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COLORADO MILEAGE-BASED USER FEE STUDY

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16. Abstract

The Transportation Research Board, Government Accountability Office, and Colorado Transportation Finance and Implementation Panel (CTFIP) suggested that Colorado pursue fees based on actual travel as an alternative to the fuel tax. Revenues from mileage-based user fees (MBUF) would not vary based on fleet fuel consumption and would instead return revenue in proportion to use of the roadway network. The 2008 CTFIP recommended specifically that the Colorado Department of Transportation (CDOT) study MBUF in more detail. This research project investigated the application of mileage-based user fees, and more expansively road usage charges, as a possible mechanism to improve funding for transportation. The final report documents: 1) state of the practice in MBUF; 2) stakeholder and public perceptions of MBUF in Colorado; 3) operations guidance; and 4) recommendations for next steps. This yielded the primary conclusion: although a mileage-based user fee system can be created in Colorado so that all Colorado drivers pay their proportional share of roadway system costs, significant issues remain from technical, policy, and public acceptance perspectives.

Implementation

Too many operational and technological questions remain unanswered, and must be tested and evaluated before the state would be ready to commit to a statewide implementation of this strategy. Rather, alternative short-term measures that can accomplish many of the objectives of mileage-based user fees – namely, an increase in revenue and better distribution of payment from alternative fuel and fuel high-efficiency vehicles – should be evaluated and considered.

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EXECUTIVE SUMMARY

Fuel taxes have long served as a reasonable user fee to pay for roadway construction as well as ongoing operations and maintenance. However, the rising cost of providing roadway capacity, particularly in urban areas, has outpaced the fuel tax's declining ability to provide necessary funding to develop and maintain an efficient system. While roadway capital and operating and maintenance costs have risen with inflation, the federal and state fuel tax rates have not. As Federal and Colorado motor fuel tax rates are set on a per gallon basis that has not changed in 20 years, transportation revenues fall as average fuel efficiency increases. The Transportation Research Board (TRB), the transportation branch of the National Academies, estimates that government regulations and sustained fuel price increases could drive a 20 percent reduction in fuel consumption per vehicle mile by 2025. This figure was determined well before the 2011 Corporate Average Fuel Economy (CAFE) standards that will yield an average fuel efficiency of 54.5 miles per gallon by 2025. As vehicle fuel efficiency increases and the market for alternative fuel vehicles grows, the ability of a fuel tax system to serve as the primary funding source for road maintenance and needed expansion is further degraded. The impacts of this decline in revenue will ultimately be felt far and wide in Colorado.

The Colorado MBUF Study

Many studies by TRB, national transportation commissions established by Congress, the Government Accountability Office, and even Colorado's Transportation Finance and Implementation Panel in 2008 have advocated that states and the federal government pursue fees based on actual travel as an alternative to the fuel tax. Revenues from user fees (MBUF) or vehicle miles traveled (VMT) fees, if properly levied, would not vary based on fleet fuel consumption and would instead return revenue in proportion to use of the roadway network. MBUF may also achieve goals outside of revenue generation, such as overall system management through congestion pricing. This research effort is a follow-up to the 2008 Colorado Transportation Finance and Implementation Panel recommendation that the Colorado Department of Transportation (CDOT) study MBUF in more detail and conduct a pilot program. The project began in 2011. The initial scope of the project included both of those elements. As the project progressed; however, CDOT decided that it was not the appropriate time to pursue a pilot program in Colorado due to lack of consensus about policy goals and objectives, stakeholder concerns, and political timing. The new project objective became to identify strategies and engage the public in developing potential MBUF options for Colorado.

This final report documents the work performed by Parsons Brinckerhoff and the Texas A&M Transportation Institute (TTI) for CDOT's Department of Transportation Development, Applied Research and Innovation Branch, including:

- State of the practice research
- Stakeholder interviews and workshop
- Development of MBUF operations guidance
- An assessment of public attitudes
- Recommendations for next steps

State of the Practice in MBUF

One of the primary goals of an MBUF system is to provide a sustainable source of funding for the construction, operation, and maintenance of the transportation system. The importance of this objective is particularly acute for domestic MBUF systems as, unlike traditional transportation funding mechanisms, such as fuel taxes, vehicle registration fees and sales and property taxes, MBUF systems are designed to more accurately reflect actual use of the roadway network. There are currently no MBUF systems oriented specifically around personal vehicles in use anywhere in the world. There are, however, similar systems. For example, truck tolling using pricing mechanisms similar to what is envisioned for a MBUF is ongoing in many central European countries such as Germany, Switzerland, Austria and the Czech Republic. Road pricing systems oriented around personal vehicles are in place in Stockholm, London and Singapore, but the pricing component imposes fees for passage into a cordon area and is thus not truly distance based. Pilot testing and technical evaluations of potential MBUF systems has occurred in Oregon, Minnesota, and Nevada. These tests have involved both proof of technology and investigation into potential policy impacts of implementing MBUF systems. These studies have shown that MBUF systems are technologically feasible, and, if coupled with time of day pricing, MBUF can impact driver behavior in ways that facilitate mobility while providing significant revenue.

MBUF fees can be based on odometer readings, or information collected from a vehicle's on-board diagnostic (OBD II) port, the “computer system” standard on every vehicle manufactured since 1996. Odometer information can either be recorded manually, or if the OBD II port is being used, it can be transmitted by cellular device, or potentially retrieved by Bluetooth device. The advantage of this arrangement is both higher precision in terms of the fee collected versus the number of miles driven and elimination of manual odometer reading. Significantly more sophisticated systems can be developed using in-vehicle devices. These devices would communicate their information using cellular technology. In addition to mileage, this type of system can also collect time of day information. Either using cellular tower triangulation or GPS information if the device is so equipped, travel location can also be taken into account. This type of device has the advantage of being able to accurately reflect miles driven, as well as provide incentives to travel outside of peak periods and to reduce travel on particularly congested roadways. The major disadvantage of this type of system is the amount of information that is collected and is transmitted to a fee collection agency. This has the potential to introduce concerns related to privacy and tracking of travel patterns. There are procedures that can be put in place that could significantly increase driver privacy; however, perceptions of privacy issues are likely to remain.

Colorado Implementation Possibilities

Following the analysis of MBUF research around the U.S., the project team developed a series of potential implementation models in order to assess their viability with stakeholders and the public. Three models for MBUF implementation were developed and tested:

Current System Model

This would be the smallest deviation from the existing transportation funding system, and would consist of some combination of:

- Maintaining the motor fuel tax as currently collected, but indexing it to either inflation, transportation program costs, or to fuel cost.
- Adding a vehicle registration "gap" fee which would make up the gap in funding due to electric and hybrid vehicles. The fee would be estimated by vehicle class/model, location of registration (urban, suburban, town, or rural), and year of manufacturer.

Infrastructure-based Model

This would be a near-term alternative to fees. It would consist of some combination of:

- Tolls on specific facilities that meet toll feasibility criteria. This model would target new vehicular capacity and would achieve system management related objectives.
- A new transportation utility fee for funding all other statewide facilities that do not meet the tolling feasibility criteria. Similar to an impact fee, real estate property owners would be assessed fees based on the trips generated by the use of their property. Unlike an impact fee, however, the utility fee is assessed on an annual basis for roadway system maintenance.

Model

This would be a medium- or long-term scenario because it represents the greatest change from current taxation. It would consist of a combination of:

- Participation in a per-mile fee assessment program that would use either bulk odometer mileage reporting (static fee per mile) or Global Positioning Satellite (GPS)-based reporting (variable fee based upon location and/or time of day).
- In the short-term, and during ramp-up for statewide fleet coverage to the fee model, a vehicle registration "gap" fee assessment would be paid at vehicle registration, as described in the Current System Model.

Stakeholder and Public Reactions

The project team conducted outreach to over 30 different stakeholder organizations in Colorado, with 19 agreeing to interviews, representing a diverse array of interests. Of these, when discussing MBUF, stakeholders said that such a system would be beneficial to Colorado because it is equitable, sustainable, and could cause behavior change with regards to travel. Stakeholders cited many problems or barriers with a potential MBUF system, however. Many noted that the general public would view MBUF as an invasion of privacy. That said, there was no consensus on how to approach the public about a potential MBUF pilot program; answers ranged from emphasizing individual convenience to explaining why more transportation funding is needed. Stakeholders said that the Current System Model is the MBUF model to be most likely embraced by the public. This is because it is most similar to the existing tax and registration funding system and as such, would require less education, public relations, and cost to implement. Following the identification of stakeholder reactions, researchers conducted focus groups in Colorado to assess public perceptions of various alternate funding mechanisms for meeting Colorado's transportation infrastructure needs. The goal of the focus groups was to have a guided exploration of MBUF, providing a fair amount of detail to the public in a cost-effective

manner. Participants in these sessions discussed how Colorado currently pays for transportation infrastructure, the state's long-term transportation funding needs, issues with the current funding system, and provided feedback on several alternative funding systems. The participants in the focus groups determined that the state should continue examining alternatives to the current transportation funding system, but articulated a clear preference for systems that are low cost and simple to use. Any new funding system developed by the state should strive to be easy to understand from the perspective of the driver and deployed at relatively low cost. In this context, there was a general preference for the Current System Model, albeit focus group participants did see value in the Model if issues could be resolved.

Conclusions

Whereas the context for expanding revenues is apparent, the mechanism by which to do so is not. This research project investigated the application of mileage-based user fees, and more expansively road usage charges, as one possible mechanism to improve funding for transportation. Certainly, there are other possibilities that are not directly tied to use of transportation services, including contributions from the state general fund (comprised of state sales and income taxes) or local mechanisms (such as property and sales taxes).
Looking forward, there are two specific findings from this research effort that informs logical next steps for CDOT.

- **CDOT has many options for increasing transportation revenue**. Colorado is not limited in its portfolio of revenue mechanisms to tap into for expanded funding – a portfolio which includes state, regional and local property taxes, development impact fees, vehicle registration fees, and tolling. Additionally, many of these mechanisms have a direct correlation to usage of Colorado's roadway system.
- **Colorado need not lead the country on MBUF development**. Stakeholders and the general public revealed a desire for CDOT to be a "near follower" as opposed to a national leader on the development of MBUF strategies. In particular, Colorado benefits from the experiences of Oregon, Minnesota, and Nevada as they continue to test and refine their approaches to MBUF and road usage charges. A significant subset of the public indicated that, when the time comes, it is appropriate for CDOT to consider and implement a change to MBUF. Their generalized advice was to avoid piecemeal efforts, and instead, make a commitment to full implementation. Realistically, making a commitment to full implementation at this time would be significantly challenged given the current state of technology. Rather than look to be on the leading-edge of MBUF, Colorado can continue to participate in research and evaluate opportunities for developing a Colorado-specific solution that follows upon the best practices of other states who are more interested in taking a leadership role.

These two findings yield the primary conclusion from this research effort: although a user fee system can be created in Colorado so that all Colorado drivers pay their proportional share of roadway system costs, significant issues remain from technical, policy, and public acceptance perspectives. Too many operational and technological questions remain unanswered, and must be tested and evaluated before the state would be ready to commit to a statewide implementation of this strategy. Rather, alternative short-term measures that can accomplish many of the

objectives of mileage-based user fees – namely, an increase in revenue and better distribution of payment from alternative fuel and fuel high-efficiency vehicles – should be evaluated and considered.

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INTRODUCTION

There are growing concerns among many in the transportation industry about the long-term sustainability of the fuel tax as the primary mechanism for funding transportation infrastructure at the state and federal level. First implemented by the State of Oregon in 1919 at a rate of one cent per gallon, fuel taxes have served the country well as a stable and reliable source of funding for nearly a century. However, it is becoming increasingly clear that fuel taxes, as currently structured, will not be able to meet the needs of a 21st century transportation system. Continued increases in the average fuel efficiency of automobiles mean that drivers can travel further than ever before on a single gallon of gasoline. This means that drivers, on average, are paying less and less in fuel taxes for every mile they drive. In fact, the Transportation Research Board (TRB) estimates that government regulations and sustained fuel price increases could reduce fuel consumption per vehicle by up to 20 percent by 2025 (TRB 2006). Furthermore, the market for vehicles that do not run on gasoline at all, such as electric vehicles, is continually developing. Many have advocated that states and the federal government pursue fees based on actual travel as an alternative to the fuel tax (TRB 2006; NSTPRS 2007; NSTIFC 2009). Revenues from user fees (MBUF) or vehicle miles traveled (VMT) fees , if properly levied, would not vary based on fleet fuel consumption and would instead return revenue in proportion to use of the roadway network. MBUF may also achieve goals outside of revenue generation, such as overall system management through congestion pricing.

Colorado Context

In 2007, Governor Ritter appointed the Transportation Finance and Implementation Panel to study transportation infrastructure needs and funding sources. As shown in Figure 1, the Panel found that by 2030, there will be a $51 billion funding gap between transportation revenue and the costs associated with simply sustaining the current transportation system. If the system were expanded, the gap would be $104 billion. The Panel noted that not only are many of the state's highways and bridges in disrepair, but that, "Many drivers also don't realize that the primary means by which we pay for transportation has eroded to less than a third of its value over the last 10 years. Gas taxes are no longer a sufficient source of funding."

Among other recommendations, the Panel supported the creation of a VMT fee pilot program, recognizing that a system that charges for roadway usage could provide a more sustainable transportation revenue source than the current motor fuel tax, as well as address congestion and environmental issues.

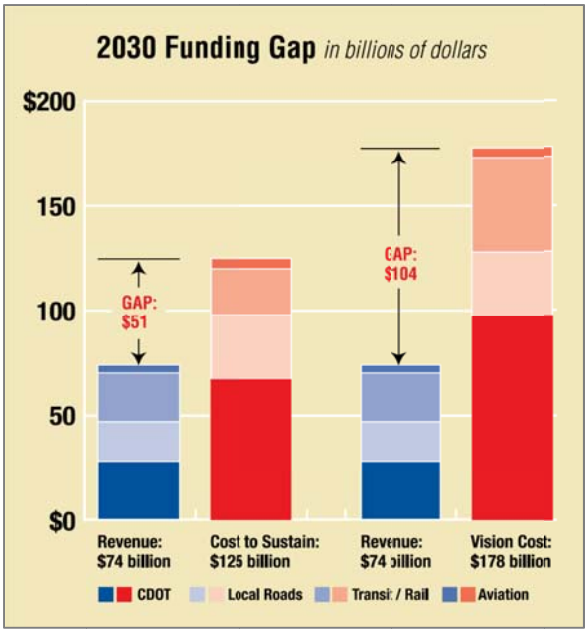

FIGURE 1: 2008 TASK FORCE FINDINGS

Project Objectives

This research effort is a follow-up to the 2008 Transportation Finance and Implementation Panel recommendation that the Colorado Department of Transportation (CDOT) study MBUF in more detail and conduct a pilot program. The project began in 2011. The initial scope of the project included both of those elements. As the project progressed; however, CDOT decided that it was not the appropriate time to pursue a pilot program in Colorado due to lack of consensus about policy goals and objectives, stakeholder concerns, and political timing. The new project objective became to identify strategies and engage the public in developing potential MBUF options for Colorado.

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WHY MILEAGE-BASED USER FEES?

Road user fee systems, of which MBUF is one of many subsets, can accomplish various policy objectives:

- Revenue Generation
- Demand Management
- Equitable Collection of User Costs
- Environmental Goals

Revenue Collection

One of the primary goals of an MBUF system is to provide a sustainable source of funding for the construction, operation, and maintenance of the transportation system. The importance of this objective is particularly acute for domestic MBUF systems as, unlike traditional transportation funding mechanisms, such as fuel taxes, vehicle registration fees and sales and property taxes, MBUF systems are designed to more accurately reflect actual use of the roadway network.

Replacement of the Revenue Generated by the Fuel Tax

The primary impetus for the examination of MBUF systems is their potential to replace fuel taxes as the primary funding source for transportation infrastructure development and maintenance. Due to the fact that they would return revenues in proportion to actual road use, not in proportion to a proxy measure such as fuel consumption or vehicle ownership levels, they are viewed as being a more sustainable revenue source in the long term (TRB 2006; NSTPRS 2007; NSTIFC 2009). Replacing fuel taxes is perhaps the most common policy objective under consideration by entities pursuing domestic MBUF studies.

Generation of Supplemental Revenue

MBUF systems do not have to be implemented as a replacement to the fuel tax, and elected officials and other policy makers may find the implementation of an MBUF system as a supplemental revenue source to have many advantages. It is common in states and municipalities to supplement spending on transportation with sales, excise, or property taxes. However, these taxes are typically regressive (with regards to both income and road use) and can unfairly distribute costs of roadways to non-users (Sorenson and Taylor 2005). Therefore, an MBUF system might be a desirable revenue source for smaller scale entities wishing to provide additional revenue for infrastructure funding, be it for highways or transit, or as a replacement to these tax mechanisms.

Facility Specific Revenue Generation

An additional policy objective of an MBUF system might be to allow for the identification of where travel is occurring (and where revenue is being generated) on a facility specific basis. This would allow the implementing entity to adjust rates on a facility-by-facility basis in order to achieve any number of goals. For example, implementing entities might adjust rates to reflect the variable costs associated with maintenance and operations on different types of facilities. Differential pricing by facility might also be utilized in situations where travel volumes are disproportionate between facilities and the implementing entity wishes to shift traffic to lower volume facilities or shift travelers to other modes or times of travel. A facility specific revenue

generation objective might also be adopted in situations where new facilities must generate revenue in order to cover development costs (Kalauskas, Taylor et al. 2009).

Jurisdictional/Area Specific Revenue Generation

An MBUF system might be implemented in such a manner that use and revenue generation can be tied to certain areas, most likely the various jurisdictions (state, county, and city) composing the overall MBUF system. Unlike systems oriented around facility specific revenue generation, this objective is concerned with collecting fees for travel within a certain area regardless of the facility being travelled on. The fee systems tested in Oregon, Minnesota and evaluated by the University of Iowa all utilized some element that allowed for travel within specific areas (be it a state or municipal area) to be identified.

System Management

System management, in this case, refers generally to influencing how drivers utilize roadway resources. Objectives associated with system management might be reducing congestion, reducing traffic volumes, increasing vehicle speeds, improving user access, or restricting unnecessary vehicle access. An MBUF system with a system management component might, for example, contain a congestion pricing element, where fees for access to infrastructure increase as volume increases. MBUF systems under development and evaluation in the United States are not being evaluated with the expectation that they will serve primarily as a system management tools but these systems are nonetheless being evaluated in terms of their support for such objectives. For example, the ODOT and MnDOT evaluations both tested the potential for varying fee rates throughout the day such that access is more expensive during periods of high congestion.

Equitable Collection of User Costs

An MBUF system might be structured in order to collect fees from road users in proportion to the costs they impose on roadway infrastructure. In most cases, fee systems oriented around collection of user costs are advanced as a means of collecting revenues from users that are disproportionately burdening the roadway network, and most existing MBUF systems that feature this objective collect fees from trucks and other heavy vehicles. Cost, for the purposes of eventual fee assessment, may be articulated in terms of actual wear and tear placed on infrastructure or in terms of externality costs associated with congestion and/or pollution. In terms of pricing for wear and tear the general practice is to levy an escalating fee schedule for heavier vehicles or for vehicles that do not have a sufficient number of axels for the proper distribution of load weight.

Environmental Goals

Cost might also be expressed in terms of environmental externalities, generally in the form of emissions. The transportation sector is a major contributor of pollutants such as carbon monoxide (CO), hydrocarbons (HC) and volatile organic compounds (VOC), oxides of nitrogen (NOx), and particulate matter (PM) that are collectively known to have negative impact on human health. The reduction of these emissions and subsequent mitigation of their effects is a growing concern for policy makers both domestically and internationally. In terms of pricing for environmental costs, one concept is to simply charge higher mileage rates for older, more polluting vehicles. In

some cases revenues generated by these systems might be used to fund alternate modes such as rail and waterways, which are viewed as being more environmentally friendly. While not a major policy consideration for the implementation of MBUF systems in the United States, environmental goal attainment is a significant component of many international fee systems and could grow in importance for domestic applications (Kalauskas, Taylor et al. 2009).

STATE OF THE PRACTICE

In 2012, Parsons Brinckerhoff and TTI concluded a review of the state of the practice in the development of MBUF systems. The purpose of that effort was to establish a base of knowledge on the deployment of MBUF systems that would facilitate a future evaluation of their potential as a transportation funding source in the state of Colorado. The research effort generated a significant amount of information, which is summarized in this section of the report and included in more detail in Appendix A.

Past Implementation

There are currently no MBUF systems oriented specifically around personal vehicles in use anywhere in the world. There are, however, similar systems. For example, truck tolling using pricing mechanisms similar to what is envisioned for a MBUF is ongoing in many central European countries such as Germany, Switzerland, Austria and the Czech Republic. Road pricing systems oriented around personal vehicles are in place in Stockholm, London and Singapore, but the pricing component imposes fees for passage into a cordon area and is thus not truly distance based. Pilot testing and technical evaluations of potential MBUF systems has occurred in the United States. These tests have involved both proof of technology and investigation into potential policy impacts of implementing MBUF systems. These studies have shown that MBUF systems are technologically feasible, and, if coupled with time of day pricing, MBUF can impact driver behavior in ways that facilitate mobility while providing significant revenue.

Technology

While there is no definitive "best" technology identified by the tests, it is clear that there are no significant technology limitations for an MBUF system. Technology is limited only by the policy objectives adopted by implementing entities. Most technology issues encountered in domestic MBUF pilot programs were eventually addressed or were deemed to be particular for the pilot and would not be significant on a larger scale deployment.

System Implementation Strategies

There is a wide range of potential implementation strategies, from simple changes in the methodology for assessing vehicle registration fees to complex systems utilizing in-vehicle or installed off-the shelf handheld Global Positioning System (GPS)-type devices. Changing registration fees would require that a logical nexus be developed between the fee to register a vehicle and the impact that that vehicle has on the roadway system. This could, and likely would, be developed by determining the average VMT and average impact per VMT that a particular type of vehicle has on the roadway system. There are no technical barriers to developing this information and implementing the system. Further, the system could be largely implemented within the existing structure that is currently used for registering vehicles in Colorado.
Privacy concerns appear to be among the most critical barriers facing implementation of more high tech systems. The collection of detailed travel data has been shown to evoke significant concerns among the public about governmental entities utilizing that data for tracking and “social engineering” purposes. From a technology standpoint, all vehicles manufactured since 1996 come equipped with on-board diagnostic systems (OBD II port) that can provide

information useful in determining travel by a vehicle. This information includes vehicular factors as speed, acceleration, and time along with information that is proprietary to individual vehicle manufacturers. The use of OBD II based technologies, as opposed to GPS-based technologies, for mileage assessment is thus one way of potentially addressing privacy concerns. Since privacy concerns are so significant, newer MBUF oriented technology systems have tended to utilize these data feeds to determine the various parameters required for MBUF assessment.

It should be noted that Progressive Auto Insurance is already utilizing the OBD II device in its "Snapshot" insurance program. Snapshot is a program to determine insurance rates based on information collected through the OBD II port and wirelessly transmitted to Progressive. The information includes mileage driven and time of day, two major elements that could be used in an MBUF system (Progressive 2011). This in essence means that "off-the-shelf" technology is available to determine an MBUF fee, and that collection and aggregation of multiple small trips, does not appear to be problematic from a cost of doing business standpoint. Taken to the logical next step, it would be possible to use data from the OBD II in a pricing scenario.
Mobile devices, such as smart phones, already incorporate a significant amount, if not all, of the technology needed to implement an MBUF system. In fact, the Minnesota MBUF trial used a mobile application ("app", in the common vernacular) developed for the Samsung Galaxy S Smartphone (Battelle 2011). There are numerous programs and apps on the market that are capable of tracking and consolidating large numbers of small pieces of data. As an example, Apple, with the user's permission, routinely tracks iPhone® usage and the user's location. There is no cost to the user, meaning that Apple is willing to absorb the cost to procure this data. This would be exactly the type of data collection necessary for an MBUF system. It should be noted, that users can opt out of Apple's data procurement.

There is no doubt that the technology exists to allow MBUFs to be implemented using mobile devices. Routines that prevent double billing if two mobile devices are making the same trip can almost certainly be developed. The phones utilized in the Minnesota pilot utilized Bluetooth® technology connected to the OBD-II port for electric switch sensing to insure that phones only collected mileage while in the participating vehicle. Phones could thus be carried outside of the vehicle, and even in another vehicle, by a pilot participant and they would not collect mileage information so long they did not detect the Bluetooth signal from the participant's vehicle. Review of the current state of the practice leaves very little doubt that the technology to implement MBUFs exists and can be developed practically from "off-the-shelf" software and hardware. Cost to implement such a system will vary depending on the system chosen, and whether Colorado mandates participation in a particular system/vendor. A program based on revised vehicle registration can be implemented at a relatively low cost. More complex mobile or onboard device transactions can likely be handled at low cost, particularly if private sector providers are allowed to participate in the system.

Summary of Recent MBUF Programs

Oregon Road Usage Charge Pilot Program

In 2006, the Oregon Department of Transportation (ODOT) conducted a user fee (MBUF) pilot that allowed participants to their fees while making fuel purchases. The technology system relied

on a data feed from the vehicular diagnostic (or OBD II) port to count miles and signals from the Global Positioning System (GPS) to identify location. There were no alternative technology options provided and all participants were required to use the specified device. The system was deemed a success in that it showed mileage fees could be collected in conjunction with the existing fuel tax collection system, but when ODOT officials began move the concept forward there was significant resistance due to outstanding policy issues such as equity, efficiency and privacy. As such, for its most recent MBUF pilot ODOT developed a new vision for deployment that was based on the following principles:

- Any technology used by drivers should be voluntary;
- Specific technologies for road usage assessment should not be mandated by the state;
- Technology-free options should be offered to enhance public acceptance.

ODOT's most recent Road Usage Charge Pilot Program (RUCPP) had a significant level of private sector involvement in technology development, technology provision and billing in order to address public concerns about government use of travel data and administrative costs. Furthermore, ODOT had numerous discussions with the state legislature and the American Civil Liberties Union (ACLU) in order craft language on the use of driver data. An open architecture platform was developed for the technology components so that if the system where to ever be implemented on a large scale it could evolve.

Participants in the RUCPP were able to choose from three technology plans as well as a no-technology, flat fee option. Plans were selected by visiting a website and choosing from among the four platforms. Sanef provided two of the technology-based plans: a simple and an advanced plan. The simple plan utilized an on-board unit (OBU) that simply counted miles traveled. The advanced plan utilized a GPS-enabled OBU that would identify out-of state mileage, which was not assessed fee. Raytheon provided a plan that utilized smartphone technology for fee assessment. Participants could also select ODOT as its plan provider. ODOT's plan utilized a basic OBU that logged only total miles and did not have a GPS component.

The pilot concluded in March of 2013 and resulted in the following findings:

- Users regarded the system as acceptable because it protected privacy, offered multiple reporting and payment choices, and was easy to use. Participants found the reporting equipment easy to install with easy account management.
- ODOT estimated that the charge levied under the RUCPP generated slightly more revenue than the fuel tax for participating vehicles.
- The mileage reporting hardware was safe and resistant to attempts at tampering and fraud.
- Participants generally found the fee to be equitable.
- ODOT concluded that the RUCPP system performed well on a number of system criteria including feasibility, accuracy, reliability, security and maintaining openness.

Based on these findings, ODOT concluded that the RUCPP met its objectives in demonstrating an easy-to-use mileage reporting and payment system. The program showed that road usage charging systems based on open systems are feasible and that a private market exists for the provision of road user charge services. Giving participants a choice of road usage charging plans

helps to achieve pilot success, and perceptions on privacy improve when the state does not operate mileage recording and tax processing systems.

Oregon Road User Fee

On July 7, 2013 the Oregon Legislature passed SB810, which authorized up to 5,000 vehicle owners to pay a 1.5c/mile road use charge in lieu of state fuel taxes. This legislation effectively created the first road user fee (MBUF) in the United States for passenger vehicles. The specifics on how miles travelled will be determined and the fee paid have not been determined yet. The legislation directs the Oregon Department of Transportation (ODOT) to work in conjunction with a Road User Fee Task Force in order define recording and reporting methods. Several methods of assessment and payment must be developed, and one of these methods must not rely on location data from the Global Positioning System (GPS).
The program is expected to be deployed in 2015. Program participants will be able to select the method of assessment and payment plan they are most comfortable with. They will also be able to opt out of the program at any time. The State of Oregon is interested in leveraging this system so that other states may utilize it if they wish to leverage their own road user fees. As such, other states and Canadian provinces can enter into an agreement with Oregon to participate.

Minnesota Department of Transportation

The Minnesota Department of Transportation (MnDOT) recently concluded its own mileage fee pilot that was initiated as the result of state legislation. The first phase of the pilot was a policy study. The second phase technology demonstration was built and operated by Battelle with SAIC acting as the evaluation contractor. Mixon Hill provided support in developing the concept of operations and procurement documents.

The technology demonstration included 500 participants drawn from the Minneapolis / St. Paul region. Participants utilized smartphones equipped with a specialized mileage assessment app. Due to the fact that smartphones can be turned off or removed from the vehicle, periodic odometer readings were taken in order to identify mileage not captured by the device. Mileage not captured on the device but identified by the odometer reading was subject to an elevated rate. The research team found that 77 percent of the mileage assessed under the demonstration was recorded on the app. Participants were provided an initial stipend from fees where then paid. While several different billing methods were tested, participants generally preferred to receive monthly invoices.

The smartphones utilized in the demonstration were also used to test various connected vehicle applications such as travel time and in-vehicle signing. Based on the results of the pilot MnDOT concluded that smartphones are a viable technology option mileage fee assessment. Drivers are increasingly familiar with their user interface and custom applications can be developed for them. However, MnDOT did find that there were some issues with the devices. For example, identical phones could be placed next to each other and might not show the exact same location. Furthermore, placement of the phone in the vehicle affected accuracy. Mounting the device near a window or on the dash was deemed the most reliable, while placing the device under the seat was the least reliable.

MnDOT also concluded that simplicity in system design was very important to participants. Most did not like having to continually remove and then reattach the smartphones from their vehicles, and there was a general preference expressed for a device that was built into the vehicle. Participants also reacted negatively to the device's visual and audio notifications issued through the connected vehicle applications.

MnDOT found that system administration was labor-intensive and required a significant level of one-on-one interaction with participants and concluded that a future deployment should perhaps be housed administratively within the state department of motor vehicles.

Washington State

In 2012 the Washington Legislature directed the Washington State Transportation Commission and the Washington State Department of Transportation to work with a 20-member Steering Committee in order to examine the feasibility of transitioning the state to a road user charge for transportation investment. The committee met four times to discuss policy issues and potential approaches to road user charging and concluded that a fee is a long-term funding solution worth further evaluation. The committee concluded that:

- Domestic and international experience with road usage charging has shown that there are numerous viable operational concepts and technologies;
- A wide range of potential road user charging options exists, from simple paper-based systems to more complex technology-based systems;
- Numerous policy issues still need to be addressed.

The steering committee developed a two phase work plan for the continued research of key questions, policy objectives, and operational concepts. Future activities would include:

- Conducting public outreach, education, and engagement;
- Refining policy objectives and frameworks;
- Developing operational concepts;
- Designing system alternatives; and
- Conducting business analyses.

A pilot test could be carried out based on the results of these research efforts. However, much of this depends on direction yet to be provided by the state legislature.

STAKEHOLDER FEEDBACK

In 2012, the project team engaged stakeholders to test the readiness of the MBUF concepts including potential business models. Stakeholders were identified with the help of CDOT and included decision makers from organizations either involved in or affected by the state's transportation system. The stakeholder organizations included:

- CDOT Department of Transportation Development
- CDOT High Performance
- CDOT Financial Management & Budget
- CDOT Government Relations
- CDOT Department of Transit & Rail
- CDOT Public Relations
- CDOT OFMB Legislative Liaison
- CDOT Statewide Transportation Advisory Committee
- Denver Regional Council of Governments
- Pikes Peak Area Council of Governments
- Pueblo Area Council of Governments
- Grand Valley MPO
- North Front Range MPO
- Regional Transportation District
- Colorado Department of Revenue
- Colorado Department of Public Health & Environment
- Colorado Department of Local Affairs
- Colorado Governor's Office of Policy & Initiatives
- Colorado Office of State Planning and Budgeting
- Colorado Office of Economic Development & International Trade
- AAA Colorado
- American Civil Liberties Union of Colorado
- American Council of Engineering Companies of Colorado
- Club 20
- Colorado Counties, Inc.
- Colorado Energy Office
- Colorado Environmental Coalition
- Colorado Environmental Partnership
- Colorado Ethics in Business Alliance
- Colorado Motor Carriers Association
- Colorado Municipal League
- Colorado Public Interest Research Group
- Colorado Regional Air Quality Council
- Colorado Union of Taxpayers
- Eagle County
- Environment Colorado
- I-70 Coalition
- Independence Institute
- Mesa County
- Metro Denver Economic Development Corporation/Metro Chamber
- MOVE Colorado
- National Conference of State Legislatures
- Southwest Energy Efficiency Project
- Transit Alliance
- Vail Resorts

Stakeholder Interviews

During the summer and fall of 2012, 19 stakeholders were interviewed about their understanding of Colorado's transportation funding situation, their understanding of MBUF concepts, and their opinion of various MBUF options. The interview script is included in Appendix B. To give a base understanding of MBUF options during the interview process, three potential models were described:

Current System Model

This would be the smallest deviation from the existing transportation funding system. It would consist of some combination of:

- Maintaining the motor fuel tax as currently collected, but indexing it to either inflation, transportation program costs, or to fuel cost.

- Adding a vehicle registration "gap" fee which would make up the gap in funding due to electric and hybrid vehicles. The fee would be estimated by vehicle class/model, location of registration (urban, suburban, town, or rural), and year of manufacturer.

Infrastructure-based Model

This would be a near-term alternative to fees. It would consist of some combination of:

- Tolls on specific facilities that meet toll feasibility criteria. This model would target new vehicular capacity and would achieve system management related objectives.
- A new transportation utility fee for funding all other statewide facilities that do not meet the tolling feasibility criteria. Similar to an impact fee, property owners would be assessed fees based on the trips generated by the use of their property. Unlike an impact fee, however, the utility fee is assessed on an on-going basis for roadway system maintenance.

Model

This would be a medium- or long-term scenario because it represents the greatest change from current taxation; however, it may yield the greatest impact on transportation funding. It would consist of a combination of:

- Participation in a per-mile fee assessment program that would use either bulk odometer mileage reporting (static fee per mile) or GPS-based reporting (variable fee based upon location and/or time of day).
- In the short-term, and during ramp-up for statewide fleet coverage to the fee model, a vehicle registration "gap" fee assessment would be paid at vehicle registration, as described in the Current System Model.

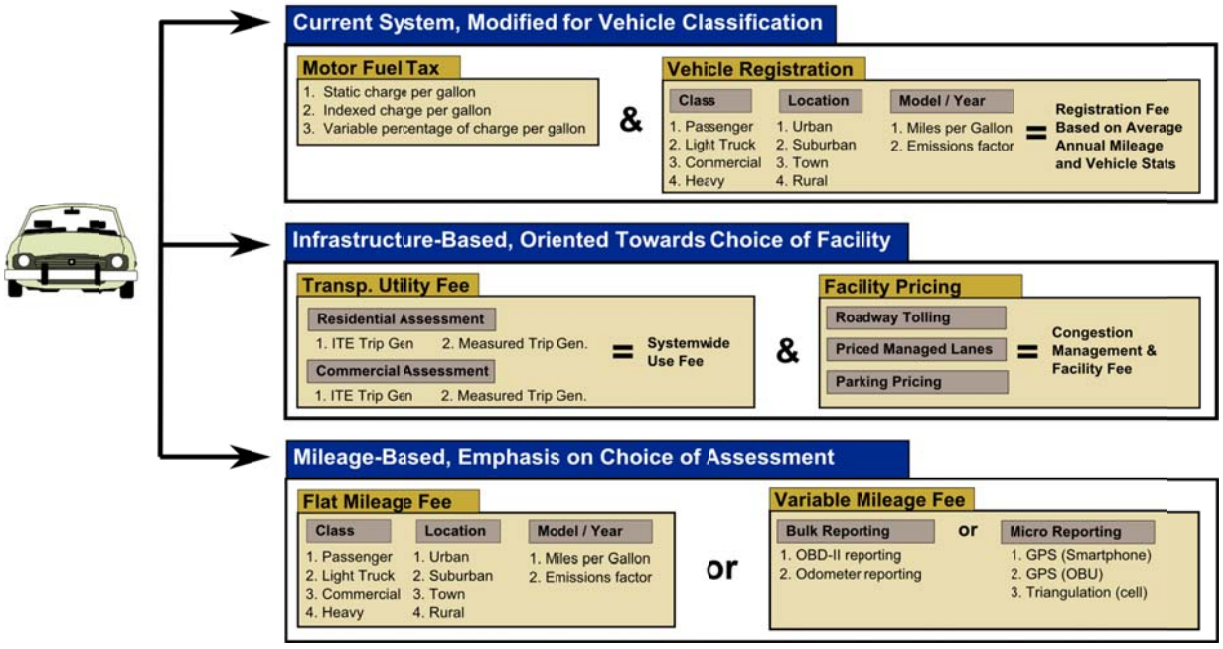

FIGURE 2: POTENTIAL MBUF SYSTEM MODELS

Table 1 is a summary of the stakeholder feedback received during the interview process.

TABLE 1: SUMMARY OF STAKEHOLDER INTERVIEWS

Question	Answer
What does your organization envision for the future of Colorado's transportation system? (Responses fell into these general categories)	• Sustainable and enhanced funding • Maintain and repair what we have • Increase safety • Choice and equity There was limited talk of expansion/enhancement.
Is Colorado on the right path to achieving this vision?	• 53 percent said yes • Most discussed lack of funding as the reason why we are on the right or wrong path.
What is your perspective on transportation finance?	• Vast majority said revenue generation is insufficient to achieve vision • All understood general magnitude of revenue gap
Are you concerned about any method of finance?	• 65 percent said motor fuel tax is unsustainable and insufficient • A few said we are not making the best use of funding we have • A few expressed equity concerns about tolling
Do you believe that the funding system warrants a change in revenue collection?	• 82 percent said yes
What mechanisms are most attractive your organization?	• 53 percent support a menu of options and that it depends on the details • Five said that MBUF is most attractive • Two said that gas taxes/registration fees should be raised
What do you see as the benefits to switching to a system based on MBUF? (Responses fell into these general categories)	• User fee that's equitable • A new, sustainable revenue stream • Would help people understand their impact on transportation system and could cause behavior change • Would be easier to legislatively enact than a tax increase
What do you see as potential problems with such a system?	• 41 percent said privacy concerns by the general public. Other responses included: • A new idea that would require an education process • Asking people to pay more • Difficult for those who have to drive long distances • Impacts on RTD buses, rental cars, taxi drivers, freight vehicles, vacationers, etc. • Does nothing to increase system capacity • Will likely be politicized • Potential of fraud • Perception of social engineering • Compatibility across different state systems • Cost of implementation • Potential to discourage alternate fuel vehicles • Could encourage vehicle registration neighboring states
If MBUF were enacted, do you think it should augment or replace the fuel tax?	• Almost evenly split between augment, replace, or phase—augment and then ultimately replace

Question	Answer
What sort of issues would your organization like to see addressed in a pilot program? (A variety of response were received)	• Deal appropriately with electric vehicles (not single out) • Deal with rural/long distance drivers • Maximize capacity on existing managed lanes • Privacy • Equitable dispersion of funds • Public acceptance and relations – need to communicate purpose, objectives, outcomes, end result) • Make it easy for the public to use • Test technology and concept in a variety of scenarios
How would you recommend approaching the public about MBUF? (A variety of response were received)	• Tell people what's in it for them • Focus on control and convenience, not on funding gap, etc. • Communicate benefits and reasons • Emphasize choice • Be transparent and discuss privacy • Get Governor's support • Make part of CDOT Statewide Plan • Make pilot the mechanism for PR/communication • Communicate state of roads/bridges, funding gap, needs • Get other agencies on board first • Get conservatives on board
Do you see any particular type of MBUF having the most public acceptance?	• 41 percent said Current System (registration "gap" fee or indexed motor fuel tax presents the least change from existing) • 18 percent said System (using smart phones or on-board systems) • 12 percent said Infrastructure-based System (tolling or facility fees)

Most stakeholders agreed that Colorado has a substantial lack of transportation funding relative to its needs. Most said that the motor fuel tax, as currently administered, is an unsustainable and insufficient funding mechanism, and that it is time for a change in revenue collection. A menu of options for funding transportation was attractive to most stakeholders including MBUF, fuel taxes, registration fees, and facility-based fees.

When discussing MBUF, stakeholders said that such a system would be beneficial to Colorado because it is equitable, sustainable, and could cause behavior change with regards to travel. Stakeholders cited many problems or barriers with a potential MBUF system, however. Many noted that the general public would view MBUF as an invasion of privacy. That said, there was no consensus on how to approach the public about a potential MBUF pilot program; answers ranged from emphasizing individual convenience to explaining why more transportation funding is needed.

Stakeholders said that the Current System Model is the MBUF model to be most likely embraced by the public. This is because it is most similar to the existing tax and registration funding system and as such, would require less education, public relations, and cost to implement.

Stakeholder Workshop

CDOT hosted a workshop on October 4, 2012 for stakeholders. The purpose of the workshop was to inform attendees about their role in the study; present on findings to date including why MBUF has been considered, the state of the practice, and the technological, public acceptance, and policy concerns that must be addressed in developing MBUF; have an educated dialogue

about MBUF applications; and give attendees an opportunity to suggest a path forward for Colorado. Approximately 25 people attended representing CDOT, other state agencies, Metropolitan Planning Organizations (MPOs), and organizations representing transportation-related concerns or a specific geography. Two county elected officials were also in attendance. Primary findings of the workshop were:

- Most believe that Colorado's transportation funding problem is major or severe
- Action needs to be taken now to at least "stop the bleeding"
- MBUF would take years to test and implement. An interim measure is needed to generate transportation revenue, most likely with existing revenue sources. A final step could be to move towards a sustainable funding source, such as MBUF.
- Most thought that Colorado should actively support MBUF activities around the U.S., but not itself be a leader on the "cutting edge"
- With regards to MBUF, most are concerned about its public acceptance / political impacts, and, the cost of implementation and collection
- Most find MBUF appealing because it would generate new revenue and better connect users with their impact on the system

POTENTIAL MBUF BUSINESS MODELS

Based on the state of the practice research and feedback from stakeholders, potential MBUF business models were developed for consideration by CDOT and the general public.
While there is little doubt that the long-term prospects for roadway funding will require changes to today's funding methodologies, that does not necessarily imply that fuel taxes, registration fees, or other existing transportation funding sources are inherently "bad" or even that they are obsolete. While some discussions of mileage-based user fees seem to assume that MBUF will replace all transportation funding mechanisms, this may not be the most efficient business model when keeping in mind why transportation funding is needed.

Funding needed for roadway infrastructure can be broken down into four primary areas:

- Routine Maintenance
- Development and improvement of local streets and collectors
- Major reconstruction of primary arterials, expressways, and interstates, and
- Capacity expansion of major arterials, expressways, and interstates.

Each of these areas has differing needs. If needs, and the desired outcomes, are allowed to drive funding mechanisms, a single “one-size-fits-all” funding mechanism will likely be insufficient. In fact, there is a natural synergy between many of these mechanisms that would allow their joint implementation to provide a superior system compared with individual implementation.

An ideal MBUF system would produce several desirable outcomes. These include:

- Cost for the transportation system would be equitably distributed among users.
- The system would accurately establish the impact of each user on the system and charge accordingly.
- Time of day, where applicable, would be taken into consideration.
- The cost of vehicle trips would become more transparent.
- Higher costs would be assessed for travel on "premium" facilities.

Additionally, keeping these outcomes in mind, roadway requirements can be divided into two categories. The first is for the basic connectivity of the roadway system. The second is the need for capacity to handle peak loading. These are two very different issues.

Basic connectivity deals with providing the connections necessary for drivers to travel to and from desired destinations. This can include rural roadways that connect farming communities with each other and to city markets as well as local roadways that connect individual houses with the major transportation system. In both of these cases, it is almost always the need for basic connectivity that controls the development of these facilities. The need for congestion relief over the majority of these types of roadways plays little, if any, role. Due to the stepwise nature of transportation improvements, i.e. the fact that it is not possible to provide one half of the lane of a roadway, it is not unusual for the hourly capacity of these types of facilities to be far greater than what the hourly demand is or is projected to become. Roadways such as these are often greenfield projects, and it is unlikely that there will be physical constraints to obtaining right-of-way. For these types of roadways, the time of day travel occurs makes little difference.

Existing funding mechanisms including fuel taxes and registration fees are a reasonable source to fund basic connectivity roadways. These sources are particularly appropriate if they are adjusted to reflect inflation, and, in the case of registration fees, adjusted to reflect the area in which they are collected as well as the vehicle type (particularly the fuel type). Other mechanisms including transportation utility fees, and even ad valorem taxes, can also be used, particularly in cases where the immediately adjoining property influences the need for and type of roadway. This influence from immediately adjoining property can include very diverse land uses such as local streets and suburban areas as well as a downtown grid system.

The requirement to provide capacity to handle peak loading is significantly different. Peak loading, while related to origin and destination, is much more based on the time of day that trips occur. Peak loading issues are almost always an urban phenomena. Adding additional peak capacity is often very difficult due to right-of-way constraints or the need for very expensive construction such as grade separation. Further, capacity added to handle peak loading conditions is unneeded at other times so travel during much of the day could be handled by a smaller roadway. This means that fuel taxes have a poor relationship to providing peak load capacity, as gasoline is consumed and taxes are collected at the same rate for all travel regardless of the time of day.

Given these two very different issues that need to be addressed as part of overall transportation funding, it is logical to consider the use of a funding system that can address basic connectivity needs along with a complementary system that addresses peak loading capacity needs.

Transportation improvements that deal with the need to provide peak hour capacity are usually made on the most efficient transportation facilities, usually, limited access freeways. To a lesser extent, major arterials might also be upgraded.

As only key facilities need to be identified, monitored, and priced to deal with peak capacity needs, it is unnecessary to monitor VMT on the other facilities. An efficient mechanism to perform this monitoring on key facilities already exists in the form of existing tolling technology. A highly synergistic system could exist with existing fuel taxes and registration fees, perhaps along with transportation utility fees and ad valorem taxes, supplemented by high-level facilities with conventional tolling. Given the rapid technology advances in tolling, particularly open road tolling, this type of system can be developed with existing technology with little or no inconvenience to the driver. In other words, it is very possible to develop an equitable, efficient, and robust transportation funding system that provides the benefits of an MBUF system using existing, familiar, technologies and processes. This type of synergistic hybrid system is illustrated in Figure 3.

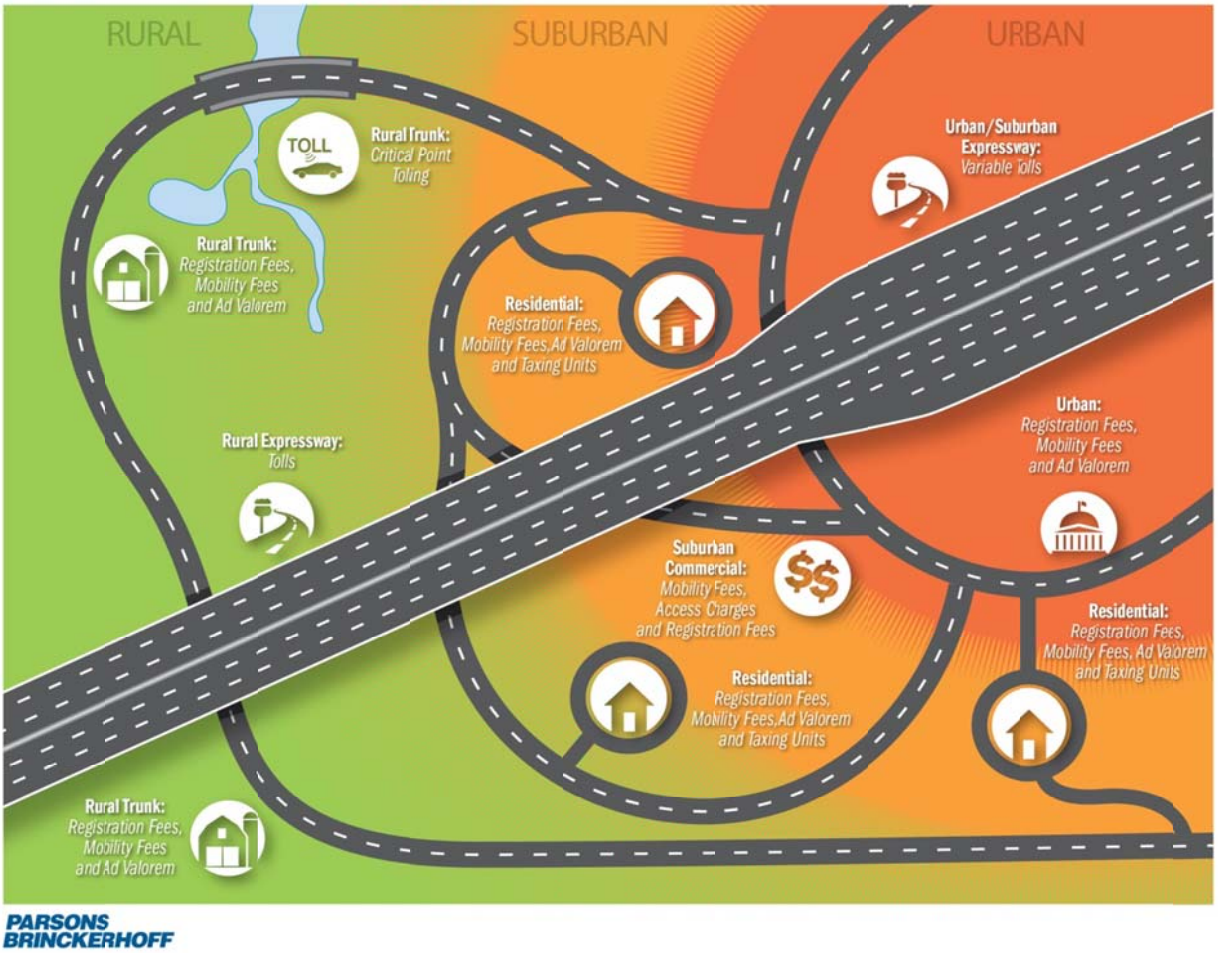

FIGURE 3: POTENTIAL HYBRID MBUF SYSTEM

It is entirely possible that, over time, sophisticated MBUF systems such as those based on GPS technologies may become publicly and politically acceptable. Such advanced funding mechanisms would require a complete overhaul of the existing transportation funding system, a process for which there is insufficient political will and motivation. Existing mechanisms, as they are currently implemented, will likely continue to fall behind in generating the transportation revenues that Colorado will need but they are widely accepted by the public. It is therefore desirable to work within these existing transportation funding frameworks to develop a system that provides benefits and funding levels in a logical and reasonable manner without overhauling the entire transportation funding system.

PUBLIC OUTREACH

In March of 2013, researchers with TTI conducted focus groups in Colorado to assess public perceptions of various alternate funding mechanisms for meeting Colorado's transportation infrastructure needs. The goal of the focus groups was to have a guided exploration of MBUF, providing a fair amount of detail to the public in a cost-effective manner. Participants in these sessions discussed how Colorado currently pays for transportation infrastructure, the state's long-term transportation funding needs, issues with the current funding system, and provided feedback on several alternative funding systems.

A total of three focus groups were conducted. One session was held in the city of Brush, located in rural, northeast Colorado. The other two sessions were held in Denver. Each session was managed by a single TTI moderator assisted by a note taker. A representative from Parsons Brinkerhoff was on hand at each session to provide technical expertise in response to participant inquiries but was otherwise not involved in the sessions.

Summary of Background Discussion

Knowledge of Transportation Funding and Finance

Participants were asked to complete a questionnaire designed to gauge initial participant knowledge about the fuel tax and asked two questions: 1) True or False – Fuel taxes go up when the price of fuel goes up, 2) True or False – State fuel taxes have not increased in the last 20 years. A majority of participants in each of the sessions correctly answered this question as false. In contrast, a majority of participants in each of the sessions answered the second question incorrectly (the correct answer is true). When asked how state highways are funded, most participants in all of the sessions indicated that highways were paid for with taxes in the general sense.

Transportation Investment

Issues related to geographic inequity were raised continually by the Brush focus group. There was a feeling among most participants that facilities in urban areas, the Front Range, and facilities serving the tourism and ski industries are given a higher priority over rural facilities. Confusion about the planning process, in terms of how projects are selected for funding and developed, was evident in all of the sessions. There was general agreement in the sessions that transportation funding mechanisms are currently insufficient for meeting the state's needs and that they will likely be unsustainable in the future. However, in most cases this judgment was qualified with arguments that the state is not properly utilizing and, in some cases, wasting available revenues.

Long-term Needs

While there was general agreement in all sessions that Colorado has a transportation funding issue, there was disagreement as to the implications of this. In response to information provided by the moderator on long-term infrastructure needs, participants in both Denver sessions accepted the information as evidence that some changes are needed in the way Colorado invests

in transportation infrastructure. Participants in the Brush focus group; however, viewed the information as confirmation of their beliefs that current funding sources are being wasted.

Focus Group Preferences for Mileage Fee Implementation

After discussing the four alternate funding models the moderator asked participants to discuss their preferred options.

The preferred option in the Brush focus group was for the Current System Model (with registration fee enhancement, as described above). There were no participants who expressed support for any of the other funding systems presented. Participants believed that the Current System Model provided fewer opportunities for fraud on the part of drivers and appeared to be the lowest of the options in terms of administrative costs. Participants indicated that this option might warrant further evaluation by the state of Colorado but they wanted more information as to why alternate funding systems are being considered and who would be involved with implementing them.

Opinion on preferred funding options was split in the first Denver session. Four of the ten participants favored the Current System Model, which was deemed to be the most feasible. Five participants favored an odometer reading-based approach, where miles traveled would be assessed through periodic odometer readings. Participants preferring this model generally believed it to be the most fair to drivers because it more accurately accounted for mileage without infringing on driver privacy by collecting location data. There was general consensus among the participants that alternate funding mechanisms warrant further examination by the state of Colorado. Participants also indicated that the state should provide more information about the costs associated with developing, operating and maintaining transportation infrastructure. Several participants indicated that the public does not have an accurate view of what such activities actually cost.

The clear preference within the second Denver session was the odometer reading model, with only one participant selecting the current system model and no participants selecting the GPS or facility tolling systems. Participants generally believed the odometer reading-based system to be the most fair, even though participants acknowledged that the system would count out-of-state mileage. Participants generally believed that the state should continue to evaluate alternate funding mechanisms, particularly in light of the information presented at the session detailing long-term needs.

Focus Group Conclusions

The following general conclusions can be drawn from these focus group sessions:

- **Alternate funding mechanisms warrant further examination** – Participants in all three sessions generally believed that the state should continue to examine potential alternatives to the current transportation funding system. However, participants also believed that there needs to be a strong focus on eliminating waste in the current funding system and that the project prioritization and programming process should be simplified and more transparent.

- **Public education efforts should include information about how projects are developed** – Based on the results of these focus groups, it can be expected that a significant portion of the public will resist consideration of alternative funding mechanisms until perceived inefficiencies in the current system are addressed. Much of this perception of waste can be tied to the complexity of the project development process. Making information available and, more importantly, accessible to the general public will help to dispel some of the misconceptions the public has about how transportation projects are carried out.

- **Simplicity and low cost administration are the most important factors to consider** – There was a clear preference in all of the sessions for systems that were simple and low cost. Any new funding system developed by the state should strive to be easy to understand from the perspective of the driver and deployed at relatively low cost.

- **Charging out of state drivers is a major concern** – One concern that was consistent across all of the road fee models was that participants could not see how out-of-state drivers would be charged. If a new transportation funding system is developed it will have to address how out-of-state drivers would pay.

CONCLUSIONS AND NEXT STEPS

The context for MBUF and other forms of road usage charges have changed significantly over the past three years. The Colorado Transportation Finance and Implementation Panel correctly identified the looming need for expanded transportation revenue in order to meet the confluence of population and employment growth coupled with declining revenues from lower per capita motor fuel tax contributions. Although the inevitability of this outcome is fairly well acknowledged, the urgency of the situation may be overstated. As shown by year in Figure 4, since the publication of the "Colorado Transportation Finance and Implementation Panel: A Report to Colorado" in January 2008, population has grown 5.86% whereas motor fuel tax receipts have only grown 1.42%. However, in the same time period, VMT has actually declined 2.26%, indicating higher motor fuel tax receipts as a percentage of VMT. This, of course, may be a momentary aberration. Given the 2011 U.S. government / industry agreement for Corporate Average Fuel Economy (CAFE) fuel efficiency of 54 miles per gallon by model year 2025, the impacts of this decline in revenue will ultimately be felt far and wide in Colorado.

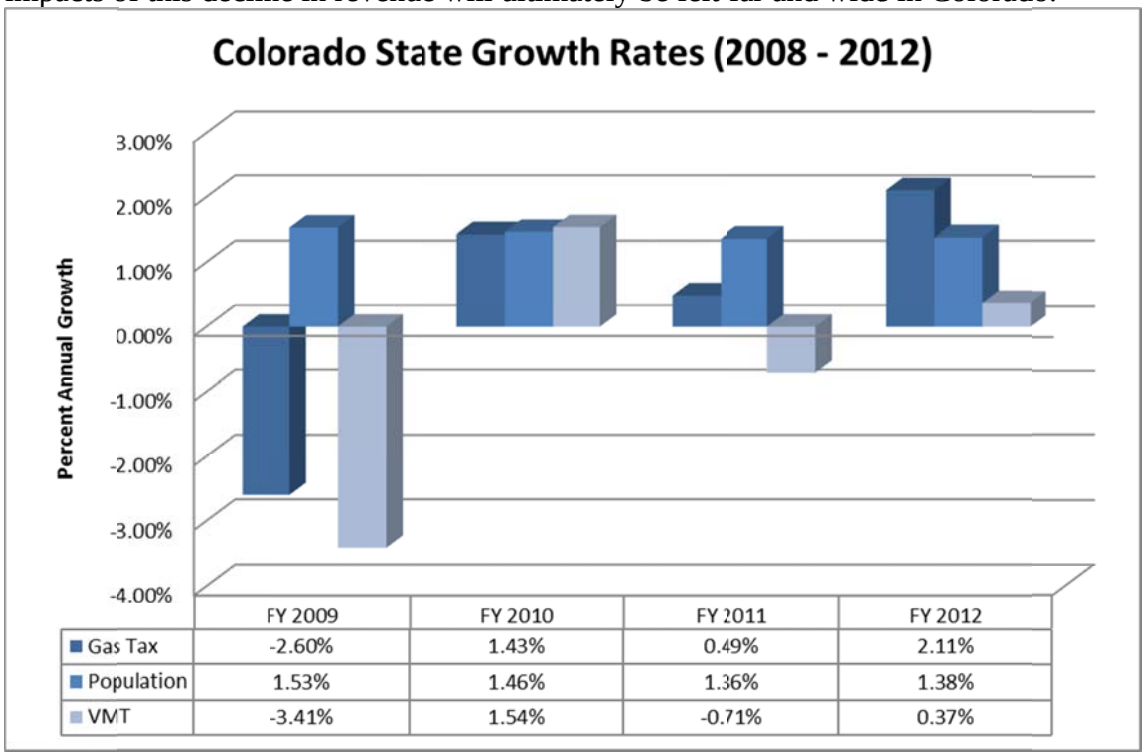

FIGURE 4: COLORADO STATE GROWTH RATES IN MOTOR FUEL TAX, POPULATION, AND VEHICLE MILES TRAVELED 2008 - 2012

Whereas the context for expanding revenues is apparent, the mechanism by which to do so is not. This research project investigated the application of mileage-based user fees, and more expansively road usage charges, as one possible mechanism to improve funding for transportation. Certainly, there are other possibilities, including contributions from the state general fund (comprised of state sales and income taxes) or local mechanisms (such as property and sales taxes), in addition to simply an increase in the motor fuel tax. In the past year, other

states have approached this need for more revenue in differing ways. Some of the notable achievements of other states include:

- Wyoming. The Wyoming legislature approved a 10-cent increase in the motor fuel tax in February 2013. This brought the state fuel tax to 24 cents per gallon, in line with that of Colorado's 22 cents. Anticipated revenue generated from the motor fuel tax increase is $72 million per year.
- Maryland. The state of Maryland increased gas taxes by 3.5 cents in 2013, coupled with an increase of up to 50 percent in static toll rates, indexing of the motor fuel tax to the Consumer Price Index, and a sales tax equivalent of 1 percent advancing to 5 percent within three years.
- Virginia. Virginia revamped its transportation funding in 2013, including an increase in the sales tax (by 0.3%), eliminating the cents-per-gallon motor fuel tax, and instead levying a 3.5% sales tax on the wholesale price of gasoline.

In addition to these states, others have expanded their application of road usage charges. Most notable to this project is Oregon's passage of mileage-based user fee legislation, SB810, in July 2013. This program allows for up to 5,000 vehicle owners to voluntarily pay a 1.5 cent per mile fee in lieu of the motor fuel tax. As it is voluntary, this legislation received considerable support in the legislature, passing the House 48 to 12 and the Senate 24 to 6. The program will be implemented over the course of the next year, and must be fully operational by July 1, 2015. Additionally, the program will allow for multiple data collection and transaction payment options that will be determined at a later date.

Despite the success of Oregon in advancing a voluntary system of adoption for mileage-based user fees, it should be noted that the context of its policy is different from that of Colorado. First and foremost, this is a limited program to demonstrate the success of MBUF as a means of substitution for the motor fuel tax. Second, unlike Colorado and many of its peers, Oregon does not use tolling to finance or maintain any of its roadways, and, does not intend to expand tolling for new highways or managed lanes. In fact, it has been posited by the Oregon director for the MBUF pilot program that the state is more inclined to support MBUF due to its aversion to tolling. Finally, Oregon does not have a state sales tax to provide revenue towards its general fund. So, whereas California, Washington, and Arizona have all used expanded sales taxes as a means of building new roadway capacity, Oregon has needed to turn to other opportunities. Colorado, by comparison, has all of these options before it.

Other states' investigation of MBUF and road usage charges has paralleled that of Colorado. Washington State is currently evaluating MBUF possibilities. The state's steering committee concluded, "that road usage charging is feasible in Washington and recommended further assessment and advancement." (Buxbaum, 2013) However, despite this finding, Washington State Transportation Commission has expressed reservations with adopting an MBUF policy while other toll-based strategies appear to have effectiveness in addressing critical state needs. It will ultimately reside in the legislature to determine whether to continue funding more work, including the development of operational concepts and a business model.

The Minnesota Department of Transportation (MnDOT) concluded its technical evaluation of MBUF and determined there were significant flaws in the system's application. MnDOT found

that the use of GPS on smartphones in its technical study was not accurate enough for MBUF data collection, as the signal is variable from phone-to-phone and is effected by physical location within the vehicle. Furthermore, efforts to track the initiation of a trip were ineffective, resulting in data loss rates of up to 35%. (Johnson 2013) Like that of Washington State, there is no apparent desire to implement MBUF directly. However, Minnesota has determined the need to continue to advance research on MBUF and has led the development of a pooled fund study for such purposes in partnership with Nevada and Washington.

As mentioned, the context for Colorado is different from its peers. This context was explored extensively throughout this research endeavor, and yielded findings that are specific to Colorado. Looking forward, there are two specific findings from this research effort that informs logical next steps for CDOT.

- **More tools are available to CDOT than its peers**. In the past century, the state of Colorado has embraced a broad perspective on revenue generation for transportation. Besides the motor fuel tax, Colorado has leveraged state, regional, and local sales taxes, state vehicle assessments, special districts, and local property taxes and development impact fees to help fund transportation infrastructure. Furthermore, Colorado has used toll revenue to fund key corridors, including E-470, Northwest Parkway, and the original construction of the Boulder Turnpike (U.S. 36). More recently, Colorado has turned to public private partnerships and priced managed lanes to provide expanded access to funding specific projects. In short, Colorado is not limited in its portfolio of revenue mechanisms to tap into for expanded funding. Additionally, many of these mechanisms have a direct correlation to usage of Colorado's roadway system.
- **Colorado need not lead the country on MBUF development**. Stakeholders and the general public revealed a desire for CDOT to be a "near follower" as opposed to a national leader on the development of MBUF strategies. In particular, Colorado benefits from the experiences of Oregon, Minnesota, and Nevada as they continue to test and refine their approaches to MBUF and road usage charges. A significant subset of the public indicated that, when the time comes, it is appropriate for CDOT to consider and implement a change to MBUF / RUC. Their generalized advice was to avoid piecemeal efforts, and instead, make a commitment to full implementation. Realistically, making a commitment to full implementation at this time would be significantly challenged given the current state of technology. Rather than look to be on the leading-edge of MBUF, Colorado can continue to participate in research and evaluate opportunities for developing a Colorado-specific solution that follows upon the best practices of other states who are more interested in taking a leadership role.

These two findings yield the primary conclusion from this research effort: although a user fee system can be created in Colorado so that all Colorado drivers pay their proportional share of roadway system costs, significant issues remain from technical, policy, and public acceptance perspectives. Too many operational and technological questions remain unanswered, and must be tested and evaluated before the state would be ready to commit to a statewide implementation of this strategy. Rather, alternative short-term measures that can accomplish many of the objectives of mileage-based user fees – namely, an increase in revenue and better distribution of payment from alternative fuel and fuel high-efficiency vehicles – should be evaluated and considered.

The primary outcome from this effort is a defined operational concept that involves a mixture of existing mechanisms for revenue collection in the state of Colorado and new policies designed to meet many of the objectives of user fees through that collection. A modest increase in fuel taxes – like those implemented in the past few months in Wyoming and Maryland or indexing to wholesale cost as is done in Virginia and North Carolina – immediately address issues of revenue sufficiency. Registration fees that are differentially assessed based upon average fuel efficiency help normalize the payment of funds. Tolls and managed lanes provide means for connecting use with specific roadways and, at the same time help manage the demand for travel through price. Finally, local connectivity can be addressed through local assessments upon the origin and destination of travel. All of these mechanisms currently exist, and therefore do not require the time to adequately address the unanswered questions found in mileage-based user fees.

However, the actions outlined above may only be practical through the short and medium term. Eventually, a static fee upon the acquisition of fuel will no longer be a sustainable means of generating transportation revenue. Whereas the alternatives comprised in the Current Systems Model can continue on their own into perpetuity, the promise of user fees are too great to ignore for the longer term. In order to prepare Colorado for this eventuality, this study concludes by encouraging state policymakers to engage in a thoughtful discussion regarding whether to use a user fee system to address future funding gaps. Additionally, Colorado may consider the partnership with the Minnesota, Washington, and Nevada Departments of Transportation in the Mileage-Based User Fee Pooled Fund Study, so as to serve the research necessary to resolve the many unanswered questions unearthed by this effort. So doing, CDOT could continue to explore a user fee system that is appropriate for Colorado, and continue to advance its development in a measured, informed, and thoughtful manner.

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APPENDIX A: STATE OF THE PRACTICE IN MILEAGE-BASED USER FEES

There are growing concerns among many in the transportation industry about the long-term sustainability of the fuel tax as the primary mechanism for funding transportation infrastructure at the state and federal level. First implemented by the State of Oregon in 1919 at a rate of 1 cent per gallon, fuel taxes have served the country well as a stable and reliable source of funding for nearly a century. However, it is becoming increasingly clear that fuel taxes, as currently structured, will not be able to meet the needs of a 21st century transportation system. Continued increases in the average fuel efficiency of automobiles mean that drivers can travel further than ever before on a single gallon of gasoline. This means that drivers, on average, are paying less and less in fuel taxes for every mile they drive. In fact, the TRB estimates that government regulations and sustained fuel price increases could drive reductions in fuel consumption per vehicle of up to 20 percent by 2025 (TRB 2006). Furthermore, the market for vehicles that do not run on gasoline at all, such as electric vehicles, is continually developing.

Many have advocated that states and the federal government pursue fees based on actual travel as an alternative to the fuel tax (TRB 2006; NSTPRS 2007; NSTIFC 2009). MBUF, if properly levied, would not vary based on the fuel efficiency of the automobile fleet and would return revenue in proportion to use of the roadway network. MBUF may also achieve goals outside of revenue generation, such as overall system management through congestion pricing.
While the MBUF concept is relatively new, there has been significant efforts dedicated to further developing the concept. This report provides an overview of the state of the practice in MBUF system development.

User Fee Pilots and Implementations

Domestic

Although considered for many decades, MBUF systems in the United States have only recently become a topic of study by governmental entities looking to find long-term replacements for the fuel tax. Initial pilots had a strong focus on testing specific technology applications and evaluating public response, while recent pilots are beginning to focus on the developing systems that can accommodate numerous different configurations.

Oregon Mileage Fee Concept and Road User Fee Pilot Program

Initiated by the Oregon Department of Transportation (ODOT), the Oregon Mileage Fee Concept and Road User Fee (RUF) Pilot Program was among the first domestic tests of the MBUF concept. The impetus for the program was state legislative concern about the long-term sustainability of the fuel tax as the primary funding mechanism for the state's infrastructure programs. The MBUF concept itself was proposed for study and evaluation by a legislatively appointed Road User Fee Task Force that was charged with developing alternatives to the fuel tax. To arrive at a preferred alternative to the fuel tax, the task force established eight evaluation criteria, as shown in Table 2. These criteria ultimately led the task force to recommend in 2003 that the state pursue a test of the MBUF concept and additional provided guidance on how to structure the pilot itself (ODOT 2005).

TABLE 2: OREGON REVENUE CRITERIA AND AFFECT ON SYSTEM DESIGN

Criteria	Language	Effect on Pilot Design
Users Pay	"Any new revenue system should be founded upon user pay methods that directly relate to provision and use of road infrastructure and services."	Fees assessed based on miles travelled. System charged only for in-state mileage
Local Government Control of Local Revenue Sources	"The state should not appropriate revenue sources that are traditionally and primarily the province of local governments."	Road user fee was designed as a replacement for the fuel tax
Revenue Sufficiency	"The new revenue system must have the ability to raise sufficient revenue to allow replacement of the gas tax as the primary revenue source for Oregon roads."	Fee was assessed on Vehicle Miles Travelled
Transparent to the Public	"A new revenue source should be visible to the persons paying it. Individual members of the public should know how much they pay in taxes or fees and understand how any new assessment is calculated."	On board technology displayed location information, fee amounts were displayed when fuel is purchased
Nongovernmental Burden	"A new revenue source should not impose substantial burdens either on taxpayers or on private sector entities involved with tax, fee or data collection."	Fee was collected in manner resembling the fuel tax and integrated into point-of-sale procedures
Enforceability	"A new revenue source must be readily enforceable, resulting in minimal tax evasion."	System was designed so that users would pay the fuel tax by default if the on-board technology did not function properly
Support Entire Highway and Road System	"A new revenue source should be designed to support the operation, maintenance and preservation of the highway and road system for the state, cities and counties in all parts of the state, as the gas tax does today."	System was designed for "seamless" transition to mileage-based fees
Public Acceptability	"A new revenue source should be acceptable to the public."	System maximized privacy protection by aggregating mileage based on zones within the vehicle

In addition to being shaped pursuant to policy goals established by the task force, the MBUF pilot was also subject to various technology and system requirements as developed by ODOT including:

- **Temporary Equipment** – All equipment (including on-board units and service station equipment) had to be installed, operated and then removed without permanent modification to participants' vehicles and/or equipment.
- **Zone differentiation and mileage counting –** OBUs had to have the ability to collect and differentiate miles driving within pre-determined geographic zones and provide this information to participants
- **Vehicle status identification –** Equipment must be capable of differentiating between mileage fee payers and fuel tax payers
- **Mileage data transmission -** Accurate and reliable transmission of mileage information for fee payers
- **Integrated administrative system –** The administrative system supporting the fee must 1) apply the mileage fee only on miles driven since last fee payment, (2) may apply a

different rate for mileage driven in different geographic areas and during different time periods, (3) deduct the fuel tax from the total fuel purchase price associated with the refuel of a participating vehicle, (4) integrate with the existing fuel tax collection system where fuel taxes are prepaid by gasoline distributors, and (5) retain sufficient data to allow for auditing and resolution of consumer challenges to mileage fees paid.

- **Integrated receipt –** Receipts must show mileage fees assessed and paid as well as a fuel tax deduction
- **Transparent system –** The system cannot require action on the part of a motorist or fuel station attendant that is different from what occurs during normal refueling transactions.

The MBUF system pilot tested by ODOT was reliant on the use of an on-board unit (OBU) that would calculate mileage using start, stop and speed data obtained through a connection with the vehicular OBD II port. Each OBU contained a geographic information system (GIS) file, essentially a digital map of Oregon, and mileage would be assigned to a zone of travel based on GPS signals received by the OBU. Zones corresponded to the State of Oregon, the Portland Metropolitan area, and out of state. Not all vehicles participating in the study had an OBD II port that could be used to calculate mileage. For these vehicles mileage was estimated using the GPS signals. Total mileage by zone would be transmitted to a central processing center whenever a participating vehicle would refuel at a participating fuel station. Aggregated mileage would be transmitted via wireless equipment located at the fueling station and the participant would be able to view their mileage totals and assessed fees on their fuel receipt.

ODOT concluded from the pilot test that (ODOT 2005):

- The vehicle mile fee concept is viable;
- Motorists can pay road user fees at the fuel pump with minimal difference in processing or administration;
- Fees can be phased in alongside the fuel tax and integrated with existing revenue systems;
- Pricing based on congestion and variables are viable;
- The fee system allows for protection of driver privacy;
- Fees can be implemented with minimal burden on business;
- Evasion can be minimized; and
- Implementation and administration costs can be kept low.

The success of the system was based on the following evaluation criteria (ODOT 2005):

- *Ease and Cost of Enforcement* – By tying fee payment into the existing retail fuel purchase and fuel tax collection framework, ODOT reduced the risk of revenue loss from equipment failure as all vehicles would default to the fuel tax. Furthermore, the system does not impose any additional compliance costs outside of technology emplacement.

- *Utility* –Researchers concluded that the system properly calculated mileage fees at the retail level, accurately completed financial transactions, and any technical glitches observed during the pilot would likely not be encountered with a broader, statewide implementation.
- *Integration with Existing Systems* - Researchers concluded that the system successfully demonstrated that mileage fees can be phased in alongside and integrated into the fuel tax collection system.
- *Cost* - Economists at ODOT estimated in 2003 that the significant costs of the prototype in-vehicle and fueling station equipment could be significantly reduced through economy of scale in a statewide implementation and that a statewide deployment of the system tested in the pilot program would cost about $33 million in capital costs. It was also estimated that the administration costs for the system would run about $1.6 million annually. It was concluded that these costs compared "favorably" with the fuel tax.
- *Net Revenue Generation Potential* – Researchers concluded that, if implemented statewide and depending on rate structure, the system would generate significant revenues for the funding of transportation infrastructure programs relative to the fuel tax.
- *Hardware and Software Availability* – It is anticipated that the technologies tested in the pilot would likely be commercially available for the support of a statewide MBUF program in the near future.
- *Hardware* – Researchers concluded that, in general, the mileage fee collection system hardware operated successfully.
- *Expandabilit*y – Researchers concluded that a statewide system could be easily expanded in terms of changes in fee rates based on the ability of the pilot test to move volunteer motorists into different fee categories.
- *Systemic precision* –Researchers concluded that the fee system could be implemented in a manner that would not require additional compliance costs on the part of motorists or service stations.
- *Evasion Potential* – Researchers concluded that the system minimized the potential for evasion due to various elements of system design such as tying fee payment to the purchase of fuel.
- *Adaptability to congestion pricing* – Congestion pricing was successfully tested by charging participants in the Portland metropolitan area a higher per mile rate for travel during peak hours.
- *Public acceptance* – Researchers concluded that the system was acceptable to the public based on feedback from participants who indicated that the payment system was convenient, privacy concerns were reduced due to familiarity with the system, and acceptance of the "user pays" concept. Over 90 percent participants indicated that they would they be willing to keep the equipment and continue paying the mileage fee if the system were expanded statewide as a replacement to the fuel tax.

Puget Sound Regional Council – Traffic Choices Study

In 2002 the Puget Sound Regional Council (PSRC) conducted a study of driver response to network tolling through a grant from the Federal Highway Administration. The aim of the *Traffic Choices Study* was to (PSRC 2008):

- Describe the behavioral response of drivers to congestion-pricing ;
- Develop an understanding of the policy issues related to the implementation of road pricing;
- Test an integrated system of technical solutions for road network pricing without deploying significant roadside infrastructure;
- Familiarize the public and policy makers with road network tolling;
- Generate price response data for use in various modeling and analysis activities;
- Develop an understanding of technological applications and standards; and
- Define the policy issues to be addressed in actual program design.

The PSRC study utilized 275 participants who were offered monetary incentives, in the form of an initial travel account from which fees were deducted, to reduce their travel in response to a road pricing regime applied over the entire roadway network in the Puget Sound region. While the study was not a test of the MBUF concept per se, it was aimed at determining traveler response to dynamic road pricing and utilized an in-vehicle technology application that could be deployed on a wider scale. The system relied on the use of GPS-based OBUs that contained an internal GIS map of the Puget Sound region. Unlike the Oregon pilot, mileage was calculated through the use of GPS signals for all participating vehicles. In addition to the internal map, each OBU contained a rate schedule for the various facilities in the area, with the rate for each facility being displayed for the traveler. Rates varied by the type of facility and the time of day. Participant travel information was uploaded on a periodic basis to a central processing center through a cellular-based GSM network.

In its final report, PSRC researchers concluded that (PSRC 2008):

- Driver responses to tolling suggested that a dramatic opportunity exists to significantly reduce traffic congestion and raise revenues for investment.
- While not all aspects of a road network tolling system have been fully demonstrated yet, the core technology for road network tolling systems is mature and reliable.
- A large-scale U.S. deployment of a GPS-based tolling program will depend on proven systems, a viable business model, and public acceptance of underlying concepts.

Implementation strategies were not a primary focus of the research effort. However, the technology consultant for the study, Siemens, did develop a basic implementation structure for full network deployment that would incorporate two basic programs: a *main* program and an *occasional* program. Participants in the main program would utilize permanently mounted OBUs, while occasional program participants would be subject to a flat fee for use of the road

network. This fee would be assessed to cover a specific amount of time and would likely vary based on the various vehicle characteristics, similar to European vignette-style programs.

University of Iowa, National Evaluation of a Road User Fee

In 2005 the Public Policy Center at the University of Iowa conducted and an evaluation of a system for collecting mileage-based user fees as a potential replacement for the fuel tax. In addition to testing the system's technical feasibility, researchers also evaluated the public acceptance issues associated with MBUF implementation. As such, system development was guided by several directives (Table 3).

The MBUF system developed by researchers was operational for two years and utilized a pool of 2,650 participants drawn from 12 areas across the country, including: Baltimore, MD; Raleigh, NC; Eastern Iowa; Austin, TX; Boise, ID; San Diego, CA; Portland, ME; Miami, FL; Chicago, IL; Wichita, KS; Billings, MT, and Albuquerque, NM. Participants received $895 for their participation.

The University of Iowa system utilized in-vehicle OBUs that received GPS-based signals to determine vehicle location in relation to a GIS file defining state, county and municipal boundaries. As in the Oregon pilot, OBUs determined mileage through a connection with the vehicular OBD II port. Under the system, each OBU calculated mileage and assigned it to a particular jurisdiction, based on GPS signals and the internal GIS file, and a per-mile rate was assigned to that mileage. Since the policy foundation for the study was that of achieving revenue neutrality with the fuel tax, per-mile rates were approximate to what each participant vehicle would pay on a regular basis in fuel taxes. This means that fee mileage rates varied from vehicle to vehicle based on vehicular class, such that lower fuel efficiency vehicles would have a higher mileage rate. The average rate for study participants was 0.9 cents per mile for the federal rate.

TABLE 3: UNIVERSITY OF IOWA POLICY DIRECTIVES

Directive	Language	Effect on Pilot Design
Reliable	An alternative system must provide a reliable revenue stream that is not jeopardized by system outages and one that the public knows accurately assesses fees.	On-board technology utilizes direct feed from vehicle odometer and speedometer for determining mileage Fees are transmitted periodically to a central billing center
User Friendly	A replacement system must be as convenient to the driving public as the fuel tax while providing more transparency to drivers regarding the amount of assessed charges.	
Flexible	Unlike the fuel tax, a replacement system should allow for the support of other national environmental and energy policy objectives.	System allows for the imposition of fees by subordinate governmental entities
Secure	Any replacement system must decrease user evasion beyond the current rate seen with the fuel tax system. A replacement system must be secure from internal and external threats to its stability.	Fee calculation occurs within the unit
Extent of Coverage	An alternative system must be nationwide and able to accommodate the disparate taxing structure of all 50 states and, in some cases, counties and cities in a comprehensive unity.	System is designed to aggregate mileage-based on zones, which can correspond to national, state, county and local jurisdictional boundaries
Cost Effective	The current fuel tax system has a low administration and operation cost and proposed alternative systems must compare favorably to it.	The system does not rely on the use of roadside infrastructure
Public Acceptability	The fee system should be acceptable to the public, which must be willing to support the adoption of a mileage-based road user charging approach	Calculation of road user charges occurs within the vehicle. Location data does not leave the on board unit

Source: (Forkenbrock 2002)

Charge information by jurisdiction was aggregated on each OBU and periodically forwarded to a network operations center (NOC) through a GPS-based network where it was then forwarded to a billing center. The NOC occasionally sent rate updates to the GIS files on the vehicular OBUs. The billing center utilized mileage information from the participants to generate and forward bills on a monthly basis (Hanley 2010).

Researchers concluded that the equipment utilized in the study was robust, but many participant vehicles had to be excluded because they were, for various reasons, incompatible with the study

OBUs. Researchers reported no difficulty in obtaining data from vehicular OBD II ports. Researchers were also successful in interpolating location in the event of a GPS signal loss. While the study is still being finalized, preliminary results have showed that (Hanley 2010):

- **Participants generally had a favorable impression of the system** - Exit surveys showed that participants were generally accepting of the system. Participants with a favorable view of the system increased from 41 percent at the beginning of the study to 70 percent at the conclusion. Those having a negative opinion of the system went from 19 percent at the beginning of the study to 17 percent at the conclusion. Those with a very negative view increased from 5.6 to 7.2 percent.
- **Privacy is important but the ability to audit is also desired** – Over the course of the study, participants were given three choices with regards to billing: a simplified bill where only the amount due to each jurisdiction was shown, a detailed statement complete record of travel, or a modified bill that had only monthly travel. In general, participants preferred to have a balance between audibility and privacy, with most participants preferring the modified bill.

Nevada Department of Transportation

The Nevada Department of Transportation is currently evaluating an MBUF assessment and payment system. The goal of the study is to explore sustainable and equitable alternatives to the fuel tax as the primary funding mechanism for transportation infrastructure programs. A recently concluded field test of one potential technology option was preceded by an exploratory study that identified fee systems based on mileage as the preferred alternative to the current fuel tax-based funding mechanism.

The recently concluded field test was based on a simplified pay-at-the-pump configuration, where pilot participants had their mileage assessed in conjunction with regular fuel purchases. Mileage was captured by in-vehicle units that utilized speed and acceleration data provided through connection with each vehicle's OBD II port. This mileage was then transmitted wirelessly to equipment located at the filling station participating in the test. Time and location data was not captured by the units and only total mileage was transmitted, meaning that there was no differentiation between miles accrued in-state or out of state. Furthermore, the rates utilized in the study did not vary, such that all vehicles, regardless of weight, type or classification were assessed the same per-mile rate. In its final report, the Nevada DOT is evaluating the fee system based on customer satisfaction, administrative costs, privacy-oriented metrics and equity. The final report on the field test is expected in early 2012.
This fee assessment and computation configuration was adopted in order to address various privacy concerns raised by the public in exploratory research efforts leading up to the pilot test. That effort included a public outreach component that included a series of public meetings, workshops, newspaper editorials, newsletters, opinion surveys in both rural and urban areas of the state, videos, and presentations. Through these efforts the Nevada DOT hoped to solicit input, identify concerns and answer questions raised by various stakeholders and decision as well as the general public. Strong privacy concerns raised by the general public ultimately led the

Nevada DOT to test a simpler pay-at-the-pump configuration instead of a GPS-based model (Nevada Department of Transportation, 2010).
The recently concluded field test was Phase II in the Nevada Department of Transportation's study, with Phase I taking the form of a preliminary study undertaken in conjunction with the University of Nevada at Las Vegas (UNLV) and the University of Nevada at Reno (UNR). As part of Phase I, researchers conducted a literature review and undertook a public outreach effort that ultimately informed the design for the field test.
Nevada DOT anticipates that Phase III of the research effort will entail a broader test of the VMT fee system over a wider geographic area with several hundred participants.

Minnesota Department of Transportation

The Minnesota Department of Transportation (MnDOT) is currently field testing a smart phone-based road user fee in the Twin Cities region of Minneapolis/St. Paul. The field test will run for a full year and will utilize a total of 500 participants. The system utilizes off-the-shelf, third party hardware in the form of Samsung Galaxy S smart phones as the primary in-vehicle mileage assessment device. All of the phones utilized in the study have had their primary functions deactivated due to safety and liability concerns, meaning that they are only capable of functioning as a mileage assessment device. The system also utilizes a Bluetooth equipped device that connects to the vehicular OBD port that transmits a vehicle-specific identification signal to the phone. This serves to notify the phone that it is in the correct vehicle and to initiate mileage assessment. In a future deployment, this arrangement would prevent a driver from being assessed mileage while carrying their phone in another vehicle.
Mileage accrued under the system is tagged with identifiers and allocated to "buckets" within the central processing system. Identifiers include time of travel, geography and facility type. The mileage fee system will thus know how many miles were travelled based on facility type and area but will not be able to determine exactly where travel occurred. Fees assessed during the course of the pilot test will vary based on:

- Country (inside and outside the United States)
- State (inside and outside Minnesota)
- Large geographic areas (metro and non-metro)
- Roadway classification (Interstate and non-Interstate)
- Time of day
- Day of week
- Direction of travel (Northbound, Southbound, etc.)
- Type of vehicle

Mileage is forwarded to a central processing system at the discretion of the driver through the phone itself. The central back office system utilizes a cloud computing configuration, allowing the system to be easily expanded in the event of wider deployment through the purchase of additional server space. The system provides participants and researchers with a web portal for the tracking of usage.

Participants in the field test are paid a lump sum amount at the outset of the pilot as well as a participatory stipend. Billing statements are generated on a monthly basis and participants are expected to pay them from the initial lump sum they received. Participants will not have to pay

an amount in excess of the lump sum. Pilot participants drive with the devices for an initial period of two months to establish a baseline of travel after which time an odometer reading is taken. After this initial odometer reading the participant begins to accrue charges through the in-vehicle smart phone. The baseline odometer reading is used to account for mileage not captured by the phone unit during the course of the study, either because the phone was turned off, not in the vehicle, or because of a malfunction. At the conclusion of the field test participants must submit to an additional odometer reading, with an additional fee being levied on the difference between the mileage accrued between the initial and final odometer readings and the total mileage captured by the in-vehicle device.

The technology component tested in this study is envisioned as a discounting mechanism for a larger, odometer reading-based fee system. In a future deployment, drivers would have the option of submitting to a manual odometer readings that would be used to determine an amount owed. However, if the driver travels out of state and would like to not be charged for that mileage, then they may utilize the in-vehicle component to discount that mileage.
As part of this evaluation, MnDOT will be evaluating the possibility of utilizing the state's DMV as an enforcement agency. The system will be set up to allow access by DMV officials in order to determine if vehicle registrations could be tied to fee payment. It is expected that in the future the denial of vehicle registrations for failure to pay VMT fees could serve as an adequate enforcement mechanism.

Oregon, Truck Road Use Electronics (TRUE)

The Oregon Department of Transportation will soon begin testing a system to automate the state's current weight- fee system for commercial trucks. The Truck Road Use Electronics (TRUE) system will rely on the use GPS-equipped OBUs mounted to the dashboards of participating vehicles. GPS signals will be used to determine the location, date and time of travel. OBUs will also be equipped with cellular and wireless transmission technologies for the daily transmission of fee related information. OBUs will also communicate with 21 weigh-in-motion sites, located throughout the state, through the use of 915 MHz Dedicated Short Range Communications (DSRC) technology. The DSRC component will be used to verify truck size and weight, and the on-board unit will notify the driver if they must enter the weigh station in the event that they are denied pre-clearance by the weigh in motion technology. Units will also provide truck drivers with additional information such as road restrictions and will automatically generate driver logs, which is expected to reduce administrative costs for shipping entities.

International Road Pricing Applications

The international pricing systems that are already in place are very different than the domestic MBUF systems discussed previously. Usually, they are applied to either specific vehicles (generally trucks), specific facilities, or in specific areas. However, these systems are still useful to examine as they serve to illustrate many of the policy and technology challenges that will be encountered in a domestic implementation.

Singapore

The current road pricing system utilized in the nation of Singapore, the Electronic Road Pricing (ERP) system, can be traced back to policies implemented under the State and City Project (SCP) with the aid of the United Nations Development Programme between 1967 and 1972. That

program made recommendations for the development of a high-density, corridor-based, strong centered urban structure (Barter 2008). Furthermore, the city-state's leaders envisioned Singapore as being a major South-East Asian business center for manufacturing, commercial and various trade industries (Kalauskas, Taylor et al. 2009). It was decided that widespread vehicle ownership and usage, and the resulting congestion, would be incompatible with these goals, and as such officials implemented a car ownership management system known as the Area Licensing Scheme (ALS). Under the ALS, a cordon was established around the most congested portion of the city which was referred to as the "Restricted Zone" (RZ). Travelers wishing to enter the RZ during working hours on weekdays (and half of the day on Saturday) were required to purchase an area license, which could be purchased at a number of different locations and came in a variety of colors and shapes, as certain vehicle classes were charged different rates. A similar system, referred to as the Road Pricing Scheme (RPS), was imposed in the mid 1990's to cover three area expressways. Both the ALS and RPS were labor intensive in terms of staffing for the administration and enforcement of the licensing program and licenses purchased for one system could not be used to access the other system. Furthermore, the ability to enter and exit each of the systems numerous times on the same license was seen as being counter to the original intent of the systems; namely to reduce congestion. Therefore, in 1989 officials with the Land Transport Authority (LTA) began the process of automating the Singapore roadway pricing systems which would eventually yield the current, fully automated, ERP system.

The current ERP system went active in 1998 and utilizes overhead gantries equipped with DSRC readers that communicate with vehicular OBUs. Upon passage through one of the ERP's 60 charging points the requisite fee is deducted from a pre-paid smart card that is inserted into the OBU. Charge coupled device (CCD) cameras and automated number plate recognition (ANPR) technology, also mounted on the gantries, are used for enforcement. All of the technology components at each entry point are managed by a local controlling unit known as an "outstation" which is connected to the central processing center via LAN line.

In automating the systems, officials grappled with whether to implement a "passive" or an "active" system. Both would require vehicles to be equipped with an on-board unit, but in the passive system drivers would receive monthly bills for road usage. In the active system, smart card technology would be utilized such that drivers would prepay for their road usage. Under the active system, whenever a vehicle would enter the charged zone, readers would detect the presence of the OBU and the charge would be deducted from the pre-paid smart card.

The system is structured such that fees to enter priced areas and facilities vary by the time of day. This serves to reduce congestion and increase mobility within the priced area. Rates for access are adjusted every three months based on routine traffic data so as to maintain desirable traffic speed bands (FHWA 2010). Rates are set in order to maintain speeds within the 85th percentile such that 85 percent of charged vehicles are travelling at free flow speeds of about 25 km/h. Transit vehicles are given free access to the priced areas, increasing their attractiveness relative to travel in a passenger vehicle. Furthermore, a significant portion of revenues from the system are allocated to transit enhancement.

System design was ultimately influenced by two functional parameters: maintaining high levels of enforcement and keeping administrative costs (in terms of staffing) low. To insure high levels

of enforcement, the system was designed such that all vehicles entering a charged area must be equipped with an OBU. Detection equipment is utilized to detect the passage of non-equipped vehicles and cameras mounted on the gantries are utilized to photograph their license plates for identification. It was decided that utilizing smart card technology, where drivers would pre-pay for their trips into the cordoned area (the "active" system), would help to keep administrative costs low as there would be less of a need for a substantial back office operation. Billing statements need not be generated by the system. Developing a system where drivers pre-pay for trips also aided in enforcement as drivers would have to pay before using the system as opposed to paying a bill after the fact.

Stockholm, Sweden

Stockholm's road user fee system grew out of a 2002 national election. At that time, road pricing was a particularly controversial proposition, as conservative parties were strongly anti-pricing while liberal parties tended to be in favor of the concept. The concept itself had been forwarded by the Stockholm Commission, a parliamentary committee formed in 2000 and charged with, among other tasks, prioritizing investment plans and producing funding strategies for investment. Ultimately, in spite of initial opposition to road pricing by social democrats, the concept was implemented so as to satisfy the Green and Left Socialist parties, who had demanded a "full-scale several-year trial with congestion charges in Stockholm" and whose support was necessary to maintain control of the government (Eliasson 2008).

Pricing is applied to vehicles entering a cordon surrounding the center of the city. Vehicles entering the priced area are charged each time they cross one of the 18 access points. Fees are levied between 6:30 AM and 6:30 PM during the work week and rates vary based on the time of day from $1.50 to $3.00 (SEK 10 to SEK 20) per crossing. This pricing system serves to reduce travel into the central area of the city during the peak hours and services to reduce overall congestion. Transit vehicles are given free access to the central city. This increases the attractiveness of transit relative to travel in a passenger vehicle. Furthermore, a significant portion of revenues generated by the priced cordon are used to fund transit enhancements. By reducing congestion in the central city, the pricing system serves to reduce overall traffic volumes and idling times, which in turn reduces vehicle related emission. Furthermore, fees for access are lower for low emitting vehicles such as motorcycles and alternative fuel vehicles. Each point of entry into the Stockholm cordon features three overhead gantries. The outer gantries are equipped with digital imaging cameras that capture the front and rear license plates of all vehicles entering the charge zone. These images are forwarded to a back office where ANPR equipment is utilized to determine the registered owner of the vehicle, who receives a monthly bill. The middle gantry is equipped with a DSRC antenna but that equipment was mostly utilized during the seven month demonstration period, after which it was decided that the ANPR technology could be utilized to support the entire pricing system, which significantly lowered costs. This decision was influenced to a great deal by existing Swedish law that requires the capture of all license plates in such situations (FHWA 2010).

Simplicity was a key criterion in system design. As such, fees are levied on a predetermined schedule and do not vary based on the point of entry or the type of vehicle, with the exception of the aforementioned exemptions. Furthermore, the system utilizes roadside cameras coupled with ANPR software that precludes the need for in-vehicle equipment. This complicates enforcement

and increases administrative costs, as vehicles must be identified and a determination of eligibility must be made. Enforcement and administrative cost are further complicated by the need to generate, mail and collect the monthly statements that are forwarded to registered vehicle owners. However, because the system is centralized and not reliant on the use of in-vehicle equipment, system flexibility is enhanced. If additional revenues are required, or if system management goals require increases in fees, it is only necessary to update rate schedules at the central data processing office. The simplicity of the system reduces its ability to better manage congestion. The simplified fee schedule cannot vary based on actual traffic volumes, precluding the imposition of dynamic pricing that might more effectively manage traffic volumes and congestion.

London, UK

London's congestion pricing system was initiated following the 2000 election of Ken Livingstone as mayor, who had run on a platform that included the implementation of congestion pricing to address traffic congestion as an alternative to capacity expansion. Congestion pricing was also forwarded as a means of providing additional funding for the city's underfunded subway system that was in need of significant upgrades and repairs. Congestion pricing was also presented as a means of reducing emissions and increasing economic vitality (Kalauskas, Taylor et al. 2009).

The road user fee system levied in London, UK is oriented around decreasing the amount of traffic entering the city center, particularly during working hours. The system is also designed to promote transit usage and improve the travel times of buses. To achieve these goals the pricing system utilized in London is structured around a cordon pricing scheme that charges for entry into the center of the city. Exemptions are provided for transit vehicles and other various types of vehicles in accordance with transit promotion objectives. The majority of the system's revenues are allocated to transit improvements.

The system utilizes over 1,360 closed circuit cameras located along the perimeter of the cordon to capture license plate images of vehicles entering the cordon. ANPR technology is utilized at a central processing facility to determine whether the passage of a vehicle into the charging zone has been pre-paid. Payment of fees can occur online, by phone or text message, or in various retail outlets. Monthly and annual passes can also be purchased. If a trip is not pre-paid then payment must be made full by the end of the day following the day the charge was incurred or the cost increases by 25 percent. A penalty of around US $65 is assessed for non-payment and can escalate the longer the amount due goes unpaid (FHWA 2010).

Fees are levied between 7:00 AM and 6:00 PM and do not vary in amount throughout the charging period. This means that the fee structure is not as effective at managing traffic volumes as a fee system that varies throughout the day on a schedule or varies based on traffic volumes. Furthermore, the fact that the fee is levied on a daily basis (drivers are only charged once per day) means that drivers may enter and exit the charged area any number of times throughout the day without paying any additional fees.

Germany

Germany's highway –based toll on heavy goods vehicles (HGV) was first implemented in 2005. The impetus for its implementation was severe infrastructure financing issues with respect to both maintenance of existing infrastructure and a severe need for added capacity. Much of this crisis can be attributed to the increase in traffic flows resulting from the continued growth of the European Union. Germany's central location, as with many countries in central Europe such as the Czech Republic and Austria, resulted in significant increases in traffic following its membership in the EU. Existing infrastructure issues were compounded due the reunification of East and West Germany, as infrastructure in the former East Germany was critically underfunded (Wieland 2005).

The implementation of the German HGV toll system was preceded by the formation of a joint stock, national highway funding company that would be responsible for the funding of infrastructure development. This entity was charged with utilizing revenues from future fee systems, as well as any other debt raising activities undertaken by the company on capital markets in order to fund infrastructure development. Formed in 2003, the Infrastructure Funding Company (IFC) was required to invest 50 percent of toll revenues into roadways, 38 percent into rail and 12 percent into inland waterways. The IFC is first required to forward revenues to the federal government which then reallocates funds back to the company, reducing risks on the part of the government. In the fall of 2001, Toll Collect, a consortium of Daimler-Chrysler (45 percent share), Deutsche Telecom (45 percent share), and Cofiroute (10 percent share), was selected to operate the future pricing system. Toll Collect was tasked with constructing and administering the system.

The distance-based fees levied under the German HGV system are applied to vehicles of 12 metric tons or more for travel on the autobahn and other select national highways. Amounts vary based on the emissions class of the vehicle such that older, heavier vehicles with a lower emissions class are assessed a higher distance charge. Fees also vary based on the number of axels in order to encourage better weight distribution. Distance travelled is determined through the use of on-board units equipped with GPS technology and a microwave-based transmitter. A backup system is utilized in the event that the GPS component is not functioning properly. The backup system relies on information from the vehicular tachometer and odometer to estimate mileage. Fee calculation occurs within the OBUs themselves, which contain a digital map that is utilized in conjunction with satellite-based GPS signals to determine the facility on which travel is occurring and to determine the appropriate distance rates. Maps and fee amounts have to be downloaded to the OBU, which is accomplished through a Global System for Mobile Communications (GSM) transmission network. When the total amount owed reaches € 20, the OBU transmits the fee information to the central processing unit through a GSM-based network. This threshold amount was adopted in order to reduce the number of transmissions required by the system. The OBU utilizes three communication channels (FHWA 2010). ANPR technology is used in conjunction with DSRC for enforcement. Mobile patrols, consisting of a fleet of 300 vehicles with 540 officers from the Federal Office of Freight (BAG), are also utilized for enforcement.

Payment of fees can be accommodated either through the OBU itself, manual payment terminals, or via the internet. OBUs are supplied free of charge by Toll Collect. Manual payment is

accommodated at a series of 3,600 payment terminals located at motorway service stations and rest areas. However, about 90 percent of all transactions are collected through the OBU (FHWA 2010).

Interoperability with other European pricing systems was a significant functional parameter in the development of the German system. This influenced the decision to utilize OBUs that relied on GPS-based information to determine location. The need for a high level of system flexibility also dictated the utilization of GPS-based technologies, as roadside equipment is not required to expand the charging network.

Switzerland

The Swiss roadway system has long seen proportionally higher volumes of foreign-based vehicles utilizing its roadway network, and the allocation of roadway coasts among users has been a focus of Swiss transportation officials for much of that time. Even as far back as 1972 it was recommended that a user fee be implemented to cover vehicle imposed costs on the roadway system, but the concept was, at that time, deemed to not be technologically feasible (Kalauskas, Taylor et al. 2009). Ultimately, the Swiss government implemented a flat fee for heavy vehicles in conjunction with a flat fee for personal vehicles. The overall system gained public acceptance because Swiss officials successfully made the case to the public that fees collected from freight traffic were insufficient cover all of its costs for road use and that the fee would aid in transferring freight movement to rail-based modes. The personal vehicles element was accepted due to a similar argument: that revenue collected from foreign travelers was insufficient, even if they were not disproportionately contributing to roadway wear and tear as with heavy vehicles. Following the opening of the St. Gotthard Road tunnel in 1980, which increased the flow of heavy goods vehicles transiting the Alps, support for the freight fee grew (Sorenson 2005). This was a result of an increased focus on shifting freight to railway based modes, and through additional rigorous political maneuvering Swiss officials gradually built public support for the use of performance based fees in order to accomplish this objective. Swiss voters in 1994 approved an initiative aimed establishing a constitutional basis for future road pricing, laying the groundwork for the current Heavy Vehicle Fee (HVF) system that is currently levied on heavy vehicles of 3.5 tons or more. Importantly, while the initiative establishes the constitutional basis for the collection of fees, the foundation of the initiative was to develop a mechanism for system management consisting of freight diversion from highway to rail. The diversion of freight to rail was desired as this diversion ultimately extends the life of the highway system through reduced wear-and-tear while simultaneously improving the overall system performance for moving both goods and people.

The current Swiss HVF program was implemented in January of 2001 and is a direct extension of the early history of roadway pricing in Switzerland as discussed above. That is, user fees are used as a primary mechanism for improving system performance as well as achieving a number of transportation policy objectives including collecting costs imposed on the transportation system by users. In this case, cost is expressed in terms of the maximum laden weight of the vehicle with vehicles capable of hauling heavier loads being assessed a distance fee. The Swiss system is also oriented around the utilization of rail relative to highway-based freight, which is accomplished through both the imposition of the fee itself and the allocation of revenues from the system to rail-based modes.

Fees are levied under the Swiss system on vehicles of 3.5 tons or greater for travel on all Swiss roadways. OBUs connect to the vehicular tachograph or odometer to determine distance travelled. Each OBU stores the maximum laden weight of the vehicle as well as the emissions class. Each OBU is also equipped with DSRC technology which communicates with overhead gantries located at all major border crossings. When a border crossing occurs the DSRC component signals the OBU to stop collecting mileage. GPS technology is used as a backup to this feature, as border crossings may occur at area that is not equipped with a DSRC gantry. Drivers must manually submit the chip from the OBU containing the aggregated travel information to a back office for monthly bill generation. In-vehicle equipment is not required, and vehicles lacking an OBU must register each trip and with the fee must be paid in full before the vehicle exits the country.

Austria

Like Colorado, the mountainous terrain of Austria requires numerous tunnels and bridges, which dramatically increases the cost of constructing and maintaining roadway and railway networks. Heavily travelled roads have been tolled since the 1960's due to use of the nation's roadways by foreign vehicles, a situation that was exacerbated by the country's entry into the European Union and subsequent increase in trade-related traffic. Furthermore, as part of EU requirements, Austria was required to reduce its overall debt, which the country set about doing by developing new construction and maintenance related revenue streams (Kalauskas, Taylor et al. 2009). To facilitate this process, Austria established a 100 percent Austrian government owned concession company known as ASFINAG. ASFINAG currently operates under a 50 year concession agreement that obligates it to build, operate, maintain and finance the Austrian primary road network.

ASFINAG initially implemented a vignette-style sticker system where travel on Austrian roadways by heavy freight vehicles could be pre-paid for a period of up to two years. However, this system did not send appropriate price signals to travelers and did not serve to effectively limit travel. In 2001 the company began development of an electronic-based tolling system that would become the GO-Maut system.

Austria's GO-Maut system levies fees on trucks with a weight of 3.5 tons or greater for travel on national highways. Rates vary based on the number of axels allowing the system to capture more revenue from vehicles that impose higher costs on the roadway network. Heavy vehicles with fewer axels exert more wear and tear on infrastructure, so this system provides an incentive to more evenly distribute loads through the use of trucks and trailers with more axels.
The GO-Maut system utilizes OBUs that communicate with 5.8 Ghz DSRC equipment mounted on overhead gantries. Distance travelled is determined by road segments travelled, meaning that actual distance is less precise than what would be generated with a GPS-based technology application. Mileage is essentially estimated based on the known distance between readers and the number of readers the vehicle passes under. This reduces the overall accuracy of the system but not to a degree that the user fee concept is undermined. However, because the system is reliant on the use of fixed infrastructure, it is not a flexible system in terms of expanding network coverage. Installation of the units is optional, meaning that the parallel vignette/sticker based system must be maintained. This increases the administrative cost of the system. Trips can be

pre-paid or paid post paid by the driver through any number of means, but the method of payment must be registered with ASFINAG.

Czech Republic

The Czech Republic began moving towards the imposition of roadway tolls following its entrance into the European Union in 2004. Like Germany and Austria, the Czech Republic sees large volumes of foreign –based trucks due to its location in Central Europe. It is estimated that about 40 percent of trucks using the Czech highway system are foreign based (FHWA 2010).The current road pricing system deployed in the country is designed to assess a higher fee per mile on trucks that place a greater strain on the roadway network in terms of wear and tear. The system replaces a vignette-style sticker program that did not send appropriate price signals to trucks. Vignettes covered a period of time for travel and thus did not accurately reflect use of the roadway network.

Fees under the Czech system are levied on trucks with a weight of 12 metric tons or greater travelling on designated national highways. Rates vary based on the number of axels. Fee amounts also vary based on the emissions class of the vehicle such that newer vehicles with cleaner engine technology are assessed a lower rate per mile.

The Czech system relies on the use of DSRC-based OBUs that are provided by Kapsch TrafficCom AB. Overhead gantries are placed between the intersections of major priced roadways allowing for pricing to occur based on the road segment travelled. Mobile as well as stationary enforcement measures are utilized. Enforcement is also carried out through the use of ANPR-based technologies. The Czech system differs from other European systems in that all heavy vehicles utilizing the Czech major roadways roadway must be equipped with on-board equipment, even vehicles exempt from the fee such as emergency response vehicles and law enforcement. However, these units can be self-installed without a professional.

Slovak Republic

The Slovak Republic's Road User Fee system was, like other countries in the region, implemented after its entry into the European Union and subsequent increases in traffic volumes. As in other RUF applications in the area, trucks were viewed as disproportionately burdening the roadway network and not paying enough for use of the roadway network. The system went online in 2010.

The distance-based fees levied under the Slovak system are applied to trucks with a weight of 3.5 tons or greater for travel on designated national highways. Rates vary based on the number of axels. The focus on collecting revenues from foreign vehicles is evident in the fact that fees are assessed only for travel on motorways, expressways and select "1st Class" roads. Fee amounts also vary based on the emissions class of the vehicle such that vehicles with cleaner engine technology are assessed a lower rate.

The Slovak system is unique in that it does not utilize any roadside infrastructure and relies solely on off-the-shelf, self-installed on-board units. These units feature GPS and DSRC components that are used for mileage assessment and enforcement respectively. The road network is divided into zones with predefined road segments comprising the network, and

mileage is accumulated based on travel within these zones (Q-Free 2010). Fees can be prepaid or post-paid by the driver.

New Zealand

New Zealand currently levies a distance based charge on freight vehicles. Under the system fees are assessed on diesel vehicles based on weight, the number of axels and the distance travelled. The system can be traced back to the Road User Fee Charges Act (RUCA) of 1977. The act was introduced in order to facilitate the imposition of charging systems that would (RUCRG 2009):

- Establish more economic price relativities between road and rail transport,
- Generate more accurate road costs for the provision of economic incentives to for all road operators to more efficiently utilize the roadway network;
- Provide the ability to adjust revenues from RUF so as to match roadway expenditures attributable to heavy vehicles;
- Ensure that each type of vehicle is assessed according to the costs it imposes on the roadway network,
- Enable to the "user-pays principle" for the financing of road construction and road maintenance.

The RUCA established who was to subject to any new RUF, what charge levels would be, what aspects of use would be assessed (weight and distance), license requirements, vehicle requirements in terms of technology, and various administrative aspects of the system. Subsequent legislation refined the overall system in terms of use of revenues and the establishment of authority on the part of various entities over the eventual system. The result of these efforts was a system wherein heavy vehicles of 3.5 metric tons or greater were required to purchase distance-based license in units of 1,000 km or multiples thereof for use of the New Zealand roadway network. Vehicles were required to be equipped with hub odometers for the verification of mileage. However, these hub odometers had reliability issues and paper-based administrative procedures were proving to be onerous. Thus, over the past few years the system has transitioned to electronic collection in lieu of the distance-based license system with hub odometer verification.

The private company ERoad is a provider of equipment and services for the system. The ERoad model is based on the US model for collecting weight distance taxes on trucks and is essentially a prepayment-based system that allows users to pre-pay for mileage in blocks. The ERoad system allows users to monitor how many miles are left on their account and replenish that amount when needed. It also provides a number of added services that the user is charged for. Verification of mileage is the most important aspect of the ERoad technology solution and allows users to replaces the current paper-based system. There are essentially two versions of the ERoad equipment (called EHubo): the service oriented version and the simplified tax version.

Policy Rationale for Mileage Fee Implementation

The implementation of existing road user fee systems, of which user fees are one of many subsets, has shown that system design needs to flow from carefully articulated policy goals and objectives. The development of policy goals is important because certain system designs can

work to either promote or hinder the attainment of policy goals. It is therefore important to determine, prior to discussing technology configurations, what the system is to accomplish. In general, user fees may be implemented to attain the following policy objectives:

- Revenue Generation
- Demand Management
- Equitable Collection of User Costs
- Environmental Goals

Revenue Collection

One of the primary goals of an MBUF system is to provide a sustainable source of funding for the construction, operation, and maintenance of the transportation system. The importance of this objective is particularly acute for domestic MBUF systems as, unlike traditional transportation funding mechanisms, such as fuel taxes, vehicle registration fees and sales and property taxes, MBUF systems are designed to more accurately reflect actual use of the roadway network. In fact, the primary impetus for the examination of MBUF systems is their potential to replace fuel taxes as the primary funding source for transportation infrastructure development and maintenance. Due to the fact that they would return revenues in proportion to actual road use, not in proportion to a proxy measure such as fuel consumption or vehicle ownership levels, they are viewed as being a more sustainable revenue source in the long term (TRB 2006; NSTPRS 2007; NSTIFC 2009).

Simply generating revenue is too broad of a policy objective to significantly influence system design. All fee systems, regardless of whether they are solely revenue generators or are implemented for system management purposes, generate revenues as a result of their status as a fee. Rather, it is the nature of the revenue being generated that will ultimately influence system design. Revenue oriented systems are structured around specific, revenue oriented objectives that are incorporated into the fee structure. This will be discussed in more detail later in the section.

Replacement of the Revenue Generated by the Fuel Tax

Replacing fuel taxes is perhaps the most common policy objective under consideration by entities pursuing domestic MBUF studies. This is primarily in response to the identification of long-term funding and financing crises resulting from structural deficiencies in the fuel tax and the ever increasing fuel efficiency of the US auto fleet (Kalauskas, Taylor et al. 2009). Most domestic MBUF pilots, with the exception of the PSRC Traffic Choices Study, have been concerned with finding replacements for the fuel tax. However, to date there are no road user fee systems that have been implemented with this objective.

In implementing a fee system oriented around replacing the fuel tax it is important for policy makers to keep in mind that the new fee will likely function very differently from the fuel tax. The fuel tax is an excise tax that is levied on the physical amount of fuel that is collected far up in the supply chain from wholesalers and distributors. These entities pay the initial fuel to the Internal Revenue Service and state collection entities and pass that cost on to other suppliers and consumers whenever the fuel is purchased. Thus, fuel taxes are effectively collected from a very small number of sources relative to the actual number of transportation system users. However, under an MBUF system it is likely that fees would have to be collected from all system users, an

aspect that will significantly increase the cost of collection and administration regardless of other policy considerations.
The influence of this policy objective on system design is determined primarily by how revenue replacement is approached from a policy standpoint. In the first approach, an implementing entity might structure the fee so as to generate revenue that, in aggregate, is equal to the revenues generated by the fuel tax. In that case fee rates are likely to be set based on aggregate measures of travel within the implementing entity. For example, in the State of Colorado it would be relatively straightforward to utilize statewide travel data to determine a fee per mile of travel that, if imposed on all travel, would generate revenue in an amount that would allow for the replacement of the fuel tax.

An alternate method of approaching this policy objective would be to implement the MBUF as a fuel tax replacement at the individual driver level. Another way of characterizing this would be to say that individual drivers would pay the same amount under the MBUF as they would under the fuel tax. As opposed to the previous system, a system implemented with this revenue objective would have to have vehicle specific data in order to determine the mileage fee rate, as the amount paid by each driver varies based on various vehicle specific factors including fuel efficiency.

Implementing an MBUF system solely as a replacement to the fuel tax does not require detailed information related to where and when travel is occurring, reducing the need for technology deployment and increasing the acceptability of the system. However, location data may be deemed necessary for equity purposes, as it may be desirable to credit drivers for mileage accrued outside of the jurisdiction of the implementing entity. While this reliance on technology would likely increase public resistance to the system, it is also likely that the offering of discounts will increase the acceptability for many. Furthermore, implementing an MBUF as a replacement fee system has the advantage of being more acceptable to the public than a fee system implemented as a supplemental revenue source or a fee implemented for system management purposes. This is due to the fact that it is more difficult to portray the fee as a “new tax” (Baker, Goodin et al. 2008).

A major drawback of implementing an MBUF as a replacement to the fuel tax is that if the fuel tax is continued, as what might occur in a voluntary deployment, there will need to be systems in place to insure that users do not pay both the fuel tax and the MBUF. ODOT addressed this issue in its pilot test by tying its fee payment to fuel purchases. However, if the MBUF is deployed such that fee collection occurs outside of fuel purchases, then other measures will have to be explored. To date no MBUF pilot has examined how to credit fuel taxes paid if deployed outside a point-of-sale collections environment.

Generation of Supplemental Revenue

MBUF systems do not have to be implemented as a replacement to the fuel tax, and elected officials and other policy makers may find the implementation of an MBUF system as a supplemental revenue source to have many advantages. It is common in states and municipalities to supplement spending on transportation with sales, excise, or property taxes. However, these taxes are typically regressive (with regards to both income and road use) and can unfairly distribute costs of roadways to non-users (Sorenson and Taylor 2005). Therefore, an MBUF

system might be a desirable revenue source for smaller scale entities wishing to provide additional revenue for infrastructure funding, be it for highways or transit, or as a replacement to these tax mechanisms.

System implications for an MBUF deployed as a supplement to the fuel tax depend on the inclusion of other policy objectives. If the system is only concerned with generating revenue, then very little detail on travel or even vehicle characteristics is required and a simple, low technology approach can be pursued. However, if the system is to utilize vehicle specific characteristics such as weight and fuel efficiency (for environmental objectives), or system characteristics such as traffic volumes (for system management objectives), then the system becomes more complicated in its requirements.

Implementing an MBUF as a supplemental revenue source removes the need to account for fuel taxes paid. This simplifies collections and allows for the development of simple collection systems outside of a point-of-sale environment. However, a major impediment to imposition is likely to be public acceptance, as a supplemental MBUF can easily be characterized as a new tax (Baker, Goodin et al. 2008; Weinstein-Agrawal 2011).

Facility Specific Revenue Generation

An additional policy objective of an MBUF system might be to allow for the identification of where travel is occurring (and where revenue is being generated) on a facility specific basis. This would allow the implementing entity to adjust rates on a facility-by-facility basis in order to achieve any number of goals. For example, implementing entities might adjust rates to reflect the variable costs associated with maintenance and operations on different types of facilities. Differential pricing by facility might also be utilized in situations where travel volumes are disproportionate between facilities and the implementing entity wishes to shift traffic to lower volume facilities or shift travelers to other modes or times of travel. A facility specific revenue generation objective might also be adopted in situations where new facilities must generate revenue in order to cover development costs (Kalauskas, Taylor et al. 2009).

An MBUF system with facility specific requirements would require significantly more information to carry out its stated objectives than a MBUF intended to replace the fuel tax. At the very least, the system must know what facilities are being travelled on and by what vehicles. This implies the use of either roadside and/or in-vehicle technologies capable of determining location on a facility specific basis. Wide area location assessment systems such as the Global Navigational Satellite System (GNSS) can be utilized for this purpose but significant potential public acceptance issues would have to be addressed, mainly due to concerns regarding the ability of such technology applications to actively track drivers. Research has shown that this concern is particularly problematic to address, as the public tends to distrust that the various measures that can be employed to protect privacy are viable and would be effectively utilized by an implementing entity (Sorenson, Ecola et al. 2009). Location data for the purposes of carrying out facility specific revenue objectives can be generated with various fixed infrastructure technology such as DSRC-based transponders or radio frequency identification (RFID). However, these technology applications require the installation of in-vehicle equipment that communicates with the roadside equipment. Roadside cameras utilized in conjunction with

ANPR can serve similar purposes without the need for in-vehicle technology, but the level of information collected under such a configuration is limited to an image of a license plate. Due to a need for technology in some form, an MBUF system implemented to collect revenues on a facility specific basis is likely to face higher levels of public resistance. However, the facility specific nature of the fee system can also be used to increase public acceptance by allowing the implementing entity to illustrate, in concrete terms, how revenues might potentially be used. Entities implementing a fee system will enjoy greater public acceptance if they can show how revenues from the fee system will be used to provide better transportation services, especially if those benefits are articulated in terms of specific projects and improvements (Baker, Goodin et al. 2008; Weinstein-Agrawal 2011).

Jurisdictional/Area Specific Revenue Generation

An MBUF system might be implemented in such a manner that use and revenue generation can be tied to certain areas, most likely the various jurisdictions (state, county, and city) composing the overall MBUF system. Unlike systems oriented around facility specific revenue generation, this objective is concerned with collecting fees for travel within a certain area regardless of the facility being travelled on. The fee systems tested in Oregon, Minnesota and evaluated by the University of Iowa all utilized some element that allowed for travel within specific areas (be it a state or municipal area) to be identified.

A fee system with area specific revenue generation as an objective would require location data, but it would not have to be provided at the level of detail required of a facility specific system, as coarse location data could be used. For example, if an MBUF were implemented at the state level, such that all mileage accrued outside of the state was free and a portion of revenues generated within urban areas would be returned to those areas, then the system would only need to know that a specific vehicle was either in or out of state and whether it was within a specified urban area. It is also not necessary, for the purposes of meeting this objective, to determine when travel is occurring. It is likely that some form of in-vehicle and/or roadside technology would be required for meeting this objective. Wide area location assessment systems such as the GNSS can be used to identify where travel is occurring but comes with significant public acceptance issues due to the mandated use of technology and the collection of travel data (Baker and Goodin 2010). Location can be determined by the use of fixed infrastructure technology, such as DSRC, RFID or ANPR, but there would have to be significant coverage in terms of infrastructure emplacement to insure that boundaries of the pricing system are efficiently demarcated. Much like the benefits associated with facility specific generation, an MBUF system oriented around area specific revenue generation would enjoy a higher level of public acceptability in that revenues can be targeted to specific improvements within those areas. If revenues are being allocated based on jurisdiction, then such a system provides for an equitable and empirically based mechanism for those allocations. If implemented at the national level, this would provide a significant improvement over the current system for allocating fuel tax revenues than is currently based on the use of formulas.

System Management

System management, in this case, refers generally to influencing how drivers utilize roadway resources. Objectives associated with system management might be reducing congestion, reducing traffic volumes, increasing vehicle speeds, improving user access, or restricting

unnecessary vehicle access. An MBUF system with a system management component might, for example, contain a congestion pricing element, where fees for access to infrastructure increase as volume increases. MBUF systems under development and evaluation in the United States are not being evaluated with the expectation that they will serve primarily as a system management tools but these systems are nonetheless being evaluated in terms of their support for such objectives. For example, the ODOT and MnDOT evaluations both tested the potential for varying fee rates throughout the day such that access is more expensive during periods of high congestion.

Fee systems incorporating a system management component are generally aimed at mitigating congestion by shifting travelers to other modes of travel, to other times of travel, to less-congested facilities, or canceling peak period trips in order to reduce congestion and increase overall throughput. In the United States, demand management objectives have been incorporated into variably priced facilities such as High Occupancy Toll (HOT) lanes, which essentially price excess capacity in High Occupancy Vehicle (HOV) lanes to allow utilization by single occupant vehicles (SOV). System management objectives are also found in international pricing applications such as London, Stockholm, and Singapore, all of which levy fees designed to regulate traffic volumes within congested urban centers. From an MBUF implementation perspective, demand management objectives might be adopted in conjunction with facility specific revenue generation objectives.

An MBUF system with demand management objectives would have similar components as a system designed with a facility specific revenue generation objectives. It would have to utilize some form of technology, either in the form of in-vehicle transponders, roadside mounted technology, or both, in order to determine where travel is occurring. This is necessary because the system must know when and where travel is occurring, an aspect that cannot be accommodated by low tech MBUF deployment options such as odometer readings. However, technology would not necessarily need to be utilized by all vehicles or cover the entire network. Only the specific facilities subject to the system management fee and the vehicles utilizing those facilities would need to be equipped.

Privacy issues might be the most predominant challenge facing the implementation of an MBUF with demand management objectives, particularly if the system requires technology usage of all drivers. If technology usage is not compulsory then the system is likely to encounter significant enforcement issues related to the collection of fees from non-equipped vehicles. Demand management objectives oriented around specific facilities might also raise concerns about diversion of traffic to other facilities.

Equitable Collection of User Costs

An MBUF system might be structured in order to collect fees from road users in proportion to the costs they impose on roadway infrastructure. In most cases, fee systems oriented around collection of user costs are advanced as a means of collecting revenues from users that are disproportionately burdening the roadway network, and most existing MBUF systems that feature this objective collect fees from trucks and other heavy vehicles. Cost, for the purposes of eventual fee assessment, may be articulated in terms of actual wear and tear placed on infrastructure or in terms of externality costs associated with congestion and/or pollution. In

terms of pricing for wear and tear the general practice is to levy an escalating fee schedule for heavier vehicles or for vehicles that do not have a sufficient number of axels for the proper redistribution of load weight.

Cost might also be expressed in terms of environmental externalities, generally in the form of emission. In terms of pricing for environmental costs, one concept is to simply charge higher mileage rates for older, more polluting vehicles. In some cases revenues generated by these systems might be used to fund alternate modes such as rail and waterways, which are viewed as being more environmentally friendly.

An MBUF implemented to collect user costs may vary based on various vehicle characteristics. This might be done in order to more closely align the cost of maintaining and operating a facility with the revenues generated by the users of that facility. MBUF systems currently deployed in central Europe for the collection of fees from trucks, which levy fees that vary based on factors such as emissions class and vehicle weight, incorporate this objective. Truck fees in the US, similarly, are based on vehicle weight meaning that those vehicles that cause the most wear and tear on the roadway network pay more. The information required for fulfilling this objective is fairly straightforward in that, at the most basic level, the system would need one-time information on the specific characteristic being priced. Most of these characteristics would not change over time and are therefore easier to account for in assessing the fee. Data would not need to be collected on a continual basis but would need to be stored somewhere that would allow for access by the entity levying the fee. This information could be stored at a back office location or within any on board equipment utilized by the system.

The benefits from implementing a system that incorporates the cost that the vehicle imposes on the system relates to economic efficiency, where the price for a given good or service is aligned as closely as possible with the actual cost of that good or service. Fuel taxes currently capture only a few user costs and they are mostly related to costs associated with emissions, since the amount paid varies based on fuel consumption. Fuel taxes are less effective at capturing costs associated with pavement wear and tear, as vehicle technologies have weakened the relationship between fuel consumption and vehicle weight. By adopting an MBUF system that collects both direct and indirect costs, an implementing entity can set prices such that revenues generated can be aligned with total system costs.

Environmental

The transportation sector is a major contributor of pollutants such as carbon monoxide (CO), hydrocarbons (HC) and volatile organic compounds (VOC), oxides of nitrogen (NOx), and particulate matter (PM) that are collectively known to have negative impact on human health. The reduction of these emissions and subsequent mitigation of their effects is a growing concern for policy makers both domestically and internationally. While not a major policy consideration for the implementation of MBUF systems in the United States, environmental goal attainment is a significant component of many international fee systems and could grow in importance for domestic applications (Kalauskas, Taylor et al. 2009).

Environmental goals may be oriented around attainment of national emissions guidelines or for the attainment of local air quality objectives. Reducing the emission of greenhouse gases (GHG)

is generally viewed as being a wider scale environmental goal, applicable at the national or state level. The most prevalent GHG carbon dioxide (CO2), and its emission is directly linked to the burning of fossil fuels in a combustion engine. The more fuel that is consumed the more CO2 that is emitted. Therefore, the most straightforward method for incorporating a CO2 reduction oriented objective would be to simply levy a fee that varies based on fuel efficiency. In this sense, fuel taxes act as the most common GHG emissions related fee. Implementing an MBUF that accounts for CO2 emissions would require knowledge on the part of the system regarding each vehicle's fuel efficiency which would entail additional record keeping on the part of the system. However, as this information would not change overtime it does not present a significant challenge in terms of administration.

Pricing to account for local attainment of air quality standards can be carried out in one of two ways. In the first approach, the MBUF would be structured to meet objectives on an *aggregate* level, where prices would be set based on measures of air quality for an entire region. This would require data related to overall air quality in the region, such as concentrations of NOx or PM, which would in turn be utilized in the assignment of fee rates. All vehicles within the charging area would be levied a uniform fee based on these levels. A second approach would be to levy fees on a *vehicle specific* basis with the aim of incentivizing those vehicles that pollute less and penalizing vehicles with higher emissions. This would require different levels of data for the assignment of fee amounts, as various vehicle characteristics and even driving characteristics might be required. Fee amounts might vary based on emissions class, as occurs in European truck pricing systems, or based on some other type of vehicle classification. Pricing might also vary based on driving behavior including acceleration patterns. Levying fees at this level of detail would require the use of in-vehicle equipment capable of collecting travel information on a second by second by basis.

Mileage Fee Operational and Functional Objectives

As discussed in the previous section, MBUF systems can be designed from an institutional and technology perspective to achieve a number of policy related goals. However, there is another set of goals and objectives that must be considered as part of implementation. Functional objectives refer not to what the system is designed to do in terms of meeting policy, but rather refer to the rules and regulations within which an MBUF system must operate. Functional objectives are equally important in determining overall system design, as certain functional objectives will preclude the ability to meet other functional objectives as well as, in some cases, policy oriented objectives.

Privacy Protection

Privacy protection is likely to be among the most important functional aspects that an MBUF system will have to address. Numerous public acceptance studies on MBUF have shown that the public has significant concerns about the potential use of technologies capable of collecting travel information for use in mileage assessment. To address these concerns, there are numerous strategies that might be employed.

The first method of addressing privacy concerns is to avoid mandating the use of additional equipment. Systems such as that being field tested in the Twin Cities region of Minnesota would treat any technology applications as an option for discounting mileage assessed under a simpler

system. Minnesota drivers would be able to pay their MBUF based on a manual odometer reading but could opt to utilize technology if they wish to discount mileage accrued out of state. Technology options can also be utilized without the need for the collection of detailed travel data. The technology system currently being evaluated in Nevada does not collect any location data and instead utilizes in-vehicle technologies for the sole purpose of determining miles travelled.

There are several options for preserving driver privacy protection in systems that utilize detailed location data. Under the strategies tested by the Oregon Department of Transportation and the University of Iowa, mileage is allocated within specified zones of travel that might correspond to jurisdictional boundaries. For example, the Oregon system could determine that mileage was accrued by study participants in the State of Oregon or in the Portland area but did not know what specific areas of the city or state or what specific facilities travel had occurred on. Privacy concerns may also be addressed through the fee computation process. Under a "thick client" fee computation process, most data processing for the purposes of determining an amount due occurs within any in-vehicle devices. In general, under a thick client approach the only information transmitted out of the vehicle is the fee amount and any other information necessary to develop a billing statement. Under a "thin client" approach the functionality of any in-vehicle devices is limited and aggregated data is transmitted to a processing center. However, there are still processes that can be undertaken to protect driver privacy. For example, aggregated travel information may be sent through a trusted third party prior to transmission for billing. This third party could use the information to provide various services to the driver and then forward only the information necessary for determining charges due to a governmental entity. Another approach, known as an anonymous loop-back proxy, would have aggregated information uploaded to a fee calculation application. This fee application would process the data and determine an amount due, which would be forwarded to the driver and the billing entity. The calculator would then remove any personal identifier information from the data set and forward to any other entities, such as planning organizations, that might make use of the data (Bomberg 2009).

Enforcement

Enforcement will be a critical component of any MBUF system. Existing fee systems have established enforcement mechanisms that vary in terms of their effectiveness. Fuel taxes must be paid as part of regular fuel purchases, which is an extremely effective enforcement mechanism as it is difficult to utilize the roadway network without first purchasing fuel. Vehicle registrations utilize a visible sticker that identifies the vehicle as being current on its registration. This is less effective than the point-of-sale centered enforcement mechanism utilized by the fuel tax but it is effective in providing an easy visual verification of fee payment for law enforcement officers. MBUF systems differ from both fuel taxes and vehicle registrations in ways that complicate enforcement. First, unlike fuel taxes that are collected from fuel distributors, an MBUF would have to be administered, collected and enforced from all drivers. This would present a significant challenge in as much that federal entities currently lack the mechanisms for administering such a system. State entities have rudimentary structures in place to collect fees from all users in the state, but, unlike vehicle registration fees, it is likely that an MBUF would have to be collected on more than an annual basis (Baker and Goodin 2010).

Therefore, one way to facilitate enforcement is to model the MBUF payment system after the current fuel tax system and tie fee payment to the purchase of fuel. For example, in a system proposed by Whitty and Svadlenak, vehicles would be equipped with RFID tags that contain information related to, among other things, each individual vehicles' fuel efficiency. Under this proposal, whenever a vehicle is refueled special equipment would read the RFID tag on the vehicle. Using each vehicle's estimated fuel efficiency, the system could estimate the number of miles that will be travelled based on the fuel purchase and place the amount due on the fuel purchase. The Nevada system is similar, in that mileage information is transmitted to a billing application whenever a vehicle is refueled.

Administrative Cost

Fuel taxes are a relatively inexpensive and efficient tax to administer. They are initially collected from fuel wholesalers and distributors when fuel is removed from the distribution system. Every purchaser/holder of the fuel from that point on then reimburses the prior holder of the fuel for taxes paid until the fuel is purchased by the consumer. Thus, the fuel tax is collected from only a few hundred sources, even though millions of drivers pay fuel taxes. Most estimates place the cost of administering fuel taxes at about 1 percent of revenues.

However, MBUF systems would be significantly more expensive to collect. Under most implementation scenarios fees would have to be collected individually from every driver. Furthermore, because most of these implementation packages are not centered within a point-of-sale context, there would need to be a system of customer accounts for enforcement purposes. While there have been no detailed studies of the potential cost of administering a domestic MBUF system, the I-95 Corridor Coalition put estimates at $30 to $40 per vehicle per year based on the experience of the Stockholm Cordon Pricing system.

System Flexibility

System flexibility refers to the ability of the pricing system to accommodate change. Change in the system could take the form of a change in rates, rate structure, or a change in geographic coverage. While system flexibility is a concern for current MBUF systems under evaluation, it is not a primary evaluation metric and this has received less attention than other factors such as enforcement.

Systems dependent on the utilization of fixed infrastructure technologies, such as DSRC or RFID, are less flexible than systems that rely exclusively on in-vehicle technology. This is due to the fact that any extension of the system's geographic coverage requires the emplacement of new infrastructure. The flexibility of in-vehicle technology can be influenced by where functionality is centered. Systems that rely on off-vehicle data processing for fee assessment and computation ("thin client") are more flexible than systems that have a high level of functionality on the part of the individual technology components ("thick client"). This is due to the fact that changes to the system, in terms of rate schedules or geographic coverage, can be accommodated through updates to a central server as opposed to updating all units currently under the purview of the system.

System Reliability

Reliability is a broad term, but in general it refers to the ability of the system to reliably collect and assess mileage that is reflective of actual use. Thus, reliability encompasses almost all

technology aspects of the system from in-vehicle to roadside equipment to any back office utilized for fee computation and assessment.

The reliability of certain configurations has not been a major focus of most MBUF pilot demonstrations but reliability has been assessed. ODOT researchers found that, in general the fee collection system utilized in that state's pilot test operated successfully. However, there was a total of 18 days where fee calculation could not occur due to various technology issues including problems with the point-of-sale systems utilized at the service stations, various hardware issues such as cables or equipment becoming disconnected, DSL communication issues, and web server down time. None of these issues affected the operations of the service stations themselves. In evaluating the system's reliability ODOT researchers developed several metrics for the various system functions as shown in Table 4.

TABLE 4: OREGON SYSTEM COMPONENT PERFORMANCE MEASURES

Function	Performance Measure	Assessment
Mileage data collection for fee calculation	Mileage collection accuracy	Overall, accurate ±2%; GPS systems far more accurate than OBD II
Associating a vehicle equipped with an on-vehicle device with the pump that is used to fuel the vehicle	Percentage of vehicles that could be correctly associated with the fuel pump	Powell station average: 88%; Sandy station average: 73 %
Read mileage data from an on-vehicle device	Percentage of devices successfully read after the vehicle fuel pump association is successful	No failures to read mileage once vehicle/fuel pump association was successful

Source: (ODOT 2005)

Furthermore, ODOT researchers concluded that the pilot OBUs accurately collected mileage data and reliably differentiated that mileage by geographic zones, as shown in Table 5.

TABLE 5: OREGON MILEAGE ACCURACY ASSESSMENT

Measure	# of Samples	Average	Max	Min
Odometer mileage recorded	46	9,493.2	68,271.0	1,332.0
Overall percent difference	46	-2.0 %	21.1 %	-18.6 %
GM/Foreign OBDII	19	-1.0 %	13.8 %	-14.5 %
Ford OBDII	8	-7.5 %	21.1 %	-18.6 %
GPS-only	19	-0.7 %	4.0 %	-9.3 %

Source: (ODOT 2005)

In order to increase the reliability of the GPS-based functions utilized in the University of Iowa's national MBUF evaluation, researchers utilized a system for interpolating location based on known data points in the event that a GPS signal was lost. If there was signal loss, and if the

mileage accrued during that loss was less than 100, then mileage was allocated based on a simple straight-line interpolation between the GPS coordinates that bound the signal outage interval. If mileage accrued during the signal loss was over 100 miles then no interpolation occurred and mileage was simply reported as uninterpolated. It was estimated that over a six month period that a total of 23 million miles were logged by study participants, of which 7.3 percent was driven without a GPS signal. Researchers estimated that most of that mileage was interpolated, and that the total uninterpolated miles represented only about 0.6 percent of the total miles driven by study participants (Hanley 2010).

Interoperability

Toll interoperability in the U.S. currently is not nationwide, although state-based interoperability is common. ETC systems have been deployed in the last two decades without much emphasis in being interoperable with other toll operators within a state or other states. This was not an issue with initial ETC systems; however, now that ETC is more widespread interoperability has become a critical issue.

In an MBUF tolling system, interoperability will likely be a key issue. While it is possible to implement MBUF on a state-by-state basis, there are significant advantages in adopting the system on a wider basis. Because MBUF will likely be implemented as either a simple revamping of the vehicle registration system, or as a system based on satellite and cellular technology, interoperability on this seemingly more complex system may be easier than has been experienced in existing ETC systems. This is due to the standardization of satellite technology, and the widespread deployment and interoperability for data transmission, such as e-mail, and cellular technologies.

Mileage Fee Technologies

MBUF systems can be implemented with relatively little technology deployment. However, simpler systems will generally not be able to achieve as wide a range of policy objectives as a more technology intensive system. In this system, some of the most common supporting technologies for road pricing, as well as future MBUF systems, are discussed.
In the past, the most common methods for collecting tolls were manual collection and automatic coin machines (ACM). Manual toll collection is the simplest method and has been in existence for as long as toll roads have existed. ACM systems have been in existence for many decades and allow for the collection of tolls without a collector through various methods including coins, tokens, smart cards, and credit cards. However, it is unlikely that either manual collection or collection through ACM-based systems will be significant component of a future MBUF system, as these systems are already in decline as a common collection medium in the tolling industry.

The tolling industry is currently moving towards ETC systems, which have been in existence for more than 20 years and continue to evolve. Under an ETC-base collection approach, fees are deducted electronically from an established customer account. These systems must be capable of:

- Determining whether a vehicle utilizing a priced facility is eligible for a fee,
- Initiate enforcement procedures for vehicles that are not eligible for use,

- Electronically apply fees for eligible vehicles without requiring them to stop.

Numerous technologies may be utilized under an ETC-based system, and it is likely that many of these technologies could be utilized under an MBUF system.

Radio Frequency Identification and Dedicated Short Range Communications

RFID and DSRC technologies are members of the same technology family and are utilized extensively within domestic and international ETC-based pricing systems as they are both mature and well proven. It is likely that the use of these technologies in an MBUF system would, on a practical level, be identical to their use in ETC systems. The major difference between the applications is likely to be that of scale, as an MBUF system would have to capture usage from many more drivers over a much wider geographic coverage. The significant penetration of RFID and DSRC into the current automobile fleet would be a significant advantage in terms of implementing an MBUF system. There is existing institutional knowledge with regards to the technology, many entities are already equipped with the requisite back-office operations, and RFID/DSRC are typically low cost relative to other fee assessment technologies that might be utilized. However, a significant disadvantage, as previously noted, is that an RFID or DSRC-based MBUF system would require a significant investment in additional roadside equipment in order to capture road usage on all facilities.

In most DSRC-based systems, a gantry mounted antenna/reader communicates with a transponder mounted on the vehicle. The gantry and in-vehicle unit may communicate along any number of DSRC frequencies that are commonly used in the tolling industry, including: 915 MHz, 2.45 GHz and 5.8-5.9 GHz bands. Japanese pricing systems and most European systems currently utilize the 5.8 GHz band, while the 915 MHz band is predominantly used in the U.S. In October 1999, the United States Federal Communications Commission (FCC) allocated 75MHz of spectrum in the 5.9 GHz band for DSRC to be used by intelligent transportation systems (ITS) (FCC 1999). The main advantage of this band is that it provides low latency, higher range, and better security. Furthermore, 5.9 GHz DSRC technology is interoperable and open source, meaning that equipment replacements, upgrades, and spares can be bought from multiple manufacturers and operate seamlessly. Table 6 shows the major transponder standards in the U.S.

TABLE 6: TRANSPONDER COMPARISON IN U.S. (IBI 2009)

Requirements	5.9 GHz	IAG	Super eGo™ (based in ISO 18000 6B)	TDMA	Title 21
Open Road Tolling	Best	Acceptable	Acceptable	Better	Acceptable
Operational	Testing	Yes	Yes	Yes	Yes
Security	Better	Acceptable	Acceptable	Acceptable	Acceptable
Read/Write	Yes	Yes	Yes	Yes	No
HOV Self Declare	Yes	Yes	Yes	Maybe	Yes
Enforcement	Better	Acceptable	Acceptable	Acceptable	Limited
Multiple Suppliers	Intent	Maybe	No	Possible	Possible
Ease of Migration	Requires installation of	Supported by current	Current Technology	Current Technology	Supported by current
Supports Intellidrive	Yes	No	No	No	No
Form Factor	Hard Case	Hard Case	Sticker Tag (Available In Hard Case)	Hard Case	Hard Case (Available In Sticker Tag)
National Costs for	Under $100 [1]	$20-25	$10	$20-25	$20-25

Note 1: A later source puts the price as low as $24.80 for 5.9 GHz transponders and $1.59-$3.05 for ISO 18000 6C transponders based on responses to the Georgia I-85 HOT lanes RFP (Samuel 2009). E-470 has adopted ISO 18000 6C transponders, with an average cost less than $1.50.

There are currently no national standards with regards to the 915 MHz band for DSRC technologies. As a result, numerous toll road and bridge operators in the U.S. are forming alliances to create their own regional standards that would support interoperability between different pricing systems. A similar level of interoperability would likely be highly desirable for an MBUF system. Furthermore, there is a movement among technology providers to develop multi-protocol DSRC technologies for the 915 MHz. band capable of communicating with different transponder and readers types. The main advantages of multi-protocol readers are interoperability and the ability to provide a migration path to a different protocol. In the last few years a new open standard, the ISO 18000-C, has been adopted by several RFID equipment manufacturers. The main benefits of this standard are that it will make interoperability easier and toll operators will not be tied to a single vendor for technology solutions. Currently Sirit and Neology offer ISO 18000-6C transponders. Transcore offers its proprietary variation 18000-6B transponders. Kapsch and Sirit both offer multiprotocol readers that support the ISO 18000-6C standard.

Another recent technology development is the offering of switchable transponders that allow the user to select a particular mode of operation. This technology has a specific niche market such as the High Occupancy Toll (HOT) lanes where it is critical to identify the occupancy of vehicles using the facility. Sirit offers the ISO 18000-6C (that has an on/off switch) and Title 21 (which offers a 3-way switch) transponders. E-470 has moved away from Title 21 to ISO 18000-6C, with complete phase out of Title 21 in 2012. This technology could have applicability in an MBUF environment if policies were enacted to provide lower mileage fees for vehicles with a higher occupancy.

The RFID technology based on the 5.9 GHz band is still in the demonstration and trial phases in U.S. Although there has been interest in advancing this technology, no toll road operator or authority has issued a Request for Proposal (RFP) specifying 5.9 GHz DRSC as the sole AVI requirement. A few recent RFPs, such as the Triangle Expressway in North Carolina and SR-520 in Washington state do mention 5.9 GHz as a requirement, but only to the extent of asking proposers for an AVI solution that will allow them to migrate from 915 MHz to 5.9 GHz in the future. The Georgia State Road and Tollway Authority I-85 HOT lanes RFP gave the option to propose either 915 MHz or 5.9 GHz technology.

Automatic License Plate Recognition and Video Tolling

Automatic License Plate Recognition (ALPR), or automatic number plate recognition (ANPR), fall under the umbrella term "Video Tolling" which is used extensively in existing toll facilities, often for enforcement purposes in conjunction with RFID and DSRC technologies. The use of ALPR in an MBUF system would be practically identical to its use in existing tolling configurations as a means of verifying roadway usage by individual vehicles in conjunction with other technologies such as RFID/DSRC.

Video tolling is performed by identifying a particular vehicle's license plate. Cameras are utilized to capture images of the plate using either visual or infrared lighting. An optical character recognition (OCR) engine then reads the number and character letters off of the plate which are then matched to an existing account associated with the vehicle. If no matching account is found then the information is sent for further processing with an enforcement entity. ALPR could therefore likely be used in an MBUF application to identify vehicles that are not equipped with an on-board device.

In general, an ALPR-based technology solution is comprised of several elements:

- A camera that takes color, black & white, or infrared images of the vehicle.
- An Illumination system, consisting of light sensors and light sources such as a flash, that illuminates the target area.
- A plate finder, which is firmware that continually searches the camera's field of view for the presence of a license plate.
- The OCR Engine software used to read the picture of the license plate. License plates vary by state or region, so vendors often offer OCR engines oriented towards a specific state or region.

The back office component of a video tolling-based system generally consists of the host, customer service center (CSC), and Violation Processing Center (VPC). Controllers forward transaction and other associated data to the host computer. In some pricing systems there is an additional tier between the facility and the host called the plaza system. However, in MBUF systems, it is likely that only the host system will exist. The main function of the host systems is to aggregate transactional data, summarize the data, generate reports, and download various files such as toll rates, toll schedules, and status list. Depending on the size of the system and its requirements, the host and the CSC can be separate or combined systems. The CSC is generally responsible for all types of transactions, matching transactions with account holders, debiting the correct toll amount, managing accounts, generating a valid tag list, and providing customer support among other activities.

Despite the recent progress made in ALPR, video tolling systems still have several shortcomings including (Persad 2007):

- poor image resolution, generally due to the license plate being out of focus;
- blurry images, particularly motion blur as a result of high vehicle speeds;
- poor lighting and low contrast due to overexposure, reflection, shadows, or plate background color or style;
- an object obscuring (part of) the plate or dirt on the plate;
- a different font, as in out-of-state plates and vanity plates, not recognized by the OCR engine;
- different plate styles; and
- circumvention techniques (such as reflective plates)

Many of these issues are resolving due to improving ALPR technologies. Issues involving circumvention and blocked plates, for whatever reason, will continue to be issues unless and until the potential of RFID tags becoming integral to the vehicle is resolved.

Cellular Tolling

Cellular tolling would utilize chip technology, similar to a cell phone chip that would be installed in a vehicle to communicate with cellular towers for the purposes of determining a distance travelled. Such a system would have an advantage in terms of potential geographic coverage given the near total coverage of cell phone signals in urban areas of the U.S. and the deployment of global positioning system (GPS) capabilities in cell phones for use in 911 phone locating. Thus, a cellular tolling-based system would be technically feasible and could likely be provided at a lower cost relative to satellite-based systems due to that fact that infrastructure is already in place (Persad 2007).

There are currently no pricing systems that utilize a cellular tolling configuration, but the concept was developed by researchers at the University of Minnesota as a mechanism for collecting road user fees as part of a potential nationwide road user fee implementation. The system would rely on the use of on-board units (OBUs) installed within a vehicle that would tie in to the vehicular data bus (OBD II port.) Through this connection, the OBU would receive information from the

vehicle related to starts, stops and speeds which would be used to estimate distance travelled. The device would monitor signals received from area cell phone towers to determine a zone of travel which could correspond to the jurisdictions of various entities. No other location information would be collected by the unit. Mileage would be aggregated by zones, the various boundaries of which would be determined by the implementing entity. This mileage information would be transmitted periodically to a back office, at which time a unique acknowledgement signal would be sent back to the OBU. When the unit receives an acknowledgement signal, it resets the mileage data. If no signal is received, the OBU continues to aggregate mileage data and retransmit information until an acknowledgement signal is finally received. Operating costs for such a system are estimated to be no more than $5/month to as low as $2/month per unit; similar in cost to sending about 2 text messages per week (Donath 2009).

Satellite Tolling

Satellite tolling utilizes satellite-based technology systems such as the Global Navigation Satellite System (GNSS) to determine exact vehicle location. There are several GNSS platforms such as the US-funded Global Positioning System (GPS), the Russian GLONASS, the European Galileo, and the Chinese Beidou. Only the GPS is a fully functional GNSS, as other GNSS platforms are in development or operating with restrictions.

Under a satellite tolling configuration, vehicles are equipped with an onboard unit (OBU) that records movement by periodically downloading time stamped location coordinates from the GNSS satellite. Some of the advantages of satellite tolling are that it does not require expensive roadside infrastructure, as with RFID and video tolling based applications. Furthermore, satellite-based systems are transparent to the driver and the extent of coverage is almost unlimited. Some disadvantages of this approach are that OBUs would need to be installed in the vehicle and the technology currently lacks the accuracy to allow for lane discrimination as might be utilized in a HOT lane configuration. Additionally, reception in certain areas is problematic, particularly in urban areas that result in the “urban canyon” effect. Perhaps the biggest disadvantage of satellite pricing is the strong privacy concerns raised by the public with regards to the perception of being actively tracked. However there are solutions to these concerns.

There are currently no pricing applications in the U.S. that utilize satellite tolling, but there have been several pilot projects. Satellite tolling has been implemented in Europe for several years for truck-based fee systems, and several vendors in Europe and Canada such as Efkon, Skymeter, and Q-Free offer satellite based tolling systems. These systems are based on GNSS positioning and cellular communications to transmit data to a back office. Skymeter claims to have developed a financial grade GPS that is highly accurate and addresses some of the disadvantages presented above such as privacy and accuracy in dense urban canyons. Q-Free offers a hybrid system where the vehicle is equipped with an OBU with a GNSS module and DSRC transponder to transmit the data. The GNSS component is used to determine vehicle location while the DSRC transponder transmits data to roadside equipment located at strategic locations equipped with AVI and ALPR. At these locations, enforcement activities can occur through taking a picture of the license plates of those vehicles not equipped with an OBU (Q-Free 2011). This system has been implemented in numerous European countries. Transcore and Raytheon offer systems that connect to the vehicular diagnostic port to calculate mileage and use GNSS for location determination.

Other Technologies

The following are technology components that are often incorporated into the technology applications that have already been discussed.

OBD II

All vehicles manufactured for use in the United States since 1996 include an On Board Diagnostics system (OBD II). This device measures many parameters relating to vehicle operation. While predominantly used for diagnosis of maintenance issues by service technicians, the OBD II can also output the information necessary to determine mileage traveled. This means that the OBD II provides a methodology for determining VMT that is already built into the majority of the nation's vehicle fleet. Many MBUF pilot systems and international pricing applications have utilized OBD II connections for mileage assessment. Furthermore, OBD II scanners that connect to a home computer via a Universal Serial Bus (USB) port are currently sold by major retailers for under $20. While this device is currently used by do-it-yourself mechanics, it shows that linkage to the vehicles OBD II system can be accomplished at very low cost. Once obtained from the OBD II port, information from the OBD II can be transmitted either via cellular links to a central billing location or via Bluetooth® or other DSRC to a gasoline pump or other collection location.

Smart Card

A smart card is a device that includes an embedded integrated circuit chip (ICC) that can be either a secure microcontroller or equivalent intelligence with internal memory or a memory chip alone (SCA 2011). The technology is used in multiple ways from keyless security systems, credit card transactions, and increasingly to identify authorized users in automobile ignition systems. The card connects to a reader with direct physical contact or with a remote contactless radio frequency interface. Smart card technology conforms to international standards (ISO/IEC 7816 and ISO/IEC 14443) and is available in a variety of form factors, including plastic cards, fobs, subscriber identity modules (SIMs) used in GSM mobile phones, and USB-based tokens (SCA 2011).

For MBUF use, smart cards could be used in conjunction with other RFID/DSRC devices to identify the user. This allows a single transponder to be used by multiple people. The smart card could also be used to verify vehicle occupancy in cases where a discount is provided for multiple vehicle occupants.

Smart cards may also be used for different payment scenarios. For instance, the smart card could be used for toll payment as well as payment for other transportation services, such as transit. Some value pricing programs have proposed providing toll credits for transit use as an incentive to use transit when practical. Smart card technology would be ideal for tracking this type of system. Smart cards could also be utilized to allow drivers to pre-purchase travel, such as occurs in the Singapore ERP system.

Mileage Fee System Configurations

The combination of technologies and systems used to levy and collect user fees combine to form an overall system architecture. The technological options for assessing and ultimately collecting

vehicle mileage fees are numerous, ranging from low-tech approaches to high-tech methods, some of which may offer a range of consumer services (Sorenson, Ecola et al. 2009). The system architecture will ultimately determine how the user charge will be accounted, assessed, and paid by road users.

The three main components of an MBUF logical architecture are (Bomberg 2009):

- *Roadway use assessment*: The collection of raw data describing vehicular movement.
- *Charge computation:* Data processing in which raw data are used to assess an amount owed.
- *Vehicle-to-back-office communication*: This refers to transmission of data for the computation of the amount owed or the transmission of the already-computed amount owed from the vehicle to a back office.

For all types of collection systems, consideration should be given to opening discussions with potential private sector partners. Further, there does not appear to be a need to select a single vendor. While this could be considered, allowing competition among multiple vendors might prove to be the most beneficial approach which also allows the broadest range of choices for consumers.

For governmental and tolling agencies, the benefits of privatization would have to be weighed against the potential pitfalls. This is, in essence, privatization of toll collection, in much the same way that many governmental agencies have privatized parking collection and enforcement, and experience in this area would likely provide insight into implementing a similar program for MBUF collection.

Assessment

Assessment refers to the collection and processing of data that relates directly to the mileage accumulated by the user. It should be noted, as indicated by Sorensen, that the mileage need not be directly measured – it can be estimated or projected (Sorenson, Ecola et al. 2009). Regardless, there are several options available for the collection of this data:

- Proxy VMT estimation using vehicle specific characteristics such as fuel efficiency;
- Certified manual odometer readings;
- Speed data from vehicle on-board diagnostics (OBD II) to compute distance traveled; and
- Detailed time and location stamping with a vehicle device on board, such as a smartphone with a GPS system on the phone.
- Detailed time and location stamping with a permanently installed vehicle device, such as a GPS system coupled with a cellular device or Connected Vehicles Initiative (formerly IntelliDrive) devices.

Mileage Estimation

There are numerous means by which mileage could be estimated under a simple, low tech MBUF system configuration. Mileage could, for example, simply be assumed and a flat fee could be levied on all drivers based on that assumed mileage. This flat fee could be developed utilizing regional, state or federal projections for vehicle miles of travel (VMT). This information would likely vary by region, meaning that it might be desirable to have fees vary from region to region for equity purposes. Additional factors that could influence the flat fee rate include

population and/or commercial density, projected variations in trip generation rates, and availability of other transportation options such as transit. Regional modeling could provide the basis for these types of VMT projections.

In implementing a flat fee based MBUF system, an implementing entity might choose to offer a variety of VMT "plans" to drivers similar to wireless plans. For example, MBUF assessment could occur as part of low mileage, moderate mileage, high mileage, or even unlimited mileage plans where the flat fee rate would vary accordingly. This would provide an element of choice that will be particularly attractive to those drivers that make relatively few trips. To prevent fraud, an MBUF program that allows plan selection would have to verify mileage by some means, either through odometer readings or the use of an OBD.

Lump sum annual payments could prove financially burdensome for many persons. It would be reasonable to provide a system that allows payments to be made annually, quarterly or monthly. Quarterly or monthly payments could be based on actual mileage or projected mileage. If based on projected mileage, reconciliation between projected and actual mileage could be made annually. The same method could be used with quarterly payments. Transportation utility fees, which have been implemented in various parts of the United States, could be used as a model for this type of system. Further, methodologies used to develop VMT estimates for transportation impact fees could be employed in estimating VMT.

Manual Odometer Readings

A manual odometer reading is the simplest approach to accurately assess mileage under an MBUF system without the use of estimation. The change in the odometer reading from one time period to the next is simply multiplied by the per-mile fee and the MBUF is calculated. While the simplicity of the system is a major benefit, there are offsetting factors. Use of manual odometer readings would not allow differential charging by facility or time of day. While there would be some benefit from a transportation demand standpoint, incorporation of time of day and facility pricing would greatly enhance the demand management element of an MBUF system.

The need for manual odometer readings also presents an element of inconvenience to both the driver and the collecting agency. However, multiple locations could be "certified" by the state to perform these inspections. This would increase convenience for drivers, and might be offered by these locations at no cost to the state. If reporting requirements were kept to a minimum then the effort required to provide this service would be minimal and offset by the provision of other services by the vendor in conjunction with the inspection. Reporting requirements could be minimized through the use of online systems that, for enforcement purposes, would require a certified login for inspectors in conjunction with vehicle specific information such as the license plate number and/or or vehicle identification number (VIN).

Depending on the frequency of odometer readings, lump sum payment could be burdensome in the same way as it could be under a VMT system. However, payment options as described above for VMT systems could also be used for odometer read systems.

It is also possible to develop a hybrid between an estimated VMT system and a manual odometer read system. Under such a system VMT can be estimated for interim payments, and an odometer reading is then used to remove any discrepancy between estimated and actual mileage.

OBD II/GPS/Cellular Systems

The operation of OBD II/GPS/Cellular Systems were previously described in Section 4, Technology Support for MBUF. While these systems introduce complexity into the MBUF process, they also have significant advantages. All of these systems can and likely would operate in an automatic manner. Inconvenience to users would be minimized, and data would be provided to the collecting agency in a manner that facilitates billing and collection. Additionally, GPS and cellular systems, and potentially OBD II systems, are able to collect data by time of day. This allows the use of time of day pricing and/or facility pricing significantly improving demand management capabilities.

Charge Computation

Charge computation refers to processing data collected during assessment in order to determine an amount owed by the user. Depending on how the system is designed, this stage may occur entirely on board the vehicle, through a third party, a customer service center, another administrative account office, or other trusted entity.
There are several possibilities for computing the charge:

- Processing an estimated charge with vehicle and location lookup tables;
- Retrieving the raw data from the vehicle and processing it in a billing (host) center;
- Processing the usage data within the on-board vehicle device itself; or
- Retrieving usage data and sending it to a third party, where it is processed before being sent to a billing office.

Systems for charge computation can either be "thick" client or "thin" client. This refers to the amount of processing of data that occurs in the vehicle, versus the amount of data processing that occurs at a collection/billing center. It is also possible for the system to be a hybrid or to work in the thick and thin modes for different clients simultaneously.

In a thin client computation system little, if any, data processing occurs within the vehicular OBU. All data collected by the OBU is uploaded out of the vehicle for processing. Depending on the technology used, a thin client system might, in addition to mileage information, send information on time of travel and location. The remote fee calculation system would then use this information to determine the appropriate MBUF. The advantage to this system is that only minimal capabilities are needed in the onboard system, increasing system flexibility. This could serve to lower the cost of any onboard equipment.

In a thick client computation system, a significant amount of data processing occurs within the unit in the vehicle. OBUs in a thick client system could perform all toll calculations and forward only the total amount due, assuming that the OBU is loaded with sufficient information on rates and relevant geography. The amount due could relate to an individual trip multiple trips, or for all travel over a given time period. While greater operational capacity is required from the onboard system, given the trend in computer and electronics pricing, the cost of an onboard

system capable of thick client operations is not as significant an issue as it would have been even a few years ago.

In a thin client system that records mileage, trip route, and time, a record exists at the billing center of virtually all the travel undertaken by driver. While protections can be put in place to safeguard this information, "tracking" movements is a significant privacy concern for many potential MBUF users. A thick client system can address many of these concerns by keeping detailed location data within the vehicle and calculating an amount due, even if fees vary based on facility and time of day. Under a thick client configuration, very little information on an individual trip is forwarded out of the vehicle compared to a thin client configuration. While fraud is certainly a bit greater concern with a thick client system, if proper business rules are set up to require data to be maintained in the onboard system for a specified period of time, perhaps 90 days, to allow audits when necessary, the potential for fraud is reduced. While an audit would decrease the level of privacy, it is far different than all information on all trips being provided to a central database.

Hybrid systems are certainly possible with the onboard device completing some of the calculations a thick client system would do, but the actual toll is calculated at the billing center. If the system were developed in such a way that incoming transmissions were identified as either coming from a thick client or a thin client, programming a single system to handle inputs from both types of clients should be possible.

Vehicle-to-Back-Office Communication

Communications refers to the transmission of pricing related information from the user to an administrative back office. This back office is then responsible for accounting, invoicing, and collections. The communication options are not mutually exclusive and could be implemented in combination with each other and include:

- Manual odometer readings, or manual OBD II data download; most typically at vehicle registration or annual inspections.
- Automated detection-based transmission through localized infrastructure, such as roadside beacons or tolling gantries, and sent to a billing center.
- Automated wide-area transmissions, downloading data from vehicles within a large radius and forwarding the data to a back office.

Using odometer readings or OBD II data, an MBUF system can be implemented on the majority of vehicles in the United States fleet with no additional in-vehicle capabilities. It is recognized that some type of alternative system for vehicles manufactured before 1996, or for those few vehicles otherwise without an OBD port would be needed; however, the number of vehicles of this type in the overall US fleet is decreasing annually.

While mileage information is available from either the OBD II or vehicle odometer, most vehicles do not have a built-in method for transmitting this information. It is possible however that this information be collected manually either at an annual inspection, during vehicle registration, or, possibly, at a series of authorized inspection stations.

Automated detection-based transmissions would occur through RFID/DSRC technology as previously described. There is a significant advantage to this system in the fact that some infrastructure is in place in tolling facilities, but selection of this type of data transmission would likely require a significant investment in additional roadside information readers to insure adequate geographic coverage.

Some pilot programs have used RFID/DSRC data transmission, and the model developed could be adapted to an area wide MBUF system. At fueling stations, vehicles participating in the Oregon pilot used DSRC to transmit mileage information to readers located at the fueling facility. A system of this type would be especially advantageous for MBUF systems that were implemented as an alternative to traditional fuel taxes. Using this type of system, not only can data be transmitted to the billing center, but the fueling station can be alerted that no fuel taxes should be collected for that transaction.

Automated wide-area transmissions have also been discussed previously. This is the most flexible of the potential communication systems, and is based on practically ubiquitous deployment of cellular systems. This is also likely to be the most expensive in terms of vehicle equipment. However, with prices on cellular communication devices falling significantly, and the already high market penetration of cellular devices, pricing is less of an obstacle than it was only a few years ago.

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APPENDIX B: STAKEHOLDER INTERVIEW SCRIPT

The first series of questions serve as an introduction of the individual interviewed as well as the role their organizations play in transportation policy in Colorado.

1. What is your role in the organization?

2. Who does your organization/entity represent?

3. To what extent do your constituents have a stake in the state's transportation system?

The next series of questions pertain to how important transportation and mobility are in regards to the interviewed organizations.

4. What does your organization envision for the future in terms of the state's transportation system?
    a. Is Colorado on the right path to achieving this vision?
    b. How does transportation funding affect this vision?

5. What is your perspective on the level of transportation finance in Colorado?
    a. Is the level of revenue generation sufficient to achieve your organization's vision of the transportation system?
    b. If insufficient, do you have a sense for how underfunded the system is?
    c. If sufficient, do you believe this will be maintained into the near future?

6. What is your understanding of how Colorado highways and roads are financed? Are you concerned about any specific method of finance? If so, what are your concerns?

Next, we present the projected state of transportation finance in Colorado (with emphasis on existing systems of revenue collection), and, the concept of alternative mechanisms of finance, with a particular emphasis on the stages (models) of mileage-based user fees – starting with fairly simplistic adjustments to vehicle registration fees to flat-fee by mile to "smart" mileage fee calculation. This presentation will be fairly simplistic, so as to serve as a primer for the MBUF concept.

7. Based upon what you have just seen and what you know independently, do you believe that Colorado's transportation funding system is at a point where a change in revenue collection is warranted?
    a. If so, what mechanisms are most attractive to your organization?
    b. If not, what measures do you look to that would indicate we had approached that threshold?

8. MBUF are a way to collect revenue based on travel, as a possible alternative to the motor fuel tax. So that we're clear, individuals would pay a fee based on the vehicle miles traveled that they drive, creating a link between the impact of the vehicle on the roadway infrastructure and transportation funding. There are many ways to measure the fees,

which we'll discuss in a moment. At this point, do you have any questions about the concept of mileage-based user fees?

9. What are your initial reactions to these ideas? How would your constituents likely react to these concepts?

10. What do you see as the benefits to switching to a funding system based on user fees? What do you see as potential problems or barriers with such a system?

11. If such a system were to be enacted, do you think it should augment the motor fuel tax, or, replace the motor fuel tax?
    a. If replace, what are the main barriers facing any attempt to replace the fuel tax? How would you recommend overcoming those barriers?
    b. If augment, what are the main barriers to adding another layer of fees upon existing systems? How would you recommend overcoming those barriers?

Finally, mention that the Colorado Department of Transportation may be interested in investigating the application of mileage-based user fees on a limited scale. This may include either limited implementation on electric vehicles (who do not pay into the highway user fund through motor fuel taxes) or in a pilot program applied to volunteers.

12. Would your organization like to be involved in the design of such an application study?

13. What sort of issues would your organization like to see addressed in the limited scale demonstration, if mileage-based user fees are to be pursued as a Colorado statewide funding strategy?

14. How would you recommend approaching the public about the purpose and need for such a demonstration? How would you recommend approaching the public about mileage-based user fees?

15. Do you see any particular concept of implementation (e.g., vehicle-class registration fees, flat-fee collected by vehicle metrics, variable-fee collected by GPS and/or smartphone, etc.) as having the greatest likelihood for success in obtaining public acceptance? What about that concept makes it acceptable?

16. If you were the one deciding, how would you choose to pursue new financing for transportation in Colorado?

APPENDIX C: FOCUS GROUP SUMMARY REPORT

In March of 2013, researchers with the Texas A&M Transportation Institute (TTI) conducted focus groups in Colorado to assess public perceptions of various alternate funding mechanisms for meeting Colorado's transportation infrastructure needs. Participants in these sessions discussed how Colorado currently pays for transportation infrastructure, the state's long-term transportation funding needs, issues with the current funding system, and provided feedback on several alternative funding systems.

A total of three focus groups were conducted. One session was held in the city of Brush, located in rural, northeast Colorado. The other two sessions were held in Denver. All of the sessions were advertised for public involvement via TTI's Facebook page. Craigslist ads were also set up to recruit participants in both the NE Colorado (Brush and surrounding communities) and Denver areas. Additionally, contacts were made with the Brush Chamber of Commerce and local library to post flyers and newsletter announcements for the Brush session. The same was done in the cities of Fort Morgan, Sterling (Logan County) and Akron (Washington County), which are adjacent to Brush. An ad was placed in Fort Morgan's semi-weekly newspaper that ran in three consecutive editions. Participants for the Denver sessions were recruited predominantly by placing an advertisement in the "Event Gigs" category on the Denver, Colorado, Craigslist website. For all sessions, TTI researchers selected participants in a manner that ensured that the participant pool was representative of the state of Colorado in terms of gender, race/ethnicity, education, and income.

Each session was managed by a single TTI moderator assisted by a note taker. A representative from Parsons Brinkerhoff was on hand at each session to provide technical expertise in response to participant inquiries but was otherwise not involved in the sessions.

Knowledge of Transportation Funding and Finance

After introductions, each focus group session opened with a discussion of how transportation investments in the state of Colorado are funded. The moderator made sure to note that the discussion was to be oriented around the funding of major interregional and interstate highways; not local roads or small rural facilities.

Participants were asked to complete two questionnaires. The first was designed to gauge initial participant knowledge about the fuel tax and asked two questions: 1) True or False – Fuel taxes go up when the price of fuel goes up, 2) True or False – State fuel taxes have not increased in the last 20 years. Participant responses to these questions are shown in Figure 5. There was some confusion among participants as to the wording of the first question. Some were unsure as to whether the question was asking if fuel tax revenues go up or if fuel tax rates go up in response to increasing fuel costs. The question was asking if fuel tax revenues increase along with fuel tax prices.

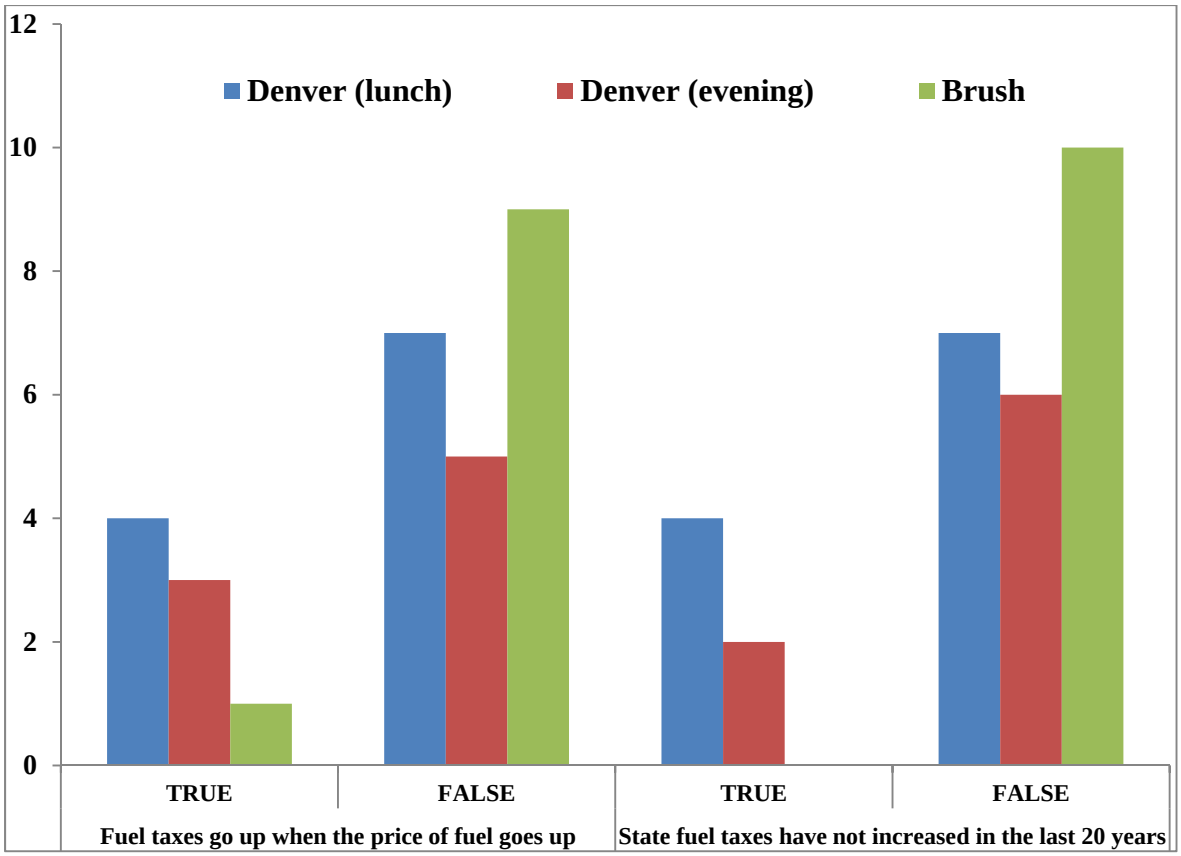


FIGURE 5: PARTICIPANT RESPONSES TO FIRST QUESTIONNAIRE

The answer to the first question is false. Fuel taxes are an excise tax on the physical quantity of gasoline purchased; not the purchase price. Therefore, a gallon of gas yields the same tax revenue regardless of the price of the fuel. A majority of participants in each of the sessions correctly answered this question, with the Brush session having the highest percentage of correct answers. The answer to the second question is true. A majority of participants in each of the sessions answered this question incorrectly. None of the Brush focus group participants answered this question correctly.

The second questionnaire was oriented around assessing participant use and perceptions of various forms of technology. Participants were asked to rate on scale of one to five (with one being “not at all” and five being “very likely”) whether they agreed with or would do the following:

- Purchase items online
- Use cell phone for internet
- Credit cards adequately protect my privacy
- I am satisfied with my internet provider’s privacy protection
- I utilize credit cards regularly
- I am satisfied with my credit card privacy protection
- Cell phone companies adequately protect my privacy
- I utilize a cell phone for calling
- I pay bills online

- I am concerned about online privacy
- I have internet access at home
- I use a GPS device for driving

Average scores for each of the focus group sessions are shown in Table 7. Participants were most likely to indicate that they had home internet access and regularly utilize a cell phone. Participants were generally less likely to trust the privacy protections offered by their credit card company relative to the protections offered by their internet service providers and cellular service providers.

TABLE 7: AVERAGE PARTICIPANT SCORING OF QUESTIONNAIRE 2

	Denver (Evening)	Denver (Lunch)	Brush	Total
Purchase items online	3.7	4.1	4.3	**4.1**
Use cell phone for internet	4.4	4.7	3.4	**4.2**
Credit cards adequately protect my privacy	2.7	3.5	3.5	**3.3**
I am satisfied with my internet provider's privacy protection	3.4	3.3	4.1	**3.6**
I utilize credit cards regularly	3.6	3.5	4.0	**3.7**
I am satisfied with my credit card privacy protection	3.1	3.3	3.8	**3.4**
Cell phone companies adequately protect my privacy	3.4	3.5	3.8	**3.6**
I utilize a cell phone for calling	4.4	5.0	4.7	**4.8**
I pay bills online	4.0	4.9	4.4	**4.5**
I am concerned about online privacy	3.7	3.9	4.3	**4.0**
I have internet access at home	4.7	4.9	4.7	**4.8**
I use a GPS device for driving	4.3	4.7	3.2	**4.1**

After these questionnaires were completed by participants, the moderator initiated the focus group with a general discussion of transportation funding in the state of Colorado. The moderator first asked participants how state highways were funded. Only one participant in the Brush focus group and one participant in the Denver lunch session specifically stated fuel taxes or gas taxes. Most participants in all of the session indicated that highways were paid for with taxes in the general sense. A few participants in each session stated that highways are paid for with "federal grants" but did not specify where they thought the funding for these grants came from. Tolling was also mentioned in each of the Denver sessions as a source of highway funding. Other sources of state transportation funding that were mentioned by participants included "government bonds."

Participants were next asked if they were aware of any ongoing transportation funding and financing issues in the state such as what might be discussed in local media. Participants in both Denver sessions stated that they either did not hear much about transportation or, if they did, it was in the context of specific construction projects. For example, one Denver participant stated that CDOT often provides information to the public about how construction will impact travel, while another stated that they heard a lot about specific projects being funded with stimulus

funds. This contrasts with what was expressed by participants in the Brush focus group, who stated that they were aware of issues with how the state funds transportation programs. One participant stated that they had heard about funding issues and agreed that there was a problem, as Colorado's road system is in bad shape relative to neighboring states like Nebraska. The poor condition of Colorado roadways relative to its neighbors was recurring theme in the Brush session and was expressed by several participants. However, Brush participants appeared to believe that the cause of the funding issue was not with funding sources but rather how the funds are expended. This will be discussed in more detail in subsequent sections of this report.

The Fuel Tax

After the initial period of discussion on transportation funding, the moderator passed out an information sheet containing general information on how the state of Colorado funds transportation infrastructure investment, basic information on the fuel tax, and data related to the long-term sustainability of fuel taxes. The complete "Fuel Tax Basics" handout is provided in the appendix to this report. Participants were given several minutes to review this information before the moderator reinitiated discussion.

Most participants in the Brush focus group had not known that fuel taxes were assessed on a per-gallon basis, even though they had generally given the correct answer to the first question on the questionnaire. One of the Brush participants stated that it would make more sense to have the fuel tax assessed on the purchase price of the fuel, like a sales tax. There was some agreement among other participants that this would be preferable, but other participants believed that this would make gasoline less affordable.

Discussion in the Denver sessions on the fuel tax information sheet was varied. There was no consensus as to the preferred structure of the fuel tax. In the lunch session, one participant noted that the structure of the fuel tax was problematic because there is increased demand for facilities in the area but drivers are not generating revenue in proportion to that demand. This participant believed that revenue should be tied to use as opposed to fuel consumption. However, another participant stated that fuel taxes fall heaviest on those that have vehicles with very low fuel efficiencies, and that since Colorado residents tend to drive more trucks and SUVs then the current structure made sense.

Another issue discussed in the sessions was that of how much the average driver pays in fuel taxes, both in terms of weekly/monthly/yearly expenditures and on a per mile basis. The fuel tax handout provided to participants contained a table (as shown in Figure 6 below) that allowed for the estimation of what each driver pays on a per mile basis in fuel taxes and, depending on how much the driver travels, how much in fuel taxes they pay per week, month and year. Reactions to this were, like other fuel tax related topics, varied. There was no census in the Brush session as to whether the average amounts paid were fair and reasonable. One participant noted that the price paid per mile is likely higher on average in rural areas, since rural residents would be less likely to own a new car and have to travel further. Most participants in the Denver sessions were surprised at how little they paid in fuel taxes. Most had assumed that they paid a greater amount. However, as in the Brush session, there was no consensus as to whether the amount being paid by each participant was fair and reasonable.

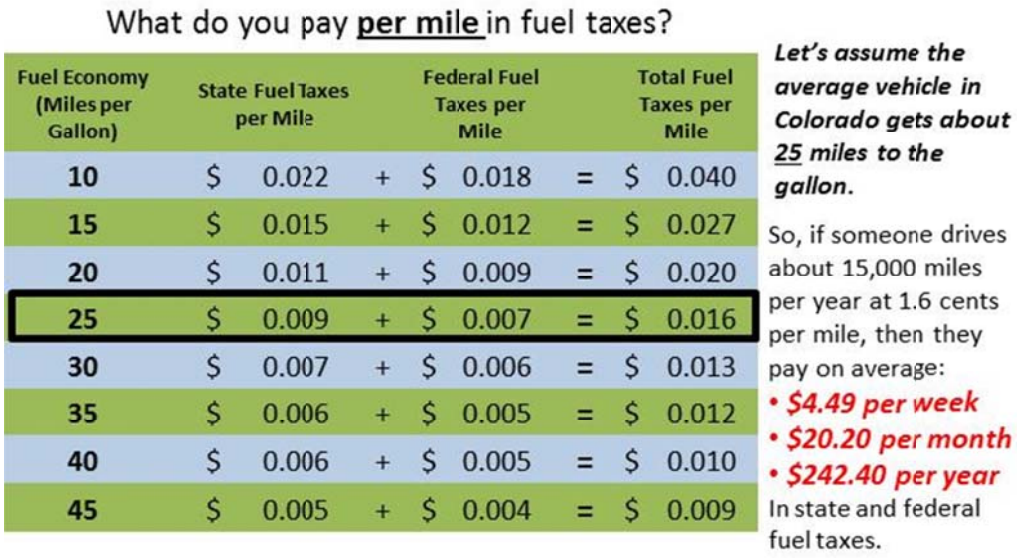


FIGURE 6: FOCUS GROUP HANDOUT - FUEL TAXES PAID PER MILE

Funding Programs

On the handout provided to focus group participants was a pie chart, shown in Figure 7, depicting the split in transportation state funding allocations between highways, transit and other programs. This graphic produced a notable split between the groups. A majority (though not unanimous) of the Brush focus group participants strongly disapproved with the allocation of nine percent of transportation to mass transit, with one participant stating that they were "offended" that the allocation was so high. Most of the participants expressing their disapproval of transit spending stated that there were no transit services in their area and they did not benefit from that type of spending. Many of these participants were careful to note; however, that transit is beneficial in areas where it is viable but that the users should be primarily responsible for the burden of supporting it. These sentiments stood in stark contrast to the opinions expressed in the Denver sessions, where transit was utilized by a far greater percentage of participants. Five of the 11 Denver lunch session's participants used transit to get to focus group session. One Denver participant even stated that they thought spending on highways was too high and asked "how much can you really spend on highways?" A participant in the Denver lunch session stated that people without cars need to have travel options, while another stated that the amount spent is low considering that transit usage has gone up "exponentially."

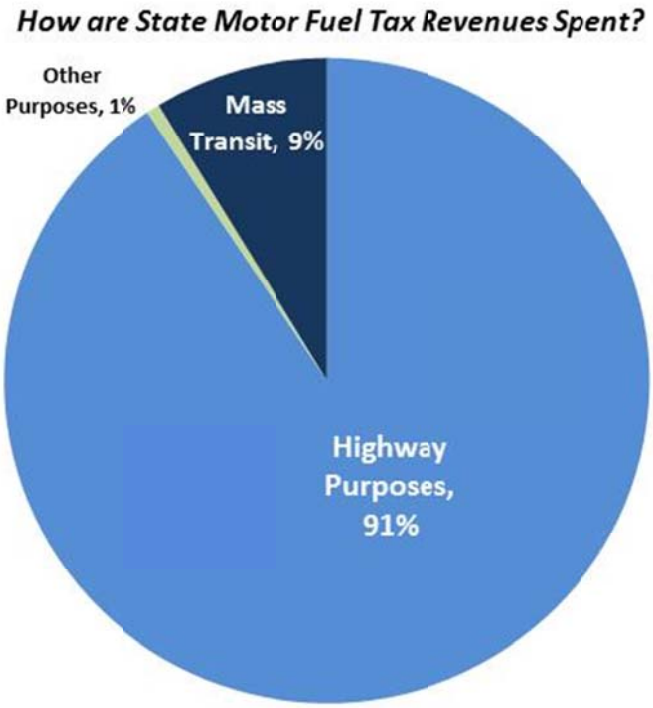


FIGURE 7: FUEL TAX HANDOUT - ALLOCATION OF STATE TRANSPORTATION FUNDS

Issues related to geographic inequity were raised continually by the Brush focus group. There was a feeling among most participants that facilities in urban areas, the Front Range, and facilities serving the tourism and ski industries are given a higher priority over rural facilities. The Brush participants generally believed that the state should place a higher value on rural mobility and adequately maintaining rural facilities given the importance of the farming and ranching sector to the state economy. Current funding and project development practices were not seen as promoting economic vitality in the region.

Confusion about the planning process, in terms of how projects are selected for funding and developed, was evident in all of the sessions. The planning process was not viewed as being rational. For example, several participants in each session made comments about facilities in their area being worked on that did not seem to warrant the attention. Similarly, participants in each section highlighted projects in their area that were in need of work but were not getting attention. As a result of these perceived discrepancies in priority, participants generally believed that programming decisions were based on factors outside of actual need. In many cases participants believed that the project programming process was unduly influenced by consultants, and that too many engineers were used on projects. The perceived excess of consultants and engineers was seen as unnecessarily complicating the project development process and a major contributor to waste of available funds. This was a major and recurring theme when discussing shortfalls in the Brush focus group. Confusion as to how the state prioritizes and programs projects was evident in both Denver sessions as well but there was not as much of a focus on waste in the system and specifically waste on consultants and engineers.

. There was general agreement in the sessions that transportation funding mechanisms are currently insufficient for meeting the state's needs and that they will likely be unsustainable in

the future. However, in most cases this judgment was qualified with arguments that the state is not properly utilizing available revenues. This sentiment was particularly evident in the Brush focus group, where the aforementioned theme of government mismanagement of tax dollars was invoked repeatedly. Assertions were repeatedly made that the facilities in most need of repair, such as those with the highest traffic volumes, were not getting the attention they deserve.

Long-term Issues

One of the charts shown on the fuel tax basics handout showed the estimated long-term percentage change in vehicle miles travelled (VMT) per person relative to fuel taxes collected per person. This chart, as shown in Figure 8, was provided to illustrate that fuel taxes may be insufficient to fund transportation infrastructure investments in the long term, as VMT will increase slightly in the long term while fuel taxes collected per person will decline.

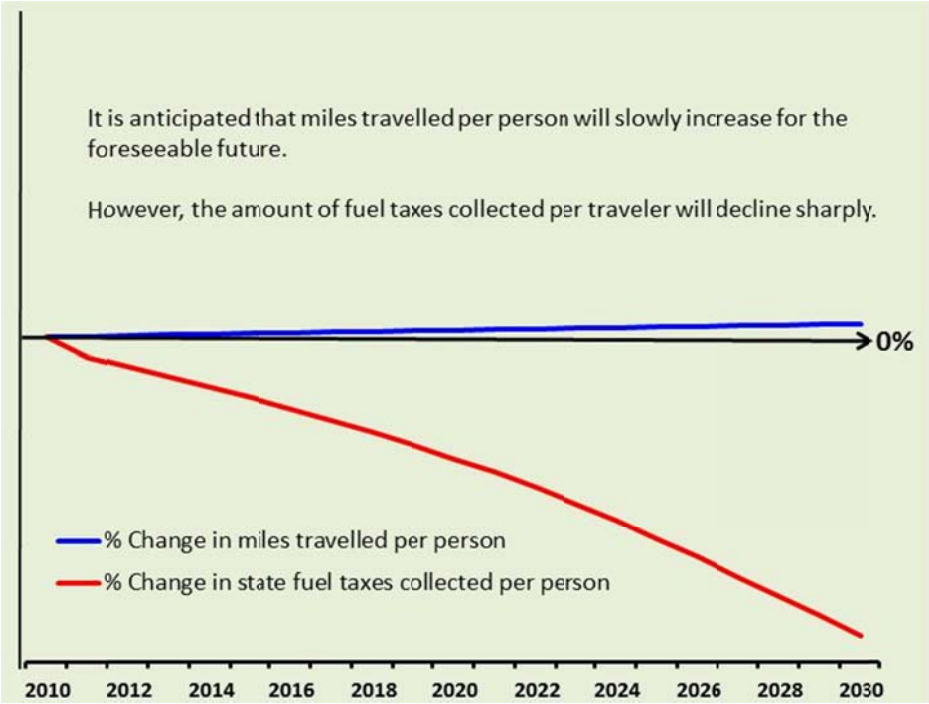


FIGURE 8: FUEL TAX HANDOUT - LONG-TERM CHANGES IN VMT AND FUEL TAXES COLLECTED PER PERSON

When asked why the trends shown in the chart might be occurring, participants in all three sessions indicated that the likely cause was continual increases in fuel efficiency. In each of the three sessions it was one participant who stated that the gap was likely due to increasing fuel efficiency and other participants agreed with that assertion.

However, the penetration of hybrids, electric vehicles and other low-paying or non-fuel tax paying vehicles was not viewed as a threat to transportation funding by the Brush focus group participants. While they did believe that the drivers of these vehicles should pay for their use of the roadway network, most Brush participants did not believe that there are, or would be, enough of these vehicles on the roadway to pose a significant threat to transportation funding. One participant even stated that these types of vehicles are “rip-offs.” Participants in the Denver sessions were split as to whether such vehicles would significantly impact long-term revenues.

Long-term Needs

After discussing the basics of state transportation funding and finance, focus group participants were provided information related to long-term needs and the shortage of revenue to address those needs as shown in Figure 9. There was some slight confusion in all of the sessions as to what the information actually meant. For example, participants in the Brush session were unsure of how to interpret congestion levels, while some participants in the Denver evening session were unsure of how to interpret pavement condition. However, a Parsons Brinkerhoff representative was on -hand as a technical expert to answer any questions participants might have about the information.

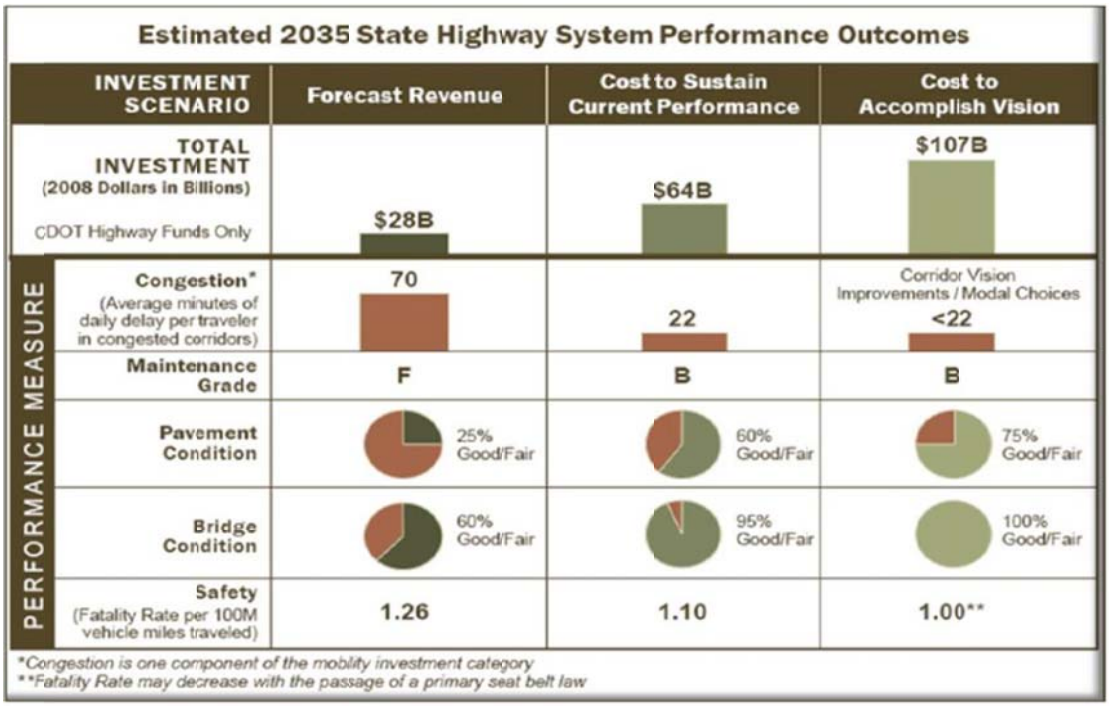


FIGURE 9: FOCUS GROUP HANDOUT - COLORADO NEEDS ASSESSMENT AND REVENUE GAP

There was general agreement in all of the sessions that the information presented illustrated that Colorado does indeed have a long-term transportation funding issue in that needs are unlikely to be met under the current funding system. One participant in the Brush focus group stated that "there is never going to be enough money," while another in the Denver lunch session wondered how the state will ever address these shortfalls given their magnitude.

While there was general agreement in all sessions that Colorado has a transportation funding issue, there was disagreement as to the implications of this. To participants in both Denver sessions the information was accepted as evidence that some changes are needed in the way Colorado invests in transportation infrastructure. One participant noted that more toll roads were likely, while another stated that private developers, such as those responsible for the construction

of sports stadiums, should step in to help fill the gap. Another proposed that other state revenue sources such as income and property taxes should be used to fill the gap.

Participants in the Brush focus group; however, viewed the information as confirmation of their beliefs that current funding sources are being wasted. One participant stated that the state has to "audit everything and cut the fat," noting again that too much money was spent on engineers. Another referenced previous information on the allocation of state funding and stated that less money should be spent on transit. At one point the moderator asked the group to assume that the state had made significant improvements to the efficiency of the project development process, in essence "cutting the fat," and to propose other solutions to these funding issues. One participant simply stated that taxes need to be raised, while another proposed taxing corporations to fill the gap. Another participant proposed expanding domestic drilling and increasing fuel taxes.

Road User Fees

After discussing Colorado's transportation funding system and the state's long-term needs, the moderator turned discussion towards potential alternatives to the current system. Participants were told that they would be discussing road user fees; and specifically some different ways of charging drivers on a per-mile basis.

There was a sentiment in the Brush focus group that mileage fees would penalize rural residents for choosing to live in the country. Participants stated that they had to drive further for goods and services such as medical care and shopping, and would therefore be "slapped" with a higher fee. One participant noted that she had several children who require regular visits to doctors that were located many miles away, and that the mileage fee would likely be excessive for her family.

Additionally, the Brush group did not feel that a mileage fee, of any type, would address the primary problems with the transportation funding system: wasteful spending and misaligned priorities. This sentiment was reinforced in much of the criticism levied by these participants against the various business models subsequently presented in the session. For example, most of the systems were seen as too expensive from an operational and administrative standpoint, essentially amounting to government job creation. Several of the systems were characterized as administrative "nightmares."

Participants in the Denver sessions were more open to the idea of charging based on use, as many believed that a system based on miles travelled would be fairer to drivers than the current system. However, this sentiment was not unanimous, and even those participants who expressed support for the various user fee models discussed in the session indicated that they had misgivings about them.

Additionally, there was minority sentiment expressed in all of the sessions that transportation infrastructure should be funded with general fund revenues as opposed to user fee revenues like the fuel tax or tolling. Participants who expressed this view, of which there were only one to two in each session, believed that the transportation system benefits everyone regardless of whether they drive on it. They therefore believed that it is more appropriate to fund transportation from general fund sources such as income and property taxes.

Registration Model

The first road user fee model presented to focus group participants for feedback was the registration model. Participants were told that under this concept, the motor fuel tax would be supplemented with revenues generated from changes in state vehicle registration fees. Drivers would be assessed a vehicle mileage fee at vehicle registrations that would be based on average fuel efficiency of their vehicle, model year, and the location of the registration. This would effectively raise registration fees for more fuel efficient vehicles that are currently underpaying for road usage on a per mile basis.

The first reaction to the registration model in all three sessions was that it would create a disincentive for people to purchase fuel efficient vehicles and would penalize drivers who choose to "go green." There was not much pushback against these assertions from other participants with the exception of one participant in each of the Denver sessions. In the lunch session, one participant stated that while the owners of very fuel efficiency vehicles would indeed be paying more in registration fees, they would be saving significantly more money in fuel costs over the year. This participant did not believe, therefore, that an increase in registration fees for these vehicles would necessarily dissuade people form purchasing them. Only one other participant in that session was convinced by this argument. Additionally, one participant in the Denver evening session stated that they did not think that the increase in vehicle registration fees for more fuel efficient vehicles would be that much relative to other costs of vehicle ownership.

One participant in the Brush focus group stated that varying the rates on a county-by-county basis would influence where people choose to live. This statement was challenged by another participant who did not feel that fees and taxes such as this really influence where people choose to live.

Participants in all three sessions stated that Colorado already has very high vehicle registration rates. As a result, many viewed an additional increase in rates, even applied only to highly fuel efficient vehicles, with apprehension. However, even with all of these criticisms participants noted that the registration model would still address the issue of fuel efficient vehicles not paying as much as other drivers for road usage.

Facility Tolls

Participants were next presented with the "facility tolls" model. Under this model, drivers would be assessed road use fees for using high-demand facilities such as interstate or US highways in a manner similar to tolling. Low-demand roads, such as local streets or rural county roads would not be tolled. Revenues generated by this system would supplement the fuel tax. Vehicles using the tolled facilities would have to have a transponder.

In all three sessions there were participants who initially supported and opposed this model. In the Brush focus group, one participant simply stated that "tolls are evil," to which another participant replied that they are a "fair way to collect from the user." There were, in fact, participants in all three sessions who expressed variations on these themes. However, most of the discussion oriented around the potential effects of implementing such a system and questions about how such an implementation would even occur.

For example, one of the major concerns with this model in all three sessions was the potential for traffic to be diverted to non-tolled facilities. This was particularly true for participants in the Denver sessions, who worried that traffic volumes could increase significantly on arterials and other local roads that they regularly utilize. One participant noted ominously that "if you toll one road you have to toll all the roads" in order to prevent this from happening. A participant in the Brush session confirmed the fears of the Denver participants by stating that if major highways through Denver were tolled then they would likely travel exclusively on non-tolled roads when passing through the area. Brush participants were also concerned about their own lack of alternatives. Participants noted that they do not have many route options for intercity travel.

There was slight opposition to charging for road use through tolls while maintaining the fuel tax. One participant in the Brush focus group stated that they would feel as if they were being "ripped off" if they had to pay a toll to use a road while that road was also receiving funding from fuel taxes. A participant in the Denver lunch session had a similar sentiment, stating that it is not right to tax people for road use through their fuel purchases while charging a toll for the use of major highways.

On additional concern raised by participants in all three sessions was the issue of how to charge out of state travelers. Participants did believe that out of state drivers would have the necessary equipment for toll assessment, and therefore did not support the idea of a road user fee that would only be paid by Colorado residents. Participants did not have any recommendations on how this issue might be addressed.

Odometer Reading

The third pricing system presented to participants was the odometer reading-based system. Under this system, the state fuel tax would be discontinued and drivers would instead be assessed a vehicle mileage fee based on a reading of the vehicular odometer. The amount due would be paid on a periodic basis and the system would support numerous different payment options.

The odometer reading-based system enjoyed strong initial support in all of the sessions. Of the systems discussed thus far it was generally perceived as being the most fair, as it was based on actual road usage but did not resemble tolling.

One issue with the odometer reading-based system that was cited by participants in all three sessions was that Colorado drivers would be charged for mileage accrued outside of the state. Thus, the system was seen as penalizing drivers who made out of state trips. Participants noted that in order for them to fully support such a system there would need to be a way to account discount out-of-state mileage. Given the attention that participants gave to charging for out of state mileage, it is interesting to note that the issue of charging ranchers for travel on their own land, which would occur under the odometer reading-based model, was only raised by one participant and it was during the Denver lunch session.

Participants in both of the Denver sessions noted that the system would likely be easy to evade due to the perceived ease of tampering with (or "rolling back") odometers and the perceived prevalence of odometers simply not working. Participants expressing these views were not in the

majority of either of the Denver sessions but no other participants in either session objected to the statements.

Additionally, as with the facility tolling system, participants in all three sessions questioned how out of state travelers would be charged under this proposed system. This was seen as a potentially problematic aspect of the system given the amount of tourism the state attracts.

Global Positioning System-based (GPS)System

The final mileage fee configuration presented to focus group participants was the GPS-based system. Under this model, the state fuel tax would be phased out and some sort of GPS-equipped technology would be used to assess miles travelled and levy a fee. The device used could be a cell phone, in-vehicle navigation device, or some other device. Participants were told that the pricing system would use the location data gathered by the in-vehicle devices to only levy fees for miles travelled within the state of Colorado. Participants were also told that all computations would occur on the GPS device and that no data regarding location would be sent to the government.

Privacy issues with the GPS model were immediately expressed in all of the sessions. The term "big brother" was mentioned in both the Brush and Denver evening session and participants in the Denver lunch session expressed concerns about government "tracking" drivers. It is important to note that these concerns were expressed even though the description of the system stated that no location data would be sent out of the vehicle. In both of the Denver sessions participants pointed out that the government already has the capacity to "track" people through their smart-phones. In the Denver lunch session this assertion was countered with the argument that drivers can choose to have a smart-phone, which is different than a governmental entity requiring a driver to have a certain technology installed in their car for tax assessment purposes.

The moderator asked each of the sessions about possible ways to overcome privacy issues. One possible solution, presented by the moderator, was for private entities to handle any information related to road usage as opposed to a governmental entity. Participants in both the Brush and Denver lunch sessions stated that this option was even worse, noting that such information would likely be used to sell drivers various goods and services that they don't need. Additionally, the moderator asked about whether a GPS-based road user fee system could be implemented on a voluntary basis. There was general skepticism that such an approach would work. As one participant in the Brush focus group stated: "Who would volunteer for this?" The moderator also asked participants if the ability of the GPS device to provide services outside of fee assessment, such as navigation, might increase the attractiveness of the GPS system. Most participants did not feel that this would be sufficient inducement to support the system; particularly since those services are already available in various other forms. A final option that was discussed for the GPS-based system was for drivers to be able to pre-purchase mileage in a manner similar to purchasing cell phone minutes, but there was little support for this option in any of the groups.

Concerns were also expressed about the technology itself. Participants in the Denver evening session observed that it would be easy to simply turn the GPS technology off in order to avoid payment. A participant in the Brush focus group stated that the GPS device he currently uses got

him lost on the way to the focus group session. Others in the session echoed this concern about the accuracy of GPS in levying charges.

There were also issues with how the technology would be paid for. Participants in the Brush session wondered who would bear the cost of supplying the requisite GPS equipment: the state or drivers. Participants in the Denver evening session noted that there could be equity concerns, as lower income drivers are less likely to have smart-phones and the burden of purchasing an in-vehicle device would be greater for them.

A final criticism that was levied against the GPS-based system in all three sessions was that the system would not capture revenue from drivers outside of Colorado. Participants did not believe that it was fair for only Colorado drivers to solely bear the burden for infrastructure development, particularly given the state's popularity among tourists. There were participants that noted that any fee system that captured additional revenue from tourists would likely be opposed by the ski industry.

Focus Group Preferences for Mileage Fee Implementation

After discussing the four alternate funding models the moderator asked participants to discuss their preferred options.

The preferred option in the Brush focus group was for the registration fee model. There were no participants who expressed support for any of the other funding systems presented. Participants believed that the registration-based model provided fewer opportunities for fraud on the part of drivers and appeared to be the lowest of the options in terms of administrative costs. Participants indicated that this option might warrant further evaluation by the state of Colorado but they wanted more information as to why alternate funding systems are being considered and who would be involved with implementing them.

Opinion on preferred funding options was split in the Denver lunch session. Four of the ten participants favored the vehicle registration model, which was deemed to be the most feasible. Five participants favored the odometer reading-based model, which was generally believed to be the most fair to drivers because it more accurately accounted for mileage. There was general consensus among the participants that alternate funding mechanisms warrant further examination by the state of Colorado. Participants also indicated that the state should provide more information about the costs associated with developing, operating and maintaining transportation infrastructure. Several participants indicated that the public does not have an accurate view of what such activities actually cost.

The clear preference among the Denver evening session was the odometer reading model, with only one participant selecting the vehicle registration model and no participants selecting the GPS or facility tolling systems. Participants generally believed the odometer reading-based system to be the most fair, even though participants acknowledged that the system would count out-of-state mileage. Participants generally believed that the state should continue to evaluate alternate funding mechanisms, particularly in light of the information presented at the session detailing long-term needs.

Conclusions from the Focus Groups

The following general conclusions can be drawn from these focus group sessions:

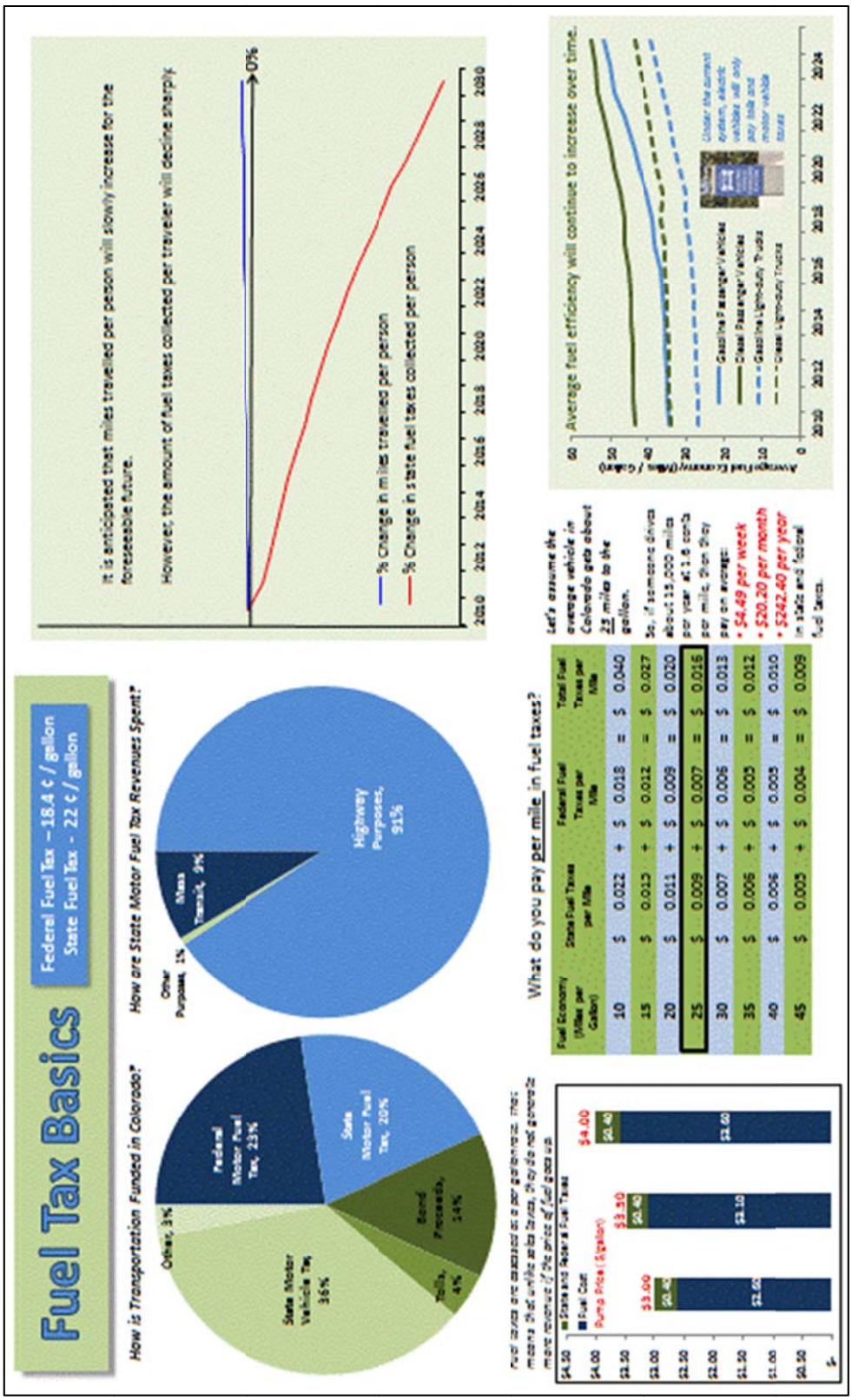
- **Alternate funding mechanisms warrant further examination** – Participants in all three sessions generally believed that the state should continue to examine potential alternatives to the current transportation funding system. However, participants also believed that there needs to be a strong focus on eliminating waste in the current funding system and that the project prioritization and programming process should be simplified.

- **Public education efforts should include information about how projects are developed** – Based on the results of these focus groups, it can be expected that a significant portion of the public will resist consideration of alternative funding mechanisms until perceived inefficiencies in the current system are addressed. Much of this perception of waste can be tied to the complexity of the project development process. Making information available and, more importantly, accessible to the general public will help to dispel some of the misconceptions the public has about how transportation projects are carried out.

- **Simplicity and low cost administration are the most important factors to consider** – There was a clear preference in all of the sessions for systems that were simple and low cost. Any new funding system developed by the state should strive to be easy to understand from the perspective of the driver and deployed at relatively low cost.

- **Charging out of state drivers is a major concern** – One concern that was consistent across all of the road fee models was that participants could not see how out-of-state drivers would be charged. If a new transportation funding system is developed it will have to address how out-of-state drivers would pay.

APPENDIX D: FOCUS GROUP HANDOUT: FUEL TAX BASICS



APPENDIX E: FOCUS GROUP HANDOUT: MILEAGE FEE MODELS

Vehicle Registration Model

Key Components:

- Maintain the motor fuel tax as collected
- Increase vehicle registration fees for those vehicle types that do not pay an equivalent share for their road use

How It Works:

- Vehicle registration fee would be estimated by vehicle model's fuel efficiency rating, year of manufacture, and location of registration
- Highly fuel efficient vehicles will pay a registration "gap" fee that accounts for fuel taxes not paid due to infrequent (or non-existent) fueling
- Fees could range as high as a few hundred dollars per year for electric and other vehicles that do not pay motor fuel taxes

Facility Tolls Model

Key Components:

- Maintain the motor fuel tax as collected for maintenance and safety requirements
- Pay for new freeway lanes or reconstructed freeways by collecting tolls.
- Unimproved freeways and state highways not on the freeway system would not be tolled.

How It Works:

- Vehicles would either have a toll transponder for toll payment or have tolls billed to their vehicle's registration address once per month
- Drivers would pay a toll on improved freeways. For example, if 10 miles of a freeway like I-70 was rebuilt or a new lane was added to **I**-25, a toll of $2 would be charged for using those freeways

Odometer-Based Mileage Fee Model

Key Components:

- Eliminate motor fuel taxes
- Pay for all road use through a “per-mile” fee.
- Pay only a flat fee per mile

How It Works:

- Mileage would be recorded by odometer readings at vehicle registration renewal / emission inspection
- Vehicle owners could pay an estimated amount every month (like electric or water fees), annually at vehicle registration, or through a periodic assessment.

GPS-Based Mileage Fee Model

Key Components:

- Eliminate motor fuel taxes
- Pay for all road use through a “per-mile” fee.
- No fee collected for out-of-state travel

How It Works:

- Mileage would be recorded by your GPS device (such as your smartphone) so that you are not assessed a fee when traveling outside Colorado.
- All computations of how much you owe is done on your GPS device – no data is sent about where you have been; only how much you owe.
- If you do not own a smartphone or have a GPS device, one will be provided for you.
- Vehicle owners could pay their actual amount used every month, annually at vehicle registration, or through a periodic assessment.