants, screening the participants, and training the participants.

8.3.1 SIZE

The Pilot Program will be conducted in Northern and Southern Nevada. The following are the target populations:

1. Residential Drivers – Drivers who primarily travel locally within their relative communities. These drivers could be retired individuals, who generally travel short distances and do not commute to work. Other drivers in this category might include telecommuters and parents and teenage drivers involved in school, shopping and recreational trips.
2. Traditional Commuters – Drivers who commute to and from work during peak periods of the day.
3. Intrastate Drivers – Drivers who engage in regional travel long distances on an intrastate basis and will include service, sales and other intrastate business enterprises.
4. Interstate Traveler – Drivers who travel for recreational and tourism purposes, while a larger portion are commercial (large trucks) travelers.

Table 8-1 shows the minimum required participants by vehicle type.

Table 8-1. Minimum Required Participants by Vehicle Type.

Type of Vehicle	Clark County		Washoe County	
	City	Rural	City	Rural
Passenger Cars	45	30	45	30
Pick-up and SUV	45	30	45	30
Hybrid vehicle	30	20	30	20
Total	120	80	120	80

8.3.2 SELECTION

Selection will be done through web posting, invitation, and public service announcements. The following describes each recruitment technique.

8.3.2.1 WEB POSTING RECRUITMENT

A recruiting document developed by the private firm should be placed on the Pilot Program website (www.vmtfeenv.com), which covers all information necessary to obtain “informed consent” from prospective participants. The recruitment document should provide a full explanation of the methods, purposes, and expected costs and benefits to the individual participant and the society as a whole. In addition, a short survey should be included to

determine general demographics, vehicle information, transportation behavior, and attitudinal characteristics of prospective participants.

To promote the Pilot Program website, a forwarding link should be placed on the State of Nevada, NDOT, and Nevada Department of Taxation websites.

8.3.2.2 INVITED PARTICIPANTS

Invited participants are individuals who receive a letter of invitation. The selection process should be made using a stratified random sample. Stratification should be based on aggregate demographic characteristics of neighborhoods in the Las Vegas and Reno areas as well as intrastate business entities, which regularly travel on Nevada roads. Aggregate data should be analyzed at the census block level in terms of distance from central business districts in Reno, Sparks, Las Vegas, North Las Vegas and Henderson and should include suburban, rural and urban fringe participants. It is recommended that for selection of participants using stratified random sampling, the private firm conducting the Pilot Program consult census demographic data from U.S. Census and Nevada Small Development Center for the greater Reno-Sparks area, the greater Carson City area, and the greater Las Vegas area. Selection should be sensitive to the geographic location relative to central business districts, distance from major shopping areas, household income level, and traffic counts for regional areas within sub-regional boundaries.

8.3.3 QUALIFICATIONS

For the Pilot Program, qualifications are vitally important. For example, certain prospective participants might have similar driving patterns that would not benefit the Pilot Program. In addition, there may be prospective participants that do not want to follow the rules of the Pilot Program or prospective participants that do not have the desired make/model type of vehicle.

During the recruitment stage, prospective participants will be told on multiple occasions that their participation is voluntary and confidential in order to obtain informed consent. The prospective participants will be told that they can, at any time, end their participation in the Pilot Program without any penalty. Additionally, any economic incentive to participation should be explicitly referenced in any and all recruitment documentation for online, telephone, or public service announcements, so that the prospective participant can make a rational choice regarding their decision to volunteer for participation.

The manner in which any data associated with the Pilot Program are collected and the time period it will be retained should be discussed with prospective participants. Prospective participants should be informed of data collection, retention, and disposal protocols.

Prospective participants should have the following qualifications:

- Valid Driver's License
- Willingness to Abide by Pilot Program Terms
- Vehicle Type
- Participant Demographics

8.3.4 SCREENING

After the prospective participants meet basic qualifications, they will go through a screening process to further refine the pool of participants. All individuals, who have indicated that they wish to participate in the Pilot Program, should be asked to download informed consent documentation from a secure website. They should read the documentation, which should include a letter from representatives of sponsoring agencies indicating the purpose of the study and the collection, use, and disposal of data associated with the study, how sponsoring agencies will protect participant privacy, and the use of the data collected by sponsoring agencies and private firm conducting the Pilot Program.

The prospective participant will have to sign the informed consent form indicating that if they are chosen from the pool of participants, they agree to participate in the study, with the proviso that they will remain anonymous and their personal information will be held in strict confidence. The participants should be informed that they are free to exit participation at any time. The signed forms should be mailed to sponsoring agencies and will be stored in a secure location by designated representatives of the private firm or sponsoring agencies.

8.3.5 TRAINING

After participants have been recruited and vetted, training will be required. The training will include informational sessions, hands on practice with hardware and software, and discussion of protocols for reporting errors or malfunctions.

8.4 PUBLIC OUTREACH AND EDUCATION

In order to effectively educate and inform the public about the Pilot Program, there must be publicity, engagement, and a period of assessment. The public outreach must be extensive to create a broad understanding of the current funding problem, the Pilot Program, the method of implementation, and the anticipated impact on individual system users.

8.4.2 OUTREACH

In conjunction with the public outreach and education efforts, the sponsoring agencies should engage / recruit as many stakeholders as possible such as local clubs (e.g., Sierra Club), business associations, and government (e.g., policy makers) to be advocates for the Pilot Program. It is vital to have advocates during the Pilot Program or possible future VMT fee system implementation to dispel inaccurate information and aid in effective communications to the public.

8.4.3 ASSESSMENT

After the initial public outreach and engagement efforts (i.e., three months), the public outreach should be assessed on its performance based on survey results, advocate opinions, and Pilot Program participants. If the public outreach has performed poorly, modifications to the approach will be developed to better explain the Pilot Program.

8.5 PAYMENT MECHANISM

Technology hardware, software, data collection, processing, and vehicle installation are described in Section 3. It is recommended that once a final technology is selected the Pilot Program protocol be modified to include a section on technology.

8.5.1 PAYMENT MECHANISM

The following areas should be evaluated in the Pilot Program: 1) availability, 2) accuracy, 3) reliability, 4) security, 5) privacy, 6) expandability, and 7) integration.

8.5.1.1 AVAILABILITY

After developing the on-vehicle unit, the private firm should evaluate the availability of the hardware and software and consider assembly of commercial-off-the-shelf (COTS) technology.

8.5.1.2 ACCURACY

Accuracy is how close a measured or calculated value (i.e., mileage) is to its actual value. Precision represents repeatability. For the Pilot Program, the accuracy and precision of the hardware and software can be evaluated to determine if there are variabilities that should be addressed in a future VMT fee system.

8.5.1.3 RELIABILITY

Reliability of the equipment must be assessed. Reliability should be evaluated with regards to how the hardware functions over time and its resistance to failure. Most hardware unreliability is the result of a component failure that results in the system not performing its intended function. Repairing or replacing the hardware component restores the system to its original state. Reliability protocols can also be developed for the software operation. Software does not fail in the same way that hardware fails. Software unreliability is the result of unanticipated results of software operations.

8.5.1.4 SECURITY

The Pilot Program system communication needs to be evaluated. For example, if the system uses wireless networks to upload / download data or make VMT fee payments, there must be security protocols developed to inhibit hackers from cracking the system. The project team recommends that the software that is developed should have embedded authorization and encryption algorithms to prevent hackers from either stealing data or cheating the system.

8.5.1.5 PRIVACY

Depending on the type of VMT fee system that would be acceptable to the public, institutional policies and system security would have to be developed to satisfy the privacy concerns. For the Pilot Program, the following areas should be evaluated:

- Data encryption at hardware or software level
- Backups to ensure data can be recovered
- Data masking to ensure that data security is maintained and sensitive road user information is not leaked outside of the authorized environment
- Data erasure after a certain period (defined by policymakers) to ensure that no sensitive data is leaked when the personal data is no longer needed

8.5.1.6 EXPANDABILITY

For the Pilot Program, the expandability of a VMT technology must be explored. From a hardware point of view, the question of how robust a system would need to be to handle the size and scale of a future VMT fee system must be determined. Also, the technology used in the Pilot Program should be evaluated for its capabilities of being expanded to a local, regional, or state level in a future VMT fee system. In addition to a central computer database system, the number of point of sale or payment centers will need to be evaluated.

From a software point of view, the software will have to have the ability to support additional network users for a future VMT fee system. As the number of participants increases, the software must be able to handle the payment computations in a timely manner without continuous updates to the software.

8.5.1.7 INTEGRATION

For the Pilot Program, integration of a VMT fee system must be explored. The Pilot Program should evaluate the capabilities of “piggybacking” the hardware and software on current and / or impending infrastructure such as toll collection facilities, the pay-at-the-pump model, and the federal Vehicle Infrastructure Integration (VII) development. Integration with current infrastructure could minimize expenses for a future VMT fee system but will also raise security and privacy concerns.

8.6 VMT FEE MODELS

For the Pilot Program, the selected hardware and software will be used to collect a full spectrum of data and the private firm will evaluate various VMT fee models. Six VMT fee models have been proposed: the first four models emphasize replacing fuel taxes with VMT fees on a revenue break-even basis; the fifth system is a pay-as-you-go scheme, basically an ad valorem tax with a VMT fee determined by an estimated budget of providing transportation services; and in the last system indirect costs are added into the VMT fee, making drivers pay the total cost of traveling. More information about those models is provided in Section 6.

8.7 COSTS

The cost elements that need to be evaluated in the Pilot Program and a future VMT fee system include, but are not limited to the following:

8.7.1 START UP

Pilot Program start up costs includes hardware and software technology for the at-the-pump sensor and administration system (e.g., central database and billing computer). As part of the Pilot Program, the private firm should evaluate costs for retrofitting vehicles with on-vehicle devices. To assist in letting the Pilot Program contract, the start up costs will need to be estimated as more information becomes available in Phase 2 of the study.

8.7.2 OPERATION

Operational cost is the cost associated with conducting the Pilot Program and includes administration and data processing. As part of the Pilot Program, the private firm should evaluate operational costs for communications (e.g., dedicated RFID, dedicated short range communications, internet) for VMT fee transmission and payment. To assist in letting the Pilot Program contract, the operational costs will need to be estimated as more information becomes available in Phase 2 of the study.

8.7.3 MAINTENANCE

Maintenance costs are costs associated with maintaining data collection, equipment, and troubleshooting problems that occur during the Pilot Program. It is anticipated that data collection will happen periodically (e.g., every two weeks). During regular downloads at a collection center, maintenance will be performed when needed. Additional time and effort will be required for troubleshooting problems during initial stages of the Pilot Program. To assist in letting the Pilot Program contract, the maintenance costs will need to be estimated as more information becomes available in Phase 2 of the study.

8.7.4 ENFORCEMENT

As part of the Pilot Program, enforcement costs should be evaluated. The private firm should develop with effective deterrents and actions against people, who evade payment or are delinquent in payment by hardware and software or institutional policies. Enforcement could include: 1) stationary equipment placed on current infrastructure that identifies the vehicle by Vehicle Identification Number (VIN) or license plate and 2) mobile enforcement. To assist in letting the Pilot Program contract, the enforcement costs will need to be estimated as more information becomes available in Phase 2 of the study.

8.7.5 AUDITING

Auditing costs depend on the amount of data that will be collected and maintained. More data typically means more auditing costs. Based the anticipated data collection, 5% of the data should be audited, including data encryption, mileage counting, zone differentiation, and fee calculation. As part of the Pilot Program, the private firm should evaluate the “audit-ability” of a future VMT fee system. To assist in letting the Pilot Program contract, the auditing costs will need to be estimated as more information becomes available in Phase 2 of the study.

8.8 EVALUATION CRITERIA

An important part of the Pilot Program is evaluating whether the goals and objectives of the Pilot Program have been met. Evaluation will include the analysis and comparison of actual progress versus prior plans, oriented toward improving plans for future implementation.

For the Administration element of the Pilot Program, the following topics should be addressed in a working paper.

- Purpose – Determine whether a VMT fee system in Nevada is feasible.
- Objectives – Test technology, address issues of a VMT fee system, and develop a protocol for future implementation.
- Organization – Provide best organizational structure for a future VMT fee system.
- Roles & Responsibilities – Discuss roles and responsibilities of personnel in future organizational structure.
- Procedures – Provide systematic and logical procedures for a future VMT fee system from administration to data collection and fee payment to fee audit.

For the Participant element of the Pilot Program, the following topics should be addressed in a working paper.

- Size – Evaluate whether size was large enough to meet objectives of Pilot Program.
- Recruitment – Evaluate which methods of recruitment worked successfully.
- Qualifications – Evaluate if Pilot Program qualifications (e.g., vehicle type, make/model, year, etc.) were large enough to meet objectives of the Pilot Program.
- Training – Evaluate Pilot Program training protocol and develop a training protocol for a future VMT fee system.

For the Outreach element of the Pilot Program, the following topics should be addressed in a working paper.

- Public Outreach – Evaluate public outreach methods used for Pilot Program. Develop documents (e.g., formal presentation, website information) for a future VMT fee system.
- Engagement – Evaluate engagement of stakeholders during the Pilot Program and determine which groups would champion a future VMT fee system.

For the Technology element of the Pilot Program, the following topics should be addressed in a working paper.

- Availability – Evaluate the availability of the hardware and software and consider assembly of commercial-off-the-shelf (COTS) technology. Evaluate potential partnering with manufacturers for a future VMT fee system.
- Accuracy & Precision – Evaluate the accuracy and precision of the hardware and software to determine if there are variabilities that should be addressed in a future VMT fee system. Develop accuracy and precision protocol for a future VMT fee system.
- Reliability – Evaluate how the hardware and software functions over time and its resistance to failure. Develop reliability protocol for a future VMT fee system.

- Security – Evaluate security protocols for the Pilot Program. This should include hardware and fee system communication.
- Privacy – Evaluate data encryption at hardware level, data backups, data masking (i.e., to ensure that data security is maintained and sensitive road user information is not leaked outside of the authorized environment), and data erasure.
- Expandability – Evaluate expandability of Pilot Program technology and develop protocol for a future VMT fee system.
- Integration – Evaluate the capabilities of “piggybacking” the hardware and software on current and/or impending infrastructure such as toll collection facilities, the pay-at-the-pump model, and the federal IntelliDrive development (formerly called Vehicle Infrastructure Integration (VII)).

For the VMT Fee Models element of the Pilot Program, the following topics should be addressed in a working paper.

- Models – Evaluate models proposed for Pilot Program and develop protocol for a future VMT fee system.

For the Costs element of the Pilot Program, the following topics should be addressed in a working paper.

- Costs – Evaluate start up costs, operation, maintenance, enforcement, and auditing for a future VMT fee system.
- Funding – Evaluate potential funding sources for a future VMT fee system.

8.9 SUMMARY

The Nevada Vehicle Miles Traveled Fee project will test the implementation of a simple and user friendly at-the-pump payment and collection mechanism that will minimize privacy concerns. The system will be similar to the existing fuel tax payment system. The pump sensor will read the vehicle odometer miles each time the vehicle goes to the pump to purchase fuel. The sensor will then apply an established rate and calculate the fee.

This study will assess and evaluate the feasibility and workability of an alternative, sustainable, easy-to-use, equitable, cost-effective, and future-oriented viable transportation funding mechanism that will potentially replace the current fuel tax funding mechanism and that will adequately meet the future transportation needs of the State of Nevada. The primary objectives of this research project are: a) assess and evaluate the feasibility of a VMT fee collection and payment mechanism specific to the State of Nevada, b) conduct proactive public outreach and education effort to educate the public, elected officials, various stakeholders, and decision makers about the critical future funding shortfalls and limitations of the current fuel tax system, c) identify and address the significant elements associated with the concept of a VMT fee, and d) design a VMT Fee Pilot Program for Nevada. The Nevada VMT Fee Study consists of three phases as listed below:

Phase I of the study was initiated in 2009 and completed in 2010. The major components of Phase I of the study include: 1) conduct comprehensive literature review of VMT fee studies

evaluated by other States to avoid duplication of efforts and to only focus on the areas that have not been adequately identified and answered in the other studies, 2) conduct comprehensive public outreach and education through public meetings, workshops, newspaper editorials, newsletters, opinion surveys in the rural and urban areas, videos, and presentations to solicit input, identify concerns and answer questions from the various stakeholders, the public, and decision makers, 3) assess and evaluate any potential privacy impacts of a VMT fee payment mechanism, 4) analyze institutional, policy, legislative, and legal aspects of a VMT fee payment mechanism, 5) develop economic models to assess and recommend equitable VMT fee for different vehicle sizes and types, and 6) design a pilot program protocol that will be used in a future VMT Pilot Program to study the feasibility of a VMT fee mechanism in Nevada.

Phase II of the study began in November 2010 and will be completed in June 2011. It will include conducting a field test to assess the feasibility and workability of implementing the new payment mechanism on a small scale. Approximately 40 volunteer vehicles will participate in the field test. The emphasis of the field test will be on a simple and user friendly at-the-pump payment and collection mechanism that will minimize privacy concerns. The pump sensor will read the vehicle odometer miles each time the vehicle goes to the pump to purchase fuel. The sensor will then apply an established rate and calculate the fee. Other components of Phase II include: identifying and defining the initial costs and operation and maintenance costs, defining the administrative structure, conducting public outreach, assessing the legal and policy aspects of a VMT program, identifying the auditing capabilities, analyzing the privacy aspects of the VMT Fee program, and developing the at-the-pump payment mechanism.

Phase III of the study will include conducting a VMT Fee Pilot Program in which a few hundred volunteer vehicles will participate to assess, evaluate and analyze the major components of a future VMT fee collection and payment mechanism, and to develop recommendations based on the pilot program data.

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APPENDIX A. RENO PUBLIC MEETING COMMENTS

Technical Breakout Session

- Different state systems must be compatible
- Data should be available on congestion, peak time
- Technology must be secure
- User should be able to access own data
- Citizen can use information / specifics
- Collection of data should be at intervals
- Equitable consideration of urban vs. rural
- Link between vehicle size and fee
- Location data has valuable and legitimate system applications
- Most people don't believe that the technology is reliable
- Must have collection method for non-metered cars
- No geographic data should be collected without consent
- Technology must be updatable
- Any system can be hacked
- Consider equipment uses based on hours and not miles
- Ensure technology does not affect safety information
- Equitable coexistence of VMT and gas tax
- Have some appeal process if technology fails
- Look at analog versus digital signal strength
- Most people see their car as an extension of home
- Option for flat fee based on mileage at premium
- Pay at pump does not work for electric cars
- System must be reliable
- Technology must be reliable
- User can opt into additional data
- User pays for aftermarket install

Administrative Breakout Session

- Data will not be collected by private entity (no contractor)
 - Public entity will securely maintain data
 - Completely secure, few people involved
 - Data is completely secure
- VMT should be seamlessly integrated following a national policy
 - Overseen by DMV at state with national guidelines
- At registration people opt for system they will use to pay their bill (but they must pick one)
 - Electric cars would pay monthly and not at pumps
 - Must register so this is where you capture how payment will be made
- Weight must be part of policy—combine weight with distance
- VMT must be extremely low cost

- Public must “trust” (must sell)
- Must be transparent
- Protection of data is a must
- Data is not going to be shared- must never be violated
- System must be reliable
- Fair and equitable
- No sharing with law enforcement
- Pay at the pump
 - If pay after use, info is more difficult to capture
 - Data should be collected at pump
 - Pay at the pump requires electric pay station
- Peak hour pricing of VMT
 - Pros / cons need to be identified
- Reciprocal agreement with other states as far as fee collection
- Aggregate data is important
- Appeal process must be put into place
 - How are fees assessed on construction equipment with hour meters (example)
 - How are fees assigned to idling
- Change should be in legislature (senate)
- Citizens would pay at pump but would have access to their account via –quarterly report / online, option to track data
- Cops are more incentivized to pull over older cars “car profiling”
- Data collected by VMT includes weight, congestion, distance
- DMV should administer VMT program
- DMV would be responsible for supplying, maintaining GPS (report to DMV if stolen)
- May use data to assist law enforcement
 - Use in aggregate to determine speeding in school zone
 - Don’t tie to individual
- Monthly bills should include area trend (by zip / region)
- New agency designed to oversee on both regional and national level
- No agency currently has resources to administer new program
 - Significant money to start new agency
- No portion of system will be fee or penalty based
 - Neither late fee nor penalties
 - There is penalty attached if fee is not paid in time
- Pay in advance
- Personal data permanently destroyed (every time person refills at gas pump)
- Prefer flat odometer reading
- There is penalty attached if fee is not paid in time (imposed by DMV)
 - Vehicles disabled if no pay

Policy Breakout Session

- Funds collected should be used for all transportation needs (including capacity & mass transit)
- If implemented, VMT should promote equity

- There should be a uniform tax rate – national rate
- The funds collected from VMT should only be used for maintenance only
- Information in VMT system should be used for equitable tax rates, congestion pricing / control and planning
- The state shall pay for all onboard equipment and maintenance associated with VMT
- Transportation policy needs to change with the times
 - Doing nothing is not an option
- Vehicles that cause road damage should pay more
- VMT system needs to be cognizant of the need for compact urban form
- VMT needs to be on federal level
- Absolutely no GPS data collected in database (no storage)
- VMT fees collected shall be used for all transportation needs
- VMT pricing (tax rate) should be sensitive to vehicle type & location (rural / urban) of driving & vehicle fuel efficiency
- Define what information is collected and how it will be used (e.g., will information be used for planning, rate adjustment, etc.)
- Fee collection should be frequent / regularly
- Give motorist option to opt out of VMT
- Information collected via VMT could make citizens more informed in their community / individual transportation choices
- Information gathered shall only be used for VMT purposes
- Maintain same structure of jurisdictions to collect and set tax rates
- Nevadans will see this as a new tax (pay go vs. monthly)
- Personal data should identify total miles (not linked to person)
- Should be a tangible reduction in VMT outside of congestion periods (>25%)
- There should be an online system to check my VMT bills
- This policy is invasive (versus other alternatives)
- This policy is the most directed to user
- There should be fee collection options decided by user
- VMT collection should be state based
- VMT will negatively impact tourism (e.g., raise rental car rates)
- Will increase equity & distribution among jurisdictions

Privacy Breakout Session

- Don't tie personal ID with user data collected, only tie to miles driven
- Data used only for VMT
- Provide an opt out (flat fee) option
- "Opt in" people must give written informed consent before data can be subpoenaed or used by anyone
- Create a Health Insurance Portability and Accountability Act (HIPAA) – type system to limit access / distribution
- Data may be used in aggregate for safety traffic control
- No way to reconstruct data on those who opted out
- Can collect any data but individual must have access
- Data should be available to law enforcement in certain circumstances
- Data should not be available to law enforcement
- I want to be able to track users of my car
- Must focus only on miles not any other data (not where, when or who) tied to vehicle
- Look at all possible data that might be collected in pilot program
 - Link to better informed policy choices
- No private firm collecting data
- No system is adequately secure
- No use in civil cases
- Personal ID may be connected to the data collected
- Personal data only for bill paying
 - Data deleted once bill paid
- Privacy violation is criminal violation
- User control of who has access and how it is used
- User option for levels of data collected beyond just miles (an opt in system)

APPENDIX B. LAS VEGAS PUBLIC MEETING COMMENTS

Technical Breakout Session

- System must account for urban and rural differences
- Technology must be secure
- Unit must be transportable
- Collection process must be inexpensive and efficient
- Must have multiple fail-safes
- System cost effective for citizen
- Limited (very) personal data
- Methodology must be secure (fail-safe)
- Pilot to include both (varied) systems
- Pre pay system or pay as you go
- Prefer pay at pump
- Verify odometer at registration
- Ability to “unsubscribe”
- Capture transient travel
- Citizen access to own information
- Collection must be frequent
- Compatible with current GPS
- Compatible with other gizmos
- Consistent odometer readings (i.e., CARFAX)
- Data collect class of vehicles
- Data collection must be cost efficient
- Data enforcement rules
- Data must be secure
- Data recorded universal (same)
- Distribution of funds must be equitable amongst roads
- Easy data uploading for citizen
- Easy enforcement
- External auto updates
- Hack proof
- If missing, device must be “locatable”
- In order to change behavior, must monitor location
- Installation has to be efficient (easy)
- Market cost of unit (retail)
- Marketable system
 - System features
 - Stylish system
- Match to already existing mileage data
- Multiple ways to access driver information (by citizen)
- No (manual) labor intense system
- No tax bill in mail

- Physical non-highway fuelling system
- Road fairness
 - Less traveled not less important
- Secure driver identification
- Secure installation
- Statewide verification system
- Subscription system (by time period)
- System back up
- System collection must be simplified (easy)
- System has choices (style)
- System has various functions
 - Route, maps, traffic, FasTrak
- System linked to driver, not car
- System must be nested (layered)
- System must easily be transferrable
- System should be linked to other driver behavior tools
- Tamper proof
- Technology must be compatible
- Tie technology to odometer reading
- Unit linked to vehicle use
- Up to date access
- Vehicle based system versus individual based system
- Wireless system

Administrative Breakout Session

- Pricing for businesses versus private vehicle owners
- Tiered system for different vehicles based upon efficiency
- Use existing system and add odometer readings to registration fees
- Pay at pump infrastructure in place could be adapted
- Comparison of revenue use
 - Benefits / costs of single revenue system versus multiple revenue systems
- Need reliable transportation alternative before program is implemented
- High overhead costs may eat up extra revenue
- Protection of system
 - Reliability (evasion)
 - Security (hacking)
- Sunset for individual records
- State only program makes enforcement more difficult as compared to national program
- Variable pricing for high occupancy / mass transit (shuttles, cars, etc.)
- Ability to shut off vehicles that evade fees
- Administration costs for out of state users
 - Process by which revenue is returned to state
- Affordability of start-up costs to users
- Double taxation perception
- Evasion versus non-usage tracking
- Government should pay for installation and maintenance
- High frequency billing (bi-weekly)
- Higher costs deter tourism
- Incentives for encouraging participation and compliance
- Limit collection to single entity
 - Privatization improves efficiency and accountability
 - Public collecting more accountable and efficient
- Parity of fees between states
 - Augment with congestion pricing
 - Augment with size and weight pricing
- Pricing for government vehicles
 - Exempting for government vehicles
- Pricing differences between rural and urban areas
- Process of revenue distribution
- Pricing structure, base fee plus VMT fees
- RV and off-road pricing
 - Higher rate
 - Lower rate
- Taxpayer costs for installation
 - Incentives
 - Enforcement / voluntary / penalty
- Variable pricing by car type
- What criteria can be used to opt-out of program

Policy Breakout Session

- VMT rates tied to vehicle classification
- There may be a need of a blended system focusing on VMT as augment gas, public transportation fees
- Citizens should have a say in whether or not VMT is implemented
- Data only available to tax department
- Personal data should not be shared
- Rate structure should not be driven by “social engineering”
- Rates set on road value rather than revenue expectation
- There should be limits on administration costs
- There should be a tiered rate system for VMT
- There should be a pre-paid option for VMT (purchase miles in advance)
- Nevada policy should capture transient travel to make the system more equitable (and reduce avoidance)
- Shuttles, buses, limos should be taxed at a lower rate
- There needs to be a discussion with the business community on potential VMT impacts
- Government should be collecting the revenue (not private sector)
- If you encourage people to drive less, then VMT might also fail to meet revenue needs
- Rates should be tiered to air quality events (e.g., stage 3 or 4 air quality alerts)
- Rates should be tied to vehicle emissions
- VMT should be a federal policy
- Congest pricing should be considered so as to ensure system reliability
- Data should only be collected by government
- Data should be available with warrant
- Data cannot be shared without warrant
- I am not certain of what the policy ranges should be
- GPS should “ping” frequently for reasons of accuracy
- Make the truckers pay their fair share
- Nevada should consider what to do about VMT if national government doesn’t take lead
- Rates should be based on where they live in relation to location of stores (basic needs)
- There should be a clear policy objective for VMT
- There should be a tiered system for alternative energy vehicles (including non-motorized vehicles)
- There should be rates based on trip type (business versus leisure or doctor visit travel)
- VMT policy rates should be tied to the vision for the transportation system
- VMT should not be the only alternative explored
- VMT should not be the only policy solution
- We should study all economic impacts of VMT
- What if VMT doesn’t meet state needs

Privacy Breakout Session

- Societal benefits should prevail over individual privacy concerns
- Government credibility is so low public won't believe data security / privacy guarantees
- Data collected only for specific purpose
- Separate individual identifiers from other data collected
 - ID system separate from individual
- Data for tax purposes only, not law enforcement (i.e., ticket for speeding)
- Data linked to vehicle, not individual
- GPS for mile collection only
- Unstable political process makes guarantees of policy less reliable
- Non-"hackable" system (secure system)
- Can't switch devices
- Data collected for miles only (no congestion pricing)
- Data collected should include factors relating to congestion issues
- Government should be able to sell data
- Government should not be able to sell data
- GPS device must be secure from break-in / theft
 - Limit actual information stored on-board
- Individuals should have access to any GPS information collected
- Individuals records should not be kept for a long time
- Law enforcement should have limited access
- Lessors should not have access to lease travel / tax records
 - Applies to all forms of leases
- Limit data accessibility to transportation revenue entities
- Should have opt-in / opt-out for any information besides miles driven
- Should not be GPS
- Technology does not exist to ensure data protection
- Vendor (private) program rather than have a private vendor holding data

APPENDIX C. SIMPSON'S 3/8 METHOD

Simpson's 3/8 method corresponds to using third-order polynomials to the integrand of four discrete data points (76). In this project, the data point is the speed over ground extracted from GPS NMEA-0183 sentences. Suppose the travel time is from t_1 to t_{n+1} , speed data updates in every 5 seconds, that is $\Delta t = t_2 - t_1 = t_3 - t_2 = t_4 - t_3 = \dots = t_{n+1} - t_n = 5s$, at each time, speed is $s(t_i)$, $i = 1, 2, 3 \dots n+1$. Applying the composite Simpson's 3/8 method, we have the mileage traveled M_t , from t_1 to t_{n+1} :

$$\begin{aligned}
 M_t &= \int_{t_1}^{t_{n+1}} s(t) dt = \int_{t_1}^{t_4} s(t) dt + \int_{t_4}^{t_7} s(t) dt + \dots + \int_{t_{n-2}}^{t_{n+1}} s(t) dt \\
 M_t &= \frac{3\Delta t}{8} [s(t_1) + 3s(t_2) + 3s(t_3) + s(t_4)] + \frac{3\Delta t}{8} [s(t_4) + 3s(t_5) + 3s(t_6) + s(t_7)] + \dots \\
 &+ \frac{3\Delta t}{8} [s(t_{n-2}) + 3s(t_{n-1}) + 3s(t_n) + s(t_{n+1})] \\
 M_t &= \frac{3\Delta t}{8} \left[s(t_1) + 3 \sum_{i=2,5,8}^{n-2} [s(t_i) + s(t_{i+1})] + 2 \sum_{j=4,7,10}^{n-3} s(t_j) + s(t_{n+1}) \right]
 \end{aligned}$$

Eq. J-1



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