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Vehicle Miles Traveled (vmt) Fee Financing Alternatives: Lessons Learned and Future Opportunities

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VEHICLE MILES TRAVELED (VMT) FEE FINANCING ALTERNATIVES:

LESSONS LEARNED AND FUTURE OPPORTUNITIES

A Thesis Presented

by

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ABSTRACT

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State Departments of Transportation (DOTs) today are seeking financing alternatives so that transportation infrastructure investments can become less dependent on the amount of fuel U.S. drivers consume. Because the fuel tax is no longer viewed as a sustainable and stable option, other financing alternatives are being considered. One such alternative includes the vehicle miles traveled (VMT) fee. Examples of such VMT fee alternatives include: 1) collection using an onboard diagnostic system (OBD), 2) collection at the fuel pump using an OBD in conjunction with GPS technology, and 3) collection at a vehicle inspection station using the OBD.

This proposed research has two primary objectives: 1) to conduct a comparative review of VMT fee alternatives and their data collection methods, payment collection processes, expected costs and revenues, and anticipated challenges; and 2) to examine the suitability of these VMT fee alternative for consideration in Massachusetts. The major results and conclusions are the fuel tax, if increased and reviewed annually, is a viable short term solution and that a VMT fee should be considered further as part of a long

term strategy. It is expected that the results of this research will be of interest to Federal and State DOT personnel and policy makers.

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CHAPTER 1

INTRODUCTION

Transportation is the infrastructural backbone of the economy. As infrastructure ages and deteriorates, chronic funding shortages threaten the longevity of the transportation system network. The Interstate Highway System and other major roadways in Massachusetts are well over fifty years old and been largely under maintained. Since these roadways are used for every day services, they are forever wearing down. [1]

Massachusetts legislation chose to develop new (and often desirable) transportation projects, but at the expense of maintaining the existing system. The Transportation Finance Commission found that many transportation agencies in the state are running structural deficits and resorting to short-term quick fixes that hide systemic financial problems because there is not enough revenue. [1]

For Massachusetts it was estimated that over the next twenty years the cost to maintain their transportation system exceeds the anticipated resources available by $15 to $19 billion. The estimate does not include any necessary expenses or enhancements which include a debt of $1.5 billion. Future funds are delegated to decreasing this debt from projects that have already been built. [1]

1.1 Massachusetts Transportation Funding

Massachusetts transportation system is funded from five sources and administered through two separate funds. Funding sources include state taxes, motor vehicle fees, federal funds, toll revenue and bond proceeds. These funding sources are maintained within the Commonwealth Transportation Fund (CTF) and Massachusetts Transportation

Trust Fund (MTTF) to segregate and fully account for transportation-related revenue and expenditures. [2]

The CTF retains revenue from the motor fuels tax, a dedicated 0.385% of the state sales tax and motor vehicle fees. The fund is used to pay debt service associated with highway maintenance and construction projects and provides funding for the operation of the Massachusetts Department of Transportation (MassDOT). It also receives federal reimbursement generated by Massachusetts's expenditures on transportation construction projects. The fund was established as part of the historic transportation reform Act and replaces the former Highway Fund, beginning in fiscal year 2011, as the principal source of transportation-related revenues and expenditures for the Commonwealth.

The following are brief descriptions and estimated revenue of the five funding sources that contribute to Massachusetts's transportation system:

- **State Motor Fuels Tax**: The Commonwealth collects 21-cents per gallon excise tax on gasoline and diesel fuel, estimated at $663.6. million in fiscal year 2011. Of the amount, 20.96 cents (99.85%) is credited to the CTF for transportation related purposes, including the special obligation (gas tax) bonds. One hundredth of one cent (.15%) is credited to the Inland Fish and Game Fund.
- **Sales Tax**: .385% of the state sales tax, estimated at $296.7 million in fiscal year 2011, is dedicated to the CTF.
- **Motor Vehicle Fees**: The Commonwealth also collects vehicle license, registration and drivers license fees, estimated at $495.3 million in fiscal year 2011.

- **Federal Funds**: The Internal Revenue Service (IRS) collects the federal fuels excise tax (18.4 cents per gallon and 24.4 cents per gallon diesel fuel) which are deposited in the Highway Trust Fund. These funds are allocated by the Federal Highway Administration (FHWA) as matching funds for projects on the State Highway System and by the Federal Transit Administration (FTA) to the MBTA and RTAs for local bus and rail programs. FHWA funds are allocated directly to the Massachusetts and expended by MassDOT for road, bridge and other transportation improvements. FTA funds are allocated to the MBTA and RTAs for rail, bus and other transit projects. [2]

The MTTF is the primary governmental fund for the MassDOT. It receives annual subsidy from the Commonwealth Subsidy from the state Revenue Source, tolls, and other fee based revenue collected by MassDOT. Below are descriptions of these revenue sources. Most budgeted expenditures of the department are paid for from this trust fund.

- **Commonwealth Subsidy from State Revenue Sources**: The Commonwealth's annual operating budget will include a transfer of funds from the CTF to the MTTF for the operation of MassDOT and supplemental assistance to the MBTA and RTAs.
- **Toll Revenue**: The reform act requires that revenues collected, on the "Western Turnpike" (I-90 west of Route 128) and the Metropolitan Highway must be spent only on the tolled system from where the revenue was raised. These tolled revenues fund the operation and maintenance of the Metropolitan Highway System and the Western Turnpike as well as debt service associated with the

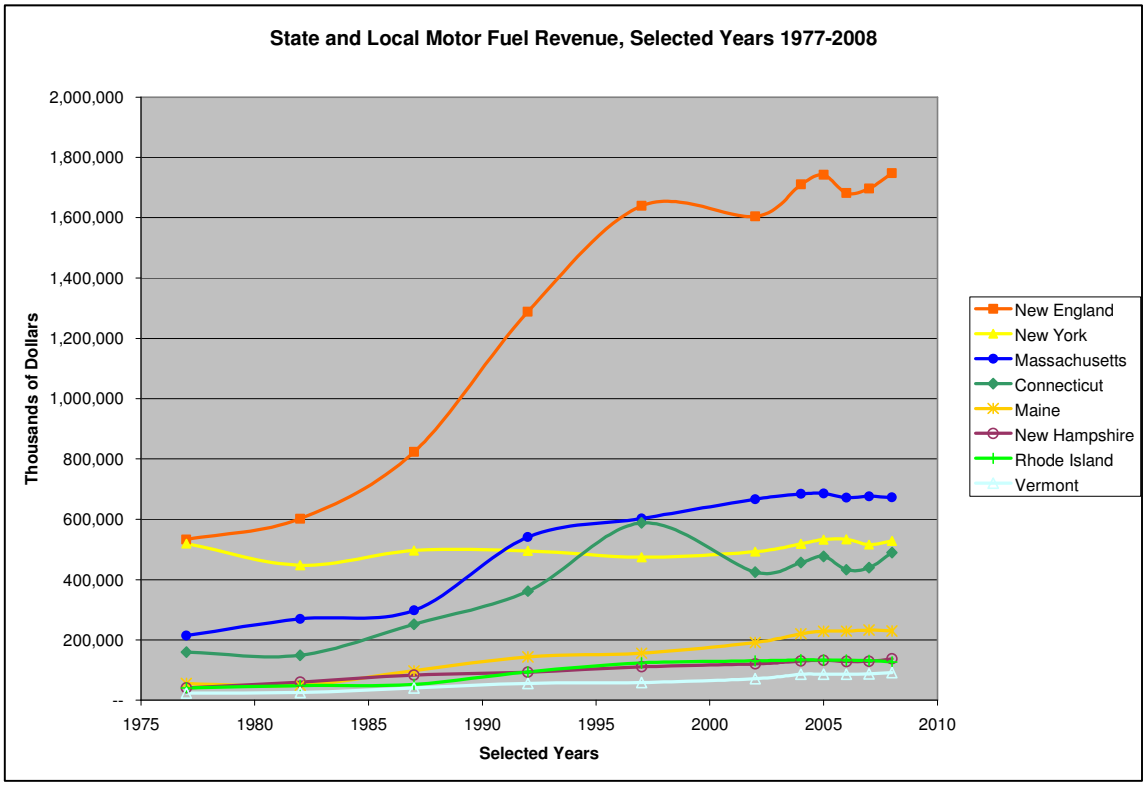
former Massachusetts Turnpike Authority, including debt incurred in the construction of the Central Artery/Tunnel Project.

- **Federal Grants**: In addition to federal gas tax revenues, federal agencies such as the FHWA provide funding for other types of projects such as Intelligent Transportation Systems designed to provide additional information to travelers. These funds are often restricted to specific projects.
- **Permits and Fees**: MassDOT collects revenues from permits and fees for the use of state highways, facilities and other sites owned by the department. These are unrestricted revenues available to support all divisions within the department. [2]

1.2 Massachusetts State Motor Fuel Tax

In recent years, due to the economy and fuel prices, Massachusetts and across America travel habits have changed. In reaction, a large population is driving newer, more fuel-efficient vehicles or switching to hybrids and electric vehicles. An increase in fuel efficiency means a decrease in fuel consumption, and subsequently revenue generated by the fuel tax has not increased in more than 6 years for Massachusetts. The revenue generated has had slight deceases. Represented in Figure 1 is the state and local motor fuel tax revenue for New England and New York. This leads to a funding gap to maintain, renovate, and construct the roadways.

Figure 1: State and Local Motor Fuel Revenue, Selected Years 1977-2008



Source: "Motor Fuel Tax Revenue." Tax Policy Center Home. Tax Policy Center: Urban Institute and Brookings Institute. <http://www.taxpolicycenter.org/taxfacts/displayafact.cfm?Docid=401>.

Also in Massachusetts, the fuel tax is failing to generate revenue because it has not been adjusted in eighteen years. These past eighteen years have seen major changes in the economy causing inflation; however the fuel tax has not been appropriately adjusted. [3] The Massachusetts fuel tax is 23.5 cents per gallon. Of that, 2.5 cents goes to an underground storage tank fund. Inflation has eroded the 21 cents such that its buying power is only 14 cents, therefore it has lost almost one third of its value since 1991. The state fuel tax once equaled 18 percent of the cost of a gallon of fuel. Now, it represents about 7 percent. The state fuel tax is a fixed amount, not a percentage of the price of a gallon. Currently, there is no component of the fuel tax that increases with inflation, unlike most other taxes. [1]

It was recommended in the Massachusetts Transportation Finance Commission Report, that an immediate increase to the Massachusetts state fuel tax of 11.5 cent per gallon would restore the value of the fuel tax to what it was in 1991. The fuel tax would increase to 35 cents per gallon. The average vehicle in Massachusetts consumed 576 gallons of fuel in 2005, representing $135 per year in fuel tax payments. The proposed 11.5 cent increase would cost an average of $66 per year per vehicle. This equals $1.25 a week, less than 18 cents a day. This increase will produce an additional $345 million per year. [1]

After this increase, it is suggested that the fee be adjusted annually to match the change in the consumer price index (CPI), (which has averaged 3 percent per year over the past two decades). This series of annual increases over the 20 years would produce an additional $5.5 billion, for a total of $12.5 billion in new revenues raised from the fuel tax.

To put these increases into perspective, the report also indicated that Massachusetts is currently among the lowest of its neighboring New England states and New York, and over 5 cents per gallon below the average of these states. Even with the proposed 35 cents increase, Massachusetts would still be below the rates in many states. Table 1: Fuel Taxes in 2007 for Neighboring States shows the difference between the current fuel tax and the proposed fuel tax for Massachusetts compared to the neighboring states. These comparisons assume that other states take no action to raise their own fuel taxes, which is unlikely because they are all facing deteriorating road and bridge systems in need of additional resources. [1]

Table 1: Fuel Taxes in 2007 for Neighboring States (Cents per Gallon)

State	Fuel Tax Rate
Vermont	20
New Hampshire	20.6
Massachusetts (today)	**23.5**
Maine	28.3
Rhode Island	31
Massachusetts (by 2008 after 11.5 cent Increase)	**35**
Connecticut	37
New York	42.4
Neighboring States Average	***28.8***

Source: Transportation Finance in Massachusetts: An Unsustainable System. Rep. Massachusetts Transportation Finance Commission

When the Finance Commission Report was released in 2007 several New England states including New York have since increased their state fuel tax. Table 2: State Motor Fuel Tax; Difference from 2005-2011, shows these increases. Connecticut has the largest increase of 24.6 cents per gallon. Figure 1 depicts Connecticut's revenue increase due to the increased fuel tax. Connecticut, along with all New England States except Massachusetts, has increased their state fuel tax. This data shows that Massachusetts is behind on raising their state fuel tax. With the proposed Massachusetts state fuel tax of 35.5 cents per gallon, Massachusetts would still be among the lowest state in New England.

Table 2: State Motor Fuel Tax, Difference from 2005-2011 (Cents per Gallon)

State	2005	2007	2011	Difference (2005 to 2011)
Massachusetts	23.5	23.5	23.5	0
New Hampshire	18	20.6	19.6	1.6
Rhode Island	30	31	33	3
Maine	25.2	28.3	31.5	6.3
Vermont	17.5	20	26.6	9.1
New York	31.9	42.4	49.5	17.6
Connecticut	25	37	49.6	24.6
Neighboring States Average			*33.3*	

Source: Gasoline Tax Rates by State http://www.gaspricewatch.com/usgastaxes.asp, http://www.californiagasprices.com/tax_info.aspx

Functionally the fuel tax has become a flat tax, and has a diminishing impact each year while more vehicles use the roads and consume fewer gallons. Less fuel consumption per mile results in less revenue per mile but the use of the roads has not reduced. Therefore, the way America's transportation network is financed must change to accommodate this new reality. The current fuel tax is no longer a sustainable option for the state to rely on. [3]

The time is approaching for the state and nation to change its policy so the infrastructure is less dependent on the amount of fuel the driving population consumes. Massachusetts needs to turn to a different source of income, such as a Vehicle Mile Travel fee, or a VMT fee. The VMT fee is also commonly referred to as a distance traveled base charge, or a road user fee. This fee, independent of the fuel tax, is dependent on the total amount of miles a vehicle travels, which the user will then be charged for. The fee collected will generate a principle constant revenue source. This source of income will allow for states to fund transportation related projects, such as road

maintenance, reconstruction, and other infrastructure needs. The VMT fee is a viable source of revenue for Massachusetts to consider implementing.

CHAPTER 2

OBJECTIVES OF THE RESEARCH

This research includes two primary objectives: 1) to conduct a comparative assessment of alternative VMT fee approaches and their data collection methods, payment collection processes, expected costs and revenues, and anticipated challenges; and 2) to examine the suitability of these VMT fee approaches for consideration in Massachusetts. It is expected that the results of this research will be of interest to State DOT personnel and state transportation policy makers.

CHAPTER 3

BACKGROUND

This section presents a comparative review of three different VMT fee alternatives being considered in the United States. These VMT fee alternatives include: Alternative 1: collection of a VMT fee using an onboard diagnostic system (OBD) with additional in-vehicle devices; Alternative 2: collection of a VMT fee at the fuel pump using an OBD in conjunction with GPS technology; and Alternative 3: collection of the fee at a vehicle inspection station using existing in-vehicle devices possibly with an OBD. The comparative review includes a brief description of the fee payment collection process, data collection methods and the anticipated costs and revenues as well as other impacts. In addition, other VMT related initiatives in the U.S. are discussed as they pertain to these three alternatives.

3.1 Major VMT Fee Finance Alternatives

3.1.1 Alternative 1: Collection using an Onboard Diagnostic System (OBD)

One pilot project in progress is being conducted is by the University of Minnesota in conjunction with the University's Intelligent Transportation Systems Institute. Table 3 is a summary of this pilot project. The small scale pilot project budget was roughly $6.8 million. The main goal of the project is to evaluate the ability to use an OBD with additional in-vehicle devices. The system is designed to determine the vehicle miles traveled and use VMT as a basis for charging a user fee. This user fee will reflect the use of the roads while ensuring data privacy. [4]

Table 3: Minnesota VMT Pilot Project Summary Table

Method of Collection	Description of Alternative	Where was the Alternative Used	Pilot or Permanent	Implementation Costs	Revenue Projections	Ability to Incorporate Congestion Pricing	Public Response	Implementation Challenges
Collection using an Onboard Diagnostic System (OBD) (Pilot Study at the University of Minnesota)	The main goal of this project is to evaluate the ability to use a standard onboard diagnostic device (OBD-II) to collect data needed in to implement a VMT fee. It will also directly and efficiently determine the vehicle miles traveled and use VMT as a basis for charging a user fee.	Currently being tested in Wright County, MN.	Pilot	A budget roughly equal to $6.8million dollars was set in place for the project. Doesn't explicitly state capital cost or operational cost,. The budget lumps everything together.	Revenue will depend on how high of a mileage fee will be charged. The expected revenue will be used to supply a permanent transportation fund therefore the fee would need to be high enough to achieve this goal.	No	Positive A study was conducted in a phase of the project to understand public acceptance. The public, once given adequate information and questions were answered, supported or grasped the concept better.	Software would need to be upload to the OBD.

The OBD is designed to gather information, such as speed, and the corresponding clock signal necessary to calculate the miles traveled. The device has a standard interface for all passenger car models since 1996. Some VMT data require calculations that extend beyond the capabilities of the OBD. A simple plug-in device installed into the standard OBD interface will handle the necessary calculations. This system design also allows data to be collected by other devices such as a GPS unit. For example, GPS capabilities could be used to implement congestion pricing strategies.

Once the data is collected and calculated, the next step is to charge the driver the VMT based fee. The plan in Minnesota is to structure the fee based on the following criteria: fuel efficiency, vehicle class and weight, facility type, time of day (in congested areas), emission levels, and urban versus rural travel. To collect the fee, the public would receive a bill and make monthly payments through appropriate channels likely using an electronic payment system. For electronic payment the driver uses a credit card, the Vehicle Identification Number (VIN) and a fuel management card. The card allows the data collection station to monitor vehicle usage by its VIN and keep up to date vehicle information such as odometer readings. [4]

An anticipated challenge with this VMT alternative (and possibly others VMT alternatives) is associated with seeking public acceptance. Through a public survey a positive public response was generated as long as the public was given adequate information, questions are answered effectively, and the concept of the system design is well understood. [4] Another potential challenge is installing the additional plug-in devices.

3.1.2 Alternative 2: Collection at the Fuel Pump using an OBD in conjunction with GPS Technology

The State of Oregon's Department of Transportation, in search for alternative transportation revenue sources, initiated a Road User Fee Pilot Program. Table 4 is a summary of this project. The project's total expenses were about $2.9 million dollars. The program's main objective was to collect information to enhance their knowledge on the VMT fee as well as mileage collection data and fee collection methods. The project was designed to determine whether or not there was a feasible way to generate funds within the State of Oregon. [5]

A year long field test examined possible data collection technologies to meet Oregon's system objectives and fiscal needs. Mileage and location data were collected through the vehicle's OBD port and through GPS technology, but lacked the radio frequency (RF) transmission capabilities to facilitate integration with participating service stations. Therefore, these and other features had to be developed and integrated into a single device. The test vehicles were outfitted with a GPS-based receiver that identifies zones for allocation of miles driven within various predefined regions. [6] Using the GPS-based receiver creates the ability to incorporate congestion pricing.

Table 4: Oregon's VMT Pilot Project Summary Table

Method of Collection	Description of Alternative	Where was the Alternative Used	Pilot or Permanent	Implementation Costs	Revenue Projections	Ability to Incorporate Congestion Pricing	Public Response	Implementation Challenges
Collection at the Fuel Pump using an OBD in conjunction with GPS Technology (Pilot Study Conduct by Oregon's Department of Transportation)	The main goal of this project is to collect information to enhance their knowledge on the VMT fee, as well as mileage collection data, and fee collection methods. This will determine whether or not there is a feasible way to generate funds within the state of Oregon.	Throughout Oregon	Pilot There is currently a bill in legislations for full implementation for hybrid and electric vehicles with all vehicles being phased in.	Total project expenses $ 2,935,679	The theory is that revenue will increase over time and eventually be the main revenue source for transportation. It has extensive ability for generation of revenue depending upon the rate structure established by the legislature. After the initial start-up period, however, the mileage fee implemented statewide would begin to generate more revenues than what the fuel tax would be expected to generate.	Yes The pilot program successfully tested congestion pricing by charging participants a higher fee when traveling in the Portland metro area during rush hour.	The pilot program found that participants believed the mileage fee system to be convenient. Participant concerns about protection of personal information during the course of the study started low and satisfaction with privacy safeguards remained high throughout the project. When surveyed, only three participants expressed serious concern with privacy of the system.	One challenge is installing the proper devices in all vehicles to obtain the appropriate information.

The device sent data to a wireless reader installed at participating service stations using a short-range radio frequency communication signal. A fuel pumping station has an existing wireless point-of-sale system, or POS, that generates data, such as the fuel volume sales. Modifying and utilizing this system, the vehicle's mileage data was collected. The owner then could be charged for the vehicle miles traveled at the fuel pump. Participants also had concerns about protection of personal information during the course of the study. Satisfaction with privacy safeguards remained high throughout the project. [6]

Though this project hailed as success, national scrutiny of Oregon's 2007 Road User Fee Pilot Program revealed design challenges and public enmity for the GPS technology employed. The principal design challenge laid within a closed system for mileage data and payment collection. Due to the means of data collection and processing associated with the pay-at-the-pump option, it has a highly-structured data flow model with limited space for adjustments and alterations. Experts noted the technology implemented was not upgradeable, and would become obsolete. [7]

To address these issues, Oregon DOT revised its road user charge model as an open technology platform that allows the marketplace to play a large role in data collection and management of accounts. The state could tap into market forces to allow the public to choose the means by which they report their mileage from approved methods, the on-board technology to suit their needs and the methods of invoicing and payment. The open technology platform allows design of a mileage data collection and payment system to access existing processes familiar and acceptable to the public such as the smart phone, navigation unit and tolling markets. [7]

3.1.3 Alternative 3: Collection at the Inspection Station using OBD

The VMT fee collection would be collected as part of a vehicle inspection program (where available) and would use existing in-vehicle devices including the odometer possibly together with an OBD. These devices would be used to obtain the data needed such as vehicle miles traveled. The VMT fee would be determined during the annual vehicle inspection. Payments would be made possibly in installments over the internet or via the U.S. Postal Service via check or credit card.

In the U.S.17 states, including Massachusetts, require each vehicle to be inspected once a year, therefore inspection station collection can potentially be a cost efficient way to implement the VMT fee by reducing capital and operational cost and generating more revenue. The revenue produced could be considerable depending on the VMT fee rate. If a fee of 2 cents/miles is charged, the revenue potential is over $1 billion depending on the number of registered vehicles and number of miles traveled in the state. Table 5 is a summary of this proposed VMT alternative.

The challenges associated with alternative 3 include creating up to date inspection software to allow for the necessary data collection to charge a VMT fee and transmit the data to a centralized agency.

Table 5: Collection at the Inspection Station using an OBD Summary Table

Method of Collection	Description of Alternative	Where was the Alternative Used	Pilot or Permanent	Implementation Costs	Revenue Projections	Ability to Incorporate Congestion Pricing	Public Response	Implementation Challenges
Collection at the Inspection Station Using an OBD	The approach is to use a standard onboard diagnostic device (OBD) to obtain the data needed, such as speed and the corresponding clock signal necessary to calculate the miles traveled to charge the user a VMT fee. The VMT fee would be tabulated during the yearly safety inspection. Then it is possible for payments to either be collected at the time of inspection or incrementally through the year either monthly or quarterly.	Not yet implemented	Planning	The implementation cost is about $70 million. This is for it to be fully implemented in the state of Massachusetts. For a pilot study the cost would be significantly reduced.	Revenue will depend on how high of a mileage fee will be charged. If a fee of 2 cents/miles is charged, the revenue potential is over $1 Billion dollars.	No	A survey has yet to be conducted	Software would need to be upload to the inspection station computers.

3.1.4 Comparative Assessment

Table 6 provides a comparative review of VMT Fee Alternatives 1, 2, and 3. The review includes a description of the data collected, the system design and devices required, installation details and costs, and payment collection process and in addition assesses the alternatives relative economic efficiency, revenue stability, and the ratio of annual revenue to annual cost. The installation cost is the anticipated expense to install the data and payment collection devices in the vehicle and to administer payment systems. Payment collection describes the payment collection process. Economic efficiency refers to the use of resources to maximize the production of goods and services. It implies an economic state in which every resource is optimally allocated to serve each person in the best way while minimizing waste and inefficiency. Revenue stability is based on the reliability and predictability of a revenue source. If revenue is more stable, it is more predicable and reliable. For example, there will always be vehicles on the road way traveling some distance; therefore with the VMT fee will be revenue generated regardless of how much fuel is consumed creating stable revenue. The variable is rated on whether it is indexed to inflation or not. The ratio of annual revenue to annual cost is to determine if the revenue generated will exceed the annual cost. If this does not occur, then it is not a viable revenue source or would not produce enough revenue to provide for transportation investments.

Table 6: VMT Fee Alternatives 1, 2, & 3 Summary Table

Alternative VMT Approachs	How Data is Collected	What Data is Collected	How the Device is Installed	Installation Cost	Payment Collection	Economic Efficency	Effectiveness	Revenue Compared to Implemnation Cost
Collection using an onboard diagnostic system (OBD)	Data will be collected using an OBD. Such a system would not require roadside data collection or new wireless infrastructure and does not depend on a GPS receiver or longitude/latitude data. (9)	Used to calculate the distance a vehicle has traveled. The OBD stores and reports only the total amount owed for each jurisdiction. No detailed route or time information is collected. (14)	Retrofitting an OBU to a wide variety of vehicles is very difficult process. Modern vehicle electronic systems are often very fragile. (14) All vehicles since 1996 are standard with an OBD but there are still many cars on the road that pre-date 1996.	Medium	it possible to vary rates by vehicle characteristics, state or regional jurisdiction, or small geographic area. Mileage fees could also be allocated among multiple jurisdictions by using the location data. (9) Fee collection could occur by the pay-at-the-pump model, a central billing agency or a debit card system under which fees would be deducted from pre-paid debit cards inserted into the onboard unit. This last option, the researchers say, could help alleviate privacy concerns since it would not be necessary to transmit mileage data for fees to be	Medium to High	Will be index to inflation	Medium to High
Collection at the Fuel pump using an OBD in Conjunction with GPS software	The data from the vehicle would be collected using an OBD installed with GPS software. The information then would be tranfered at the fuel pump for payment. The stored mileage totals from this device would be transmitted wirelessly via short range radio frequency to the gas station's point-of-sale system for application of the mileage fee rates. Integration with current systems can be achieved.	The data collected includes, total miles a vehicle travels and types of roads and networks the vehicle had driven on. The software is capable of tabulating the distance spent on each type of road or network and generating the correct amount the drives is to be billed. Congestion and other pricing options are available. (9)	The OBD would have to be installed with GPS software. Also new software would need to loaded into the fuel pump. The software can be made compatable with the fuel pump operating system therefore there isn't the need for new fuel pumps. (4) (9)	Medium Cost of implementation and administration is low. (9) Retrofitting vehicles with out mileage-calculating equipment, such as the OBD, appears expensive and difficult.	The payment would be collected at the fuel pump. There is the option to have the data sent from the fuel pump to an off shore location and have the driver billed for the milage traveled. (4) (9)	Medium to High	Will be index to inflation	Medium
Collection at an Inspection Station using the OBD	The data is collected by making use of the OBD. The information would then be transferred to the Inspeciton Station computers.	The OBD is used to calculated the total miles a vehicle had traveled, therefore the data collected is the vehicles total milage.	Retrofitting an OBU to a wide variety of vehicles is very difficult process. Modern vehicle electronic systems are often very fragile. (14) All vehicles since 1996 are standard with an OBD but there are still many cars on the road that pre-date 1996. Also new software would need to be installed on to the Inspection Station computers to make them capable of collecting the apporiate mileage information from the vehicles.	Medium/ Low	The payment would be collected at the inspection station or a bill would be sent to the driver to pay monthy or quartiarly. Similar to a utility bill.	Medium to High	Will be index to inflation	Medium to High

3.2 Other VMT Related Initiatives

3.2.1 Electric Vehicles

There are an estimated 56,000 electric vehicles currently in use in the United States. It is estimated that by 2015, a million electric vehicles will be on the U.S. streets. Nissan and Chevrolet are among the leading electric vehicle dealers, with nearly every major manufacturer, such as Ford, planning to introduce vehicles with electric motors in the coming years. Electric vehicles have limited success due to challenges with battery technology, where the max mileage is 100 miles without recharging, creating "range anxiety" – the fear that the car will run out of juice before getting to a battery charger . While drivers of gas-powered vehicles can easily stop at a station to fill up, drivers of electric vehicles currently have no such option. [8]

The companies ECOtality Inc. and Coulomb Technologies are creating peace of mind to electric vehicles owners by installing charging station networks across the U.S. with the assistance of American Recovery and Reinvestment Act (ARRA) funds. ECOtality is tasked with supervising construction of EV projects, the largest elective vehicle infrastructure rollout in the world, installing over 15,000 charging stats in 16 states. Coulomb Technologies has a ChargePoint America programming to provide 4600 public and home stations in nine metropolitan areas by next October. [8]

There are many other companies working to provide an electric grid infrastructure in the U.S. and around the world. A leader in the creation of these grids is Better Place. Shai Agassi founded Better Place in 2007. The vision is to develop a transportation network fueled only by electricity and run it in a similar manner to the mobile phone industry. The premise was to build and sell electric cars inexpensively, making their batteries interchangeable. They will then be able to sell charges, similar to the way

minutes for cell phones are sold. Israel was the leader in pushing for implementation of such an infrastructure, but the Better Place network has expanded to now include Australia, California, Hawaii, Denmark and Ireland. [9]

3.2.2 Taxing Electric Vehicles

An electric vehicle grid is the future for electric cars. By creating a recharging station infrastructure, electric cars will now be allowed to recharge at other locations aside from their home. These stations would create a way to charge a fee on electric cars that are not currently paying into the fuel tax. The tax can be included in the price per kw/hr of electricity, similar to how the fuel tax is included in the price per gallon of gas.

The state of Oregon is looking at a similar approach. Moving past the original pay-at-the-pump model, the state's Road User Fee Task Force now proposes legislation (HB2328) for a vehicle road usage charge to electric and plug-in hybrid vehicle under an open technology platform because these vehicles pay either little to no fuel tax. The task force decided applying a distance based charge to the new fleet would be consistent with Oregon's 92-year-old policy of "users pay for the roads," where Oregon was the first state to adopt the fuel tax in 1919. [7]

The transportation committee adopted amendments to HB 2328 to apply a tax rate of 1.43 cents per mile. This rate is comparable to what an average motor vehicle pays in Oregon fuel tax. The amendments also allowed the Oregon DOT to apply a new tax program to up to 5,000 non-electric volunteer motorists operating vehicles of 10,000 pounds or less. Finally the bill functions under an open system that could allow motorist many options for data generation and payment collection. The bill defines the open technology platform as "an integrated system based on common standards and an

operating system accessible to the marketplace whereby components performing the same function can be readily substituted or provided by multiple providers." [7]

The open technology platform helps solve the privacy concerns that emerged from Oregon's original Road User Fee Pilot Program, previously discussed in the section 3.1.2, by eliminating the mandate for GPS receiver to be placed in vehicles. Rather, HB 2328 requires development of more than one method of collecting and reporting the number of miles traveled and at least one method must not involve vehicle location technology. The bill requires that a vehicle subject to the charge, must be capable of electronically reporting an odometer reading. Still, motorists who want to differentiate their mileage by geographic location could use their own GPS receivers certified by ODOT for that purpose. [7]

The bill on April 4, 2011 to apply a vehicle VMT fee to operators of the emerging electric vehicle fleet advanced to the House Committee on Transportation and Economic Development where six were in favor and two opposed-on an evenly split bipartisan positive vote. The bill now heads to the House Committee on Revenue. If passed by both the house and signed by the Governor, the new road usage tax would become effective January 1, 2014 for 2014 model years and beyond. [7]

3.2.3 Collection Using a GPS On-Board Device

The University of Iowa Private Policy Center in conjunction with the Civil and Environmental Engineering Department and Electrical-Computer Engineering Department is conducting a road user study to collect VMT fee data. Table 7 is a summary of this project. The funds to conduct the evaluation were provided by Congress in a 2005 Highway Bill. It is part of a $16.5 million study financed by the U.S.

Table 7: University of Iowa VMT Pilot Project Summary Table

Method of Collection	Description of Alternative	Where was the Alternative Used	Pilot or Permanent	Implementation Costs	Revenue Projections	Ability to Incorporate Congestion Pricing	Public Response	Implementation Challenges
Collection Using a GPS On-Board Device (Pilot Study by University of Iowa)	The main focus of the study is to make sure that the system is reliable, secure, flexible, user-friendly, and most importantly, cost efficient. The participants will also be evaluated on their experience using the system and how accepting they are of the system. The research will consider drivers' attitudes towards their privacy using the onboard computers.	The first cities involved in the study were Baltimore, MD, San Diego, CA, Austin, TX, the North Carolina's Research Triangle, Boise and eastern Iowa. Cities that later joined were Portland, ME, Chicago, IL, Miami, FL, Wichita, KS, Billings, MT, and Albuquerque, NM.	Pilot	N/A	The VMT if implemented will be an alternate revenue source for transportation funds and will possible used for congestion elevation or pricing.	Yes	The only public response for this project is through the participants. They will be asked to evaluate their experience, once completed.	Implementation challenges include public acceptance and implementation costs. Costs include establishing an outreach process to inform the public on the need and benefits of such a VMT based approach, setting up a payment center to collect, store the mileage data, to process payments, and procuring in-vehicle devices including the OBC unit and the associated software.

Department of Transportation—it received funding in the 2005 federal highway bill, SAFETEA-LU (Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users) —and pooled funds from 15 state departments of transportation. [10]

The main focus of the study is to make sure that the system is reliable, secure, flexible, user-friendly, and most importantly, cost efficient. Another objective of the project is to determine how the VMT fee functions in different states, certain counties, and municipalities. The participants will also be evaluated on their experience using the system and how accepting they are of the system. [10] The research will consider drivers' attitudes towards their privacy using the onboard computers. [6]

There will be about 1,400 participants from six different cities across the United States [10]. The first cities involved in the study were Baltimore, MD, San Diego, CA, Austin, TX, the North Carolina's Research Triangle, Boise and eastern Iowa. Cities that later joined were Portland, ME, Chicago, IL, Miami, FL, Wichita, KS, Billings, MT, and Albuquerque, NM. [6]

The OBD in conjunction with a GPS will calculate the distance the participant has driven within the states, certain counties, and municipalities. The device is similar the in-vehicle device used in the Oregon pilot project, but it will not transfer data and collect a fee at the fueling station. Each vehicle will be categorized by fuel efficiency and given a class identity. The OBD will calculate the total dollar amount that would be owed if the mileage charge were operational based on the distance traveled within each jurisdiction. Each jurisdiction has its own per-mile charge. [10] No actual fee was collect and the participants were compensated for their involvement in the study. [6]

3.2.4 Puget Sound

The Puget Sound Regional Council conducted a pilot project from 2005 to 2007 on congestion based pricing. Congestion based pricing is similar to VMT fee in the devices used to collect the data and track the miles and locations traveled. The project aimed to accurately describe the behavioral response to the congestion-based tolling of roadways, better understand issues of policy related to the implementation of road tolling, and test an integrated system of technical solutions to the problem of tolling a large network of roads without installing substantial physical hardware on the roadside. It received support from the Federal Highway Administration and the Washington State Department of Transportation. [6, 11]

There were 450 participants from 275 households in the greater Seattle region. Each vehicle was equipped with in-vehicle devices featuring GPS receivers, digital roadmaps and cellular communications. For each part of the tolled network, congestion charges were established based on the prevailing congestion levels and time of the day. An allotted travel budget account was created for each participant in the study. Each account had enough money to pay the congestion tolls for his or her expected travel patterns. The in-vehicle devices were used to record their travel and corresponding charges were subtracted from the pre-allotted travel budget. As an incentive to alter their travel behavior, participants were allowed to keep any remaining balance from their allocation at the end of the study. [6, 11]

The summary report offers primary conclusions for the study. According to the report, drivers' response to tolls suggests there is a dramatic opportunity to significantly reduce traffic congestion and raise revenues for investment. This report shows a

successful way to implement congestion pricing. Using the same technology, a VMT fee could be collected that incorporates congestion pricing. [6, 11]

The report warns that installing in-vehicle tolling devices is expensive—an estimated $665 million for installation of equipment in vehicles in the Puget Sound region alone. A large-scale U.S. deployment of a GPS-based road tolling program will depend on proven systems, a viable business model, and public acceptance. The report warns that the public might see road tolling as unfair unless they understand that directly charging users addresses existing inequalities in the transportation system and improves overall economic efficiency. Privacy concerns would have to be addressed concerning the data that leaves the vehicle and what safeguards are in place to limit the data's availability and use. [6, 11]

CHAPTER 4

RESEARCH METHOLOGY AND RESULTS

4.1 Research Objectives

This research includes two primary objectives: 1) to conduct a comparative review of VMT fee alternatives and their data collection methods, payment collection processes, expected costs and revenues, and anticipated challenges; and 2) to examine the suitability of these VMT fee approaches for consideration in Massachusetts. It is expected that the results of this research will be of interest to State DOT personnel and state transportation policy makers.

4.2 Research Tasks and Results

In order to achieve the objectives stated above, the following tasks were accomplished:

Task 1: Conduct a literature review of past and ongoing VMT fee initiatives including research studies and pilot projects with an emphasis on the identification of major VMT fee alternatives being considered in the U.S. The results of this task are presented in Section 3.0.

Task 2: Examine the suitability of the three VMT fee alternatives discussed in Section 3.1 for consideration in Massachusetts. The alternatives are: 1) collection using an onboard diagnostic system (OBD), 2) collection at the fuel pump using an OBD in conjunction with GPS technology, and 3) collection at a vehicle inspection station using the OBD. The fuel tax will also be included for comparison. The results of Task 2 are presented below.

4.3 Research Results

This section of the paper examines the suitability of the three VMT fee alternatives discussed in the previous section for consideration in Massachusetts. The alternatives VMT fee collection methods are: 1) collection using an OBD with additional in-vehicle device for data storage and/or transmission, 2) collection at the fuel pump using an OBD in conjunction with GPS technology, and 3) collection at an inspection station using existing in-vehicle device including possibly an OBD unit. The fuel tax will also be included for comparison.

4.3.1 Qualitative Analysis

A non-numerical method used to determine the suitability of VMT alternatives includes a qualitative analysis. A qualitative analysis consists of potential impacts, challenges, and cost parameters. Potential impacts and challenges associated with each alternative are rated as being high, medium, or low.

Table 8 presents a summary of the potential impacts and anticipated challenges the three VMT alternatives if considered for use in Massachusetts. Impacts related to: revenue potential, revenue stability, cost equity, revenue distribution equity, economic efficiency, and network coverage. Challenges concern costs, privacy security, and fuel efficiency. [12]

Revenue potential is the possible revenue produced by using one of the VMT alternatives. Revenue stability relates to the reliability of a revenue source. For example, the fuel tax is an unreliable revenue source because it is impacted by inflation and has not been increased in two decades. Therefore, the existing revenue from the fuel tax is predictable, but it is not generating sufficient amounts of revenue. If indexed to inflation, the fuel tax revenue levels would be more stable.

All VMT fee alternatives score high on revenue stability because they are more reliable and predictable, provided the rates are reviewed periodically. The fuel tax performs poorly in terms of cost equity, because historically, in most states, it has failed to charge an appropriate road user fee to heavy vehicles in proportion to damage to the roadway surface. Also, it has not been increased in over a decade.

VMT fee based alternatives are said to provide "network coverage" because VMT fees are charged based on odometer readings which are miles traveled on the entire highway network including toll roads, freeways, expressways, collectors, and local streets.

Table 8: Potential Impacts and Challenges Related to Alternative VMT Approaches

	Existing Fuel Tax	**Alternative 1:** Collection using an onboard diagnostic system (OBD) with additional in-vehicle devices	**Alternative 2:** Collection at the Fuel Pump using an OBD in Conjunction with GPS Technology	**Alternative 3:** Collection at an Inspection Station using existing in-vehicle devices
Impacts				
Revenue Potential	Low	High	High	High
Revenue Stability	Low/ Medium	Medium/High	Medium/High	Medium/ High
Cost Equity	Low	Medium	Medium	Medium
Revenue Distribution Equity	Low	Low	Medium/High	Low
Economic Efficiency	Low	Medium/High	Medium/High	Medium/High
Network Coverage	Low	Low	Medium/High	Low
Challenges				
Capital Costs	Low	Medium	Medium/ High	Low/ Medium
Operational Costs	Low	Low/Medium	Low/ Medium	Low/ Medium
Privacy Concerns	Low	Low	Medium	Low
Security Concerns	Low	Low	Medium	Low
Promote Fuel Efficiency?	No	Yes	Yes	Yes

Revenue distribution equity relates to how revenue is collected and distributed. Some argue that the fuel tax does not have distributional equity. The VMT fee alternatives could be designed to achieve distributional equity by allocating some or all of VMT based revenues to each local jurisdiction based on miles traveled in each jurisdiction. This assumes that the miles traveled can be estimated perhaps using GPS technology. The VMT fee collection at the pump in conjunction with GPS

technology scores medium to high at revenue distribution equity because it is the only approach that can provide estimates of miles traveled in each local jurisdiction.

Economic efficiency implies an economic state in which every resource is optimally allocated to serve each person in the best way while minimizing waste and inefficiency. An economic system is said to be more efficient than another if it can provide more goods and services for society with out using more resources. [Ref]

Table 8 also represents the challenges encountered in the implementation of the three VMT fee alternatives. These challenges relate to capital and operational costs, privacy, security concerns, and fuel efficiency. The capital cost is the total cost to initially implement each VMT fee approach. The operational cost is the amount to keep the VMT fee collection process and systems up and running each year. For many users privacy is a major concern. Privacy is the freedom from intrusion from the government or outside party. Security is a concern for the VMT fee system on an operational base. For example, an anti-virus and/or a software program would be installed on the in-vehicle device to protect against the altering of VMT data or retrieving personal information. The preceding criteria will be rated on a low, medium, or high scale. The final criterion is whether or not a VMT promotes fuel efficiency and will be a yes, no, or possibly.

The fuel tax has the lowest capital and operational costs, with the VMT fee collection at an inspection station using existing in-vehicle devices as a close second. Both the fuel tax and VMT fee collection at an inspection station have little or no privacy concerns and both approaches score well in terms of security.

The VMT fee alternative, collection using an OBD with additional in-vehicle devices, is not far behind the fuel tax and collection at an inspection station. Collection at

the fuel pump using an OBD in conjunction with GPS technology would require the largest capital cost, with more operational cost required, and privacy and security concerns, each with a medium rating.

Finally all VMT fee encourage fuel efficiency. In order for it to promote fuel efficiency the tax would need to be indexed to inflation and take into account more fuel efficient vehicles.

Table 9 evaluates parameters including revenue potential, capital cost, operation cost, and other impacts significant to implementation of alternative VMT fee approaches in Massachusetts [12]. The most expensive alternative to implement and operate is collection at the fuel pump using an OBD in conjunction with GPS technology, but does not generate more revenue than the other two alternatives. The least expensive VMT alternative to implement and operate is collection at the inspection station using existing in-vehicle device generating the same revenue as the other two VMT fee alternatives. If the existing fuel tax is modified, proposed fuel tax, the operational and capital cost would be significantly less than a VMT fee alternative.

Table 9: Cost Parameters Related to Alternative VMT Fees

Parameters	Proposed Fuel Tax	Alternative 1: Collection using an onboard diagnostic system (OBD) with additional in-vehicle devices	Alternative 2: Collection at the fuel pump using an OBD in Conjunction with GPS technology	Alternative 3: Collection at an Inspection Station using existing in-vehicle devices
Revenue Potential	About $1 Billion	More than $1 Billion	More than $1 Billion	More than $1 Billion
Capital Costs	About $0	About $130 Million	About $1 Billion	About $45 Million
Operational Costs	Less than $10 Million	About $35 Million	About $110 Million	About $35 Million
Other Impacts	No Significant Impacts is Expected	Reduction in VMT is possible	Both VMT Reduction and Route Shift are possible	Reduction in VMT is possible

4.3.2 Quantitative Analysis – Net Present Value

For the comparative evaluation between alternative 1, 2, 3, and the fuel tax, the NPV was calculated. When calculating the NPV, the capital cost and operational cost are necessary. Table 10 provides a summary of the capital and operational costs for alternative 1, 2, and 3 along with the fuel tax. A detailed breakdown of the capital and operational cost is in Appendix A.

Table 10: Cost Calculations

Collection Method	Cost	
	Capital	Operational
Current Fuel Tax	$ -	$ 1,000,000.00
Alternative 1	$ 131,250,000.00	$ 31,987,500.00
Alternative 2	$ 1,094,500,000.00	$ 112,000,000.00
Alternative 3	$ 43,750,000.00	$ 33,200,000.00

The calculation of NPV requires revenues, interest rates, and compounding years. All of these variables were assumed. The revenues used in the NPV calculations are shown in Table 11: VMT Fee Potential Revenue. The revenue was dependent on the VMT Fee, the average mileage driven in one year by a vehicle in Massachusetts (11,000 mile/ year), and the number of registered vehicles in Massachusetts (5,000,000 registered vehicles). The interest rates chosen were 1%, 3%, 5% and the NPV was calculated assuming 5, 10, 15, and 20 year analysis periods, as shown in Appendix B.

Table 11: VMT Fee Potential Revenue

VMT Fee	Potential Revenue
$0.02/mile	$ 1,100,000,000.00
$0.03/mile	$ 1,100,000,000.00
$0.04/mile	$ 2,200,000,000.00
$0.05/mile	$ 2,750,000,000.00

After the NPV calculations were completed, the next step is to compare the results. Based on the NPV analysis, the best alternative is the one with the highest positive NPV.

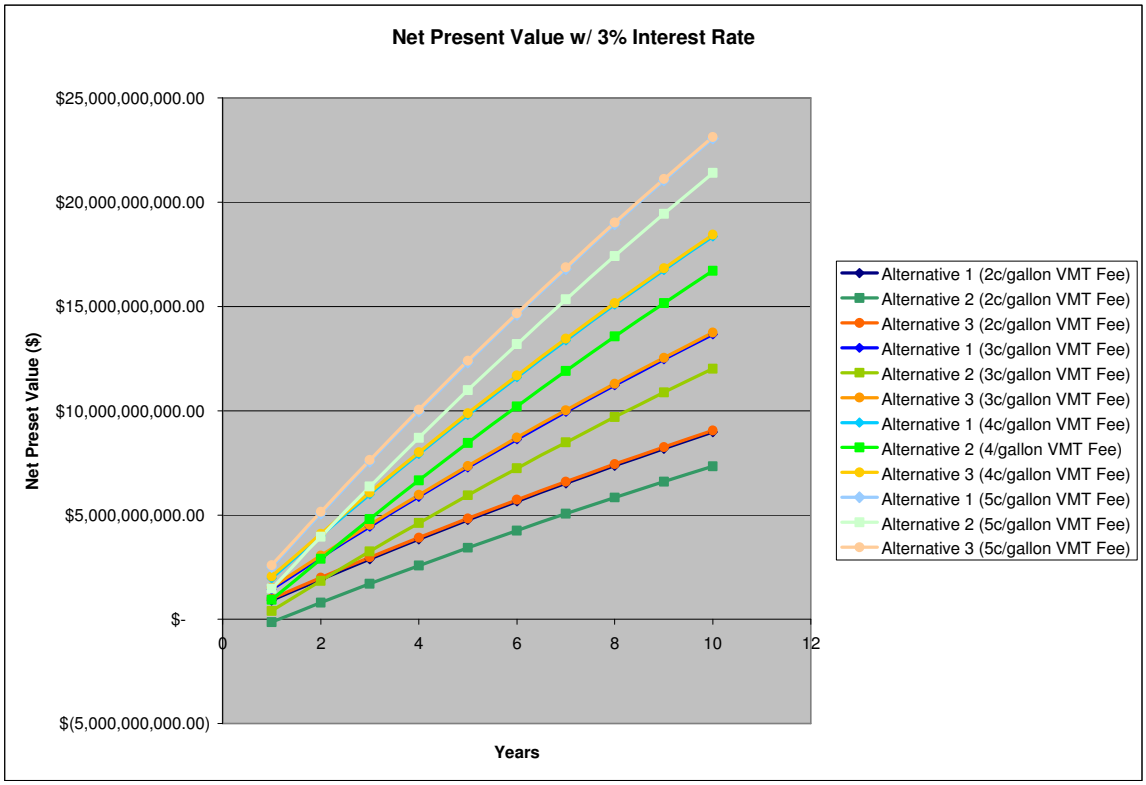
An example of the NPV calculation for an interest rate of 3% with a 10 year analysis period is shown in Table 10: Net Present Value Summary Table. The computations for the values in Table 12 are shown in Appendix C: Net Present Value Sample Calculation. No NPV value for any of the alternatives and fuel tax are less than zero, therefore they are all feasible. The alternative with the highest NPV is alternative 3 with $18 billion. Alternative 1 has an NPV close to Alternative 3 with a difference of $100 million. Figure 1 includes a graphical representation of Table 12 to aid in the NPV comparison. As mention, alternative 1 and 3 have similar NPVs. Figure 1 reinforces this calculation because alternative 1 and 3 are always over lapping, showing how minimal

the $100 million is. A complete set of tables and graphs for the NPV calculations with different interest rates and compounding years are in Appendix D.

Table 12: Net Present Value Summary Table

Net Present Value				
Interest Rate 3%				
Compounding Periods 10 Years				
Collection Method	**VMT Fee Rate**			
	$0.02/mile	**$0.03/mile**	**$0.04/mile**	**$0.05/mile**
Current Fuel Tax	$ 5,646,994,277.95	$ 5,646,994,277.95	$ 5,646,994,277.95	$ 5,646,994,277.95
Alternative 1	$ 8,979,113,257.21	$ 13,670,724,817.44	$ 18,362,336,377.67	$ 23,053,947,937.89
Alternative 2	$ 7,333,340,402.73	$ 12,024,951,962.96	$ 16,716,563,523.19	$ 21,408,175,083.41
Alternative 3	$ 9,056,270,386.27	$ 13,747,881,946.50	$ 18,439,493,506.73	$ 23,131,105,066.95

Figure 2: Net Present Value (NPV) with a 3% Interest Rate



In Section 5.0 below, previously discussed qualitative analysis in section 4.3.1 is used in conjunction with results the NPV quantitative analysis to assess which alternative is the best suited for implementation in Massachusetts.

CHAPTER 5

SUMMARY AND CONCLUSION

Although the current fuel tax is not a perfect financing approach in terms of equity, revenue stability, and economic efficiency, it has been viewed historically by elected officials and the public as an acceptable approach to generate revenues to finance transportation. With modifications, such as indexing it to inflation, the fuel tax may be a suitable approach in the next five years while we continue to identify ways to gain public acceptance and to reduce the implementation costs of VMT fee based alternatives.

5.1 Short Term Solution - Fuel Tax

For Massachusetts, the fuel tax, if indexed to inflation, provides the most viable short term approach for meeting the needs of additional revenue. It can serve as the primary source of revenue during the initial time period while the VMT fee, not yet in place, and can serve as an alternative fee for older vehicles that can not be easily converted to collect a VMT fee. The fuel tax may also remain as a "green fee" in order to accelerate acceptance of new, cleaner, and more fuel efficient vehicles.

Based on a recent report by the Massachusetts Transportation Finance Commission, an immediate increase of 11.5 cent per gallon would help restore the value of the fuel tax to what it was in 1991, meaning the fuel tax would increase to 35 cents. The report also indicates that over a 20-year period, given today's level of fuel efficiency and travel patterns, this proposed increase will close the funding gap by about $7.0 billion. After this increase, the fuel tax should be adjusted annually to match the change in the consumer price index (CPI), (which has averaged 3 percent per year over the past

two decades). This series of annual increases over 20 years would produce an additional $5.5 billion, for a total of $12.5 billion in new revenues raised from the fuel tax.

If the concept of moving to a VMT fee is unattractive, it would be possible to generate sufficient revenue from the fuel tax by increasing it at a higher rate than proposed above. An additional one-time increase in the tax of 20 cents in 2017 would raise $6 billion between 2017 and 2026, assuming current fleet fuel efficiency.

However, it should be noted that improvements in fuel efficiency are inevitable, and this will negatively impact fuel tax revenues. If the average vehicle is able to achieve a 15 percent increase in fuel efficiency by 2026, Massachusetts will see a $2 billion reduction in fuel tax collections over the 20-year period, reducing the total collected from $12.5 billion to $10.5 billion. [1] By this time, it is expected that the value produced from the fuel tax will erode to a point where alternative solutions, such as the VMT fee, will be instituted providing additional revenue capacity.

5.2 Long Term Solution - VMT Fee

The VMT fee is suitable to consider as a long term financing approach. The VMT fee collected at the safety inspection station using existing in-vehicle devices is a reasonable choice for states already implementing a periodic vehicle inspection. For this approach, the capital and operational costs are low. A VMT fee collected at the fuel pump using an OBD in conjunction with GPS technology could provide additional features such as congestion pricing, but at greater capital and operation costs. Also, the GPS technology received a negative public response. The VMT fee collected using an OBD with additional in-vehicle devices for data storage and/or transmission may be considered an acceptable approach due to its lower capital and operational cost. The

revenue generated using any of the VMT approaches would be the same, provided that fee rates are adjusted appropriately.

For Massachusetts it was recommended a VMT fee or toll be considered for use on all major highways because these highways provide a level of convenience above and beyond that of local roads. A VMT fee has added benefits because it is a sustainable revenue source, is independent of fuel consumption, and has the potential to promote fuel efficiency. If a VMT fee of 5 cents per mile were in place on Massachusetts's interstate roadway system, a net revenue of approximately $550 million per year ($5.5 billion over 10 years) could be generated, which is about 80 percent of what Massachusetts collected from the fuel tax in 2007 ($675 million). In addition, expanding VMT fee can address the often noted inequity issues associated with the existing toll system. [1]

APPENDIX A

COST CALCULATION BREAKDOWN

	Category	Total Number of Units	Estimated Cost, $ Per Unit	Total Cost for Category, $
Alternative 1: Collection Using an OBD with additional In-Vehicle Devices	Additional In-Vehicle Devices	5,000,000	20	100,000,000
	Fee Processing Clearinghouse	1	25,000,000	25,000,000
	Contingency Fee (10%)			6,250,000
	Total Implementation Cost:			**131,250,000**
	Electronic Transaction Cost	5,000,000	0.05	250,000
	Mailing Expenses	55,000,000	0.44	24,200,000
	Equipment Maintenance of In-Vehicle Device	2,500	15	37,500
	Equipment Maintenance @ FPC	1	1,250,000	1,250,000
	Personnel Salary	125	50,000	6250000
	Total Operational Cost:			**31,987,500**

	Category	Total Number of Units	Estimated Cost, $ Per Unit	Total Cost for Category, $
Alternative 2: Collection at the Fuel Pump using an OBD in Conjunction with GPS Technology	Equipment @ Gas Stations	3,000	15,000	45,000,000
	Central Processing Clearinghouse	1	200,000,000	200,000,000
	In-Vehicle Equipment	5,000,000	150	750,000,000
	Contingency Fee (10%)			99,500,000
	Total Implementation Cost:			**1,094,500,000**
	Electronic Transaction Cost	1,000,000,000	0.02	20,000,000
	Equipment Maintenance @ GS	3,000	1,500	4,500,000
	Equipment Maintenance @ Vehicle	5,000,000	15	75,000,000
	Personnel Salary	250	50,000	12500000
	Total Operational Cost:			**112,000,000**

	Category	Total Number of Units	Estimated Cost, $ Per Unit	Total Cost for Category, $
Alternative 3: Collection at the Inspection Station using existing In-Vehicle Devices	Equipment @ Vehicle Inspection Stations	2,500	5,000	12,500,000
	Fee Processing Clearinghouse	1	25,000,000	25,000,000
	Contingency Fee (10%)			6,250,000
	Total Implementation Cost:			**43,750,000**
	Electronic Transaction Cost	5,000,000	0.05	250,000
	Mailing Expenses	55,000,000	0.44	24,200,000
	Equipment Maintenance @ VIS	2,500	500	1,250,000
	Equipment Maintenance @ FPC	1	1,250,000	1,250,000
	Personnel Salary	125	50,000	6250000
	Total Operational Cost:			**33,200,000**

APPENDIX B

NET PRESENT VALUES FOR ALTERNATIVE 1, 2, AND 3

Alternative 1 Net Present Value Calculations						
Interest Rate (%)	1%	3%	5%	1%	3%	5%
VMT Fee ($)	0.02			0.03		
Year						
1	$ 926,188,118.81	$ 905,655,339.81	$ 885,904,761.90	$ 1,470,742,574.26	$ 1,439,635,922.33	$ 1,409,714,285.71
2	$ 1,973,156,553.28	$ 1,912,359,553.21	$ 1,854,623,582.77	$ 3,056,873,835.90	$ 2,964,767,885.76	$ 2,877,299,319.73
3	$ 3,009,758,963.64	$ 2,889,742,284.67	$ 2,777,212,935.97	$ 4,627,300,827.62	$ 4,445,478,529.86	$ 4,274,999,352.12
4	$ 4,036,097,983.80	$ 3,838,657,557.93	$ 3,655,869,462.83	$ 6,182,179,037.25	$ 5,883,061,679.48	$ 5,606,142,240.12
5	$ 5,052,275,231.49	$ 4,759,934,522.26	$ 4,492,685,202.69	$ 7,721,662,413.12	$ 7,278,773,475.22	$ 6,873,897,371.54
6	$ 6,058,391,318.31	$ 5,654,378,176.95	$ 5,289,652,573.99	$ 9,245,903,379.33	$ 8,633,833,471.09	$ 8,081,283,210.99
7	$ 7,054,545,859.71	$ 6,522,770,074.71	$ 6,048,669,118.09	$10,755,052,850.82	$ 9,949,425,700.09	$ 9,231,174,486.66
8	$ 8,040,837,484.86	$ 7,365,869,004.58	$ 6,771,542,017.23	$12,249,260,248.33	$ 11,226,699,708.82	$10,326,309,034.91
9	$ 9,017,363,846.40	$ 8,184,411,654.93	$ 7,459,992,397.36	$13,728,673,513.20	$ 12,466,771,561.96	$11,369,294,318.96
10	$ 9,984,221,630.10	$ 8,979,113,257.21	$ 8,115,659,426.06	$15,193,439,121.98	$ 13,670,724,817.44	$12,362,613,637.11
11	$ 10,941,506,564.45	$ 9,750,668,210.89	$ 8,740,104,215.29	$16,643,702,100.97	$ 14,839,611,473.24	$13,308,632,035.34
12	$ 11,889,313,430.15	$10,499,750,690.18	$ 9,334,813,538.37	$18,079,606,040.57	$ 15,974,452,886.64	$14,209,601,938.42
13	$ 12,827,736,069.46	$11,227,015,233.18	$ 9,901,203,369.88	$19,501,293,109.47	$ 17,076,240,666.64	$15,067,668,512.78
14	$ 13,756,867,395.50	$11,933,097,313.77	$ 10,440,622,257.03	$20,908,904,068.78	$ 18,145,937,540.43	$15,884,874,774.08
15	$ 14,676,799,401.49	$12,618,613,896.87	$ 10,954,354,530.50	$22,302,578,285.92	$ 19,184,478,194.59	$16,663,166,451.50
16	$ 15,587,623,169.79	$13,284,163,977.54	$ 11,443,623,362.38	$23,682,453,748.44	$ 20,192,770,091.84	$17,404,396,620.48
17	$ 16,489,428,880.98	$13,930,329,104.41	$ 11,909,593,678.46	$25,048,667,077.66	$ 21,171,694,263.92	$18,110,330,114.74
18	$ 17,382,305,822.75	$14,557,673,887.77	$ 12,353,374,931.87	$26,401,353,542.24	$ 22,122,106,081.48	$18,782,647,728.32
19	$ 18,266,342,398.76	$15,166,746,492.98	$ 12,776,023,744.64	$27,740,647,071.53	$ 23,044,836,001.43	$19,422,950,217.45
20	$ 19,141,626,137.39	$15,758,079,119.40	$ 13,178,546,423.46	$29,066,680,268.84	$ 23,940,690,292.65	$20,032,762,111.86

Interest Rate (%)	1%	3%	5%	1%	3%	5%
VMT Fee ($)	0.04			0.05		
Year						
1	$ 2,015,297,029.70	$ 1,973,616,504.85	$ 1,933,523,809.52	$ 2,559,851,485.15	$ 2,507,597,087.38	$ 2,457,333,333.33
2	$ 4,140,591,118.52	$ 4,017,176,218.31	$ 3,899,975,056.69	$ 5,224,308,401.14	$ 5,069,584,550.85	$ 4,922,650,793.65
3	$ 6,244,842,691.60	$ 6,001,214,775.05	$ 5,772,785,768.28	$ 7,862,384,555.58	$ 7,556,951,020.25	$ 7,270,572,184.43
4	$ 8,328,260,090.69	$ 7,927,465,801.02	$ 7,556,415,017.41	$10,474,341,144.14	$ 9,971,869,922.57	$ 9,506,687,794.69
5	$ 10,391,049,594.75	$ 9,797,612,428.18	$ 9,255,109,540.39	$13,060,436,776.38	$ 12,316,451,381.13	$11,636,321,709.23
6	$ 12,433,415,440.34	$11,613,288,765.22	$ 10,872,913,847.99	$15,620,927,501.36	$ 14,592,744,059.35	$13,664,544,484.98
7	$ 14,455,559,841.92	$13,376,081,325.46	$ 12,413,679,855.23	$18,156,066,833.03	$ 16,802,736,950.83	$15,596,185,223.79
8	$ 16,457,683,011.81	$15,087,530,413.07	$ 13,881,076,052.60	$20,666,105,775.28	$ 18,948,361,117.31	$17,435,843,070.28
9	$ 18,439,983,180.01	$16,749,131,469.00	$ 15,278,596,240.57	$23,151,292,846.81	$ 21,031,491,376.03	$19,187,898,162.17
10	$ 20,402,656,613.87	$18,362,336,377.67	$ 16,609,567,848.16	$25,611,874,105.75	$ 23,053,947,937.89	$20,856,522,059.21
11	$ 22,345,897,637.49	$19,928,554,735.60	$ 17,877,159,855.39	$28,048,093,174.01	$ 25,017,497,997.95	$22,445,687,675.44
12	$ 24,269,898,650.98	$21,449,155,083.10	$ 19,084,390,338.47	$30,460,191,261.40	$ 26,923,857,279.57	$23,959,178,738.51
13	$ 26,174,850,149.49	$22,925,466,100.10	$ 20,234,133,655.68	$32,848,407,189.50	$ 28,774,691,533.56	$25,400,598,798.58
14	$ 28,060,940,742.07	$24,358,777,767.09	$ 21,329,127,291.13	$35,212,977,415.35	$ 30,571,617,993.75	$26,773,379,808.18
15	$ 29,928,357,170.36	$25,750,342,492.32	$ 22,371,978,372.50	$37,554,136,054.80	$ 32,316,206,790.05	$28,080,790,293.50
16	$ 31,777,284,327.09	$27,101,376,206.14	$ 23,365,169,878.57	$39,872,114,905.75	$ 34,009,982,320.43	$29,325,943,136.67
17	$ 33,607,905,274.35	$28,413,059,423.43	$ 24,311,066,551.02	$42,167,143,471.04	$ 35,654,424,582.94	$30,511,802,987.30
18	$ 35,420,401,261.73	$29,686,538,275.18	$ 25,211,920,524.78	$44,439,448,981.22	$ 37,250,970,468.88	$31,641,193,321.24
19	$ 37,214,951,744.29	$30,922,925,509.88	$ 26,069,876,690.27	$46,689,256,417.05	$ 38,801,015,018.33	$32,716,803,163.09
20	$ 38,991,734,400.29	$32,123,301,465.90	$ 26,886,977,800.26	$48,916,788,531.74	$ 40,305,912,639.15	$33,741,193,488.65

Alternative 2 Net Present Value Calculations						
Interest Rate (%)	1%	3%	5%	1%	3%	5%
VMT Fee ($)	0.02			0.03		
Year						
1	$ (116,282,178.22)	$ (135,276,699.03)	$ (153,547,619.05)	$ 428,272,277.23	$ 398,703,883.50	$ 370,261,904.76
2	$ 852,250,318.60	$ 796,008,059.20	$ 742,597,505.67	$ 1,935,967,601.22	$ 1,848,416,391.74	$ 1,765,273,242.63
3	$ 1,811,193,384.75	$ 1,700,168,018.64	$ 1,596,069,053.02	$ 3,428,735,248.73	$ 3,255,904,263.83	$ 3,093,855,469.17
4	$ 2,760,641,965.10	$ 2,577,993,221.98	$ 2,408,899,098.11	$ 4,906,723,018.54	$ 4,622,397,343.52	$ 4,359,171,875.40
5	$ 3,700,690,064.45	$ 3,430,250,700.95	$ 3,183,022,950.58	$ 6,370,077,246.08	$ 5,949,089,653.91	$ 5,564,235,119.43
6	$ 4,631,430,756.88	$ 4,257,685,146.55	$ 3,920,283,762.46	$ 7,818,942,817.90	$ 7,237,140,440.68	$ 6,711,914,399.46
7	$ 5,552,956,194.94	$ 5,061,019,559.76	$ 4,622,436,916.63	$ 9,253,463,186.04	$ 8,487,675,185.13	$ 7,804,942,285.20
8	$ 6,465,357,618.75	$ 5,840,955,883.26	$ 5,291,154,206.31	$10,673,780,382.22	$ 9,701,786,587.51	$ 8,845,921,224.00
9	$ 7,368,725,365.10	$ 6,598,175,614.82	$ 5,928,027,815.54	$12,080,035,031.90	$10,880,535,521.85	$ 9,837,329,737.14
10	$ 8,263,148,876.33	$ 7,333,340,402.73	$ 6,534,574,110.03	$13,472,366,368.22	$12,024,951,962.96	$10,781,528,321.09
11	$ 9,148,716,709.24	$ 8,047,092,624.01	$ 7,112,237,247.65	$14,850,912,245.76	$13,136,035,886.37	$11,680,765,067.70
12	$10,025,516,543.80	$ 8,740,055,945.64	$ 7,662,392,616.81	$16,215,809,154.22	$14,214,758,142.11	$12,537,181,016.86
13	$10,893,635,191.88	$ 9,412,835,869.56	$ 8,186,350,111.25	$17,567,192,231.90	$15,262,061,303.02	$13,352,815,254.15
14	$11,753,158,605.83	$10,066,020,261.71	$ 8,685,357,248.81	$18,905,195,279.11	$16,278,860,488.37	$14,129,609,765.86
15	$12,604,171,886.96	$10,700,179,865.73	$ 9,160,602,141.72	$20,229,950,771.40	$17,266,044,163.46	$14,869,414,062.72
16	$13,446,759,294.02	$11,315,868,801.68	$ 9,613,216,325.45	$21,541,589,872.67	$18,224,474,915.98	$15,573,989,583.54
17	$14,281,004,251.50	$11,913,625,050.18	$10,044,277,452.81	$22,840,242,448.19	$19,154,990,209.69	$16,245,013,889.09
18	$15,106,989,357.92	$12,493,970,922.50	$10,454,811,859.82	$24,126,037,077.41	$20,058,403,116.21	$16,884,084,656.28
19	$15,924,796,393.98	$13,057,413,516.99	$10,845,797,009.35	$25,399,101,066.75	$20,935,503,025.44	$17,492,723,482.17
20	$16,734,506,330.68	$13,604,445,162.13	$11,218,163,818.43	$26,659,560,462.12	$21,787,056,335.38	$18,072,379,506.83

Interest Rate (%)	1%	3%	5%	1%	3%	5%
VMT Fee ($)	0.04			0.05		
Year						
1	$ 972,826,732.67	$ 932,684,466.02	$ 894,071,428.57	$ 1,517,381,188.12	$ 1,466,665,048.54	$ 1,417,880,952.38
2	$ 3,019,684,883.83	$ 2,900,824,724.29	$ 2,787,948,979.59	$ 4,103,402,166.45	$ 3,953,233,056.84	$ 3,810,624,716.55
3	$ 5,046,277,112.71	$ 4,811,640,509.02	$ 4,591,641,885.33	$ 6,663,818,976.69	$ 6,367,376,754.21	$ 6,089,428,301.48
4	$ 7,052,804,071.99	$ 6,666,801,465.07	$ 6,309,444,652.69	$ 9,198,885,125.43	$ 8,711,205,586.61	$ 8,259,717,429.98
5	$ 9,039,464,427.71	$ 8,467,928,606.86	$ 7,945,447,288.28	$11,708,851,609.34	$10,986,767,559.82	$10,326,659,457.12
6	$11,006,454,878.92	$10,216,595,734.82	$ 9,503,545,036.45	$14,193,966,939.94	$13,196,051,028.95	$12,295,175,673.45
7	$12,953,970,177.15	$11,914,330,810.50	$10,987,447,653.77	$16,654,477,168.26	$15,340,986,435.87	$14,169,953,022.33
8	$14,882,203,145.69	$13,562,617,291.75	$12,400,688,241.68	$19,090,625,909.17	$17,423,447,995.99	$15,955,455,259.37
9	$16,791,344,698.71	$15,162,895,428.88	$13,746,631,658.74	$21,502,654,365.51	$19,445,255,335.92	$17,655,933,580.35
10	$18,681,583,860.11	$16,716,563,523.19	$15,028,482,532.14	$23,890,801,351.99	$21,408,175,083.41	$19,275,436,743.19
11	$20,553,107,782.28	$18,224,979,148.73	$16,249,292,887.75	$26,255,303,318.80	$23,313,922,411.08	$20,817,820,707.80
12	$22,406,101,764.64	$19,689,460,338.57	$17,411,969,416.91	$28,596,394,375.05	$25,164,162,535.03	$22,286,757,816.95
13	$24,240,749,271.92	$21,111,286,736.47	$18,519,280,397.05	$30,914,306,311.93	$26,960,512,169.93	$23,685,745,539.95
14	$26,057,231,952.39	$22,491,700,715.02	$19,573,862,282.91	$33,209,268,625.68	$28,704,540,941.68	$25,018,114,799.96
15	$27,855,729,655.83	$23,831,908,461.19	$20,578,225,983.72	$35,481,508,540.27	$30,397,772,758.92	$26,287,037,904.72
16	$29,636,420,451.32	$25,133,081,030.28	$21,534,762,841.64	$37,731,251,029.97	$32,041,687,144.58	$27,495,536,099.73
17	$31,399,480,644.87	$26,396,355,369.20	$22,445,750,325.37	$39,958,718,841.56	$33,637,720,528.72	$28,646,486,761.65
18	$33,145,084,796.90	$27,622,835,309.91	$23,313,357,452.73	$42,164,132,516.39	$35,187,267,503.61	$29,742,630,249.19
19	$34,873,405,739.51	$28,813,592,533.89	$24,139,649,954.98	$44,347,710,412.27	$36,691,682,042.34	$30,786,576,427.80
20	$36,584,614,593.57	$29,969,667,508.63	$24,926,595,195.22	$46,509,668,725.02	$38,152,278,681.88	$31,780,810,883.62

Alternative 3 Net Present Value Calculations						
Interest Rate (%)	1%	3%	5%	1%	3%	5%
VMT Fee ($)	0.02			0.03		
Year						
1	$ 1,012,487,623.76	$ 991,978,155.34	$ 972,250,000.00	$ 1,557,042,079.21	$ 1,525,958,737.86	$ 1,496,059,523.81
2	$ 2,058,267,449.27	$ 1,997,539,471.20	$ 1,939,869,047.62	$ 3,141,984,731.89	$ 3,049,947,803.75	$ 2,962,544,784.58
3	$ 3,093,693,019.08	$ 2,973,812,593.40	$ 2,861,410,997.73	$ 4,711,234,883.06	$ 4,529,548,838.59	$ 4,359,197,413.89
4	$ 4,118,866,850.57	$ 3,921,650,576.12	$ 3,739,069,997.84	$ 6,264,947,904.02	$ 5,966,054,697.66	$ 5,689,342,775.13
5	$ 5,133,890,446.11	$ 4,841,881,627.30	$ 4,574,935,712.23	$ 7,803,277,627.74	$ 7,360,720,580.26	$ 6,956,147,881.08
6	$ 6,138,864,303.08	$ 5,735,309,832.33	$ 5,370,998,297.36	$ 9,326,376,364.10	$ 8,714,765,126.46	$ 8,162,628,934.36
7	$ 7,133,887,923.84	$ 6,602,715,856.63	$ 6,129,153,140.34	$10,834,394,914.95	$10,029,371,482.00	$ 9,311,658,508.91
8	$ 8,119,059,825.59	$ 7,444,857,627.80	$ 6,851,205,371.76	$12,327,482,589.06	$11,305,688,332.04	$10,405,972,389.44
9	$ 9,094,477,550.09	$ 8,262,470,997.86	$ 7,538,874,163.58	$13,805,787,216.89	$12,544,830,904.89	$11,448,176,085.18
10	$10,060,237,673.35	$ 9,056,270,386.27	$ 8,193,796,822.45	$15,269,455,165.24	$13,747,881,946.50	$12,440,751,033.51
11	$11,016,435,815.20	$ 9,826,949,404.15	$ 8,817,532,688.05	$16,718,631,351.72	$14,915,892,666.50	$13,386,060,508.10
12	$11,963,166,648.71	$10,575,181,460.34	$ 9,411,566,845.76	$18,153,459,259.13	$16,049,883,656.80	$14,286,355,245.81
13	$12,900,523,909.62	$11,301,620,349.84	$ 9,977,313,662.63	$19,574,080,949.63	$17,150,845,783.30	$15,143,778,805.53
14	$13,828,600,405.56	$12,006,900,825.09	$10,516,120,154.89	$20,980,637,078.85	$18,219,741,051.75	$15,960,372,671.94
15	$14,747,488,025.31	$12,691,639,150.57	$11,029,269,195.13	$22,373,266,909.75	$19,257,503,448.30	$16,738,081,116.13
16	$15,657,277,747.83	$13,356,433,641.33	$11,517,982,566.79	$23,752,108,326.48	$20,265,039,755.63	$17,478,755,824.89
17	$16,558,059,651.32	$14,001,865,185.76	$11,983,423,873.13	$25,117,297,848.00	$21,243,230,345.27	$18,184,160,309.42
18	$17,449,922,922.10	$14,628,497,753.17	$12,426,701,307.75	$26,468,970,641.59	$22,192,929,946.87	$18,855,974,104.21
19	$18,332,955,863.46	$15,236,878,886.57	$12,848,870,293.09	$27,807,260,536.22	$23,114,968,395.02	$19,495,796,765.91
20	$19,207,245,904.42	$15,827,540,181.13	$13,250,935,993.42	$29,132,300,035.87	$24,010,151,354.38	$20,105,151,681.82

Interest Rate (%)	1%	3%	5%	1%	3%	5%
VMT Fee ($)	0.04			0.05		
Year						
1	$ 2,101,596,534.65	$ 2,059,939,320.39	$ 2,019,869,047.62	$ 2,646,150,990.10	$ 2,593,919,902.91	$ 2,543,678,571.43
2	$ 4,225,702,014.51	$ 4,102,356,136.30	$ 3,985,220,521.54	$ 5,309,419,297.13	$ 5,154,764,468.85	$ 5,007,896,258.50
3	$ 6,328,776,747.04	$ 6,085,285,083.79	$ 5,856,983,830.04	$ 7,946,318,611.02	$ 7,641,021,328.98	$ 7,354,770,246.19
4	$ 8,411,028,957.46	$ 8,010,458,819.21	$ 7,639,615,552.42	$10,557,110,010.91	$10,054,862,940.76	$ 9,589,888,329.71
5	$10,472,664,809.37	$ 9,879,559,533.21	$ 9,337,360,049.92	$13,142,051,991.00	$12,398,398,486.17	$11,718,572,218.77
6	$12,513,888,425.12	$11,694,220,420.60	$10,954,259,571.36	$15,701,400,486.14	$14,673,675,714.73	$13,745,890,208.35
7	$14,534,901,906.06	$13,456,027,107.37	$12,494,163,877.48	$18,235,408,897.17	$16,882,682,732.75	$15,676,669,246.05
8	$16,535,905,352.53	$15,166,519,036.29	$13,960,739,407.12	$20,744,328,116.01	$19,027,349,740.53	$17,515,506,424.81
9	$18,517,096,883.70	$16,827,190,811.93	$15,357,478,006.79	$23,228,406,550.50	$21,109,550,718.96	$19,266,779,928.39
10	$20,478,672,657.12	$18,439,493,506.73	$16,687,705,244.56	$25,687,890,149.01	$23,131,105,066.95	$20,934,659,455.61
11	$22,420,826,888.24	$20,004,835,928.86	$17,954,588,328.15	$28,123,022,424.76	$25,093,779,191.22	$22,523,116,148.20
12	$24,343,751,869.55	$21,524,585,853.26	$19,161,143,645.86	$30,534,044,479.96	$26,999,288,049.72	$24,035,932,045.90
13	$26,247,637,989.65	$23,000,071,216.76	$20,310,243,948.44	$32,921,195,029.67	$28,849,296,650.22	$25,476,709,091.34
14	$28,132,673,752.13	$24,432,581,278.41	$21,404,625,188.99	$35,284,710,425.41	$30,645,421,505.07	$26,848,877,706.04
15	$29,999,045,794.19	$25,823,367,746.03	$22,446,893,037.13	$37,624,824,678.63	$32,389,232,043.75	$28,155,704,958.13
16	$31,846,938,905.14	$27,173,645,869.93	$23,439,529,082.98	$39,941,769,483.79	$34,082,251,984.23	$29,400,302,341.08
17	$33,676,536,044.69	$28,484,595,504.79	$24,384,896,745.70	$42,235,774,241.37	$35,725,960,664.30	$30,585,633,181.98
18	$35,488,018,361.08	$29,757,362,140.57	$25,285,246,900.66	$44,507,066,080.57	$37,321,794,334.27	$31,714,519,697.12
19	$37,281,565,208.99	$30,993,057,903.46	$26,142,723,238.73	$46,755,869,881.75	$38,871,147,411.91	$32,789,649,711.54
20	$39,057,354,167.31	$32,192,762,527.64	$26,959,367,370.22	$48,982,408,298.76	$40,375,373,700.89	$33,813,583,058.61

APPENDIX C

NET PRESENT VALUE SAMPLE CALCULATION

Net Present Value Calculations for Alternative 3:

$$F = P(1+i)^n \quad \text{or} \quad P = \frac{F}{(1+i)^n}$$

$P = 43{,}750{,}000 = 4.375x10^7$

$i = .03$

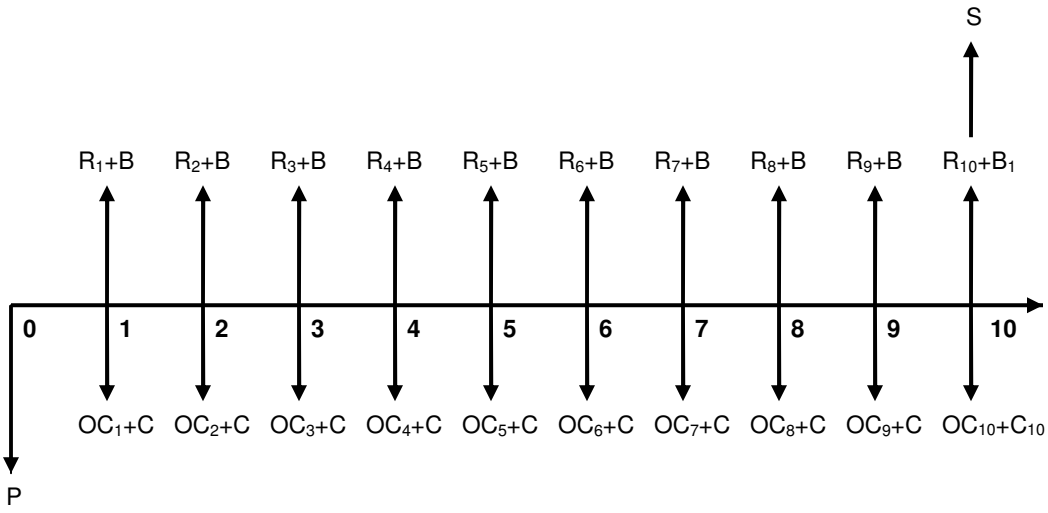
$n = 10$

$F = (4.375x10^7)(1+.03)^{10}$

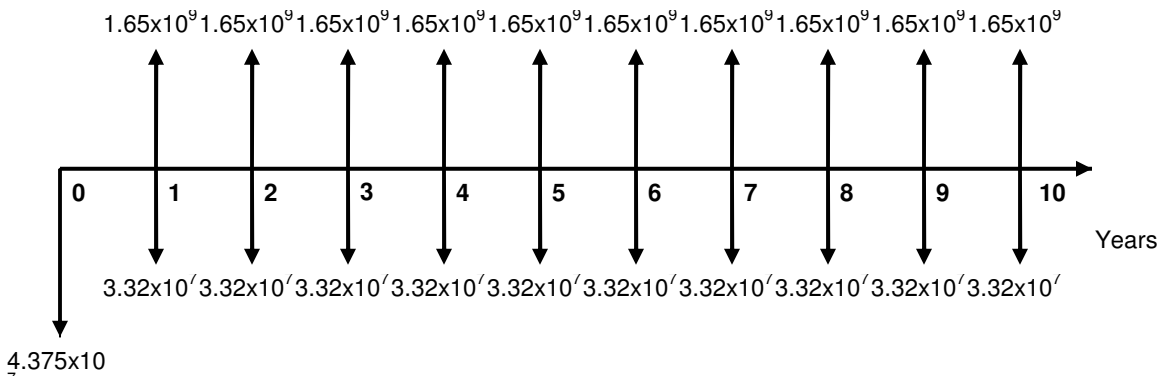
$F = 5.879x10^7$

If there wasn't a one time implantation cost and it was going to be paid back over 10years, then F or P would have to be annualized?

Cash Flow Diagram:



Cash Flow Diagram for Alternative 3:



$$\Delta R_j = R_o(1+i)^j - R_o$$

$$R_o = 0 \therefore$$

$$NPV = BPV - CPV$$

$$NPV = \sum_{j=1}^{n} \frac{(R_j + B_j) - (OC_j + C_j)}{(1+i)^j} + \frac{S}{(1+i)^n} - P$$

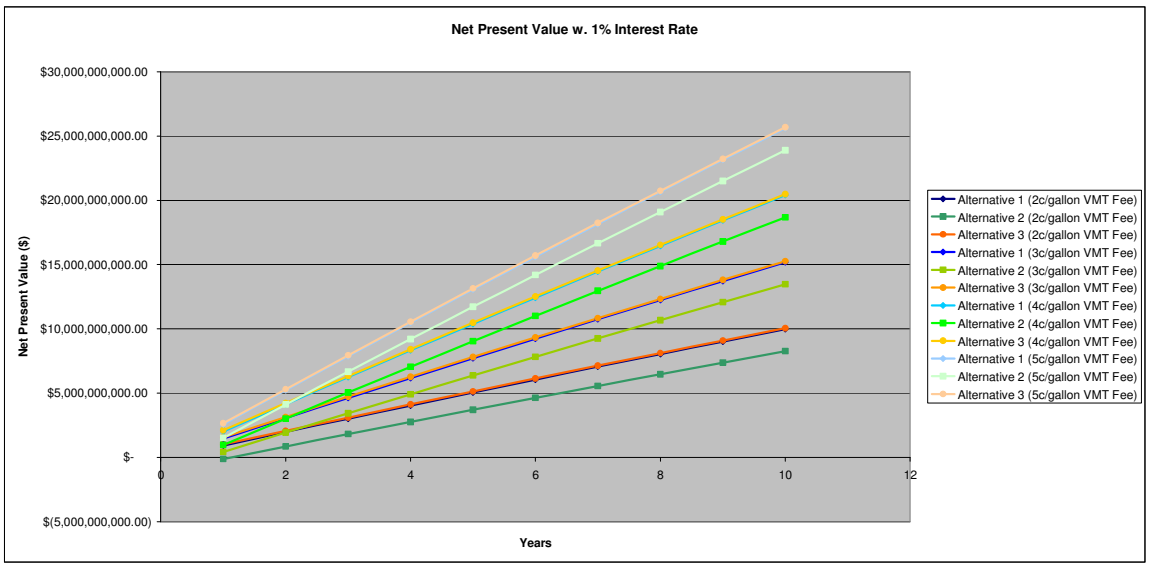
$$NPV_3 = \frac{1.65x10^9 - 3.32x10^7}{(1+.03)^1} + \frac{1.65x10^9 - 3.32x10^7}{(1+.03)^2} + \frac{1.65x10^9 - 3.32x10^7}{(1+.03)^3} +$$
$$\frac{1.65x10^9 - 3.32x10^7}{(1+.03)^4} + \frac{1.65x10^9 - 3.32x10^7}{(1+.03)^5} + \frac{1.65x10^9 - 3.32x10^7}{(1+.03)^6} + \frac{1.65x10^9 - 3.32x10^7}{(1+.03)^7} +$$
$$\frac{1.65x10^9 - 3.32x10^7}{(1+.03)^8} + \frac{1.65x10^9 - 3.32x10^7}{(1+.03)^9} + \frac{1.65x10^9 - 3.32x10^7}{(1+.03)^{10}} + 0 - 4.375x10^7$$

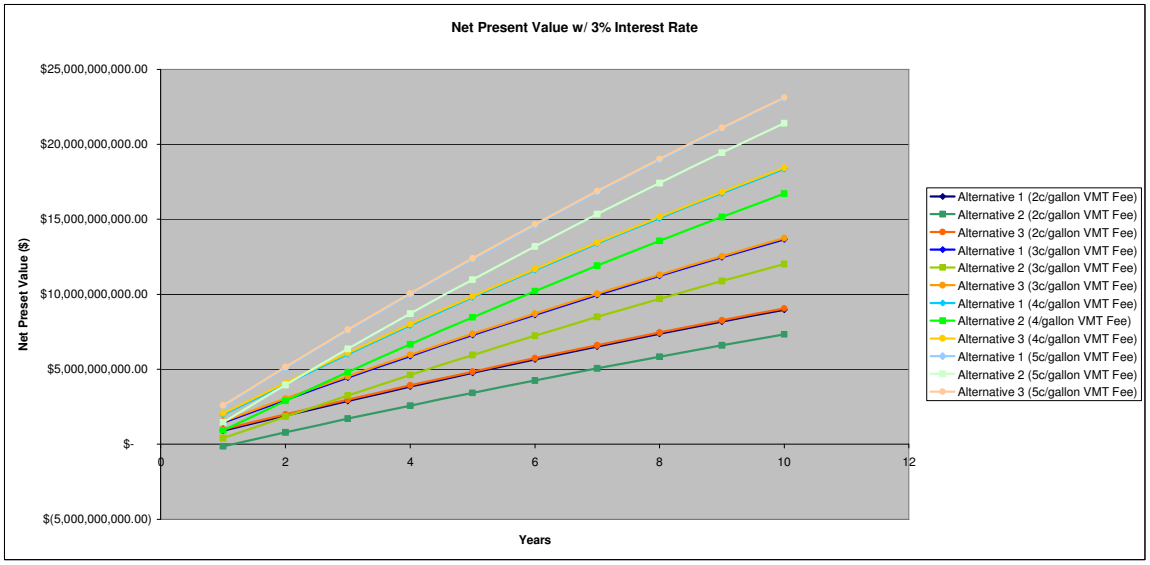
$$NPV_3 = 1.57x10^9 + 1.52x10^9 + 1.48x10^9 + 1.44x10^9 + 1.39x10^9 + 1.35x10^9 +$$
$$1.31x10^9 + 1.28x10^9 + 1.24x10^9 + 1.203x10^9 + 4.375x10^7$$

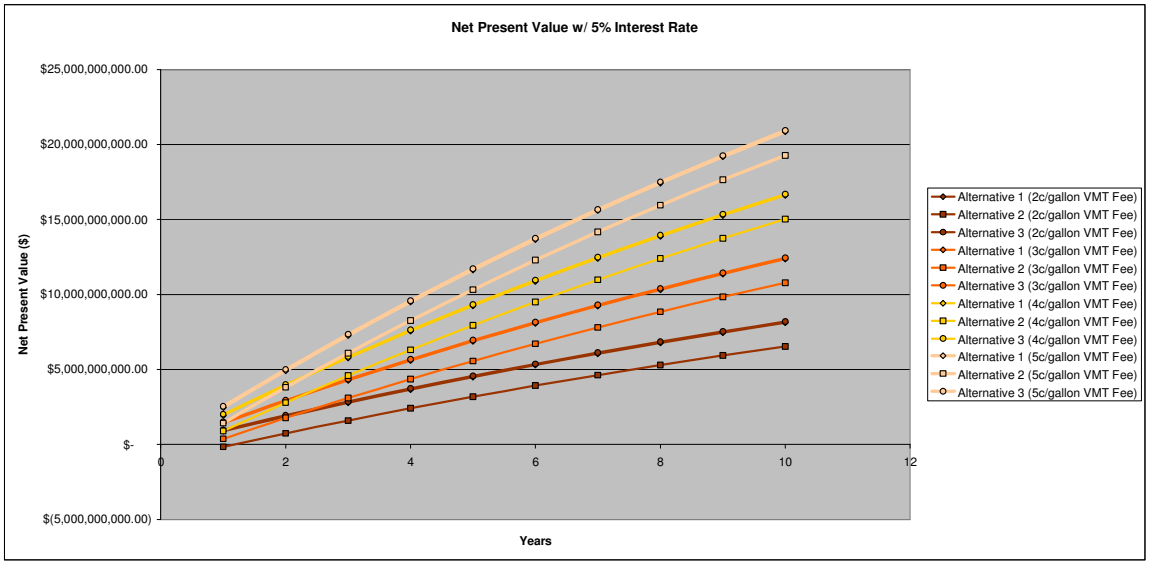
$$NPV_3 = 1.37x10^7 = 13{,}700{,}000$$

APPENDIX D

NET PRESENT VALUE REPRESENTED GRAPHICALLY







REFERENCES

1. *Transportation Finance in Massachusetts: An Unsustainable System*. Rep. Massachusetts Transportation Finance Commission, 28 Mar. 2007. Web. 10 Jan. 2011. <http://www.eot.state.ma.us/downloads/tfc/tfc_findings.pdf>.

2. "FY2011 H 2 - Budget Development - Transportation Reform." *Mass.Gov*. Commonwealth of Massachusetts State Government. Web. 04 Nov. 2011. <http://www.mass.gov/bb/h1/fy11h1/exec_11/hbuddevcost.htm>.

3. US DOT Misreports Gasoline Tax Revenue." *TheNewspaper.Com: Front Page*. Web. 10 Jan. 2011. <http://www.thenewspaper.com/news/26/2635.asp>.

4. "Technology Enabling Near-Term Nationwide Implementation of Distance Based Road User Fees," Prepared by a team at Intelligent Transportation Systems Institute and University of Minnesota; June 2009.

5. Whitty, James M., "Oregon's Mileage Fee Concept and Road User Fee Pilot Program", Oregon Department of Transportation; Salem, 2007. http://www.oregon.gov/ODOT/HWY/RUFPP/docs/RUFPP_finalreport.pdf

6. The Council of State Governments. "Focus on Vehicle Miles Traveled Fee - A Trend in America Special Report." Mar. 2010. Web. 11 Mar. 2011. <http://www.csg.org/policy/documents/TIA_VMTcharges.pdf>.

7. Mileage Based User Fee Alliance (MBUFA). "The Need for Alternative Transportation Funding." "Getting to Yes on VMT: An Open System Approach to Mileage Based User Charges." "Advances VMT Tax Bill for Electric Vehicles." Spring 2011. Print.

8. Donahue, Brain. "Trading the Pump for the Plug." "Tech Companies Deploy Stations Needed for Power Cars." *InTransition* Winter 2011: 5+. Print.

9. Meinhold, Bridgette. "Better Place Makes Electric Vehicle Grids a Reality | Inhabitat - Green Design Will Save the World." *Green Design Will save the World | Inhabitat*. 10 Dec. 2008. Web. 20 Jan. 2011. <http://inhabitat.com/better-place-vehicle-network-expanding-quickly/>.

10. National Evaluation of a Mileage-Based Road User Charge; The University of Iowa, Public Policy Center; http://www.roaduserstudy.org/Default.aspx

11. Puget Soung Regional Council. "Traffic Choices Study - Summary Report." Apr. 2008. Web. 11 Mar. 2011. <http://www.psrc.org/assets/37/summaryreport.pdf>.

12. Plotnikov, Michael. *An Evaluation of Alternative Transportation Financing Approaches*. Presentation at Tech Day. March. 2010

13. Bruun, Eric Christian. *Better Public Transit Systems: Analyzing Investments and Performance*. Chicago, IL: Planners, American Planning Association, 2007. Print.