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Toll and Fuel Tax Collection Costs in the 21st Century

By Daryl S. Fleming, Ph.D., PE

with contributions by
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Reason Foundation

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Executive Summary

Since completion of the Interstate Highway System in the early 1990s, America has continued to rely mostly on motor fuel taxes at the federal and state levels to meet the need for maintaining the U.S. highway system. This worked well for some time as traffic (measured by vehicle miles traveled) routinely increased a few percent every year. However, these user tax rates have not kept pace with inflation, and recent large increases in the price of fuel and a lagging economy have reduced traffic growth rates the last few years. Since 1982, money from the Highway Trust Fund (HTF) has also been diverted to pay for transit and other non-highway projects. Hybrid vehicles and Corporate Average Fuel Economy (CAFE) standards have also eroded this source of revenue by making cars more fuel-efficient. Meanwhile, annual traffic growth over the last three decades (prior to the recent economic downturn) has led to major recurring congestion on most urban corridors during peak periods, emphasizing the need for new and expanded roadway facilities. In

addition, many highways are aging and in serious need of reconstruction. Clearly, the U.S. highway funding mechanism must change.

A number of alternate revenue sources exist. Prior to the Federal Aid Highway Act of 1956 that enabled development of the Interstate highway system, tolls played a major role in the development and maintenance of many major inter-city highways. But the introduction of federal fuel taxes and the HTF refocused major highway funding away from tolls. Fuel taxes were also a much easier and, at that time, less expensive means for collecting revenue than tolls. But advances in toll collection technology have significantly reduced the costs of toll collection. First introduced nearly three decades ago, electronic toll collection (ETC) is now nearly ubiquitous on U.S. toll roads and bridges. Since the early 1990s we have also seen the development of open-road tolling (ORT), which allows transponder-equipped vehicles to bypass toll booths at highway speed, and more recently all electronic tolling (AET) has eliminated the need for toll booths altogether by eliminating cash toll collection at the roadside.

AET has reduced the direct operating costs of toll collection. In addition, AET has eliminated the secondary costs of manual toll collection such as traffic hazards at toll plazas, traffic congestion (and related emissions and fuel consumption), noise and consumptive land use. Nevertheless, though tolling technology and toll collection have become much more efficient, the conventional wisdom prevails:

Toll collection costs are disproportionately larger than the costs of collecting fuel taxes.

This study challenges this conventional wisdom. It addresses the lack of reliable and uniformly reported data on the costs of collecting both fuel taxes and tolls, and the inaccurate and misleading information reported by those with a vested interest in sustaining fuel taxes and resisting greater use of tolls. This study analyzes recent data on the costs of collecting motor fuel taxes. Since several toll authorities are transitioning from manual or ORT to AET, this study compares data on toll collection costs from three toll agencies already operating in a fully AET environment to provide a common baseline. It also addresses collection costs for potential U.S. mileage-based user fee (MBUF) programs.

Since AET is a relatively new concept for toll collection, this study presents the basic AET operations plan and business model. It also identifies the principal factors that affect toll collection costs in an AET operating environment, including functioning frameworks that, when implemented with best practices, enable the operator to keep collection costs to a minimum. As well, it explores a number of opportunities to further reduce the cost of toll collection. Though every toll facility operation may not be able to employ all of these methods, the additional methods discussed can be used when the political will exists to further reduce collection costs.

The most significant ramifications of this research on major transportation policy issues include:

1) **The cost of collection for motor fuel tax revenues is significantly greater than the widely believed figure of 1% of the revenue collected.**

Indirect costs, such as losses incurred at several levels of the process and taxes hidden in the collection of revenues (some are even imposed on those exempt from the fuel tax program), suggest that the costs of motor fuel tax collections may well be in the vicinity of 5% of the revenue collected. Also, continued use of motor fuel taxes to generate roadway funding rather than collecting this revenue through variable, time-of-day tolls to manage traffic and reduce congestion levels introduces an opportunity cost with a monetary value that could be well over 15% of the revenue collected by the existing fuel tax programs. In addition, since motor fuel tax receipts are routinely raided for other purposes, the opportunity costs associated with fuel taxes compared with AET could be even greater.

2) **The cost of collection for all electronic tolling is significantly less than most historical toll collection cost data suggest.**

Since the introduction of AET, the toll industry in North America has undergone a period of rapid change. Technology has eliminated the need for toll booths, the labor costs associated with toll collectors manning toll booths 24/7, toll plazas and the large infrastructure investments needed to support these facilities. Though AET has back-office processing, customer services, and violation and enforcement costs not incurred with cash toll operations, AET has also eliminated the costs of operating the infrastructure necessary to sustain cash toll operations, along with the safety, operational and environmental impacts of toll plazas. AET also eliminates the revenue losses from cash "leakage" (an inevitable cost in cash toll lanes), and, when priced appropriately, recovers the costs associated with additional processing and lost revenue from those attempting to defraud the system.

3) **Toll collection cost data from toll operators that have taken full advantage of AET technology and its basic business plan are an indicator of what toll collection costs can be if deployed in a new framework on a much broader scale.**

Historical toll collection cost data for large public agencies burdened with institutional problems from decades of political interference, including labor restrictions that curtail their ability to convert to ETC operations in existing toll lanes, do little to provide an appropriate benchmark of what toll collection costs can or should be. Also, since many facilities have recently implemented AET and are still encountering the transition costs of converting to AET, their current cost data do not represent typical toll collection costs in

an AET environment—especially an AET program to toll major highways on a broader basis.

4) **Cost data for some AET operations in the United States demonstrate that the net collection costs of an AET operation can be in the vicinity of 5% of the revenue collected for a $5.00 toll (or 8% of revenue collected for a $2.00 toll).**

This suggests that toll collection costs can be (and are in some cases) similar in magnitude to the actual costs of collecting federal and state motor fuel taxes. Once opportunity costs of retaining motor fuel taxes in lieu of using tolls to manage congestion are considered, tolls are clearly a more cost-effective option for generating revenue for our highway system.

5) **When AET service fees are priced correctly, the (low) cost of tag (transponder) transactions is the best overall indicator of AET collection costs.**

Pricing service fees and penalties within an AET operation appropriately recovers all operating costs beyond those needed to process basic transponder transactions. Service fees and penalties on non-members of the AET program and defrauders cover the additional costs of processing those toll options.

6) **Toll collection costs can be reduced beyond those already demonstrated by toll road operators using AET.**

Recent efforts by the Alliance for Toll Interoperability (ATI) to develop a nationwide hub (clearinghouse) for toll transactions should further reduce AET collection costs. Once the toll operator has vehicle ownership information, he still must get the vehicle owner to pay. Interagency cooperative agreements such as that recently implemented by Maine, New Hampshire and Massachusetts may help solve this problem. Legislation may also be necessary at the state level to criminalize toll evasion (which is theft) to enable operators to legally collect outstanding tolls. Consolidation of processing functions between toll and other agencies, such as the motor vehicle departments, could also reduce AET operating costs.

7) **Keeping the AET operations plan simple will reduce toll collection costs.**

AET operations should avoid complex schemes that are inappropriate for its design. This includes multifarious vehicle classification schemes often used with manual toll collection, dynamic pricing operations rather than simpler time-of-day tolling, and complicated HOV free passage, commuter, environmental and other discount programs and travel credit schemes. For example, offering credit to customers when it is not necessary can increase toll collection costs by as much as 50%, and, once credit is offered, this practice is very difficult to change. All add to the complexity and cost of toll collections, as well as to the

likelihood of errors occurring in the billing process, which can lead to significant public relations problems and, in some cases, put the entire revenue collection program at risk.

8) An AET solution for mileage-based user fee charging could be implemented cost-effectively on limited-access corridors today.

AET allows for pricing all vehicles on the roadway by class (not just carbon-fueled vehicles), as well as by where and when each vehicle is operated. Toll operators now have the ability to establish and monitor the financial controls necessary to conduct a detailed financial audit of toll operations in an AET program. Collecting tolls linked to specific highway facilities also avoids the likelihood that the toll revenue would be spent on other uses. Traffic diversions to non-tolled routes can be minimized by ensuring that the customer is always offered value for the toll being paid and by regulating motor carrier traffic diversions with local ordinances if penalties are established at a level sufficient to deter others from diverting their trips.

9) Waiting for further improvements in technology before starting the shift in the funding of major highways from fuel taxes to all electronic tolls is unwarranted.

Opportunities to further reduce toll collection costs through technology may exist. Tellingly, even though the viability of AET was demonstrated on Toronto's Highway 407 ETR in the late 1990s, it was 15 years before AET achieved broad industry acceptance—twice the life cycle of most aspects of toll systems. In addition, many of the opportunities to further reduce the cost of collecting tolls will likely come from cooperative arrangements between toll and other agencies supporting the motor vehicle industry to share databases, back-office processing and customer service functions. These opportunities exist today and do not depend on further technology.

The results of this research demonstrate that with existing technology and a proper operating framework, the costs of collecting fuel taxes and the costs of collecting tolls for an urban corridor can be very similar. In fact, when all the costs of collection are considered in both cases, the cost of collecting tolls in some toll operations today may actually be less than the total costs of collecting motor fuel taxes.

In addition to giving toll operators the ability to significantly reduce their collection costs, AET enables the operator to manage congestion through value pricing—a powerful tool to combat congestion, pollution and related social costs. The benefits of AET are difficult to overestimate. This study does not extend its scope to address second-order benefits of congestion management such as lower health care costs related to decreases in pollution, increased regional productivity or improved quality of life, but examining the straightforward direct benefits is compelling enough. Simply, major expressways that do not use tolling incur an opportunity cost due to their inability to manage congestion and its effects. AET is thus a powerful tool to manage problems beyond simply generating revenue.

The clear advantages of AET are not an indictment of previous policies; AET is simply an enabling technology that was not previously available. An apples-to-apples comparison of the collection costs of motor fuel taxes vs. tolling via AET shows that tolling is as efficient a tool to collect revenue for our roadways as motor fuel taxes—and, in some cases, it may be more efficient. Once the possible traffic-management benefits of using AET (or the opportunity costs of retaining motor fuel taxes instead of using AET with a value-pricing toll schedule) are considered, AET is a much more cost-effective tool for collecting revenue for expressways.

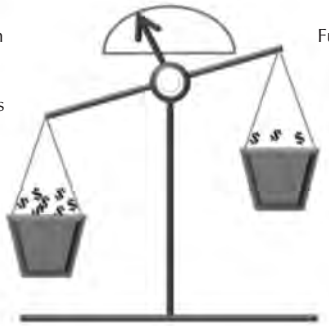
The policy implications of this research are significant. This work demonstrates that 21st-century all electronic tolling is already a viable alternative to motor fuel taxes as a highway user fee. In particular, toll collection costs in the vicinity of 5% of the revenue collected are entirely possible today using proven methods and technology. From the road user's perspective, 21st-century tolling offers the opportunity to charge for use of a specific highway, when it is used, and by the type of vehicle being operated. As with paying one's water bill or electric bill, the toll customer pays a user fee for the service provided. From the highway operator's perspective, AET provides much more flexibility to price the entire vehicle mix than do motor fuel taxes. When implemented with a value-pricing toll schedule, AET can also be used to manage traffic—offering significant benefits that motor fuel tax programs cannot provide. And since tolls are not tied to fuel efficiency, the continuing progress in this area of technology will not diminish revenue, as with fuel taxes. Moreover, the fact that tolls are typically restricted to paying for the facility being tolled (and therefore far less likely to be diverted to non-highway purposes) increases their credibility as a true user fee. This direct linkage is likely to be viewed by highway users as fairer than other pricing programs and less susceptible to manipulation by elected officials.

The time to embrace electronic tolls as a primary source of highway funding is now. Though the viability and benefits of AET were first demonstrated in the late 1990s, we are just now seeing the broad adoption of AET in the United States—approximately 15 years later. This suggests that, even if a better technology for a mileage-based user fee were on the immediate horizon (which does not appear to be the case), the toll systems installed today would require at least one major systems upgrade before this new technology is proven and ready for broad implementation. Therefore, waiting for further technology to offer additional efficiencies in per-mile charging would offer few benefits at a significant cost and needlessly delay the transition from fuel taxes to 21st century tolling.

Conventional Wisdom on Collection Costs of Toll and Motor Fuel Tax Programs

Conventional Wisdom

Toll Collection
Toll Plazas
Manual Toll Collection
Congestion
Fuel Consumption
Environmental Impacts
Safety
Theft

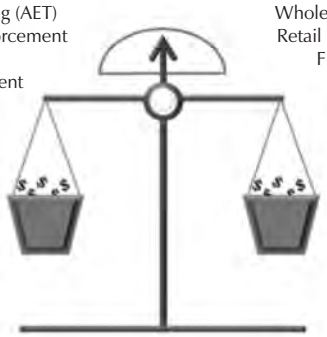


Motor Fuel Taxes
Retail Sales
Fuel Color Additives
Spot Enforcement

Collection Costs of Toll and Motor Fuel Tax Programs with AET and All Costs Considered

21st Century Tolling (AET)

Toll Collection
All Electronic Tolling (AET)
Violations and Enforcement
Processing
Account Management
Customer Services

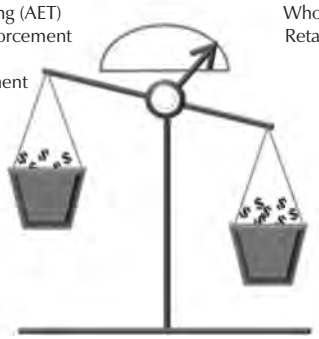


Motor Fuel Taxes
Wholesale Sales (Federal)
Retail Sales (Some States)
Fuel Color Additives
Spot Enforcement
Hidden Taxes
Loopholes
Theft

Costs of AET and Motor Fuel Tax Programs Once Opportunity Costs Are Considered

21st Century Tolling (AET)
Considering Opportunity Costs

Toll Collection
All Electronic Tolling (AET)
Violations and Enforcement
Processing
Account Management
Customer Services



Motor Fuel Taxes
Wholesale Sales (Federal)
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Fuel Color Additives
Spot Enforcement
Opportunity Cost
Hidden Taxes
Loopholes
Theft

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Part 1

Introduction

Approximately $10 billion in toll revenue was collected in the United States during 2010, close to one-third of what the federal government collected in fuel taxes. Nevertheless, much of the literature suggests that toll collection costs are still too prohibitive for tolling to be used as a broadly based method of paying for highways. In fact, one recent study summarily dismissed tolls as a viable option by stating that their collection costs typically consume from 20% to 25% of the revenue collected, while also noting that fuel taxes do not require the construction of toll plazas and toll booths.[1] However, that study, even though it was published in August 2011, completely overlooked the benefits of current proven technology such as all electronic tolling (AET) as well as other changes and trends in the toll industry that demonstrate opportunities to significantly reduce toll collection costs.

There are several possible reasons for this misconception, including a shortage of reliable, accurate and current toll collection cost information in the literature. Though public toll authorities are required to publish cost information, each compiles its toll collection costs based on its own policies, business rules and management needs, making it difficult to determine what is even included in the reported collection costs, and making it nearly impossible to compare the collection costs of one operator to those of the next. Many toll authorities are also burdened with costs resulting from political interference and other legacy issues that can greatly increase operating costs. In addition, the toll industry has gone through a period of rapid change, from the broad introduction of electronic toll collection (ETC) in the late 1980s, to open road tolling (ORT) in the 1990s, and conversions to AET over the last several years. The one-time costs of these conversions invariably skew the data, especially at agencies with extensive legacy problems, making it even more difficult to get representative information on the actual costs of toll collection.

Not all of the inappropriate observations of toll collection costs are naïve interpretations of reported data. Some are clearly deliberate attempts to mislead the reader.

Not all of the inappropriate observations of toll collection costs are naïve interpretations of reported data. Some are clearly deliberate attempts to mislead the reader. For example, one recent study asserts that the costs of collecting tolls can exceed 30% of the revenue collected.[2] The toll

operations cost data used to substantiate this claim came from three large public agencies that have a long history of being subject to political interference and that still had extensive cash toll collection operations. Two of the three were also incurring significant one-time expenditures to convert from manual to ETC toll operations—one-time costs that appeared to be included in the annual collection cost data. As a result, those not familiar with toll operations interpret these metrics as appropriate benchmarks for typical toll collection costs, then cite these statements in other work, and over time they become conventional wisdom.

Many toll authorities are burdened with numerous legacy problems such as labor contracts, complex vehicle classification schemes, commuter discount programs and other constraints that can significantly add to the cost of toll collection. The costs associated with sustaining these burdens should not be incurred by new toll programs. Therefore, this project did not conduct an exhaustive historical study of current toll collection costs. Instead, we proceeded as follows.

Many toll authorities are burdened with numerous legacy problems such as labor contracts, complex vehicle classification schemes, commuter discount programs and other constraints that can significantly add to the cost of toll collection.

First, we compiled a brief history of tolling and motor fuel taxes as highway revenue sources and established the need for a replacement funding source. Then, to explain why toll collection costs are so misunderstood, we reviewed some of the challenges associated with proper interpretation of reported toll collection costs. We also critically analyzed three recent studies that reported relatively high toll collection costs, putting their findings in the context of the stated purpose of each study, the data they reported, how they represented the information, and how this information relates to collection costs in the rapidly changing toll industry.

We then challenged conventional wisdom by presenting a new analysis of reported costs of collecting motor fuel taxes to establish an “all costs included” baseline metric for comparison. We also reviewed state-of-the-art practices in the toll industry and how they have affected toll collection costs, and we developed three case studies of leading-edge AET operations, describing how each has realized significant reductions in the net costs of collecting toll revenue. We also estimated what toll collection costs for new AET toll operations should be if the tolling system is designed and operated via emerging AET best practices. Finally, we identified the policy implications of the findings of this research.

Part 2

The Need for Change in Highway Funding

America relies on highways to meet our needs for personal travel and goods movement—locally, regionally and nationally. Sustaining a well-maintained highway system that meets our mobility needs is critical to economic vitality. But America has allowed real (inflation-adjusted) highway funding to decline for over two decades. The result is that most states can no longer afford to properly maintain their existing highways, let alone modernize them and provide the new capacity necessary to meet increased travel demands.

Early Funding Programs

Some people think of highways paid for by fuel taxes as the way things have always been done, but there is nothing unusual or new about tolling. In England in the late 17th and early 18th centuries, turnpike trusts were developed in response to declining roadways following the introduction of narrower wheels, heavier coaches and an increase in traffic. Local authorities (parishes) privatized stretches of highway through acts of Parliament, with tolls paying for construction and improvements.

Some people think of highways paid for by fuel taxes as the way things have always been done, but there is nothing unusual or new about tolling.

Here in North America the toll finance model, which establishes a direct link between the user fee and the facility being funded, saw extensive use in the 19th century for early U.S. turnpikes in the pre-auto era. Most turnpikes were privately owned, operated and maintained, and users paid a toll to use the roadway. Most ferries operated on a similar basis. The toll finance model was also used to build a number of major superhighways in the middle of the 20th century, including the Pennsylvania Turnpike, the Florida Turnpike, the New Jersey Turnpike, the New York State Thruway and others. However, unlike earlier highways, these toll roads were planned and built by state and local authorities based on presumed regional and local needs and financed by bonds to be

paid off over time from toll revenues. Tolls collected from those using the facility also paid for the costs of collecting the tolls, as well as the operation and maintenance of each facility.

The principle of using fuel taxes to fund highways on a cash basis originated at the state level, when Oregon enacted the first motor fuel tax for highway funding in 1919. In the decade that followed, the other (then 47) states and the District of Columbia did likewise. Many states created highway trust funds, and some were given constitutional status to ensure that the fuel taxes would be used only for highway purposes.

The use of motor fuel taxes to fund highway projects at the federal level began with the Federal Aid Highway Act of 1956 that established the Interstate Highway System, the construction of which was to be funded on a cash basis (rather than being financed as toll roads were) via a newly created Highway Trust Fund (HTF). Money for this fund would be collected and replenished via new federal taxes on gasoline and diesel fuel, a relatively efficient means of collecting revenue at that time, with funds allocated by formula to each state to build its portion of the planned network of highways. On most Interstate projects, the federal government, via the HTF, paid for 90% of the cost, with the state providing 10%. Most major highways that had already been built or were under development with tolls were included in the Interstate system, and tolls remained in place on most of these facilities due to bond covenants. In addition, even though the Federal Aid Highway Act paid for most of the construction costs for the remainder of the Interstate System, it did not initially provide funding for the operation and maintenance of this system (though Congress eventually allowed some HTF funds to be used for those purposes).

Federal funding of the Interstates via fuel taxes provided a revenue stream that was sustainable at the time and provided the long-term commitment which, to a great extent, was necessary to get the Interstate Highway System built. At the same time, federal funding also eliminated the direct (user pay) link between the funding of major highways and the users of each facility. Fuel taxes are an indirect user fee, and because they are indirect, they are susceptible to political manipulation. The HTF at the federal level and fuel tax trust funds at the state level became targets of opportunity for those seeking funding for non-highway projects.

Federal energy and environmental policies are increasingly at cross-purposes with dependence on petroleum sales as the primary source of highway funding.

Meeting Expanding Funding Needs from a Shrinking Base

The Interstate Highway System has been considered complete by most since the opening of the link of I-70 through Glenwood Canyon, Colorado, in 1992. However, funding requirements for this vitally important network for interstate travel and commerce are ongoing:[3]

- Highways, once built, require significant ongoing maintenance to remain useful (pavement rehabilitation, bridge maintenance);
- Much of this maintenance has been deferred, and pavement and bridge replacements (now needed throughout the network) will be far more expensive than the original construction;
- Where Americans live and work has changed dramatically, requiring additional facilities that were not planned decades ago (e.g., the missing Interstate link from Phoenix to Las Vegas); and,
- Many of the Interstate highways built several decades ago do not meet existing and projected traffic demands.

Major highways have a design life of 50 to 60 years and even with regular maintenance will need to be rebuilt after reaching that point. Doing so will be far more costly than the original construction because of decades of inflation and the need to meet today's design and safety standards.

Many experts have concluded that taxes on fuel are not sustainable long term as the country's principal source of highway funding, while others are suggesting that

> *Travelers and the public would benefit greatly from a transition to a fee structure that charged vehicle operators more directly for use of the roads.*[4]

The public has lost confidence in the existing federal program, making it politically impossible to increase the taxes on gasoline and diesel. These taxes were last increased in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 (which went into effect in 1993). A similar problem exists in many states.

Also, federal energy and environmental policies are increasingly at cross-purposes with dependence on petroleum sales as the primary source of highway funding. The Energy Policy Conservation Act of 1975 established corporate average fuel economy (CAFE) standards for passenger cars and light trucks. The initial goal was to double the fuel economy of new cars to 27.5 mpg by 1985. In 2010, CAFE standards were increased to require 35.5 mpg by 2016.[5] And in 2011, the administration announced (and gained auto industry agreement to) CAFE standards requiring 54.5 mpg by 2025.[6] Encouraged by various types of federal subsidies, the number of electric, alternative fuel and hybrid vehicles is increasing and is expected to go on increasing in coming decades.

Moreover, although the federal government continues to collect motor fuel taxes and deposit the proceeds in the HTF, these funds are no longer committed solely to highways. A transit account was created in the HTF in the 1982 reauthorization legislation that today accounts for 20% of the spending. The 1991 reauthorization act further opened HTF monies to non-highway uses, allowing portions of the highway monies distributed to the states to be used for other purposes. In fact, raiding of the HTF has become so significant that a 2010 Reason Foundation study found that eliminating non-highway spending from the HTF would provide for over a 30% increase in federal highway funding.[7]

Many states have also allowed the use of state fuel tax revenue to support all forms of transportation, despite the funds coming only from highway users. As of 1998, 24 states had highway-only trust funds, 14 had transportation trust funds, seven had both, and five had neither. Therefore, only 24 had a constitutional provision limiting the use of motor fuel taxes to highways and bridges while at least six others have a similar requirement in statute.[8] Nonetheless, most states have faced significant deficits over the last several years, a trend that is expected to continue for some time. As states face increasing fiscal deficits, we would expect them to use highway trust funds intended for roadways for non-transportation purposes.[9]

Therefore, the real purchasing power for construction and maintenance of highways has been in a downtrend for over two decades. Federal fuel taxes have experienced a significant shortfall since the arrival of the current depressed economy. Since state fuel tax revenue, like federal fuel tax revenue, is based on the amount of fuel sold, state fuel tax revenues are experiencing a similar decline.

In addition to providing a viable and reliable source of funding, tolls have also been proven to be an effective tool for congestion reduction.

Back to the Basics

Given the declining real yield from fuel taxes, some state and regional agencies have gone back to the toll finance model to pay for new or rebuilt highway facilities. A highway (or a significant portion of it) is financed with bonds issued by a public agency and these bonds, as well as the costs of highway operations and maintenance, are paid for via toll revenues. Some agencies, such as the Oklahoma Turnpike, have been able to develop a statewide network of toll roads by treating the roadway needs of the state as a system and using links in more populated areas to cross-subsidize links serving rural areas. About half the states have also passed legislation to permit public private partnerships to design, finance, build, operate and maintain new highways or rebuild existing highways under long-term concession agreements. These projects are typically financed via a combination of debt and equity. In most cases tolls are the principal source of revenue to repay the investors and to operate and maintain these facilities. Some public agencies have even leased

existing tolled assets to the private sector (e.g., the Indiana Toll Road) under similar long-term concession agreements, which include the responsibility to add capacity and modernize the highway to meet a variety of performance requirements—all to be paid for via tolls.

Unlike fuel taxes or proposals for universal vehicle miles traveled (VMT) fees or mileage-based user fees (MBUF), tolls are typically linked to the facility on which they are collected by being integrated into the financing process through bond covenants. Thus users pay for the costs of the particular highway they are using (which means they will pay more for a costly to build highway than for an inexpensive to build highway). Also, toll finance constraints usually limit the ability of the state to divert toll revenues to other purposes at a later date. Tolls can also be used to manage congestion by varying the charge based on varying traffic levels. Though concerns about diversion of traffic to non-tolled facilities are real and must be addressed, the effectiveness of variable tolling as a tool to manage demand and reduce congestion is well documented in the literature—and has been demonstrated by more than 15 years of its use in high occupancy toll lane projects across the country. Therefore, in addition to providing a viable and reliable source of funding, tolls have also been proven to be an effective tool for congestion reduction.

In 1997, all electronic tolling (AET) was introduced on Highway 407 in Toronto, demonstrating the collection of all tolls in a free-flow environment without toll collectors, toll booths, toll plazas or a physical barrier of any kind.

Technology to the Rescue

Historically, tolls have been collected by a toll collector at a toll plaza that formed a physical barrier across the highway, requiring every vehicle to stop. Electronic toll collection (ETC)—tolling the vehicle automatically as it rolled through the toll plaza—was first implemented in 1983 on the Coronado Bridge in San Diego. The benefits of this technology led to rapid public acceptance, and by the early 1990s, vehicles were being tolled at prevailing speeds in lanes that bypassed the toll plaza (open road tolling or ORT). And, in 1997, all electronic tolling (AET) was introduced on Highway 407 in Toronto, demonstrating the collection of all tolls in a free-flow environment without toll collectors, toll booths, toll plazas or a physical barrier of any kind.

AET eliminates the need for toll plazas and manually collecting tolls at the roadside, benefiting the roadway owner and the customers by:

- Reducing the labor costs of sustaining toll collection 24/7 at the roadside, enhancing net revenue for the toll operator;
- Providing customers with a much higher level of service, as tolling is no longer inconvenient and a physical imposition; and,

- Eliminating all the negative impacts of toll plazas: safety, congestion and environmental impacts.

AET also greatly reduces opportunities to abuse the system. By taking the toll collector out of the transaction process, AET eliminates revenue "leakage" at the roadside, a problem that has plagued toll collection efforts since their inception. AET also defeats other opportunities to abuse our toll collection and taxation systems, such as providing an auditable trail for all tolls paid by commercial customers, and, through automation of discount programs (should the public demand they be continued until an alternative pricing scheme can eliminate their need) in lieu of ticket books and tokens, circumventing the opportunity for customers to write off their tolls twice at tax time.

AET also enables variable and congestion pricing—options difficult to implement in a reliable, accurate and auditable manner with cash tolling. Since the real estate to provide toll plazas and the extensive capital infrastructure necessary to sustain them are not required, AET can also be easily retrofitted to existing non-tolled highways, enabling (for the first time) the use of tolling on a broad scale on primary urban expressway networks.

Although AET eliminates the need for toll collectors, toll plazas, toll booths and most other roadside infrastructure, it does create the need for back office operations to manage accounts, maintain transponder inventories, process transactions, provide customer services, and manage a collections and violation enforcement effort not required with manual toll collection. However, when priced and managed appropriately, AET is still much more efficient than collecting tolls manually, resulting (also for the first time) in the costs of toll collection being much closer to the cost of collecting other forms of highway revenues. Unfortunately, for many the new reality of 21st century toll collection costs has yet to overcome conventional wisdom.

Part 3

Interpreting Reported Toll Collection Costs

Most toll operators in the United States are some form of public authority. Public disclosure mandates require them to prepare and publish annual reports, including a summary of their actual toll collection costs. These annual reports are usually available on the Internet within a few months after each agency closes its fiscal year, and generally include some explanatory notes as to how the numbers were derived. Most of these annual reports are prepared consistent with generally accepted accounting principles (GAAP) and certified as such by an external auditor. Though GAAP guidelines give the agency substantial flexibility to compile and report its cost information, these reports should provide an indication of how each agency's costs vary from year to year.

Should the agency decide to compile or report its cost data differently, GAAP rules require, as a minimum, a footnote describing the change made during the data compilation process and what impact it may have on the summary metric to enable appropriate comparisons from one year to the next. Also, several other factors that affect the costs provided in these annual reports make it difficult to develop reliable toll collection costs. The most significant of these are discussed below.

Lack of a Standard for Compiling Toll Collection Costs

There is no recognized standard for compiling and allocating toll collection costs in a uniform manner from one agency to the next. The lack of such a standard, especially in light of the multitude of different possible approaches to reporting capital and operating costs, makes it impossible to compare costs directly. If a standard is developed, it needs to answer the following questions:

- Should the capital costs of toll systems and maintenance be included in a summary of toll collection costs?
- Should the capital costs of the buildings, power, communications and other physical infrastructure necessary to sustain toll operations be included?
- If the facilities required to support toll operations also support other agency needs, such as traffic management systems (TMS), intelligent transportation systems

(ITS), police and security personnel, roadway maintenance and other functions, what portion of the costs of these facilities should be allocated to toll collection?

- Over what period should toll collection capital costs be amortized?

In the absence of such a standard, toll collection cost data are typically reported with insufficient supporting documentation to identify the specific costs included—greatly limiting the ability to conduct a thorough evaluation of the information provided without extensive further research. This research would generally require detailed interviews with toll operations personnel at the facility reporting the data to identify the specific costs that are included in each metric.

Rapid Changes in the Toll Industry

The toll industry has been going through a period of rapid change. Many toll authorities have recently converted (or are in the process of converting) from cash to cash/open road toll (ORT) operations, or from cash or cash/ORT operations to all electronic toll (AET) operations. An agency's toll collection costs using these automated systems are usually considerably less once these conversions have been successfully completed. However, conversion costs from cash to ORT/AET operations can be significant, including:

- Modifying infrastructure to support the revised toll operations plan;
- Upgrading systems (toll conversion modifications, traffic management and communications);
- Restructuring operations and retraining personnel;
- Sustaining both cash and ETC operations during the transition period; and
- Adjusting to sustaining toll operations under the new business model once the transition to AET is complete.

What portion, if any, of these costs of conversion should be considered in an analysis of toll collection costs?

Variations in Toll Operations

Many factors vary from one toll authority to the next, issues that can have a major impact on an agency's toll collection costs. The most significant of these include the agency's:

- Toll operations plan (e.g., customer service policies, toll schedules, vehicle classifications, credit vs. pre-paid accounts, commuter/other discount programs);
- Structural and legacy issues, such as the agency's charter, labor union agreements, bond covenants and other institutional factors;

- Level of automation of the toll operation (e.g., percent cash vs. ORT/AET operations);
- Level of active interoperability with other toll operators, e.g., through transaction consolidators like the multi-state E-ZPass (Inter Agency) Group (IAG) and California Toll Operators Committee (CTOC);
- Level of cooperation with state motor vehicle registration agency to enable billing vehicle owners who are not actively registered in an automated toll program (resolving this may require legislation at the state level recognizing failure to pay a toll as theft); and
- Violation enforcement program strength (including local laws and regulations).

The last two issues become significant with the advent of ORT/AET operations.

Inherent Weaknesses in Historical Evaluations

Ideally, the analyst conducting a historical evaluation of reported toll collection costs at several toll agencies would attempt to normalize (conform to a common reference point—"apples to apples" in layman's terms) the data. This process would require an agency to extensively review what is included in its cost data and adjust reported toll collection cost information so that the metrics used for comparison all include the same subset of toll collection costs. Though this can be done, the exercise for toll collection cost data is tedious at best, and it requires getting the detailed information necessary to verify that the costs reported are only the costs the analyst needs. Unfortunately, the tasks required to normalize these data do not stop there.

Since they operate differently based on local legal, policy and institutional factors, various toll authority operations plans should be considered in any effort to standardize data for this type of analysis. However, this normalization, rather than being strictly analytical, must be somewhat subjective due to the nature of the factors causing variations in toll collection costs and the fact that there is not sufficient information to statistically isolate the relative impact of each factor. Similarly, any institutional issues, such as differences in the agencies' charters, political intrusion, labor union rules and contract terms also need to be considered. Any operating conditions unique to an agency for the period for which the data are reported would also need to be considered, such as being in the middle of a transition from cash to AET operations. For these reasons, normalization of toll collection cost data in the United States for the last decade has not been possible. In fact, the rapid changes the industry has undergone in converting from cash to ORT/AET operations suggest that a conventional historical evaluation of toll collection cost data would be misleading to most analysts trying to estimate toll collection costs for policy or cost estimation purposes.

Historical evaluations look backward in time and offer the analyst a glimpse of what has happened—not what is currently happening or will likely happen in the near future. Even in

situations (and this is not one of those situations) where outliers in the data can be identified and discarded, the remaining information normalized, and a rigorous statistical analysis conducted on the remaining data, the most that an analyst can demonstrate is what toll collection costs were within a given range over a certain reporting period. In some situations, it might be possible to identify one or more of the primary factors that drive toll collection costs, if the database is large enough and the data are clean. Unfortunately, these evaluations give no insight into why toll collection costs have been historically within the given range, or why and to what extent these causal factors impact toll collection costs.

Metrics for Toll Collection Costs

Most toll operators have used two metrics to monitor and report toll collection costs:

- Cost as a percentage of revenue collected; and
- Cost per toll transaction.

Though both metrics are intended to measure the efficiency of toll operations, they actually monitor different things. In fact, both metrics are usually tracked and reported. Which metric is of greater significance depends on the type of organization managing the toll operation and how it operates.

The private sector tends to focus on changes in cost per toll transaction, since even small improvements in this metric can mean significant gains in net revenue. This metric is subject to differences in the efficiency of the design of the toll collection scheme, such as whether the toll operator:

- uses a barrier system;
- accumulates tolls to consolidate transactions; and
- emulates conventional ticket programs.

To a certain extent it also depends on the operation's size. Nonetheless, cost per transaction is a truer measure of efficiency of the toll collection process than cost as a percentage of revenue collected, since it is not directly subject to variations in the amount of the toll collected.

Public sector managers tend to focus on collection costs as a percentage of revenue collected, since this is consistent with how most public agencies monitor expenditures and manage their budgetary processes. Monitoring toll collection costs as a percentage of revenue collected validates the previous year's budget and expedites the budgeting process for next year. In addition, if there is no change in the average toll and no spike in traffic growth, reporting the cost of toll collection as a fraction of revenue collected can provide an overall indication of the level of efficiency of the toll collection effort from one year to the next—and one that can be readily understood by the public.

Cost as a percentage of revenue collected is also directly comparable to reported estimates for the cost of collecting motor fuel tax revenue. Therefore, it is the primary metric relevant to many policy discussions, such as for direct comparisons with the cost of collecting motor fuel taxes, and this study uses it in the same manner. In other comparisons we use the cost per toll transaction or both metrics to demonstrate observations where appropriate.

Cost per transaction is a truer measure of efficiency of the toll collection process than cost as a percentage of revenue collected, since it is not directly subject to variations in the amount of the toll collected.

Establishing Toll Collection Cost Benchmarks

A 2008 study attempted to benchmark AET operations, but it encountered a number of problems.[10] The most significant of these challenges to developing benchmark metrics for toll collection costs included:

- There is no standard cost accounting procedure for reporting toll collection costs;
- Each agency operates according to its specific charter, local laws, policies and business rules (all impacting toll collection costs); and
- Historical evaluations provide a broad indication of what toll collection costs were but do little to identify representative current costs of collection.

More recently, two other factors have contributed to the challenge of developing appropriate toll collection cost benchmarks:

- The toll industry has been going through the transition from cash to automated toll collection methods—rendering most available data essentially useless for these purposes; and
- Metrics used to monitor toll collection costs vary depending on the owner (public vs. private) and type of operation being managed (cash/ORT/AET).

Therefore, it is nearly impossible to normalize published toll collection cost data due to the lack of a uniform set of data reporting standards, as well as the many variables that affect toll collection costs from one agency to the next. But this hasn't stopped researchers from attempting to develop representative toll collection costs.

A Critique of Recent Collection Cost Studies

Part of the due diligence process conducted by public agencies requires comparison of their operating costs (or in some cases projected operating costs) to those of other agencies that provide similar services. Since tolling is now becoming a primary option for funding on many major U.S. highway projects, the federal government and those planning major highway infrastructure projects are all expressing an interest in toll collection costs. Those with vested interests in status-quo revenue generation systems are also concerned about toll collection costs.

Several recent studies have responded to this need by providing a glimpse into the complex issues surrounding toll collection costs, through high-level comparative evaluations, while cautioning readers on interpreting the information published and/or transferring these data to other facilities. Others have simply published the data available with little, if any, understanding of what they are publishing or how the information should be interpreted. In addition, some appear to have selectively chosen toll collection cost data that are disproportionately high. In some cases they have even included capital cost expenditures—civil construction work that had nothing to do with toll systems or toll collection costs—and presented their results as illustrative examples of "typical" or "benchmark" metrics to further a non-tolling agenda. This study provides a summary review of three of these publications as representative samples of the limited toll collection cost data available in the literature. Detailed critiques of each can be found in the Appendix.

Report 1: "Comparative Analysis of Toll Facility Operational Costs," prepared by IBI Group, Inc., for the Washington State Department of Transportation, February 22, 2007.

This WSDOT report is consistent with current industry practices for the review, evaluation and management of toll operations in the public sector. It presented collection cost information logically with appropriate cautions regarding transfer of this information without a thorough understanding of toll collection costs for each facility. This report also met WSDOT's requirement for a due diligence review of its estimated costs for toll collection on the Tacoma Narrows Bridge. However, the data reported provide little guidance on toll operations costs for a modern AET toll program.

Report 2: "Defining the Legacy for Users: Understanding Strategies and Implications for Highway Funding," American Transportation Research Institute (ATRI), May 2007.

The ATRI authors state in their executive summary that they provide the perspective of the end user (trucking industry) on the use of tolls and other user fees for financing roadway infrastructure, and this position is evident throughout the report. The ATRI document was clearly written to convince the reader that collecting tolls is very expensive compared to other revenue collection methods, in addition to costs for several safety, congestion and environmental issues associated with collecting tolls. In fact, all of these secondary costs, including accidents at toll plazas, are the result of manual toll collection methods. In

addition, though the authors did mention that ETC could reduce some labor costs, the authors did not mention AET, even though AET eliminates most of the direct costs and all of the indirect costs of collecting tolls manually. The ATRI authors also failed to note that in 2007 many authorities were already converting to AET or were well into the planning effort necessary to do so at the time their document was published.

The authors also presented annual variations in several agencies' cash flows—issues that are professionally managed on a regular basis using GAAP—to suggest that most toll authorities operate at a loss and imply that the toll systems and/or the cost of their operation caused these shortfalls. Compiling and misrepresenting information in the manner they did is simply wrong and inexcusable. In fact, most of the information on toll collection, toll authorities and toll programs in general in the ATRI document is misleading and inappropriate. Most of the ATRI authors' conclusions are also unsubstantiated by either the information they provide or by the experiences of others.

Report 3: "Costs of Alternative Revenue-Generation Systems," NCHRP Report 689, Project 19-08, National Cooperative Highway Research Program, Transportation Research Board of the National Academy of Sciences, March 2011.

The NCHRP report is consistent with current industry practices for review and summary of data. Information appears to have been presented as reported, and the tabular and graphic presentations in the report were done in a professional manner. While this study provides user fee collection cost data for toll, fuel tax and VMT fee applications, most of the toll collection cost data failed to consider the aforementioned subtleties that skew the data and resist standardization—even though one primary source for toll collection cost data was the WSDOT study (Report 1 reviewed above) that emphasized the limitations of these data.

Nevertheless, some of the toll collection and fuel tax cost data assisted our research once properly interpreted. But since VMT fee operations are relatively new in the U.S., the collection cost data reported were European estimates. The researchers reviewed several pilot projects in the United States, but provided no cost data. The NCHRP research was also fraught with a series of challenges, not the least of which is the fact that the investigators, by their own admission, had little experience with proposed alternative revenue collection methods.

The investigators provided toll collection cost data for several U.S. and Canadian toll authorities and attempted to normalize the data. Graphical presentations of the information clearly indicated that the research failed to eliminate outliers (data points that were significantly different from others reported) for each metric being evaluated, which is standard practice in such studies. Use of misleading outliers is obvious to anyone with a basic understanding of how those authorities' toll collection programs work and the local institutional issues that affect their toll collection costs. The result is that summaries of the means and observed ranges of several metrics that the NCHRP document presents do not represent typical toll collection costs, and, if interpreted at face value, mislead the reader.

In addition, the research made little attempt to identify the benefits of AET, including the significant reductions possible in toll collection costs. Nor did the NCHRP study report on current trends in the way toll collection programs are structured that have led to further reductions in toll collection costs. It also overlooked how toll collection costs might be reduced even further by applying lessons learned from adjacent, parallel industries such as large transaction processing houses that serve commercial operations.

Limitations of Published Toll Collection Cost Data

The three reports reviewed above are typical of the documentation available on the broad subject of fuel tax and tolling comparisons. All the reports, to one extent or another, review and evaluate toll collection and other costs reported by toll authorities. All also provide specific information and data points relevant to a policy evaluation of alternative user fees to sustain highway funding. However, only one report [WSDOT] cautions the reader on the limitations of the data provided.

These research efforts had different purposes and the usefulness of their results is limited for various reasons:

Study	Purpose	Limitations	Results
1	Validate a budget for a new publicly operated toll program	Optimizing net revenue is not an objective	Limited information on ways to reduce collection costs
2	Present an end user's perspective on tolls as a user fee	Subject to investigator bias	Toll collection costs misrepresented
3	Determine efficiency of alternate collection methods	Researchers' lack of familiarity with alternate user fees evaluated	Limited interpretation of data reported

All three reports suffer from taking a broad historical perspective of costs incurred, instead of focusing on those agencies that have significantly reduced toll collection costs, identifying how they did it, and suggesting ways to further reduce toll collection costs using proven methods and technologies. The remainder of this document will focus on this forward-looking perspective.

Part 4

The Real Costs of Collecting Motor Fuel Taxes

An apples-to-apples comparison of the costs of various revenue collection methods requires considering all direct costs, such as operational, administrative, collection, losses and enforcement costs, as well as adjusting for variations in the measurement metrics for monitoring the costs of each operation. A balanced comparison should also recognize indirect costs of each collection method and recognize inherent strengths and weaknesses in the ability of each revenue collection method to be properly managed and monitored. This section applies that sort of scrutiny to the costs of collecting motor fuel taxes (MFT) and the following section applies the same approach to AET.

Conventional Wisdom

A 2011 report to FHWA identified the cost of collecting motor fuel taxes as a percentage of revenue collected at approximately 1%, including all deductions by state collection agencies, expenses of collecting and administering motor fuel taxes, expenses of inspecting motor fuel and other costs or deductions by the collecting agencies.[11] This metric seems to be relatively consistent from year to year, with the reported costs of collecting motor fuel taxes ranging from 0.9% to 1.4% of collected revenue from 2003 to 2007, and averaging 1.1% during this period.[12] Indeed, reported data suggest that out-of-pocket costs of collecting MFT are about 1.1%.

Yet, this estimate does not reflect many of the actual costs of collecting MFT. The direct costs of collection at the public agencies responsible for reporting MFT collection costs are relatively easy to compile, but like reporting variations in the toll industry, reporting anomalies from one agency to the next, and in some cases between departments within an agency, can lead to significant variation in what is included in reported costs of collection. Notwithstanding the tendency of public agencies to underestimate their operating costs in such situations, this 1.1% estimate does not consider indirect costs of collecting motor fuel taxes or losses from the revenue stream, as discussed below.

Abuses of the System

Significant abuses of the federal and state fuel tax collection programs occurred in the 1980s. As a result of the Tax Reform Act (TRA) in 1986 and the Omnibus Budget Reconciliation Act (OBRA) in 1993, the federal fuel tax collection point was moved from the retail point of sale to the terminal rack (bulk wholesale at fuel terminal distribution point) for gasoline and diesel fuel sales, respectively. In addition to allegedly reducing the number of large-scale evasion schemes, this legislation was reported to have reduced the cost of collections. Though it may have decreased the reported costs of collections as it was measured, this improved program for collecting motor fuel taxes also introduced a number of indirect costs to the process of collecting this revenue stream.

This revised federal MFT collection program placed a significant share of the costs of recording and reporting motor fuel taxes on distributors of motor fuel. The costs of collecting and reporting these taxes incurred by distributors, including the distributor's mark-up on these costs for profit and risk has been almost certainly been passed on to retailers under this revised MFT collections program. Similarly, the retailer's mark-up on these costs for profit and risk has been almost certainly passed on to consumers. It is highly unlikely that these indirect costs of collection for MFT are reported correctly and properly considered in the estimates of cost of collection (expressed as a percentage of revenue collected). Nevertheless, these costs are real and form a hidden tax on consumers of motor fuel at both the distributor and retail levels—a fee that is collected from the consumer to pay for the cost of collecting the tax but ends up as cost recovery and profit to the companies processing the transactions. In fact, the hidden tax on consumers at the retail level is more egregious than the hidden tax at the wholesale level since consumers at the retail level are paying a hidden tax on a hidden tax.

Though it may have decreased the reported costs of collections as it was measured, this improved program for collecting motor fuel taxes also introduced a number of indirect costs to the process of collecting this revenue stream.

The motor fuel tax collection program is rife with additional indirect costs of collection, since points of taxation for both gasoline and diesel fuel still vary widely from state to state, including collection of fuel tax revenue at the terminal rack, wholesale and retail sale locations.[13] Appropriate inclusion of many of these indirect costs in reported MFT collection costs is also highly unlikely. Therefore, though the estimated collection cost of motor fuel taxes has, historically, been reported at or near 1% of the revenue collected from one year to the next, the real cost of collecting motor fuel taxes in the supply chain has been repeatedly underestimated.

Tax Filing and Other Indirect Costs

Estimates of MFT collection costs fail to adequately capture other indirect costs of collecting motor fuel taxes as well. For example, the cost to the IRS for processing and managing fuel tax credits is easily addressed and apparently included in reported collection costs. However, it is impossible to track and verify the time and expense incurred by exempt users in recording and summarizing the necessary data and completing and submitting Federal Form 4136 with its annual tax filing with the Internal Revenue Service (IRS). The fact that we have a Paperwork Reduction Act (44 U.S.C. 3501) that estimates the level of effort necessary to complete such filings indicates that these are real costs to the collection of motor fuel taxes and a hidden tax on those exempt from the taxation program. Requiring users to file exemptions to get refunds of taxes they were not supposed to pay also opens the door to fraud and abuse. Though we have no way of estimating these types of indirect losses, they are a real cost of collection.

While ensuring total compliance with all filing requirements would be prohibitively expensive, clearly some motor fuel tax revenue goes uncollected. In fact, the literature commonly documents reported losses from abuse of the system. For example, a recently published summary of "*On-road Fuel Tax Enforcement Sample Statistics*" suggests a fuel tax collection violation rate in the vicinity of 1%.[14] Though clearly not reported as part of the cost of collection of motor fuel taxes, these losses are a real cost of the collection of fuel tax revenues since the lost funds are not available for roadway improvements. Therefore, if this estimate is accurate, the real cost of collecting motor fuel tax revenues as a percentage of revenue collected is at least 2.1% of the revenue collected without consideration of the other indirect costs identified above.

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Discrepancies in the Data

The reported data have major discrepancies. Therefore, revenue losses from violations during the collection of fuel taxes may be significantly higher than the 1.5% to 4% typically reported for on-road fuel tax enforcement efforts, as suggested by Table 1.

Table 1: Estimates of Lost Revenue from MFT Evasion in the United States in the 1990s				
Year	Source	Method	Lost Revenue	% Tax Revenue
2001	KPMG	Comparison of fuel supplied to taxed gallons	$170 to $920 M/Yr	~1.5%
1996	Council of State Governments/Governor's Policy Advisors	Literature review, survey of state tax administrators, econometric analysis	$666M to $1.5B/Yr	~2%
1996	Mingo & Associates	Comparison of fuel consumed vs. fuel taxed (diesel, all states)	n/a	21%
1994	FHWA	Literature review/analysis of auditing data	$3B/Yr	~4%
1992	Nat. Assoc. of Truck Stop Operators	Diesel fuel consumed at truck stops vs. gallons taxed	$3B/Yr	~4%

Source: *"Identifying and Quantifying Rates of State Motor Fuel Tax Evasion,"* NCHRP Report 623, Transportation Research Board, March 2011, p. 9.

For example, that same NCHRP report notes that "*164 kerosene inspections were conducted in PA resulting in 46 violations for illegal use of the untaxed fuel,*" a violation rate of 28%, yet Pennsylvania's "*Sample*" violation rate in the same summary table of reported data was just 0.49%.[15] Though this is just one observation, it is a significant discrepancy from the summary data reported and calls the entire reporting process into question. In addition, on-road fuel tax enforcement can assist in catching those motorists using dyed diesel fuel (fuel dyed to demonstrate that it is tax exempt and for non-highway use) only if the abuser is actually caught with dyed diesel fuel in his vehicle's fuel tank through random inspections. Also, random inspections cannot capture those who abuse the dyeing systems, by methods such as tampering with the dye equipment, failing to spray the dye into the fuel when refueling, and using fuel additives to hide the dye, nor does this enforcement program enable the capture of those violating the fuel tax program by other means.

Other opportunities for abuse of the system are many and varied, ranging from reporting abuses (false refund claims, failure to remit taxes and falsely filing International Fuel Tax Association reports), to bootlegging (illegally transferring fuel across state or international borders and/or reporting fuel's transfer when it was not transferred), daisy chains (a series of dummy corporations formed to establish a paper trail that makes tax-free transactions look legitimate) and a host of other fuel tax evasion schemes—all which call into question the validity of the MFT violation rate typically quoted of 1%.[16]

Exemptions and Other Opportunities for Abuse

In addition, even though everyone benefits from the roadway network, fuel tax exemptions have been granted to a variety of special interest groups, some via federal policy, and in most states a number of special groups have been granted exemptions (e.g., transit buses and school buses). Though exemptions are also granted in the toll industry, the extent of those exemptions is typically far less than with motor fuel tax collections. In fact, in some states these motor fuel tax exemptions are so extensive that simply averaging the states' reported fuel taxes on gasoline and diesel fuel

(resulting in approximately 20¢ per gallon for state fuel taxes in 2006) is misleading, since the actual state fuel tax rate in some jurisdictions is significantly less than that reported, given the large volumes of state tax-exempted gasoline and diesel fuel. In addition to reducing the actual revenue collected, these exemptions can lead to fraud and abuse of the fuel tax programs, further reducing the effective rate of taxation on motor fuels at the state level. Thus the "sample" fuel tax violation rates of from 0.47% to 1.84% reported in this study are overly optimistic.[17] This appears to be particularly true for motor fuel taxes on diesel fuel, where non-compliance rates tend to be far greater than for gasoline. Therefore, the real cost of fuel tax collections is more than likely several times the 1% of revenue collected figure that is typically reported as conventional wisdom.

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Limited Enforcement and Compliance Efforts Since 2000

In the 1990s, state and federal agencies sought to increase fuel tax compliance. The federal government modified the collection of MFTs to reduce the incidence of fraud. Many states (though not all) followed the lead of the federal government and moved the point of collection of state MFTs from retail to wholesale outlets during this period so that this aspect of the tax collection process would be easier to manage. Some states also implemented other changes to reduce fraud and abuse. For example, Minnesota modified its agriculture gasoline tax refund law in 1998, and average MFT refund requests for non-highway use went from $3.7 million to $1.1 million a year.[18] Therefore, some of these losses no longer exist. Still, opportunities to defraud the MFT programs still exist at many levels and can take many forms. Since relatively little research has examined evasion of the federal and state MFT programs over the last decade, and enforcement and compliance efforts have been limited (especially with reduced operating budgets over the last several years), the likelihood of fraud and abuse creeping back into the system is very high—especially in light of the amount of funds involved.

Estimated Cost of Collection of Motor Fuel Taxes

Though compliance efforts appear to be far less frequent and aggressive in nature over the last decade or so, one relatively recent research effort, a 2006 study that estimated evasion of motor fuel taxes in Montana in 2004, reported 2.1% and 16.3% tax evasion rates for gasoline and diesel fuel, respectively.[19] Though the authors did not have detailed 2004 data, a summary of 2006 data for the following state and federal tax rates for gasoline and diesel fuel, including total fuel tax rates for each type of fuel, is provided below.

2006 Fuel Tax Rates in Montana (¢ per gallon)

	Gasoline	Diesel
State	27.75	27.75
Federal	18.40	24.40
Totals	46.15	52.15

Composite federal and state tax rates are thus similar. Therefore, since diesel fuel taxes collected were approximately one-third of all fuel taxes collected in Montana in 2006,[20] and assuming that evasion rates in 2006 were similar to 2004, an estimate of all fuel tax violations expressed as a percentage of revenue collected in 2006 can be generated by:

(2/3 fuel * 2.1% evasion) + (1/3 fuel * 16.3% evasion) = 6.8% fuel evasion

Therefore, even without considering many of the indirect costs of collecting motor fuel taxes in the supply chain, estimates of the total cost of motor fuel taxes for at least one state (Montana) in 2004 could be nearly 8%:

Reported out-of-pocket costs of collecting MFT	1.1%
Estimated MFT revenue losses from fraud and abuse	6.8%
Total	7.9%

Though the analysis presented here applies to just one state, it is nearly eight times the metric usually referenced as the cost of collecting MFT revenue as a percentage of revenue collected (1%). A review of the real costs of collecting motor fuel taxes in other states would likely produce different results, though there is no reason to assume that Montana is atypical. Indeed, even if the levels of fraud and abuse in other states were only half those estimated in Montana, the estimated total losses from fraud and abuse would still be 3.4%, and the estimated cost of collection for motor fuel taxes would be 1.1% + 3.4% = 4.5%, which is more than four times the conventional wisdom's 1%.

Opportunity Costs of Retaining MFT as a Highway Funding Source

The emergence of AET has reduced toll collection costs and offers other benefits that were previously not possible or part of the benefit/cost calculus. Since AET enables the active management and reduction of congestion on major corridors, the opportunity costs associated with retaining motor fuel taxes—an avoidable cost when a more assignable and flexible revenue stream such as AET is available—need to be considered. This is especially true in light of the nature of how delays are encountered in recurring congestion. Studies commonly have found that delay increases exponentially with traffic on a fixed amount of road capacity.[21] In fact, once traffic volumes reach capacity, a 16% increase in traffic typically results in a 50% increase in vehicular delays.[22] Since most of our major urban corridors are operating at capacity for several hours a day during peak periods (i.e., traffic demand exceeds capacity), AET can be used to implement time-

of-day pricing on these major urban corridors. In fact, if AET could reduce overall peak period traffic (by inducing people to combine their trips or make them during off-peak periods) by just 5% (a very modest assumption in light of motorists' known sensitivities to pricing), the benefits would be huge. Adjusting for congestion based on incident and weather-related delays, this small reduction in traffic should reduce peak period delays from traffic congestion by approximately 10%.[23]

Recent estimates of the costs of congestion in U.S. urban areas approach $100 billion/year.[24] Thus this conservative estimate of savings from reduced congestion suggests that the opportunity cost of using motor fuel taxes in lieu of tolls to raise revenue for urban highways is at least $10 billion/year (10% of $100 billion/year) or about 15% of the current level of revenue collected through federal and state motor fuel taxes. *Therefore, a conservative estimate of the opportunity costs from retaining MFT in lieu of variable tolling as a revenue source is 15% of the MFT revenue collected.*

This estimate of opportunity costs does not consider possible savings from anticipated reductions in traffic crashes that could be realized from reduced levels of traffic congestion.[25] There are also several other indirect benefits that are difficult to quantify, including increased trip-time reliability, that would be realized from a reduction in congestion.[26] This estimate also doesn't consider structural flaws in the MFT program. An AET revenue collection program can be (and is typically) dedicated to one or more specific highway facilities through bonding covenants. The result is that an AET revenue stream will usually be less likely to be raided for other purposes. Therefore, 15% of the MFT collected each year is a conservative estimate of the opportunity costs associated with retaining the motor fuel tax in lieu of a value-priced, AET revenue collection program.

In summary, as long as highways are funded by motor fuel taxes rather than a modern, congestion-priced AET program for urban expressways, a conservative estimate of the overall costs of retaining the motor fuel tax could be close to 20% of the revenue collected—20 times the metric usually referenced as conventional wisdom for the cost of collecting motor fuel taxes.

Conventional estimated collection cost	1.1%
Estimated fraud and abuse	3.4%
Opportunity costs (congestion, structural flaws)	15.0%
Total	19.5%

Part 5

Toll Collection Costs Using AET

With the advent of AET the role of the toll facility operator is similar to that of a public utility, such as those providing other network utility services (electricity, natural gas, water, cable, telephone). The operator is providing a service for a fee and the life-cycle costs associated with charging customers for that service are the collection costs. Prior to AET, these costs included the infrastructure and labor necessary to establish and sustain manual toll operations at each toll plaza, as well as some costs associated with the transfer and management of funds collected. However, with AET most of these costs are no longer incurred. As with cash toll collection, AET collection costs include the costs of managing the funds collected—but the similarities of the two types of operation stop there. AET costs include the provision and maintenance of roadside and back-office systems necessary to monitor vehicular transactions and manage customer accounts, the cost of on-board units (OBUs), and the customer services necessary to provide user-friendly access to the program. AET collection costs also include the expenses associated with outside service providers necessary to sustain toll operations such as credit card and clearing house transaction fees, as well as the costs associated with sustaining a collections and violations and enforcement effort.

With the advent of AET the role of the toll facility operator is similar to that of a public utility, such as those providing other network utility services.

The AET Operations Plan

The key to significantly lower-cost tolling in the 21st century is all electronic tolling (AET). AET systems use electronic sensors to identify most vehicles through an on-board transponder. This is accomplished by a radio-frequency identification (RFID) link. For customers without a transponder, a process referred to as license plate tolling (LPT) captures an image of the vehicle's license plate. Other sensors at the roadside automatically identify each vehicle's classification per the designated toll schedule. Those customers who have actively enrolled their vehicle in the AET program are then tolled electronically by the system identifying the vehicle through the radio frequency link or an image of the vehicle's license plate and posting the appropriate toll to their account. Some authorities also charge a service fee per transaction for those actively enrolled who use the LPT option to cover the additional costs of processing and verifying the image of their vehicle's license plate and to discourage abuse of this tolling option.

Customers pre-enrolled in the AET program are usually required to pre-pay tolls to a debit account, though some facilities offer a credit option on pre-enrolled accounts. Pre-paid and post-paid flexibility may be attractive to different market segments, especially services supporting commercial customers. Since the costs of managing these credit accounts are higher than those of a pre-paid toll account, there is usually a monthly service fee imposed to offset the additional costs incurred by the toll operator.

Vehicle owners who have not actively enrolled their vehicles in the AET program are typically considered occasional customers and sent a notice through the mail for the outstanding toll and a service fee commensurate with the cost of processing the toll for the convenience of not having to enroll in the AET program. Customers for which a proper mailing address cannot be found through the Department of Motor Vehicles (DMV) and other sources (if allowed) are sent to collections where a larger service fee is imposed to recover the costs of additional processing. Those customers who have still not paid, including those who are actively trying to evade the toll, are considered violators and assessed an additional fee to recover the costs of the violations/enforcement (V/E) program and the small amount of tolls that remain uncollectible. This additional fee is usually sufficient to deter most violation activity. The key points to be made in consideration of an AET pricing plan are:

- Revenues are earned for services provided, much like payment of one's electricity or water bill;
- Service fees and penalties, where imposed, can be tailored to the level of effort required to sustain the services provided, as well as collections and V/E activity; and
- Tolls and charges are directly linked to customer accounts rather than broadly distributed over all users, such as with taxation of motor fuel at the wholesale rack.

All three mechanisms help greatly in making and keeping the payment process efficient, transparent, fair to the traveling public and resistant to manipulation. The accounting process is also straightforward, something difficult to attain with other programs.

The AET Business Model

Properly converting from a cash toll operation, or a hybrid cash and ETC or open road tolling (ORT), to AET involves far more than simply replacing old toll collection equipment with new. The public sector mindset—that a toll has to be collected from every vehicle even if we have to make everyone sit in a queue five miles long every morning and evening—is no longer valid. If this is coupled with the premise that everyone pays the same toll based on their vehicle classification, regardless of the level of service offered, the AET conversion is destined for problems. For optimum results (including the lowest toll collection costs), AET requires implementing a new operations mindset: a commercial business model. In fact, one senior

executive at a major toll agency that has successfully converted to AET has embraced this commercial business model:

> *I have pretty much banned the word patron from our vocabulary along with 'motoring public' and the like. We have Customers with a capital 'C'.*[27]

The more successful AET operators have abandoned the traditional police powers model (collect a toll from every vehicle no matter what the cost) and embraced a market-driven (retail) model where the end user—the customer—must be provided a clear value and treated fairly. As a result, the primary objective becomes to collect tolls accurately, reliably and cost-effectively, in a customer-oriented, user-friendly manner. The following objectives, presented in order of their respective priorities, should guide this process:

Provide clear value. Make the AET process friendly to the maximum number of customers feasibly possible. Always keep your customers informed and give them an opportunity to buy (in this case, pay their toll), in a number of user-friendly and convenient ways.

Make collections as efficient as possible. Collect funds in advance by actively enrolling customers in pre-paid toll accounts that are replenished (automatically where possible) once the balance drops to a pre-determined threshold. Debit the pre-paid account using one of the following systems:

- Vehicle-mounted transponders linked to a customer's AET account; or, next best,
- A license plate toll (LPT) process based on the vehicle's license plate number linked to the customer's AET account; or
- An LPT toll process based on retrieving the customer's billing information from the DMV or other appropriate source, and sending the customer a notice in the mail for the balance due that includes the appropriate toll for the trip and a service fee (or fees) due for the convenience of not having to actively enroll in the AET program.

Properly converting from a cash toll operation, or a hybrid cash and ETC or open road tolling (ORT), to AET involves far more than simply replacing old toll collection equipment with new.

Process customers who have not voluntarily paid the toll and/or service fee within a pre-determined time after notification, or whose billing information cannot be found through conventional means, through an active collections program.

Process the remaining customers—those who cannot be found, those who do not pay their notices when duly served, and those who purposely choose to defraud the system—as violators.

Toll operators must be able to impose penalties on violators that are sufficient to discourage most potential violators and persuade those who do violate to pay swiftly. This might include the introduction of a process by which a toll operator could initiate an administrative action that quickly escalates penalties and ultimately results in the denial of license plate renewal until outstanding debts owed to the toll operator are repaid. This type of process is critical to the sustainability of any AET operation. Without an appropriate deterrent factor, the number of toll violations can escalate to the point where they become unmanageable.

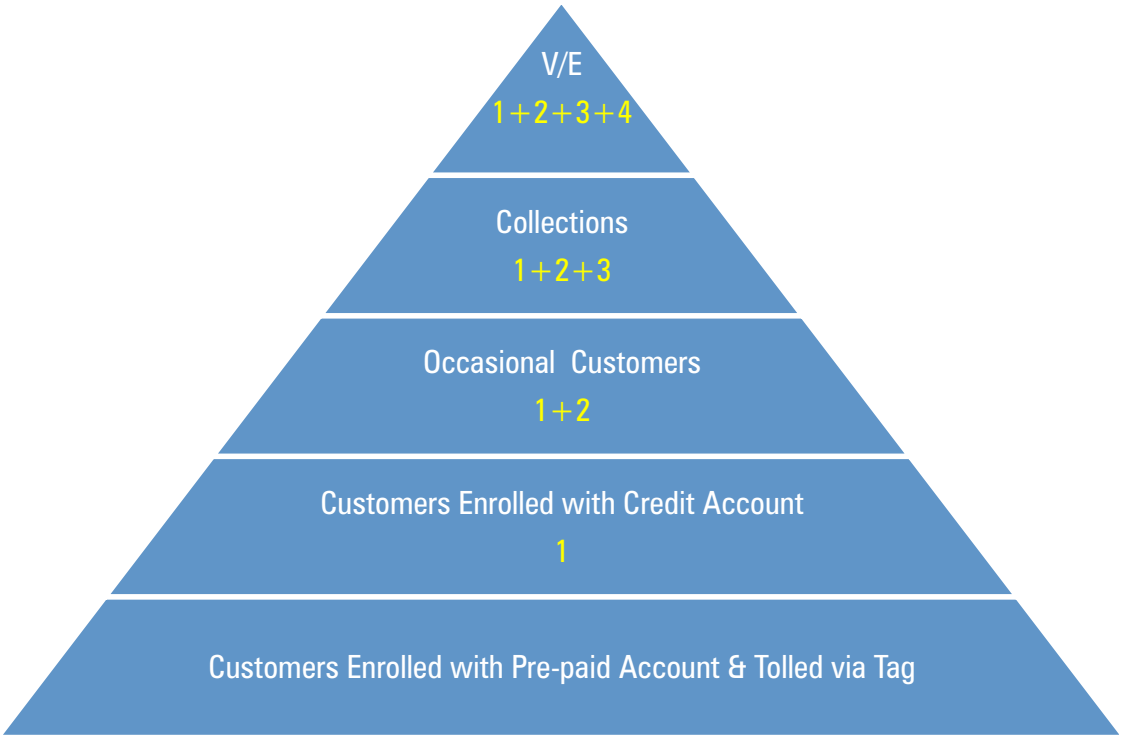
To reduce the cost of collection and keep the toll operation in a stable and self-sustaining mode, it is important to avoid cross-subsidizing one aspect of the AET operation with another. All service fees should be set at a level to recover the cost of processing required to collect the toll at each level of the process (Figure 1). In this manner, those who require an additional level of service to pay their toll, such as those using the LPT option, pay for that premium service. Similarly, lost toll revenue (from those violators not possible or feasible to find) is covered from the penalties assessed on those who are found. **In fact, when AET is operated and priced appropriately, the tag transaction rate is also the "effective transaction rate" because administrative fees and penalties offset the additional processing costs of all non-tag transactions.** Therefore, since AET eliminates leakage in cash toll operations and provides the opportunity for the toll operator to recover losses incurred from accounts that are inefficient or inappropriate to collect in the AET operation, conversion of a manual or hybrid toll operation to AET offers the toll operator an opportunity to significantly increase net revenue.

Varying from this basic business model and pricing scheme could lead to lost revenue and may require review and revision of the AET operations plan. Examples of such ill-advised variations include:

- offering credit accounts to those customers actively enrolled in the AET program;
- changing the definition of occasional customers; and
- providing a mail-in (after the fact) LPT option, discount packages, dynamic toll pricing plans and other modifications.

In fact, the available AET data suggest that just offering credit accounts to all actively enrolled customers can increase AET collection costs as much as 50%—a significant increase in collection costs from a business rule that, once incurred, is almost impossible to retract.

Figure 1: The All Electronic Tolling (AET) Pricing Model
(Fees Numbered in Yellow)



FEES (Yellow Numbers Above)

1 is the monthly account maintenance fee for those actively enrolled in the ETC program who (if given the opportunity) choose to pay their accounts on a credit basis.

2 is the fee charged to occasional customers for the convenience of not having to actively enroll in the ETC program. This fee is set at a level to recover the costs of finding and invoicing these customers. An additional fee is usually assessed if a second notification is required.

3 is the surcharge imposed to recover the costs of the collections process.

4 is the penalty assessed to recover the costs of V/E processing and any tolls that may be uncollectable.

NOTES:

- Not to Scale
- V/E is violations enforcement processing
- Where: Pre-paid accounts with tags on vehicles pay tolls only. (A fee may be imposed to recover processing costs if the toll is debited from a license plate read.)

Equity and Traffic Diversion Issues

Some have challenged this pricing scheme as inequitable. However, customer treatment is fair as long as the toll operator:

- Ensures that customers have been informed that they are being tolled, how they will be tolled and how to actively enroll in the AET program (i.e., how to avoid service fees and penalties associated with not actively enrolling in the AET program);
- Offers one or more user-friendly and cost-effective opportunities for both enrolled and occasional customers to pre-pay a toll (e.g., via LPT);
- Establishes a user-friendly means for transponder sales and cash replenishment to serve the unbanked community, including at least one no-surcharge option for cash customers to pre-pay their tolls;
- Offers a grace period for those caught in an emergency; and
- Properly addresses the public relations issues for these conversions prior to their implementation.

Other benefits not traditionally available also become possible with AET. AET's improvements in safety compared with collecting tolls manually in a toll plaza are significant. Crash data from conversions from manual to open road tolling on Florida's turnpike system show a 60% reduction in accidents.[28]

The operator still needs to dispatch maintenance crews to service AET roadside equipment. However, these professionals are trained in how to do this safely. Since most motorists are not professional drivers, the safety benefits of eliminating the toll plazas, as well as removing the people from the toll booths in those physical barriers, are so extensive that *not* converting to AET at this point could be perceived as putting the public and the authority's employees at unnecessary risk.

Traffic diversion to non-tolled parallel routes less suitable for through trips than major highways is also routinely cited as a major drawback of tolling—especially when diverted trips are heavily laden with commercial vehicle traffic, with increased congestion on the surface streets, pavement damage and safety issues being the primary concerns. Though some non-commercial traffic will inevitably divert to non-tolled routes, this can be minimized by the toll operator ensuring that the tolled facility offers genuine value to the customer. Minimizing diversions of commercial heavy vehicles can be accomplished through local regulatory ordinances similar to those already imposed in most states for selected routes (e.g., commercial vehicle prohibitions for "all Interstates, U.S. and State highways within the I-285 loop in Atlanta"[29]) provided that those responsible for enforcement of this activity in the local jurisdictions are accorded the authority to do so, and that the fine imposed on those caught violating the local ordinances is sufficient to provide a deterrent effect.

AET Case Studies: Best Practices

Examining the experience of three agencies currently operating solely with AET provides a better understanding of the cost of toll collection with a 21st century AET system. These agencies have further reduced operating costs through innovative approaches:

- Colorado Department of Transportation (CDOT) I-25 Managed Lanes;
- Fort Bend County Toll Road Authority (FBCTRA); and
- Tampa-Hillsborough Expressway Authority (THEA).

Although these are relatively small toll operations where one would expect unit operating costs to be relatively high, all three have been able to achieve operating cost efficiencies that much larger toll agencies have not yet obtained. The methods by which they have accomplished these efficiencies offer industry best practices.

By presenting actual operations cost data and appropriate interpretive information for these operations, this research shows how cost-effective toll collection programs can be, using existing AET technology and operating frameworks. Unlike historical cost data blindly aggregated and reviewed for means and averages, these data offer decision makers an indication of the proven cost-effectiveness of AET operations to enable comparisons with alternate highway revenue collection schemes.

Unless otherwise noted, agency costs not associated with the cost of toll collection are not included in unit toll collection cost comparisons in these case studies, including:

- Roadway enforcement not related to toll operations;
- Roadway maintenance (e.g., plowing snow);
- Cost of buildings required to support civil infrastructure; and
- Administrative overhead not directly related to toll operations.

The summary below presents basic statistics for each of the three toll operations investigated.

Case Study 1: Colorado DOT I-25 Managed Lanes

Summary	Collection Cost ¢/Transaction	Cost as % of Revenue
Tag Transactions(1)	7.3¢	3.9%
All Transactions(2)	54.0¢	28.7%

$2.25M/Yr. revenue on 1.18M transactions/yr. (average toll @ $1.88)

(1) The tag transaction rate is also the "effective transaction rate" when AET is operated and priced appropriately. (Refer to The AET Business Model section above.)

(2) Includes all administrative, systems and operating costs except capital costs of roadside toll systems (this facility has only one toll gateway).[30] May include some operating costs not attributable to operations. Even small administrative costs overwhelm metrics in a micro operation.

Toll Operations Supported: All Electronic Tolling (AET)

- Seven miles of existing, reversible HOV lanes on I-25 between downtown Denver and U.S. 36 were converted to I-25 HOV/express lanes June 2, 2006.
- Vehicles with two or more occupants travel through the toll zone for free in a lane marked HOV.
- All other vehicles pass through the toll zone lane marked Toll (transponder preferred).
- License plate tolling (LPT) was introduced as an option on January 1, 2009, at no surcharge. Customers are invoiced for tolls during the previous month. Advance registration is not required.
- Payment must be received by the date specified or transactions become toll violations.
- Time-of-day pricing tolls range from 50¢ to $4.00 with an $18.00 surcharge for 4+ axles.
- Tolls are posted on signs in advance of the entrance but the vehicle is charged the toll when it crosses the toll collection point at 58th Avenue, not when it enters the facility.
- HOV/express lanes are closed for maintenance 3:00 a.m. to 5:00 a.m. and 10:00 a.m. to noon each weekday.

Agency Observations/Strategic Factors That Impact Agency Costs

- Management team of High-Performance Transportation Enterprise housed and staffed by CDOT
- Contracts/fully interoperable with E-470 Public Highway Authority (E-470 PHA)
- Management staff, legal, accounting and office space provided by CDOT

Transactions

- ~86% of toll trips are transponder transactions and ~13% of toll trips are LPT
- ~98% effective collection rate and ~0.6% violation rate

Administration/Other Operating Costs

- $0.64M/yr. total operating cost/$0.43M to E470 PHA (oversight, management and operations)
- Contracted system operations and maintenance to E-470 PHA ($0.10M/yr.) and toll enforcement ($37,500/yr.)

Case Study 2: Fort Bend County Toll Road Authority (FBCTRA)

Summary	Collection Cost ¢/Transaction	Cost as % of Revenue
Tag Transactions(1)	5.0¢	6.25%
All Transactions(2)	10.6¢	13.25%

$17.5M/yr. revenue on ~25M transactions/yr. (average toll @ $0.80)

(1) The tag transaction rate is also the "effective transaction rate" when AET is operated and priced appropriately. (Refer to The AET Business Model section.)
(2) Includes all administrative and maintenance costs attributable to toll operations except for capital costs of road-side systems. Notably, there are only a few toll gateways.[31]

Toll Operations Supported: All Electronic Tolling (AET)

- 2 roads @ 6.5 miles each serving commuters into Houston
- EZTag since July 14, 2008
- 70% tag penetration when converted to AET
- Scheduled to open a new facility to connect two roads in 2012

Agency Observations/Strategic Factors That Impact Agency Costs

- Agency is a virtual operation
- Contracts with Harris County Toll Authority (HCTRA) for toll operations
- ½ FTE manager and ½ FTE maintenance manager
- Contract law enforcement
- Fully interoperable with HCTRA
- No full-time staff, no office, no vehicles, no unfunded liabilities
- Autonomy not an issue

Transactions

- 91%–92% of trips are transponder transactions
- 3%–4% of trips are license plate tolls (LPT) (informal as a customer courtesy)
- 97–98% effective collection rate
- 1.5% –2% violation rate
- Cite about 1 person/day for failure to pay the toll and impound their vehicle. Gross violators may be arrested.

Administration/Other Operating Costs

- Total cost of toll collection ~$2.35M/yr.
- Contract with HCTRA @ 5¢/transaction includes costs of credit/debit card processing
- Cost of violations enforcement/collections is ~$665k/yr.

Case Study 3: Tampa-Hillsborough Expressway Authority (THEA)

Summary	Collection Cost ¢/Transaction	Cost as % of Revenue
Tag Transactions (SunPass®) [1]	11.6¢	9.1 %
All Transactions [2]	12.8¢	10.1 %

Approximately $43.2M in toll revenue on 32.8M transactions/yr.

Average toll for ETC @ $ 1.27; average toll for LPT $1.45

(1) The tag transaction rate is also the "effective transaction rate" when AET is operated and priced appropriately. (Refer to The AET Business Model section.)

(2) Includes all systems and administrative costs attributable to toll collection. May also include some operating costs not attributable to toll operations that we were unable to separate from the cost data. (Refer to uncollectable note below.)

Toll Operations Supported: All Electronic Tolling (AET)

- The Selmon Expressway is a 15-mile, four-lane divided toll road with 10 miles of three reversible express lanes (REL) in the median.
- The REL opened in 2006 with tolls collected using either the Florida-based pre-paid SunPass® transponder or license plate tolling (LPT).
- Transponder tolls vary from 50¢ to $1.50 depending on the distance driven.
- LPTs are billed via invoices and incur a 25¢ surcharge. Payment for LPT must be received by the date specified or transactions become a violation and go to court.

Agency Observations/Strategic Factors That Impact Agency Costs

- THEA contracts with Florida Turnpike Enterprise (FTE) for Sunpass® (tag) transaction processing
- THEA in partnership with Miami-Dade Expressway (MDX) for LPT transactions (processed in a combined service center in northwest Miami-Dade County).
- Lane systems maintenance is provided by a vendor under contract to THEA.
- THEA management housed in a building owned by THEA.

Transactions

- ~79.5% of toll trips are SunPass® transponder transactions; ~15.2% LPT
- Tolls uncollectible at ~5.3%. THEA was just starting its active enforcement program when data for this study were collected.

Administration/Other Operating Costs

- $4.81M/yr. total operating cost
- FTE for Sunpass® (tag) account management/transaction fees @ 4.25¢ per transaction plus pro-rated cost of tags and 2.25% credit card processing ($1,108,230)
- Share of MDX/THEA operations for VTC and VES ($893,818) and management fee for THEA operations ($150,000)
- THEA internal staff, communications, lane maintenance and contingency ($849,829)

Interpretive Analysis

The collection costs of all three toll operations selected for review present strengths and challenges. On the plus side, each facility operates in urban areas where customers are familiar with toll facilities. Each also serves commuter traffic (typical of most urban toll operations). And yet, several characteristics challenge keeping operating costs down at these facilities. The most significant of these include:

- FBCTRA and THEA are relatively small toll operations based on the number of transactions processed, and CDOT is essentially a micro toll operation;
- FBCTRA and THEA, with average tolls of 80¢ to $1.27, respectively, charge tolls toward the low end of the range typically encountered on today's urban toll roads; and
- CDOT's I-25 Managed Lanes and THEA's Reversible Express Lanes are open to customers only during limited periods of the day (operations are not 24/7).

There are also three other discriminators for these toll operations that should be stressed:

- All three toll programs are new AET operations (AET being the new norm);
- Each toll operator contracts with other nearby toll authorities for account management and transaction processing (transponder, LPT and VEP) so as to achieve economies of scale that would be otherwise unreachable; and
- FBCTRA is a virtual authority operating with only a skeletal staff that is outsourced to a management vendor—eliminating its facility costs and keeping its management costs to a minimum.

Significantly, FBCTRA's operating structure makes it very easy for the board of directors to replace the management team if they are unhappy with management performance.

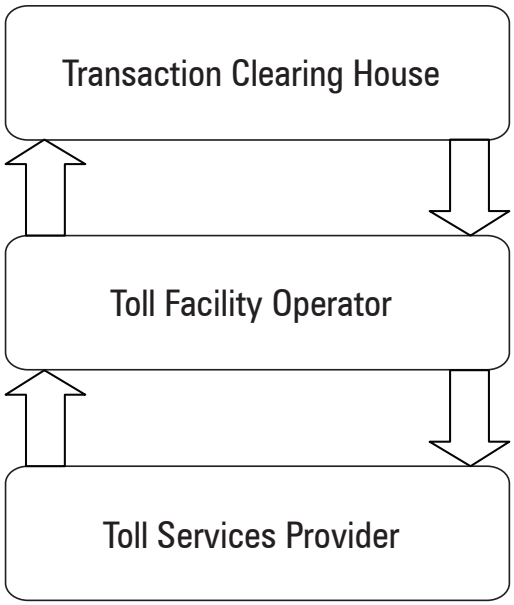
In addition, most of the professionals in charge of successfully implementing these projects were relatively new to the toll industry. Though this would normally be considered a handicap, these professionals were all seasoned veterans from other industries (a plus) and not burdened with a legacy of structural and operational concepts considered conventional wisdom in the toll industry. In particular, these professionals recognized that a toll authority did not necessarily need:

- A large, full-time administrative staff;
- Its own, unique front- and back-office operation; and
- A large building to house staff and IT systems.

These agencies outsourced the provision of services, systems and facilities, enabling them to realize significant reductions in their costs of toll collection. Indeed, many large existing agencies are already addressing their administrative and other burdens through cost-cutting efforts including transitioning to AET and outsourcing more services, and some are even considering consolidation of operations. Particularly, these three agencies have very aggressively managed their toll collection costs.

Structurally, AET collection costs are incurred at several levels (Figure 2). Anything that can be done to eliminate all or part of the processing requirements at each of these levels will reduce collection costs—and this is exactly what these agencies have done.

Figure 2: AET Processing Levels



Specifically, these agencies are:

- Operating an ETC program under the trade name of a large, nearby toll authority and having that authority distribute transponders and provide customer services, accounts management and processing functions, eliminating many of the interoperability issues that require toll clearing house processing and greatly reducing toll facility operating costs;
- Operating as a virtual authority, keeping civil infrastructure and staffing levels at a minimum, which significantly reduces toll collection costs, especially for smaller toll operations; and
- Outsourcing toll systems maintenance at two levels, primary on-call maintenance provided by the systems integrator, and routine maintenance provided by local technicians, to significantly decrease toll services provider costs.

The result is that toll operations for all three programs are very cost-effective—especially considering the relatively small size of each operation.

Table 2 presents a summary of salient information from each of these three case studies. The most important conclusions are the following:

- Toll collection costs, even in a relatively small toll operation, can be competitive with the costs of collection of fuel tax revenue when evaluated on a percent of revenue collected basis (~4% to 5% of revenue collected) when normalized to a $5 toll, which is equivalent to an average combined rate of federal and state fuel taxes at 45¢/gallon and an average fill-up of 11 gallons;
- The costs of collection for transponder transactions, even in relatively small toll operations, indicate the real costs of collection under AET. When service fees and penalties are priced appropriately, service fees on those who elect not to enroll in the AET program and penalties imposed on scofflaws to cover lost toll revenues from those who cannot be found recover all operating costs beyond processing transponder transactions; and
- Contracting out toll transactions, accounts management and processing to larger nearby toll authorities can offer significant savings in operations costs by capturing efficiencies those authorities have already gained from economies of scale.

Table 2: Summary of Observations from AET Case Studies			
Observation	CDOT I-25	FBCTRA	THEA
Reversible Managed Lanes	Yes	No	Yes
License Plate Tolling (LPT) Option	Yes	As a Courtesy	Yes
Virtual Organizations	No	Yes	No
Tolls Collected 24/7	No	Yes	No
Annual Revenue	$2.25M	$17.5M	$43.2M
Annual Transactions	1.18M	25.0M	32.8M
Average Toll			
▪ Transponders	$1.88	$0.80	$1.27
▪ LPT Surcharge	None	n/a	$0.25
Transaction Rates			
▪ Transponder	86%	91.5%	79.5%
▪ LPT[1]	13%	3.5%	15.2%
Transponder (Tag) Transaction Costs[2,3]			
▪ Collection Cost (¢/Transaction)	7.3¢	5.0¢	11.6¢
▪ Cost as % of Revenue Collected	3.9%	6.25%	9.1%
All Transactions[2]			
▪ Collection Cost (¢/Transaction)	54¢ [5]	10.6¢	12.8¢
▪ Cost as % of Revenue Collected			
○ Observed	28.7% [5]	13.3%	10.1%
○ Normalized to $5.00 Toll [4]	13.1% [5]	4.4%	4.8%
Roadside Enforcement	Limited	Yes	Limited
Violation Rate	0.6%	1.5%	6.4%[6]

NOTES

1. Tolling by capturing an image of the license plate of the vehicle.
2. CDOT I-25 and FBCTRA do not include capital costs of road-side systems.
3. Representative operating costs for comparison purposes.
4. Equivalent to an average combined rate of federal and state fuel taxes at 45¢/gallon and an average fill up of 11 gallons and credit card fees for all toll revenue @ 2.25%. Credit card fees added after normalization to provide conservative estimate of collection costs. Actual costs of credit card processing would be somewhat less do to contracted third party toll services, ACH and cash transactions.
5. Since this is a micro toll operation, even small administrative costs can overwhelm these metrics.
6. Authority was just starting its violations and enforcement effort. 36.6% of these violations and fees had been collected at the time this metric was reported.
   - Credit card transaction fees @ ~2.25% can be as high as 50% of toll collection costs expressed as a % of revenue collected for situations where larger tolls are collected—an indication of just how efficient these toll operations are.
   - As the number of transactions increases, the cost of their collections as a percentage of revenue collected decreases dramatically.
   - Aggressive management of exceptions processing for both transponder and LPT transactions can have a significant impact on reducing toll collection costs.
   - An effective violations enforcement program is necessary to keep violations in check.
   - Contracted rates for automated tag transactions ranging from 4.25¢ plus transponder costs and credit card fees to 7.3¢ (including transponder costs and credit card fees) suggest that the marginal cost of the contracting agencies to process additional transactions is ~7.5¢ per transaction.

CDOT, FBCTRA and THEA have demonstrated that significant savings in toll collection costs can be realized when a toll authority implements AET and abandons conventional wisdom regarding the structural and operations framework necessary to collect tolls—but the management of these authorities didn't do this alone. The results they have achieved are a tribute to their prowess and ingenuity, as well as the diligence and cooperative efforts of the agencies they have partnered with to make these efficiencies in toll collection costs happen. Most notably, the E-470 Public Highway Authority, the Harris County Toll Road Authority, the Miami-Dade Expressway Authority and Florida's Turnpike Enterprise program contribute significantly to the success of these programs. A number of other toll authorities have also realized that cooperative efforts such as those presented above can result in significant savings in their collection costs.

AET Collection Cost Projections

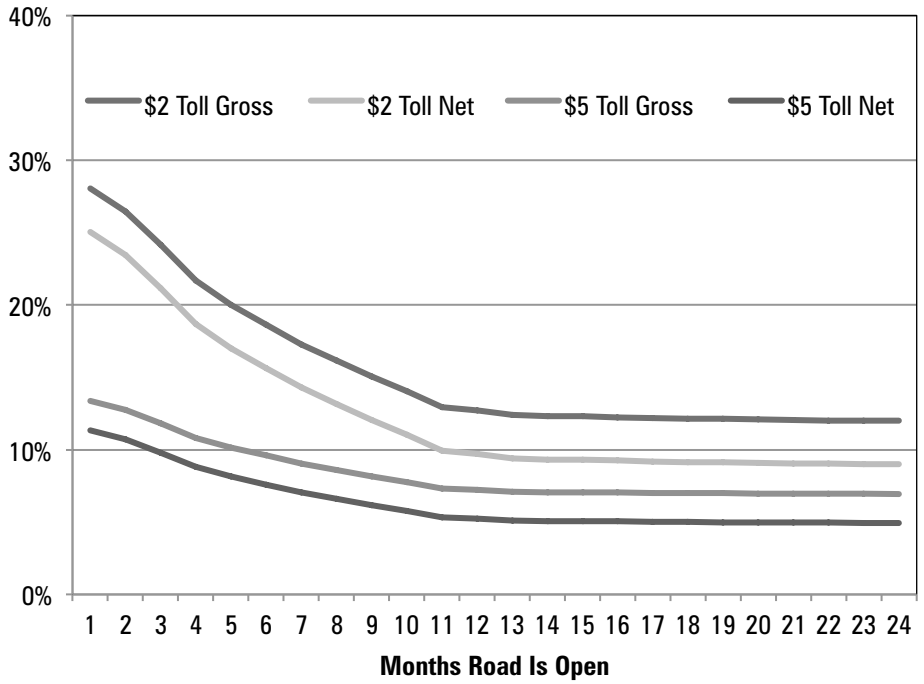
Observed toll collection costs from the three case studies reflect toll collection costs recently estimated by eTrans's proprietary capital and operating cost models for a privately operated toll facility of similar size, estimated use and operating characteristics as the THEA operation on the Selmon Expressway (Figure 3).

For many professionals, establishing a new AET operation or converting existing toll operations to AET is a new experience—and one taken with some trepidation. The costs while getting the majority of customers enrolled in the ETC program and transponders mounted on their vehicles are of particular concern.

These projections estimate the operator's cash flow requirements during deployment and initial operations, therefore, they should be considered conservative estimates of anticipated toll collection costs. For example, if a carefully developed marketing program communicates the value to customers correctly, 10% tag penetration in month 1 would likely be a worst-case scenario. This research assumes all critical management and customer interface functions are completed by the private toll road operator, while other more routine and manually intensive functions are to be outsourced to access the efficiencies that can be gained by relying on more efficient special services offered by the private sector. This research included local costs for rental of office space in lieu of amortizing the capital costs of a large administration building so that the flexibility and efficiencies that this approach offers the toll operator as its needs change over time could be considered.

Estimates of gross toll collection cost include the costs incurred managing accounts receivable, collecting tolls and service fees from those not actively enrolled in the ETC program, as well as the costs of processing those accounts that go into collections and those abusing the system (gross violators). If the toll operator deploys and manages the collections effort and violations enforcement program correctly and assesses appropriate service fees and penalties, the costs of collections beyond pre-paid accounts for transponder tolls should be self-supporting once the revenue stream from these operations is established. Adjusting the gross collection cost estimates accordingly resulted in these estimates of net collection costs.

Figure 3: Estimated AET Collection Costs (% of Toll Revenue)



NOTES:

1. Estimates of toll collection costs for AET deployed on a new, privately operated toll facility in the United States (no other ETC operations nearby) with 28 tolled traffic lanes by 15 toll gateways (sets of toll gantries), prepaid active enrollment programs and disposable tags at $3.00/tag. Processing loads assumed were:

	Month 1	Month 36
ETC penetration*	10%	80%
Daily transactions	40,000	90,000

   * Vehicles without tags tolled via LPT option.

2. A weekday/weekend & holiday/time-of-day pre-paid toll pricing scheme was assumed. Implementation of credit accounts, dynamic pricing, HOV and other discount programs could increase collection costs significantly.
3. Cost projections were developed on a monthly basis and include estimates of all capital, administration and marketing, and operations and maintenance costs that would be encountered, as well as central clearing house and credit card processing fees.
4. Gross estimates include costs to process LPT, manage accounts receivable, process collections and catch those abusing the system. Net estimates assume that these costs and any tolls that cannot be collected are recovered with service fees and penalties.
5. Estimates of toll systems capital costs were amortized over 7 years (IT systems) and 30 years (civil work to support IT systems, gantries and fiber).
6. Interoperability functionality assumed to be provided by regional clearinghouse.
7. All costs projected by eTran's proprietary capital and operating cost models.

These projections are similar in magnitude to the costs of sustaining toll operations observed in the three case studies. They also demonstrate that the toll charged can have a significant impact on the perceived effectiveness of the toll operation when using collection costs as a percentage of revenue collected as the metric to monitor efficiency. For example, once a toll operation establishes a steady-state mode, gross toll collection costs expressed as a percent of toll revenue go from about 12.0% for average tolls of $2.00 (typical of a new AET privately operated program) or 7.0% for average tolls of $5.00.

If the toll operator deploys and manages the collections effort and violations enforcement program correctly and assesses appropriate service fees and penalties, the costs of collections beyond pre-paid accounts for transponder tolls should be self-supporting once the revenue stream from these operations is established.

These estimates include credit card transaction fees @ 2.25% of the revenue collected. Yet, many toll operators have been able to significantly reduce the costs of their credit card transaction fees recently by implementing direct withdrawal programs (ACH transactions) from the bank accounts of those customers actively enrolled in the ETC program who are willing to participate. Contracts with third party toll providers serving rental car companies, other fleet owners and customers from other states also reduce the toll operator's costs of credit card transactions. In addition, many of the collection costs estimated for this private toll operation, such as costs of processing LPTs and other anomalies that occur in the toll lanes, should be recovered by service fees. After considering these adjustments, estimates of net toll collection costs for this relatively small toll operation should range from 9.0% of toll revenue collected for $2.00 tolls to 5.0% for tolls of $5.00, putting this private toll operation at about the same level of efficiency as case studies 2 and 3 above, based on collection costs expressed as a percentage of total revenue collected. These estimates are consistent with reported toll collection costs in the private sector.[32] They are also competitive with the real costs of collection within the motor fuel tax program.

Collection Costs for Mileage-Based User Fees

Many are proposing mileage-based user fees (MBUF)—also known as vehicle miles traveled (VMT) fees—as a means to supplement and eventually replace fuel taxes as the primary highway funding source. The simplest way to implement such a program would be to collect a fee from the owner when initially registering the vehicle based on an estimate of its annual mileage. When the vehicle registration is renewed a year later, the fee for the prior year would be revised, based on the vehicle's odometer reading. Any adjustments necessary in annual use of the vehicle can be made during the vehicle's license renewal. Also, if imposed similar to a parking ticket, the vehicle owner

is responsible for the vehicle regardless of who is driving the vehicle. Without requiring any special technology on the vehicle, this type of program could vary the fee, if desired, based on the:

- Jurisdiction where the vehicle is registered;
- Type of vehicle being driven (e.g., motorcycle, car, light duty truck); and
- Other factors, such as the vehicle's propulsion system type or emissions rating.

This type of fee program would require increased enforcement during the vehicle registration process to reduce odometer tampering and other attempts to defraud the system, but should be manageable with existing management tools and proven enforcement methods.

A number of other options for monitoring a vehicle's VMT in a more aggressive manner have been suggested, including tracking vehicles via existing vehicle tracking programs (commercial vehicles) and cell phone networks. However, most of those advocating monitoring VMT in a more aggressive manner as a revenue source envision a GPS-based VMT fee program.[33] Since monitoring vehicle miles traveled can be accomplished at the vehicle's annual registration, GPS-based and other VMT fee proposals typically intend to price additional parameters based on when and where the vehicle is driven. In ascending order of complexity, these parameters could include:

- Weight-miles traveled (commercial vehicles);
- Jurisdiction(s) where the vehicle is driven;
- The specific roadway (or type of roadway) on which the vehicle is driven;
- The time of day the vehicle is driven based on a pre-determined pricing schedule; and
- A dynamically priced fee schedule based on real-time traffic/congestion levels.

A weight-distance pricing program for trucks could, for example, integrate with the International Fuel Tax Association (IFTA) program that already allocates motor fuel taxes paid by commercial vehicles in one jurisdiction to other jurisdictions where the vehicle is operated. This approach would help minimize the costs of collecting such a fee. However, several challenges would have to be addressed prior to implementation of a broader (all-vehicles) GPS VMT fee program. The most significant of these include:

- Political acceptance—GPS pricing programs invoke "Big Brother" privacy concerns;
- Security and integrity of the fee collection system—the GPS link is a single point of failure (fatal flaw) in these types of systems;
- Cost of the infrastructure to enforce a GPS VMT fee collection system (an extensive roadside system of gantries, cameras and other sensors similar to that required to enforce an AET system); and
- Complexities associated with auditing a GPS-based VMT fee program.

Also, as with any technology, as the complexity of the pricing scheme increases, the cost of collections increases. For example, the cost of collections for the German GPS-based truck VMT fee program was about 25% of the revenue collected for its third full year of operation even though the pricing scheme was quite simple (kilometers driven, number of axles and emissions category of vehicles).[34] This data point is particularly significant since the relative size of the average fee being collected and the total revenue collected with this user fee program are both quite large. Estimated costs of collection for two systems here in the United States are of similar magnitude,[35] suggesting that GPS-based VMT fee programs are likely to be relatively inefficient from a cost of collections perspective compared to both AET and MFT programs.

Alternatively, some are suggesting that toll technology is now to the point where mileage-based user fee charging can be implemented on a broad scale.

> *There is considerable discussion of the transportation industry moving toward a vehicle miles traveled charge as a way to supplement or eventually replace the fuel tax. For tolling to play a leading role in replacing the gas tax, the industry must strive to reduce its cost of collection.* [36]

As demonstrated by the three case studies above, AET can accomplish many of the efficiencies in the cost of collection necessary for this to happen. Of the many other ways to further reduce toll collection costs via AET, some of the more likely options are addressed in Part 6.

Part 6

Opportunities to Further Reduce Toll Collection Costs

Converting manual, ETC and ORT operations to AET can significantly reduce toll collection costs. As noted above, AET also offers toll authorities the opportunity to cooperate in ways never before possible, resulting in lower toll collection costs for all.

Simple Is Good

AET creates numerous opportunities to increase the complexity of tolling schemes. Varying tolls by time of day, day of week and special pricing on holidays are all easy to implement automatically in a reliable and auditable manner simply by setting parameters in the tolling system. Thus a time-based, value priced toll schedule can be an effective congestion management tool. Still, the confusion and ill-will that some of these pricing programs can create with a naïve public can significantly increase the costs of public communications, even when implemented with an aggressive public information campaign. Sustaining a minimal level of customer service during billing disputes and explanations of unexpected tolls and service fees can also be problematic and erode the extra revenue generated from peak tolls. In addition, the systems, operational and cost impacts of peak period pricing programs amplify the challenges when deploying a dynamic (real-time) toll pricing scheme. Alternatively, flat-rate pass programs, which offer the opportunity to simplify operations and significantly reduce operating costs, may be appropriate for situations and/or times of substantial excess capacity on the facility being priced. Studies show the success of these types of programs varies significantly.

Varying tolls by time of day, day of week and special pricing on holidays are all easy to implement automatically in a reliable and auditable manner simply by setting parameters in the tolling system.

The operating costs and effectiveness of each of these pricing program options will vary from one operation to the next depending on a host of issues—not the least of which is public acceptance. Since what may work well in one community could be troublesome or prohibitively expensive in

another, each tolling scheme should be weighed on its own merits. Still, it is usually best to keep things as simple as possible. Just because you can do something doesn't necessarily mean you should do it.

Avoid Non-Revenue, Credit and Other Preferential Programs

AET has also given toll operators the ability to more easily provide for exemptions to the tolling program. Non-revenue accounts can be easily established and, once vehicles listed in a non-revenue account are assigned a transponder, each toll transaction for that vehicle can be processed automatically by the toll system as a non-revenue transaction. Nevertheless, as with exemptions for fuel tax programs, all such exemptions must be aggressively monitored to avoid fraud and abuse. For example, if the authority's toll services manager used the authority's vehicle (normally a non-revenue transaction) to take his family to the beach over the weekend, this toll transaction should be a revenue transaction—but the system would have no way of knowing this. Therefore, non-revenue accounts should be limited to only those that truly warrant this status, and all activity on each non-revenue account must be closely monitored and significant penalties imposed for those found abusing the program.

It is usually best to keep things as simple as possible. Just because you can do something doesn't necessarily mean you should do it.

Some have also suggested introducing frequent user credits similar to the airline frequent flier programs in an effort to reward frequent customers. First, if the AET program is being managed as it should, all customers are paying a fair price for the value they receive for the service they are getting and such programs are not necessary. (Refer to discussion on The AET Business Model in Part 5 of this document.) Second, all programs of this nature will lead to increased operating costs that are usually underestimated. The most significant of these costs include:

- The program's administration;
- Revenue losses; and
- The costs of carrying accrued credits on customer accounts as a liability on the authority's books.

Moreover, such a program would incur monitoring costs to encourage and reward a practice—namely the use of the same vehicle by several customers to accrue and take advantage of frequent user points—that would provide no benefit for the agency, road congestion, highway condition, the environment, the traveling public or any other aspect of travel.

Third, complex programs that are difficult to understand and/or that offer benefits to some and not to others run the risk of generating unnecessary ill will with customers. Human nature dictates that

there will always be misunderstandings about such preferential programs and, even when the customer is given the benefit of the doubt, some customers will invariably feel that they have been wronged. Finally, once a preferential program is started, cancelling it is extremely difficult. Therefore, all such programs should be avoided, if possible, and if an authority finds it necessary to implement a program of this nature, it should keep it as simple as possible to minimize the impact on operating costs.

Other Possible Savings

AET also offers a number of other opportunities to further reduce toll collection costs using existing, proven technologies and commercial services already available today.

> *The solution, in my opinion, is to transition from expensive in-house backroom and customer services operations. There are companies that can perform these services more efficiently and less expensively than we can, which will better position us for the future.*[37]

In this discussion, we assume that the toll operator's primary objectives are to:

- Collect revenue accurately, reliably and cost-effectively;
- Maintain a positive, user-friendly customer interface; and
- Cooperate with other state and local toll authorities.

The most significant opportunities to further reduce toll collection costs include re-engineering toll operations to optimize the benefits of AET by:

- Simplifying toll and vehicle classification schedules;
- Offering user-friendly and cost-effective solutions to enhance customer service;
- Increasing the efficiency of exceptions processing functions (managing the anomalies) in the back office; and
- Strengthening the collections and enforcement process.

Additional inter-agency cooperation and consolidation of services include:

- Interoperability agreements with other toll authorities (e.g., the recent cooperative agreement among the toll agencies of Maine, Massachusetts and New Hampshire);
- Consolidation of transaction processing and accounts management functions; and
- Consolidation of collections and automated enforcement functions for toll and other agencies.

Integration of value-added third-party services to better serve customers who travel between states on a regular basis, rental car companies, fleet management services and unbanked communities. These services include:

- Interoperability services/transaction consolidators;
- Cash account processing; and
- Integrated billing services.

Some states (e.g., Massachusetts and New Jersey) have recently consolidated toll authorities in an attempt to reduce the cost of collections. Yet, most of the cost-saving methods identified above do not require consolidation at the agency level. In fact, the three case studies presented in this study exemplify local and regional toll authorities capturing the economies of scale available from larger, more efficient and cost-effective operations, while retaining local autonomy and control of their operations.

Recent efforts to pre-authorize (certify) systems and equipment to sustain core AET operations by the industry trade organization OmniAir, and make better use of existing options for interoperability (e.g., license plate tolling) by the Alliance for Toll Interoperability (ATI) will also help reduce toll collection costs. The current efforts of the ATI to develop a nationwide clearinghouse to enable customers of toll, transit, parking and ferry operations to use one transportation account to pay for their services should prove particularly useful since license plates are the ubiquitous on-board device for all motor vehicles.

Other opportunities to reduce toll collection costs may also develop. Though consolidation of core government services for automobiles may not be possible everywhere, should the political will to do so exist, core support services at state toll facilities and other state operations supporting motor vehicles could consolidate by integrating redundant vehicle-oriented databases and customer services. The opportunities for savings and enhanced revenue streams are significant. For example, a large portion of the databases necessary to support toll operations and the vehicle ownership portion of the DMV have significant redundancies. Overlapping data requirements for DMV functions, toll operations, collections (toll, parking, automated enforcement) and violations enforcement processing are presented graphically in Figure 4. Significant synergies between these operations are possible if their databases are integrated. These synergies also lead to reduced collection costs for all functions.

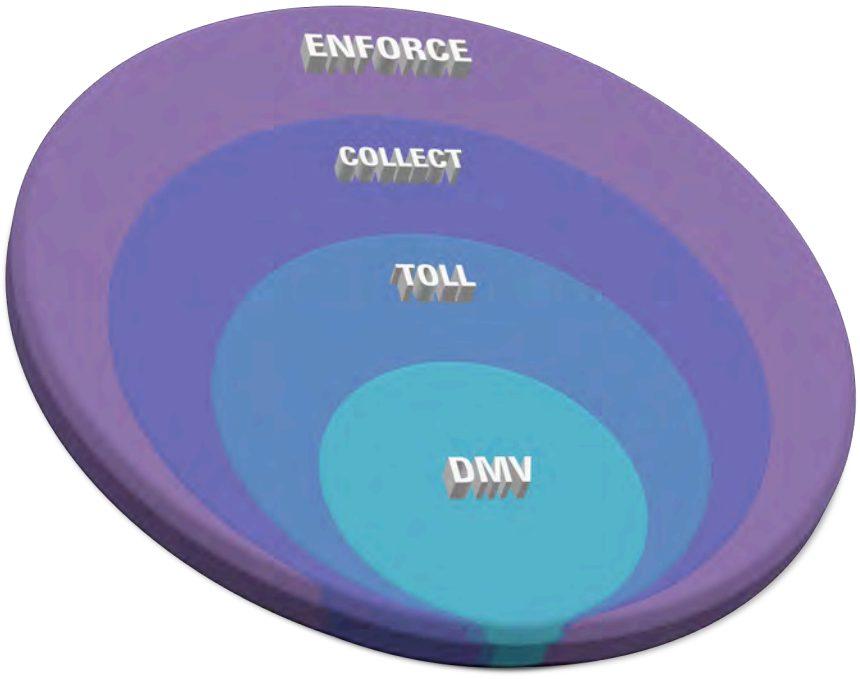
The toll operator must constantly update its vehicle ownership database through customer input and other sources via ongoing operations. Most toll operators also continually request vehicle ownership information from the DMV because this is legislated on them and to get ownership information for those vehicles not already in their databases. However, vehicle ownership information in the DMV database is traditionally unreliable, partly because the DMV must rely on the vehicle owners to take the initiative to update their information with the DMV. Consolidating these two databases would resolve many of the latency and other issues associated with the DMV vehicle ownership databases. In addition, the toll operator is constantly monitoring all vehicles that

use its facility. Correlating this information with vehicle registration information, a very easy task if the two databases are integrated (or simply one database), would go a long way toward resolving fraud and abuse of the vehicle registration program. The extent of integration possible will dictate the amount of savings realized, but the possible savings, as well as the possible increases in revenue for both the toll operator and the DMV, are considerable.

Significant expansion of existing tolling efforts, such as deployment of a nationwide tolling program for the Interstate Highway System and major corridors, should also increase the level of transaction processing to the point where, if the toll industry adopted an industry-wide commercial business model, it would have access to the kinds of very low transaction processing costs already enjoyed by the commercial sector (e.g., bulk processing rates for credit card transactions).

Where agencies are thoroughly entrenched in structural and legacy problems (e.g., burdensome labor union and bonding agreements), local officials wish to retain control of all transactions (limiting interoperability options). Without an aggressive violations enforcement program it may be difficult to achieve many of these cost reductions. All of these opportunities are technically feasible today, and the potential savings are significant.

Figure 4: Overlapping Data Requirements for Several Functions



Part 7

Conclusions and Policy Implications

This work has challenged several aspects of the conventional wisdom in the highway revenue collection world, demonstrating that they no longer apply given today's technology and other means to collect revenue for highway funding. The most significant of these findings include:

- The cost of collection for motor fuel tax revenues is significantly greater than 1% of the revenue collected;
- The cost of collection for all electronic tolling is significantly less than most historical toll collection cost data suggest;
- Toll collection cost data from operators that have taken full advantage of AET technology and its basic business plan indicate what toll collection costs could be if deployed in a new framework on a much broader scale;
- Cost data for the AET operations in the United States demonstrate that the net collection costs of an AET operation can be in the vicinity of 5% of the revenue collected for a $5.00 toll (or 8% of revenue collected for a $2.00 toll);
- When AET service fees are priced correctly, the cost of tag transactions is the best indicator of AET collection costs, since service fees cover the costs of more-expensive tolling options;
- Additional reductions in toll collection costs beyond those already demonstrated by agencies having deployed AET are also possible;
- Keeping the AET operations plan simple will reduce toll collection costs;
- An AET solution for MBUF charging could be implemented cost-effectively on limited-access corridors today; and
- Waiting for further improvements in technology before starting the shift in funding of major highways from fuel taxes to all electronic tolls is unwarranted.

We can now (for the first time) charge a fee for the use of major highways based on demand as we do with other infrastructure and utilities. We need only the political will to modify existing restrictions and put the frameworks in place to do this cost-effectively.

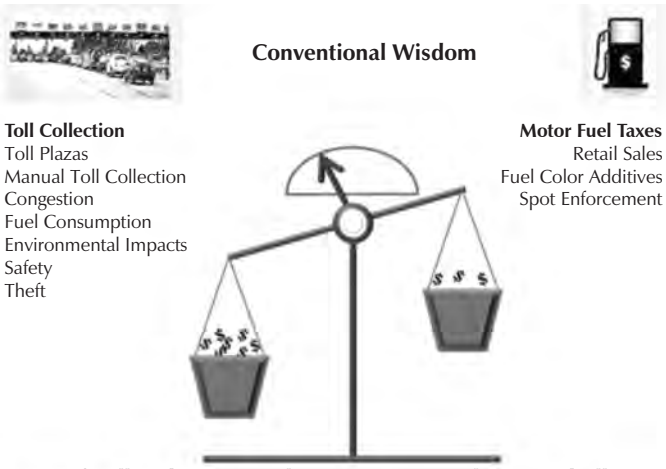
Many have argued that using toll finance to rebuild and modernize the Interstate system would be cost-prohibitive. Yet the introduction of AET has gone a long way toward making this not only a

feasible option but a plausible reality. This is especially true in light of recent efforts toward establishing nationwide electronic tolling interoperability. Technical advances in the accuracy and reliability of automated systems such as vehicle classification, image capture and optical character recognition (OCR) functions, coupled with re-engineering of toll operations to take advantage of the opportunities that AET offers, will lead to additional benefits from AET systems.

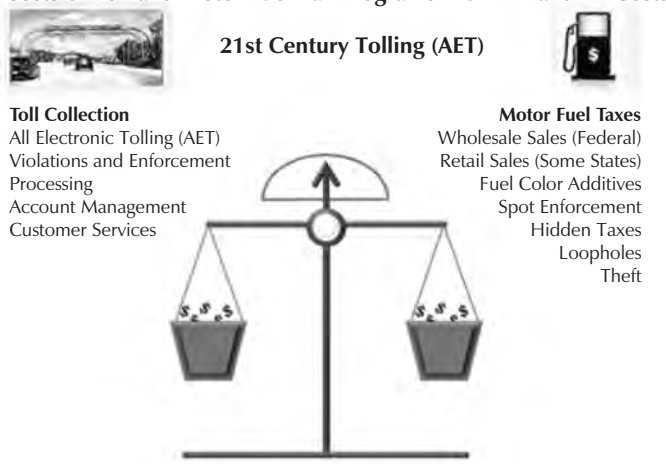
When all data are considered, the collection cost for AET compares very favorably to the cost of collecting motor fuel taxes. Once opportunity costs are considered, including the fact that AET programs can be used to manage congestion through value, time-of-day pricing programs, AET is a much more efficient means of collecting revenue for our motorways than motor fuel taxes (Figure 5). The fact that toll revenue is usually linked to bonds and less susceptible to political raiding for non-highway purposes is an additional benefit of tolls as a funding source.

In fact, should the political will exist to do so, an urban-wide (or even nationwide) MBUF program could be implemented now, with AET on primary, access-controlled highways, such as urban freeways and long-distance Interstates. This would require instrumenting only the entry and exit points of all primary corridors, installing a low-cost, disposable transponder on each vehicle, and enrolling all registered motor vehicles through a cooperative effort with departments of motor vehicles. Since most entry and exit ramps are no more than two lanes, most of the entry and exit points would not even need gantries, since roadside systems to reliably toll vehicles can be installed either in the pavement or mounted on poles adjacent to the entry and exit lanes in these situations.

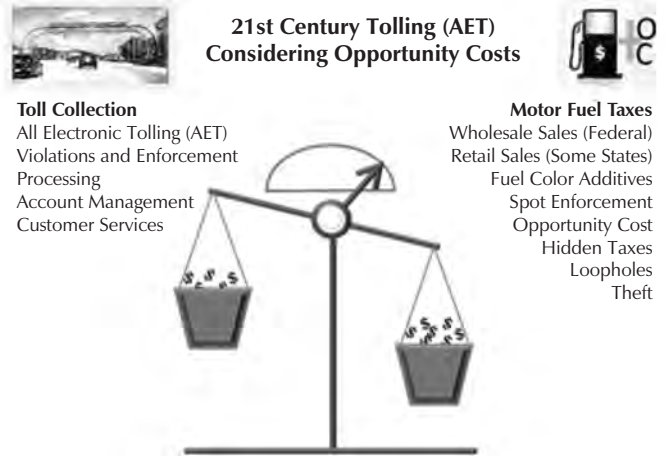
Figure 5: Cost of Collection Comparisons



Collection Costs of Toll and Motor Fuel Tax Programs with AET and All Costs Considered



Costs of AET and Motor Fuel Tax Programs Once Opportunity Costs Are Considered



About the Authors

Daryl S. Fleming, Ph.D., PE is president of The eTrans Group, Inc., a company which he co-founded with several other professionals in 1998 that provides advisory services to the transportation industry. Among his major accomplishments over his 35 year career, Dr. Fleming was deputy program manager for Hughes/Raytheon HTMS for the Highway 407 ETR® project in Toronto, Ontario, the first fully automated toll road. Dr. Fleming is credited with major contributions to several innovative advances in the transportation industry, such as all electronic tolling (AET), congestion-based pricing, and state and federal pre-clearance programs for commercial vehicles. He is recognized as one of the world's leading experts in the application and operation of automated systems for toll collection, automated enforcement, CVO pre-clearance and other ITS applications.

Dr. Fleming advises state DOT, port authority, toll agency officials and the private sector on the appropriate application of technology to increase the efficiency of operations of transport projects from both the owner's and user's perspective. Dr. Fleming also assists in the procurement of these technologies, as well as the management of their development, installation, verification and operation.

Prior to forming eTrans, Dr. Fleming held senior management positions at a large vendor serving the transportation industry, a technology provider, a major public agency and a nationwide consulting firm. Dr. Fleming was also a member of the civil engineering faculty at the University of Colorado for several years, and he has taught in the extension programs at University of California, Berkeley, and California Polytechnic State University, Pomona.

Dr. Fleming earned a Ph.D. and a M.Sc.E. in transportation planning and engineering from the University of New Brunswick, Fredericton, and a B.Sc.E. in civil engineering from the University of Maine, Orono. Dr. Fleming is also a registered professional engineer in several states and in Canada.

Contributing Authors

Thomas L. McDaniel, Ph.D., has over 35 years' experience in the development and management of state-of-the-art transportation projects. Also a founder of eTrans, Dr. McDaniel installed the first toll RFID toll system in North America on the Coronado Bridge in 1983. Since then he has been one of the leading innovators of the ETC industry in roles including project manager for Hughes/Raytheon HTMS on the Highway 407 ETR® in Toronto, Ontario, the first fully automated toll road. Dr. McDaniel is also a subject matter expert in RFID, artificial intelligence-based decision making algorithms, video detection and video enforcement technologies for the toll industry. Dr. McDaniel holds a B.A. from Earlham College, Richmond, Indiana, and a Ph.D. from Purdue University.

Ramon L. Grijalva, Ph.D., an associate of eTrans**,** has over 30 years' experience in management, mechanical and systems engineering, technology development, business development and finance. Dr. Grijalva has led a number of small-scale and large-scale engineering projects and has successfully created new, small high technology businesses. Dr. Grijalva has been active in the toll industry since 1993, working first as an integrator, then an ETC vendor and now as an advisor to toll authorities and the private sector. Dr. Grijalva has also been active in ASTM and IEEE standards organizations to support electronic toll and traffic management (ETTM) systems. Dr. Grijalva holds a B.S.M.E. from California State University Northridge, an M.B.A. from California State University, Dominguez Hills, and a Ph.D. from the Peter F. Drucker Graduate School of Management at Claremont Graduate University.

Luis Alberto Sánchez-Ruiz, PE, an associate of eTrans, has over 15 years' experience in the management, operation and deployment of electronic toll collection (ETC) and other intelligent transportation systems. Mr. Sánchez-Ruiz's experience ranges from operations and program management positions for the AutoExpreso® ETC program in Puerto Rico, one of the more innovative recent ETC programs, to the management of numerous ITS deployment projects throughout North America. Mr. Sánchez-Ruiz holds a B.Sc. in civil engineering, cum laude**,** from the University of Puerto Rico at Mayagüez, and an M.Sc. in transportation engineering from The University of Texas at Austin.

Appendix A

Appendix: Assessment of Three Recent Studies on the Cost of Toll Collection

Report 1: "Comparative Analysis of Toll Facility Operational Costs," prepared by IBI Group, Inc., for the Washington State Department of Transportation, February 22, 2007.

Objective

The primary purpose of this investigation was to support a Washington State Department of Transportation (WSDOT) effort to complete a due diligence review of its estimated toll collection costs for a planned ETC project on the Tacoma Narrows Bridge (TNB).

Methodology

This report identified the methodology used to gather information, including a review of the annual reports of eight public sector toll authorities in the United States, chosen for their "similarities in scope and function to the Tacoma Narrows Bridge,"[38] followed by "requests for additional, specific operations cost information."[39] However, before presenting any of the results of this investigative work, the authors noted that

> *There is a great range in the size and scope of toll facilities and how they are operated, including what expenses are considered operations costs and how the configuration of the facility affects these costs.*[40]

The authors also noted that variations between toll authorities should also be considered, including:[41]

- The magnitude and type of facility;
- The method of toll collection;
- The division of responsibilities;
- Violations processing functions;
- The availability of customer website and integrated voice response (IVR) systems'

- Cost accounting variations
- Maintenance programs; and
- Bond covenants.

In addition, the report noted that these metrics can vary significantly from one agency to the next. In particular:

- There are many factors that can affect reported toll collection costs, some well beyond each agency's control;
- There is no consistent means of reporting toll collection costs from one agency to the next; and
- Direct comparison or transfer of these data from one agency to the next would be inappropriate.

Nevertheless, we note that the report defined toll collection costs as the costs of staff and consumables for manual toll collection, customer service costs for ETC including violation enforcements, and contract administration and oversight.

Toll Collection Cost Data

A comparison of reported toll collection costs (cost per toll transaction and cost as percentage of toll revenue) was also provided for each of the eight public agencies reviewed.[42] Average 2005 toll collection costs at each agency for all toll transactions were reported to range from 23¢ to 62¢ per toll transaction. This may be because five of the eight agencies have been collecting tolls for several decades and are burdened with a host of legacy toll collection and business rules that can significantly increase their toll collection costs. On the other hand, two of the three agencies reporting toll collection costs from 23¢ to 31¢ per toll transaction had started collecting tolls within the last 10 to 15 years, with Caltrans being the one outlier in this group reporting toll collection costs on its seven bridges in the San Francisco Bay Area at 29¢ per toll transaction. The two other toll operators, E-470 in Denver and the Transportation Corridors Agencies (TCAs) in Orange County, California, reported toll transaction costs of 23¢ and 31¢ per toll transaction respectively. In addition, all but one of the toll facilities for which reported toll collection costs were reviewed (SR-91 Express Lanes) were bearing the financial burden of supporting both manual and ETC toll collection systems in 2005, and the SR-91 Express Lanes were undergoing the transition from private to public sector operation as well as implementing a major road-side systems upgrade at that time.

Several other factors may, collectively, have affected these reported toll collection costs:

- Toll operations plans at these toll authorities vary significantly (e.g., some used gates as positive enforcement in their ETC lanes while others used automated enforcement programs);

- The percentage of ETC transactions on the hybrid toll operations ranged from 23% on Caltrans's bridges to 73% at the TCAs (SR-91 is an outlier for this metric in this sample since it is at 100% ETC);
- Average tolls collected at most of these facilities were greater than $2; and
- The costs each agency actually reported in this metric could vary significantly. (It was not clear, for example, whether these agencies reported leakage—losses due to theft and error in their cash lanes as a toll collection cost.)

For example, the metric for SR-91 (managed lanes) appears to include several costs not included in the other cases, such as staffing of a roadside violation station (for HOV-3 enforcement), operation of their traffic operations center (TOC) and some roadway maintenance.

Toll collection costs per transaction varied significantly among the eight agencies investigated, which is to be expected since the range of toll operations types and the average of tolls collected varied significantly. By contrast, toll collection costs as a percentage of the revenue collected were relatively similar, ranging from 14% to 20%. There are two primary reasons for this apparent consistency:

- All but one of the cost observations (SR-91) are for hybrid (cash and ETC) operations; and
- All of the facilities are public-sector operated.

Toll collection costs on a new facility that has an all electronic tolling (AET) operations plan should be significantly lower.

Summary – Review of Report 1

The WSDOT report is consistent with current industry practices for the review, evaluation and management of toll operations in the public sector. It also met WSDOT's requirement for a due diligence review of its estimated costs for toll collection on the Tacoma Narrows Bridge. However, the data reported provide little guidance on toll operations costs for a modern AET toll program.

Report 2: "Defining the Legacy for Users: Understanding Strategies and Implications for Highway Funding," American Transportation Research Institute (ATRI), May 2007.

Objective

The primary purpose of this effort was described as follows:

> *Define and understand the current state of transportation needs and finance in the United States, with particular attention paid to the financing of highway infrastructure maintenance and expansion.*[43]

The report also notes that, though a lot of research has been devoted to "*the issue of paying for highway infrastructure, inadequate attention has been paid to critical funding and infrastructure issues,*"[44] and that this study is an attempt fill the gap in research by "*providing rational benefit-cost assessments for transportation investment levels and priorities.*"[45]

Methodology

This study relied on publicly available information sources, including private, academic, state and U.S. DOT data sets. Recognizing the current funding environment, evaluations focused on systems needs and a range of financing methods to determine "*cost and benefit assessments of existing funding mechanisms, new alternative finance strategies, and their relative impacts on transportation system revenue and users*."[46] This study also reportedly evaluated several different methods for highway funding, including state and federal fuel tax revenues, state debt financing, credit assistance to states, tolls and mileage-based user fees.

However, the ATRI authors note early in their Executive Summary that their study provides the trucking industry's perspective of tolls and other user fees for financing roadway infrastructure. The liberties taken in the presentation of information in the ATRI document and recommended policy directives leave no doubt in the reader's mind that the ATRI document presents a trucking industry view of the topic.

Since the focus of our present study is on toll collection costs, our review will focus on the section of the ATRI study that addresses tolls—Highway Finance Strategy #4: Tolls.[47]

Toll Collection Costs: Manual vs. AET

The ATRI authors set the tone of their assessment of tolls as an alternate method for collecting roadway user fees by stating in the very first line of this section,

> *The concept of tolled transportation has been a contentious issue in the United States for many years.*[48]

After a brief discussion of why tolls are now being considered as an additional source of transportation funding by many states, the authors note:

> *Toll critics, however, do not believe that tolling aligns with stated U.S.DOT goals of increased user access, mobility and system efficiency, nor is tolling as efficient a revenue collection method as excise taxes on fuel.*[49]

The authors also note that:

> *A central criticism of highway tolling within the literature is the inefficient means by which payment is exchanged for use of a service.*[50]

To substantiate their claim, the authors then present a lengthy discussion on their perspective of the costs associated with toll collection:

> *Such direct costs include: 1) the construction and maintenance of facilities and other infrastructure used to collect tolls (collection booths, widened roadways, additional roadway signage and lighting, administrative offices; electronic toll collection systems); 2) the staffing required to facilitate a tolling enterprise (toll collectors, administrative officials, maintenance personnel, enforcement personnel); and 3) the non-labor related costs of operations (electricity and other overhead inputs).*[51]

The authors then cite a wide range of indirect costs of toll collection, including:

- *Increased travel time due to congestion at toll plazas;*
- *Decreased fuel economy and increased wear and tear on vehicles due to frequent stopping;*
- *Increased pollution due to acceleration and deceleration and congestion related slow-downs;*
- *Increased accidents at or near tolling areas; and*
- *Revenue theft.*[52]

Most of the direct costs noted in this study and all of the indirect costs of toll collection identified in this study are incurred by manual and hybrid (manual plus ETC) toll collection programs. However, the authors fail to recognize that at the time the ATRI document was published (May 2007):

- AET could eliminate the need to collect tolls manually;
- The inherent cost savings (both direct and indirect) associated with the AET process had been well established; and,
- Many toll authorities were either in the planning stages to convert to AET operations, or had their conversions to AET operations well under way.

Therefore, to present toll collection costs as the ATRI study did in 2007 was misleading and inappropriate.

The authors eventually admit that "*electronic payment designs do have the potential to reduce certain labor costs,*" but then immediately suggest that the capital cost of converting to these programs is prohibitive, citing one ETC conversion effort that went 37% over budget.[53] However, it is common knowledge in the industry that the cost overruns on that project were the result of legal and institutional problems that were being resolved during the transition period from manual to automated toll operations, and cost overruns of this magnitude are not typical. Indeed, the costs of sustaining manual toll collection are so high that the estimated cost savings from upgrading to AET can usually recover the cost of its deployment within three years, and in some situations the time to cost recovery (payback) can be even less.[54] Quantification of the significant safety benefits that AET offers would reduce the length of the payback period even further.

Criticisms of Toll Authority Management and Operations

Toward the end of the general discussion on tolls the ATRI authors conclude that:

> *... a survey of FHWA's State Administered Toll Road and Crossing Facilities (FHWA, 2005b) reveals that many U.S. toll administrations are operating at a loss.*[55]

This is yet another very misleading statement, only this time it is directed toward the management and operations of the toll authorities. FHWA's State Administered Toll Road and Crossing Facilities database does include a number of *ferry crossings* that routinely operate at a loss and are openly subsidized. But, historically, the few toll agencies (not "many" as suggested above) that have operated at a loss for any significant length of time have declared bankruptcy, which is the natural course of these types of problems. In addition, though a bankruptcy may result in investors in the roadway facility incurring a loss, this doesn't impose losses on the general population through increased taxes unless one or more local agencies have guaranteed payment of the bonds. Insulating the public from financial exposure is one of the reasons why public private partnerships are so attractive, as they transfer most of the major risks of a project to the private sector.

The dire financial situation that the ATRI document suggested was being encountered by "*many U.S. toll administrations*" was not really happening in 2007. Nor is it happening in 2012, even after several years of a lagging economy. Nevertheless, the ATRI document attempts to substantiate the "losses" argument by presenting a summary of total toll receipts, total disbursements and what it reports as "*shortfalls*" at five major toll authorities in the United States in its: Table 4: Toll System Shortfalls – 2005.[56] Though the title of the summary table suggests that the data provided are the direct result of the toll systems' collection costs, a review of annual reports for these agencies and other publicly available information indicates that the data reported as "toll systems shortfalls" clearly include the capital costs of major civil construction projects unrelated to the toll collection costs each agency had underway in 2005.

A toll authority's cash outlays can vary significantly from one year to the next, especially if the capital costs of major facility expansions, systems upgrades and other ongoing improvements are included. Such projects are all planned and scheduled so that their cash flow requirements can be met. Therefore, a simple review of an authority's annual cash receipts and disbursements that demonstrate a "*shortfall*" for one fiscal year is not an indication that the authority is in financial distress. To even suggest that this is the case is irresponsible. To imply that these normal variations in annual expenditures are the result of deficiencies in each agency's toll operations by labeling this summary "*Toll Systems Shortfalls*" is misleading and inappropriate.

The Costs of Sustaining Legacy Toll Operations

The ATRI study provides a tabular summary of toll collection costs for three large toll authorities in the United States in Table 5: Cost to Revenue Ratios for Select Large Toll Authorities.[57] All three authorities selected for review—the New Jersey Turnpike Authority (NJTA), the New York State Thruway Authority (NYSTA) and the Ohio Turnpike Commission (OTC)—have been operating for decades and are subject to the inefficiencies imposed by repeated political intervention in business decisions. In addition, two of the three authorities (NJTA and NYSTA) were well into converting from manual toll collection to ETC during the period for which data were reported (2004 to 2006) and were managing such legacy issues such as labor union challenges while downsizing their staffs. The third authority (OTC) was still collecting all tolls manually, having deferred conversion to ETC operations because of the costs and difficulties associated with managing these legacy issues during conversion.

Therefore, the collection cost-to-revenue ratios reported for these three authorities, ranging from 21.9% to 30.3% of revenue collected,[58] are disproportionately high and certainly not representative of those in the toll industry that had already implemented AET. The report also portrayed collection cost information for motor fuel taxes as only 0.2% of revenue collected, which is unrealistically low.[59] In addition, as noted above, the ATRI authors are mixing one-time capital costs and annual operating costs in their tolling cost estimates. In fact, by 2007 many toll authorities were well on the way to converting manual and hybrid (manual and ETC) toll operations to AET to eliminate the extensive cost (both direct and indirect) of stopping vehicles on the roadway to collect a toll. Nevertheless, this did not deter the ATRI authors from stating that

> *These are conservative estimates, and a more detailed analysis of available financials, however, will likely show higher revenue collection cost ratios.*[60]

Summary – Review of Report 2

The ATRI authors state in their Executive Summary that they will be providing the perspective of the end user (trucking industry) on the use of tolls and other user fees for financing roadway infrastructure. This position is evident throughout the report. The ATRI document was clearly written to convince the reader that collecting tolls is very expensive compared to other revenue collection methods and that there are also several safety, congestion and environmental issues associated with collecting tolls—additional costs of

collection that need to be considered. However, all of these secondary costs, including accidents at toll plazas, are the result of manual toll collection methods. In addition, though the authors did mention that ETC could reduce some labor costs, the authors did not mention AET—even though AET eliminates most of the direct costs and all of the indirect costs of collecting tolls manually. In addition, the ATRI authors failed to note that in 2007 many authorities were already converting to AET or well into the planning effort necessary to do so at the time their document was published.

The authors also presented annual variations in several agencies' cash flows—issues that are professionally managed on a regular basis using GAAP—to suggest that most toll authorities operate at a loss and to imply that the toll systems and/or the cost of their operation were the causal factor of these "shortfalls." Compiling and misrepresenting the information in the manner they did is simply wrong and inexcusable. In fact, most of the information on toll collection, toll authorities and toll programs in general in the ATRI document is misleading and inappropriate. Therefore, most of the ATRI authors' conclusions are unsubstantiated by either the information they provide or by the experiences of others.

Report 3: "Costs of Alternative Revenue-Generation Systems," NCHRP Report 689, Project 19-08, National Cooperative Highway Research Program, Transportation Research Board of the National Academy of Sciences, March 2011.

Objective

The stated objective of this recent research effort was to

> *...(1) examine, compare, and present the administrative, collection, and compliance costs of user-based revenue-generation systems, such as motor fuel taxes, tolls, and VMT fees; and (2) examine the potential feasibility of alternative revenue-generations systems....*[61]

This study reviewed collection costs of several alternate roadway user fees: (1) motor fuel taxes, (2) tolling, (3) VMT fees, (4) cordon pricing (one of several toll operations plans) and (5) parking fees. The focus of this work was, therefore, much broader than the WSDOT study reviewed above.

Methodology

The fact that compliance costs are included in their stated objective is good. Yet, a summary of the overall methodology of this research effort notes that the research team

> *... relied initially on existing literature and discussions with knowledgeable experts to develop an accounting framework for the analysis and to gain understanding of the limitations faced in making cost comparisons. The team collected information from recent VMT-fee trials in Europe and the United States and from the experience of toll authorities. However, the research was **limited** by reluctance of private operators and government agencies to release data on their operations, as well as **by the lack of experience with proposed alternative revenue-collection methods**.*[62] (emphasis added)

The research team's lack of experience with the topic being researched, especially toll collection costs, is evident throughout the document in their use of basic terminology. For example, congestion charging and cordon pricing (both special tolling applications) were identified as separate categories of user fees for this research. The term "leakage" was also repeatedly used in reference both to revenue losses in cash toll lanes and to non-payment of tolls in AET operations. Though some in the toll industry have interchanged the two terms, especially during the early AET conversions, "leakage" has traditionally been used to refer to revenue losses in cash toll collection as a result of human error and theft, while non-payment in the AET application is mostly an accounts receivable issue. Leakage in cash toll collection and accounts receivable in AET are both serious issues that can lead to lost revenue. But they are fundamentally different operational mechanisms that must be managed in different ways. Therefore, interchanging these two terms is inappropriate. Finally, the investigators also consider all roadway user fee collection alternatives, including tolling, as a form of taxation. Toll payments are usually thought of as a project financing tool, similar to utility bills. Tying tolls to debt coverage on specific bonds introduces stability into

the financing process used to develop or maintain a specific roadway facility. Linking to specific infrastructure through bonds also introduces stability into applicable policy discussions.
The research team's misuse of basic terminology, including referring to tolls as a tax instead of a user fee, demonstrates a basic misunderstanding of tolling in general, as well as the systems and operations required to sustain toll operations. Thinking of toll revenues as a source of project-specific funds as opposed to a tax enables one to appreciate the value of AET. The team's use of an inappropriate conceptual framework calls into question the reliability of its conclusions regarding the feasibility of using toll collection on a much broader basis to develop a comprehensive roadway funding program.

Operations Cost Data for Toll and Other User Fee Programs

As with most research efforts, the work of others is reviewed first, after which the NCHRP investigators describe their own research. They then introduce analytical evaluations and develop conclusions from the information obtained. However, little unique investigative effort appears to have been conducted in this study, especially regarding toll collection costs.

Review of Other Studies

A high-level comparative analysis of toll operations is presented in section 2.2.8 of the NCHRP summary report.[63] That section provides two very misleading charts on toll collection costs. First, toll collection cost data are presented as a percentage of total revenue reported in the WSDOT study reviewed above, ranging from 14% to 20% of the toll revenue collected.[64] However, their summary does not provide any of the cautionary statements offered by the WSDOT study regarding the proper interpretation and use of the information. Second, the researchers provide data from another study that used a model "*to forecast toll-collection costs and revenues over 20 years*" for several lengths of corridors and toll operations plans.[65] The model is reported to have been based on observed capital and operating cost data from seven major U.S. toll operations. Though civil infrastructure costs (such as office space, power, communications and toll system costs) appear to have been included in these projections of operating cost, no other descriptive information is provided on the models' structure or input assumptions.

The NCHRP investigators make several observations about the results of their model, all of which are erroneous since the model results simply do not represent reality.[66] For example, the model estimates suggest that:

- Capital and operating costs of the average 10-mile corridor for both transponder and video tolling applications are greater than the revenue collected. Under this scenario one would never be able to cost-effectively toll a bridge; and
- There is no variation in collection costs for the three basic tolling technologies (video, transponder, and GPS) to price vehicle miles traveled.

Since neither of these situations could possibly be the case, the results of the model and any conclusions derived from its results are questionable.

Toll and Other Collection Cost Data Reported

Toll and other user fee collection cost data reported by the NCHRP investigators are presented in their Chapter 4.[67] These data suggest that toll collection costs range from 8% to 90% of the revenue collected. The toll transaction cost information they report covers a similar broad range of values, ranging from 9¢ to nearly $1.00 per transaction.[68] A review of this information illustrates that they used no uniform standard for reporting toll collection cost data. The researchers undertook an extensive effort to summarize the toll collection cost data available. Yet, they failed to notice the significance of some of the toll collection cost data they summarized, especially data points that are clearly outliers to their observations. For example, all but two of the reported toll collection costs were well below 30% of the revenue collected—with the remaining two being at approximately 42% and 90% of the cost of revenue collected,[69] with the latter observation being information reported from a facility with a unique operations plan that focused on traffic management versus collecting tolls and was still in its experimental phase. Therefore, their methods for analyzing toll collection cost data and their interpretation of the results, like their review of other research efforts, are of little use to an analyst trying to determine what toll collection costs could be if implemented on a broad scale in an AET operations mode.

The investigators for this work attempted to address the fact that the toll industry has been going through a rapid period of change by researching only reports that have included toll collection cost data over the last three to five years.[70] But the reports reviewed were mostly for large public agencies that were formed in the 1950s, that have been subject to decades of political influence, and that operate under outdated business rules and legacy toll operations concepts. At the time this cost information was reported, most of these agencies were also going through the transition from manual toll collection to ETC operations and burdened with the costs of sustaining both manual and ETC toll systems and operations for the period for which the data were reported.

Toll operational, administrative, collection and enforcement costs for each toll authority reviewed were summarized graphically, using both the cost as a percentage of total revenue and cost per toll transaction metrics. Though the investigators noted that they made an attempt to normalize the data, several of the cost observations were clearly for unique operating conditions, yet still included in the summaries. How each toll authority operates and allocates its costs, which can vary widely from one authority to the next, also affects these data. Therefore, the graphical summaries, though colorful, are meaningless to an analyst looking for representative costs of an AET operation implemented on a broad scale.

VMT and cordon pricing observations in the NCHRP report are also limited by the projected costs of one European application and European pricing programs, respectively. Therefore, these analyses provide little insight into collection costs for alternate user fee programs. However, the investigators collected and present a substantial amount of information on the cost of collecting motor fuel taxes—data that are also relevant to this research and difficult to find in the literature.[71]

Endnotes

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[31] Ibid

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[61] "Costs of Alternative Revenue-Generation Systems," p. 5.

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[65] Ibid., p. 21.

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Reason Foundation
5737 Mesmer Ave.
Culver City, CA 90230
310/391-2245
310/391-4395 (fax)
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