DEVELOPMENT OF AN ELECTRONIC VEHICLE MILES TRAVELLED TOLL MODEL

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DEDICATION

I dedicate this work to my family and friends who gave me support and motivation when I needed it most.

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by

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THESIS

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ABSTRACT

This thesis presents the reasons why the fuel tax is no longer a viable source of revenues and suggests new sources of funding. One possibility is to replace the fuel tax with a distance-based toll applied nationwide. Vehicle miles travelled (VMT) fee is compared to the fuel tax, and the relationship between road infrastructure spending and fuel taxation in the United States (U.S.) and the European Union (EU) is explored. Also the European approach to taxation and tolling is described and compared to the situation in Texas.

The development of a statewide distance-based toll model to estimate the feasibility of a set base toll rate, regarding revenues is presented. The aim is to offer an alternative to the current road infrastructure financing system in the U.S. based mainly on the fuel-tax which has been having problems with balancing the outlays and receipts since 2001 and is no longer self-sufficient. The model differentiates the toll price to three categories of vehicles and three emission classes, following a trend from the EU that motivates fleet-renewal and lowers emissions. Also a decision situation is described by an influence diagram and a sequence flowchart, identifying factors that lead to a successful implementation of a distance-based program.

Findings of this thesis can be used to enlighten the decision situation foregoing a distance-based toll implementation and help decision makers with the dilemma of whether to implement a distance based toll or rather continue with the current system based on the fuel tax revenues.

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CHAPTER 1: INTRODUCTION

In the last decade, both the United States (U.S.) and the European Union (EU) have faced increasing congestion, air pollution from traffic and insufficient budget to cover costs of road infrastructure. All these problems have much in common. Transportation is facing a crisis as new issues are encountered, such as insufficient capacity, air pollution, infrastructure deterioration and many others. To solve or at least mitigate these problems, more funding is needed. In the case of Texas, Durden (2010) in his work “Funding Texas Highways for the Next 20 Years” estimated that “by 2012 existing revenues [budget], unless expanded and/or augmented, will be fully consumed by debt service and the cost of operating and maintaining the existing system.” The ideal goal is to have a self-supporting transportation system, which would generate sufficient revenues to cover costs of maintenance, modernization and also new projects.

According to the current transportation financing system in the U.S., the revenues derive mainly from the fuel tax, which was introduced more than 100 years ago to approximate the road usage, and also from toll, vehicle registrations and ownership tax. In the EU, funding comes from the fuel tax, toll, road tax, highway time coupons and other sources (such as State Budget and privatization). Unfortunately, as Whitty (2007) points out, the fuel tax has now become “rather a general tax unrelated to use, than a fee for service” as the correlation between fuel consumption and road usage is changing. The change can be seen in Figure 1.1, where the fuel consumption is not rising as quickly as the vehicle miles of travel are.

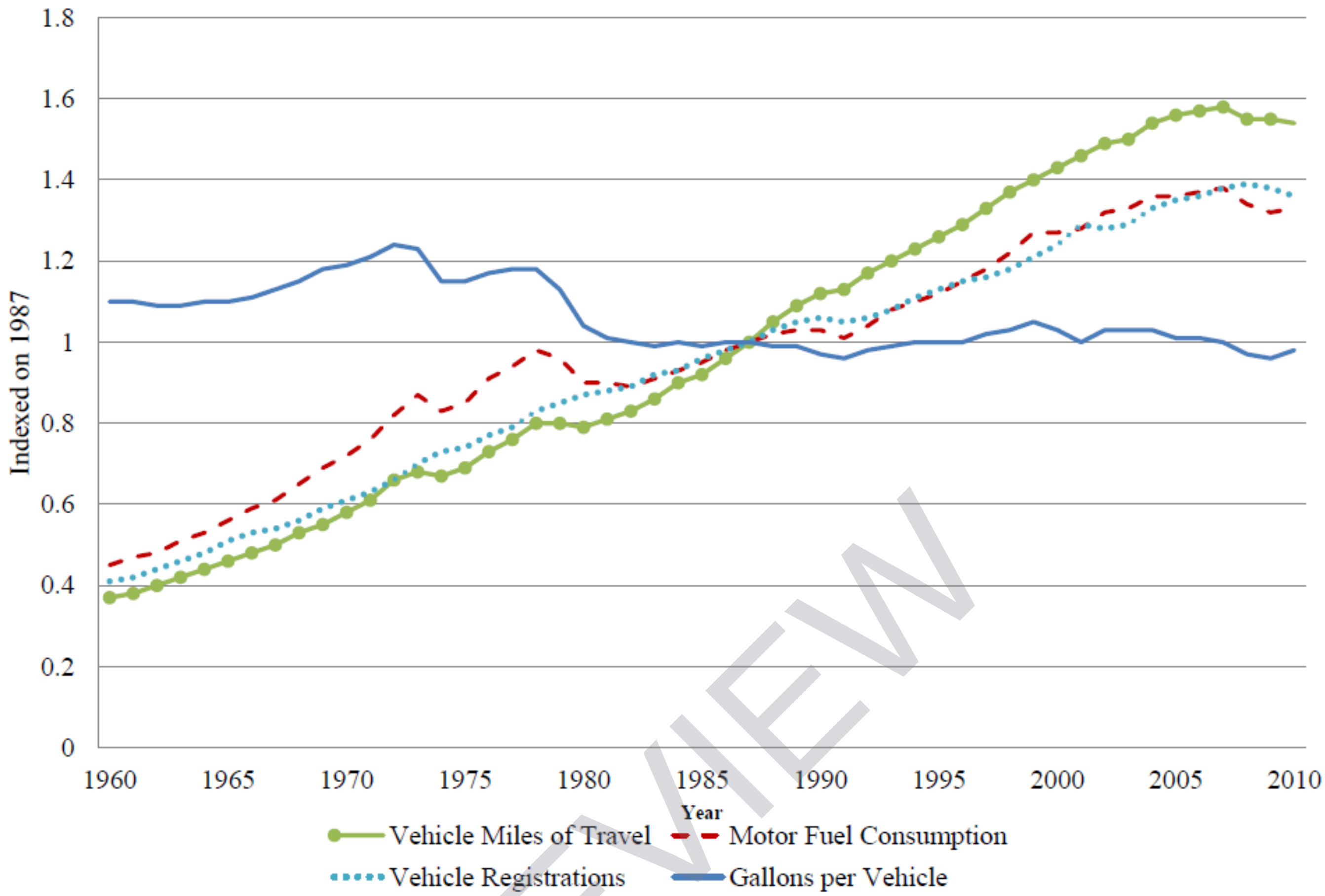

Figure 1.1 Vehicle Registrations, Fuel Consumption and Vehicle Miles of Travel as Indices
Source: FHWA Highway Statistics (2010)

Therefore, it is very important to think about a new, stable source of funding, particularly because it is a very serious decision to change the fundamentals of the transportation financing system. It is not a change that can be made day to day, as long time of planning must be carried out. The reason for action is not only the shortfall in receipts and outlays. With the world oil supplies estimated to run out in less than 50 years (Ward, 2011), increasing fuel efficiency and alternative-fuel-based vehicles entering the markets, the need to find a fuel tax replacement is becoming urgent.

A solution to this problem might be the replacement of the fuel tax with the vehicle miles travelled (VMT) fee, as the basis of a new transportation financing system, with rates set to provide a sufficient source of revenues to cover costs of building, operating and maintaining roads and highways

(plus collection costs, on board unit (OBU) distribution costs, enforcement costs and connected ITS applications costs). As for the VMT, a more accurate term would be distance travelled, but vehicle miles travelled has become the dominant term among policy makers and media in the United States. Even other terms are used, e.g. the mileage or kilometer charge in Europe. (Donath et. al., 2009)

1.1 VMT Fee vs. Fuel Tax

As mentioned earlier, the fuel tax is no longer a reliable indicator of road usage. Baker, et al. (2011a) indicates that "government regulation and continued increases in fuel prices could cut fuel consumption in the United States by 20 percent by 2025. While good news for the environment, this does not bode well for tax revenues generated by gasoline sales."

In 2011, Balducci, et al. conducted research for the Transportation Research Board about "Costs of Alternative Revenue-Generation Systems." The objective of the research "was to develop a methodology that can be used to analyze and compare the administrative, collection, and compliance costs of highway revenue-generation mechanisms" (Balducci et al., 2011). It focused on five usage-based charges: fuel tax, tolling, VMT fee and also congestion and cordon pricing. The discoveries concerning the fuel tax and the VMT fee are interesting for this thesis. For comparison, the tolling is also included in Table 1.1.

Table 1.1 Cost comparison between revenue systems – fuel tax, VMT fee and tolling

	Fuel Tax [1]	**VMT Fee** [2]	**Tolling** [1]
Cost per Line Mile	$50	$4,042	$150,595
Annual Operating Cost per Vehicle	$1.22	$75.16	N/A
Operating Costs	0.92% of revenues	6.6% of revenues	33.5% of revenues
Biggest Spending Item		administration costs 3.4% of revenues	collection costs 20% of revenues

[1] based on data collected in 2007 in U.S.
[2] based on the revenue forecast to be collected in the Netherlands

Source: (Balducci et al., 2011)

When compared, the VMT fee appears as the golden mean between the fuel tax and tolling. Although the VMT fee cost per line mile is 80 times higher than for fuel tax, it is still 37 times less than for tolling (tolling versus fuel tax is 3011 times higher). The low costs of the fuel tax are caused by its easiness. The tax is given and collected with every fuel purchase. The money collected go straight from the fuel company to the government's account. Invasions of this system are rare. Whilst for the VMT fee or the tolling, there always must be a strong enforcement to make the users pay. Also the costs building and operating of such tolling system increases the total costs.

Annual operating costs per vehicle for the VMT fee are 61 times higher than for fuel tax, which may seem like a quite high number, but considering that it includes all the infrastructure, applications, devices and enforcement costs, it is still a reasonable number.

The VMT fee operating costs are also reasonable, because with the 6.6% share on revenues are 7 times higher than operating costs for fuel tax (0.92% of revenues) but still 5 times less than for tolling (33.5% of revenues).

As for the biggest spending item, in a VMT system it is according Balducci, et al. (2011) the administrating costs with 3.4% of revenues, represented by wages and salaries, finance, accounting and audit activities, management and professional services, procurement and purchasing of toll equipment, planning activities related to toll-system development and expansion and buildings and utilities. This disaccords with the results of the congestion pricing trial-run in Seattle, Washington, where the majority of operating costs were costs of data communications (Pryne, 2008).

For tolling, the biggest spending item is the collection costs, taking away 20% of revenues. According to Balducci, et al. (2011), these costs include operation and maintenance of tollbooths, operation and maintenance of ETC and video tolling systems as well as related information technology hardware and software, customer account management, payment processing and inventory, distribution, and sale of OBU units.

As it appears from Table 1.1, the VMT toll is a golden mean between fuel tax and tolling – not as expensive as tolling and more usage corresponding and fair (from the point of view that alternative fuel based vehicles do not pay any tax).

Balducci, et al. (2011) also points out the other problem with the fuel tax: "another factor affecting the motor fuel tax revenue system is that fuel tax rates have not been indexed for inflation or increased at the federal level since 1993. From 1993 to 2008, the purchasing power of the federal gasoline tax, which has remained at the fixed rate of 18.4 cents per gallon, has declined by 33%." The easiness of simply increasing the fuel tax to get more revenues, it is only a speciosity. The resistance of tax payers increasing taxes is a strong hold-back here and it forces the government to keep the taxes at the existing level as long as it is feasible (and maybe even beyond that).

Table 1.2 shows Gasoline and Diesel Motor Fuel Taxes in the U.S. The state part includes the state excise tax and the other state tax. And there is also the federal part. It can be seen that the fuel tax on diesel is higher than on gasoline (in the EU is the opposite trend – see Table 2.1).

Table 1.2 Gasoline and diesel motor fuel taxes in the U.S. (¢/gal)

	State Excise	**Other State**	**Total State**	**Federal**	**Total State and Federal**
Gasoline	20.9	9.5	30.4	18.4	48.8
Diesel	19.0	10.6	29.6	24.4	54.0

Source: American Petroleum Institute (2012a)

As stated before, the current transportation system is not receiving sufficient revenues to cover its needs. Evidently, simple repeated increase in the fuel tax is not a solution. Aside from the possibility of basing the new transportation system on revenues from the VMT toll, there are other options. Balducci, et al. (2011) organized the known revenue systems into categories on the basis of taxation:

• **Vehicle ownership**

– Registration fees

– Licensing fees

– Personal property taxes

• **Highway user fees**

– Toll roads

– Congestion/cordon pricing

– High occupancy toll lanes

– VMT fees

• Energy consumption

– Motor fuel taxes

– Sales taxes on motor fuels

– Utility fees

• Beneficiary and local option fees

– Beneficiary charges/value capture

– Transportation impact fee

– Local option sales taxes

– Local option property taxes.

Note: In Texas there is no personal property tax, but in other states of the U.S. the personal property tax might be applicable. Part of the property tax may be used to finance transportation infrastructure.

From all these sources it is possible to get finances for the road network operation, maintenance and building. As for this thesis, it will mostly focus on the highway user fees and it will possibly show the VMT fee as a workable solution worth of a consideration when dealing with insufficient founding and congestions. This work will describe the current conditions in the U.S and in the EU. It will also summarize the VMT trial-runs. Then the factors leading to a successful VMT program will be explored and transformed into a model, to support a decision whether to do a VMT program or not.

1.2 Thesis Objective

This thesis is focused on a summary of electronic distance-based toll systems in the U.S. and the EU and on creating of a model to estimate the price of a VMT toll – with the objective to collect revenues needed to budget road maintenance, rehabilitation programs and connected operating costs.

Also the American and European approach is compared and recommendations are given for the application of the model.

1.3 Thesis Outline

Chapter 1 describes the motivation for a distance-based fee and compares the VMT fee with the fuel tax.

Chapter 2 describes the situation in the U.S. and the EU, and discusses topics such as relationship between road infrastructure spending and fuel taxation, tolling in Texas and Czech Republic, public acceptance, technical solution, and it also reviews methodologies.

Chapter 3 focuses on a development of an influence diagram, sequence flowchart and the final model.

Chapter 4 shows a case study for Texas with three different scenarios.

Chapter 5 summarizes all important findings of this thesis.

CHAPTER 2: LITERATURE REVIEW

2.1 U.S. Current State-of-the-Art

The fuel tax, which was introduced to approximate the road usage, is now nearly a century-old. It was first enacted in 1919 in Oregon and other states soon followed. The federal gasoline excise tax was introduced in 1932, with 1 cent per gallon (3.87 liters) (Tax Foundation, 2008). Now the gasoline federal tax is 18.4 cents (since October 1997). Together with state and local taxes, the fuel tax adds up to 48.8 cents per gallon of gasoline and 54.0 cents per gallon of diesel (US average, American Petroleum Institute, 2012a). Gasoline taxes combined at the local, state and federal level can be seen within Figure 2.1, which shows that the level of taxation differs among the states. The lowest level of taxation is in the southern states, whereas the coastal states have the highest level of fuel taxation (higher than the U.S. average). However these are still very low compared to fuel taxes in EU (see Table 2.1).

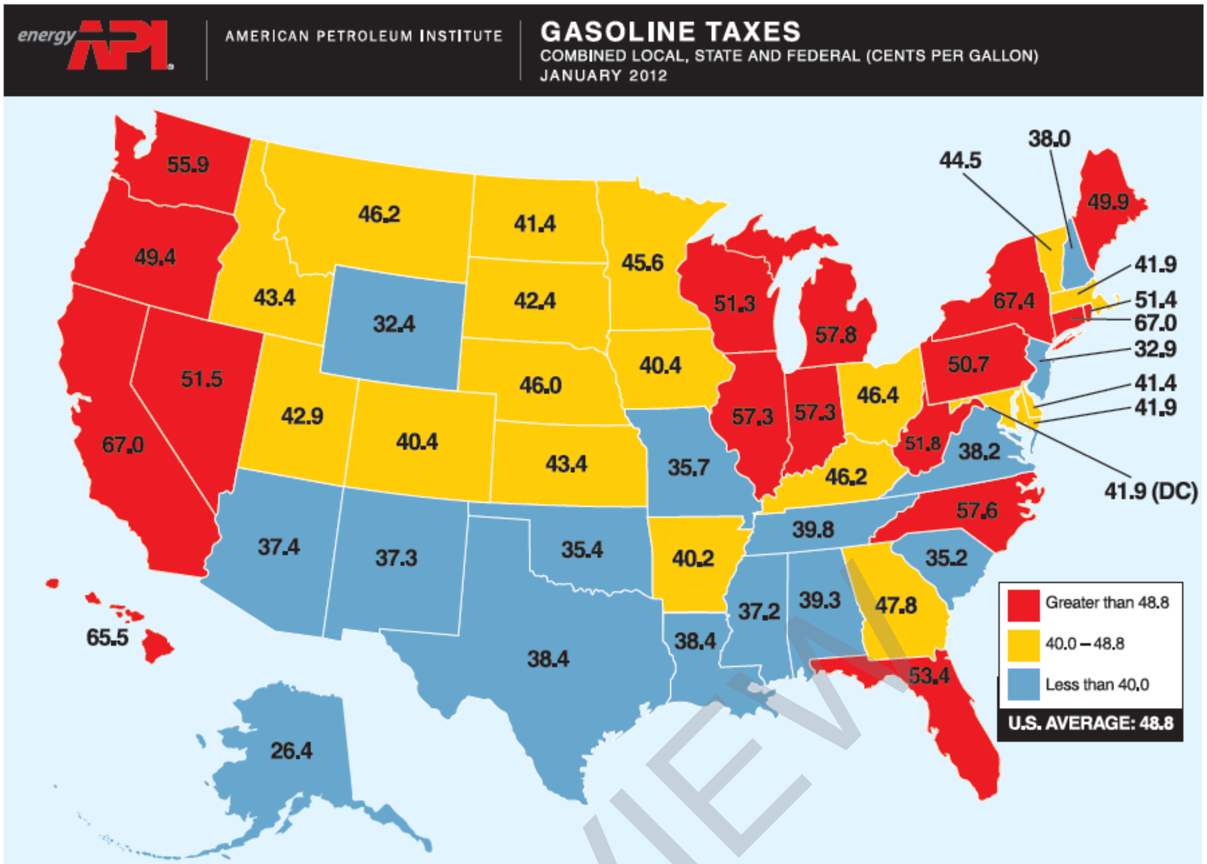

Figure 2.1 Gasoline taxes in the U.S., combined local, state and federal (¢/gal)
Source: American Petroleum Institute (2012b)

According to the FHWA (2010), the revenues collected from the federal part of the fuel tax in the U.S. flow into one of the several accounts forming the Highway Trust Fund. It was founded in 1956 and consists mostly of the Highway Account and the Mass Transit Account. Approximately 83 to 87% (depending on the fuel type) is deposited into the Highway Account (used for financing of road construction and maintenance), 11 to 15% goes to the Mass Transit Account. Other contributions to the Highway Trust Fund come from excise taxes on the sale of tires, trucks, buses, trailers and heavy vehicle use.

As Orszag (2008) states in “Overview of the Highway Trust Fund,” most of the federal government’s surface transportation programs are funded from the Highway Trust Fund and some transit programs receive appropriations from the Treasury’s General Fund.

As Elmendorf, et al. (2008) claims in “Issues and Options in Infrastructure Investment,” the balances in the Highway Account stayed steadily in the vicinity of $10 billion during the 1980s and in

the first half of the 1990s. But from 1996 to 2000 the receipts exceeded the outlays and the unexpected balance in the Highway Account grew from $10 billion in 1995 to a peak of about $23 billion in 2000 (see Figure 2.2). In general, spending has exceeded revenues since 2001 and Elmendorf, et al. (2008) predicted that in case the recent trend persists and spending from the Highway Trust Fund continues to exceed its revenues, the balances in the Highway Account will be depleted during fiscal year 2009.

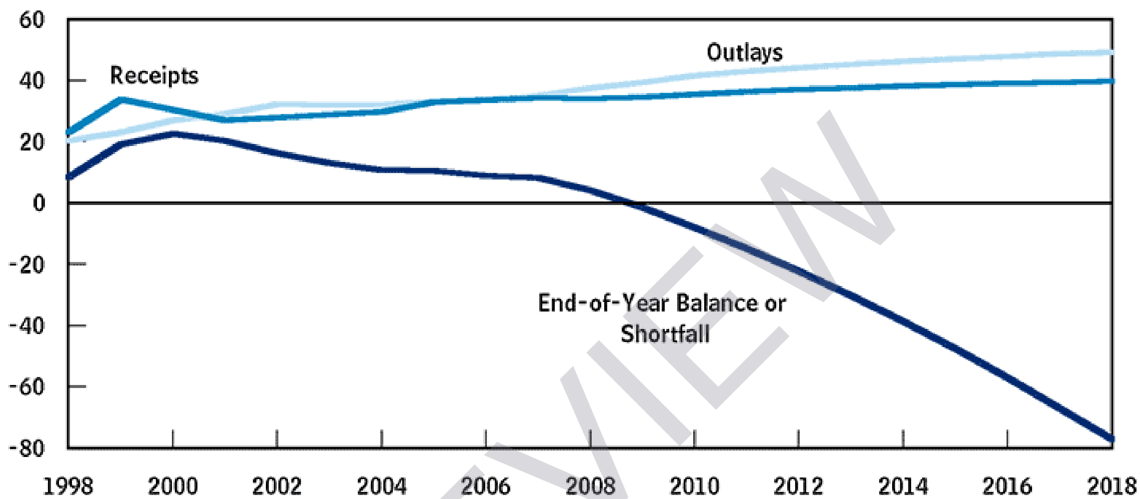

Figure 2.2 Actual and projected highway account annual receipts, annual outlays and cumulative balances or shortfalls, in bil. of $

Source: Elmendorf, D. W., et al. (2008)

As it showed, the Highway Account was depleted even earlier, in September 2008 (September is the end of the federal fiscal year), when Congress had to transfer $8 billion from the General Fund to cover a shortfall in the Highway Account. This happened again in 2009, the Highway Account was unable to meet obligations and required an infusion from the General Fund of $7 billion in 2009 (Elmendorf et al., 2010). In 2010 it required $14.7 billion (FWHA, 2012a). Results of years 2011 and 2012 do not suggest any improvement and probably the Highway Account will later require another infusion.

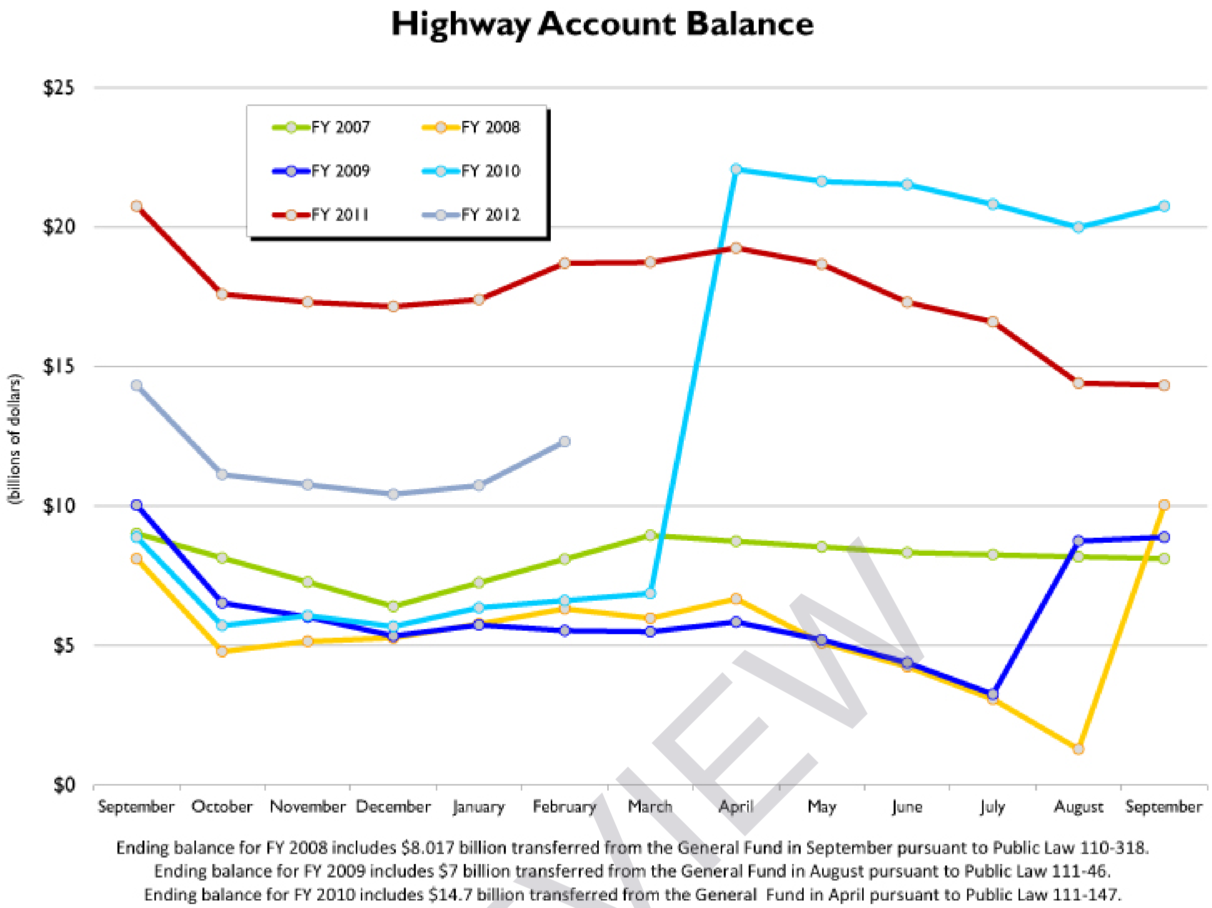

Figure 2.3 Highway Account balance

Source: FWHA (2012a)

Sequence from the top in September: 2011, 2012, 2009, 2007,2010, 2008.

Figure 2.3 indicates the U.S. has been having problems with the Highway Account balance in the last years. The source of finances for road infrastructure is experiencing severe problems, which will not get better with time. It is about time to come up with a new concept of obtaining funding. That is where the distance-based tolling can be considered as a possible replacement, as it offers an income depending on actual usage (which is linked to the wear-out) and is more fair for all road users, including alternative fuel based vehicles (who at the moment do not pay any equivalent to the fuel tax).