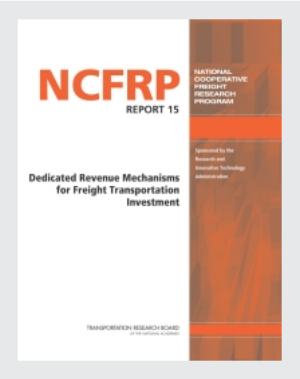

Dedicated Revenue Mechanisms for Freight Transportation Investment

DETAILS

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AUTHORS

NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

NCFRP REPORT 15

Dedicated Revenue Mechanisms for Freight Transportation Investment

The Tioga Group, Inc.
Philadelphia, PA

Economic Development Research Group, Inc.
Boston, MA

Shama Gamkhar
Austin, TX

Steptoe & Johnson LLP
Washington, DC

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NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

America's freight transportation system makes critical contributions to the nation's economy, security, and quality of life. The freight transportation system in the United States is a complex, decentralized, and dynamic network of private and public entities, involving all modes of transportation—trucking, rail, waterways, air, and pipelines. In recent years, the demand for freight transportation service has been increasing fueled by growth in international trade; however, bottlenecks or congestion points in the system are exposing the inadequacies of current infrastructure and operations to meet the growing demand for freight. Strategic operational and investment decisions by governments at all levels will be necessary to maintain freight system performance, and will in turn require sound technical guidance based on research.

The National Cooperative Freight Research Program (NCFRP) is a cooperative research program sponsored by the Research and Innovative Technology Administration (RITA) under Grant No. DTOS59-06-G-00039 and administered by the Transportation Research Board (TRB). The program was authorized in 2005 with the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). On September 6, 2006, a contract to begin work was executed between RITA and The National Academies. The NCFRP will carry out applied research on problems facing the freight industry that are not being adequately addressed by existing research programs.

Program guidance is provided by an Oversight Committee comprised of a representative cross section of freight stakeholders appointed by the National Research Council of The National Academies. The NCFRP Oversight Committee meets annually to formulate the research program by identifying the highest priority projects and defining funding levels and expected products. Research problem statements recommending research needs for consideration by the Oversight Committee are solicited annually, but may be submitted to TRB at any time. Each selected project is assigned to a panel, appointed by TRB, which provides technical guidance and counsel throughout the life of the project. Heavy emphasis is placed on including members representing the intended users of the research products.

The NCFRP will produce a series of research reports and other products such as guidebooks for practitioners. Primary emphasis will be placed on disseminating NCFRP results to the intended end-users of the research: freight shippers and carriers, service providers, suppliers, and public officials.

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FOREWORD

By Andrew C. Lemer
Staff Officer
Transportation Research Board

NCFRP Report 15 explores taxes and fees that might be used to raise revenue to support government investment in freight transportation facilities, primarily for highway transportation. As the final product of NCFRP Project 29, "New Dedicated Revenue Mechanisms for Freight Transportation Investment," this report assesses such revenue-generating mechanisms as motor-vehicle fuel tax surcharges, vehicle registration fees, and distance-based road-user fees, considering their likely effectiveness and efficiency as well as the administrative and institutional issues likely to affect their viability at a national level. The information will be useful to government policy makers and senior agency officials responsible for funding highway and other infrastructure investments to facilitate goods movement throughout the nation.

In discussions related to the federal surface transportation legislation, the American Association of State Highway and Transportation Officials and a number of other associations have proposed that consideration be given to establishing mechanisms for raising revenues nationally to support investments in infrastructure developed explicitly to facilitate the movement of freight. The proposal stems from a recognition of the importance of efficient freight transportation to the nation's economy, the significant differences between desirable design and operating characteristics of infrastructure serving freight versus passenger transportation, and the desire to maintain the "user pays" principle that has been a foundation of past federal support for transportation infrastructure investment. Suggestions of freight-dedicated mechanisms that might be adopted have included customs duties, shipping-container fees, bill-of-lading fees, weight-based and weight-distance taxes and fees, transportation-value taxes, vehicle sales taxes and registration fees, carbon taxes, and others.

The feasibility and likely effectiveness of such mechanisms will be influenced not only by the economics of the freight transportation industry and its customers, but also by a complex web of federal and state laws and international trade agreements. Evolving technology enabling collection and enforcement and concerns that particular taxes and fees may impose disproportionate burdens on particular segments of the economy are also important. In addition, its multimodal nature is a fundamental characteristic of freight transportation; current institutional arrangements for raising revenues and public-sector investment in transportation infrastructure are organized largely around single modes.

Previous studies of some of these mechanisms have been made within a context of specific legislative proposals or general exploration of public policy initiatives. Congress and many other stakeholders are interested in identifying all viable options and the implications—both unfavorable and favorable—as well as their potential effectiveness as a source of funds to

maintain and enhance the nation's goods-movement capabilities. NCFRP Project 29, "New Dedicated Revenue Mechanisms for Freight Transportation Investment," was motivated by a perceived need for a more comprehensive framing of feasible, practical options that merit consideration in current policy development discussions. Such research could then inform these current discussions as well as become a basis for subsequent analysis of the broader consequences of implementing dedicated revenue mechanisms to support freight transportation investment at a national level.

A team led by The Tioga Group, Inc., conducted research to (1) identify feasible, practical options for providing dedicated revenue mechanisms to support investment in freight transportation infrastructure; (2) provide a comprehensive analysis of the functioning and implications of the potentially most viable options; and (3) assess the relative merits of these potentially most viable options and describe, in detail, requirements for their implementation and operation. The product of the research was intended to be, in effect, a feasibility study of specific revenue mechanisms rather than a review of broad national consequences of implementing one or several such mechanisms as matters of public policy. This report presents the results of the team's work. The document will be most useful as a review of issues to be considered by agency officials, other policy makers, and the public concerned about mobilizing resources to support infrastructure investment intended primarily to facilitate freight transportation.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

SUMMARY

Dedicated Revenue Mechanisms for Freight Transportation Investment

This research explores potential sources of revenue that might be dedicated to support freight-oriented investment in the nation's surface transportation system. The objectives of this research were the following:

- Identify feasible, practical options for providing dedicated federal revenue and finance mechanisms to support investment in freight transportation infrastructure.
- Provide a comprehensive analysis of the functioning and implications of the most potentially viable options.
- Assess the relative merits of these most potentially viable options and describe in detail requirements and steps required for their implementation and operation.

For purposes of this analysis, it is assumed that the federal fuel and excise tax system remains in place as the major revenue source for federal transportation infrastructure funding, and that any dedicated mechanisms would be used to fund a national infrastructure program analogous to the Highway Trust Fund. Some of the mechanisms considered in this study were found to be more suitable for project-specific funding. While project-specific alternatives are valuable and can reduce the need for national-level funding, those options were analyzed separately.

Candidate Revenue Mechanisms and Screening

The research team evaluated a wide range of proposed federal freight infrastructure revenue generation mechanisms and concluded that the leading feasible options are a fuel tax surcharge, distance/vehicle "vehicle miles traveled" (VMT) fees, and federal vehicle registration fees. These options were described and analyzed in detail. Other options were excluded for reasons of feasibility and applicability to freight infrastructure. These included international trade fees, freight tonnage or ton-mile fees, freight value or value-added taxes, waybill taxes, and carbon taxes or cap-and-trade proceeds.

Public-private partnerships (PPPs) have received considerable attention in the literature and are frequently included in proposed strategies for mobilizing infrastructure funding. For railroads, and potentially for other modes, investment tax credits (ITCs) for capacity enhancements are widely considered a viable means of inducing additional beneficial private investment. Both options were found to be more suitable as project-specific strategies than as candidates for a national program. PPPs and ITCs are given extensive treatment in Appendix E.

Fuel Tax Surcharge

Increasing the existing federal fuel taxes on diesel fuel and gasoline would appear to be a straightforward way to increase overall revenue for transportation infrastructure. However, such an overall fuel tax increase would not yield a dedicated revenue stream for freight infrastructure. Most discussions to date of fuel tax increases, conversions, or improvements have not been focused on trucks or freight. The exception has been the Freight FOCUS Act of 2010, which proposed a $0.12 per gallon increase in the diesel fuel tax with income tax credits or refunds for exempt or non-freight uses.

Fuel Tax Options

The fuel tax options considered in this study would most accurately be labeled fuel tax *surcharges,* levied on some subset of the truck population. The fuel tax options considered in this study are the following:

Diesel Fuel Tax with Non-Freight Refunds. This option, similar to what is proposed in the Freight FOCUS Act of 2010, would target freight highway users through an increase in the diesel fuel tax coupled with annual tax refunds or tax credits for non-freight vehicles. Freight vehicle operators would simply see a tax increase with no new record-keeping or filing requirements. Other diesel fuel purchasers would have to incorporate refund or credit requests in income tax filings. The fuel tax surcharge itself would be collected through the existing system with no incremental cost.

Diesel/Gas Tax with Non-Freight Refunds. To cover all highway freight vehicles, or all medium- and heavy-duty trucks, it would be necessary to cover all fuel types, including gasoline, natural gas, ethanol, etc. Doing so would spread the tax burden more equitably across freight vehicles, but would dramatically expand the scope and costs of compliance.

Diesel Fuel Tax with Vehicle ID. Another option for a freight-only fuel tax surcharge is an electronic tag, on-board unit (OBU), or radio frequency identification (RFID) system to identify the vehicle at fueling locations. There are several technologies available, most relying on dedicated short-range communications (DSRC) or other wireless systems. Federal implementation costs would be substantial, as would collection and enforcement costs.

Diesel/Gas Tax with Vehicle ID. Expanding a high-tech vehicle ID system to cover all fuel types while distinguishing freight from non-freight vehicles would increase implementation, collection, and compliance costs significantly. All U.S. vehicles would have to be equipped with ID tags to signal the appropriate tax rate at fueling locations.

Collection

In all of these fuel tax options, the incremental collection, implementation, and compliance costs are attributable to the need to distinguish freight from non-freight vehicles.

The Leaking Underground Storage Tank (LUST) Trust Fund is a mode-neutral fund created in 1986 to fund federal oversight or cleanup of leaking underground fuel storage tanks. The LUST fund is capitalized through a $0.001 per gallon excise tax on gasoline and other motor fuels and provides a precedent for operating a mode-neutral freight fund.

The federal fuel tax is very economical to collect. The tax is paid to the Internal Revenue Service by the producer or importer of the fuel twice each month from roughly 1,000 "rack" locations—the points at which fuel leaves wholesale storage for delivery to retail outlets. The system is highly efficient because it does not require vehicle identification or vehicle-by-vehicle transactions and accounting. Making a fuel tax vehicle-specific negates much of the fuel tax's efficiency advantage.

A low-tech tax collection mechanism would use the current system. The additional diesel or gas tax would be collected for all fuel delivered from wholesale "rack" locations, and all customers would pay the same tax rate at the pump (or equivalent purchasing method). Eligibility for a refund or credit would depend on vehicle type. Trucks that operate and purchase fuel in more than one state are required to reconcile taxes paid and fleet VMT by state under the International Fuel Tax Agreement (IFTA) system. An annual or periodic statement reconciling fuel taxes owed could also be a means of collecting or adjusting a federal tax or surcharge.

A high-tech approach would involve the use of wireless technology to identify the vehicle and the appropriate fuel tax rate at the point of purchase. A high-tech approach of this kind would be similar to gas station payment for VMT fees. In both cases, the gas station itself would have to be equipped with technology to identify vehicles and charge the appropriate tax rate. Tagging all diesel vehicles (or for a diesel/gas option, all vehicles) would be very costly.

VMT Fees

A VMT system would charge vehicle owners based on the number of miles traveled on public roads and highways. VMT fees (also known as mileage-based user fees, or MBUFs) have been proposed as a broad-based replacement for fuel taxes. VMT fees have poor support or face opposition from the public and the transportation industry.

Types of VMT Fees

While there are numerous variations on VMT fees, they can be split into two basic types, distance/vehicle VMT fees and time/location VMT fees.

Distance/Vehicle VMT Fees. Distance/vehicle VMT fees would vary by vehicle class and charge operators according to the miles traveled by each vehicle. VMT fees would vary directly with mileage, fulfilling the policy desire for "user fees" instead of taxes. VMT fees could be implemented through a more costly, high-tech, OBU system or through a low-cost/low-tech mix of OBU, commercial, and self-reporting systems. In either case, there would be high federal implementation, collection, and enforcement costs, and a longer implementation period than other options. Distance/vehicle VMT fees would not support congestion pricing or transportation demand management/travel demand management (TDM) options.

Time/Location VMT fees. Time/location VMT fees would permit incorporation of TDM, tolling, and congestion pricing. National time/location VMT fees for freight and service trucks, however, do not appear to be publicly acceptable for the foreseeable future due to high costs, lack of national benefits, and persistent privacy issues.

Collection

The complexity of distance/vehicle and time/location VMT fee systems requires more elaborate collection mechanisms than other revenue-generation strategies. For passenger cars (and light trucks used for personal transportation), it is generally thought that implementation of VMT fees will eventually require universal installation of on-board devices to track miles traveled and automatically communicate either the raw information or a VMT fee total to the tax-collecting authority. Implementation of distance/vehicle VMT fees in much of the freight and service trucking sector may be much easier than implementation in the passenger sector due to existing reporting systems, use of commercial OBUs, and other options not ordinarily available to passenger-car owners.

Annual collection costs for a distance/vehicle VMT fee are variously estimated to range from about $10 to $100 per vehicle. The lowest figures are informal "guesstimates" that are not backed by empirical data or formal estimation techniques. The research team's informed estimate would be $35 per vehicle based on the administrative and collection costs of a state E-ZPass system. This estimate is used later in this report in cost comparisons of revenue options.

Privacy

VMT fee systems, particularly time/location VMT fees, raise serious public and political issues of privacy. These issues can be resolved legally and technologically but remain powerful emotional and political barriers. In particular, there appears to be strong public opposition to systems that use a global positioning system (GPS) or equivalent technologies to determine and record detailed vehicle location records. The concerns over privacy, and particularly over GPS, are a formidable barrier to time/location VMT fees. The technological issues can be resolved through the use of so-called "thick" OBU clients that calculate and pay VMT fees rather than transmitting location data. Commercial systems that aggregate and pay VMT fees for entire fleets likewise address the privacy issues. Legality is unlikely to be an issue for these approaches, although there are lingering legal concerns over the ongoing collection of detailed location data. Available surveys, however, strongly suggest that adverse public reaction to the *perception* of privacy invasion would create barriers to implementation of time/location or GPS-based VMT fees.

Registration Fees

The simplest and most cost-effective means of generating revenue for a dedicated freight infrastructure fund would be an expanded federal registration fee on Class 4–8 trucks of all types. While a registration fee would not be a direct user fee, it would be a proxy for potential impacts of truck size and load demands on infrastructure wear and design requirements.

Federal registration fees could be implemented by expanding the Heavy Vehicle Use Tax (HVUT) system, which presently covers Class 7–8 trucks. A registration fee would be the quickest and most efficient option to implement because it would require no new technology and could be collected and enforced via minor expansions of existing systems. Such a system has the advantage of simplicity, low implementation and collection cost, and potential application to non-highway modes.

The current HVUT collection mechanism could be used as is, but expanded to cover Class 4–8 trucks. The HVUT amount due is an annual lump sum. For large carriers with 25 or more vehicles, electronic filing is accomplished using a credit card or other means of electronic payment. There would be a relatively small increase in labor and electronic processing capability required, but no new technology.

An alternative to direct federal registration fee collection would be "piggybacking" on the state registration fee process. All states currently factor vehicle weight or weight class into their registration fees, so a federal registration fee that varied by vehicle weight class should be compatible. Truck owners would make one annual payment covering both state and federal fees. Besides the lower collection cost, "piggybacking" would reduce industry compliance cost.

Combined Strategy Options

The complexity of the freight transportation industry and the infrastructure funding challenge suggests that the candidate funding mechanisms may be more effective in combination than separately. In particular, registration fees might supplement fuel taxes or

VMT fees to cover electric or hybrid vehicles, capture the impact of vehicle size or weight characteristics, or create policy-oriented incentives. A combined federal freight infrastructure revenue strategy could also embrace PPPs and ITCs. As the research team found, these options can facilitate access to multiple capital sources and accelerate the project funding and development process. The availability of multiple revenue and funding tools would thus increase the ability of federal planners and decision-makers to create an equitable, effective, revenue strategy with appropriate incentives.

Summary Comparisons

Table 1 summarizes and compares the leading revenue options based on key evaluation criteria. The ratings are relative rather than absolute. Moreover, many of the rankings depend on the details of revenue mechanism design rather than fundamental characteristics. Presented below is a discussion of how the revenue options compare on the evaluation criteria.

Table 1. Revenue mechanism comparison matrix.

Screening Criteria	Fuel Tax Surcharge	VMT Fee	Federal Registration Fee
Revenue			
Revenue potential	High	High	High
Stability/sustainability of revenues over time	Moderate	High	Mixed
Need for indexing	High	High	High
Implementation and Costs			
Time to implement	Moderate	Long	Short
Federal implementation cost	Low	High	Very Low
Recurring collection and enforcement cost	Low	High	Low
Industry implementation cost	Low	High	None
Industry compliance cost	Moderate	High	Low
Revenue Efficiency			
Collection cost efficiency	High	Low	High
Net federal revenue/net industry cost	High	Low	High
Scale economics	Potential	High	Low
Technical Feasibility			
Technical feasibility	High	High	High
Potential for evasion	Moderate	High	Low
High vs. low tech	High/Low	High	Low
Multimodal Application			
Coverage of multiple modes	Potential	Low	Potential
Modal neutrality	Potential	Low	Potential
Linkage between Use and Payment			
Emphasize user fees over taxes	Moderate	High	Low
Proportional to truck size and weight	High	Potential	High
Incentives and Impacts			
Incentives for productivity gains	Low	Low	Low
Incentives for user behavior	Low	Low	Low
Transportation system impacts	Low	Low	Low
Modal shift (e.g., from truck to rail)	Moderate	Low	Low
Environmental impact	Low	Low	Low
Economic impacts	Low	Low	Low
Equity			
Between payers, users, and beneficiaries	Moderate	Potential	Moderate
Between public- and private-sector users	Low	Potential	Potential
Between freight, passenger, and service users	Potential	Potential	Moderate
Political and Public Acceptance			
Likely legal challenges	Low	Likely	Possible
Legislative feasibility	Low	Low	Moderate
Freight stakeholder positions	Moderate	Adverse	Moderate
International legality	High	Questionable	High
Public and commercial privacy issues	None	Serious	None

Revenue and Costs

For comparison purposes, the research team set an annual gross revenue goal of $5 billion for all three options. Table 2 shows revenue and cost estimates for the options described above as applied to either Class 4–8 freight trucks or all Class 4–8 trucks. As indicated, the rates required to yield $5 billion in gross revenue depend on the subset of trucks to which the rates are applied. Widening the scope yields lower rates.

The three leading options all have the potential to yield substantial revenue to fund freight infrastructure. There are no inherent limits, so the revenue potential is primarily an issue of political, industry, and public acceptance of appropriate taxes or fees. The sustainability of fuel tax revenue over time in the freight sector is higher than in the passenger sector, but still subject to diminishing growth. VMT fees will grow as VMT continues to grow. Truck registration fees vary with the size of the fleet, which tends to diminish or not grow as quickly during economic slowdowns.

Revenue mechanisms that build on existing tax, fee, or regulatory systems without introducing new technology or infrastructure have the lowest implementation, collection, and compliance costs, and the closest implementation horizon. A federal registration fee would be the quickest and least expensive. Estimates for industry compliance costs are lower for low-tech options and higher for high-tech options. For the fuel tax surcharges with tax system refunds or credits, the compliance costs would be borne primarily by non-freight purchasers who would need to file for refunds or credits.

The differences in cost translate into differences in revenue efficiency. Table 2 provides estimates of net annual federal revenue ($5 billion less collection and annualized implementation cost) and annual industry cost ($5 billion plus annualized implementation and compliance costs). From Table 2 it can be seen that

- The highest efficiency ratios are for the diesel fuel tax with tax refunds and the vehicle registration fees due to their absence of significant implementation costs. Both of these options build on existing collection systems.
- Options that rely heavily on technology, namely the fuel taxes with vehicle ID and the VMT fees, have high implementation and collection costs that dilute their revenue-generating effectiveness.
- The lowest efficiency ratio is for the diesel/gas fuel tax with tax refunds since it would require the great majority of vehicle owners—about 240 million—to file for refunds.

The low-tech variation on fuel tax surcharges and the federal registration fee yield the greatest net federal revenue at the lowest industry cost, and are therefore the most efficient. VMT fees would likely show the greatest scale economies, with efficiency rising as the fee rises. VMT fees for trucks would also be much more efficient if there were a national VMT system for passenger vehicles in place.

The maximum long-term potential net revenue from the various options is influenced by the following:

- Annual federal costs of collection and enforcement.
- Diesel tax revenue lost from conversion to gasoline-powered trucks.
- Fuel, VMT, and registration revenue cost from truck-to-rail modal shifts.

Estimates of these adjustments and net federal revenue for 2012 are shown graphically in Figure 1. The research team calibrated the revenue model at $5 billion annually. Therefore, the net revenue results are most trustworthy at that revenue target. As the revenue target and tax burden escalate from $5 billion to $20 billion annually, the efficiency of most options declines slightly as transportation activity shifts from truck to rail. The exception is the

Table 2. Revenue and costs for $5 billion target.

Fuel Tax Surcharge Options	$/Gal	Annual Federal Collection and Enforcement Cost	Federal Implementation Cost	Freight Industry Implementation Cost	Annual Private-Sector Compliance Cost	Net Annual Federal Revenue	Annual Industry Cost	Ratio
Diesel fuel tax with non-freight tax refunds								
Class 4-8 freight	$ 0.25	$ 5,107,469	$ -	$ -	$ 127,686,726	$ 4,994,892,531	$ 5,127,686,726	0.97
Diesel/gas* tax with non-freight refunds								
Class 4-8 freight	$ 0.17	$ 242,924,162	$ -	$ -	$ 6,073,104,051	$ 4,757,075,838	$ 11,073,104,051	0.43
Diesel fuel tax with vehicle ID								
Class 4-8 freight	$ 0.25	$ 48,925,309	$ 1,500,000,000	$ 489,253,095	$ 244,626,547	$ 4,801,074,691	$ 5,342,477,166	0.90
Class 4-8 all types	$ 0.20	$ 62,276,359	$ 1,500,000,000	$ 622,763,594	$ 311,381,797	$ 4,787,723,641	$ 5,435,934,516	0.88
Diesel/gas* tax with vehicle ID								
Class 4-8 freight	$ 0.17	$ 70,758,380	$ 3,000,000,000	$ 707,583,795	$ 353,791,898	$ 4,629,241,620	$ 5,495,308,657	0.84
Class 4-8 all types	$ 0.14	$ 90,067,377	$ 3,000,000,000	$ 900,673,766	$ 450,336,883	$ 4,609,932,623	$ 5,630,471,636	0.82
VMT Fee Options	**$/VMT**	**Annual Federal Collection and Enforcement Cost**	**Federal Implementation Cost**	**Freight Industry Implementation Cost**	**Annual Private Sector Compliance Cost**	**Net Annual Federal Revenue**	**Annual Industry Cost**	**Ratio**
VMT Distance/ Vehicle Fee - OBU/Options								
Class 4-8 freight	$ 0.028	$ 297,654,328	$ 3,000,000,000	$ 1,768,959,488	$ 764,190,499	$ 4,402,345,672	$ 6,117,982,396	0.72
Class 4-8 all types	$ 0.022	$ 365,235,818	$ 3,000,000,000	$ 2,251,684,414	$ 972,727,667	$ 4,334,764,182	$ 6,423,064,550	0.67
VMT Distance/ Vehicle Fee - OBU Only								
Class 4-8 freight	$ 0.028	$ 297,654,328	$ 3,000,000,000	$ 3,537,918,975	$ 764,190,499	$ 4,402,345,672	$ 6,471,774,294	0.68
Class 4-8 all types	$ 0.022	$ 365,235,818	$ 3,000,000,000	$ 4,503,368,829	$ 972,727,667	$ 4,334,764,182	$ 6,873,401,433	0.63
Excise Tax Options	**$/Vehicle**	**Annual Federal Collection and Enforcement Cost**	**Federal Implementation Cost**	**Freight Industry Implementation Cost**	**Annual Private Sector Compliance Cost**	**Net Annual Federal Revenue**	**Annual Industry Cost**	**Ratio**
Annual Registration Fee								
Class 4-8 freight	$ 707	$ 50,000,000	$ -	$ -	$ 176,895,949	$ 4,950,000,000	$ 5,176,895,949	0.96
Class 4-8 all types	$ 555	$ 50,000,000	$ -	$ -	$ 225,168,441	$ 4,950,000,000	$ 5,225,168,441	0.95

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of *Highway Statistics 2009* (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

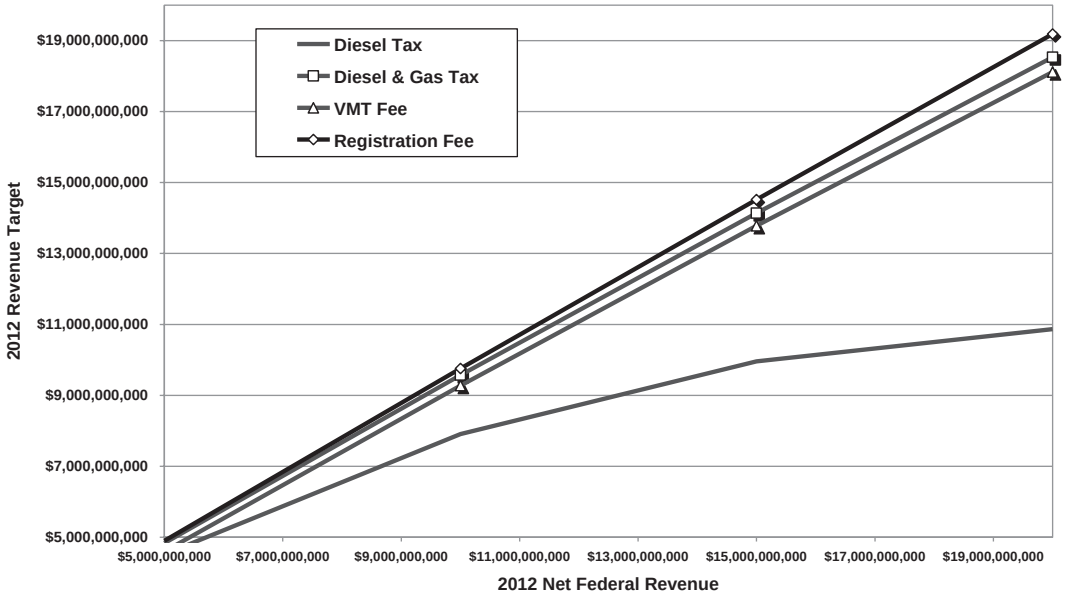


Figure 1. Revenue targets and net revenue.

diesel-only fuel tax surcharge, which loses much of its value due to increased conversion of medium-duty truck fleets to gasoline.

The loss of revenue is limited by the underlying inelasticity of demand for freight transportation. As the economic impacts and analysis suggest, the adverse impact on commodity production and consumption would be relatively small. This observation is confirmed by the long-term resilience of freight demand in the face of steady increases in underlying fuel prices that exceed the tax or fee level envisioned in this analysis.

Long-Term Revenue Outlook

The long-run revenue available from each option depends on the growth expected in the tax or fee base—fuel use, VMT, or truck registrations—and the offsetting costs and diversions

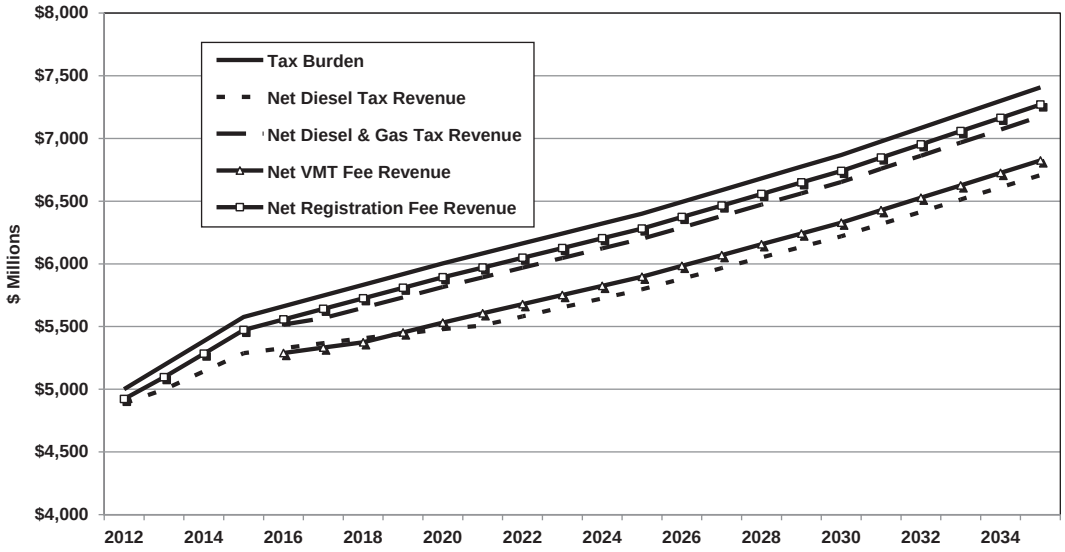


Figure 2. Long-term revenue estimates.

discussed above. The patterns and relationships are shown graphically in Figure 2. As the graph shows, there would be a multiyear implementation lag for revenue from the two technology-dependent sources, the diesel and gas tax with vehicle ID and the VMT fee. Net revenue from the vehicle registration fee and the diesel and gas tax surcharge tracks the gross tax burden closely. Net revenue from the VMT fee and the diesel-only tax surcharge grow at similar rates but at a lower level due to the high collection cost of VMT fees and the conversion to gasoline trucks for a diesel tax surcharge.

Indexing

Any proposed revenue mechanism would need to incorporate indexing or some other means of adjustment to fulfill long-term freight infrastructure funding needs. There are two cost indexes specifically designed to reflect highway construction costs: the FHWA's National Highway Construction Cost Index (NHCCI) and the Bureau of Labor Statistics's Producer Price Index (PPI) for the Highway and Street Construction Industry ("BHWY"). There are also indexes published by trade associations and industry journals.

Technical Feasibility

Technical feasibility within the freight sector is not an issue for any of the leading options, although time/location VMT fees do present some technical challenges. The differences show up in implementation time, cost, and evasion potential. For all three candidate mechanisms, low-tech implementation approaches result in lower implementation, collection, and compliance costs; shorter implementation timelines; and greater revenue-generation efficiency. In all three cases, low-tech collection methods could build on existing systems. High-tech collection solutions may offer greater precision, potential linkages to future traffic-management systems, or other non-revenue advantages, but would entail higher implementation, collection, and compliance costs.

Multimodal Application

The potential of fuel taxes and registration fees to cover multiple modes depends on system design and policy choices. A fuel tax surcharge could cover all modes that use fuel. A single multimodal fuel tax surcharge for freight infrastructure is technically feasible, but an attempt to create and allocate such a fund is likely to encounter serious political and institutional barriers. VMT is basically a highway transportation metric. Attempting to apply VMT fees to rail or water modes would entail costly and potentially onerous record-keeping, administrative, and enforcement costs without a clear connection between such fees and freight infrastructure requirements. Vehicle registration fees can conceivably be applied to the full range of freight transportation modes and the equipment they employ (absent any specific statutory prohibitions). Excise taxes have previously been assessed on a wide range of commodities, and there is no reason in principle why federal registration fees could not be assessed on other trucks, railroad cars or locomotives, or waterborne vessels.

Linkage between Use and Payment

There are challenges in making any revenue source correspond as closely as possible to vehicle infrastructure impacts. As with other factors, the degree to which each option is a "user fee" depends on system design. Fuel taxes and VMT fees are user fees, with the linkage between use and payment dependent on program details. The ability of

distance/vehicle VMT fees to link use, impact, and payment depends on the payment scale applied to trucks of different classes and weights. Registration fees are not closely linked to infrastructure use.

Incentives and Impacts

The tax and fee rate levels contemplated in this analysis would not create strong incentives for change in freight industry operations. The changes in overall cost structure would be minor—far less than the fuel cost variability that the industry has recently experienced. Freight and service truck operators already have stronger cost incentives to minimize mileage and fuel use, so any new incentives would be slight. The transportation system impacts, environmental impacts, and economic impacts would all be modest. The exception would be a diesel tax surcharge that widened the cost gap between diesel fuel and gasoline, thus encouraging the substitution of gasoline-powered trucks for diesels.

Equity

Equity among users, vehicle types, and industry segments is again a matter of system design more than an intrinsic feature of each option. One serious issue is the definition of "freight vehicles" and the choice of fuels to tax. There is no straightforward, unambiguous way to classify vehicle types or industry segments as "freight," and medium and heavy trucks use gasoline as well as diesel. Proposals to tax freight trucks exclusively would raise equity issues between freight and service truck operators. Each option, if implemented, would also have to cope with exemptions for off-road and public-sector uses; electric and hybrid vehicles; and international trucking. Combining revenue sources (for example, using registration fees to cover electric vehicles that would not pay fuel taxes) may be a more effective strategy than attempting to adapt one option for all applications.

CHAPTER 1

Background and Research Approach

Freight Infrastructure Funding Issues

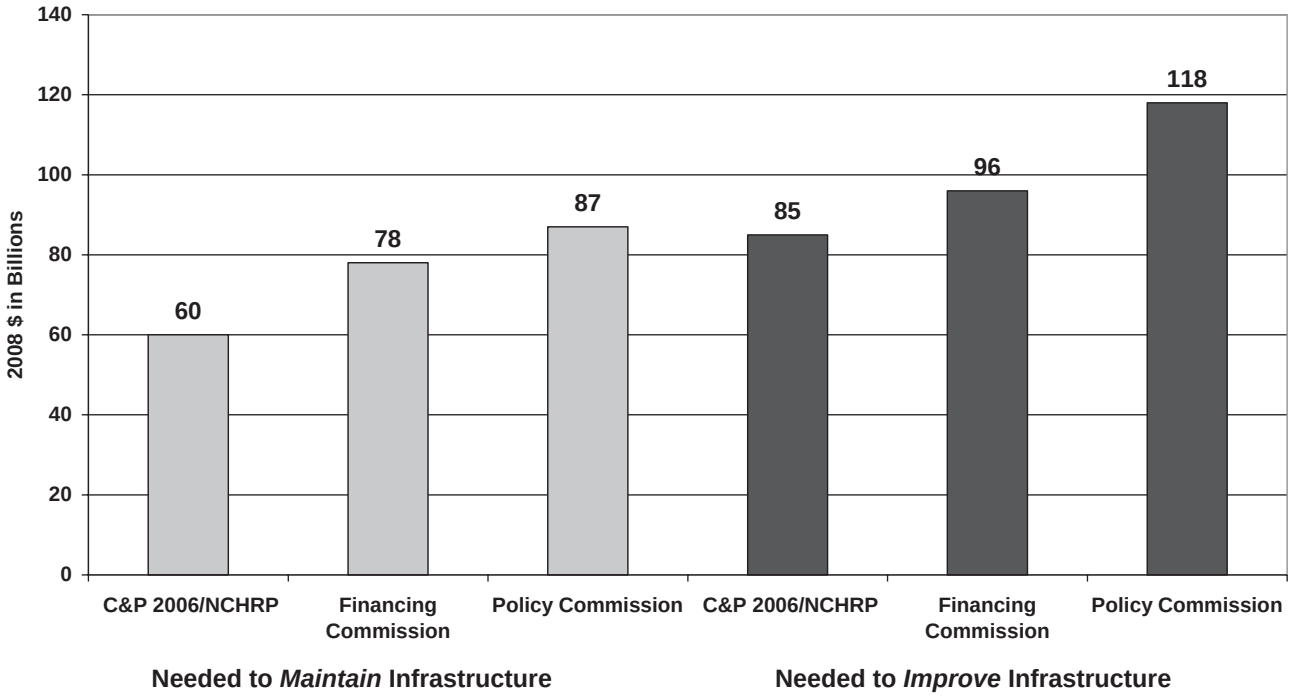
This research explores viable sources of revenue to support freight-oriented investment in the nation's surface transportation system. Public- and private-sector concerns with freight mobility, economic development, U.S. competitiveness in world markets, and conflicting freight and passenger needs for limited highway and rail capacity have led to proposals for a separate freight infrastructure trust fund or funding program with a dedicated revenue source. Examples of potential funding mechanisms include customs revenues, container fees, bill of lading fees, weight-based taxes, weight-distance taxes, freight transportation value taxes, annual highway user vehicle fees, annual highway miles traveled fees, sales taxes on motor vehicles, national vehicle safety inspection fees, and carbon tax or cap-and-trade proceeds.

The U.S. DOT's 2008 Conditions and Performance Report indicated that public capital investment from all levels of government in highways totaled $78.7 billion (FHWA and FTA, 2008). In 2008, the net revenue of the Highway Trust Fund's Highway Account was $37.3 billion, about half of the total public highway investment. The same U.S. DOT report projects an annual federal, state, and local highway investment need of about $175 billion to achieve funding of projects with a positive benefit to cost ratio. AASHTO is recommending funding at the rate of $62.5 billion per year from Congress over the next 6 years. The National Surface Transportation Infrastructure Financing Commission report compiled various estimates of long-term federal funding requirements (National Surface Transportation Infrastructure Financing Commission, 2009). The funding totals required to improve the nation's infrastructure (see Figure 3), average $100 billion (in 2008 dollars).

At present, approximately $37 billion is being raised annually through federal fuel and excise taxes, but the revenue is falling short of existing demand for funds. Transfers from the General Fund have been required in each of the past 3 years, totaling $34.5 billion. The reasons for the revenue shortfall are well documented:

- The fuel tax is not indexed and has not been increased since 1993. Meanwhile, highway program costs have increased 119%.
- Improving technology and tighter fleet fuel-efficiency standards for automobiles have increased composite average fuel mileage by 45% since 1971. While the number of heavy truck miles per gallon has been flat, ton-miles per gallon more than doubled between 1975 and 2005.
- A large number of highway users, mainly government agencies and schools, are exempted from paying the tax. Off-road uses are not taxed. The American Transportation Research Institute (ATRI) estimates the annual cost of these exemptions at between $1 billion and $1.5 billion.
- A substantial portion of the tax revenue is dedicated to mass transit, and portions of the Highway Account funds are diverted to non-highway uses.
- Fuel tax evasion is a significant problem, resulting in an annual loss estimated at 6.5%, or about $2.2 billion annually.
- Long-term viability of the fuel tax may be threatened by transition from fossil carbon-based fuels to electricity and hydrogen.

In the absence of new sources, freight-related tax revenue growth will be modest at best. Table 3 shows that the freight-related contributors to the Highway Trust Fund are expected to grow at less than 2% annually, which is not enough to keep up with inflation, much less reduce the backlog of infrastructure needs. The Inland Waterway Trust Fund, supported by the fuel tax paid by tug and barge operators, may even decline if industry ton-miles continue to decline as projected.



Source: National Surface Transportation Infrastructure Financing Commission, 2009.

Figure 3. Average annual federal capital needs, 2008–2035 (2008 dollars).

As a result, there are a number of suggestions for reforming the existing fuel tax system and for creating a dedicated mechanism to fund freight infrastructure. Embedded in the overall concept of freight infrastructure revenue mechanisms are multiple possible goals:

- Incremental dedicated funding for freight infrastructure.
- Project-specific funding.
- Transportation demand management/travel demand management (TDM) measures.
- Environmental mitigation or improvement.
- Increased private-sector investment to supplement or leverage government revenue.

Numerous potential freight infrastructure funding mechanisms have been suggested as alternatives or supplements to existing sources.

Study Scope and Objectives

There are three stages to the process of funding freight infrastructure—generating the revenue, dedicating the funds to freight needs, and allocating the money to projects.

The scope of this study corresponds to the first stage—generating revenue—although the willingness of the freight industry to pay taxes or fees also depends on how the money is used. The objectives of this research were the following:

Table 3. Freight-related tax revenue forecasts.

Funding Source	Basis of Forecast	2009	2035	CAGR
Highway Trust Fund				
Diesel & Special Fuels Tax	Energy Use*	$ 7,000,779,000	$ 10,310,113,982	1.5%
Heavy Vehicle User Tax	Ton-miles**	$ 962,628,000	$ 1,554,368,397	1.9%
Truck Sales Tax	Ton-miles**	$ 1,890,021,000	$ 3,051,842,365	1.9%
Truck Tire Excise Tax	Ton-miles**	$ 314,276,000	$ 507,465,690	1.9%
Inland Water Way Trust Fund				
Inland Water Way Fuel Tax	Ton-miles**	$ 76,000,000	$ 66,192,481	-0.5%

Sources: * U.S. Energy Information Administration, April 2011, ** Team extrapolation of FHWA data.
CAGR = compound annual growth rate.

- Identify feasible, practical options for providing dedicated federal revenue and finance mechanisms to support investment in freight transportation infrastructure.
- Provide a comprehensive analysis of the functioning and implications of the potentially most viable options.
- Assess the relative merits of these potentially most viable options and describe in detail requirements and steps required for their implementation and operation.

For purposes of this analysis, it is assumed that the federal fuel and excise tax system remains in place as the major revenue source for federal transportation infrastructure funding. The options addressed in this study would therefore generate new revenue to be dedicated to freight infrastructure through either supplementary federal fuel or excise taxes within the current system or revenue mechanisms outside of and parallel to the current federal system.

The candidate mechanisms are therefore viewed as potential supplements to the existing federal system of fuel taxes and other excise taxes, rather than as replacements. Most of the reviewed literature, however, is concerned with replacing the fuel tax system with an entirely new system to cover both passenger cars and trucks. This difference in perspective complicates the use of cost and revenue estimates from the literature. If a VMT fee system were implemented for all 250 million U.S. vehicles, for example, then the cost of covering 9 million medium- and heavy-duty trucks would be marginal.

The emphasis of this study is on mechanisms for generating *new* revenue for freight transportation infrastructure. Diversion of other revenue streams, such as customs revenue now used for other purposes, would not add any new net funds to federal programs. Likewise, recapture of Highway Trust Fund funds presently diverted to other uses, notably transit funding, would not increase the total funds available within the federal budget. Closure of exemptions to the fuel tax would transfer funds from other state, local, and federal agencies to the Highway Trust Fund, but again would not add net revenue. Recapture of diverted Highway Trust Fund funds and closure of exemptions would, however, result in substantial additional funding for highways and shift the burden of funding transit and paying for formerly exempt vehicles to other sources. The trucking industry has frequently pointed out that a significant portion of the fuel taxes it pays are used for non-highway uses. The diversion to transit funding was estimated at a cumulative $50 billion from 1994 through 2005.

Study Tasks

The study team began by reviewing existing literature and domestic and international experience to prepare a comprehensive list of potential freight funding and financing mechanisms. There is wide agreement in the surveyed literature on the great volume of freight moved in the United States, the high volume increases expected in the long run, the inadequacy of existing infrastructure to manage the throughput, and the lack of specific programs to fund future infrastructure requirements. A standalone literature review was prepared and is presented as Appendix A.

The study team then compiled a list of possible freight infrastructure funding mechanisms and criteria for initial screening. The list of potentially feasible options was narrowed considerably as many turned out to be impractical for various reasons or to be more suitable for project-specific funding than for national application.

The study team recommended carrying forward seven potential revenue mechanisms as candidates for additional analysis: fuel tax surcharge, VMT fees, PPPs, ITCs, registration fees and excise taxes, waybill taxes, and carbon taxes. The research team recommended that the fuel tax surcharge, VMT fee, and excise tax options should be carried forward into detailed analysis of collection mechanisms and concepts of operation and into the final report.

Literature Review Results

The literature reviewed for this study (see Appendix A) focuses on the need for new revenue sources for transportation projects in general and for freight infrastructure specifically, and on conceptual discussions of various potential revenue mechanisms. A few sources make concrete recommendations for new revenue sources; most suggest a range of options for further study. Only a very few sources discuss the mechanics of possible revenue options in any detail.

Sources agree that the current state of affairs includes the following:

- Heavy usage of existing facilities and attendant congestion.
- Under maintenance or inadequate state of physical facilities.
- Weakness of fuel taxation and depletion of the Highway Trust Fund, stemming from multiple causes.
- Unmet need for targeting funding for freight infrastructure.

The literature on alternative revenue generation mechanisms is focused almost exclusively on private automobiles. Issues particularly relevant to freight movement—such as use of graduated VMT fees for different truck sizes, the role of federal excise taxes, and the use of commercial fuel card and fuel tax allocation systems for VMT fees—have been largely neglected.

Revenue Options

The array of funding options discussed in the literature draws on existing taxes and fees, on pilots and demonstrations, and on new funding sources that could be used for

freight infrastructure. These funding options include the following:

- **Existing fuel taxes.** The current fuel tax regime is described in the literature in detail, including accounting rules, diversion of funds to non-highway sources, and especially exemptions.
- **VMT fees.** A VMT fee is a user fee charged to each vehicle per mile traveled on all roads or on specific segments of roads (e.g., Interstate highways). There are multiple options for VMT implementation. This revenue-generation mechanism has received extensive treatment, starting with the National Surface Transportation Infrastructure Financing Commission and most recently by the RAND Corporation (Sorenson et al., 2009).
- **Vehicle and freight weight taxes.** Variations on vehicle weight taxes include vehicle or axle weight taxes, freight tonnage taxes, and freight weight-distance taxes. These main taxes are meant to reflect the impact of weight (vehicle or freight) on the roads. Oregon uses a weight-distance tax currently. The ATA has evaluated this option.
- **Freight transportation or waybill tax.** A freight services or waybill tax would be assessed on the price or equivalent value of transportation services. PricewaterhouseCoopers (PwC) has developed a waybill tax proposal for the American Road and Transportation Builders Association.
- **Dedicated customs duties.** Both diverting existing revenues from customs duties or revenue generated by a surcharge on existing customs duties have been considered as revenue options. The California Marine and Intermodal Transportation System Advisory Council examined this option as a source of funding for maritime infrastructure projects.
- **PPPs.** PPPs are a broad topic and represent the attempt to attract private equity capital to public infrastructure investment. Examples range from Chicago-area tollways to leasing out the Indiana Turnpike.
- **ITCs.** Short line railroads have enjoyed a tax credit worth about $170 million annually; it has lapsed, but is expected to be extended. This credit evidently has been serving its purpose of boosting private capital investment. Class I railroads are seeking a similar provision applying to them as well.

Criteria for Evaluation

Criteria for evaluation have also been supplied in the literature, both by the trucking industry and most notably by the National Surface Transportation Infrastructure Financing Commission. The trucking industry lists seven criteria: efficiency, equity, effectiveness, enforceability, competitiveness, neutrality, and non-intrusiveness. The National Surface Transportation Financing Commission developed a more elaborate list, including a weight for each criterion. The National Surface Transportation Financing Commission places the maximum weight on the revenue potential of each option and promotion of efficiency (minimizing economic costs of revenue generation and inducing socially desirable behavioral responses). The user fee/benefit tax principle and the political acceptability of the revenue option are also given high weights.

In the literature, two revenue options are considered main contenders based on their revenue-generating potential as well as other criteria. These are modified fuel taxes and VMT fees.

Other options do not fare as well in the literature. Weight-based taxes (vehicle and freight) are attractive because they allow for variations in charges based on costs imposed by freight movements on roads and infrastructure. However, these revenue mechanisms have different effects on private, commercial, and government use of vehicles for freight transportation. They also require levels of information that could be considered intrusive. A similar case can be made against waybill taxes. On the other hand, customs duties, while relatively easy to implement, are likely to be a disappearing tax base as international trade agreements limit the duties that member countries can impose on imported goods and services. Congestion- or value-pricing mechanisms are primarily suited for demand management rather than revenue generation. From the literature, it appears that freight congestion charges are not very effective in changing freight transportation demand or its timing. Market and profitability considerations are more important determinants of the timing and distance of freight transport.

There is strong support in the literature for user fees over taxes. "The paramount difference between a tax and fee is based on the purpose of the charge. A charge that covers the cost of providing a service to the payer is a fee. A charge that raises revenue for general spending without conferring any exclusive benefit to the payer is a tax" (Henchman and Greaves, February 2009).

The current fuel tax occupies a middle ground between user fee and tax. Parties pay a set amount per gallon of fuel purchased regardless of how much, where, and when they travel on federal or state highways. The high correlation between gallons purchased and miles traveled, however, makes the fuel tax levy effectively proportional to road use (the "user pays" principle). The earmarking of federal fuel taxes to the federal Highway Trust Fund and the dedicated use of this fund for transportation infrastructure projects creates a "user fee" structure of funding for transportation in the United States (with exceptions to dedicated uses causing a dilution of the user fee structure). There is, however, little agreement in the literature regarding how to assess the "user pays" principle in practice, considering the various revenue options. Issues and questions raised regarding four funding mechanisms (tolls, VMT, freight transportation or waybill tax, and PPPs) are listed below:

- **Tolls.** Are they a good way to ensure that the user pays, or are they more trouble than they are worth? This is largely an argument of theory versus practice. Economists generally favor tolls, while truckers see the practical disadvantages of collection as outweighing the benefits.
- **VMT.** Will or should highway usage be billed back to users on a VMT basis, superseding the fuel tax as a surrogate user fee? Can VMT be applied in a way that comports with neutral, accepted tax principles? Two national commissions, seeing the difficulties of the fuel-based trust fund, have called for exploring this concept. Much of the trucking industry, however, drawing from the practical difficulties of implementation in Oregon, remains opposed to this form of charging for road services.
- **Freight transportation or waybill tax.** Can a tax on the value of transportation services be administered adequately and fairly? Would it apply only to carriage transported for a price, as with the existing air cargo tax, or would it extend as well to private carriage of goods?
- **PPPs.** Many parties laud the concept of PPPs while being short on specifics. The trucking industry, however, generally opposes the leasing or concession-based operation of public roads by private concerns and has opposed creating new tolled truck-only lanes while cars remain on untolled lanes.

CHAPTER 2

Option Screening

Candidate Revenue Mechanisms

This study started with a very broad look at possible revenue mechanisms based on a review of the literature and current (early 2010) proposals. The research team developed a list of over 30 possible revenue mechanisms in eight major categories:

- **VMT fees**
  - Distance-only VMT fees
  - VMT fees with congestion pricing or TDM options
- **International trade fees**
  - Container fees
  - Harbor Maintenance Tax increase
  - *Ad valorem* import/export fees
  - Customs revenue
- **Vehicle, sales, and excise taxes and fees**
  - Truck/trailer tire tax
  - Truck/trailer sales tax
  - Truck registration fee
  - Vehicle inspection fee
  - Vehicle weight tax
  - Axle weight fee
  - Commercial driver's license fee
- **Freight activity and value taxes or fees**
  - Freight waybill/bill of lading tax
  - Freight ton-mile tax
  - Heavy vehicle fee
  - Freight tonnage tax
  - Freight transportation value tax
- **Fuel tax reform**
  - Fuel tax rate increase
  - Fuel tax rate indexing
  - Reduced exemptions
  - Recapturing interest earned
  - Reduced diversions
  - Coverage of alternative fuels
  - Diesel fuel tax supplement
  - British thermal unit (BTU) fee
- **Carbon taxes**
  - Carbon tax
  - Cap-and-trade proceeds
- **Investment incentives**
  - PPPs
  - ITCs
- **Tolling**
  - Tolling new roads
  - Tolling existing roads
  - Tolling truck lanes
  - Congestion pricing

Most of the proposals are user fees intended to link the cost of building and maintaining infrastructure to its use for moving freight. Most discussions of infrastructure finance also anticipate a major role for PPPs or ITCs to encourage private investment in freight infrastructure and leverage public resources.

Screening Criteria

Screening criteria for the candidate revenue mechanisms entailed more than just revenue yield. Although the primary purpose of these proposals is to generate revenue, they are also expected to promote efficiency, reduce environmental impacts, and promote equity. The screening criteria reflect a mix of factors that can be quantified or decided in some definitive way (such as the legal status of Harbor Maintenance Taxes) and others that rely on more qualitative factors (such as public acceptance). The criteria used include the following:

- Technical and legal feasibility
- Institutional feasibility
- Revenue potential
- Public-sector implementation, collection, and enforcement cost

- Private-sector implementation and compliance cost
- Incentives for efficiency
- Environmental incentives and impacts
- Modal impacts
- Economic impacts
- Potential for TDM, congestion pricing, or road pricing
- Indications of public acceptance

Options Screened Out

The following revenue mechanism options were screened out—international trade fees, freight tonnage or ton-mile fees, freight value or value-added, waybill taxes, and carbon taxes or cap-and-trade proceeds. A discussion of each of the screened-out revenue mechanism options follows.

International Trade Fees

International trade fees (container fees, Harbor Maintenance Taxes, customs fee diversion) do not appear to be viable options to fund domestic freight infrastructure. Fees assessed on international containers may be a means to fund port-area infrastructure or other projects directly related to international container movements, but were not found to be an appropriate mechanism to fund the broad range of U.S. freight infrastructure. Likewise, dedicating a portion of customs fees (or adding a surcharge) for the broad range of U.S. domestic freight infrastructure does not appear practical and, furthermore, could complicate or violate international trade agreements. Also, diverting existing fees would not increase the total resources available.

For situations in which international trade fees are legal, they appear more suitable to project-specific or port-area infrastructure funding.

Freight Tonnage or Ton-Mile Fees

Freight tonnage or ton-mile fees that depend on the actual weight of freight being moved were found to be impractical, if feasible at all. The difficulties with using these kinds of fees include the following:

- Most freight shipments are not weighed, and attempting to weigh all such shipments would be costly, slow, and cumbersome.
- The weight of vehicles varies during multistop trips, and attempting to account for such changes would be extremely burdensome.
- Freight tonnage or ton-mile measures would not apply to heavy service vehicles with impacts and infrastructure needs similar to those of freight vehicles.

The Oregon State "ton-mile tax" cited in some literature discussions is actually based on the declared maximum gross weight of the vehicle, not on the actual weight of freight.

Freight Value or Value-Added

The value of goods being shipped and the value created through freight transportation were reviewed as possible bases for taxes or fees, but were found to be infeasible for the following reasons:

- Freight value and value-added are only tenuously related to freight infrastructure requirements or impacts.
- The value of many (if not most) freight shipments is unknown or undocumented and not readily established. Both value and value-added are conceptually hard to define for movements such as solid waste, used shipping containers, or empty trailers.
- While an estimation method for shipment-by-shipment value-added is valid conceptually, it would be extremely difficult to implement and would likely lead to market distortions.

Waybill Taxes

Taxes or fees on the cost of transportation service ("waybill" or "bill of lading" taxes) have been discussed in the literature on a conceptual level. Canada taxes transportation services as part of a broader sales tax system, as do some European countries. A waybill tax seems conceptually simple, does not need any technology, and would apply to all modes. As a practical matter, however, a waybill tax would have serious drawbacks. Some difficulties with waybill taxes are the following:

- The cost of freight transportation and the invoice amount to the transportation customer are poor proxies for infrastructure impact or needs.
- Much, if not most, highway freight transportation is conducted by private fleet operations in which no transportation bill or invoice is generated. (See Appendix B.) An attempt to estimate the implicit cost of private fleet transportation would be highly complex, difficult to implement, and likely to create market distortions.

A tax on waybills, bills of lading, or transportation services thus appears to have very limited potential as a freight infrastructure funding mechanism.

Carbon Taxes or Cap-and-Trade Proceeds

For the foreseeable future, carbon taxes are a conceptually attractive but pragmatically difficult revenue-generation

mechanism for freight infrastructure. Carbon taxes have some potential advantages:

- They can be mode neutral, especially carbon production taxes that are embedded in fuel costs.
- The collection costs would be low, with no technology requirements.
- Carbon taxes could offer a clean slate for narrowing or eliminating fuel tax exemptions.

For transportation, however, a carbon tax is essentially a fuel tax. Carbon taxes are ordinarily viewed as environmental initiatives, and funding sources for mitigation and remediation programs, not infrastructure. To fund infrastructure, carbon taxes would have to be much higher and transportation given a much larger revenue share than in any proposals to date. Imposing carbon taxes on other modes and on exempt users that do not pay fuel taxes would create additional acceptance barriers.

Public-Private Partnerships and Investment Tax Credits

Public-Private Partnerships

PPPs have received considerable attention in the literature and are frequently included in proposed strategies for infrastructure funding. The research team analyzed the different types of PPPs used in transportation infrastructure projects and evaluated the potential opportunities to leverage public funding with private sources of funding or to obtain other financial advantages. In reviewing existing projects described as PPPs, three categories of PPPs were selected for analysis—concession agreements, grant agreements, and other types of agreements.

PPPs appear to be a viable means of facilitating project-specific funding, thereby reducing the pressure on nationwide funding mechanisms. The research team determined that the major value of PPPs is not in providing capital that would otherwise be inaccessible, but in facilitating more rapid capital investment at a comparable or even lower financing cost. The sources of PPP funding can, for the most part, be accessed through revenue bonds or other instruments. The efficiency attributes of private-sector development and operation are, theoretically, accessible through outsourcing and design-build contracts without private financing. PPPs, however, may prove to be a quicker and more flexible means of tapping those funding sources and efficiencies. In that respect, the true function of PPPs may be more institutional than economic. PPPs are given extensive treatment in Appendix E.

Investment Tax Credits

For railroads, and potentially for other modes, ITCs for capacity enhancements are widely considered a viable means of inducing additional beneficial private investment. The research team reviewed the ITC program for short line railroads as a guide to the form of potential multimodal applications.

An ITC can be effective in encouraging additional private investment of a particular type or in a general development direction. As such, an ITC can supplement the public sectors' own infrastructure investment efforts. There is very limited evidence, however, on the amount of new private investment that is induced by ITCs.

ITCs appear to be a potentially valuable part of a comprehensive freight transportation financing package but can do only part of the job by themselves. The usefulness and effectiveness of ITCs for infrastructure funding will depend heavily on what projects are eligible, what the tax credit rate is, and how permanent the ITC becomes. Investment tax credits are also treated at greater length in Appendix E.

Leading Candidates

The research team narrowed the field to three conceptual candidates—fuel tax surcharges, VMT fees, and federal vehicle registration fees. The three leading revenue mechanism candidates are analyzed in the following three chapters and compared in the final chapter. The basis for comparison includes:

- Revenue potential
- Technical feasibility
- Implementation costs and efficiency
- Indication of public acceptance
- Incentives
- Modal coverage and impacts
- Equity
- Linkage between use and payment
- Transportation system impacts

As noted in the introduction, the various revenue mechanism proposals are largely conceptual. With few exceptions, the amounts, coverage, collection mechanisms, and so forth have not been worked out in detail. Accordingly, the research team has assembled information and models from multiple sources and developed detailed scenarios to enable relative comparisons. For purposes of those comparisons, the research team set a common annual gross revenue goal of $5 billion for all three options. The comparisons at the $5 billion target level are supplemented by estimates at other levels to illustrate the presence or lack of scale economies.

CHAPTER 3

Fuel Tax Surcharge

Concept

The federal fuel taxes are the "base case" against which other revenue generation mechanisms are commonly compared, and a fuel tax increase or surcharge is a major freight infrastructure funding option. At present, approximately $34 billion is being raised annually through federal fuel taxes. The current federal tax rates are shown in Table 4. While the taxes on gasoline and diesel fuel are familiar to motorists and truckers, all other significant motor fuels are also taxed at varying rates.

There were an estimated 7 million Class 4–8 trucks with freight body types that used about 20 million gallons of diesel fuel and 9 million gallons of gasoline in 2008. That fuel use would have generated about $6.5 billion in gross federal fuel tax revenue. While it is conceivable that this amount or some annual portion could be set aside for freight infrastructure funding, such an option would bring no more revenue into the system and would not promote the objectives of this project.

Taxes or fuel purchases have been the major source of federal highway funding for over 70 years. Federal taxes are currently levied on sales of diesel fuel, gasoline, and all alternative fuels except hydrogen and electricity. Diesel fuel is the primary energy source for domestic freight transportation by road, rail, and water, so a higher tax on diesel fuel would be a logical candidate for a freight infrastructure revenue mechanism. A significant portion of medium-duty trucks use gasoline, however, and a greater disparity between diesel and gasoline taxes would likely encourage use of more gasoline-powered trucks. Moreover, national objectives for emissions reduction and energy self-sufficiency might be served by encouraging the use of alternative fuels such as ethanol or natural gas. These considerations suggest that analysis of fuel-based freight infrastructure revenue options should be comprehensive rather than focusing exclusively on diesel.

Fuel use is a good proxy for vehicle activity and varies inherently with vehicle weight and load. However, fuel tax revenue per vehicle mile will tend to decline with increased efficiency, presenting a dilemma since increased revenue and increased efficiency are both goals. Also, there are extensive exemptions to federal fuel taxes that must be factored into any evaluation. Finally, fuel taxes are currently based on gallons sold rather than on price and not indexed, nor have they been increased to maintain buying power since 1993.

The revenue option considered in this chapter would most accurately be labeled a fuel tax surcharge, levied on some subset of the truck population. Which trucks should pay a fuel tax surcharge and how they should be identified are difficult questions (these questions are discussed in detail in Appendix B).

It is also possible to envision an overall fuel tax increase with some portion of the increased revenue set aside for freight infrastructure. This approach is supported by some industry associations, but does not meet the objective of a dedicated funding source since it would be subject to the same diversion and variability that adversely affects the current system.

A fuel tax infrastructure fund is already in place for the U.S. inland waterway system. Tug and towboat operators on the inland system pay 20 cents per gallon of fuel (predominantly diesel). The tax revenue goes to the Inland Waterways Trust Fund and is intended to pay for half of federal waterway infrastructure projects (the other half typically being a local match). In 2010, Inland Waterways Trust Fund revenues were $73.9 million, equivalent to about 369 million gallons of fuel. Like the Highway Trust Fund, the Inland Waterways Trust Fund has not kept up with infrastructure needs. In early 2010, the Waterways Council worked with the U.S. Army Corps of Engineers to develop a proposal for a 6- to 9-cent increase in the inland waterways fuel tax. This proposal was documented in the Inland Marine Transportation System Capital Projects Business Model Final Report (the "ITMS plan") (Inland Marine Transportation Systems Capital Investment Strategy Team, April 2010).

The Class I freight railroads reportedly used 3.9 billion gallons of diesel fuel in 2008. (Association of American Railroads,

Table 4. Federal highway user excise taxes and percentage allocation.

Motor fuel taxes				
		Distribution of Tax		
Type of Excise Tax	Tax Rate (cents)	Highway Account, Highway Trust Fund (percent)	Mass Transit Account, Highway Trust Fund (percent)	Leaking Underground Storage Tank Trust Fund (percent)
Gasoline	18.4 per gallon	83.9	15.5	0.5
Diesel	24.4 per gallon	87.9	11.7	0.4
Gasohol	18.4 per gallon	83.9	15.5	0.5
Liquefied petroleum gas	18.3 per gallon	88.4	11.6	0
Liquefied natural gas	24.3 per gallon	92.3	7.7	0
M85 (from natural gas)	9.25 per gallon	83.5	15.5	1.1
Compressed natural gas	144.47 per thousand cubic feet	93.3	6.7	0
Truck-related taxes - all proceeds to Highway Account				
Tires	9.45 cents for each 10 pounds of the maximum rated load capacity over 3,500 pounds.			
Truck and trailer sales	12 percent of retailer's sales price for tractors and trucks over 33,000 pounds gross vehicle weight (GVW) and trailers over 36,000 pounds GVW.			
Heavy-vehicle use	Annual tax for trucks 55,000 pounds and over GVW: $100 plus $22 for each 1,000 pounds (or fraction thereof) in excess of 55,000 pounds. Maximum tax: $550.			

Source: GAO Analysis of FHWA data.

2009), about 20% of that used by Class 4–8 diesel freight trucks. Some states levy fuel taxes on off-road users, specifically railroads. The Alabama state tax has been the subject of major litigation. The most recent development occurred in March 2011, when the U.S. Supreme Court reversed a U.S. Court of Appeals in finding that a railroad could indeed bring suit to halt the Alabama state tax (CSX Transp., Inc. *v.* Ala. Dept of Revenue, No. 09-250, 2011 WL 588790, U.S. Feb 22, 2011). The court did not nullify the tax, and the issue will likely move to federal district court.

Discussions to date of fuel tax increases, conversions, or improvements have not been focused on trucks or freight. The exception has been the Freight FOCUS Act of 2010, which proposed a $0.12 per gallon increase in the diesel fuel tax with income tax credits or refunds for exempt or non-freight uses.

A number of modifications to the fuel tax have been suggested:

- **Increase the tax rate.** Based on *total* highway capital program needs identified by FHWA and AASHTO, the fuel tax rates need to increase by about 100%. The increase could be implemented gradually, and a portion dedicated to freight infrastructure.
- **Index for inflation.** Creating an automatic, inflation-based, adjustment mechanism would maintain the buying power of the fuel tax. There are a number of proposals based on alternative indexes.
- **Index for average fuel economy.** A proposed automatic adjustment in the fuel tax based on average fuel economy would align the tax more closely with actual highway demand.
- **Convert to a BTU tax.** One proposal would tax fuel based on its energy value. Depending on the rates charged, this would alter the present structure of gasoline, diesel, and special fuels taxes.
- **Reduce exemptions.** Reducing or eliminating the exemptions for government agencies and schools would spread the true cost of road use more equitably among the users, increase incentives for wise use of energy, and reduce the need to raise fuel tax rates. Public agencies would have to make tax obligations up from other revenue sources, however, effectively transferring other tax revenues to highway use.
- **Reduce evasion.** Increasing enforcement or other measures to reduce evasion would increase the net yield from any tax system and reduce the need to increase rates.
- **Reduce diversion.** Part of the fuel tax is dedicated to the Mass Transit Account, and some of the Highway Account is diverted to non-highway projects. Eliminating non-highway uses would recover more of the net revenue for highway projects or freight infrastructure, but the transit funds would have to be made up from other sources.

- **Convert to a sales tax.** AASHTO has proposed converting the fuel excise tax from a "unit tax" (per unit of sales) to an *ad valorem* tax (on the value of sale), which presumably would increase with the price of fuel and maintain buying power.

Most of these proposals, however, are aimed at reforming the existing fuel tax system rather than at using dedicated fuel taxes to support freight infrastructure. Creating a dedicated fuel tax revenue stream for freight infrastructure would require increasing or surcharging fuel taxes for freight trucks, or for all medium and heavy trucks.

Selectively raising the fuel tax to support highway infrastructure in general is a straightforward prospect. Raising the fuel tax to support just *freight* infrastructure, however, introduces two sets of complications:

- There is not an easy, clear, or consistent definition of "freight" vehicles to which an increased fuel tax might apply.
- While diesel is the predominant fuel for heavy-duty vehicles that haul freight, most diesel vehicles do not haul freight and some medium-duty freight vehicles use gasoline.

Freight FOCUS Act of 2010

In an attempt to increase funding for freight-related highway projects, the ATA worked with Rep. Richardson's (D-CA) office to draft the Freight FOCUS Act of 2010, which was introduced in September 2010. The legislation would create a new trust fund, "The Goods Movement Trust Fund" to address critical freight transportation needs.

The fund would be financed by a $0.12 per gallon increase in the diesel fuel tax that would be adjusted annually for inflation. Non-freight diesel fuel uses would be eligible for tax refunds or tax credits, just as non-road uses are eligible at present. In addition, a $3 billion annual contribution would be provided by the General Fund. Specific projects would be selected competitively and allocations for environmental and security projects would total 8%. The bill attempted to ensure that revenue would be distributed proportionally to each mode's financial contribution to the program. In the bill as introduced, the tax would only apply to highway users, but could eventually include rail and waterway modes.

As drafted, the Act would only apply to commercial transport of goods for a fee. For-hire motor carriers and owner-operators would pay the higher tax, private fleet operators would not. The disparity raises equity issues and the potential for market distortions similar to a waybill tax.

The proposal attempts to ensure that revenue generated from a new tax on diesel fuel to be paid by commercial highway users will be used for projects of importance to those users. It would also halt increasing diversions of the fuel tax.

Diesel Fuel Tax with Non-Freight Refunds

This option, as proposed in the Freight FOCUS Act of 2010 would target freight highway users through an increase in the diesel fuel tax coupled with annual tax refunds or tax credits for non-freight vehicles. This approach has the advantages of a very short implementation time and low collection and compliance costs. Freight vehicle operators would simply see a tax increase with no new record-keeping or filing requirements. The tax itself would be collected through the existing system with no incremental cost.

Although the Freight FOCUS Act refers generically to "refunds" for non-freight vehicles, what is truly envisioned are refunds for public agencies and tax credits for commercial firms (motor carriers or private fleets). Although many service fleet operators may not owe enough tax in a given year to use the credit, this problem is not inherent in the refund/credit approach and could be remedied in revised legislation or tax rules.

The use of tax credits or refunds for some vehicles opens up a potentially valuable policy option—variable tax rates. By varying the refund or credit, it would be possible to encourage or discourage different vehicle and fuel combinations. For example:

- Lower tax rates (higher refunds) for newer diesel engines with lower emissions.
- Lower tax rates (higher refunds) to encourage the use of more efficient diesel engines in passenger vehicles and small trucks.

Most industrial nations tax diesel fuel at lower rates than gasoline. The higher BTU content of diesel fuel and the greater fuel efficiency and durability of diesel engines reduce overall fuel consumption. Lower diesel taxes thus promote fuel conservation and reduce the dependence of those nations on imported oil. As a consequence, diesel passenger cars and light trucks are far more prevalent in other nations.

Diesel/Gas Tax with Non-Freight Refunds

To cover all highway freight vehicles, or all medium- and heavy-duty trucks, it would be necessary to cover all fuel types, including gasoline, natural gas, ethanol, and so forth. Doing so would spread the tax burden more equitably across freight vehicles, but would dramatically expand the scope and costs of compliance. There are roughly 7 million medium- and heavy-duty vehicles with freight body types, but around 250 million U.S. vehicles overall. Over 240 million non-freight vehicles would then be eligible for tax refunds or credits. The

costs of compliance for tax refund approaches would entail record keeping and documentation of fuel purchased and federal tax paid, documentation of vehicle type (presumably from state vehicle registration), completion and filing of tax forms, and tax return auditing and enforcement.

Record keeping could be greatly simplified for users of gasoline company credit cards or commercial fuel cards. Through straightforward accounting changes, those card systems should be able to provide customers with monthly and annual summaries of federal taxes paid. Users of cash, purchase orders, bulk fuel, or other credit cards would likely have a greater record-keeping burden.

Diesel Fuel Tax with Vehicle ID

A second major option for a freight-only fuel tax is an electronic system to identify the vehicle at fueling locations. There are several technologies available, most relying on dedicated short-range communications or other wireless systems.

Federal implementation costs would be substantial, as would collection and enforcement costs. At a marginal tax rate of $0.25 per gallon, a long-haul truck driver buying 200 gallons would have a $50 incentive to evade the higher tax rate.

Diesel/Gas Tax with Vehicle ID

Expanding a high-tech vehicle ID system to cover all fuel types while distinguishing freight from non-freight vehicles would increase implementation, collection, and compliance costs significantly, comparable to a distance/vehicle VMT fee. All U.S. vehicles would have to be equipped with tags to signal the appropriate tax rate at fueling locations.

In all of these fuel tax options, the incremental collection, implementation, and compliance costs are attributable to the need to distinguish freight from non-freight vehicles. This need would not exist if the fuel tax increase were universal and freight infrastructure funds were set aside by legislative choice or formula.

Concept of Operations

Current Collection Mechanism

The federal fuel tax is very economical to collect. The tax is paid to the Internal Revenue Service (IRS) by the producer or importer of the fuel and passed along to the highway user who pays at the pump. The federal fuel tax is generally collected twice each month from "rack" locations—the point at which fuel leaves wholesale storage for delivery to retail outlets (see Figure 4). There are roughly 1,000 such locations. The annual collection cost for the federal fuel tax has been estimated at approximately 0.2% of revenue (American Transportation Research Institute, May 2007), determined by the research team to be roughly $70 million annually in 2010.

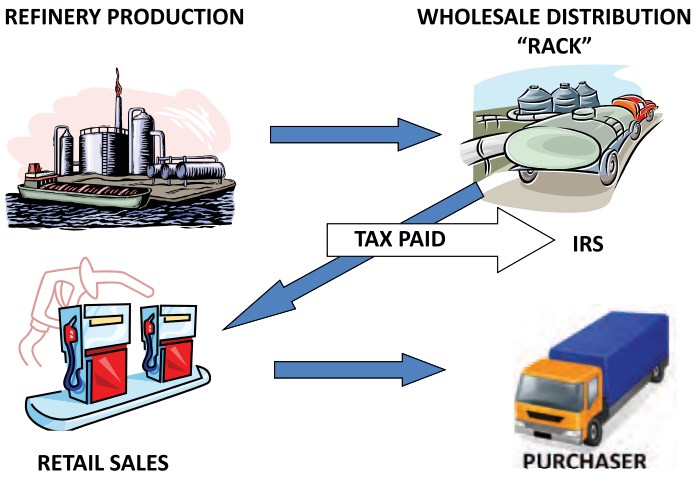


Figure 4. Fuel tax collection.

Retail fuel purchasers are effectively reimbursing retailers and wholesalers for the taxes already paid. Bulk fuel purchasers pay taxes if not exempt. Exempt purchasers either buy bulk fuel, have credit cards that exempt them from taxes, or file for refunds with their income taxes. Credit card fees and other collection costs are absorbed by retailers and wholesalers.

International Fuel Tax Agreement

Trucks that operate and purchase fuel in more than one state are required to reconcile taxes paid and fleet VMT by state under the IFTA system. The system allows motor carriers to pay each state an amount based on the total miles operated in that state. Carriers report gallons purchased, fuel tax paid, and miles operated in each state to the IFTA. The IFTA calculates the net amount owed by each carrier to each state. An annual or periodic statement reconciling fuel taxes owed could also be a means of collecting or adjusting a federal tax or surcharge.

Tax Refund/Credit Systems

Tax refund or credit systems for fuel tax surcharges, similar to the system proposed in the Freight FOCUS Act of 2010, could be either low-tech or high-tech and could distinguish different types and classes of trucks.

Low-Tech Approach

A low-tech tax collection mechanism would use the current system (shown in Figure 4). The additional diesel or gas tax would be collected for all fuel delivered from wholesale "rack" locations, and all customers would pay the same

tax rate. Establishing eligibility for a refund or credit would depend on a system of vehicle type designations.

Freight Class 4–8 or 7–8 Vehicles. Targeting a fuel tax surcharge on "freight" vehicles raises the definitional issues addressed in Appendix B. The most likely basis for distinguishing freight vehicles appears to be body type—vehicles capable of hauling freight would be taxed, whether or not they actually hauled freight. Vehicle body type would have to be part of the vehicle registration information and linked to the vehicle identification number (VIN). Vehicle registration showing a non-freight body type would qualify the operator for a refund or credit.

All Class 4–8 or 7–8 Vehicles. If the higher diesel or gas tax rate were applied to all Class 4–8 vehicles, then vehicle registration information showing a vehicle to be Class 1–3 would entitle the vehicle operator to a refund or credit. If the system taxed Class 7–8 vehicles only, then Class 1–6 vehicles would be exempt.

This system would be relatively simple, but would place the record-keeping and tax-filing burden on those with the exemption. For a diesel-only tax, those diesel fuel customers that did not operate taxed vehicles, including owners of diesel Class 1–3 trucks and diesel automobiles, would have to file annual, quarterly, or periodic forms with the IRS to obtain a refund or credit. Similar forms are currently used by those who purchase taxed diesel fuel for off-road and non-vehicle uses and later seek refunds or credits:

- IRS Form 4136—Credit for Federal Tax Paid on Fuels (annual).
- IRS Form 720—Quarterly Federal Excise Tax Return (quarterly).
- IRS Form 8849—Claim for Refund of Excise Taxes (periodic).

Federal collection and enforcement costs would consist of incremental tax return processing, auditing, and follow-up costs. New forms and instructions would have to be created to implement non-freight refunds of increased diesel taxes, but the research team did not attempt to estimate the cost of doing so. Private-sector compliance costs would be borne by non-freight diesel fuel customers who would file for refunds. If the tax increase surcharge were expanded to include gasoline and alternative fuel trucks, the group of non-freight record keepers would expand to include all vehicle owners and operators.

High-Tech Approach

A high-tech approach would involve the use of wireless technology to identify the vehicle and the appropriate fuel tax rate at the point of purchase. A high-tech approach of this kind would be similar to gas station payment for VMT fees. In both cases, the gas station itself would have to be equipped with technology—for instance, RFID or DSRC—to identify vehicles and charge the appropriate tax rate. Tagging all diesel vehicles (or, for a diesel/gas option, all vehicles) would be very costly.

For a fuel tax, it matters which vehicle is at which pump and buying which fuel. It might be necessary to employ a system similar to bulk systems that use a vehicle identity reader on the fuel nozzle itself.

Revenues and Costs

Rate Structure and Gross Revenue

The amount and structure of a fuel tax surcharge depends on the revenue goal and the scope of its application. For a given revenue goal, wider application (e.g., to all Class 4–8 trucks versus just freight trucks) allows lower tax rates. For a given tax rate, wider application yields greater revenue. Table 5 illustrates this relationship using 2008 vehicle populations estimated from 2002 Vehicle Inventory and Use Survey (VIUS) data.

There are multiple variations on fuel tax options and at least four ways each can be applied. The primary options in Table 5 are shaded in gray under the working assumption that the system will cover either all Class 4–8 freight vehicles, or Class 4–8 trucks of all types. The other option shown is for just Class 7–8, the heavy-duty trucks now covered by the HVUT.

The first option, a diesel fuel tax with non-freight refunds or credits, would apply to an estimated 4.9 million diesel gross vehicle weight (GVW) Class 4–8 vehicles with freight body types. Those trucks used about 19.9 billion gallons of diesel fuel in 2008, so a surcharge tax of $0.25 per gallon would be required to generate $5 billion in new annual gross tax revenue. The tax revenue received would be higher, covering all non-exempt diesel fuel purchases, but the rest would be refunded. The federal government would benefit from the "float" between the time taxes were paid and when they were refunded. The federal government would also gain windfall income from anyone who failed to claim the refund. If the surcharge applied to just Class 7–8, the rate would have to be $0.33 per gallon to generate $5 billion.

The second fuel tax option is a surcharge covering both diesel- and gasoline-powered freight trucks. Since this option would cover more vehicles, the rate could be lower—$0.17 per gallon for Class 4–8 trucks or $0.30 per gallon for Class 7–8 trucks only.

The third option, a diesel fuel tax with vehicle identification at point of purchase, could be applied to all types of

Table 5. Fuel surcharge rate structure.

Fuel Tax Surcharge Options	2008 Vehicles	2008 Gallons Purchased	$/Gal Required for $5 Billion Gross Revenue	Gross Revenue @ $0.12/Gal	Gross Revenue @ $0.25/Gal
Diesel fuel tax with non-freight tax refunds					
Class 7&8 freight	3,769,296	15,360,180,292	$ 0.33	1,843,221,635	3,840,045,073
Class 4-8 freight	**4,892,531**	**19,937,451,447**	**$ 0.25**	**2,392,494,174**	**4,984,362,862**
Diesel/gas* tax with non-freight refunds					
Class 7&8 freight	4,147,443	16,901,160,573	$ 0.30	2,028,139,269	4,225,290,143
Class 4-8 freight	**7,075,838**	**28,834,600,558**	**$ 0.17**	**3,460,152,067**	**7,208,650,139**
Diesel fuel tax with vehicle ID					
Class 7&8 freight	3,769,296	15,360,180,292	$ 0.33	1,843,221,635	3,840,045,073
Class 7&8 all types	3,932,630	16,025,777,776	$ 0.31	1,923,093,333	4,006,444,444
Class 4-8 freight	**4,892,531**	**19,937,451,447**	**$ 0.25**	**2,392,494,174**	**4,984,362,862**
Class 4-8 all types	**6,227,636**	**25,378,110,126**	**$ 0.20**	**3,045,373,215**	**6,344,527,531**
Diesel/gas* tax with vehicle ID					
Class 7&8 freight	4,147,443	16,901,160,573	$ 0.30	2,028,139,269	4,225,290,143
Class 7&8 all types	4,327,163	17,633,532,832	$ 0.28	2,116,023,940	4,408,383,208
Class 4-8 freight	**7,075,838**	**28,834,600,558**	**$ 0.17**	**3,460,152,067**	**7,208,650,139**
Class 4-8 all types	**9,006,738**	**36,703,169,928**	**$ 0.14**	**4,404,380,391**	**9,175,792,482**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

diesel trucks—service and mixed categories as well as freight body types. If applied to Class 4–8 freight types, this option would require a surcharge of $0.25 per gallon to reach $5 billion, the same as the comparable tax refund option. If applied to all Class 4–8 diesel trucks, the rate would drop to $0.20 per gallon. If restricted to Class 7–8 trucks, the required surcharge would be higher.

The fourth fuel tax option, a diesel/gas tax with vehicle ID, could cover all Class 4–8 trucks regardless of fuel type and generate $5 billion in gross tax revenue at $0.14 per gallon. The surcharge would be correspondingly higher if the vehicle coverage were more restrictive.

Table 5 also shows the gross revenue from applying a $0.25 per gallon surcharge to the 2008 truck population. Revenue would range from $3.8 billion to $9.2 billion.

Collection and Enforcement Costs

The research team developed a rough estimate of federal collection and enforcement costs for tax refund options by allowing an arbitrary $1.00 for the cost of processing annual tax refunds or credits for non-freight diesel or gas fuel purchasers. There were roughly 10 million U.S. diesel vehicles in 2008. Table 6 shows that there would be roughly 5 to 6 million vehicles eligible for refunds. The average collection cost per vehicle is calculated based on the number of Class 7–8 or 4–8 diesel freight vehicles, which constitutes less than half the total.

A diesel/gas tax refund system could have high total and average collection costs due to the expense of handling the very large number of refunds. These hypothetical diesel/gas options are thus unlikely to be cost-effective unless the refund handling cost is much less than the cost estimated above. These figures illustrate the difficulty of simultaneously covering all the freight trucks, both diesel and gas, while exempting all other vehicles. These cost estimates would rise to the extent that tax refunds were filed quarterly rather than annually.

The collection cost estimates for the fuel tax options with vehicle ID are likewise somewhat arbitrary. The estimate of $10 per vehicle reflects a common rule of thumb used in VMT fee discussions. This estimate is in all likelihood too low for VMT systems but is used here to reflect the simpler ID system required to determine whether or not a given vehicle should pay the incremental tax. The research team located no actual estimates for this specific function.

Costs for a vehicle ID system rise with the number of vehicles involved. The research team did not attempt to reflect scale economies since these costs would be driven by the number of vehicles to be equipped, the number of locations to be equipped and maintained, and the number of transactions handled.

The collection cost estimates for fuel tax options do not include any incremental cost of tax collection itself since that would be accomplished under the existing fuel tax system at

Table 6. Fuel tax surcharge collection and enforcement costs.

Fuel Tax Surcharge Options	Annual Federal Collection and Enforcement Cost	Average Collection Cost per Vehicle
Diesel fuel tax with non-freight tax refunds		
Class 7&8 freight	$ 6,230,704	$ 1.65
Class 4-8 freight	**$ 5,107,469**	**$ 1.04**
Diesel/gas* tax with non-freight refunds		
Class 7&8 freight	$ 245,852,557	$ 59.28
Class 4-8 freight	**$ 242,924,162**	**$ 34.33**
Diesel fuel tax with vehicle ID		
Class 7&8 freight	$ 37,692,961	$ 10.00
Class 7&8 all types	$ 39,326,297	$ 10.00
Class 4-8 freight	**$ 48,925,309**	**$ 10.00**
Class 4-8 all types	**$ 62,276,359**	**$ 10.00**
Diesel/gas* tax with vehicle ID		
Class 7&8 freight	$ 41,474,434	$ 10.00
Class 7&8 all types	$ 43,271,631	$ 10.00
Class 4-8 freight	**$ 70,758,380**	**$ 10.00**
Class 4-8 all types	**$ 90,067,377**	**$ 10.00**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

wholesale locations. Credit and fees would be absorbed by retailers as they are at present.

Implementation and Compliance Costs

Table 7 provides estimates of federal government and freight industry implementation costs for a fuel tax surcharge.

Fuel taxes with tax refunds have no significant implementation costs. Such costs as are incurred would encompass developing and disseminating regulations, forms, and so forth. There would be no implementation costs to the industry because the higher tax rate would be paid through the existing fuel tax system.

Federal implementation cost estimates for fuel taxes with vehicle ID are derived from the Oregon pilot project, which is one of the few sources for experience-based estimates. The Oregon estimates yield a national total of roughly $3 billion to equip 160,000+ gas stations or equivalent data exchange points. The diesel fuel tax with vehicle ID option assumes that half the locations would have to be equipped, while the diesel/gas option assumes the full number.

As Table 7 shows, the estimates allow an average of $100 for an electronic vehicle ID system. This is a lower amount than that allowed for an on-board unit/electronic on-board recorder (OBU)/EOBR capable of two-way communication, data logging, and so forth. The estimates also assume that only the taxed vehicles would be equipped, which may be a conservative assumption.

Both federal and industry implementation costs are converted to annual cost equivalents. The federal infrastructure is assumed to have a 10-year life and industry OBUs/EOBRs a 5-year life.

Industry Compliance Costs

The Table 8 estimates for industry compliance costs are rough because there is little, if any, objective data to support estimates. Compliance costs for diesel or diesel/gas fuel taxes with tax refunds for non-freight use would be incurred by the non-freight users, not by the trucking industry. Table 8 allows an average of $25 per vehicle to cover the cost of record keeping and filing for the refund. This estimate becomes very large for the diesel/gas option because it would include over 240 million non-freight vehicles.

Net Revenue and Revenue Efficiency

Table 9 provides estimates of net annual federal revenue ($5 billion less collection and annualized implementation costs) and annual industry cost ($5 billion plus annualized implementation and compliance costs). The table gives the annual total, the average per vehicle federal revenue and private-sector cost, and the ratio of net federal revenue to total private cost.

While the ratio of net federal revenue to total private cost in Table 9 is only one measure of revenue efficiency, it is immediately apparent that some options are markedly more efficient than others.

- The highest ratios are for the diesel fuel tax with tax refunds due to the absence of significant implementation costs. These options build on existing collection systems.
- Options that rely heavily on technology, namely the fuel taxes with vehicle ID, have high implementation and collection costs that dilute their revenue-generating efficiency.
- The lowest ratio is for the diesel/gas fuel tax with tax refunds since it would require the great majority of vehicle owners (about 240 million) to file for refunds.

The other key statistic shown is the annual average cost per vehicle. The diesel fuel tax with non-freight refunds achieves part of its apparently high efficiency by placing a relatively heavy burden on relatively few trucks. The lowest average cost per truck is for the widest possible application of registration fees, i.e., to all Class 4–8 trucks.

Evasion and Enforcement

There could be significant potential for evasion in a fuel tax surcharge system. Some potential issues are the following:

- There may be no automatic link between the vehicle and the fuel purchased for the vehicle, creating an opportunity for those with both Class 1–3 and Class 4–8 vehicles (construction firms, for example) to credit more fuel use to the smaller, exempt trucks.
- The higher taxes on diesel fuel could also create greater incentives to use untaxed off-road fuel, especially for bulk fuel purchasers.
- If electronic tags identified freight vehicles that should pay higher taxes, there would be a strong incentive to remove or deactivate the tags to avoid taxes.
- If the tags identified non-freight vehicles and exempted them from higher taxes, there would be a black market for exemption tags.

In either high-tech or low-tech approaches, there would have to be mechanisms and processes for appeals and exceptions where a freight type vehicle is used for non-freight purposes (e.g., a Class 6 diesel tractor being used to pull a luxury travel trailer).

If the fuel tax surcharge applies only to freight vehicles there would be an incentive to deliberately misclassify vehicles,

Table 7. Fuel tax surcharge implementation cost estimates.

Fuel Tax Surcharge Options	Federal Implementation Cost	Average Federal Implementation Cost per Vehicle	Annual Equivalent Assuming 10-Year Life	Freight Industry Implementation Cost	Average Industry Implementation Cost per Vehicle	Annual Equivalent Assuming 5-Year Life
Diesel fuel tax with non-freight tax refunds						
Class 7&8 freight	$ -	$ -	$ -	$ -	$ -	$ -
Class 4-8 freight	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Diesel/gas* tax with non-freight refunds						
Class 7&8 freight	$ -	$ -	$ -	$ -	$ -	$ -
Class 4-8 freight	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Diesel fuel tax with vehicle ID						
Class 7&8 freight	$ 1,500,000,000	$ 398	$ 150,000,000	$ 376,929,607	$ 100.00	$ 75,385,921
Class 7&8 all types	$ 1,500,000,000	$ 381	$ 150,000,000	$ 393,262,970	$ 100.00	$ 78,652,594
Class 4-8 freight	**$ 1,500,000,000**	**$ 307**	**$ 150,000,000**	**$ 489,253,095**	**$ 100.00**	**$ 97,850,619**
Class 4-8 all types	**$ 1,500,000,000**	**$ 241**	**$ 150,000,000**	**$ 622,763,594**	**$ 100.00**	**$ 124,552,719**
Diesel/gas* tax with vehicle ID						
Class 7&8 freight	$ 3,000,000,000	$ 723	$ 300,000,000	$ 414,744,339	$ 100.00	$ 82,948,868
Class 7&8 all types	$ 3,000,000,000	$ 693	$ 300,000,000	$ 432,716,314	$ 100.00	$ 86,543,263
Class 4-8 freight	**$ 3,000,000,000**	**$ 424**	**$ 300,000,000**	**$ 707,583,795**	**$ 100.00**	**$ 141,516,759**
Class 4-8 all types	**$ 3,000,000,000**	**$ 333**	**$ 300,000,000**	**$ 900,673,766**	**$ 100.00**	**$ 180,134,753**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

Table 8. Industry compliance cost estimates.

Fuel Tax Surcharge Options		Annual Private-Sector Compliance Cost
Diesel fuel tax with non-freight tax refunds		
Class 7&8 freight	$	155,767,598
Class 4-8 freight	**$**	**127,686,726**
Diesel/gas* tax with non-freight refunds		
Class 7&8 freight	$	6,146,313,915
Class 4-8 freight	**$**	**6,073,104,051**
Diesel fuel tax with vehicle ID		
Class 7&8 freight	$	188,464,804
Class 7&8 all types	$	196,631,485
Class 4-8 freight	**$**	**244,626,547**
Class 4-8 all types	**$**	**311,381,797**
Diesel/gas* tax with vehicle ID		
Class 7&8 freight	$	207,372,169
Class 7&8 all types	$	216,358,157
Class 4-8 freight	**$**	**353,791,898**
Class 4-8 all types	**$**	**450,336,883**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

use "service" vehicles to haul freight, or otherwise circumvent a freight designation. One obvious strategy would be to haul freight in trailers behind "service" vehicles.

Behavior Incentives

Fuel taxes provide behavioral incentives to minimize fossil fuel use and associated environmental impact. From an economist's perspective, these excise taxes charge the fuel user for the externalities associated with fuel use. When sized properly in conjunction with state taxes, federal fuel taxes can provide meaningful incentives. The study team found relatively little literature on the behavioral impact of the current federal fuel taxes. It is not clear how effective federal fuel taxes are in affecting behavior or how high they would have to be raised to do so. In considering the behavioral issue, there are two parts to focus on—buying trucks and operating trucks.

Buying Trucks

Raising the price of fuel through a tax surcharge should encourage the development and purchase of more fuel-efficient vehicles. A 2010 study by the National Research Council's Board on Energy and Environmental Systems and TRB documented several measures that could be taken to improve fuel economy in medium- and heavy-duty trucks and found that taxing fuels could provide superior incentives for improving fuel economy (Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles, 2010):

> **Finding 7-2.** Fuel taxes offer a transparent and efficient method for internalizing the potential societal costs of climate change and oil imports (e.g., energy security) and reducing fuel consumption in road transport. Fuel taxes operate to make fuel-saving technologies more attractive and provide incentives for saving fuel in operations, while involving fewer unintended consequences than standards.
>
> **Recommendation 7-1.** Although the committee recognizes the political difficulty associated with increasing fuel taxes, it strongly recommends that Congress consider fuel taxes as an alternative to mandating fuel-efficiency standards for medium- and heavy-duty trucks (p. 176).

Unfortunately, the 2010 study does not provide guidance on the amount of tax necessary to create the desired incentives.

The 2010 study and other observers comment on the more fuel-efficient vehicles used in other countries and the greater use of transit (Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles, 2010, p. 176). The data in Table 10 suggest that part of the reason may be the much higher fuel taxes in other developed nations. European drivers pay gasoline taxes at least 10 times those in the United States and diesel taxes that are 6 to 9 times higher. The European taxes are lower for diesel than for gasoline, accounting in part for the greater popularity of diesel as an automobile and light-truck fuel there.

In those other developed countries, the tax usually accounts for more than half the cost of fuel, since the underlying untaxed fuel price is not much different than in the United States. A fuel tax of this magnitude is far beyond anything contemplated in any current proposal.

Table 9. Fuel tax surcharge net revenue and efficiency.

Fuel Tax Surcharge Options	Net Annual Federal Revenue	Net Annual Avg. Rev. per Vehicle	Annual Industry Cost	Annual Avg. Cost per Vehicle	Ratio
Diesel fuel tax with non-freight tax refunds					
Class 7&8 freight	$ 4,993,769,296	$ 1,325	$ 5,155,767,598	$ 1,368	**0.97**
Class 4-8 freight	**$ 4,994,892,531**	**$ 1,021**	**$ 5,127,686,726**	**$ 1,048**	**0.97**
Diesel/gas* tax with non-freight refunds					
Class 7&8 freight	$ 4,754,147,443	$ 1,146	$ 11,146,313,915	$ 2,688	**0.43**
Class 4-8 freight	**$ 4,757,075,838**	**$ 672**	**$ 11,073,104,051**	**$ 1,565**	**0.43**
Diesel fuel tax with vehicle ID					
Class 7&8 freight	$ 4,812,307,039	$ 1,277	$ 5,263,850,725	$ 1,397	**0.91**
Class 7&8 all types	$ 4,810,673,703	$ 1,223	$ 5,275,284,079	$ 1,341	**0.91**
Class 4-8 freight	**$ 4,801,074,691**	**$ 981**	**$ 5,342,477,166**	**$ 1,092**	**0.90**
Class 4-8 all types	**$ 4,787,723,641**	**$ 769**	**$ 5,435,934,516**	**$ 873**	**0.88**
Diesel/gas* tax with vehicle ID					
Class 7&8 freight	$ 4,658,525,566	$ 1,123	$ 5,290,321,037	$ 1,276	**0.88**
Class 7&8 all types	$ 4,656,728,369	$ 1,076	$ 5,302,901,420	$ 1,225	**0.88**
Class 4-8 freight	**$ 4,629,241,620**	**$ 654**	**$ 5,495,308,657**	**$ 777**	**0.84**
Class 4-8 all types	**$ 4,609,932,623**	**$ 512**	**$ 5,630,471,636**	**$ 625**	**0.82**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

Table 10. Motor fuel tax rates for selected countries (USD/gallon, 2009).

COUNTRY	GASOLINE	DIESEL
Belgium	$ 4.69	$ 2.93
France	$ 4.56	$ 3.36
Germany	$ 4.85	$ 3.63
Italy	$ 4.36	$ 3.42
Japan	$ 2.68	$ 1.66
Netherlands	$ 5.18	$ 3.25
United Kingdom	$ 4.36	$ 4.37
United States	$ 0.39	$ 0.46

Source for foreign rates is data collected by the U.S. Department of Energy from various sources. Rates were converted to U.S. currency using current exchange rates.

U.S. figures include the weighted average of state taxes.

Operating Trucks

The current fuel tax is a small factor in the operating costs of medium- and heavy-duty trucks. The American Transportation Research Institute (2010) estimates that fuel taxes currently average $0.062 per mile, or 3.6% of an average operating cost of $1.73 per mile. The total U.S. diesel fuel tax average was reported by ATRI to be $0.522 per gallon in April of 2010, of which $0.244, or 47%, is the federal tax. The federal fuel tax would therefore be about $0.029 per mile, or 1.7% of average operating cost. A change in what is already such a small part of the total cost is unlikely to change operations or driver behavior significantly. Moreover, the federal tax is far less than the day-to-day fluctuation in fuel prices, which are roughly 10 times as important to marginal operating costs.

Truck fleet operators already have strong incentives to minimize fuel use by minimizing mileage, and many do so aggressively. Most over-the-road truckload operators pay drivers by the authorized mile, typically defined as the minimum distance required to position the empty truck, obtain the load, and deliver the load. The driver is not compensated for any additional miles run and must obtain authorization for detours, stops for repairs, or other deviations. Less-than-truckload (LTL) firms operating under the Teamster Master Freight Agreement pay a combination of hours and miles, again strictly controlled. Tightly managed local and regional trucking operations, such as UPS and FedEx, employ highly sophisticated routing algorithms to minimize costs. Operators of small freight and service fleets may be less sophisticated, but are no less diligent in cost minimization.

Raising the diesel tax alone or increasing the existing disparity between diesel and gasoline taxes could encourage fleet operators to substitute gasoline vehicles for diesel vehicles where there were long-term cost advantages. According to industry sources, the current rule of thumb is that the higher initial cost of a diesel engine is outweighed by its greater fuel economy and longer life for annual operation over 20,000 to 30,000 miles. The most recent VIUS data (from 2002) show that the share of gasoline trucks drops from about 45% of Class 4–5 medium-duty trucks to about 9% of heavy-duty Class 7–8 trucks. Class 6 can be considered the "battleground" for diesel and gasoline power, with about 58% diesel and 42% gasoline. Recent diesel engine cost increases due to stricter emissions regulations and slightly reduced fuel economy have increased industry interest in gasoline-powered trucks. Ford recently introduced a new gasoline-powered F-650 Class 6 truck model targeted at this market. The potential impact of gas-for-diesel substitution is estimated as part of the economic impact analysis.

Implementation

Implementation of an overall increase in the diesel or gasoline fuel tax would not require changes to the regulations or collection system or introduce any industry compliance needs beyond paying higher taxes. Implementation of a selective increase or surcharge, however, would be much more complex.

Many of the implementation steps for a diesel fuel tax surcharge with refunds or credits for non-freight use are spelled out in the Freight FOCUS Act of 2010. The Freight FOCUS Act would amend the Internal Revenue Code to increase the federal diesel fuel tax by $0.12 per gallon and link that rate to a cost of living adjustment. The Act would further amend the Internal Revenue Code to refund the extra diesel tax paid to fuel purchasers that do not pay income tax (e.g., public agencies and charitable organizations). The Act would provide income tax credits equal to taxes paid for non-freight purchasers who file income tax returns. The Freight FOCUS Act defines "freight" as "goods transported for a fee by a water, land, or air transportation mode." That definition would appear to cover commercial for-hire transportation, but not private fleet operations. As noted in Appendix B, only about 24% of the medium- and heavy-duty truck fleet is owned by

motor carriers or owner-operators; so, as drafted, the Freight FOCUS Act would cover only a fraction of the trucks on the highway.

Definition Development

To apply a fuel tax surcharge to vehicles used in goods movement, a broader, yet unambiguous, definition would have to be developed. As noted in the discussion of common issues, "freight" vehicles could be defined by body type or by industry, but neither approach yields a precise fit with goods movement. Moreover, service industry, construction, and utility vehicles of similar size have similar infrastructure requirements and would benefit from many "freight" projects such as truck climbing lanes or bypasses. It may therefore be both more practical and more equitable to apply a fuel tax surcharge to all medium- and heavy-duty trucks.

Parallel considerations affect the choice between a diesel-only surcharge or a surcharge across all fuel types used by medium- and heavy-duty trucks. Given that a gas-powered truck and a diesel-powered truck of the same size have the same infrastructure needs and impacts, it would be more equitable to impose the same fuel tax surcharge on both fuel types. Yet this approach would apply the surcharge to all 250 million vehicles in the United States and require refunds or credits for over 240 million vehicles.

The types of vehicles and types of fuel subject to a fuel tax surcharge would most likely be decided in legislation, while the precise definition of "freight" vehicles would more likely be decided in IRS rule making. While the process could be contentious, it could likely be completed within a year from the passage of legislation, permitting a short implementation timeline relative to technology-dependent options.

Vehicle ID Technology

The underlying technology required to identify vehicles for the purpose of fuel tax surcharges is already available in the form of RFID and DSRC systems. The implementation steps for a national vehicle ID system would include evaluation and certification of vehicle and fueling site hardware; development of communications software, protocols, and so forth; and a multiyear deployment schedule.

Vehicle identification devices (e.g., active or passive transponders), once specified, could be required equipment on new vehicles and retrofitted to existing vehicles. RFID and DSRC devices tend to be relatively low-powered and would not need to interface with complex vehicle electronic systems. A typical approach would be to develop performance standards and test procedures and then certify devices from multiple manufacturers (much as was done with converters in the changeover from analog to digital television signals).

Filling station devices would need to identify vehicles and impose fuel tax surcharges accordingly. At least one commercial system (Easy Fuel) uses vehicle ID devices located at the filling cap and on the fuel hose nozzle to verify the identity of the vehicle being filled. Many filling stations already have separate cash and credit card prices or separate self-service and full-service prices, so the point-of-sale systems in use can accommodate multiple pricing options.

Development and certification of such systems would likely be a multiyear process. Deployment at 160,000+ fuel retailers would likewise take several years. The magnitude of the deployment task would be reduced substantially if only diesel fuel were taxed.

Fuel tax exemptions for government non-profit and off-road vehicles are currently implemented either through bulk sale, special credit cards, or other non-technological means. Handling bulk fuel purchases for fleet operators such as utilities and telecommunications firms that do not haul freight would require some similar arrangement.

Phase-In

Table 11 displays the research team's working assumptions regarding phase-in of fuel tax surcharge options. Options that used the existing collection system through tax refunds or credits are assumed to be implementable within a year of approval and generate full net federal revenue in the first year of application. There are no significant federal implementation costs. Since many contract freight rates have fuel cost surcharge provisions, the research team assumed that trucking operators would be able to pass on 66% of the increased taxes to customers in the first year and 100% in the second year. Compliance costs are not covered by fuel tax surcharges and would take longer to be passed through to customers. The research team assumed that 33% would be passed through the first year, 66% the second year, and 100% the third year.

The options with vehicle ID technology are assumed to require a 5-year implementation period during which the federal government would be incurring development and deployment costs, but would not be receiving revenue. The timing of the pass-through to customers is assumed to be the same as the tax refund option, but to start after the 5-year implementation period.

Advantages

A federal fuel tax surcharge would have significant advantages as a revenue mechanism:

- A fuel tax is fair in that it is proportional with highway use and infrastructure impact. The tax burden would increase with both vehicle weight and miles traveled.

Table 11. Fuel tax surcharge implementation.

Revenue Option	Years to First Revenue	Federal Implementation Cost Phase-In Years	Tax Burden Passed to Customers First Year	Tax Burden Passed to Customers Second Year	Tax Burden Passed to Customers Third Year	Implementation and Compliance Cost Passed to Customers First Year	Implementation and Compliance Cost Passed to Customers Second Year	Implementation and Compliance Cost Passed to Customers Third Year
Diesel fuel tax with non-freight refunds								
Class 7&8 freight	1	1	66%	100%	100%	33%	66%	100%
Class 4-8 freight	**1**	**1**	**66%**	**100%**	**100%**	**33%**	**66%**	**100%**
Diesel/gas* tax with non-freight refunds								
Class 7&8 freight	1	1	66%	100%	100%	33%	66%	100%
Class 4-8 freight	**1**	**1**	**66%**	**100%**	**100%**	**33%**	**66%**	**100%**
Diesel fuel tax with vehicle ID								
Class 7&8 freight	5	5	66%	100%	100%	33%	66%	100%
Class 7&8 all types	5	5	66%	100%	100%	33%	66%	100%
Class 4-8 freight	**5**	**5**	**66%**	**100%**	**100%**	**33%**	**66%**	**100%**
Class 4-8 all types	**5**	**5**	**66%**	**100%**	**100%**	**33%**	**66%**	**100%**
Diesel/gas* tax with vehicle ID								
Class 7&8 freight	5	5	66%	100%	100%	33%	66%	100%
Class 7&8 all types	5	5	66%	100%	100%	33%	66%	100%
Class 4-8 freight	**5**	**5**	**66%**	**100%**	**100%**	**33%**	**66%**	**100%**
Class 4-8 all types	**5**	**5**	**66%**	**100%**	**100%**	**33%**	**66%**	**100%**

Source: Tioga Group Analysis.
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

- A fuel tax creates a small incentive for fuel efficiency, and raising the tax would increase the incentive. Varying the tax rates on alternative fuels can encourage development of fossil fuel alternatives, which is consistent with current public policy objectives.
- The LUST Fund provides a working example of a multimodal excise tax on fuel.
- The federal fuel tax is already in place and is very economical to collect.
- If implemented through tax refunds or credits, a fuel tax surcharge would not require any new technology and could be implemented relatively quickly.
- The low cost of implementation and lack of technology requirements makes a fuel tax surcharge implemented through tax refunds or credits for non-freight users a revenue-efficient option.
- The fuel tax system already covers all alternative motor fuels except electricity and hydrogen. If hydrogen becomes a transportation fuel in the coming decades, it can be included in the existing system.
- The fuel tax system is compatible with state fuel taxes, and there is a reconciliation and allocation system (IFTA) in place.

Disadvantages

A fuel tax surcharge could have significant drawbacks, depending on how it is implemented:

- A tax surcharge on "freight" only would raise equity and definitional issues between freight and service vehicles.
- A diesel-only surcharge implemented via tax refunds or credits would raise equity issues and encourage greater use of gasoline-engine trucks.
- A diesel and gasoline tax surcharge would affect all vehicles and require refunds or credits for some 240+ million vehicles each year.
- A technology-based distinction between vehicles would require lengthy and costly technology development and deployment processes.

CHAPTER 4

Fees for Vehicle Miles Traveled

Concept

A VMT fee system would charge vehicle owners based on the number of miles traveled on public roads and highways. VMT is a direct measure of vehicle activity. VMT fees (also called mileage-based user fees, or MBUFs) are the leading candidate to replace fuel taxes as the major source of federal highway funding and are discussed extensively in the literature. The proposed switch from fuel-based taxation to mileage-based fees is motivated in part by the projected erosion of fuel-based tax revenue due to improved fuel efficiency and alternate sources of power. National VMT for passenger, freight, and service vehicles, in contrast, is expected to grow indefinitely. VMT fees would also facilitate coverage of hybrid, alternative fuel, and electric vehicles that would otherwise make little or no contribution under the current fuel tax regime.

Mileage-based fees have been addressed throughout the reviewed literature and are generally perceived as the leading candidate for funding a freight infrastructure program. There are as yet no detailed proposals for U.S. VMT fees. There have been a small number of tests and pilot projects, but most discussions of VMT fees or MBUFs remain at the conceptual level. Moreover, analysis to date of VMT fees has focused almost exclusively on passenger cars. There is a truck VMT system in operation on the German Autobahn network, but information on freight VMT system concepts is otherwise very sparse.

While there are numerous variations on VMT fees, they have in common the concepts of fees based on vehicle type and miles traveled and of automated collection via on-board devices of some kind (often referred to generically as OBUs). Proposals for VMT fees can be split into two basic types:

- **Distance/vehicle VMT fees,** in which the fee is based on the miles traveled, regardless of where the mileage is incurred. For freight applications, VMT fees would presumably vary by vehicle type and weight class.
- **Time/location VMT fees,** in which the fee would vary by some combination of time and location, as well as by vehicle type or class. Time/location VMT fees would allow incorporation of TDM options such as congestion pricing, road pricing, and tolling.

The National Surface Transportation Infrastructure Financing Commission has recommended that the United States move to such a system. If a VMT fee system were implemented for all vehicles, a higher rate could be charged for medium- and heavy-duty trucks with the additional revenue used for freight infrastructure funding. The scope of this study, however, is focused on separate, dedicated funding sources for freight infrastructure.

Distance/Vehicle VMT Fees

Distance/vehicle VMT fees would be a revenue-generating mechanism with minimal potential for congestion pricing or other TDM options beyond creating a mild incentive to minimize distance traveled. By varying the fee with the vehicle type, a distance/vehicle VMT system could collect a weight-distance tax similar to that levied in Oregon.

Proposals to date for VMT fees do not address the differences between vehicle types, nor are there any concrete proposals for VMT fee amounts. Some VMT fee proposals implicitly or explicitly anticipate varying the fee according to the size or weight class of the vehicle affected. This approach may be contrasted with VMT fees for passenger vehicles or private automobiles, which may or may not vary with vehicle type or size. There are no known proposals to assess fees for freight vehicles on the basis of distance traveled only (which would be a pure VMT fee), but neither are there concrete proposals for graduating VMT fees by vehicle type or weight.

Time/Location VMT Fees

Time/location VMT fees that can vary by location, route, or time create the option for congestion pricing, tolling, road pricing, or other TDM measures. The means by which time,

location, or route might be determined include GPS, automatic vehicle location (AVL), DSRC, and other technologies. It is generally assumed that time/location VMT systems would include all the features of distance/vehicle VMT systems, as well as incremental capabilities to vary fees on the basis of factors beyond distance traveled or vehicle class. A key challenge is identifying the additional cost, complexity, and privacy issues inherent in time/location VMT proposals with TDM capability and balancing them against the benefits. A true cost/benefit analysis of TDM and road pricing strategies is beyond the study scope, as is any evaluation of road pricing or TDM concepts themselves.

For a time/location VMT system to be operational, vehicles need to be fitted with equipment capable of tracking the number of vehicle miles traveled by location, such as installation of a GPS receiver. The GPS receiver would be connected to a geographic information system (GIS) database that records the number of miles traveled within delineated jurisdictions. Each jurisdiction could have a fee schedule based on functional road class, vehicle type, or other factors that is used to calculate fees the vehicle owner owes based on the mileage traveled.

Time/location VMT fees would have much higher capital, deployment, and collection costs. In the most elaborate form, time/location VMT could have federal, state, and local components (National Chamber Foundation of the U.S. Chamber of Commerce, 2005, p. IX).

Time/location VMT fees would raise issues of privacy and confidentiality. GPS-based or equivalent systems would have the inherent capability to reveal detailed information about where the vehicle has traveled and when. For some, this capability raises concerns regarding personal privacy, although there are means by which privacy concerns can be addressed. In the commercial sphere, GPS data could reveal the location of a company's customers, the frequency with which those customers are served, the home locations of drivers, and elements of the company's business strategy.

The incremental benefits of time/location VMT fees would mostly consist of *opportunities* for congestion pricing or road pricing on routes not otherwise equipped for tolling. Unless a national congestion management or toll system emerges, all such benefits would be at the state or regional level and will depend on state or local initiatives for implementation. There would be no significant nationwide benefits to time/location VMT systems.

Area-Based VMT Congestion Pricing

Area-based congestion pricing would likely be simpler to implement than route-based road pricing, and could use "consumer-grade" or coarse-resolution GPS rather than high-resolution GPS. Area-based VMT fees would entail a surcharge for entering a defined area, typically a congested urban center. The surcharge could be a flat fee, a mileage-based fee, a time-based fee, or some combination. The implementation of area-based congestion pricing would entail knowledge or recognition of vehicle location, thus raising privacy issues.

VMT Road Pricing

Road pricing, defined here as fees that vary by route, would require high-resolution GPS or an equivalent technology to distinguish routes with sufficient accuracy. High-resolution GPS would be an added cost for consumer systems. High-resolution GPS technology, however, is built into many commercial truck location systems, so the marginal cost of adding location capability to the commercially equipped fleet could be relatively low. Only a small portion of the fleet is equipped this way, however. The administrative and collection cost would be substantially higher than for a distance/vehicle VMT system. The marginal benefit of road pricing would depend on how and where it is applied.

A system that charged different rates for the Interstate Highway System, or for the designated National Highway System, would be applicable to most of the country. Such a system could, however, encourage diversion to secondary routes less capable of accommodating heavy-truck traffic. Moreover, such a system would turn the Interstate system into toll roads, which is contrary to current rules.

Tolling Interoperability

Tolling interoperability, often mentioned as a benefit of time/location VMT systems, is apparently being achieved through other means. A substantial degree of coordination through electronic toll collection has been achieved through E-ZPass, which covers 15 states (see Figure 5). Vermont and Connecticut have not joined E-ZPass, but those states have no toll facilities. A similar system, FastTrak, covers toll bridges and highways in California. The benefits of a truly national tolling system are questionable, as the frequency with which the same vehicle would use toll facilities in multiple states that are not part of E-ZPass is probably minimal.

Parking Fee Collection

Parking fee collection is another proposed application of time/location VMT fees (Grush, 2010). There apparently is significant potential to reduce the cost of collecting money from parking meters and issuing tickets and reduce evasion and embezzlement through GPS-enabled fee collection. The vehicle owner (primarily a passenger-car owner) would benefit from added convenience, but may also "lose" from more

Figure 5. State coverage of E-ZPass.

consistent fee collection. The major beneficiaries would be municipal parking authorities. Moreover, the use of time/location VMT systems to handle parking raises serious privacy issues since it would entail detailed knowledge of vehicle location and time. Finally, the benefits would mostly be in large metropolitan areas.

Realization of Benefits

The congestion management capabilities of time/location VMT systems are of no benefit unless congestion management systems themselves are implemented. Time/location VMT systems would enable congestion management pricing in any well-defined area and would further enable fees to vary by time and vehicle type. This ability would dramatically reduce the implementation barriers and costs of congestion pricing. The practical feasibility of congestion pricing itself, however, is open to question. Congestion pricing has been discussed for decades, but no serious proposals for implementation have surfaced in the United States. Worldwide, congestion pricing remains rare. For those cities that are the prime candidates, such as Manhattan and downtown San Francisco, bridge, tunnel, and highway tolls are already being used as rough congestion management tools. Perhaps most basically, if VMT fees were only applied to medium- and heavy-duty trucks, the scope of congestion pricing or road pricing would be likewise limited.

VMT Fee Pilot Projects

There have been three significant U.S. VMT fee pilot projects:

- The Oregon Department of Transportation (DOT) Road User Charge Pilot, which took place in 2006–2007.
- The National Road User Charge Pilot, which began in 2008 and is continuing under the University of Iowa's Public Policy Center.
- The New York Truck VMT Fee Project, completed in 2011.

The Oregon DOT Road User Charge Pilot is the best known and most completely documented of the studies. Vehicles in the study were equipped with GPS-based OBUs that could transmit VMT data at specially equipped gas stations. Almost 300 motorists participated, but no commercial trucks were involved. The Oregon pilot demonstrated the technical feasibility of the collection system and successfully dealt with privacy issues by not transmitting or storing detailed movement information.

The National Road User Charge Pilot has involved participants in multiple states and cities. No actual VMT fees are collected, and participants are compensated. The major objective of the tests is to determine whether OBUs can perform as expected and whether they are acceptable to drivers. The 4-year project began in 2008 and is expected to be complete in 2012.

While published findings are not yet available, the NCFRP Project 29 study team was able to interview the project manager.

The New York study, conducted by Delcan Corporation, is the only pilot project concerned with trucks. The project objective is to "establish a revenue-neutral, mileage-based tax model that generates support from [the] motor carrier industry and [the] public sector" (Mudge, April 20, 2010). Preliminary findings and observations from this study include confirmation that many large trucks are already equipped with telematics that can track VMT. The contractor anticipates developing a fee structure that can vary by type of road (e.g., thruways versus local roads) and by time of day (e.g., peak vs. off-peak)—essentially a time/location VMT system. The preliminary proposed base fee is $0.106 per non-thruway mile and $.051 per mile plus existing tolls for thruway travel. The project will also investigate the use of IFTA filings for VMT fee payment.

The Oregon DOT Road User Charge Pilot and the National Road User Charge Pilot are both revenue neutral. The New York study includes examination of different fee structures for trucks but it, too, is revenue neutral. None of these studies addresses public acceptance of VMT fees in addition to current fuel taxes. The New York pilot is focused on trucks and should yield more insight into the workability of VMT fee systems for truck fleets.

The principal results of these pilot projects to date has been to establish technical feasibility, gain some limited insight into costs, and determine that participants are more favorably disposed toward VMT fees and privacy issues after they have experienced the system.

International Experience

Truck VMT fees are in place in Switzerland and Germany. Swiss road pricing dates back to 2001. The current system uses on-board GPS-based units that record vehicle route and mileage. The data are transmitted monthly to the Swiss Customs Agency, who then bills the truck owner. More than 60,000 trucks participate. The German truck toll system is based on each truck's emissions classification, axle loading (weight per axle), and mileage. The GPS-based, electronic system began on January 1, 2005, and its major goal is to raise revenue. The system uses multiple technologies. The Swiss and German systems, like the Oregon and national pilot studies, demonstrate the technical feasibility of VMT systems. The German system also provides some precedent for fee differentiation based on emissions characteristics and axle loading.

A third European system proposed for the Netherlands was recently cancelled. The Dutch system, which would have applied to both passenger vehicles and trucks, was deemed too controversial by a new government and the project was shelved. In retrospect, it appears to close observers that insufficient attention was paid to institutional and political questions while technical problems were being solved (Jongman, April 21, 2010).

Congestion Pricing Examples

Examples of congestion pricing can be seen in Singapore, Stockholm, and London:

- The **Singapore** example is essentially an automated toll system. Entry fees are charged to all vehicles entering central Singapore. The area-based system is implemented through DSRC tags on all vehicles. DSRC readers on the entrance routes to central Singapore are placed on overhead gantries. The system charges the fee to a debit account, but does not identify the vehicle, driver, or time. No data are stored in the OBU. There are no fees for vehicles that operate solely within the toll perimeter.
- **Stockholm,** like Singapore, is an "island" city with limited access routes. Tolls are charged on those routes for vehicles entering the central city. As in Singapore, vehicles that stay within the toll perimeter are not charged.
- Access to central **London** is priced using license plate recognition (LPR) technology.

Time/location VMT fee systems would be a more flexible means of implementing such TDM measures. In effect, the Singapore, Stockholm, and London systems charge vehicles for using routes that lead into congested areas. GPS-based or equivalent time/location VMT systems would allow more variability in fee structure by location, time of day, and so forth. The cost of collection would be reduced for the congestion management agency, but the capital cost to vehicle owners would be much higher.

Concept of Operations

Collection Requirements

The complexity of distance/vehicle and time/location VMT fee systems requires more elaborate collection mechanisms than other revenue-generation strategies. For distance/vehicle fees the collection mechanism should do the following:

- Identify the vehicle and type (e.g., VIN) and link it to a fee account and the vehicle owner.
- Track mileage and determine the total since the last reading.
- Communicate automatically with a stationary reader, communicate via cell phone or Internet, provide downloadable data, or allow for manual reading.
- Provide for auditing and enforcement.
- Resist evasion or tampering.

Dedicated On-Board Units

Most analysis of VMT options to date assume or conclude that vehicles would be equipped with some kind of device (generically an OBU) to automatically track, record, and report mileage for distance/vehicle VMT systems. In their simplest form, VMT-compatible OBUs would record mileage traveled and report that mileage when queried electronically (via DSRC, RFID, or cellular) or read manually. In effect, such devices would be remote-reading odometers. The device would also have to identify the VIN, which would be linked to a VMT fee account. The need for the VIN would be twofold if distance/vehicle VMT fees vary by vehicle type.

For an OBU to obtain mileage data from the vehicle itself, it would have to be either retrofitted to a wide variety of mechanical or electronic odometers or built into new vehicles by the original equipment manufacturer (OEM).

GPS technology is **not** necessary for distance/vehicle VMT fee implementation. As multiple studies have pointed out, the OBD II data link, standard on newer automobiles, provides electronic access to odometer readings. Transmission or downloading of these readings is sufficient for distance-based systems. Similar connections provide access to electronic odometer readings for trucks. Older trucks, however, do not have such connections and would require more complex installations or manual readings.

One preliminary observation of "The National Evaluation of a Mileage-based Road User Charge" is that passenger-car retrofits are unlikely to be a practical strategy due to the complexity of OEM electronic systems on newer cars. Moreover, retrofitted OBUs would likely be far more vulnerable to tampering than units integrated with OEM systems. Commercial OBUs or EOBRs for trucks are designed as either retrofits or OEM installations and can successfully interface with most truck electronic systems.

"The National Evaluation of a Mileage-based Road User Charge" has distinguished two OBU types or approaches with markedly different implications for privacy and collection cost. "Thin" OBU clients (see Figure 6) transmit raw information on vehicle identity, miles traveled, location (relative to taxing jurisdictions), and perhaps route and time. Information is compiled, and VMT fees are determined and assessed at a centralized location.

"Thick" OBU clients (see Figure 7) download information on fee rules periodically. The "thick" OBU client then calculates corresponding VMT fees for vehicle activity and transmits only fee information and vehicle identity at designated billing intervals.

While a thick OBU technology may be more expensive, the thick OBU approach would drastically reduce bandwidth and central processing needs, as well as preserving privacy. In this respect, a thick OBU is akin to a digital taxi meter that applies a predetermined rate structure to cumulative vehicle activity and returns a calculated fare. The thick OBU client would effectively be an electronic third party, taking information from the operator and calculating (and possibly paying) fees owed. The public fee collection agency would then be in the position of establishing rules and procedures, disseminating rules to thick OBU clients and other users, receiving payments, and auditing and enforcement.

Commercial Telematics

The use of commercial telematics systems coupled with third-party VMT fee calculation, reporting, and payment

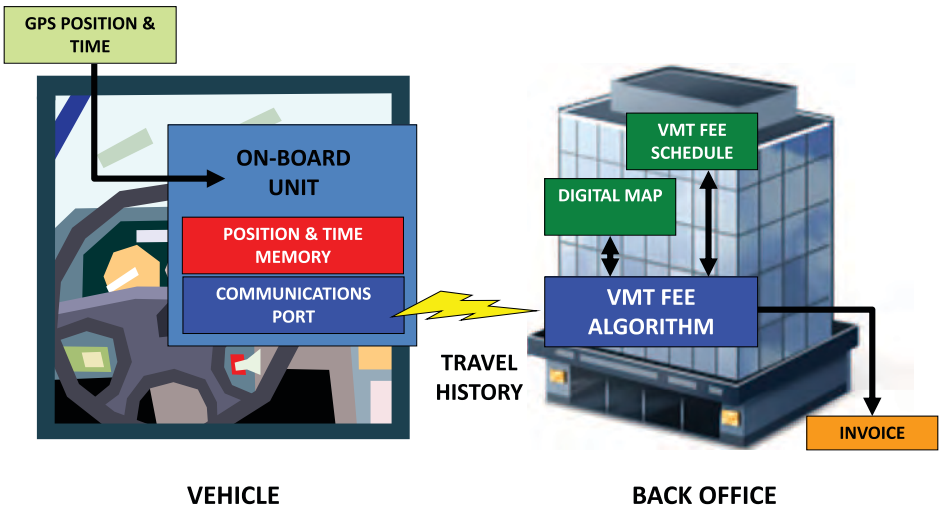


Figure 6. "Thin" client data flow.

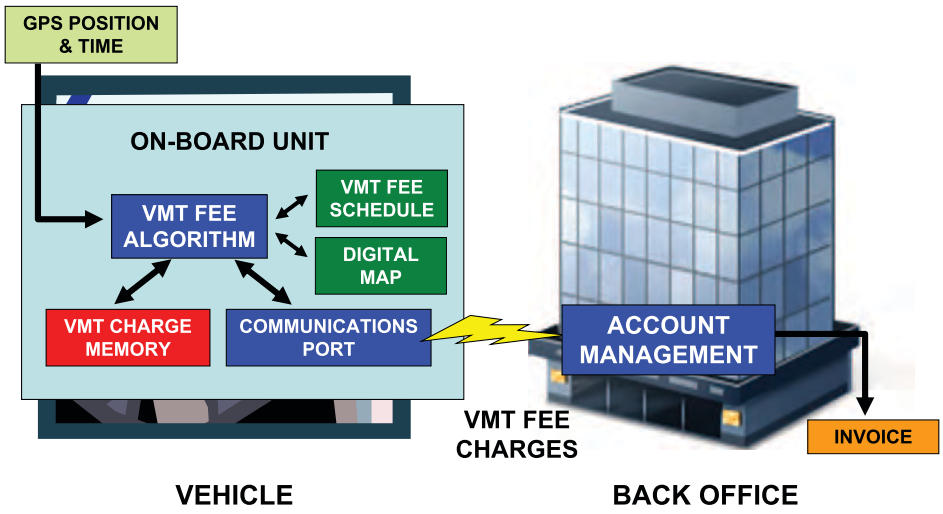


Figure 7. "Thick" client data flow.

could greatly facilitate implementation of a VMT fee system for trucks. The generic term "telematics" covers a wide range of commercial or in-firm systems installed in trucks to communicate with central dispatchers and information systems. A substantial portion of the commercial vehicle fleet (estimated by the study team at roughly 10%) is already equipped with EOBRs or GPS-based or cellular-based location and communications systems such as those offered by Qualcomm, Teletrac, or numerous other vendors. These telematics systems have been installed for the fleet operator's own reasons, including monitoring hours of service compliance and driver performance. As the costs of these systems decline in real terms, their advantages become more apparent. As the need for mandated compliance monitoring increases, these systems will become more common.

The VMT-compliant OBUs proposed for use in VMT fee collection, the EOBRs used by many truck operators, and the broader classification of "telematics" have a complex relationship. Appendix B addresses this issue in detail. The functions of these systems can overlap, with most EOBRs and telematics systems in use having the capability to record and report vehicle VMT. More elaborate commercial trucking systems with GPS or other AVL capabilities might also meet the requirements of time/location VMT fee collection. If VMT system implementation provides options for compliance, many truck operators would likely choose to use or upgrade their existing systems rather than incurring the cost of additional technology.

It is reasonable to expect that commercial or in-house EOBR and telematics systems developed in the future would support any implemented VMT fee collection system, given the rapid turnover of telematics technology and the multi-year implementation expectation for VMT systems. Although EOBRs and telematics systems can be costly in terms of acquisition, installation, service fees, and upkeep, the *incremental* cost of VMT compliance should be low for distance-based fees. Thick-client capabilities would be somewhat more costly than thin-client capabilities. Time/location VMT capabilities would add high incremental costs to EOBRs that simply recorded hours, miles, and vehicle conditions for download, but low incremental costs to GPS/AVL telematics applications.

Another option would be to require OEM VMT-compliant OBU installation for new trucks. However, the long life of heavy-duty diesel vehicles means that the truck population turns over very slowly, limiting the effectiveness of such a strategy. While it is common for aggressive carriers to turn over their fleet in 5 to 10 years, the vehicles retired by those carriers typically "cascade" into less demanding services where they often last another 10 to 15 years. As port drayage truck replacement and clean truck programs demonstrate, 10- to 20-year-old trucks still operate in large numbers, and 30-year-old trucks are not exceptional. Trucks can last even longer in seasonal or agricultural use.

The concept of thick-client monthly fee reporting in place of thin-client vehicle activity reporting raises the possibility of fleet-based reporting and payment for operators of multiple vehicles. Truck fleets equipped with Qualcomm, Teletrac, or similar electronic event recording systems already have the ability to generate detailed monthly reports of vehicle activity. These monthly reports could be the basis for monthly VMT fee submissions for the entire fleet, completely resolving any routine privacy issues and streamlining the collection process.

Appendix C provides additional detail on the use of on-board devices in trucking.

Mobile Device Alternatives

Recent pilot studies in Oregon have demonstrated the feasibility of using mobile "smartphone" applications to

automate the Oregon weight-distance tax. The Oregon Department of Transportation's (ODOT's) Truck Road Use Electronics (TRUE) test used five modified BlackBerry smartphones with a custom computer application to calculate mileage, combine the mileage with data on truck configuration and number of axles, calculate the tax, and create a tax bill for payment. The test was successful, and, although it was not a direct test of VMT applications, it suggests that there may be ways to implement VMT systems without vehicle OBUs. The use of smartphones in this application is also consistent with technology trends in the trucking industry, in which low-cost cellular-based communications are being used for new purposes.

Recent revelations that iPhones were retaining location data reinforce the conclusion that non-GPS smartphone systems are a possibility. The adverse public and government reaction to the iPhone revelation, however, illustrated public antipathy to the concept of location tracking.

Fuel Consumption Basis for Collection

A VMT fee based on fuel purchase and estimated miles per gallon would be a fuel tax that varied by vehicle type. Presumably, estimated miles per gallon would be designated for each vehicle based on size, weight, engine type, or some combination of factors. To vary fuel taxes by vehicle, however, requires either a means of automatically identifying the vehicle and adjusting the tax rate at the time and place of purchase, or retroactively adjusting the tax rate through refunds or credits. This mechanism, then, is essentially the same as the proposals for fuel tax surcharges or selective rate increases.

Vehicle fuel consumption can vary greatly depending on the individual vehicle, the route traveled, and the load carried. Two identical Class 8 diesel tractors could have very different average fuel consumption if one were used for urban gasoline deliveries (traveling short distances in congested conditions and hauling empty trailers half the time) and the other were used by an interstate truckload firm (traveling long distances at highway speeds with lighter trailers but loaded 90% of the time). Fuel consumption under such circumstances would not be an accurate proxy for VMT.

Self-Reporting

Self-reporting of odometer readings as a VMT implementation strategy has been considered; however, it has been dismissed in the literature as being cumbersome, costly, unreliable, and prone to evasion. Self-reporting, however, is already universal practice for all truck fleets that operate and purchase fuel across state boundaries and for other fleets and drivers subject to hours-of-service rules. Interstate operators are required to track and report vehicle miles traveled and fuel purchased by state so that state fuel tax revenue can be apportioned according to miles driven. For such carriers, self-reporting of fleet total VMT is already in place. Many other fleet operators record mileage for their own management purposes.

Figure 8 is an example of a standard truck driver's log used to record hours, miles, and other activity. For-hire and private fleet operators may collect this data to monitor driver hours of service, fuel use, vehicle utilization, maintenance needs, and other operating factors. Firms that do

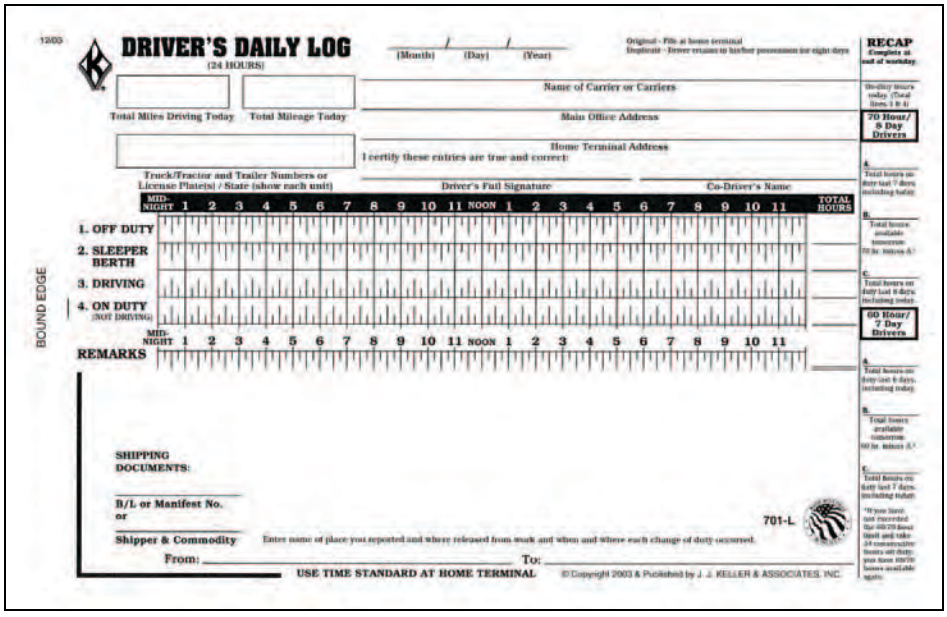


Figure 8. Sample driver's log form.

so already have VMT records that could be used as a basis for fee calculation and auditing, although precision may be lacking.

There is a legitimate concern over accuracy and completeness in self-reporting options. Drivers can and do falsify logs and may not have strong incentives to accurately report miles traveled There are no readily available, reliable data on the prevalence of this practice, partly because there is rarely an independent audit trail against which logs can be checked.

Self-reporting would probably have to remain as a fallback option during any implementation period for automated reporting. Operators who have not installed OBUs capable of tracking and reporting VMT or have not implemented other solutions could be afforded a manual tracking and self-reporting option, with appropriate auditing.

Periodic Inspection

Some proposals suggest obtaining odometer information as part of routine vehicle inspections. This option is considered to be very costly in terms of time and labor. States that do inspect vehicles typically do so annually, which would mean a long time between large payments. A number of states, notably California, do not inspect vehicles annually. California has a biennial emissions certification process in which mileage information could be taken, but there is no verification by any public body.

One collection option would be a prepayment system with annual adjustments made through periodic inspections. This option would be similar to estimated income taxes, where quarterly tax payments are based on the previous year's income and reconciled with annual filing.

Periodic inspection could also be used for compliance auditing and enforcement. By linking reported VMT to vehicle registration, it would be relatively easy to "flag" registrations for vehicles reporting suspiciously low VMT. Such vehicles could have their odometers checked before registration was renewed and any mileage discrepancies (and any penalties) addressed at that time. While odometer tampering is all too feasible at the time of a vehicle sale, it would be more difficult to consistently alter odometer readings at regular inspections.

Passing Readers

Passing inspection via overhead gantries or wayside readers is commonly used for DSRC/RFID toll card systems such as E-ZPass. Overhead gantries and wayside readers are only practical, however, when vehicle traffic must pass through a limited number of check points. Successful applications include road pricing systems in Singapore and Stockholm, island cities whose entrances and exits are limited. Such installations are unlikely to be suitable for rural and suburban areas or sprawling metropolises, such as Chicago or Los Angeles. License plate optical character recognition (OCR) readers have been used in Canada and London for tolling systems. All of these passing reader options may be suitable for triggering payments for congestion pricing, road pricing, or other TDM functions, but would not be feasible for collecting VMT data.

The problem of physical data collection is most challenging for freight and service vehicles that spend most of their operating life in one locale. A substantial portion of the total truck population has a routine operating range of 50 miles or less. Such vehicles might go for long periods without passing a data collection point, or these vehicles may be able to avoid them indefinitely. Examples might include propane delivery trucks in rural areas, farm trucks that are rarely driven into urban areas, local delivery vehicles used on a fixed route, and local tradesman's vehicles and construction equipment.

Gas Station Data Collection

One common proposal is to "read" electronic odometers at gas stations and to add the VMT fee to the amount charged for fuel. This system was used in the Oregon DOT Road User Charge Pilot. Conceptually, the system would function as follows:

- Vehicles would be equipped with OBUs.
- Gas stations (including unmanned "card-lock" fueling sites used by truck fleets) would be equipped with electronic OBU readers.
- At the station, the OBU would communicate the mileage and vehicle identity to the user fee system, and the fee system would determine how many miles had been driven since the last reading and add the fees to the fuel bill.

This option raises some implementation questions. Most discussions of a system based on gas station data collection appear to assume a credit card transaction in which the driver can simply add the VMT user fee to the fuel bill. In such a case, the driver could fill the tank at whatever cost and also pay the VMT fee (assuming a sufficient credit card limit). A cash customer could face a problem. For example, a customer with $2.75 due in VMT fees can only buy $17.25 worth of fuel with a $20 bill. Thus, the fuel pump may have to display the VMT fee due before the purchaser decides how much gas to buy. Such an eventuality would require modification of fuel pumps, a costly proposition. Although it may be uncommon for cash to be used to pay for enough fuel to fill the 250-gallon tank on a Class 8 tractor, cash transactions for smaller medium-duty trucks are probably more prevalent.

Table 12. Medium- and heavy-duty truck fueling locations.

Fueling Location	Trucks (thousands)	Trucks %	Miles (millions)	Miles %
Gas Station	2,441	49%	36,263	26%
Truck Stop	862	17%	52,809	38%
Own Facility	1,565	31%	43,791	32%
Other Non-public Facility	146	3%	4,448	3%
Total	**5,014**	**100%**	**137,311**	**100%**

Source: 2002 VIUS (U.S. Census Bureau, 2004, Table 3a).

Bulk Fuel

The proposed collection of VMT fees at gas stations or with fuel cards raises the question of vehicles that do not frequent gas stations. These vehicles include fleets whose fuel is purchased in bulk and dispensed at operating terminals. Table 12 shows the distribution of fueling locations for medium and heavy-duty trucks using 2002 VIUS data. About 34% of the total trucks use either their own facilities or other facilities not open to the general public to refuel, and they account for about 35% of the VMT.

For freight transportation, the category of non-exempt bulk fuel purchasers is the most serious issue. Bulk-fueled fleets likely include major parcel or less-than-truckload (LTL) companies such as UPS, FedEx, or Yellow Freight that maintain terminals as operating bases for their truck fleets; construction companies; and utilities.

The issue is most serious for the largest fleets. As Table 13 shows, the share of trucks using their own fuel facility or other fuel facilities not open to the public grows with fleet size. The widespread use of non-public fueling facilities would complicate any VMT reporting system tied to commercial fuel purchases.

The options for obtaining odometer readings for such fleets include using EOBRs or telematics, installing OBU readers at company terminals, requiring periodic visits to gas stations or other reader sites, and periodic self-reporting.

One mitigating factor is that very large freight and service fleets are probably the most likely to use OBUs or EOBRs for their own communications, dispatching, and management purposes. Fleets using such devices would not need to check odometer readings at fueling locations.

There are also commercially available fuel management systems that address the bulk fuel issue. A February 2010 *Municipal Fuel Management Advisory* by the Massachusetts Office of the Inspector General reviewed a wide range of issues related to control of fuel purchases and delivery by public agencies and recommended the use of carefully managed fuel cards and electronic management systems for bulk fuel (Massachusetts Office of the Inspector General, February 2010). Research into available systems for managing bulk fuel located three types applicable to VMT fees:

- Keypad entry systems, in which the driver enters vehicle identification and odometer readings (FuelMaster is one commercial system).
- Automated systems that use wireless communication between vehicle ID tags and dispenser systems to control

Table 13. Share of trucks by fleet size and primary fueling facility—2002.

Truck Fleet Size	Gas Station	Truck Stop	Own Facility	Other Facility	Total
No Fleet	96.4%	1.6%	1.7%	0.3%	100.0%
1 to 5	73.8%	6.1%	18.2%	1.9%	100.0%
6 to 10	55.3%	5.7%	35.5%	3.4%	99.9%
11 to 20	41.1%	5.1%	48.9%	4.9%	100.0%
21 to 50	48.3%	6.3%	44.4%	1.0%	100.0%
51 or More	48.3%	6.3%	44.4%	1.0%	100.0%
Overall	93.9%	1.8%	3.7%	0.5%	99.9%

Source: U.S. Bureau of the Census, "2002 Vehicle Inventory and Use Survey," Microdata file, January 2005. Data generated by Stacy Davis, Oak Ridge National Laboratory, March 2005.

access and record usage (Easy Fuel and Fleet Control are two commercial systems).
- Mobile fueling trailers with monitoring equipment.

These systems, like the fuel card systems, offer regular reporting of vehicle and fleet mileage that could be used to calculate VMT fees. These systems may be justified for fleet operators, such as public agencies, construction firms, utilities, and trucking companies. They are unlikely to be cost-effective for farmers or others with small fleets.

Fuel Cards

Fuel companies offer fleet credit card options that can be used to differentiate VMT fee vehicles from fuel tax vehicles, to track fuel taxes paid, and to track manually entered odometer readings with fuel purchases. One simple approach would be to issue VMT-compliant fleets with fuel cards that automatically add taxes to fuel purchases. This approach would implement "gas station" payment without any additional technology.

Gasoline credit cards already offer features that could greater facilitate fuel tax/VMT transition. Chevron and Texaco Business Card Services, for example, offer multiple options to fleet managers, including links between cards and specific vehicles, and a requirement for the driver to enter odometer readings before receiving fuel. Tax-exempt cards are available for government fleets. Cards can be linked either to drivers or to vehicles.

Fleet fuel cards—such as CSI, Wright Express, Fuel Express, or Fleet One—are intended for commercial or private truck fleet operators and are accepted at most fueling stations regardless of brand or ownership. These services offer extensive reporting options. Drivers can be required to enter vehicle ID, personal identification numbers (PINs), and odometer readings when buying fuel. The resulting reports detail mileage, fuel use, and miles per gallon by vehicle and for the fleet. These cards can thus be used to calculate and pay vehicle and fleet VMT fees automatically without any additional technology.

Fuel cards are, in theory, available to any vehicle owner. In combination with third-party reporting and payment, fuel cards or gasoline company cards could provide a non-technological implementation of VMT fees. For fleets using these fuel cards, implementing VMT fees would be a nearly costless accounting change. Fuel cards are credit cards, and their transaction cost is borne by the retailer as a percentage of sales.

Reliance on fuel card systems for VMT fee collection does, however, have some potential drawbacks. The difficulty is linking the credit card to the vehicle and ensuring that the vehicle being fueled is indeed paying VMT fees. Public agencies sometimes have problems with employees using government credit cards to fuel private vehicles. The potential for evasion could be significant if tax-exempt credit cards are used to fuel non-VMT vehicles in a mixed fleet or vehicles in an entirely different fleet.

Many truck drivers carry and use multiple fuel cards. If a driver used Card A, reported 750 miles since the last reading, and then switched to Card B, he could be charged duplicate VMT fees for the 750 miles on Card A. The issue becomes more complex if drivers use a mix of VMT-compliant fuel cards, conventional fuel or gasoline company cards, other credit cards (e.g., Visa or MasterCard), debit cards, company charge accounts, cash, and bulk fuel. Many fuel retailers already offer lower prices for cash payment, and an opportunity to evade VMT fees would increase the incentive to use cash for drivers or fleet operators. It would be extremely costly to attempt to audit cash fuel sales to determine whether VMT fees had been paid.

International Fuel Tax Agreement Reporting

Trucks that operate and purchase fuel in more than one state already reconcile taxes paid and fleet VMT by state under the IFTA system. IFTA is an agreement among all states (except Alaska and Hawaii) and all Canadian provinces (except Northwestern Territories, Nunavut, and Yukon) to simplify the reporting of fuel used and tax paid by motor carriers operating in more than one jurisdiction.

Persons or organizations that operate qualified motor vehicles are subject to IFTA licensing. A qualified motor vehicle is defined as a motor vehicle used, designed, or maintained for transportation of persons or property and having one of the three following characteristics:

- Having two axles and a GVW or registered GVW exceeding 26,000 pounds (i.e., GVW Class 7–8).
- Having three or more axles regardless of weight.
- Used in combination, when the weight of such combination exceeds 26,000 pounds gross vehicle or registered gross vehicle weight.

Vehicles enrolled under IFTA display IFTA decals issued by their home state. In 2009, state DOTs issued 2.5 million sets of IFTA decals for trucks, so approximately that many vehicles were covered by the IFTA system. That total is roughly 25% of the medium- and heavy-duty fleet. There were about 290,000 IFTA accounts, suggesting an average of a bit less than 10 vehicles per account (2009 IFTA Annual Report). Table 14 indicates that about 11% of the truck population routinely operates interstate. Together, the 25% with IFTA decals and the 11% routinely operating interstate suggests that many vehicles occasionally operate interstate and have IFTA decals for that purpose or that fleet operators may

Table 14. Intrastate versus interstate operations.

Primary Jurisdiction	Trucks (thousands)	Trucks %	Miles (millions)	Miles %
Intrastate	4,196	89%	84,974	68%
Interstate	496	11%	40,901	32%
Total	**4,692**	**100%**	**125,875**	**100%**

Source: 2002 VIUS (U.S. Census Bureau, 2004, Table 3a).

routinely enroll the whole fleet in IFTA even though some of the trucks usually remain within one state.

If a VMT system took only mileage into account, the IFTA system could be used largely as is, simply by calculating the VMT fee. If the VMT fee varied by vehicle type, the fleet operator would have to total the mileage traveled by each type or class of vehicle and then calculate a total amount due.

Note that an IFTA-like system would enable a fleet operator to make a single payment for all trucks in the fleet. This approach would obviate the need for a public agency to query individual OBUs for each truck. Because the IFTA return also shows gallons of fuel purchased, the IFTA-like return could be audited for compliance using standard ranges of fuel consumption. The company's internal records would then become the audit trail, if needed. In this regard, an IFTA-like return would function like a "thick" OBU client, except that it would be for an entire fleet rather than for an individual vehicle.

IFTA is a self-reporting system, whether the reported mileages are obtained from OBUs or manual logs. Since the primary purpose of IFTA is allocating fuel taxes already paid, the fleet owner does not have a major financial stake in accuracy. If an IFTA-like system were used to determine VMT fees owed, fleet operators would have an incentive to under-report mileage and auditing may be necessary. Distance/vehicle VMT fees would depend only on total mileage accuracy by vehicle type, but implementing time/location VMT fees may not be feasible through an IFTA-like system.

Third-Party Reporting

Third-party reporting could reduce the number of trucking industry fee payers and the accompanying government collection cost. There are multiple options for third-party VMT reporting and fee payment including the following:

- Commercial telematics or EOBR providers who calculate and pay the VMT fees on behalf of the fleet operator.
- Fuel card providers who offer third-party reporting and payment.
- IFTA, which is itself effectively a third-party tax revenue allocation system, and could become a VMT revenue allocation system.

Owned versus Leased Vehicles

Implementation of VMT systems will have to take the difference between owned and leased units into account. While it is operation of the vehicle that accumulates VMT, it may be necessary to assess and collect VMT fees through the registered owner. Freight and service fleet operators use a mix of owned, long-term leased, and short-term rental vehicles to meet their needs. Table 15 gives some examples of large fleets and the reported ownership and leasing mix. Many major leasing companies, notably GE Capital, offer comprehensive fleet management services that include payment of taxes.

Table 15. Ownership/leasing mix of large fleets.

Fleet	Total Vehicles	Owned	Leased/Rented
AT&T	77,480	94%	6%
UPS	72,633	100%	0%
Verizon	58,768	100%	0%
FedEx	36,701	100%	0%
Coca-Cola Ent.	22,455	100%	0%
PepsiCo, Inc.	19,297	92%	8%
ServiceMaster	15,198	32%	68%
Salvation Army	14,600	0%	100%
Qwest Communications	13,700	0%	100%
DHL Express	18,586	93%	7%
Xerox Corp.	10,000	0%	100%
Interstate Brands	8,238	75%	25%
Aramark Services	8,208	30%	70%

Source: *Automotive Fleet,* 2009.

Time/Location Collection Requirements

Time/location VMT fees that can vary by location, route, or time create the option for congestion pricing, tolling, road pricing, and other TDM measures that are ordinarily absent in distance/vehicle VMT proposals. The means by which time, location, or route might be determined include GPS, AVL, DSRC, and other technologies.

For a time/location VMT system to be operational, vehicles need to be fitted with equipment capable of tracking the number of vehicle miles traveled by location, such as a GPS receiver. The GPS receiver would be connected to a GIS database that records the number of miles traveled within delineated jurisdictions. Each jurisdiction could have a fee schedule based on functional road class, vehicle type, or other factors that is used to calculate the fees that the vehicle owner owes based on the miles traveled.

The popularity and features of satellite-based GPS and cellular-based AVL systems have led to their consideration as VMT fee implementation options. Because such systems could track and report mileage accurately by time and location without being integrated with mechanical or electronic vehicle systems, they are the leading candidates for VMT fee implementation. Such devices have been used in some of the pilot studies. Once it is assumed that a GPS/AVL-enabled OBU will be required for distance/vehicle VMT fees, the incremental cost of implementing more elaborate time/location VMT fees appears low.

The use of GPS systems for congestion pricing, road pricing, tolling, or other applications is limited by system resolution. So-called "consumer grade" or "coarse resolution" GPS may have a claimed accuracy of ±5 meters, but the available literature suggests that this accuracy is not always achieved, particularly in adverse conditions. Moreover, an accuracy of ± 5 meters is not sufficient to distinguish lanes on a highway, to distinguish operation on a frontage road from an adjacent freeway, or to distinguish operation on a public road from off-road operation on an adjacent construction site. Research on GPS-enabled vehicle systems under NCFRP Project 14, "Truck Drayage Systems," found that false readings could be generated by vehicles operating just outside geofenced perimeters. At best, it appears that consumer-grade or coarse-resolution GPS could support area-based congestion pricing under which fees are charged for entry to a well-defined central business district (e.g., Manhattan) during specified times.

So-called "military grade," or "high-resolution," GPS systems are capable of extremely fine resolution, but are much more expensive to acquire and operate. Many individual drivers of passenger vehicles find GPS systems attractive and justified for their own purposes, basically location and navigation. Those needs are met by a consumer-grade, coarse-resolution GPS. Requiring high-resolution GPS for tolling or road pricing would impose substantial incremental costs, even for those already using GPS.

Area-based congestion pricing would likely be simpler to implement than route-based road pricing and might use consumer-grade or coarse-resolution GPS rather than high-resolution GPS. Area-based VMT fees would entail a surcharge for entering a defined area, typically a congested urban center. The surcharge could be a flat fee, a mileage-based fee, a time-based fee, or some combination. The implementation of area-based congestion pricing would entail knowledge or recognition of vehicle location, thus raising serious privacy issues.

Evasion and Enforcement

The incentive for evading VMT fees could be significant. The annual Class 7–8 VMT fee estimates shown in Table 25 range from $1,759 to $1,848. By way of comparison, typical owner-operator earnings could range from $25,000 to $40,000 per year, so VMT fees could be 5% of an owner-operator's annual income. The most serious evasion problems would probably stem from fleet owners who systematically underreported mileage or otherwise manipulated the system. A fleet owner with 10 Class 8 vehicles would have roughly $18,000 annually at stake; a fleet of 100 Class 8 tractors could pay roughly $180,000 in annual federal VMT fees.

Methods of Evading VMT Fees

A VMT fee system may offer substantial opportunities and incentives for evasion, including the following:

- Disconnecting, tampering with, or resetting an OBU.
- Disconnecting or resetting a mechanical or electronic odometer.
- Underreporting in a manual system.
- Underreporting or manipulating a fuel card system.
- Avoiding fuel-linked reporting by purchasing fuel with cash.
- Operating an unregistered vehicle.

Tampering with OBUs

The notion of creating a tamperproof OBU system is illusory. The simplest tampering method would probably be to cut power to the OBU. GPS-based devices can be defeated by shielding the device from a GPS signal or removing the antenna. GPS signals can also be jammed to avoid revealing GPS location, using readily available and inexpensive devices. These devices are illegal to own or use in the United States, but can be easily obtained through online vendors.

While some proposals include "tamperproof" seals on OBUs, research on "tamperproof" seals for international

cargo security and other purposes has found that such seals can be readily defeated (Johnston, 2003). Moreover, the cost of physically inspecting OBUs for seal integrity would be prohibitive. There will be over 5 million vehicle operators with incentives to beat the system. A VMT system would therefore entail either a substantially higher rate of evasion or a very high cost of enforcement.

Tampering with Odometers

Evasion through tampering with electronic vehicle odometers is a distinct possibility for a VMT system. Odometer fraud is already considered a significant problem in used-car sales, where "rolling back" the odometer to show lower mileage can raise the sale value. Hardware and software for resetting mechanical or electronic odometers are openly sold. A digital "reprogrammer" capable of changing odometer settings in multiple vehicles sells for $200 to $400, and it is claimed that the procedure takes only a few minutes once the cable connection is made.

Instructions for resetting odometers of many kinds are available on the Internet. For example, see the following (as of May 23, 2011):

- http://www.youtube.com/watch?v=eCnK3v9PLPM&feature=related.
- http://www.youtube.com/watch?v=q4vr1LIOhuI&feature=related.
- http://www.youtube.com/watch?v=sRKCr4Nh-tQ&feature=related.

At present, odometer tampering appears to be aimed at one-time adjustment for selling used vehicles or avoiding mileage penalties in vehicle leases. Frequent tampering to foil monthly or random VMT fee readings would be more difficult, but not impossible. It is possible to imagine a fleet owner investing in a reprogrammer or having dishonest fueling station operators or employees offer to reset odometers for a small fee.

The extent and impact of tampering might be reduced in three ways:

- Audits to compare reported mileage and fuel purchased with typical fuel consumption averages.
- More frequent or random OBU readings.
- Substantial penalties.

Manipulating Fuel Cards

The gas station or fuel card options for collection may be subject to systematic evasion by drivers who falsify the odometer readings they enter or who switch cards between vehicles. For the evasion to persist, the driver (on his own or at the direction of his employer) would have to keep a second log book. Substantial underreporting would, however, appear as exceptionally poor fuel mileage (low miles per gallon) that could signal the need for verification or audit. To pass an audit, the driver or owner would have to alter the odometer reading on the truck itself.

Cash Fuel Purchases

If VMT payments are linked for reporting or auditing purposes to fuel purchases, there may be a particular problem with drivers who pay cash, as the transaction would not link the quantity of fuel to the vehicle or its odometer reading. A truck operator could escape reporting or avoid the appearance of buying too much fuel for the reported VMT by periodically supplementing fuel card purchases with cash transactions. Most of the 160,000+ fuel retailers in the United States are also convenience stores that sell a variety of merchandise. Fuel cards and some bulk fueling systems can be made to refuse to dispense fuel without an acceptable odometer reading, but commercial fueling stations will probably have to continue to accept cash. Moreover, a side payment of half the applicable VMT fees in cash in return for the lack of a transaction record would leave both buyer and seller better off until caught.

Unregistered Vehicles

An unregistered vehicle would still need fuel, but it would not pay VMT fees. Some vehicle owners already avoid registering their vehicles to avoid the registration fees or the costs of bringing their vehicles up to state standards for safety or emissions. There would be an increased incentive to avoid registering the vehicle or to file a false certificate of non-operation if by doing so the owner could save hundreds or thousands of dollars in VMT fees. There are already penalties for operating an unregistered vehicle, and there may have to be additional penalties for not paying VMT fees.

Enforcement Options

Three enforcement options are discussed below—linking VMT fees to registration, fuel card auditing, and direct VMT fee payment by vehicle drivers or owners.

Linking VMT Fees to Registration

To ensure that the owner of every applicable vehicle is paying VMT fees, each vehicle will need a separate, unique account that records payments and can be audited. Each vehicle already has such an account—the state vehicle registration

record. It should be a straightforward process to link the VIN to a record of VMT fee payments and flag anomalies for audit. It would also be possible for the tax-collecting authority to bill owners of non-paying vehicles a default minimum annual levy, plus a penalty for non-payment. Vehicles without a satisfactory payment record could be denied annual re-registration, or outstanding payments could be collected as part of re-registration (following the example of video rental stores). Vehicles that have paid suspiciously low VMT fees or no VMT fees at all could be flagged for odometer reading verification as part of the annual registration process, even in states (such as California) that do not have regular annual inspections. Owners who have underpaid their VMT fees could be required to pay the difference, plus a penalty, as part of the registration process. It would also be possible to send invoices for estimated VMT fees to owners of vehicles for which fees have not been paid or for which low fee payments suggest evasion. States already send out registration invoices, so the processes could be combined. The cost of adding VMT fee tracking to these registration databases, however, is unknown.

Fuel Card Auditing

Auditing and enforcement would be relatively simple for users of fuel cards. Fuel card providers can deliver reports with mileage entered, fuel purchases, and equivalent miles per gallon for each vehicle. The tax-collecting agency could request or obtain fuel usage data for any vehicle for which abnormally low fees were paid. Within limits, the accuracy of mileages entered at each fuel purchase would not matter much. A driver who underreported mileage on one occasion to reduce VMT fees would either eventually pay the fees when he reported a correct mileage later, or he would have to go on underreporting indefinitely. It would be possible to block fuel purchases for drivers entering implausibly low mileages or at least to require the driver to verify the mileage before proceeding. An alternative would be to issue warnings on suspicious mileage entries and require official verification if underpayments continue. Requiring odometer readings would also make it more difficult for drivers to switch fuel cards between vehicles. If the VMT fee rate for a Class 4 truck is lower than the rate for a Class 6 truck, there would be an incentive to use the fuel card for the Class 4 truck to fill the Class 6 truck. While it is possible that some truck owners may be able to "game" the system in this way, significant evasion of this kind would become progressively more apparent the longer it persisted.

Direct VMT Fee Payment by Vehicle Drivers or Owners

A significant part of current fuel tax evasion is attributable to fuel dealers who may collect fuel taxes from customers but underpay them to the federal government. Direct VMT fee payment by vehicle drivers or owners may reduce this problem, but at a much higher collection cost.

Federal Collection Requirements

Each collection option described above has a corresponding federal requirement for receiving and processing payments. For VMT fees, the number of transactions will vary with the number of vehicles reporting, the frequency of reporting, and the degree to which owners report on a consolidated fleet basis.

Table 16 provides illustrative estimates of potential transaction volumes for the various VMT fee alternatives. An average fleet size of five vehicles is used for these estimates (based on an industry rule of thumb, as there are no solid data available), as well as a working assumption that 50% of the truck population would use fleet-based reporting and payments. A higher average fleet size and greater prevalence of fleet-based reporting would reduce the transaction volume.

The estimates in Table 16 range from a minimum of 2.5 million transactions for annual reporting for the smallest popu-

Table 16. VMT transaction volume estimates.

		Reporting Basis		Annual Transactions for Collection Interval (millions)			
VMT Tax Options	2008 Vehicles	Avg. Vehicles per Fleet	% of Fleet Reporting	Bi-Weekly	Monthly	Quarterly	Annual
VMT Distance/ Vehicle Tax - OBU/Options							
Class 7&8 freight	4,147,443	5	**50%**	258.8	29.9	10.0	2.5
Class 7&8 all types	4,327,163	5	**50%**	270.0	31.2	10.4	2.6
Class 4-8 freight	**7,075,838**	**5**	**50%**	**441.5**	**50.9**	**17.0**	**4.2**
Class 4-8 all types	**9,006,738**	**5**	**50%**	**562.0**	**64.8**	**21.6**	**5.4**
VMT Distance/ Vehicle Tax - OBU Only							
Class 7&8 freight	4,147,443	5	**0%**	431.3	49.8	16.6	4.1
Class 7&8 all types	4,327,163	5	**0%**	450.0	51.9	17.3	4.3
Class 4-8 freight	**7,075,838**	**5**	**0%**	**735.9**	**84.9**	**28.3**	**7.1**
Class 4-8 all types	**9,006,738**	**5**	**0%**	**936.7**	**108.1**	**36.0**	**9.0**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004).

lation with a fleet-based report option to 936.7 million for biweekly reporting by individual OBU-equipped vehicles in the broadest coverage.

Relatively frequent reporting and payment may be desirable to maintain steady federal cash flow and to avoid single large annual payments that could threaten truck owner finances. With the very large number of transactions shown in Table 16, one logical approach might be to adopt staggered quarterly billing. This would provide a steady federal revenue stream with one-third of the transactions required for monthly billing.

Comparison of Distance/Vehicle VMT Collection Options

The alternatives discussed above range from a mixed system of existing options (self-reporting, commercial OBUs, IFTA, and fuel cards) to nationwide deployment of new technology (mandatory VMT-compatible OBUs). These alternatives can be usefully considered as progressions in time and scope.

The fastest, least costly, and least disruptive approach to implementing distance/vehicle VMT fees would be to establish a rate schedule and payment requirement and allow multiple methods for meeting the requirement. Truck fleet operators who participate in IFTA or who use fuel cards could use information from those systems to calculate and pay VMT fees. Users of commercial telematics systems would likely be able to do the same. Owner-operators and operators of small fleets could use manual odometer readings or driver logs to self-report. As the VMT fee became a routine part of trucking operations and management, owners of fleets too large for efficient self-reporting would likely migrate to one of the other payment options. Fleet-by-fleet calculation and payment of fees would be supplemented or replaced by third-party payment through IFTA, fuel card companies, telematics providers, or independent firms.

Under this scenario, eventual transition to telematics or OBU deployment would be motivated by industry needs and preferences rather than by mandate. It would be far more efficient for telematic or OBU applications to be consolidated at the fleet level so that, for example, AT&T would submit one fleet payment rather than 77,480 individual vehicle payments (see Table 15).

It is also possible to envision a VMT system with a target time horizon for electronic reporting and payment (5 years, for example). In that scenario, the federal government would certify one or more OBU/EOBR systems as VMT-compliant, and the trucking industry would be required to purchase, install, and employ one of those systems for VMT fee payment.

A mandatory OBU system could impose a significant financial burden on truck fleet operators that did not find telematics systems cost-effective for their own purposes. As explained in Appendix B, commercial telematics systems typically cost $500 or more per vehicle, creating a high threshold for small fleets for which communications and record-keeping benefits would be minimal. VMT compliance would likely add little to system cost, but the minimum price of a single-purpose VMT-compliant system could easily approach that $500 figure.

The marginal value of a nationwide OBU system for trucks appears small when there are multiple, less costly options for fleet-based reporting and payment. The substantial public-sector investment in OBU communications and processing would likewise appear less cost-effective than submission of electronic records and payments from a small number of third-party reporters and individual reports from small fleets or owner-operators.

These comparisons could change substantially if a national VMT system were implemented for all vehicles. With the required communications, processing, and auditing/enforcement system set up for the roughly 240 million private passenger vehicles, the incremental cost of accommodating 10 million medium-duty and heavy-duty trucks would be far less than in a truck-only system. The unit cost of dedicated, VMT-compliant OBUs would also likely decline.

Costs and Revenues

VMT Fee Structure

As of early 2001, there had been no concrete, detailed proposals developed for either distance/vehicle or time/location VMT fees. The studies reviewed for this project have included conceptual amounts, such as $0.01 per mile, to illustrate the revenue potential or as a basis for surveying public opinion. Pilot projects have been intentionally "revenue neutral" so that participants pay the same amount in VMT fees that they would have paid in fuel taxes.

"Flat" Distance-Only VMT Fee

The literature reviewed to date contains little analysis of the VMT rates or rate structure that would be required to meet various funding targets. Table 17 provides a starting point by estimating the "flat" distance-based VMT fee that would be required to generate $5 billion in gross fee revenue from the roughly 227 billion truck VMT in 2008. The corresponding VMT fee would be about $0.022 per mile. Table 17 applies that flat, revenue-neutral VMT fee to a range of vehicle types and compares the outcome with estimated current federal fuel tax payments.

As Table 17 indicates, medium-duty trucks traveling 12,000 miles annually would pay about $264 in VMT fees in addition to $344–371 in estimated fuel taxes, and a Class 8

Table 17. "Flat" VMT fee example.

GVW Class and Fuel Type	GVW Limit	Est. Annual VMT*	Est. MPG**	Est. Annual Gallons	Fuel Tax $/Gal	Fed Fuel Taxes	"Flat" $/VMT Rate	Annual "Flat" VMT Fee
Diesel								
4	16,000	12,000	8.5	1,412	0.244	**$ 344**	0.022	**$ 264**
5	19,500	12,000	7.9	1,519	0.244	**$ 371**	0.022	**$ 264**
6	26,000	15,000	7.0	2,143	0.244	**$ 523**	0.022	**$ 330**
7	33,000	40,000	6.4	6,250	0.244	**$ 1,525**	0.022	**$ 879**
8	33,000	80,000	5.7	14,035	0.244	**$ 3,425**	0.022	**$ 1,759**

* Rough estimate - needs better data.
** 2002 Data.

diesel tractor running 80,000 miles annually in long-haul service would pay about $1,759 in VMT fees in addition to $3,425 in estimated fuel taxes.

Vehicle Weight Adjustments

To account for vehicle weight, a VMT system would have to vary by weight class or operating weight. The literature on VMT fees has thus far been concerned almost exclusively with passenger cars and light trucks used for personal transportation. The gross operating weight of passenger cars and light trucks used in personal transportation ordinarily varies from about 3,000 to 7,000 lb. In that relatively narrow weight range, it may be a reasonable policy to charge all such vehicles the same VMT rate under the implicit assumption that they all have nearly the same infrastructure impact per mile traveled. That assumption breaks down, however, when applied to medium- and heavy-duty trucks, whose gross operating weight can range from 10,000 lb (the minimum for Class 3) to 105,000 lb (the maximum for Class 8 in some states). While the impact of weight is controversial, there is no doubt that a loaded 105,000-lb tractor and semi-trailer has a greater impact than a 10,000-lb delivery van.

To reflect user impacts, a VMT system would have to subdivide the national truck fleet into groups with roughly similar highway impacts and assign an appropriate fee scale. There are a number of vehicle classification systems in use. The most common is the GVW system shown in Table 18.

Table 19 takes a simplified approach to an illustrative weight-indexed VMT structure. For Classes 4–6 and for Classes 7–8, a "vehicle weight index" is based on the ratio of the weight range midpoint. The "indexed $/VMT rate" is then set to distribute a $5 billion gross revenue goal between the two vehicle groups according to estimated VMT in each group. The approach in Table 19 effectively assumes that infrastructure impact is a linear function of vehicle weight, a fairly conservative approach. Compared to the annual "flat" fee estimates in Table 17, this fee structure would, of course, shift some of the burden from medium-duty trucks to heavy-duty trucks.

State Weight-Distance Tax Systems

Four states—Oregon, New York, New Mexico, and Kentucky—have "weight-distance" or "ton-mile" taxes. A number of other states have had ton-mile taxes or some variation in the past, but have discontinued them due to collection expense, compliance costs imposed on carriers, legal challenges, and concerns over the impact on state economic development and competitiveness. For the states that have weight-distance taxes, implementing them has required coping with the same weight-related issues that a national distance/vehicle VMT fee faces.

Table 18. Truck classifications.

Weight Class	Minimum GVW (lb)	Maximum GVW (lb)	VIUS Category	Common Category
Class 1		6,000	Light-Duty	Light-Duty
Class 2	6,001	10,000	Light-Duty	Light-Duty
Class 3	10,001	14,000	Medium-Duty	Light-Duty
Class 4	14,001	16,000	Medium-Duty	Medium-Duty
Class 5	16,001	19,500	Medium-Duty	Medium-Duty
Class 6	19,501	26,000	Light-Heavy	Medium-Duty
Class 7	26,001	33,000	Heavy-Duty	Heavy-Duty
Class 8	33,001	80,000	Heavy-Duty	Heavy-Duty

Table 19. Example of weight-indexed VMT cost structure.

GVW Class and Fuel Type	GVW Minimum	GVW Maximum	GVW Midpoint	Vehicle Weight Index	Est. Annual VMT	Fed Fuel Taxes	Wt. Indexed $/VMT Rate	Annual Wt. Indexed VMT Fee
Diesel								
4	**14,000**	16,000				**$ 344**		
5	16,000	19,500	20,000	**1.0**	12,362	**$ 371**	**0.011**	**$ 133**
6	19,500	**26,000**				**$ 523**		
7	**26,000**	33,000	53,000	**2.7**	64,764	**$ 1,525**	**0.029**	**$ 1,848**
8	33,000	**80,000**				**$ 3,425**		

Oregon's "weight-mile" tax replaces the state fuel tax for vehicles over 26,000 lb (nominally GVW Classes 7 and 8). Oregon defines a "declared weight" as follows (Oregon Department of Transportation, October 2008):

> Weight-mile tax is paid on a declared weight basis. The TAX DECLARED WEIGHT is the weight of the vehicle and the load that represents the heaviest weight the vehicle will actually carry in a given configuration for the reporting period.

Table 20 shows the applicable tax rates for vehicles with declared weights of 26,001 to 80,000 lb. The rate schedule is not linear—rates rise with weight at an additional .0024 cents for each additional 2,000 lb at the lowest level and rise faster at higher weights. Note that the Oregon tax system does *not* attempt to ascertain the actual operating weight of the vehicle and its load.

New York's tax (see Table 21) is imposed in addition to state fuel taxes and at lower rates than Oregon's tax. The New York rates are also more complex, with different rates for laden and unladen operations. The distinction is critical because New York is faced with the task of attempting to tax many trucks that are only in the state for a short distance due to its geographic position among the northeast states.

New Mexico's taxes are much lower and have not been increased in over 20 years. The numbers in Table 22 are in mills, each mill being 1/10 of a cent or 1/1000 of a dollar.

Kentucky's rate is the simplest: $.0285 per mile for trucks over 59,999 lb.

Table 23 uses the inherent relationship in the Oregon weight-mile and fuel tax structure to develop a third possible VMT fee scenario. The fuel-tax-equivalent VMT fee for Classes 1–6 and the Oregon weight-mile tax for Classes 7–8 (based on the same midpoint weights as in Table 19) yield a set of annual VMT fee estimates. Those estimates closely resemble existing federal rate equivalents for Classes 1–6 (which is to be expected since the Oregon state fuel tax rates are similar to the federal rates). For larger trucks, the "Oregon" rates would be 39% higher for Class 7 and 110% higher for Class 8.

Table 20. Oregon weight-mile tax rates.

WEIGHT GROUP	MILLS PER MILE (1/10 OF 1 CENT)	DOLLARS PER MILE DECIMAL FRACTION	WEIGHT GROUP	MILLS PER MILE (1/10 OF 1 CENT)	DOLLARS PER MILE DECIMAL FRACTION
26,001 - 28,000	49.8	0.0499	52,001 - 54,000	83.3	0.0833
28,001 - 30,000	52.8	0.0528	54,001 - 56,000	86.4	0.0864
30,001 - 32,000	56.2	0.0562	56,001 - 58,000	90.0	0.0900
32,001 - 34,000	57.6	0.0576	58,001 - 60,000	94.1	0.0941
			60,001 - 62,000	99.0	0.0990
34,001 - 36,000	59.9	0.0599			
36,001 - 38,000	63.0	0.0630	62,001 - 64,000	104.5	0.1045
38,001 - 40,000	65.4	0.0654	64,001 - 66,000	110.4	0.1104
40,001 - 42,000	67.7	0.0677	66,001 - 68,000	118.3	0.1183
			68,001 - 70,000	126.6	0.1266
42,001 - 44,000	70.2	0.0702	70,001 - 72,000	135.0	0.1350
44,001 - 46,000	72.6	0.0726			
46,001 - 48,000	74.9	0.0749	72,001 - 74,000	142.7	0.1427
48,001 - 50,000	77.4	0.0774	74,001 - 76,000	150.0	0.1500
50,001 - 52,000	80.3	0.0803	76,001 - 78,000	157.2	0.1572
			78,001 - 80,000	163.8	0.1638

Table 21. New York state highway use tax table.

Tax rate tables for highway use tax
Schedule 1
Gross weight method

Table 1

Laden non-Thruway miles
Tractors and trucks

Weight	Rate
18,001 to 20,000	$0.0084
20,001 to 22,000	0.0098
22,001 to 24,000	0.0112
24,001 to 26,000	0.0126
26,001 to 28,000	0.0133
28,001 to 30,000	0.0140
30,001 to 32,000	0.0147
32,001 to 34,000	0.0154
34,001 to 36,000	0.0161
36,001 to 38,000	0.0168
38,001 to 40,000	0.0175
40,001 to 42,000	0.0182
42,001 to 44,000	0.0196
44,001 to 46,000	0.0210
46,001 to 48,000	0.0224
48,001 to 50,000	0.0238
50,001 to 52,000	0.0252
52,001 to 54,000	0.0266
54,001 to 56,000	0.0280
56,001 to 58,000	0.0294
58,001 to 60,000	0.0308
60,001 to 62,000	0.0322
62,001 to 64,000	0.0336
64,001 to 66,000	0.0357
66,001 to 68,000	0.0378
68,001 to 70,000	0.0399
70,001 to 72,000	0.0420
72,001 to 74,000	0.0455
74,001 to 76,000	0.0490
76,001 to 78,000	0.0518
78,001 to 80,000	0.0546
80,001 and over add $0.0028 per ton and fraction thereof	

Table 2

Unladen non-Thruway miles
Tractors (with trailers)

Weight	Rate
7,001 to 8,500	$0.0084
8,501 to 10,000	0.0098
10,001 to 12,000	0.0112
12,001 to 14,000	0.0126
14,001 to 16,000	0.0133
16,001 to 18,000	0.0140
18,001 and over add $0.0007 per ton and fraction thereof	

Table 3

Unladen non-Thruway miles
Trucks (alone or with trailers)
Tractors (without trailers)

Weight	Rate
18,001 to 20,000	$0.0084
20,001 to 22,000	0.0098
22,001 to 24,000	0.0112
24,001 to 26,000	0.0126
26,001 to 28,000	0.0133
28,001 to 30,000	0.0140
30,001 and over add $0.0007 per ton and fraction thereof	

Source: New York State Department of Taxation and Finance, November 2009.

Table 22. New Mexico state weight-distance tax tables.

Weight Distance Mill Rates (Effective July 01,2004)

Weight Class	Gross Vehicle Weight	Haul Rate		Weight Class	Gross Vehicle Weight	Haul Rate	
		Full	One-way			Full	One-way
1	26,001 - 28,000	0.01101	0.00734	15	54,001 - 56,000	0.02729	0.01819
2	28,001 - 30,000	0.01188	0.00792	16	56,001 - 58,000	0.02862	0.01908
3	30,001 - 32,000	0.01277	0.00851	17	58,001 - 60,000	0.02993	0.01995
4	32,001 - 34,000	0.01364	0.00909	18	60,001 - 62,000	0.03124	0.02083
5	34,001 - 36,000	0.01452	0.00968	19	62,001 - 64,000	0.03258	0.02172
6	36,001 - 38,000	0.01539	0.01026	20	64,001 - 66,000	0.03390	0.02260
7	38,001 - 40,000	0.01673	0.01115	21	66,001 - 68,000	0.03521	0.02347
8	40,001 - 42,000	0.01805	0.01203	22	68,001 - 70,000	0.03652	0.02435
9	42,001 - 44,000	0.01936	0.01291	23	70,001 - 72,000	0.03786	0.02524
10	44,001 - 46,000	0.02069	0.01379	24	72,001 - 74,000	0.03926	0.02617
11	46,001 - 48,000	0.02201	0.01453	25	74,001 - 76,000	0.04071	0.02714
12	48,001 - 50,000	0.02333	0.01555	26	76,001 - 78,000	0.04221	0.02814
13	50,001 - 52,000	0.02465	0.01643	27	78,001 - 80,000	0.04378	0.02919
14	52,001 - 54,000	0.02596	0.01731				

Table 23. Graduated VMT fees based on Oregon rates.

GVW Class and Fuel Type	GVW Minimum	GVW Maximum	GVW Midpoint	Est. Annual VMT	Fed Fuel Taxes	"Oregon" W-D Tax Rate	"Oregon" Ratio	Equivalent VMT Fee	Annual "Oregon" VMT Fee
Diesel									
4	**14,000**	16,000			**$ 344**				
5	16,000	19,500	20,000	12,362	**$ 371**	**0.041**	**1.000**	**0.013**	**$ 159**
6	19,500	**26,000**			**$ 523**				
7	**26,000**	33,000	53,000	64,764	**$ 1,525**	**0.087**	**2.131**	**0.027**	**$ 1,770**
8	33,000	**80,000**			**$ 3,425**				

Source: Tioga Group analysis.

Passenger-Car Equivalents

Ideally, VMT fees for trucks or other vehicles would be based on passenger car equivalents (PCEs). PCEs measure the impact of other vehicles on infrastructure and congestion compared to passenger cars. Nominal PCEs for trucks are around 2.0 because, while a truck may be much longer than an automobile, a truck does not require a multiple of the intervehicle spacing. As trucks get larger and heavier, the PCE increases with the stopping distance, because more space must be allowed between vehicles.

The use of PCEs to scale VMT fees would require a standardized PCE methodology. Although there are suggested practices for estimating PCEs, they typically vary with terrain and traffic levels. In heavy traffic or on steep grades, the effective PCE of a tractor-trailer may be 4.0 or higher. Table 24 provides examples of truck PCEs from FHWA's *HPMS Field Manual* (Office of Highway Policy Information, May 2005).

The literature review located no discussions of the use of PCEs for truck VMT fees. It would appear that substantial technical work would be required to construct a standardized PCE methodology for that application.

Table 24. Examples of PCE factors for trucks.

Two-Way Flow Rates (passenger cars/hr)	Type of Terrain		
	Level	Rolling	Mountainous
0-600	1.7	2.5	7.2
>600-1,200	1.2	1.9	7.2
>1,200	1.1	1.5	7.2

Source: Office of Highway Policy Information, May 2005.

Comparison of Potential Fee Structures

The various distance/vehicle fee structures postulated above would have somewhat different impacts on trucks. Table 25 displays the possible VMT fee rates by vehicle class and the resulting annual fee totals for the annual mileages used in previous tables. Note that Table 25 does not attempt to take other federal or state fees or taxes into account.

The major difference is between the "flat" fee option and the two weight-adjusted fee options; the two different methods of adjusting for weight yield similar results. The cost impact to vehicle operators would depend on their annual mileage (as expected for a VMT fee).

The largest cost impacts would affect Class 8 trucks and tractors. Con-way Inc. reportedly operates around 12,000 Class 8 tractors. If each one averages about 50,000 annual miles, as assumed in the analysis, the most aggressive weight-indexed VMT fee schedule would cost the company around $22 million annually (*Transport Topics Top 100 For-Hire Carriers—2011,* 2011, p. 4). At the other extreme, a local owner-operator who used a Class 8 tractor for a local sand and gravel business might only travel 20,000 miles annually. Under the less aggressive "Oregon" scenario, that owner-operator would see an annual increase of $540, or about $45 per month. While that amount seems less impressive than the J. B. Hunt example, it would be an unwelcome burden to a local owner-operator.

Table 25. Potential distance/vehicle fee structures.

GVW Class and Fuel Type	Fuel Tax Equivalent $/VMT	Annual Fuel Tax	"Flat" $/VMT Rate	"Flat" Annual VMT Fee	Wt. Indexed $/VMT Rate	Annual Wt. Indexed VMT Fee	"Oregon" Eqv. VMT Fee	Annual "Oregon" VMT Fee
Diesel								
Class 4	0.029	$ 344	**0.022**	$ 264				
Class 5	0.031	$ 371	**0.022**	$ 264	**0.011**	$ 133	**0.013**	$ 159
Class 6	0.035	$ 523	**0.022**	$ 330				
Class 7	0.038	$ 1,525	**0.022**	$ 879	**0.029**	$ 1,848	**0.027**	$ 1,770
Class 8	0.043	$ 3,425	**0.022**	$ 1,759				

Source: Tioga Group analysis.

Time/Location Congestion Fee Structure

The research team did not investigate or analyze possible time/location fee amounts above those involved in distance/vehicle fees. The additional fees for TDM measures would almost certainly be set by local, regional, or state toll authorities. None of the studies or discussions to date envision a national TDM program.

Revenue Potential

Revenue potential varies with VMT fee rates and the number of vehicles affected. Table 26 shows the relationship for an annual gross revenue target of $5 billion.

The fee rates would be the same for $5 billion gross revenue whether collected via mandatory OBUs or through some combination of reporting and payment options. The required average VMT fee would decline from $0.048 per mile, if applied to just Classes 7 and 8 freight trucks, to a low of $0.022 per mile for all Class 4–8 vehicles. The actual rate should vary by GVW class or some other means to reflect size and weight differences.

Federal Collection and Enforcement Costs

Many studies and reports express collection costs as a percentage of revenue received. While this expression of revenue received is revealing, it is of limited value since collection costs will remain roughly the same if tax or fee rates change.

VMT fee collection costs would be a function of the number of vehicles, collection points, and transactions, and collection costs would not be expected to vary significantly with the actual fee rate. The exception would be if credit cards are accepted as payment by the collection agency itself, whether on a transaction-by-transaction basis or as the basis for a prepaid account (similar to toll card accounts). At present, credit card purchases of fuel result in credit card fees payable by the retailer. The collection agency (IRS) actually collects the taxes from the wholesalers, who do not pay credit card fees. If a federal collection agency accepts credit cards or deducts from prepaid accounts linked to credit cards, the federal collection agency will incur the credit card fees. Credit card fees typically range from 2 to 4%, although a federal agency might be able to negotiate a favorable rate.

Most VMT fee proposals are "pay-as-you go," meaning that fees are collected at frequent intervals rather than monthly or annually. This feature, however, would entail a very large number of transactions. Weekly transactions for 10 million medium- and heavy-duty trucks would yield over 500 million annual transactions. At $0.10 per transaction, that annual cost would be $52 million. This is a small number compared to the totals handled by credit card or telephone systems, but it is a huge increase over the present fuel tax system, which involves roughly 24,000 annual transactions.

Annual collection costs for a distance/vehicle VMT fee are variously estimated to range from about $10 to $100 per vehicle. These figures are mostly informal "guesstimates" that are not backed by empirical data or formal estimate techniques. The most appropriate estimate obtained by the research team is a figure of $35 per vehicle for the administrative and collection costs of a state E-ZPass system. That estimate is used in later cost comparisons of revenue options. Higher estimates were obtained from the proposed Dutch VMT fee system. Bidders on that system estimated about $75 per vehicle for annual costs without depreciation and $100 per vehicle with depreciation. The highest estimate was derived from data and announcements of the German Autobahn truck fee collection system, which had average annual collection and overhead costs of $804 per vehicle.

The cost of enforcement will depend on the incentives and opportunity for evasion; the cost of auditing to detect evasion; and the costs of investigation, prosecution, fine assessment, or other measures. These factors will vary depending on how VMT fees are implemented. In the Oregon pilot project and proposed implementation, for example, vehicles that did not

Table 26. VMT fee rates for $5 billion gross revenue.

VMT Fee Options	2008 Vehicles	2008 Vehicle MilesTraveled	$/VMT Required for $5 Billion Gross Revenue
VMT Distance/ Vehicle Fee - OBU/Options			
Class 7&8 freight	4,147,443	104,740,386,072	$ 0.048
Class 7&8 all types	4,327,163	109,279,065,702	$ 0.046
Class 4-8 freight	**7,075,838**	**178,694,663,105**	**$ 0.028**
Class 4-8 all types	**9,006,738**	**227,458,000,401**	**$ 0.022**
VMT Distance/ Vehicle Fee - OBU Only			
Class 7&8 freight	4,147,443	104,740,386,072	$ 0.048
Class 7&8 all types	4,327,163	109,279,065,702	$ 0.046
Class 4-8 freight	**7,075,838**	**178,694,663,105**	**$ 0.028**
Class 4-8 all types	**9,006,738**	**227,458,000,401**	**$ 0.022**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).

or could not pay VMT fees would be charged fuel taxes as a default, so the incentive for evading VMT fees would be small.

The research team was unable to locate any estimates of enforcement costs for VMT fees, in part because enforcement costs are usually included in administrative cost estimates. Information on the enforcement costs for IFTA reporting or for state weight-distance taxes is not readily available and therefore provides little guidance.

Enforcement costs are therefore an unknown and a candidate for further research. The range of possible evasion methods and the evasion incentives for truck fleet operators, however, suggest that substantial resources may have to be devoted to enforcement activities.

The average collection cost per vehicle shown in Table 27 is based on collection and enforcement cost estimates of $35 per vehicle, plus an amount to reflect the use of credit cards and the fees charged by credit card companies. The estimate assumes that half the payments are made by credit card and that the average credit card fee is 2%. The result is to add $50 million to each collection cost estimate for VMT fees. The average fee per vehicle thus includes the $35 base amount plus a portion of the credit card fee that declines with the number of affected vehicles.

Implementation and Compliance

The federal implementation cost estimates for VMT fees draw on the Oregon pilot project estimates. In this case, the options differ in the level of industry implementation cost but are identical in federal data infrastructure requirements. According to the Convenience Store Association, there are over 160,000 retail fuel sellers in the United States. To collect VMT fees at these locations, they would all have to be equipped with wireless OBU readers and appropriate communications equipment. The communications equipment could probably be shared with lines used for credit card transactions. The cost of equipping fuel dealers with OBU readers, however, would be substantial. The Oregon pilot project estimated a capital cost of roughly $17,556 per station in 2007 dollars or about $18,300 in 2010 dollars. For the 160,000+ locations in the United States, the capital cost would be roughly $3 billion.

Table 28 provides estimates of federal government and freight industry implementation costs. Federal and industry implementation costs are converted to annual equivalents.

The industry costs are estimated at $500 per vehicle, which covers OBU/EOBR equipment cost and installation. The OBU/industry options version assumes that half the affected trucks use OBUs/EOBRs at $500 each, yielding an average of $250 per vehicle. The mandatory OBU option assumes that the entire affected fleet would be equipped.

Of the roughly 9 million Class 4–8 trucks in the United States, about 6.7 million were in fleets of four vehicles or more in 2005. (Bureau of Transportation Statistics, 2010, Table 1-14) Based on a rough average fleet size of 100 vehicles for fleets of 25 or more and 10 vehicles for fleets of 4 to 24, there were roughly 300,000 fleets that could report on a consolidated basis. At an estimated annual cost of $300 each, their annual compliance cost would be $90 million. The remaining 3.3 million trucks are either operated singly or in fleets of less than four vehicles. If reporting individually at $300 each ($25 per month), their annual compliance cost would be $990 million. The annual total for the 10 million trucks would be $1.08 billion, or an average of $108 per truck. VMT fee compliance costs are therefore estimated in Table 29 at $108 per vehicle per year for the estimated 2008 truck fleet.

This is a very rough estimate, and should be supplanted by future research. Note, however, that economies of scale for reporting and compliance are dramatic and would favor larger fleets.

Net Revenue and Revenue Efficiency

Table 30 provides estimates of total net annual federal revenue from VMT fees ($5 billion less collection and annualized implementation costs) and total annual industry cost

Table 27. VMT fee collection and enforcement costs.

VMT Fee Options	Annual Federal Collection and Enforcement Cost	Average Collection Cost per Vehicle
VMT Distance/ Vehicle Fee - OBU/Options		
Class 7&8 freight	$ 195,160,519	$ 47.06
Class 7&8 all types	$ 201,450,710	$ 46.55
Class 4-8 freight	**$ 297,654,328**	**$ 42.07**
Class 4-8 all types	**$ 365,235,818**	**$ 40.55**
VMT Distance/ Vehicle Fee - OBU Only		
Class 7&8 freight	$ 195,160,519	$ 47.06
Class 7&8 all types	$ 201,450,710	$ 46.55
Class 4-8 freight	**$ 297,654,328**	**$ 42.07**
Class 4-8 all types	**$ 365,235,818**	**$ 40.55**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).

Table 28. VMT fee implementation cost estimates.

VMT Fee Options	Federal Implementation Cost	Average Federal Implementation Cost per Vehicle	Annual Equivalent Assuming 10-Year Life	Freight Industry Implementation Cost	Average Freight Industry Implementation Cost per Vehicle	Annual Equivalent Assuming 5-Year Life
VMT Distance/ Vehicle Fee - OBU/Options						
Class 7&8 freight	$ 3,000,000,000	$ 723	$ 300,000,000	$ 1,036,860,847	$ 250.00	$ 207,372,169
Class 7&8 all types	$ 3,000,000,000	$ 693	$ 300,000,000	$ 1,081,790,786	$ 250.00	$ 216,358,157
Class 4-8 freight	**$ 3,000,000,000**	**$ 424**	**$ 300,000,000**	**$ 1,768,959,488**	**$ 250.00**	**$ 353,791,898**
Class 4-8 all types	**$ 3,000,000,000**	**$ 333**	**$ 300,000,000**	**$ 2,251,684,414**	**$ 250.00**	**$ 450,336,883**
VMT Distance/ Vehicle Fee - OBU Only						
Class 7&8 freight	$ 3,000,000,000	$ 723	$ 300,000,000	$ 2,073,721,693	$ 500.00	$ 414,744,339
Class 7&8 all types	$ 3,000,000,000	$ 693	$ 300,000,000	$ 2,163,581,572	$ 500.00	$ 432,716,314
Class 4-8 freight	**$ 3,000,000,000**	**$ 424**	**$ 300,000,000**	**$ 3,537,918,975**	**$ 500.00**	**$ 707,583,795**
Class 4-8 all types	**$ 3,000,000,000**	**$ 333**	**$ 300,000,000**	**$ 4,503,368,829**	**$ 500.00**	**$ 900,673,766**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).

Table 29. VMT fee compliance cost estimates.

VMT Fee Options	Annual Private-Sector Compliance Cost
VMT Distance/ Vehicle Fee - OBU/Options	
Class 7&8 freight	$ 447,923,886
Class 7&8 all types	$ 467,333,620
Class 4-8 freight	**$ 764,190,499**
Class 4-8 all types	**$ 972,727,667**
VMT Distance/ Vehicle Fee - OBU Only	
Class 7&8 freight	$ 447,923,886
Class 7&8 all types	$ 467,333,620
Class 4-8 freight	**$ 764,190,499**
Class 4-8 all types	**$ 972,727,667**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).

($5 billion plus annualized implementation and compliance costs) and shows these costs broken down to net annual revenue per vehicle and annual cost per vehicle. Table 30 also shows the ratio of net federal revenue to annual industry cost.

As with the fuel tax surcharge options, the more technology-dependent options have lower efficiency ratios due to their higher implementation and compliance costs.

Privacy Concerns

The proposed approaches to assessing VMT fees typically involve using OBUs to record, store, and transmit road use data. These proposals have raised privacy concerns regarding the government's ability to track the movements of individuals. Whether these concerns are legitimate as a practical matter depends on the nature and specificity of the data recorded. There are numerous potential VMT fee system designs, ranging from systems that collect no information about the movements of individuals to systems that collect detailed GPS data about every movement a vehicle makes.

As a legal matter, it appears likely that virtually any system design would comply with existing constitutional and statutory privacy protections. The Fourth Amendment to the U.S. Constitution protects individuals' "reasonable expectations of privacy." However, the U.S. Supreme Court has found electronic monitoring of vehicle movements to be consistent with the Fourth Amendment because, according to the Court, an individual cannot have a reasonable expectation of privacy in his or her movements in public. These precedents suggest that collecting information regarding vehicle movements via a VMT fee system would not violate the Fourth Amendment. One potential exception is a system that provides the government with detailed GPS route data. Federal courts have upheld the use of limited GPS vehicle tracking based on the Supreme Court precedents permitting electronic vehicle monitoring. However, some courts have indicated that they might view continuous or widespread detailed GPS tracking as constitutionally distinguishable from the type of limited and relatively imprecise tracking approved by the Supreme Court.

The recent (2011) uproar regarding revelations that Apple iPhones were tracking and retaining user location data reveals the depth of feeling over such privacy issues. Apple was promptly sued, and several governments began immediate inquiries. Apple was effectively forced to modify the iPhone operating system to eliminate retention of location data.

To avoid potential constitutional challenges, a road user fee system should therefore be designed so that it does not provide detailed route information to the government or third-party collector of the data. The "thick-client" system meets this criterion. The above conclusions do not change if the government uses a private third party to collect the data, since a third party collecting the data on behalf of the government will be subject to the same constitutional standards. However, if a third-party collector were involved, it would be critical for the authorizing statute to make the third party subject to strict data security and protection obligations of the same sort that would apply were the government collecting the data itself.

The privacy and data confidentiality issue may be easier to manage in the commercial trucking sector. Fleet operators assume that they have a right to know what their vehicles are doing at all times, including vehicles operated under contract by subhaulers. The widespread use of telematics and EOBR event recording and location systems has already made much of the trucking industry comfortable with third-party handling of vehicle activity data. Existing safeguards and protocols appear to be satisfactory. Fleet operators engaged in interstate operations and those in states with weight-distance taxes already track and report fleet miles traveled by state, building that data up from electronic or manual vehicle records.

There are no statutory privacy protections that would prohibit a VMT fee system. There are federal statutory provisions regarding the use of "tracking devices." However, it is not clear whether these provisions would apply to most VMT fee systems. Even if the provisions did apply, they would not

Table 30. VMT fee net revenue and efficiency.

VMT Fee Options	Net Annual Federal Revenue	Net Annual Avg. Rev. per Vehicle	Annual Industry Cost	Annual Avg. Cost per Vehicle	Ratio
VMT Distance/ Vehicle Fee - OBU/Options					
Class 7&8 freight	$ 4,504,839,481	$ 1,086	$ 5,655,296,055	$ 1,364	**0.80**
Class 7&8 all types	$ 4,498,549,290	$ 1,040	$ 5,683,691,777	$ 1,313	**0.79**
Class 4-8 freight	**$ 4,402,345,672**	**$ 622**	**$ 6,117,982,396**	**$ 865**	**0.72**
Class 4-8 all types	**$ 4,334,764,182**	**$ 481**	**$ 6,423,064,550**	**$ 713**	**0.67**
VMT Distance/ Vehicle Fee - OBU Only					
Class 7&8 freight	$ 4,504,839,481	$ 1,086	$ 5,862,668,224	$ 1,414	**0.77**
Class 7&8 all types	$ 4,498,549,290	$ 1,040	$ 5,900,049,934	$ 1,363	**0.76**
Class 4-8 freight	**$ 4,402,345,672**	**$ 622**	**$ 6,471,774,294**	**$ 915**	**0.68**
Class 4-8 all types	**$ 4,334,764,182**	**$ 481**	**$ 6,873,401,433**	**$ 763**	**0.63**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).

impose any standards beyond what is required by the Fourth Amendment. There are also some state laws prohibiting the use of tracking devices. To the extent that these laws would conflict with a federally mandated VMT system, they presumably would be preempted. A more detailed discussion of these privacy issues prepared by the research team's consulting legal counsel is attached as Appendix D.

Behavior Incentives

It has been argued that a direct measure of highway impact (a VMT fee) will create better incentives for efficient routing (i.e., minimizing VMT) than a fuel tax. This may be less important for the medium- and heavy-duty truck sector than for passenger vehicles. Truck fleet operators already have strong incentives to minimize miles and hours, and many do so aggressively. A VMT fee roughly equivalent to the current fuel tax would change truck operating costs by no more than 2%. Such a small change is unlikely to change operations or driver behavior.

A VMT fee is generally expected to be a stronger incentive for efficiency than the fuel tax because it relates directly to the decision of whether or not to make a given trip and what route to take on that trip. Freight movements are a function of customer demand. Freight carriers choose whether or not to take a given piece of business and make the trips associated with that business. Given the close attention freight carriers pay to cost and the small part that fuel taxes or VMT fees would play in that cost, it seems unlikely that the difference between a fuel tax and a VMT tax would be decisive.

Time/location VMT fees that incorporate TDM or tolling may have greater behavioral impacts than distance/vehicle VMT fees, but the behavioral response of freight carriers and service providers is still constricted by demand. Both freight carriers and service providers may be able to choose whether or not to serve a particular time, location, and route combination, but ultimately the customer needs to have the freight delivered and the service provided.

It seems likely that carriers and service providers would seek to pass along congestion fees, tolls, or other similar expenses in the form of price increases or surcharges. Their price increases or surcharges would then become incentives for the customer to reduce shipments or receipts, to reschedule, or to relocate. The PierPass program at the Ports of Los Angeles and Long Beach is essentially a congestion fee program and has resulted in up to 40% of the applicable business being handled in off-peak hours. Much of the shift, however, resulted from customer choices rather than trucker choices.

The greatest long-term impact of time/location VMT fees may therefore be manifested in the ways and places in which business is done. Initially, time/location VMT fees would encourage freight-dependent and service-dependent businesses to relocate outside the fee zones and off toll routes. These incentives, however, are primarily functions of congestion pricing, road pricing, or tolling features and are not attributable to the VMT fees per se.

Implementation

Legislation and regulations to implement such a VMT system in place of fuel taxes would have to address the following issues:

- The scale of VMT charges for increasing vehicle weights.
- The fee indexing method.
- Dedication of VMT revenue to highway uses.
- The method and options for fee collection and compliance.
- Penalties for evasion and means of enforcement.
- Provisions for international trucks.
- Requirements, if any, for vehicle manufacturers to install OBUs as OEM equipment.
- Technical specifications of VMT-compliant OBUs, or a means for developing such specifications.
- Privacy safeguards.
- Implementation timeline and budget.

Faced with these kinds of challenges, most government and industry stakeholders contacted in the course of this study have responded with some variation on "Why don't we just fix the fuel tax?"

Implementation of VMT systems in the freight and service trucking sectors involves key policy issues that have been only peripherally addressed in the literature to date. To date, almost all the research and study has been focused on the VMT fee concept, the collection technology, and privacy issues. Passenger-focused VMT fee discussions have usually assumed or concluded that each vehicle would have to be equipped with an OBU capable of automatically recording and reporting VMT. This viewpoint is based in turn on the assumption or conclusion that passenger-vehicle operators do not track and report their mileage by other means and could not do so efficiently.

There is a need for additional research on methods for varying distance/vehicle VMT fees by vehicle type. There are many different possibilities besides the examples presented above. As noted above, there are two relationships at issue:

- The relationship between vehicle type (however classified) and actual or average operating weight.
- The relationship between actual or average operating weight and infrastructure requirements and costs.

Additional research would be required if an attempt is made to incorporate axle weights or PCEs in the methodology.

Table 31 shows the research team's working assumptions regarding the implementation phase-in time and pass-through

Table 31. VMT fee implementation phase-in schedule.

Revenue Option	Years to First Revenue	Federal Implementation Cost Phase-In Years	Tax Burden Passed to Customers First Year	Tax Burden Passed to Customers Second Year	Tax Burden Passed to Customers Third Year	Implementation and Compliance Cost Passed to Customers First Year	Implementation and Compliance Cost Passed to Customers Second Year	Implementation and Compliance Cost Passed to Customers Third Year
VMT Distance/ Vehicle Fee - OBU/Options								
Class 7&8 freight	5	5	33%	66%	100%	33%	66%	100%
Class 7&8 all types	5	5	33%	66%	100%	33%	66%	100%
Class 4-8 freight	**5**	**5**	**33%**	**66%**	**100%**	**33%**	**66%**	**100%**
Class 4-8 all types	**5**	**5**	**33%**	**66%**	**100%**	**33%**	**66%**	**100%**
VMT Distance/ Vehicle Fee - OBU Only								
Class 7&8 freight	5	5	33%	66%	100%	33%	66%	100%
Class 7&8 all types	5	5	33%	66%	100%	33%	66%	100%
Class 4-8 freight	**5**	**5**	**33%**	**66%**	**100%**	**33%**	**66%**	**100%**
Class 4-8 all types	**5**	**5**	**33%**	**66%**	**100%**	**33%**	**66%**	**100%**

of tax burden and compliance costs for VMT fee options. The implementation period is assumed to be 5 years due to the need to develop a system for fee collection, auditing, and enforcement and to develop and deploy the necessary technology. The federal government would incur costs, but receive no revenue in this 5-year period.

For purposes of modeling economic impacts, the research team assumed that about one-third of the industry tax burden and compliance costs would be passed on in the first post-implementation year, two-thirds in the second year, and all by the third year. This 5-year implementation timeline for the medium- and heavy-duty trucking sector is much shorter than the timelines estimated in the literature for the passenger-vehicle fleet.

Advantages

The key advantages of VMT fees include a strong linkage between road use and fee structure, meeting the policy preference for user fees as opposed to taxes. VMT fees would facilitate coverage of hybrid, alternative fuel, and electric vehicles that would otherwise make little or no contribution under a fuel tax regime. VMT fees are user fees to the degree that use equates to vehicle miles traveled. VMT fees could differentiate between vehicle types and classes and could thus approximate vehicle tare weight, but would not reflect the net weight of freight or other vehicle loads.

VMT fee systems also hold out the possibility for linkage between federal, state, regional, or local programs, particularly where time/location VMT systems or other means can distinguish miles operated by jurisdiction. If cost-effective time/location capabilities can be added to a distance/vehicle VMT system, a multipurpose system could emerge for both collecting revenue and implementing TDM measures. Such a system could also accumulate data on highway activity for planning purposes. The potential for simultaneously establishing national interoperability standards for tolling systems is also an attraction.

National freight truck VMT is expected to continue to grow while fuel consumption plateaus or grows more slowly due to improved efficiency. VMT fees would still require indexing, however, to retain buying power in the face of inflation.

A freight or truck VMT fee system could also be viewed as a pilot for eventual replacement of fuel taxes with VMT fees for all vehicles.

Disadvantages

Drawbacks to a distance/vehicle VMT system include complexity and high implementation, collection, compliance, and enforcement costs. There would be substantially greater opportunities for evasion relative to fuel taxes.

Another drawback of VMT fee proposals is the very long implementation time. An AASHTO report, for example, anticipates a 20-year timeline to allow for additional studies, pilot projects, technology advances, legislative and regulatory steps, and eventual implementation with a phase-in period (AASHTO, September 2007, p. 13).

Time/location VMT fees would have substantially higher implementation costs than distance/vehicle fees and raise privacy issues that probably can be resolved legally and technically, but may still affect political feasibility. The cost/benefit balance of time/location VMT systems is open to question, as they would benefit only a small portion of the vehicle population, and the advantages of these systems over existing toll systems are unclear.

VMT concepts would be difficult to apply to non-highway modes. The incremental behavioral incentives envisioned for VMT fees in the passenger sector may not be as strong in the trucking sector, where mileage is already often tracked and minimized.

The revenue potential and user equity features of VMT fees would be diluted to the extent that government vehicles are exempted. Exemptions would also complicate the collection system.

The public acceptance barriers to a distance/vehicle VMT system are substantial. The concept can, with reason, be characterized as more costly and invasive than fuel taxes with few compensating benefits.

CHAPTER 5

Federal Registration Fee

Concept

An annual or periodic federal vehicle registration fee appears to be a flexible candidate mechanism for funding freight infrastructure. Such a system has the advantage of simplicity, low implementation and collection costs, and potential application to non-highway modes. Non-fuel federal excise taxes and fees currently apply almost exclusively to the heaviest truck classes. Due to this limited scope, non-fuel excise taxes and registration fees have received little attention as replacements for the fuel tax. Excise taxes are typically assessed on sales or commercial transactions of some type. Registration fees are typically annual, periodic, or one-time assessments for owning and operating a vehicle on public rights-of-way (including waterways or airports). Although excise taxes and registration fees are not directly related to vehicle infrastructure use or impacts, a carefully constructed system could use such levies to approximate use and fund freight infrastructure. *NCHRP Web-Only Document 102: Future Financing Options to Meet Highway and Transit Needs* considered vehicle registration fees to be a potential "high yield," program-based revenue source (Cambridge Systematics, Inc., et al., 2006).

Vehicle ownership per se is only a rough proxy for infrastructure use, but it offers a simple, low-cost option for generating revenue. An annual federal freight vehicle registration fee, either paid directly or added on to state registration fees, could be targeted or graduated for specific vehicle types or sizes, since all on-road vehicles must be registered with the states already. The federal taxes on new heavy vehicle sales and on heavy vehicle tires also generate highway funds. These taxes, however, have, with some justification, been criticized for discouraging the purchase of new vehicles or tires when such purchases could advance safety, fuel efficiency, and emissions reduction efforts. Unless graduated by age, an annual registration fee would be neutral with respect to new vehicle purchases. If graduated by size or weight, an annual registration fee could encourage users to choose the smallest (and presumably most fuel-efficient and lowest emissions) truck that will perform the task at hand.

Federal and State Excise Taxes and Fees

This section discusses federal excise taxes and registration fees—the HVUT; the tire tax; and federal truck, tract, and trailer tax on retail sales—as well as state registration fees.

Federal Excise Taxes and Registration Fees

At the federal level, heavy-duty trucks currently pay HVUT, a tire tax, and a sales tax. The three federal non-fuel taxes single out heavy trucks and are understandably unpopular with truck owners and operators. In the past, there have been taxes on automobiles, motorcycles, buses, parts and accessories, inner tubes, and tread rubber, but all have been repealed. As Figure 9 shows, since the late 1980s there have just been the three truck taxes (HVUT, sales tax, and tire tax). Figure 9 also graphically illustrates the volatility of the revenues from these taxes and fees and their vulnerability to economic cycles. The sales tax, in particular, drops drastically during recessions when truck sales drop and recovers dramatically thereafter.

Currently, these three federal non-fuel excise taxes (HVUT, tire tax, and sales tax) account for 10% of the Highway Trust Fund revenue used for highway purposes—about $3.2 billion. (See Figure 10.)

The three non-fuel federal taxes would have expired September 30, 2011[Sections 4051(c) (first retail sale), 4481(f) (heavy vehicle use tax) and 4071(c) (tires) of the Internal Revenue Code of 1986, as amended (IRC)], but have been extended into 2012. Within the industry, there were those who favored allowing the three taxes to expire and folding their functions into the fuel tax. Exactly how that would have been accomplished is not clear.

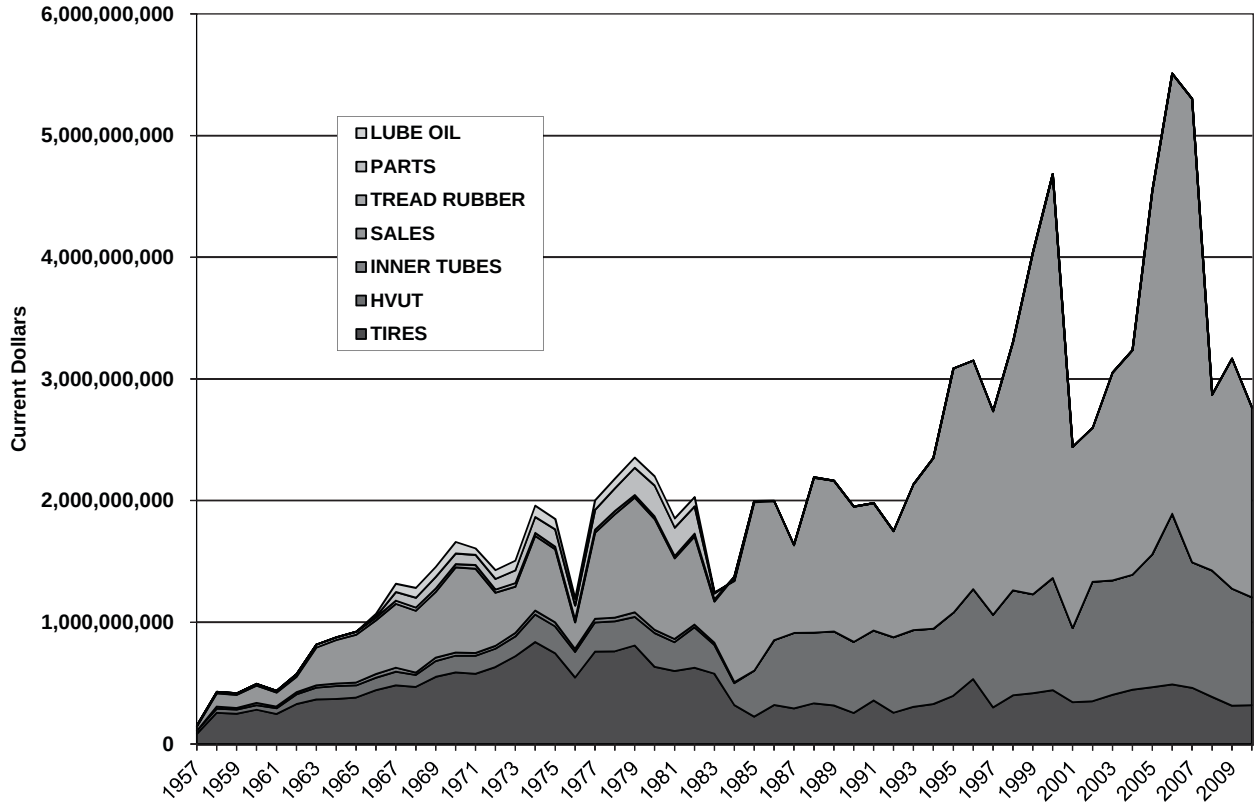
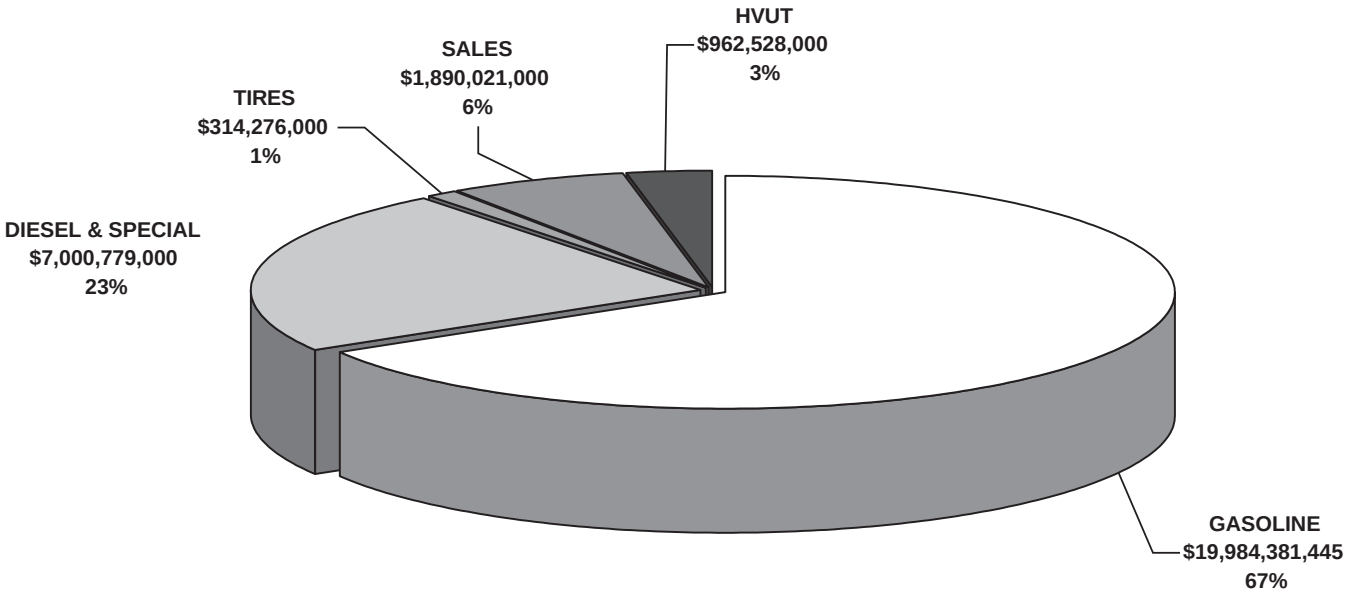


Figure 9. Federal excise and sales tax revenue.



SOURCE: FHWA

Figure 10. 2009 Highway Trust Fund highway revenue sources.

Heavy Vehicle Use Tax

The HVUT is assessed annually on heavy vehicles operating on public highways at registered gross weights equal to or exceeding 55,000 lb. The gross taxable weight of a vehicle is determined by adding the unloaded weight of the motor vehicle and any trailers together with the maximum load customarily carried on road by the truck-trailer combination. Trucks with a registered weight of 55,000 to 75,000 lb pay $100 plus $22 for each 1,000 lb over 55,000 lb to a maximum of $550.

The HVUT is a significant source of transportation funding. As of 2009, the HVUT brought in $963 million to the Highway Trust Fund. In 2001, HVUT receipts slumped due to the sagging economy and its impact on the motor carrier industry. Between 2001 and 2006, the HVUT rebounded due to economic growth and the incentive to "pre-buy" or purchase trucks prior to 2007 to avoid the new EPA emissions rule. Thereafter, HVUT revenue has been relatively stable.

Because it is applicable only to vehicles in the highest gross vehicle rating classification, the HVUT is targeted at—but not exclusive to—freight-carrying vehicles. The HVUT tax rate rarely changes, and it is not indexed. The last change was in 1984. All proceeds go to the highway portion of the Highway Trust Fund.

The HVUT is not a use tax, as it does not vary with highway use, but it can be regarded as an additional annual fee to cover some of the cost impacts of heavier vehicles. A tax of this type could be a companion to fuel or VMT user fees, which are largely distance-based, or a standalone revenue source for freight infrastructure.

Tire Tax

The federal tire tax is applicable to new tires sold by manufacturers or importers at a rate of $0.0945 for each 10 lb of load capacity over 3,500 lb. The rate is lower for bias ply or "super single" tires, and certain federal government agencies are exempt. This formula exempts many tires and concentrates on those used by trucking. The rate of taxation rarely changes, and it is not indexed. The last change was in 1981. All proceeds go to the highway portion of the Highway Trust Fund. Tire taxes provided $314 million to the Highway Trust Fund in 2009.

The tire tax has simplicity of administration, collection, and payment in its favor. The collection activities are limited to businesses that sell new commercial vehicle tires, not the 10 million trucks themselves.

The tire tax is a user fee in the sense that tire consumption and purchase of new tires is a direct result of road use (although off-road vehicle tires can also be taxed).

Federal Truck, Tractor, and Trailer Tax on Retail Sales

There is a federal tax on the first retail sale of trucks, tractors, and trailers, including parts and accessories when these are purchased with the new vehicle. The tax applies only to the largest such vehicles, based on the manufacturer's rated gross vehicle weight. The rate of taxation rarely changes (the last change was in 1983), and it is not indexed. All proceeds go to the highway portion of the Highway Trust Fund.

Trucks over 33,000 lb GVW (Class 8) and trailers over 26,000 lb GVW pay 12% of the retail sales price. New Class 8 tractors and straight trucks typically sell for $100,000 or more, so the average federal sales tax would start at around $12,000 per unit. This tax provided about $1.9 billion to the Highway Trust Fund in 2009.

Like the tire tax, this federal tax has simplicity of administration, collection, and payment in its favor. The collection activities are limited to businesses that sell new trucks. Vehicles that do not haul freight are included. This tax does, however, require a lump sum payment with vehicle purchase, so it is not a "user fee."

The general economic downturn has dramatically affected heavy-duty truck sales. There was also a decline in heavy-duty truck sales in 2006 and 2009 because of the 2007 and 2010 requirements to use diesel engines with reduced emissions (but with higher purchase prices and fuel consumption). As of late 2010, new truck sales remain depressed. According to the Truck and Engine Manufacturers Association (formerly the Truck Manufacturers Association), OEMs faced the following losses in sales from 2006 to 2009 (Truck Manufacturers Association, 2009):

- Sales of Class 6 trucks dropped from 70,000 sold in 2006 to 22,000 sold in 2009.
- Sales of Class 7 trucks dropped from 91,000 sold in 2006 to 39,000 sold in 2009.
- Sales of Class 8 trucks dropped from 284,000 sold in 2006 to 95,000 sold in 2009.

The sales base for any new revenue stream will presumably recover over time to sustainable, fleet-replacement levels somewhere between the apparently unsustainable peak of the last expansion and the current trough. A proposal to impose a new tax on purchases will probably elicit strong opposition from an already depressed industry, and any such revenue source will likely be cyclical.

State Registration Fees

In 2008, state vehicle registration fees generated about $6 billion from trucks. State registration fees are based on combinations of vehicle weight, age, value, and use, with weight

Table 32. California state registration fee weight table.

Gross/Combined Vehicle Weight Range	Fee
10,001 - 15,000	$ 332
15,001 - 20,000	$ 447
20,001 - 26,000	$ 546
26,001 - 30,000	$ 586
30,001- 35,000	$ 801
35,001 - 40,000	$ 937
40,001 - 45,000	$ 1,028
45,001 - 50,000	$ 1,161
50,001 - 54,999	$ 1,270
55,000 - 60,000	$ 1,431
60,001 - 65,000	$ 1,562
65,001 - 70,000	$ 1,701
70,001 - 75,000	$ 2,004
75,001 - 80,000	$ 2,064

being the dominant factor. Every state includes vehicle weight in fee calculations, with most using GVW class designations. Vehicle weight is the only registration factor in 30 states and the District of Columbia. These 30 states either assign a fee to each weight class or assess a flat fee plus an increment for additional weight. As an example, California's registration fee weight table is shown in Table 32.

A number of states also include either vehicle age or model year in fee calculations. These states include Arizona, California, Iowa, Minnesota, Mississippi, Missouri, Montana, Nevada, New York, North Dakota, and South Dakota. Such registration fees generally decline with age, reflecting declining value and productivity.

Several states include vehicle purchase price or value in the registration fee calculation, including Colorado, Maine, Nevada, and West Virginia. A few states include vehicle type or use in registration fees, including Indiana, New York, and Washington. Nevada also considers the number of axles. Washington has a Vehicle Safety Inspection Fee of $16. Nevada has a Basic Government Services Tax of 4% of vehicle value (see Table 33). This tax also applies to other types of goods and services.

Table 33. Nevada Basic Government Services Tax for a $20,000 sale price.

$20,000	
x .35	DMV Valuation - will not change over time (NRS 371.060)
$7,000	
x .85	DMV Valuation is depreciated 15% when vehicle is two years old (NRS 371.040)
$5,950	
x .04	Government Services Tax is 4% of valuation (NRS 371.040)
$238	

Source: International Registration Plan, Inc., n.d.(a).

Utah and Wyoming have equalized highway use taxes (EHUTs) that take vehicle age and weight into account. Utah's fee schedule is shown in Table 34. Indiana has a Commercial Vehicle Excise Tax (CVET).

A federal registration fee could use one of the state systems discussed or be based on a separate federal schedule.

Collection Mechanism

Fee collection mechanisms already exist that, if expanded or modified, could be used to collect federal registration fees. The following options are discussed below:

- Expanding the current HVUT collection mechanism.
- Building on existing registration fee allocation systems—the International Registration Plan (IRP) and the Unified Carrier Registration Plan (UCRP).
- "Piggybacking" on the state registration fee process.

Table 34. Utah equalized highway use tax.

Vehicles or Combination Registered Weight	Age of Vehicle	Equivalent Tax
12,000 pounds or less	12 or more years	$ 10.00
12,000 pounds or less	9 to 11 years	$ 50.00
12,000 pounds or less	6 to 8 years	$ 80.00
12,000 pounds or less	3 to 5 years	$ 110.00
12,000 pounds or less	less than 3 years	$ 150.00

Vehicles or Combination Registered Weight	10 to 12 Mo Reg	7 - 9 Mo Reg	4 - 6 Mo Reg	1 - 3 Mo Reg
12,001 - 18,000 pounds	$ 150.00	$ 135.00	$ 90.00	$ 45.00
18,001 - 34,000 pounds	$ 200.00	$ 180.00	$ 120.00	$ 60.00
34,001 - 48,000 pounds	$ 300.00	$ 270.00	$ 180.00	$ 90.00
48,001 - 64,000 pounds	$ 450.00	$ 405.00	$ 270.00	$ 135.00
64,001 pounds and over	$ 600.00	$ 540.00	$ 360.00	$ 180.00

Source: International Registration Plan, Inc., n.d.(b).

Expanding the Current HVUT Collection Mechanism

The HVUT is an annual lump sum and can be a significant cash flow impediment for some motor carriers. For large carriers with 25 or more vehicles, electronic filing is accomplished using a credit card or other means of electronic payment. Because the fee is payable by the vehicle owner, owner-operators must make the payments even if they are subhaulers for larger firms.

The current HVUT collection mechanism could be used as is, but expanded to cover Class 4–8 trucks. There would be a relatively small increase in labor and electronic processing capability required, but no new technology.

Building on Existing Registration Fee Allocation Systems

Truck owners pay registration fees that vary by state and which must be apportioned among the states in which they operate. There are two systems in place that could become building blocks for a low-cost federal registration fee collection system—the IRP and the UCRP.

International Registration Plan

The IRP is a registration reciprocity agreement among states of the United States, the District of Columbia, and provinces of Canada providing for payment of license fees on the basis of fleet distance operated in various jurisdictions. Essentially, all larger trucks and buses that operate across state lines ("apportionable" vehicles) are required to register and pay fees according to a schedule set by each jurisdiction. Trailers are not covered.

Unified Carrier Registration Plan

This is a program under which interstate commercial truck and bus carriers register their interstate fleets with a base state and pay a fee based on the number of vehicles in the fleet. The level of the fee is set by FMCSA, but is collected by the relevant state. The funds are used to assist the states in carrying out certain safety and carrier monitoring functions. The Unified Carrier Registration (UCR) Agreement is established by federal law in the UCR Act, which is part of SAFETEA-LU, enacted August 10, 2005. The UCRP is the organization of state, federal and industry representatives responsible for developing, implementing, and administering the UCR Agreement. The UCR Agreement is the interstate agreement, developed under the UCRP, governing the collection and distribution of registration information and fees generated ("UCR fees"). Section 4304 of the UCR Act imposes fees, for example, on motor carriers first applying for federal authority and on some third parties accessing data in the system. Their only purpose is to provide funds to maintain the UCRP.

The IRP, UCRP, or a new, similar type of organization could conceivably replace the existing HVUT collection system at a comparable cost.

"Piggybacking" on State Registration Fees

An alternative to direct federal registration fee collection would be "piggybacking" on the state registration fee process. All states currently factor vehicle weight or weight class into their registration fees, so a federal registration fee that varied by vehicle weight class should be compatible.

Annual registration fee notices would include both a state fee amount and a federal fee amount. All trucks, regardless of where they are operated, have a "base state" for licensing and registration under the UCRP. The federal fee would be added only in the base state. Truck owners would make one annual payment covering both state and federal fees. The federal portion would be aggregated and forwarded on a monthly or biweekly basis, with the states benefiting from the "float" between collection and forwarding. The "float" would help to offset the additional state record-keeping and accounting cost, most of which should be automated. Besides the lower collection cost, "piggybacking" would reduce industry compliance costs.

Revenues and Costs

The following aspects of revenues and costs are discussed below—fee structure, federal collection and enforcement costs, implementation and compliance costs, and net revenue and revenue efficiency.

Fee Structure

The registration fee rates would depend on the revenue goal and the classes of vehicles covered. Table 35 shows the relationship for an annual gross revenue target of $5 billion.

Application of the fee to Class 7 and 8 freight trucks only (by body type) would require average annual fees of $1,206 per vehicle, more than twice as much as the current HVUT maximum. The average registration fee required would drop from $1,206 to $555 if the fee were applied to all Class 4–8 trucks rather than applied to just Class 7 and 8 freight trucks. This is effectively equivalent to expanding coverage of the HVUT (which has a maximum of $550 per vehicle) to all Class 4–8

Table 35. Registration fee rates for $5 billion gross revenue.

Excise Tax Options	2008 Vehicles	$/Vehicle Required for $5 Billion Gross Revenue
Annual Registration Fee		
Class 7&8 freight	4,147,443	$ 1,206
Class 7&8 all types	4,327,163	$ 1,155
Class 4-8 freight	**7,075,838**	**$ 707**
Class 4-8 all types	**9,006,738**	**$ 555**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).

trucks (the HVUT currently covers Class 8 trucks only). The amount that would accrue from applying a registration fee to all Class 4–8 trucks would be in addition to excise taxes (HVUT, sales tax, and tire tax) paid into the Highway Trust Fund. If those existing taxes expire or are folded into a revised fuel tax, the amounts in Table 35 would be the only annual federal excise taxes or registration fees on trucks. The figures in Table 35 are averages; a sliding scale would likely be applied to reflect size and weight.

If the tire and sales taxes were allowed to expire, federal Highway Trust Fund revenue would be reduced by about $2.2 billion annually (see Figure 10). In this case, there would be a need for a registration fee that was 44% higher (e.g., $799 versus $555 for all Class 4–8 vehicles in Table 35) to make up the lost revenue.

Federal Collection and Enforcement Costs

The collection cost of a federal vehicle registration fee for Class 7 and 8 freight vehicles is estimated at 5% of the current HVUT revenue (see Table 36). The average cost is shown as declining for increasing vehicle fleet coverage, with the total cost capped at $50 million annually. This assumption reflects expected economies of scale and potential piggybacking on state registration fee systems. There is no separate credit card fee allowance for excise taxes because credit cards are already used for the HVUT and should be reflected in the 5% rule of thumb.

Implementation and Compliance Costs

There are no significant federal or industry implementation costs for registration fees. The compliance cost for registration fee systems (see Table 37) was roughly estimated at $25 per vehicle per year, the same as the commercial fee for IFTA filing. This is the cost of paperwork or services to pay the fee, not the fee itself.

Net Revenue and Revenue Efficiency

Table 38 provides estimates of total net annual federal revenue ($5 billion less collection and annualized implementation cots) and total annual industry cost ($5 billion plus annualized implementation and compliance costs) and also shows these costs broken down to net annual revenue per vehicle and annual cost per vehicle. Table 38 also provides the ratio of net federal revenue to annual industry cost.

The very high efficiency ratios for a federal registration fee are due to the low collection cost, low compliance cost, and

Table 36. Estimated annual collection and enforcement costs.

Excise Tax Options	Annual Federal Collection and Enforcement Cost	Average Collection Cost per Vehicle
Annual Registration Fee		
Class 7&8 freight	$ 46,150,189	$ 11.13
Class 7&8 all types	$ 46,517,004	$ 10.75
Class 4-8 freight	**$ 50,000,000**	**$ 7.07**
Class 4-8 all types	**$ 50,000,000**	**$ 5.55**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).

Table 37. Registration fee compliance cost estimates.

Excise Tax Options	Annual Private-Sector Compliance Cost
Annual Registration Fee	
Class 7&8 freight	$ 103,686,085
Class 7&8 all types	$ 108,179,079
Class 4-8 freight	**$ 176,895,949**
Class 4-8 all types	**$ 225,168,441**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).

absence of implementation costs. A registration fee would use existing collection systems without the need for deploying new technology.

Evasion and Enforcement

To evade a federal registration fee, vehicle owners would have to either misclassify their vehicle or not register it. Piggybacking on the state fee system would reduce the potential for evasion and the federal enforcement cost. Since federal fees would be paid with state fees, only the existing state enforcement efforts would be required.

Behavior Incentives

The federal excise taxes have, with some justification, been criticized for discouraging the purchase of new vehicles or tires when such purchases could advance safety, fuel-efficiency, and emissions-reduction efforts. Registration fees avoid the disincentives that truck sales or tire taxes create. Registration fees are also less cyclical than sales taxes. While truck sales can vary widely with economic conditions, the working fleet tends to grow slowly from year to year. Unless graduated by age, an annual registration fee would be neutral with respect to new vehicle purchases. If graduated by size or weight, an annual registration fee could encourage users to choose the smallest (and presumably most fuel-efficient and lowest emissions) truck that could perform the task at hand.

A higher or broader federal registration fee would discourage operators from keeping older medium- and heavy-duty trucks for occasional or seasonal use. Such uses are often dominated by old, inefficient, high-polluting trucks with questionable safety status, so such an incentive might be seen as a public benefit.

Implementation

An expanded federal registration fee would require legislation to extend the HVUT, expand it beyond Class 8 trucks (preferably to all Class 4–8 trucks), and set an appropriate rate schedule and administrative expansion of the HVUT collection system to accommodate more invoices and payments.

Table 39 shows an illustrative phase-in schedule for a federal registration fee. It assumes that the fee can be made effective within the first year after legislation passes because no new technology need be deployed and the existing HVUT collection mechanism can be used. If the HVUT were to expire, there would be a need to rebuild a collection system.

The phase-in schedule anticipates that only about a third of the fees incurred by truck operators can be passed on to customers in the first year due to rigidities of existing contacts and rigorous rate competition. By the third year, all the fees would have been passed onto customers in the form of rate increases.

Advantages

Annual federal registration fees have some compelling advantages:

- Annual fees of various types are already being collected by every state and by the federal government.
- While the current cost of collection is reportedly relatively high in percentage terms (5%), the collection cost is unlikely to rise significantly if fees are increased, yielding high overall revenue efficiency.

Table 38. Registration fee net revenue and efficiency.

Excise Tax Options	Net Annual Federal Revenue	Net Annual Avg. Rev. per Vehicle	Annual Industry Cost	Annual Avg. Cost per Vehicle	Ratio
Annual Registration Fee					
Class 7&8 freight	$ 4,953,849,811	$ 1,194	$ 5,103,686,085	$ 1,231	**0.97**
Class 7&8 all types	$ 4,953,482,996	$ 1,145	$ 5,108,179,079	$ 1,180	**0.97**
Class 4-8 freight	**$ 4,950,000,000**	**$ 700**	**$ 5,176,895,949**	**$ 732**	**0.96**
Class 4-8 all types	**$ 4,950,000,000**	**$ 550**	**$ 5,225,168,441**	**$ 580**	**0.95**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).

Table 39. Registration fee phase-in schedule.

Revenue Option	Years to First Revenue	Federal Implementation Cost Phase-In Years	Tax Burden Passed to Customers First Year	Tax Burden Passed to Customers Second Year	Tax Burden Passed to Customers Third Year	Implementation and Compliance Cost Passed to Customers First Year	Implementation and Compliance Cost Passed to Customers Second Year	Implementation and Compliance Cost Passed to Customers Third Year
Annual Registration Fee								
Class 7&8 freight	1	1	33%	66%	100%	33%	66%	100%
Class 7&8 all types	1	1	33%	66%	100%	33%	66%	100%
Class 4-8 freight	**1**	**1**	**33%**	**66%**	**100%**	**33%**	**66%**	**100%**
Class 4-8 all types	**1**	**1**	**33%**	**66%**	**100%**	**33%**	**66%**	**100%**

Source: Tioga Group Analysis.

- The public appears less sensitive to increases in registration fees than to other taxes or fees. Voters in California have recently approved increases in vehicle registration fees for specific purposes.
- State and federal fees are already scaled by vehicle weight, providing a valuable precedent.
- Vehicle excise taxes, sales taxes, and registration fees are independent of fuel consumed or mileage operated, and provide a means of addressing electric, hybrid, and alternate-fuel vehicles.
- A registration fee offers the opportunity to selectively reduce or raise the fee for specific vehicle types. It would be possible to build in incentives to purchase new vehicles, smaller vehicles, or alternative fuel vehicles. In this respect, a registration fee system could achieve some of the same goals as an investment tax credit.
- A broader federal registration fee for trucks could be implemented very quickly, especially if undertaken as an extension and expansion of the existing HVUT.
- Piggybacking on the state registration fee process may further reduce collection and enforcement costs.

Disadvantages

The disadvantages of registration fees include the following:

- Lack of a direct linkage between the registration fee and highway use (registration fees are not true "user fees").
- Potential disincentives to renew vehicle registrations or incentives to operate unregistered vehicles.
- Potential disincentives to purchase new vehicles if registration fees rise as a result.
- No potential for automated collection.

CHAPTER 6

Economic Impacts

Economic Impact Methodology

The research team used existing econometric models to estimate the relative economic impacts of the leading revenue mechanism candidates. This analysis was undertaken to determine the overall impact of a freight infrastructure tax or fee, any differences between the candidate mechanisms, and the relative impact on different transportation and industry segments. As in the cost and efficiency comparisons, the analysis set the tax burden at $5 billion annually for all options to maintain comparability.

The economic impacts of tax scenarios were estimated by "following the dollar" of tax, implementation, and compliance costs. For each of the leading revenue mechanism candidates, these costs are immediately felt at the vehicle level—either at the pump (the fuel tax scenarios), by mile traveled (VMT fee scenario), or by the vehicle (registration fee scenario). In the short term, for-hire trucking firms will bear some of these costs. Ultimately, the additional costs will be reflected in higher rates and higher delivered commodity prices, which will translate into higher industry production costs, and ultimately affect the growth potential in these industries. Along the way, trucking companies and industries with private fleets will shift their behavior to minimize their tax burden.

The methodology for estimating the economic impacts of each scenario essentially follows the same six steps:

- Estimate tax, implementation, and compliance costs.
- Estimate how each cost accrues to trucking market segments.
- Estimate how costs pass through market segments to yield higher commodity prices.
- Estimate how higher commodity prices accrue to industries.
- Estimate how higher production costs affect industry growth potential.
- Estimate possible substitution effects as fleets reduce their tax burden.

The six steps would apply to freight-carrying, Class 4–8 trucks in the following four major tax scenarios:

- Diesel fuel tax with non-freight tax refunds.
- Diesel/gas tax with vehicle ID.
- VMT distance/vehicle fee—OBU/options.
- Annual registration fee.

Cost Accrual by Trucking Market Segments

The research team determined how scenario tax, implementation, and compliance costs would accrue to six trucking market segments:

- Private (Fixed Contract)
- Private (Variable Contract)
- For-Hire (Long-Term Fixed)
- For-Hire (Long-Term Variable Contract)
- For-Hire (Short-Term Fixed Contract)
- For-Hire (Short-Term Variable Contract)
- For-Hire (Spot Market)

The study team determined how the basis of taxation or cost accrual varies by trucking segment. Information was compiled from VIUS, the Freight Analysis Framework (FAF), the U.S. Census Bureau, and other sources to determine the share of total trucks by market segment. Truck counts by class and private/for-hire split were determined by scaling 2002 VIUS truck counts up to 2008 levels according to vehicle counts estimated by the U.S. Census. The resulting truck counts by class are shown in Table 40. Further allocation for private and for-hire truck counts into contract markets was accomplished by applying assumptions about average annual miles per truck to market segment mileage data.

Average operating characteristics were determined by estimating how each commodity reported by FAF uses each

Table 40. Estimated 2008 vehicle counts for freight-carrying trucks.

Market	Engine Type	Class 4-5	Class 6	Class 7-8	Total
Private	Diesel	625,035	619,128	2,511,127	**3,755,291**
	Gasoline/Other	769,852	452,090	251,924	**1,473,866**
For-Hire	Diesel	114,662	119,291	1,258,169	**1,492,122**
	Gasoline/Other	141,228	87,107	126,223	**354,559**
Totals		**1,650,777**	**1,277,616**	**4,147,443**	**7,075,838**

Source: Tioga Group.

of the six market segments. These utilization rates were combined with 2008 FAF data to determine the average VMT, commodity loading, backhaul percentage, and average haul length for each market segment. These results are summarized in Table 41.

Cost Accrual by Commodity and Industry

Once cost accrual by market segment was determined, it was possible to determine how costs ultimately passed through to commodities, resulting in higher commodity prices for industries consuming them. This pass-through would not be immediate. In for-hire market segments, some costs would be temporarily borne by the trucking sector, only to be passed through after contracts could adjust accordingly. Assumptions about the timeline for pass-through costs are as follows:

- **Diesel fuel tax.** Costs begin accruing 1 year after implementation begins.
  - **Tax cost.** In the first year of cost accrual, two-thirds of costs are passed through to consumers (with one-third absorbed by the for-hire trucking industry). In all subsequent years, the tax cost is fully passed through.
  - **Implementation and compliance cost.** In the first and second year of cost accrual, 1/3 and 2/3 of costs are passed through to customers, respectively. In all subsequent years, costs are fully passed through.
- **Diesel/gas fuel tax and VMT fee.** Costs begin accruing 5 years after implementation begins.
  - **Tax cost.** In the first year of cost accrual, two-thirds of costs are passed through to consumers. In all subsequent years, the tax cost is fully passed through.
  - **Implementation and compliance cost.** In the first and second year of cost accrual, one-third and two-thirds of costs are passed through to customers, respectively. In all subsequent years, costs are fully passed through.
- **Registration fee.** Costs begin accruing 5 years after implementation.
  - **Tax, implementation, and compliance costs.** In the first and second years of cost accrual, one-third and two-thirds of costs are passed through to consumers, respectively. In all subsequent years, the tax cost is fully passed through.

The purpose of these assumptions is to acknowledge the differences in implementation timelines for low-tech mechanisms such as diesel tax refunds or registration fees, compared to technology-dependent diesel tax or VMT fee systems.

Table 41. Baseline trucking market volumes and shipping characteristics—2008.

	SEGMENT VOLUMES			SHIPPING CHARACTERISTICS		
Market Segment	Ton-trips moved by segment (millions)	Total VMT including backhauls (millions)	Ton-miles moved by segment (millions)	Average length of haul (miles)	Backhaul % of VMT	Avg. tons per loaded trip
Private (Fixed)	2,339	46,269	436,525	187	31%	12.96
Private (Variable)	2,516	43,850	423,488	168	31%	13.2
Private - TOTAL	**4,856**	**90,119**	**860,013**			
Long-Term Fixed	795	18,351	165,436	208	30%	12.44
Long-Term Variable	1,644	38,780	339,679	207	27%	12.11
Short-Term Fixed	1,466	35,269	329,964	225	28%	12.57
Short-Term Variable	4,539	78,033	737,140	162	32%	12.97
Spot Market	724	13,465	124,750	172	33%	12.5
For Hire - TOTAL	**9,168**	**183,898**	**1,696,970**			
All Truck - TOTAL	**14,024**	**274,017**	**2,556,983**			

Sources: FAF, VIUS, Oak Ridge.

Actually, implementation timelines are not yet predictable given the conceptual state of most proposals.

Estimated costs were passed through each market segment to translate to higher delivered commodity prices. For private market segments, costs were passed to commodities based on the unit of taxation or fee by commodity. For for-hire market segments, costs were passed to commodities assuming that the costs would be reflected in higher per-vehicle-mile shipping rates.

The research team then determined which industries would ultimately bear the long-run costs of taxation, implementation, and compliance. The allocation was based on how industries use the affected commodities. Industries purchase either raw or intermediate commodities, add value, and sell the final product. As the delivered prices of any single commodity increase, industry impacts depend on how much of the final good value is determined by the affected commodity. This information is expressed as the "absorption," or "use," Table in an input-output economic model.

Cost Effect on Industry Growth Potential

For each of the industries listed in Table 42, the total costs of taxation, implementation, and compliance passed through from trucking translate into higher production costs. At the national level, these higher production costs reduce profits, thereby limiting the growth potential of industries by reducing the amount of capital they have for investment. Lower rates of investment ultimately reduce long-run productivity growth rates. Therefore, to estimate this effect, a statistical relationship between industry profits and productivity was established using Bureau of Economic Analysis data on components of gross domestic product (GDP).

With the statistical relationship between industry profits and productivity established, the study team then assumed that all production cost increases translated into lower industry profits and estimated the ensuing reduction in productivity. Results, shown in Table 42, indicate that a $5 billion tax burden reduces economic activity by roughly $500 million, so each additional dollar of truck tax or fee reduces long-run GDP by about $0.10. Associated with this lost GDP is lower personal income and general tax (corporate and personal income tax) revenue.

Tax Substitution Effects

Additional taxes or fees will lead businesses to change their behavior to minimize their tax burden. The research team analyzed two potential strategies that businesses might use to minimize their tax burden if additional taxes or fees are imposed:

- Substituting gasoline-powered trucks for diesel-powered trucks (applies to the diesel tax scenario only).
- Shipping by rail intermodal instead of truck (applies to all scenarios).

These substitution strategies were modeled because they were determined to be the primary options available to minimize tax burden. However, the following behaviors would also be expected to reduce net tax revenue, albeit to a lesser degree than the two listed above:

- Higher load factors (applies to fuel and VMT tax), thereby shipping more ton-miles using fewer truck miles.
- Better vehicle utilization (applies to excise tax), thereby shipping more freight using fewer trucks.
- Fewer empty backhauls (applies to fuel and VMT tax), thereby shipping more ton-miles using fewer truck miles.

Fleet Mix (Applies to Diesel Tax Only)

For the diesel fuel tax, the most significant option businesses would have to minimize the tax burden is to switch to trucks that burn other fuels. To estimate this effect, the study team designed a simple model of the tradeoffs businesses face in

Table 42. Economic impact of increased taxes (GDP, $m2010).

	Scenario			
Aggregated Industry Sector	Diesel Tax	Diesel/Gas Tax	VMT Fee	Registration Fee
Agriculture and Forestry	3	3	3	2
Mining	50	53	59	45
Utilities	0	0	0	0
Construction	80	86	96	80
Manufacturing	147	155	171	129
Wholesale Trade	24	27	30	30
Retail Trade	14	15	17	15
Transportation and Warehousing	27	31	35	40
Services	121	132	147	133
Government	0	0	0	0
TOTALS	**466**	**501**	**558**	**475**

Table 43. Diesel/gasoline cost model assumptions.

	Class 4-5 Trucks	Class 6 Trucks	Class 7-8 Trucks
Add'l price of diesel truck ($)	300	1,200	3,000
Add'l cost of operating gasoline truck (cents/mi.)	2.6	6.2	11.7
Break-even (annual miles per truck)	11,400	19,370	25,580
% of fleet that is diesel-burning (2008)*	44.80%	57.80%	90.90%

*Source: VIUS, updated to 2008 using Census.

Table 44. Average miles per truck for private and for-hire fleet mix.

Operator Type	Class 4-5	Class 6	Class 7-8
Private	13,515	11,559	25,116
For-Hire	23,417	24,697	78,234
Average	**15,050**	**13,682**	**42,846**

deciding whether to buy a diesel or gasoline truck. The research team did not model costs for other fuel types, such as natural gas, assuming that the portion of the truck market using other fuel types would continue to be negligible for the forecast period in question. Generally, diesel-burning trucks are more expensive to purchase, but they deliver lower per-mile operating costs through better fuel economy, lower maintenance costs, and longer operational life. Separate models were built for Class 4 and 5, Class 6, and Class 7 and 8 trucks. Model assumptions are shown in Table 43. This is a highly simplified model, suitable only for these high-level estimates.

In Table 43, the key result is the break-even point—the annual miles per truck at which diesel and gasoline trucks cost approximately the same. When the fleet average miles per truck is above this threshold, the majority of trucks should be diesel; when the fleet average miles per truck is below the threshold, the majority of trucks should be gasoline. In reality, the fleet for each class is composed of trucks operated under a range of conditions. Table 44 shows how the fleet breaks down for private versus for-hire operation. Underlying these averages is a distribution of annual miles per truck, per truck class. The probability of any single operator purchasing a diesel truck rather than a gasoline truck will depend on how heavily the operator plans on utilizing the truck.

To model the fleet mix change, a binomial logistical distribution was assumed for each truck class type, where the probability of purchasing a diesel truck is based on the relative cost of diesel versus gasoline for that class's average annual miles per truck. Once this distribution was fitted, the additional tax cost was used to modify the relative cost and a new fleet mix resulted. Table 45 shows the model results.

Diversion to Rail (Applies to Fuel and VMT Tax Scenarios)

To estimate diversion to rail intermodal, the research team calibrated a binary mode choice for each commodity model using the FAF database. The mode choice increment was 10 tons of freight (an average truck load), and applied only to trip lengths greater than 700 miles. The intermediate and final results are shown in Table 46.

Table 46 shows the wide variation in cross-modal elasticity by commodity, from a low of 0.0% for live animals to a high of 17.9% for plastics and rubber. In general, lower value commodities with no special handling characteristics are more likely to switch to rail if the cost of trucking rises. Many such

Table 45. Fleet mix change modeling.

Measure	Class 4-5	Class 6	Class 7-8
Baseline truck count (2008)	1,650,778	1,277,617	4,147,443
Baseline diesel trucks	739,697	738,420	3,769,296
Baseline diesel truck percent	44.8%	57.8%	90.9%
Baseline add'l cost of operating gas truck (c/mi.)	2.6	6.2	11.7
Baseline break-even annual miles/truck	11,400	19,370	25,580
New add'l cost of operating gas truck (c/mi)	0.3	3.3	8.9
New break-even annual miles/truck	large	~30,000	~40,000
New fleet % diesel	28.6%	45.5%	82.3%
New diesel truck count	472,765	580,740	3,411,799
Lost diesel trucks	266,932	157,680	357,497
Avg. annual miles per lost truck	15,000	14,000	20,000
Lost truck-miles	4,004,486,488	2,187,558,646	7,151,258,814
Lost diesel gallons consumed	400,949,836	269,237,987	851,340,335
Lost tax revenue from fleet change	**$ 93,751,612**	**$ 62,954,248**	**$ 199,063,627**

Table 46. Potential diversion to rail intermodal.

SCTG Code	SCTG Description	Baseline Data			Add'l Shipping Cost ($m/yr)				Lost Truck Miles (Billions)			Lost Trucks	Lost Revenue ($m/yr)			
		Annual Truck Trips >700 miles	Cross Mode Elasticity	Baseline Trucking Cost $m	Diesel Tax	Diesel/ Gas Tax	VMT Fee	Reg. Fee	Diesel Tax	Diesel/ Gas Tax	VMT Fee	Reg. Fee	Diesel Tax	Diesel/ Gas Tax	VMT Fee	Reg. Fee
01	Live animals/fish	11,669	0.0%	2,710	22	22	23	11	0	0	0	0	0.0	0.0	0.0	0.0
02	Cereal grains	502,725	1.5%	28,522	290	310	345	286	7	8	9	193	0.3	0.2	0.2	0.1
03	Other ag prods.	1,494,025	3.7%	19,193	187	193	212	128	53	55	60	962	2.0	1.5	1.7	0.7
04	Animal feed	762,507	2.8%	10,856	158	185	212	585	31	37	42	3,055	1.2	1.0	1.2	2.2
05	Meat/seafood	1,302,373	3.0%	5,793	72	80	90	119	49	55	62	2,138	1.9	1.5	1.7	1.5
06	Milled grain prods.	2,316,159	3.6%	12,044	159	180	204	337	110	125	141	6,124	4.1	3.5	4.0	4.3
07	Other foodstuffs	4,133,421	3.0%	23,598	291	325	366	483	153	171	192	6,686	5.8	4.8	5.4	4.7
08	Alcoholic beverages	584,917	2.7%	4,723	50	52	58	27	17	18	19	238	0.6	0.5	0.5	0.2
09	Tobacco prods.	16,111	0.4%	142	1	2	2	1	0	0	0	1	0.0	0.0	0.0	0.0
10	Building stone	47,643	0%	668	8	9	10	9	0	0	0	0	0	0	0	0
11	Natural sands	271,546	0%	12,765	152	170	192	174	0	0	0	0	0	0	0	0
12	Gravel	701,350	0%	36,820	384	402	444	230	0	0	0	0	0	0	0	0
13	Nonmetallic minerals	563,918	0%	5,588	51	53	59	28	0	0	0	0	0	0	0	0
14	Metallic ores	10,341	0%	657	7	8	9	6	0	0	0	0	0	0	0	0
15	Coal	28,016	0%	3,742	29	27	29	15	0	0	0	0	0	0	0	0
16	Crude petroleum	0	0%	2,035	16	15	16	8	0	0	0	0	0	0	0	0
17	Gasoline	182,339	0%	9,208	130	152	173	200	0	0	0	0	0	0	0	0
18	Fuel oils	361,242	0%	10,164	147	173	198	247	0	0	0	0	0	0	0	0
19	Coal-n.e.c.	733,348	0%	16,130	226	265	302	381	0	0	0	0	0	0	0	0
20	Basic chemicals	862,236	17.0%	6,524	53	51	55	25	118	115	124	1,496	4.5	3.2	3.5	1.1
21	Pharmaceuticals	492,108	8.4%	2,626	24	23	25	12	38	36	39	479	1.4	1.0	1.1	0.3
22	Fertilizers	1,598,636	10.1%	13,061	156	175	197	164	192	215	243	5,328	7.2	6.0	6.8	3.8
23	Chemical prods.	1,822,323	6.0%	17,124	207	232	261	217	133	148	167	3,651	5.0	4.1	4.7	2.6
24	Plastics/rubber	2,680,035	17.9%	13,328	120	119	129	57	431	428	465	5,374	16.3	12.0	13.0	3.8
25	Logs	31,519	0.1%	10,943	80	76	81	41	0	0	0	0	0	0	0	0
26	Wood prods.	3,168,079	4.3%	23,934	248	265	294	155	140	150	166	2,304	5.3	4.2	4.7	1.6
27	Newsprint/paper	1,200,216	17.1%	6,344	59	58	63	28	190	188	204	2,373	7.2	5.3	5.7	1.7
28	Paper articles	765,835	4.4%	5,331	59	64	71	41	38	40	45	687	1.4	1.1	1.3	0.5
29	Printed prods.	2,839,760	6.4%	11,974	118	119	130	61	180	182	198	2,440	6.8	5.1	5.6	1.7
30	Textiles/leather	1,040,118	8.6%	5,059	51	51	56	26	90	91	99	1,217	3.4	2.5	2.8	0.9
31	Nonmetal min. prods.	2,620,674	1.2%	25,080	310	346	390	321	38	42	48	1,033	1.4	1.2	1.3	0.7
32	Base metals	2,647,706	8.3%	19,495	178	176	191	85	200	199	216	2,518	7.6	5.6	6.0	1.8
33	Articles-base metal	2,391,032	3.7%	14,403	134	133	144	64	82	82	88	1,036	3.1	2.3	2.5	0.7
34	Machinery	1,107,983	1.9%	10,035	104	107	118	60	22	23	25	331	0.8	0.6	0.7	0.2
35	Electronics	1,472,081	9.1%	7,422	68	68	73	34	123	122	132	1,595	4.6	3.4	3.7	1.1
36	Motorized vehicles	2,188,905	8.4%	12,600	115	115	124	55	169	168	182	2,131	6.4	4.7	5.1	1.5
37	Transport equip.	77,837	6.7%	799	8	8	8	4	5	5	5	65	0.2	0.1	0.2	0.0
38	Precision instrument	312,082	10.4%	2,099	22	24	27	14	35	37	41	576	1.3	1.0	1.1	0.4
39	Furniture	1,261,080	4.0%	6,397	72	77	86	49	56	61	68	1,016	2.1	1.7	1.9	0.7
40	Misc. mfg. prods.	1,647,085	5.3%	9,130	99	109	123	83	95	104	117	2,079	3.6	2.9	3.3	1.5
41	Waste/scrap	290,032	0.7%	23,391	204	203	220	97	2	2	2	21	0.1	0.0	0.1	0.0
42	Unknown freight	1,143,072	13.7%	12,248	135	149	167	112	173	190	212	3,764	6.5	5.3	5.9	2.7
43	Mixed freight	105,593	0.6%	9,375	115	127	142	99	1	1	1	17	0.0	0.0	0.0	0.0
	TOTALS	**47,789,677**		**474,082**	**5,119**	**5,495**	**6,118**	**5,177**	**2,971**	**3,096**	**3,414**	**60,930**	**112.0**	**86.6**	**95.5**	**43.1**

commodities, however, are already moved predominantly by rail, so the potential for further modal shift is reduced.

Economic Impact Findings

The economic impact methodology described above yields a high-level understanding of how the different federal revenue mechanisms may impose costs on different industries in the U.S. economy over the long term and how those costs will affect the output of those industries. Since the reduced capacity for output is the principal economic impact on U.S. industries, economic impacts are summarized in terms of (1) costs imposed by industry and (2) output lost by industry. Further impact on different economic indicators could be derived from changes in output.

Table 47 shows how tax, implementation, and compliance costs ultimately accrue to broad industry groups. On

Table 47. Long-run tax and cost accrual to industry groups ($m2010).

Industry Group	Diesel Tax	Diesel/Gas Tax	VMT Fee	Registration Fee
Agriculture and Forestry	222	237	263	241
Mining	477	509	566	430
Utilities	372	396	440	332
Construction	603	649	723	607
Manufacturing	2,080	2,215	2,460	2,004
Wholesale Trade	62	69	77	77
Retail Trade	47	51	57	54
Transportation and Warehousing	210	237	267	308
Services	665	720	804	708
Government	379	412	461	416
TOTALS	**5,119**	**5,495**	**6,118**	**5,177**

Table 48. Average annual miles per truck by truck class and fleet type.

Fleet type	Class 4-5	Class 6	Class 7-8
Private	13,515	11,559	25,116
For-Hire	23,417	24,697	78,234

Source: 2002 Vehicle Inventory and Use Study (U.S. Census Bureau, 2004).

a percentage basis, the fuel tax and VMT fee scenarios are all relatively similar. These three scenarios primarily differ in magnitude from implementation and compliance costs. The registration fee scenario, however, shows a somewhat different impact on industry sectors because the mechanisms of cost accrual are different for that single scenario.

For the fuel tax and VMT fee scenarios, tax cost accrual to market segments is by truck miles (for the diesel tax, just diesel-truck miles). In contrast, the registration fee option accrues to market segments by truck count. This different mechanism of accrual translates into a significant difference in which market segments bear the immediate tax burden. Fundamentally, for-hire fleets use trucks much more intensively than private fleets. 2002 VIUS data (see Table 48) indicate that for-hire Class 6 through 8 trucks drive over twice as many miles per year as equivalent trucks in private fleets, and for-hire Class 4 through 5 trucks drive nearly twice as many miles per year as equivalent trucks in private fleets.

This means that taxes accruing on a per-mile basis (the fuel and VMT options) more heavily affect for-hire fleets, whereas the registration fee, which is levied on a vehicle basis, accrues more heavily to private fleets. These costs are then passed on to commodities based on which commodities depend on market segments, and then to industries based on how they use commodities. Ultimately, the cost accrual pattern shown in Table 47, and the resulting economic impacts shown in Table 49, are the consequence of how costs first pass through market segments.

Table 49 shows how the additional tax scenarios translate into long-run economic loss for the United States. With less profit from higher production costs, businesses will have less money to invest in product development and equipment, leading to lower economic growth potential than would otherwise occur. How these impacts occur by industry depends, first, on the magnitude of the increased production cost shown in Table 47. Beyond this, industries differ in their ability to turn investment into productivity. For example, the process of GDP growth for utilities and government sectors is relatively independent of production costs, and therefore higher pro-

Table 49. Economic impacts of tax scenarios as lost 2021 GDP ($m2012).

Industry Group	Diesel Tax	Diesel/Gas Tax	VMT Fee	Registration Fee
Agriculture and Forestry	3	3	3	2
Mining	50	53	59	45
Utilities	0	0	0	0
Construction	80	86	96	80
Manufacturing	147	155	171	129
Wholesale Trade	24	27	30	30
Retail Trade	14	15	17	15
Transportation and Warehousing	27	31	35	40
Services	121	132	147	133
General Government*	0	0	0	0
TOTALS	**466**	**501**	**558**	**475**

*Does not include net tex revenue

Table 50. Net annual government revenues ($m2010).

Revenue Type	Diesel Tax	Diesel/Gas Tax	VMT Fee	Reg. Fee
Gross Tax Revenue	5,000.0	5,000.0	5,000.0	5,000.0
Government Collection & Enforcement Costs	-4.8	-70.8	-297.7	-50.0
Lost Revenue from Diesel to Gas Fleet Conversion	-355.8	0.0	0.0	0.0
Lost Revenue from Truck to Rail Diversion	-112.0	-86.6	-95.5	-43.1
Revenue, Net of Gov't Cost and Substitution Effects	**4,527.4**	**4,842.6**	**4,606.8**	**4,906.9**

duction costs have minimal impact on these sectors. In contrast, manufacturing and service sectors are very sensitive to production costs and can readily convert increased profitability into investment and ensuing productivity.

It should be noted that no long-run employment impacts are estimated to occur. Rather, the primary economic consequence of the four options (from industry's perspective) is slower GDP growth and lower incomes.

Finally, Table 50 shows net annual government revenues. The registration fee is the most efficient mechanism because it has low collection and enforcement costs, and it has minimal substitution effects. The diesel tax and VMT fee are both relatively inefficient compared to the other two scenarios. For the diesel tax, many businesses will be flexible in their choice of engine type and therefore migrate toward gasoline-powered trucks. For the VMT fee, the primary inefficiency is the relatively high collection and enforcement costs that come from essentially creating a new collection mechanism rather than expanding existing collection methods.

CHAPTER 7

Findings and Conclusions

Leading Revenue-Generation Options

Development and evaluation of a revenue mechanism to fund freight infrastructure entails a multilevel series of choices and tradeoffs. At the highest level is the basis of fees or taxation itself—the activities, assets, or transactions that will be taxed, tolled, or surcharged. The choices and tradeoffs progress through identification of target vehicles, activities, and payers to details of the revenue collection mechanism and handling of privacy issues.

The research team evaluated a wide range of proposed federal freight infrastructure revenue generation mechanisms and concluded that the leading feasible options are a fuel tax surcharge, distance/vehicle VMT fees, and vehicle registration fees.

Other options, such as taxes on freight tonnage, freight value, ton-miles, value added, or transportation cost, were found to be impractical. Some options, such as international trade fees, were found to be ill-suited as national domestic funding mechanisms, although they may be effective when applied to specific port or trade needs.

This section discusses the research team's conclusions on the leading feasible revenue-generating options, a potential complementary role for PPPs and ITCs, the potential for increased effectiveness by using the leading feasible revenue-generating options in combination, and, finally, the relationship of each of the leading feasible revenue-generation options to current or proposed overall funding systems.

Fuel Tax Surcharge

Increasing the existing federal fuel taxes on diesel fuel and gasoline would initially appear to be the most straightforward way to increase overall revenue for transportation infrastructure. An overall fuel tax increase is supported by key industry stakeholders and appears to have relatively good public acceptance. However, an overall fuel tax increase would not yield a dedicated revenue stream for freight infrastructure.

A separate, dedicated fuel tax surcharge for freight vehicles entails multiple complications. A fuel tax surcharge could be targeted to medium- and heavy-duty trucks either by giving tax refunds or credits to other vehicles or by identifying taxable vehicles at the point of fuel purchase. The tax refund/credit option is low-tech and low-cost, but places the administrative burden on those who do not pay the tax. A tax surcharge on diesel fuel for Class 4–8 trucks with freight body types would cover only around 58% of the medium- and heavy-duty truck fleet, leaving approximately 3 million service trucks and gasoline-powered freight trucks out of the new revenue system. Covering all diesel Class 4–8 trucks would still leave out about 3.1% of the fleet, or 1.6 million vehicles. If the dedicated fuel tax surcharge covered both diesel and gasoline, it would involve virtually all 250 million U.S. vehicles.

The existing fuel tax system is highly efficient because it does not require vehicle identification, or vehicle-by-vehicle transactions and accounting. Making a fuel tax surcharge vehicle-specific negates much of the fuel tax's efficiency advantage. Technological means to identify vehicles at the point of fuel purchase would dramatically increase the implementation and collection costs of that option.

Inland waterway operators pay a fuel tax of $0.20 per gallon, with the revenue dedicated to infrastructure projects via the Inland Waterways Trust Fund. There is an industry-backed proposal to raise this tax by at least $0.06 per gallon.

It is technically feasible to levy a fuel tax on railroads. Some states do so now, although there is a legal challenge in progress. It would be difficult, however, to justify charging a mode that provides its own infrastructure a fuel tax to fund infrastructure.

The LUST Trust Fund is a mode-neutral fund created in 1986 to fund federal oversight or cleanup of leaking underground fuel storage tanks. The LUST fund is capitalized

through a $0.001 per gallon excise tax on gasoline and other motor fuels, which produced $188 million in 2009. Revenue is collected through the Highway Trust Fund (highway and rail), Inland Waterway Trust Fund, and the Airport and Airway Trust Fund. The LUST excise tax is a concrete example of a practical, dedicated revenue mechanism to support specific transportation infrastructure investment. It provides a precedent for operating a mode-neutral freight fund.

Distance/Vehicle VMT Fees

Distance/vehicle VMT fees would vary by vehicle class, and operators would be charged according to the miles traveled by each vehicle. These VMT fees would have the advantages of varying directly with mileage and fulfilling the policy desire for "user fees" rather than taxes. The cost of implementing distance/vehicle VMT fees, however, would be relatively high. VMT fees could be implemented through a costly, high-tech OBU approach or through a low-cost/low-tech mix of OBU, commercial, and self-reporting systems. In either case, there would be high federal implementation, collection, and enforcement costs and a longer implementation period than other options. Part of the attraction of VMT fees to planners and policy makers is the potential for incorporating TDM or congestion-pricing features into the revenue system. These options, however, would not be feasible with distance/vehicle VMT fees. VMT fees have relatively poor support or opposition from the public and the transportation industry.

Time/location VMT fees would permit incorporation of TDM, tolling, and congestion pricing. National time/location VMT fees for freight and service trucks, however, do not appear to be feasible or publicly acceptable for the foreseeable future. The high costs, lack of national benefits, and persistent privacy issues make it difficult to imagine circumstances under which such a system would be palatable to the industry or the public. Moreover, the TDM benefits of time/location VMT fees depend on local implementation of TDM features.

VMT fee systems, particularly time/location VMT fees, raise serious public and political issues of privacy. These issues may be able to be resolved legally and technologically, but they will nonetheless remain powerful emotional and political barriers to VMT fee systems. In particular, there appears to be strong opposition to systems that use GPS or equivalent technologies to determine and record detailed vehicle location records. The technological issues can be resolved through the use of so-called "thick" OBU clients that calculate and pay VMT fees rather than transmitting location data. Commercial systems that aggregate and pay VMT fees for entire fleets likewise address the privacy issues. Legality is unlikely to be an issue for these approaches, although there are lingering legal concerns over the ongoing collection of detailed location data. Available surveys and other data, however, strongly suggest that adverse public reaction to the *perception* of privacy invasion would make time/location or GPS-based VMT fees publicly unacceptable.

Vehicle Registration Fees

The simplest and most cost-effective means of generating revenue for a dedicated freight infrastructure fund would be a federal registration fee on Class 4–8 trucks of all types. A registration fee would not be a direct user fee, but it would be a proxy for potential truck infrastructure impact and requirements. Such registration fees could be implemented by expanding the HVUT system, which presently covers Class 7–8 trucks. Alternatively and perhaps more efficiently, a federal registration fee could be "piggybacked" on state registration fee collection. The system could incorporate the IRP, which already collects and allocates registration fees across multiple states and Canada. A registration fee would be the quickest and most efficient option to implement because it would require no new technology and could be collected and enforced via minor expansions of existing systems.

Public-Private Partnerships and Investment Tax Credits

The research team analyzed the different types of PPPs used in transportation infrastructure projects and evaluated the potential opportunities to leverage public funding. The research team determined that the major value of PPPs is not in providing capital that would otherwise be inaccessible, but in facilitating more rapid capital investment at a comparable or even lower financing cost. The sources of PPP funding can, for the most part, be accessed through revenue bonds or other instruments. The efficiency attributes of private-sector development and operation are, theoretically, accessible through outsourcing and design-build contracts without private financing. PPPs, however, may prove to be a quicker and more flexible means of tapping those funding sources and efficiencies. In that respect, the true function of PPPs may be more institutional than economic. These findings suggest that PPPs are not a substitute for revenue-generation mechanisms, but a complement that can make other mechanisms more effective by giving public agencies more choices over the timing of investments.

For railroads and potentially for other modes, ITCs for capacity enhancements are widely considered a viable means of inducing additional beneficial private investment. An ITC can be effective in encouraging additional private investment of a particular type or in a general development direction. As such, an ITC can supplement the public sector's own infrastructure

investment efforts. There is very limited evidence, however, on the amount of new private investment that is induced by ITCs. ITCs appear to be a potentially valuable part of a comprehensive freight transportation financing package, but can do only part of the job by themselves. Their usefulness is particularly limited until decisions are made on the kinds and amount of freight infrastructure to build.

Combined Strategy Options

The complexity of the freight transportation industry and the infrastructure funding challenge suggests that the candidate funding mechanisms may be more effective in combination than separately. In particular, registration fees might supplement fuel taxes or VMT fees to do the following:

- Cover electric or hybrid vehicles that would not pay fuel taxes commensurate with their infrastructure needs or impacts.
- Capture the impact of vehicle size or weight characteristics that are not reflected in a VMT fee system.
- Create incentives to turn the vehicle fleet over faster, to use fuel-efficient tires, or to take other actions consistent with national policy goals.

A combined federal freight infrastructure revenue strategy could also embrace PPPs and ITCs. As the research team found, these options can facilitate access to multiple capital sources and accelerate the project funding and development process. The availability of multiple revenue and funding tools would thus increase the ability of federal planners and decision-makers to create an equitable, effective revenue strategy with appropriate incentives.

Relationship to Overall Infrastructure Funding

While this study focused on separate revenue mechanisms for freight transportation and infrastructure, the research team noted that the options differ in their relationship to current or proposed overall funding systems.

Targeting fuel tax increases on freight movements or medium- and heavy-truck movements introduces complications that the current fuel tax system avoids. The current fuel tax system is efficient in part because there is no need to differentiate between vehicles or vehicle uses. Targeting the tax requires a means of either differentiating vehicles at the point of purchase via some technological means (e.g., a vehicle ID system) or adjusting the post-purchase tax burden (via refunds). The increased cost, complexity, and evasion possibilities inherent in targeting the tax negate some of the fuel tax advantages. Those advantages could be preserved by increasing all fuel taxes and allocating a portion of the revenue to freight infrastructure based on a formula, guidelines, or legislative outcomes. That approach, however, is essentially the current system operating with higher revenues and does not guarantee freight infrastructure funding or link the level of funding to the level of freight activity.

The infrastructure required for a VMT fee system would likely exhibit very strong scale economies. Whether the data are communicated via roadside readers, wireless connections at gas stations, Internet connections to OBUs, or cellular connections to smartphones, a truck-only or freight-only system would require the same national coverage as an all-vehicle system. Application of VMT fees or higher VMT fees to the trucking sector would appear much more efficient if a passenger-vehicle VMT system were already in place.

Revenue

This section discusses the research team's conclusions regarding revenue and costs, tax or fee rates, federal collection and enforcement costs, maximum revenue potential, long-term revenue outlook, and indexing as they relate to the revenue-generating mechanisms studied.

Revenue and Costs

For revenue-generating mechanisms, costs and cost/benefit comparisons are critical. Existing fuel taxes are an efficient, cost-effective revenue mechanism due to the simplified collection mechanism and other features that have become institutionalized over the 70+ years that fuel taxes have been collected. Restricting additional fuel taxes to freight trucks or even to all Class 4–8 trucks, however, significantly complicates fuel tax collection and increases its cost. By comparison, VMT fees would be costly to collect and enforce; implementing the technology and collecting the fees for 9 million trucks would involve high capital and compliance costs. In contrast to VMT fees, collection mechanisms are already in place for vehicle registration fees. Although registration fees are currently more costly to administer, collect, and enforce than fuel taxes in percentage terms, this is not the case in terms of absolute dollars.

Tax or Fee Rates

The tax or fee rates associated with each of the three leading revenue-generating options depend on the revenue goal, the bases for taxes or fees, and the annual quantities for those bases. Table 51 shows the relationship for an annual gross revenue target of $5 billion.

Table 51. Tax or fee rates for $5 billion gross revenue.

Revenue Option	Basis			
Fuel Tax Surcharge Options	**2008 Vehicles**	**2008 Gallons Purchased**	**$/Gal Required for $5 Billion Gross Revenue**	
Diesel fuel tax with non-freight tax refunds				
Class 7&8 freight	3,769,296	15,360,180,292	$	0.33
Class 4-8 freight	**4,892,531**	**19,937,451,447**	**$**	**0.25**
Diesel/gas* tax with non-freight refunds				
Class 7&8 freight	4,147,443	16,901,160,573	$	0.30
Class 4-8 freight	**7,075,838**	**28,834,600,558**	**$**	**0.17**
Diesel fuel tax with vehicle ID				
Class 7&8 freight	3,769,296	15,360,180,292	$	0.33
Class 7&8 all types	3,932,630	16,025,777,776	$	0.31
Class 4-8 freight	**4,892,531**	**19,937,451,447**	**$**	**0.25**
Class 4-8 all types	**6,227,636**	**25,378,110,126**	**$**	**0.20**
Diesel/gas* tax with vehicle ID				
Class 7&8 freight	4,147,443	16,901,160,573	$	0.30
Class 7&8 all types	4,327,163	17,633,532,832	$	0.28
Class 4-8 freight	**7,075,838**	**28,834,600,558**	**$**	**0.17**
Class 4-8 all types	**9,006,738**	**36,703,169,928**	**$**	**0.14**
VMT Fee Options	**2008 Vehicles**	**2008 Vehicle MilesTravelled**	**$/VMT Required for $5 Billion Gross Revenue**	
VMT Distance/ Vehicle Fee - OBU/Options				
Class 7&8 freight	4,147,443	104,740,386,072	$	0.048
Class 7&8 all types	4,327,163	109,279,065,702	$	0.046
Class 4-8 freight	**7,075,838**	**178,694,663,105**	**$**	**0.028**
Class 4-8 all types	**9,006,738**	**227,458,000,401**	**$**	**0.022**
VMT Distance/ Vehicle Fee - OBU Only				
Class 7&8 freight	4,147,443	104,740,386,072	$	0.048
Class 7&8 all types	4,327,163	109,279,065,702	$	0.046
Class 4-8 freight	**7,075,838**	**178,694,663,105**	**$**	**0.028**
Class 4-8 all types	**9,006,738**	**227,458,000,401**	**$**	**0.022**
Excise Tax Options	**2008 Vehicles**	**2008 Vehicles Operated**	**$/Vehicle Required for $5 Billion Gross Revenue**	
Annual Registration Fee				
Class 7&8 freight	4,147,443	4,147,443	$	1,206
Class 7&8 all types	4,327,163	4,327,163	$	1,155
Class 4-8 freight	**7,075,838**	**7,075,838**	**$**	**707**
Class 4-8 all types	**9,006,738**	**9,006,738**	**$**	**555**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

Federal Collection and Enforcement Costs

Estimates of federal collection and enforcement costs are summarized in Table 52. The lowest estimates are for the diesel fuel taxes with non-freight tax refunds, because that option uses the existing fuel tax system. There would be a small additional cost to process refunds or credits for several million non-freight diesel fuel purchasers. The costs for a diesel/gas option are much higher because refunds or credits would have to be processed for over 240 million vehicles.

The freight VMT fee options do not exhibit economies of scale as the number of affected vehicles rises because much of the cost is driven by vehicle-by-vehicle transactions. There would be economies of scale as the amount of the fee rose. The registration fees do have economies of scale in collection because there is an existing system and the marginal cost of adding vehicles to that system would be small.

Maximum Revenue Potential

The potential maximum, long-term, net revenue from the various options is influenced by annual federal costs of collection and enforcement; diesel tax revenue lost from conversion to gasoline-powered trucks; and fuel, VMT, and registration revenue lost from truck-to-rail modal shifts.

Table 52. Estimated annual collection and enforcement costs.

Revenue Option	Basis	Collection Costs	
Fuel Tax Surcharge Options	**2008 Vehicles**	**Annual Federal Collection and Enforcement Cost**	**Average Collection Cost per Vehicle**
Diesel fuel tax with non-freight tax refunds			
Class 7&8 freight	3,769,296	$ 6,230,704	$ 1.65
Class 4-8 freight	**4,892,531**	**$ 5,107,469**	**$ 1.04**
Diesel/gas* tax with non-freight refunds			
Class 7&8 freight	4,147,443	$ 245,852,557	$ 59.28
Class 4-8 freight	**7,075,838**	**$ 242,924,162**	**$ 34.33**
Diesel fuel tax with vehicle ID			
Class 7&8 freight	3,769,296	$ 37,692,961	$ 10.00
Class 7&8 all types	3,932,630	$ 39,326,297	$ 10.00
Class 4-8 freight	**4,892,531**	**$ 48,925,309**	**$ 10.00**
Class 4-8 all types	**6,227,636**	**$ 62,276,359**	**$ 10.00**
Diesel/gas* tax with vehicle ID			
Class 7&8 freight	4,147,443	$ 41,474,434	$ 10.00
Class 7&8 all types	4,327,163	$ 43,271,631	$ 10.00
Class 4-8 freight	**7,075,838**	**$ 70,758,380**	**$ 10.00**
Class 4-8 all types	**9,006,738**	**$ 90,067,377**	**$ 10.00**
VMT Fee Options	**2008 Vehicles**	**Annual Federal Collection and Enforcement Cost**	**Average Collection Cost per Vehicle**
VMT Distance/ Vehicle Fee - OBU/Options			
Class 7&8 freight	4,147,443	$ 195,160,519	$ 47.06
Class 7&8 all types	4,327,163	$ 201,450,710	$ 46.55
Class 4-8 freight	**7,075,838**	**$ 297,654,328**	**$ 42.07**
Class 4-8 all types	**9,006,738**	**$ 365,235,818**	**$ 40.55**
VMT Distance/ Vehicle Fee - OBU Only			
Class 7&8 freight	4,147,443	$ 195,160,519	$ 47.06
Class 7&8 all types	4,327,163	$ 201,450,710	$ 46.55
Class 4-8 freight	**7,075,838**	**$ 297,654,328**	**$ 42.07**
Class 4-8 all types	**9,006,738**	**$ 365,235,818**	**$ 40.55**
Excise Tax Options	**2008 Vehicles**	**Annual Federal Collection and Enforcement Cost**	**Average Collection Cost per Vehicle**
Annual Registration Fee			
Class 7&8 freight	4,147,443	$ 46,150,189	$ 11.13
Class 7&8 all types	4,327,163	$ 46,517,004	$ 10.75
Class 4-8 freight	**7,075,838**	**$ 50,000,000**	**$ 7.07**
Class 4-8 all types	**9,006,738**	**$ 50,000,000**	**$ 5.55**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

Table 53 provides estimates of these adjustments and net federal revenue for 2012, assuming pass-through to customers is complete by then. The results are shown graphically in Figure 11. The research team calibrated the revenue model at $5 billion annually. Therefore, the net revenue results are most trustworthy at that revenue target. As the revenue target and tax burden escalate from $5 billion to $20 billion annually, the efficiency of most options declines slightly as transportation activity shifts from truck to rail intermodal. The exception is the diesel-only fuel tax surcharge, which loses some of its value due to increased conversion of truck fleets to gasoline.

The team modeled two behavioral responses—diesel-to-gas conversion and truck-to-rail mode switch. There are other responses with less drastic impacts on net revenue, such as higher load factors, greater truck utilization, and fewer backhauls. Moreover, as tax rates rise, so will the industry response. Finally, one open question is how enforcement costs are likely to change as taxes increase.

Neither of the behavioral responses modeled are directly affected by a registration fee. As mentioned, a registration fee would create an incentive to do the same amount of shipping with fewer trucks (higher load factors, better utilization, and so forth). For the registration fee diversion effect, the research team converted lost truck miles to reduced truck purchases based on the average miles per truck over the entire fleet (roughly 38,000 miles per truck). Lost revenues were calculated by applying the average registration fee per truck to "lost trucks."

Table 53. Revenue targets and net revenue.

Option	Revenue Adjustments	2012 Revenue Target $ 5,000,000,000	$ 10,000,000,000	$ 15,000,000,000	$ 20,000,000,000
Diesel Tax	Federal Collection and Enforcement	$ 4,752,587	$ 4,752,587	$ 4,752,587	$ 4,752,587
	Diesel to Gas Conversion Loss	$ 355,769,487	$ 1,615,614,452	$ 3,973,834,308	$ 7,244,679,437
	Truck to Rail Mode Switch Loss	$ 112,042,354	$ 443,418,999	$ 994,129,934	$ 1,764,175,159
	Net Revenue	$ 4,519,895,702	$ 7,906,374,161	$ 9,960,383,379	$ 10,867,672,971
Diesel & Gas Tax	Federal Collection and Enforcement	$ 70,758,380	$ 70,758,380	$ 70,758,380	$ 70,758,380
	Diesel to Gas Conversion Loss	$ -	$ -	$ -	$ -
	Truck to Rail Mode Switch Loss	$ 86,593,064	$ 331,921,358	$ 735,984,882	$ 1,298,783,636
	Net Revenue	$ 4,836,250,883	$ 9,572,797,229	$ 14,138,880,660	$ 18,534,501,175
VMT Fee	Federal Collection and Enforcement	$ 297,654,328	$ 347,654,328	$ 397,654,328	$ 447,654,328
	Diesel to Gas Conversion Loss	$ -	$ -	$ -	$ -
	Truck to Rail Mode Switch Loss	$ 95,525,793	$ 349,536,807	$ 762,033,041	$ 1,333,014,495
	Net Revenue	$ 4,599,554,493	$ 9,276,224,217	$ 13,782,354,844	$ 18,117,946,373
Registration Fee	Federal Collection and Enforcement	$ 50,000,000	$ 50,000,000	$ 50,000,000	$ 50,000,000
	Diesel to Gas Conversion Loss	$ -	$ -	$ -	$ -
	Truck to Rail Mode Switch Loss	$ 43,054,872	$ 169,277,094	$ 378,666,668	$ 671,223,591
	Net Revenue	$ 4,901,076,525	$ 9,757,649,555	$ 14,519,719,092	$ 19,187,285,135

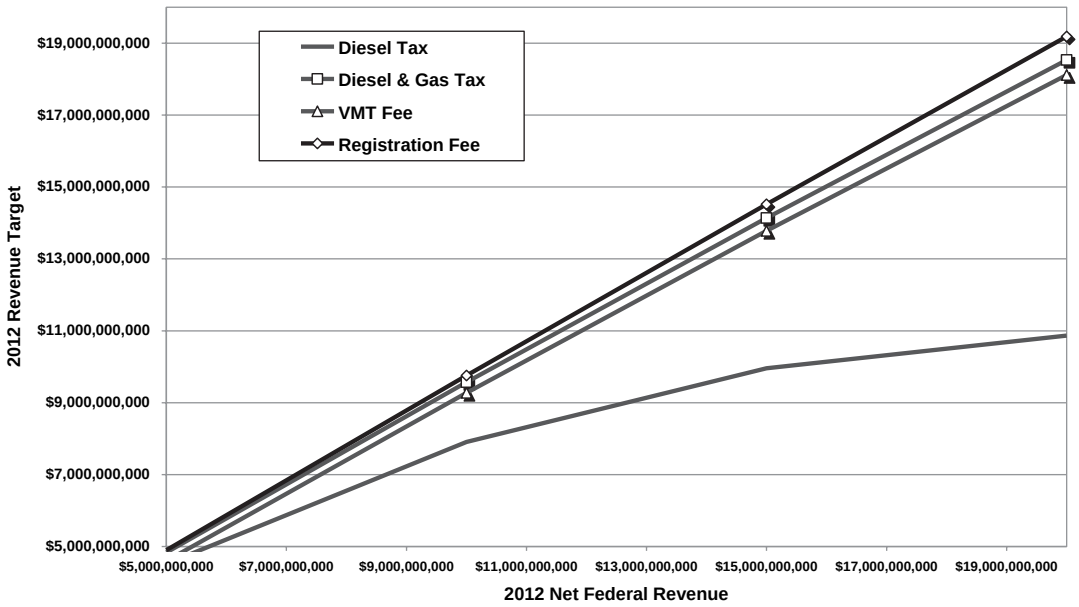


Figure 11. Revenue targets and net revenue.

The loss of revenue is limited by the underlying inelasticity of demand for freight transportation. As the economic impacts and analysis suggest, the adverse impact on commodity production and consumption would be relatively small. This observation is confirmed by the long-term resilience of freight demand in the face of steady increases in underlying fuel prices that exceed the tax or fee levels envisioned in this analysis.

Long-Term Revenue Outlook

The long-term revenue available from each option depends on the growth expected in the tax or fee base (fuel use, VMT, or truck registrations) and the offsetting costs and diversions discussed above. Table 54 summarizes available forecasts and extrapolations of forecasts for transportation activity in VMT, fuel use, and ton-miles. The growth rates vary by transportation segment, forecast source, and measurement basis. These factors were used to determine the long-term net revenue potential for each of the modeled options.

Table 55 shows an increasing tax burden for the private sector for 2012 to 2035 and the net revenue available under each option. The patterns and relationships are shown graphically in Figure 12.

For the diesel-to-gas conversion, the team used a 10-year linear phase-in. This basically assumes that diesel trucks operate about 10 years, that the average age of the current fleet is random (i.e., that there are as many 7-year-old trucks in operation as 2-year-old trucks), and that the diesel-to-gas conversion is made at the end of a truck's useful life.

Truck-to-rail mode switch is assumed to phase-in based on contract expirations (the only thing preventing immediate diversion where the economics work). The phase-in value for tax-burden pass-through to customers was used as a proxy for contract expirations. For the two fuel tax scenarios, the first, second, and third year values are 67%, 100%, and 100% respectively. For the VMT and excise tax scenarios, the equivalent values are 33%, 67%, and 100%.

As the graph in Figure 12 shows, there would be a multi-year implementation lag for revenue from the two technology-dependent sources, the diesel and gas tax with vehicle ID and the VMT fee. Net revenue from the vehicle registration fee and the diesel and gas tax surcharge tracks the gross tax burden closely. Net revenue from the VMT fee and the diesel-only tax surcharge grow at similar rates but at a lower level due to the high collection cost of VMT fees and the conversion to gasoline trucks for a diesel tax surcharge.

These growth patterns differ from those predicted for passenger vehicles or fuel use and VMT as a whole. Table 56 displays the most recent U.S. Department of Energy forecasts of long-term energy use by mode. As is apparent, the growth rate for heavy-duty vehicles (and rail) is much higher than for light-duty vehicles (cars and light trucks).

Although the fuel economy of trucks has improved and will continue to improve, the improvements for heavy-duty trucks are much smaller than the improvements for passenger cars, and increasing truck sizes and loads tend to offset technical fuel economy gains. Truck fuel use, VMT, and registrations therefore tend to grow at similar rates, and the long-term revenue growth outlook for the various options is likewise similar.

Table 54. Forecasts of U.S. transportation activity.

Factor	Information Source or Methodology	2010 Estimate	2030 Estimate	2010-2030 CAGR
Total VMT: millions of miles				
Passenger VMT	Extrapolated from FHWA Reported Statistics 1980-2000	3,313,673	4,516,142	1.56%
Truck VMT*		249,710	348,836	1.69%
Freight Truck VMT				
TL VMT	Assumes 85% (non-government, non-private fleet share) -- Vehicle type shares assumed to grow from 2008 distribution at rate consistent with ATA forecast (but maintaining linear control totals)	106,912	152,762	1.80%
LTL VMT		3,099	4,922	2.34%
Private Fleet VMT		102,243	138,826	1.54%
Non-Freight Truck VMT				
Private Service Truck VMT	Federal Highway Statistics 2008 (10% of heavy trucks government owned, assumes comparable share of VMT)	12,486	17,442	1.69%
Government Truck VMT		19,977	27,907	1.69%
Military Truck VMT		4,994	6,977	1.69%
Truck VMT by Class				
Class 1	Actual VMT from Federal Highway Statistics (extrapolated as above); classification shares derived from VIUS: http://www.census.gov/svsd/www/97vehinv.html as of July 1, 2005	3,063,963	4,167,306	1.55%
Class 2		25,697	35,898	1.69%
Class 3		23,361	32,634	1.69%
Class 4		9,089	12,697	1.69%
Class 5		7,939	11,091	1.69%
Class 6		18,099	25,284	1.69%
Class 7		8,992	12,561	1.69%
Class 8		156,533	218,671	1.69%
Truck VMT by Road Type				
Not on NHS	Extrapolated truck VMT from above allocated to highway systems based on FAF/NHPN from FHWA website.	61,067	82,053	1.49%
Interstate		124,557	178,333	1.81%
Non-Interstate STRAHNET		13,709	19,920	1.89%
STRAHNET connector		1,181	1,543	1.35%
Other NHS		48,159	65,596	1.56%
Approved Inter-Modal Connector		1,038	1,390	1.47%
Fuel Use: millions of gallons				
Highway				
Gasoline, diesel and other fuels (million gallons)	Estimates extrapolated from federal highway statistics -- if a trend appeared non-linear, an average is noted. On-highway vs. off-highway diesel is not readily available	185,867	232,003	1.11%
Truck, total		37,561	43,588	0.75%
Single-unit 2-axle 6-tire or more truck		9,320	8,709	-0.34%
Combination truck		28,241	34,879	1.06%
Truck (percent of total)		20	18	-0.59%
Rail, Class I (in freight service)				
Distillate / diesel fuel (million gallons)		3,916	3,916	0.00%
Water				
Residual fuel oil (million gallons)		5,248	5,248	0.00%
Distillate / diesel fuel oil (million gallons)		2,078	2,078	0.00%
Gasoline (million gallons)		1,310	1,865	1.78%
Pipeline				
Natural gas (million cubic feet)		519,677	265,571	-3.30%
Freight Transportation: millions of ton-miles				
TOTAL U.S. ton-miles of freight (millions)	These estimates are extrapolated from available federal transportation statistics on U.S. ton-miles	**4,380,007**	**5,287,600**	**0.95%**
Air carrier, domestic, all services		**16,989**	**23,921**	**1.73%**
Intercity truck		**1,541,024**	**2,229,420**	**1.86%**
Class I rail		**1,904,373**	**2,786,096**	**1.92%**
Domestic water transportation		**478,993**	**97,723**	**-7.64%**
Coastwise		*152,771*	*Declining*	NA
Lakewise		*50,478*	*40,963*	-1.04%
Internal		*274,089*	*246,269*	-0.53%
Intraport		*1,656*	*2,242*	1.53%
Oil pipeline		**587,249**	**576,097**	**-0.10%**

Table 55. Long-term revenue estimates.

Year	Tax Burden	Net Revenue (millions)			
		Diesel Tax	Diesel & Gas Tax	VMT Fee	Registration Fee
2012	$ 5,000	$ 4,885	$ -	$ -	$ 4,921
2013	$ 5,192	$ 4,997	$ -	$ -	$ 5,095
2014	$ 5,384	$ 5,143	$ -	$ -	$ 5,284
2015	$ 5,576	$ 5,287	$ -	$ -	$ 5,472
2016	$ 5,662	$ 5,328	$ 5,516	$ 5,289	$ 5,556
2017	$ 5,747	$ 5,368	$ 5,566	$ 5,332	$ 5,640
2018	$ 5,833	$ 5,406	$ 5,649	$ 5,374	$ 5,724
2019	$ 5,918	$ 5,443	$ 5,732	$ 5,453	$ 5,808
2020	$ 6,004	$ 5,479	$ 5,815	$ 5,532	$ 5,892
2021	$ 6,083	$ 5,508	$ 5,892	$ 5,605	$ 5,970
2022	$ 6,163	$ 5,580	$ 5,969	$ 5,678	$ 6,048
2023	$ 6,242	$ 5,652	$ 6,045	$ 5,751	$ 6,126
2024	$ 6,321	$ 5,724	$ 6,122	$ 5,824	$ 6,204
2025	$ 6,400	$ 5,796	$ 6,199	$ 5,897	$ 6,281
2026	$ 6,494	$ 5,880	$ 6,290	$ 5,983	$ 6,373
2027	$ 6,588	$ 5,965	$ 6,380	$ 6,070	$ 6,465
2028	$ 6,681	$ 6,050	$ 6,471	$ 6,156	$ 6,557
2029	$ 6,775	$ 6,135	$ 6,562	$ 6,242	$ 6,649
2030	$ 6,869	$ 6,219	$ 6,652	$ 6,328	$ 6,741
2031	$ 6,976	$ 6,317	$ 6,757	$ 6,428	$ 6,847
2032	$ 7,084	$ 6,415	$ 6,861	$ 6,527	$ 6,952
2033	$ 7,192	$ 6,512	$ 6,965	$ 6,626	$ 7,058
2034	$ 7,300	$ 6,610	$ 7,070	$ 6,726	$ 7,164
2035	$ 7,407	$ 6,707	$ 7,174	$ 6,825	$ 7,269

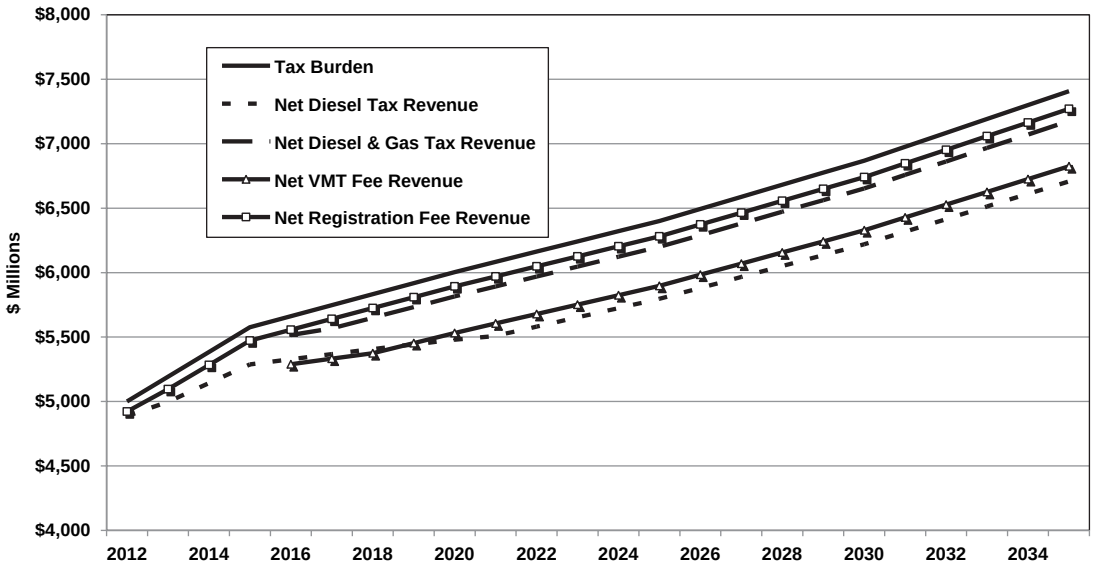


Figure 12. Long-term revenue estimates.

Table 56. Long-term energy consumption by mode (quadrillion Btu).

Segment	2009	2035	CAGR
Light-duty vehicles	16.71	18.39	0.4%
Heavy-duty vehicles	4.53	6.68	1.5%
Air	2.66	3.07	0.6%
Marine	1.24	1.35	0.3%
Rail	0.56	0.76	1.2%
Pipeline	0.65	0.67	0.1%
Total	**26.35**	**30.92**	**0.6%**

Source: U.S. Energy Information Administration, April 2011.

Indexing

Any proposed revenue mechanism would need to incorporate indexing or some other means of adjustment to fulfill long-term freight infrastructure funding needs. There are at least two purposes to indexing taxes or fees:

- To keep the taxes or fees in proportion with broader cost and price trends so that fuels, VMT fees, or registration fees do not become markedly more or less expensive than other goods and services and introduce market distortions.
- To preserve (or improve) revenue buying power for building and maintaining transportation infrastructure.

Federal fuel taxes have not been increased since 1993, and there is no mechanism for adjusting them to reflect inflation. Revenues have not risen with inflation as consumer goods prices typically do, and the buying power of fuel tax revenue has eroded as the cost of infrastructure and maintenance has risen.

Figure 13 illustrates the erosion of fuel tax buying power by comparing existing Highway Trust Fund Highway Account fuel tax rates with indexed rates based on the Consumer Price Index (CPI, with 1956=100) and on fuel economy (with 1970=100). The graph therefore shows what the 1956 fuel tax rates would have become if they had increased at the same rate as the CPI or fuel economy. These trend lines understate the magnitude of the full problem as they do not account for the impact of increased truck weights.

The following conclusions are evident:

- Since 1956, the tax on diesel fuel has largely kept pace with inflation while the much more financially important tax on gasoline (approximately 70% of fuel tax revenue) has lagged inflation since the early 1970s.
- Neither tax has kept pace with the combined impact on buying power from both inflation and increased fuel economy.

These observations make a clear case for indexing future taxes or fees used to support infrastructure. The pattern shown in Figure 13 is not intrinsic to the fuel tax. Any federal or state tax or fee that is not appropriately indexed will face the same issues. VMT fees offer the advantage of increasing with vehicle travel and road use, regardless of vehicle technology or power source. This feature will not, however, obviate the need to either index VMT fees or adjust them periodically to account for inflation. Registration fee revenues would grow as the subject vehicle fleet grows over time. While there is thus some parallel between registration fee revenue and infrastructure needs, the increasing size and capacity of vehicles, and the rising unit costs of infrastructure would require a registration fee to be indexed as well.

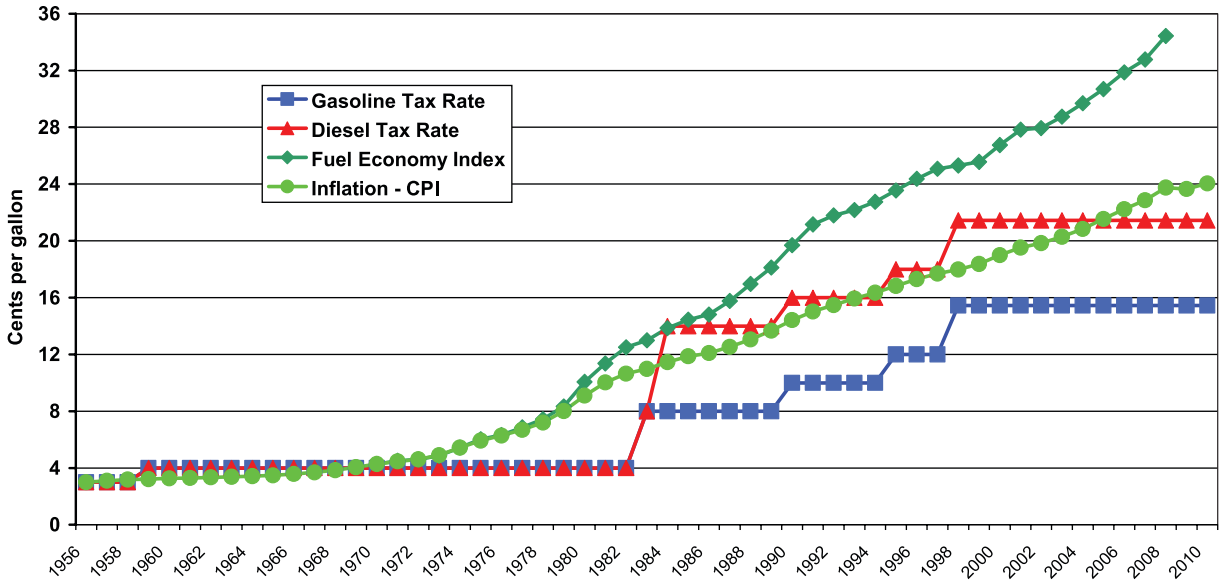


Figure 13. The impacts of inflation and fuel economy on federal motor fuel taxes.

There are two cost indexes specifically designed to reflect highway construction costs—FHWA's NHCCI and an overall PPI for the Highway and Street Construction Industry compiled by the Bureau of Labor Statistics (BLS) ("BHWY"). NHCCI can be used both to track price changes associated with highway construction costs and to convert current dollar expenditures on highway construction to real or constant dollar expenditures. NHCCI tracks price changes through a database of bids received on state transportation projects in 45 states. NHCCI is intended to replace FHWA's dated Bid-Price Index (BPI). "BHWY" covers inputs, principally materials and services, but does not include labor.

Figure 14 compares these two indexes with the BLS CPI on a common basis of 2003=100. There is a marked divergence between the BLS PPI/BHWAY and the FHWA NHCCI starting in 2007. This may be because the prices of material inputs, especially those derived from petroleum, continued to rise during the recession (as reflected in the BLS PPI/BHWAY). Bids may have declined due to scarcity of contracts and intense competition (FHWA NHCCI).

There are also indexes published by trade associations and industry journals. The American Road and Transportation Builders Association in the monthly *Construction Material Cost Report* tracks changes in material prices. The *Engineering News-Record,* a leading engineering industry journal, publishes a Construction Cost Index (CCI), a Building Cost Index (BCI), and a Materials Cost Index (MCI) that are widely used in the construction industry. All three indexes have a materials and labor component. The CCI can be used where labor costs are a high proportion of total costs. The BCI is more applicable for structures. The MCI covers concrete, steel, and lumber cost changes.

The final choice of a basis for indexing freight taxes or fees will be affected by analytical concerns and policy goals. Nonetheless, there is a need to find or develop a workable cost index methodology.

Implementation and Costs

This section discusses the research team's conclusions regarding implementation and compliance costs and implementation and phase-in of the leading revenue-generating options.

Implementation and Compliance Costs

Table 57 provides estimates of federal government and freight industry implementation costs. The fuel tax is well established, and its operation is embedded in industry practice. Any new option will inevitably seem disruptive and complex by comparison, but, with sufficient industry knowledge, the disruption can be assessed and the risks reduced. Revenue mechanisms that build on existing tax, fee, or regulatory systems without introducing new technology or infrastructure have the lowest implementation, collection, and compliance costs, and the closest implementation horizon. For the fuel tax surcharges with tax system refunds or credits, the compliance costs would be born primarily by non-freight purchasers who would need to file for refunds or credits.

The estimates for industry compliance costs shown in Table 58 are lower for low-tech options that do not require technology and higher for high-tech options that do.

Implementation and Phase-In

The varying implementation costs, implementation timelines, and annual net federal revenues of the leading options would yield significantly different levels of funding during the phase-in period. Table 59 displays the estimated net federal revenue for the first 10 years after approval and the

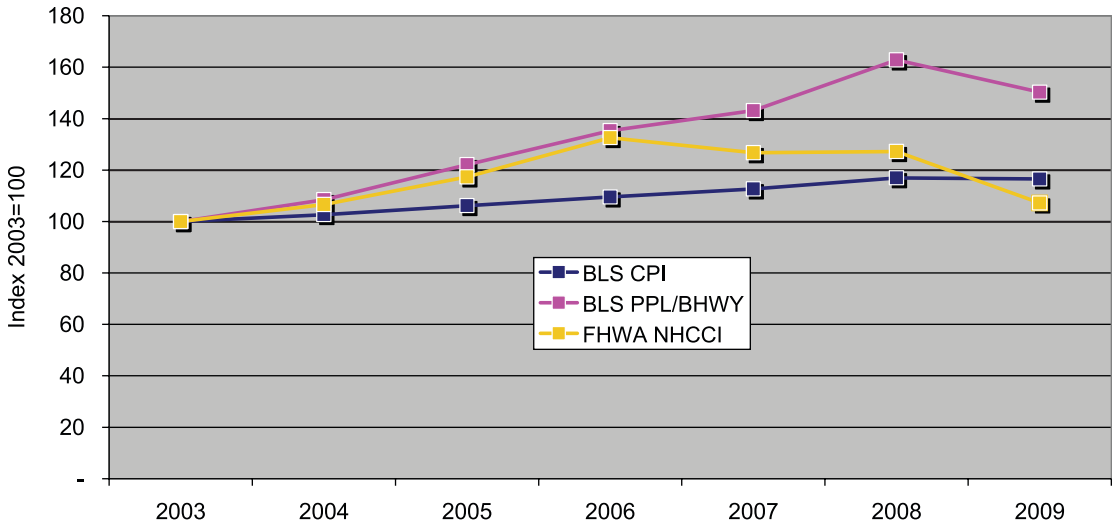


Figure 14. Comparison of highway construction cost indexes.

Table 57. Implementation cost estimates.

Fuel Tax Surcharge Options	Federal Implementation Cost	Avg. Federal Implementation Cost per Vehicle	Annual Equivalent Assuming 10-Year Life	Freight Industry Implementation Cost	Avg. Industry Implementation Cost per Vehicle	Annual Equivalent Assuming 5-Year Life
Diesel fuel tax with non-freight tax refunds						
Class 7&8 freight	$ -	$ -	$ -	$ -	$ -	$ -
Class 4-8 freight	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Diesel/gas* tax with non-freight refunds						
Class 7&8 freight	$ -	$ -	$ -	$ -	$ -	$ -
Class 4-8 freight	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Diesel fuel tax with vehicle ID						
Class 7&8 freight	$ 1,500,000,000	$ 398	$ 150,000,000	$ 376,929,607	$ 100.00	$ 75,385,921
Class 7&8 all types	$ 1,500,000,000	$ 381	$ 150,000,000	$ 393,262,970	$ 100.00	$ 78,652,594
Class 4-8 freight	**$ 1,500,000,000**	**$ 307**	**$ 150,000,000**	**$ 489,253,095**	**$ 100.00**	**$ 97,850,619**
Class 4-8 all types	**$ 1,500,000,000**	**$ 241**	**$ 150,000,000**	**$ 622,763,594**	**$ 100.00**	**$ 124,552,719**
Diesel/gas* tax with vehicle ID						
Class 7&8 freight	$ 3,000,000,000	$ 723	$ 300,000,000	$ 414,744,339	$ 100.00	$ 82,948,868
Class 7&8 all types	$ 3,000,000,000	$ 693	$ 300,000,000	$ 432,716,314	$ 100.00	$ 86,543,263
Class 4-8 freight	**$ 3,000,000,000**	**$ 424**	**$ 300,000,000**	**$ 707,583,795**	**$ 100.00**	**$ 141,516,759**
Class 4-8 all types	**$ 3,000,000,000**	**$ 333**	**$ 300,000,000**	**$ 900,673,766**	**$ 100.00**	**$ 180,134,753**

VMT Fee Options	Federal Implementation Cost	Avg. Federal Implementation Cost per Vehicle	Annual Equivalent Assuming 10-Year Life	Freight Industry Implementation Cost	Avg. Industry Implementation Cost per Vehicle	Annual Equivalent Assuming 5-Year Life
VMT Distance/ Vehicle Fee - OBU/Options						
Class 7&8 freight	$ 3,000,000,000	$ 723	$ 300,000,000	$ 1,036,860,847	$ 250.00	$ 207,372,169
Class 7&8 all types	$ 3,000,000,000	$ 693	$ 300,000,000	$ 1,081,790,786	$ 250.00	$ 216,358,157
Class 4-8 freight	**$ 3,000,000,000**	**$ 424**	**$ 300,000,000**	**$ 1,768,959,488**	**$ 250.00**	**$ 353,791,898**
Class 4-8 all types	**$ 3,000,000,000**	**$ 333**	**$ 300,000,000**	**$ 2,251,684,414**	**$ 250.00**	**$ 450,336,883**
VMT Distance/ Vehicle Fee - OBU Only						
Class 7&8 freight	$ 3,000,000,000	$ 723	$ 300,000,000	$ 2,073,721,693	$ 500.00	$ 414,744,339
Class 7&8 all types	$ 3,000,000,000	$ 693	$ 300,000,000	$ 2,163,581,572	$ 500.00	$ 432,716,314
Class 4-8 freight	**$ 3,000,000,000**	**$ 424**	**$ 300,000,000**	**$ 3,537,918,975**	**$ 500.00**	**$ 707,583,795**
Class 4-8 all types	**$ 3,000,000,000**	**$ 333**	**$ 300,000,000**	**$ 4,503,368,829**	**$ 500.00**	**$ 900,673,766**

Excise Tax Options	Federal Implementation Cost	Avg. Federal Implementation Cost per Vehicle	Annual Equivalent Assuming 10-Year Life	Freight Industry Implementation Cost	Avg. Industry Implementation Cost per Vehicle	Annual Equivalent Assuming 5-Year Life
Annual Registration Fee						
Class 7&8 freight	$ -	$ -	$ -	$ -	$ -	$ -
Class 7&8 all types	$ -	$ -	$ -	$ -	$ -	$ -
Class 4-8 freight	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Class 4-8 all types	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

Table 58. Compliance cost estimates.

Fuel Tax Surcharge Options	Annual Private-Sector Compliance Cost
Diesel fuel tax with non-freight tax refunds	
Class 7&8 freight	$ 155,767,598
Class 4-8 freight	**$ 127,686,726**
Diesel/gas* tax with non-freight refunds	
Class 7&8 freight	$ 6,146,313,915
Class 4-8 freight	**$ 6,073,104,051**
Diesel fuel tax with vehicle ID	
Class 7&8 freight	$ 188,464,804
Class 7&8 all types	$ 196,631,485
Class 4-8 freight	**$ 244,626,547**
Class 4-8 all types	**$ 311,381,797**
Diesel/gas* tax with vehicle ID	
Class 7&8 freight	$ 207,372,169
Class 7&8 all types	$ 216,358,157
Class 4-8 freight	**$ 353,791,898**
Class 4-8 all types	**$ 450,336,883**
VMT Fee Options	**Annual Private-Sector Compliance Cost**
VMT Distance/ Vehicle Fee - OBU/Options	
Class 7&8 freight	$ 447,923,886
Class 7&8 all types	$ 467,333,620
Class 4-8 freight	**$ 764,190,499**
Class 4-8 all types	**$ 972,727,667**
VMT Distance/ Vehicle Fee - OBU Only	
Class 7&8 freight	$ 447,923,886
Class 7&8 all types	$ 467,333,620
Class 4-8 freight	**$ 764,190,499**
Class 4-8 all types	**$ 972,727,667**
Excise Tax Options	**Annual Private-Sector Compliance Cost**
Annual Registration Fee	
Class 7&8 freight	$ 103,686,085
Class 7&8 all types	$ 108,179,079
Class 4-8 freight	**$ 176,895,949**
Class 4-8 all types	**$ 225,168,441**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

net present value (NPV). In both cases, the estimates are for application to Class 4–8 freight trucks; wider application would yield higher total numbers but also greater disparities.

The large differences in NPV are traceable to the higher implementation costs and longer lead times before the first revenue from technology-dependent options.

Revenue Efficiency

This section discusses the research team's conclusions regarding net revenue and net cost and scale economies as these relate to the leading revenue-generating mechanisms.

Net Revenue and Net Cost

Table 60 provides estimates of net annual federal revenue ($5 billion less collection and annualized implementation costs) and annual industry cost ($5 billion plus annualized implementation and compliance costs), and these costs are broken down into net annual revenue per vehicle and annual cost per vehicle. Table 60 also provides the ratio of net federal revenue to annual industry cost. This ratio can be used to compare the overall revenue efficiency of the various options. The numerical values shown in Table 60 would be regarded as rough approximations suitable for relative comparisons. Table 60 shows the following:

- The highest efficiency ratios are for the diesel fuel tax with tax refunds and the vehicle registration fees, due to their absence of significant implementation costs. Both of these options build on existing collection systems.
- Options that rely heavily on technology, namely, the fuel taxes with vehicle ID and the VMT fees, have high

Table 59. Net federal revenue during phase-in for Class 4–8 freight trucks.

Revenue Option	Federal Net Revenue by Year for Class 4-8 Freight Trucks (millions)										
	1	2	3	4	5	6	7	8	9	10	NPV
Diesel fuel tax with non-freight refunds	$ -	$4,995	$4,995	$4,995	$4,995	$4,995	$4,995	$4,995	$4,995	$4,995	**$ 33,812**
Diesel/gas tax with non-freight refunds	$ -	$4,757	$4,757	$4,757	$4,757	$4,757	$4,757	$4,757	$4,757	$4,757	**$ 32,202**
Diesel fuel tax with vehicle ID	$(300)	$ (300)[a]	$ (300)	$ (300)	$4,801	$4,801	$4,801	$4,801	$4,801	$4,801	**$ 18,984**
Diesel/gas tax with vehicle ID	$(600)	$ (600)	$ (600)	$ (600)	$4,629	$4,629	$4,629	$4,629	$4,629	$4,629	**$ 17,203**
VMT Distance/ Vehicle Tax - OBU/Options	$(600)	$ (600)	$ (600)	$ (600)	$4,402	$4,402	$4,402	$4,402	$4,402	$4,402	**$ 16,256**
VMT Distance/ Vehicle Tax - OBU Only	$(600)	$ (600)	$ (600)	$ (600)	$4,402	$4,402	$4,402	$4,402	$4,402	$4,402	**$ 16,256**
Annual Registration Fee	$ -	$4,950	$4,950	$4,950	$4,950	$4,950	$4,950	$4,950	$4,950	$4,950	**$ 33,508**

[a] Parentheses mean cost rather than revenue.

Table 60. Revenue efficiency comparisons.

Fuel Tax Surcharge Options	Net Annual Federal Revenue	Net Annual Avg. Rev. per Vehicle	Annual Industry Cost	Annual Avg. Cost per Vehicle	Ratio
Diesel fuel tax with non-freight tax refunds					
Class 7&8 freight	$ 4,993,769,296	$ 1,325	$ 5,155,767,598	$ 1,368	**0.97**
Class 4-8 freight	**$ 4,994,892,531**	**$ 1,021**	**$ 5,127,686,726**	**$ 1,048**	**0.97**
Diesel/gas* tax with non-freight refunds					
Class 7&8 freight	$ 4,754,147,443	$ 1,146	$ 11,146,313,915	$ 2,688	**0.43**
Class 4-8 freight	**$ 4,757,075,838**	**$ 672**	**$ 11,073,104,051**	**$ 1,565**	**0.43**
Diesel fuel tax with vehicle ID					
Class 7&8 freight	$ 4,812,307,039	$ 1,277	$ 5,263,850,725	$ 1,397	**0.91**
Class 7&8 all types	$ 4,810,673,703	$ 1,223	$ 5,275,284,079	$ 1,341	**0.91**
Class 4-8 freight	**$ 4,801,074,691**	**$ 981**	**$ 5,342,477,166**	**$ 1,092**	**0.90**
Class 4-8 all types	**$ 4,787,723,641**	**$ 769**	**$ 5,435,934,516**	**$ 873**	**0.88**
Diesel/gas* tax with vehicle ID					
Class 7&8 freight	$ 4,658,525,566	$ 1,123	$ 5,290,321,037	$ 1,276	**0.88**
Class 7&8 all types	$ 4,656,728,369	$ 1,076	$ 5,302,901,420	$ 1,225	**0.88**
Class 4-8 freight	**$ 4,629,241,620**	**$ 654**	**$ 5,495,308,657**	**$ 777**	**0.84**
Class 4-8 all types	**$ 4,609,932,623**	**$ 512**	**$ 5,630,471,636**	**$ 625**	**0.82**
VMT Fee Options	**Net Annual Federal Revenue**	**Net Annual Avg. Rev. per Vehicle**	**Annual Industry Cost**	**Annual Avg. Cost per Vehicle**	**Ratio**
VMT Distance/ Vehicle Fee - OBU/Options					
Class 7&8 freight	$ 4,504,839,481	$ 1,086	$ 5,655,296,055	$ 1,364	**0.80**
Class 7&8 all types	$ 4,498,549,290	$ 1,040	$ 5,683,691,777	$ 1,313	**0.79**
Class 4-8 freight	**$ 4,402,345,672**	**$ 622**	**$ 6,117,982,396**	**$ 865**	**0.72**
Class 4-8 all types	**$ 4,334,764,182**	**$ 481**	**$ 6,423,064,550**	**$ 713**	**0.67**
VMT Distance/ Vehicle Fee - OBU Only					
Class 7&8 freight	$ 4,504,839,481	$ 1,086	$ 5,862,668,224	$ 1,414	**0.77**
Class 7&8 all types	$ 4,498,549,290	$ 1,040	$ 5,900,049,934	$ 1,363	**0.76**
Class 4-8 freight	**$ 4,402,345,672**	**$ 622**	**$ 6,471,774,294**	**$ 915**	**0.68**
Class 4-8 all types	**$ 4,334,764,182**	**$ 481**	**$ 6,873,401,433**	**$ 763**	**0.63**
Excise Tax Options	**Net Annual Federal Revenue**	**Net Annual Avg. Rev. per Vehicle**	**Annual Industry Cost**	**Annual Avg. Cost per Vehicle**	**Ratio**
Annual Registration Fee					
Class 7&8 freight	$ 4,953,849,811	$ 1,194	$ 5,103,686,085	$ 1,231	**0.97**
Class 7&8 all types	$ 4,953,482,996	$ 1,145	$ 5,108,179,079	$ 1,180	**0.97**
Class 4-8 freight	**$ 4,950,000,000**	**$ 700**	**$ 5,176,895,949**	**$ 732**	**0.96**
Class 4-8 all types	**$ 4,950,000,000**	**$ 550**	**$ 5,225,168,441**	**$ 580**	**0.95**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
Notes: * "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

implementation and collection costs that dilute their revenue-generating effectiveness.

- The lowest ratio is for the diesel/gas fuel tax with tax refunds since it would require the great majority of vehicle owners—about 240 million—to file for refunds.

The other key statistic shown is the annual average cost per vehicle. The diesel fuel tax with non-freight refunds achieves part of its apparently high efficiency by placing a relatively heavy burden on relatively few trucks. The lowest average cost per truck is for the widest possible application of registration fees, that is, to all Class 4–8 trucks.

Scale Economies

Technology-intensive revenue-generation options demonstrate significant economies of scale because their implementation, collection, and compliance costs are essentially independent of the tax or fee rates and the resulting gross revenue. Table 61 displays tax or fee rates, net federal revenue, industry cost, and the ratio of revenue to cost for gross revenue targets of $5 billion, $10 billion, and $20 billion. The ratio of revenue to cost rises for all options as the revenue goal increases, but the improvements are greatest for the high-tech options—fuel taxes with vehicle ID and the VMT fees. Even at the $20 billion scale, however, the ratios for the OBU-only VMT options remain noticeably lower.

Technical Feasibility

Technical feasibility within the freight sector is not an issue for any of the options, although time/location VMT fees do present some technical challenges. The technical differences show up in implementation time, cost, and evasion potential.

Table 61. Scale economies.

Revenue Option	$5 Billion Revenue Goal				$10 Billion Revenue Goal				$20 Billion Revenue Goal			
Fuel Tax Surcharge Options	**$/Gal**	**Net Annual Federal Revenue (billion)**	**Annual Industry Cost (billion)**	**Ratio**	**$/Gal**	**Net Annual Federal Revenue (billion)**	**Annual Industry Cost (billion)**	**Ratio**	**$/Gal**	**Net Annual Federal Revenue (billion)**	**Annual Industry Cost (billion)**	**Ratio**
Diesel fuel tax with non-freight tax refunds												
Class 7&8 freight	$ 0.33	$ 5.0	$ 5.2	**0.97**	$ 0.65	$ 10.0	$ 10.1	**0.99**	$ 1.30	$ 20.0	$ 20.2	**0.99**
Class 4-8 freight	**$ 0.25**	**$ 5.0**	**$ 5.1**	**0.97**	**$ 0.50**	**$ 10.0**	**$ 10.1**	**0.99**	**$ 1.00**	**$ 20.0**	**$ 20.1**	**0.99**
Diesel/gas* tax with non-freight refunds												
Class 7&8 freight	$ 0.30	$ 4.8	$ 11.1	**0.43**	$ 0.59	$ 9.9	$ 13.8	**0.72**	$ 1.18	$ 19.8	$ 26.1	**0.76**
Class 4-8 freight	**$ 0.17**	**$ 4.8**	**$ 11.1**	**0.43**	**$ 0.35**	**$ 9.9**	**$ 13.8**	**0.72**	**$ 0.69**	**$ 19.8**	**$ 26.1**	**0.76**
Diesel fuel tax with vehicle ID												
Class 7&8 freight	$ 0.33	$ 4.8	$ 5.3	**0.91**	$ 0.65	$ 9.7	$ 10.3	**0.95**	$ 1.30	$ 19.8	$ 20.3	**0.98**
Class 7&8 all types	$ 0.31	$ 4.8	$ 5.3	**0.91**	$ 0.62	$ 9.7	$ 10.3	**0.95**	$ 1.25	$ 19.8	$ 20.3	**0.98**
Class 4-8 freight	**$ 0.25**	**$ 4.8**	**$ 5.3**	**0.90**	**$ 0.50**	**$ 9.7**	**$ 10.3**	**0.94**	**$ 1.00**	**$ 19.8**	**$ 20.3**	**0.97**
Class 4-8 all types	**$ 0.20**	**$ 4.8**	**$ 5.4**	**0.88**	**$ 0.39**	**$ 9.6**	**$ 10.4**	**0.92**	**$ 0.79**	**$ 19.8**	**$ 20.4**	**0.97**
Diesel/gas* tax with vehicle ID												
Class 7&8 freight	$ 0.30	$ 4.7	$ 5.3	**0.88**	$ 0.59	$ 9.6	$ 10.3	**0.93**	$ 1.18	$ 19.7	$ 20.3	**0.97**
Class 7&8 all types	$ 0.28	$ 4.7	$ 5.3	**0.88**	$ 0.57	$ 9.5	$ 10.3	**0.93**	$ 1.13	$ 19.7	$ 20.3	**0.97**
Class 4-8 freight	**$ 0.17**	**$ 4.6**	**$ 5.5**	**0.84**	**$ 0.35**	**$ 9.5**	**$ 10.5**	**0.90**	**$ 0.69**	**$ 19.6**	**$ 20.5**	**0.96**
Class 4-8 all types	**$ 0.14**	**$ 4.6**	**$ 5.6**	**0.82**	**$ 0.27**	**$ 9.4**	**$ 10.6**	**0.88**	**$ 0.54**	**$ 19.6**	**$ 20.6**	**0.95**
VMT Fee Options	**$/VMT**	**Net Annual Federal Revenue (billion)**	**Annual Industry Cost (billion)**	**Ratio**	**$/VMT**	**Net Annual Federal Revenue (billion)**	**Annual Industry Cost (billion)**	**Ratio**	**$/VMT**	**Net Annual Federal Revenue (billion)**	**Annual Industry Cost (billion)**	**Ratio**
VMT Distance/ Vehicle Fee - OBU/Options												
Class 7&8 freight	$ 0.048	$ 4.5	$ 5.7	**0.80**	$ 0.095	$ 9.6	$ 10.7	**0.90**	$ 0.191	$ 19.4	$ 20.7	**0.94**
Class 7&8 all types	$ 0.046	$ 4.5	$ 5.7	**0.79**	$ 0.092	$ 9.5	$ 10.7	**0.89**	$ 0.183	$ 19.3	$ 20.7	**0.94**
Class 4-8 freight	**$ 0.028**	**$ 4.4**	**$ 6.1**	**0.72**	**$ 0.056**	**$ 9.5**	**$ 11.1**	**0.85**	**$ 0.112**	**$ 19.3**	**$ 21.1**	**0.91**
Class 4-8 all types	**$ 0.022**	**$ 4.3**	**$ 6.4**	**0.67**	**$ 0.044**	**$ 9.4**	**$ 11.4**	**0.82**	**$ 0.088**	**$ 19.2**	**$ 21.4**	**0.90**
VMT Distance/ Vehicle Fee - OBU Only												
Class 7&8 freight	$ 0.048	$ 4.5	$ 5.9	**0.77**	$ 0.095	$ 9.6	$ 10.9	**0.88**	$ 0.191	$ 19.4	$ 20.9	**0.93**
Class 7&8 all types	$ 0.046	$ 4.5	$ 5.9	**0.76**	$ 0.092	$ 9.5	$ 10.9	**0.88**	$ 0.183	$ 19.3	$ 20.9	**0.93**
Class 4-8 freight	**$ 0.028**	**$ 4.4**	**$ 6.5**	**0.68**	**$ 0.056**	**$ 9.5**	**$ 11.5**	**0.82**	**$ 0.112**	**$ 19.3**	**$ 21.5**	**0.90**
Class 4-8 all types	**$ 0.022**	**$ 4.3**	**$ 6.9**	**0.63**	**$ 0.044**	**$ 9.4**	**$ 11.9**	**0.79**	**$ 0.088**	**$ 19.2**	**$ 21.9**	**0.88**
Excise Tax Options	**$/Vehicle**	**Net Annual Federal Revenue (billion)**	**Annual Industry Cost (billion)**	**Ratio**	**$/Vehicle**	**Net Annual Federal Revenue (billion)**	**Annual Industry Cost (billion)**	**Ratio**	**$/Vehicle**	**Net Annual Federal Revenue (billion)**	**Annual Industry Cost (billion)**	**Ratio**
Annual Registration Fee												
Class 7&8 freight	$ 1,206	$ 5.0	$ 5.1	**0.97**	$ 2,411	$ 10.0	$ 10.0	**0.99**	$ 4,822	$ 20.0	$ 20.1	**0.99**
Class 7&8 all types	$ 1,155	$ 5.0	$ 5.1	**0.97**	$ 2,311	$ 10.0	$ 10.0	**0.99**	$ 4,622	$ 20.0	$ 20.1	**0.99**
Class 4-8 freight	**$ 707**	**$ 5.0**	**$ 5.2**	**0.96**	**$ 1,413**	**$ 9.9**	**$ 10.1**	**0.99**	**$ 2,827**	**$ 20.0**	**$ 20.2**	**0.99**
Class 4-8 all types	**$ 555**	**$ 5.0**	**$ 5.2**	**0.95**	**$ 1,110**	**$ 9.9**	**$ 10.1**	**0.98**	**$ 2,221**	**$ 20.0**	**$ 20.2**	**0.99**

Source: Tioga Group Analysis of 2002 VIUS (U.S. Census Bureau, 2004) and Table VM-1 of Highway Statistics 2009 (FHWA, 2009).
* "Gas" in this case includes gasoline, natural gas, propane, alcohol fuels, and blends.

For all three candidate mechanisms, low-tech implementation approaches result in lower implementation, collection, and compliance costs; shorter implementation timelines; and greater revenue-generation efficiency. In all three cases, low-tech collection methods could build on existing systems.

- Diesel or diesel/gas tax increases with refunds or credits for non-freight or light-vehicle operators could be implemented through relatively small changes in the existing fuel tax and income tax systems.
- VMT fees for trucks could be implemented through a combination of IFTA participation, commercial fuel card systems, and self-reporting enforced through cross-checks with state registration systems.
- A federal vehicle registration fee (or an extension of the HVUT) could be implemented through the existing HVUT system or by piggybacking on state vehicle registration systems.

High-tech collection solutions may offer greater precision, potential linkages to future traffic-management systems, or other non-revenue advantages, but would entail higher implementation, collection, and compliance costs. Implementation costs would include technology development, system and network deployment, and vehicle ID tag or OBU installation. Implementation costs would recur due to technology turnover, equipment lifespan, and new vehicle purchases. Federal collection and enforcement costs would include data bandwidth, systems operation and maintenance, auditing, and enforcement actions. Compliance costs would include OBU maintenance and replacement, record-keeping, and tax/fee transaction costs.

Multimodal Application

One major issue to be addressed across all the alternatives is the extent to which they could be applied to multiple freight modes or to trucks only. The nation's freight infrastructure encompasses highways, roads, railroads, ports, inland and coastal waterways, airports, and pipelines. From a national planning and policy perspective, it would be desirable to have an infrastructure funding mechanism that could cover all these modes as required to achieve revenue and policy objectives. In most contexts, "freight infrastructure" refers to the surface modes—highway, rail, and water—and excludes pipeline and air. This study follows that convention. Airport infrastructure and operations, including air cargo, have their own revenue sources and funding infrastructure. There is little or no public involvement in pipeline infrastructure.

This section discusses the three leading revenue-generating options—fuel tax surcharge, VMT fee, and registration fee—in terms of their potential application to multiple freight transportation modes.

Multimodal Fuel Tax Surcharge

A fuel tax surcharge could cover all modes that use fuel. Off-road uses, which include railroads, waterways, and air freight operations, are currently exempt from the major federal fuel taxes. Railroads and waterways do, however, contribute to the LUST fund, so there is a precedent for fuel taxation across the surface modes.

Table 62 illustrates multimodal fuel tax surcharge options. Currently, diesel trucks pay $0.244 per gallon in federal fuel tax and inland waterway vessels pay $0.20. Of the total, only the inland waterway portion, $73.9 million, is dedicated to

Table 62. Multimodal fuel tax options.

Fuel Tax Option		2008 Gallons Used			Revenue	
		Class 4-8 Diesel Trucks	Class I Railroads	Inland Waterways	Total	Dedicated to Freight Infrastructure
		19,937,451,447	3,911,178,000	369,500,000		
Current Tax Rates	Rates	$ 0.244	$ -	$ 0.200		
	Revenue	$ 4,864,738,153	$ -	$ 73,900,000	**$ 4,938,638,153**	**$ 73,900,000**
2010 Proposed Infrastructure Tax Rates*	Rates	$ 0.364	$ -	$ 0.260		
	Revenue	$ 7,257,232,327	$ -	$ 96,070,000	**$ 7,353,302,327**	**$ 2,488,564,174**
Uniform Infrastructure Rate	Rates	$ 0.450	$ 0.206	$ 0.206		
	Revenue	$ 8,980,962,631	$ 807,489,697	$ 76,285,826	**$ 9,864,738,153**	**$ 5,000,000,000**
IMTS Rate	Rates	$ 0.504	$ 0.260	$ 0.260		
	Revenue	$ 10,048,475,529	$ 1,016,906,280	$ 96,070,000	**$ 11,161,451,809**	**$ 6,296,713,656**

* Rate from Freight FOCUS Act and ITMS Plan.

freight infrastructure. Applying the two 2010 infrastructure proposals, the Freight FOCUS Act and the Inland Marine Transportation Systems (ITMS) plan, would add $0.12 to the truck tax and $0.06 to the waterways tax, yielding about $2.5 billion for freight infrastructure. Of the $2.5 billion, $96.1 million would be dedicated to waterways.

A uniform infrastructure fuel tax of $0.206 applied across all modes would yield the $5 billion gross revenue target for freight infrastructure used in other study comparisons, of which $76.3 million would be dedicated to inland waterways.

Finally, an infrastructure fuel tax equal to the ITMS proposal for a minimum increase in the waterways tax ($0.26 per gallon) would yield $6.3 billion for freight infrastructure, of which $96.1 million would be dedicated to inland waterways.

These examples, however, raise the issue of dedicated multimodal funds versus dedicated modal funds. One of the problems with the Highway Trust Fund is that it is not dedicated solely to highway uses. Trucking industry support for fuel tax increases is contingent on dedication to highway uses. The Inland Waterways Trust Fund is already a dedicated modal fund. The Freight FOCUS Act, as drafted, stipulated that 92.5% of the revenue from any one mode be dedicated to projects for that mode and that half of any multimodal revenue would be prorated by the ratio of single-mode contributions. These observations suggest that a single multimodal fuel tax surcharge for freight infrastructure is technically feasible, but an attempt to create and allocate such a fund is likely to encounter serious institutional barriers.

Multimodal VMT Fee

The research team analyzed the potential for application of VMT concepts to railroads and waterways; however, "vehicle miles traveled" is basically a highway transportation metric. For both railroads and waterways, defining and applying VMT metrics would be highly problematic. For railroads, the definition of "vehicle" can be ambiguous, since trains are made up of changing mixes of freight cars and locomotives. The actual miles traveled are not recorded in railroad operations. Moreover, a VMT fee for trains to travel over private railroad lines would be hard to justify. For waterways, "miles traveled" is difficult to define and is unrelated to infrastructure requirements. Attempting to apply VMT fees to rail or water modes would thus entail costly and potentially onerous record-keeping, administrative, and enforcement costs, without a clear connection between such fees and freight infrastructure requirements.

Multimodal Registration Fee

Vehicle registration fees can conceivably be applied to the full range of freight transportation modes and the equipment they employ (absent any specific statutory prohibitions).

Table 63. 2008 estimated vehicle counts.

Mode	Vehicles	%
Highway		
Class 7-8 Trucks	4,327,163	45.7%
Class 4-6 Trucks	4,679,575	49.4%
Rail		
Locomotives	24,047	0.3%
Freight Cars	416,180	4.4%
Inland Waterways		
Tow and Tug Boats	4,000	0.0%
Barges	28,000	0.3%
Total	**9,478,965**	**100.0%**

Federal excise taxes are now applied to heavy-duty truck registrations, the sale of new heavy-duty trucks, and heavy-duty truck tires. In general, vehicles that operate on public roads or waterways are registered at some level of government (or perhaps more than one level) and pay fees. Vehicles that operate on private land or off road (notably railroad equipment) are not registered and do not pay fees. Excise taxes have previously been assessed on a wide range of commodities, and there is no conceptual reason why federal registration fees could not be assessed on other trucks, railroad cars or locomotives, or waterborne vessels.

As Table 63 shows, there were roughly 9.5 million medium-duty trucks, heavy-duty trucks, locomotives, freight cars, tow and tug boats, and barges in U.S. service in 2008. Of those, the trucks account for 95%. A federal registration fee of $555 (see Table 51) would yield an additional $262 million annually if applied to rail and inland waterway vehicles.

Linkage between Use and Payment

Fuel taxes and VMT fees are user fees, with the linkage between use and payment dependent on program details. The ability of distance/vehicle VMT fees to link use, impact, and payment depends on the payment scale applied to trucks of different classes and weights. Registration fees are not closely linked to infrastructure use.

The policy attraction of VMT systems is based in part on a preference for user fees over taxes. Many published sources consider VMT to be a better user fee than fuel taxes or excise taxes, which are regarded as an indirect measure of use.

The "use" of a highway, road, or other transportation infrastructure is a function of four interrelated variables—miles traveled, GVW, gross axle weight, and congestion impact. The degree to which a revenue mechanism can take these factors into account determines how closely the fee can correspond to the use.

Miles Traveled

Miles traveled is a relatively clear concept and relatively easy to define for trucking. Miles traveled is the major fac-

tor in the need for infrastructure capacity and in the wear and tear on roads. Most highway vehicles would rarely travel significant distances off public roads, but there are obvious exceptions for vehicles used in agriculture, resource extraction (e.g., mining and lumber), construction, and the military. The present system allows those vehicles to use untaxed fuel. To continue the exemptions, a VMT fee would either have to exempt the vehicles or exempt the off-road miles (possible with GPS or self-reporting systems). A registration fee system would exempt the vehicle based on type, ownership, or place of use.

Gross Vehicle Weight

The weight of the vehicle is another major factor in the need for infrastructure and infrastructure maintenance. Actual GVW includes the tare weight of the vehicle, the weight of the fuel and equipment on board, the weight of the load, and the weight of the driver and any passengers. As a practical matter, it is impossible to determine actual gross in-use vehicle weight without weighing every single vehicle on every single trip leg. Vehicles are classified by their gross vehicle weight restriction (GVW or GVWR), which is one basis for reliably attributing weight characteristics. A fuel tax indirectly captures some of the weight and size impact because larger, heavier vehicles typically have higher fuel consumption and thus pay higher effective tax rates per mile. If the impact is a function of GVW, then the GVW classification or an equivalent classification system can be used to graduate appropriate user or registration fees. Registration fees need only classify the truck once, when first registered. A graduation method could depend on the relationship between GVW and some average operating weight and between that average operating weight and highway impact. The study team could locate no usable data on average gross operating weight. The concepts of average operating weight and the distribution of operating weight by GVW class appear to have received little attention to date.

Gross Axle Weight

Gross axle weight, in its simplest form, is the GVW divided by the number of axles. More complex issues of weight distribution entail application of complex "bridge formulas," but those issues are more often addressed by vehicle configuration and inspection than by fees. The tire "footprint" also makes a small difference. Fuel taxes do not vary with axle weight. Axle weight distinctions have not been addressed by VMT fee discussions to date, but the number of axles is a factor in some toll calculations and state registration fees. Vehicles with more axles usually pay higher tolls and fees, presumably under the assumption that more axles mean more weight. VMT fees could be varied by the number of axles, but, because for any given weight, road impacts *decline* with the number of axles, the VMT rates should go *down* for additional axles in the same vehicle class.

Congestion Impact

The congestion impacts of trucks are sometimes measured in PCEs. The minimum PCE for trucks would ordinarily be the ratio of their length to passenger-car length, which varies between 1.0 and 3.0. The effective PCE for heavy trucks increases in congested traffic, in stop-and-go traffic, and on grades because the slower acceleration of heavy trucks increases the impact on other vehicle speeds. On steep grades with heavy congestion, truck PCEs may exceed 4.0. As with axle weights, there have been no VMT proposals that attempt to incorporate PCEs into the fee schedule. Fuel taxes capture PCEs only to the extent that PCEs correspond to weight and fuel use. Registration fees can also take length into account for straight trucks, truck tractors, and trailers.

These considerations illustrate the challenges faced in making any revenue source correspond as closely as possible to vehicle infrastructure impacts. The impact of gross vehicle weight and axle weight on pavement has been a controversial issue, and the congestion impact of trucks in mixed flow is a new area of study. Attempting to build a more precise reflection of use impacts into a VMT or a registration fee schedule will likely raise serious political and equity issues as well as technical difficulties. One option may be to charge all vehicles the same distance-based VMT fee and use other mechanisms, such as registration fees, to reflect the difference between vehicles and their impact. This option would have the advantage of simplifying VMT fee compliance, collection, and enforcement.

Incentives

The revenue mechanisms analyzed would not have strong productivity or behavioral incentives, largely because their impacts would be small compared to other freight and service industry cost factors. The incentives that the revenue mechanisms may provide are described in the following:

- A fuel tax surcharge or VMT fee that focused on trucks with freight body types would encourage the use of other truck types to move freight, including the use of freight trailers behind service vehicles such as medium-duty pickups.
- Mileage-based VMT fees would encourage truck drivers and dispatchers to minimize mileage, but since they already have strong incentives to do so, the marginal impact would be small.
- The use of OBUs for a VMT fee system would likely accelerate the adoption of telematics by the trucking industry.

Table 64. Impact of $0.25/gallon diesel fuel surcharge.

Factor	Truck	Rail	Inland Waterways
Fuel Share of Operating Cost	31%	26%	50%
2008 Fuel $/Gal.	3.95	3.12	3.32
Increase at $0.25/Gal.	6.3%	8.0%	7.5%
Operating Cost Increase	**2.0%**	**2.1%**	**3.8%**

Sources: ATA, Coosa-Alabama River Improvement Association, U.S. DOE, Tioga Group estimates.

- If graduated by size or weight, an annual registration fee could encourage users to choose the smallest (and presumably most fuel-efficient and lowest-emissions) truck that will perform the task at hand.
- A higher or broader federal registration fee would discourage operators from keeping older medium- and heavy-duty trucks for occasional or seasonal use. Such uses are often dominated by old, inefficient, high-polluting trucks with questionable safety status, so such an incentive might be seen as a public benefit.
- A diesel fuel tax surcharge could have more behavioral impact. A tax surcharge that increased the cost of diesel fuel relative to gasoline could lead to significant substitution of gasoline-powered medium- and heavy-duty trucks for the present diesel fleet.

The environmental impacts of the three leading revenue options would likely be equally modest. VMT fees, especially time/location VMT fees that incorporate congestion pricing, are expected to have significantly favorable impacts on passenger-car driving habits, based on the results of pilot programs. Passenger-car drivers, however, don't have the strong existing cost incentives to minimize mileage that truck drivers do, nor do passenger-car drivers have the supervision of cost-conscious managers and dispatchers.

Impacts

The relatively modest incentives created by the various options suggest that transportation system impacts of the taxes or fees will be minimal. With the exception of the possible substitution of gasoline trucks for diesel trucks with the diesel tax surcharge, the taxes or fees would not tend to change the way freight haulers operate.

The analysis of modal shift in Chapter 6 (see Table 46) estimated annual lost truck miles at between 3.2 and 3.7 billion, roughly 1.5% of the annual total for Class 4–8 trucks. The relatively small impact is due to the predominance of truck movements under 500 miles where rail is not competitive and to the relatively small increase in overall trucking costs.

In a multimodal application, an identical diesel fuel tax surcharge could have very different operating cost impacts on the highway, rail, and inland water modes. Table 64 shows estimates of the percentage operating cost impact of a $0.25 per gallon diesel fuel tax surcharge. These estimates are imprecise due to the difficulty of obtaining comparable data on operating cost structures. The estimates do, however, illustrate the range of impacts. The percentage increase in the example is actually lowest for trucks, because trucks already pay the highest fuel costs. The impact is greatest for the inland waterways carriers because fuel is such a large part of their cost structure.

Chapter 6 analyzed economic impacts in terms of (1) costs imposed on industry and (2) output lost by industry. The resulting economic impact estimates are shown in Table 65. The greater impacts of the diesel/gas tax and the VMT fee are due to their higher implementation and industry compliance costs. The estimates are in the vicinity of $500 million, about 10% of the $5 billion gross tax revenue target used for the analysis. As Chapter 6 noted, the primary economic consequence of the tax (from industry's perspective) is slower GDP growth and lower income rather than long-term employment loss.

Equity

For most revenue-generating options, equity is an issue of design and implementation. There are equity issues with the fuel and excise taxes as currently implemented, but those issues could be resolved. The equity effects on freight, service, and passenger users will depend on fee system design. Proposals to tax freight trucks exclusively would raise equity issues between freight and service truck operators.

Targeting Freight Vehicles

To fund infrastructure through a tax or fee on "freight" vehicles or their operations, it is necessary to define the subject vehicles with precision. While most discussions of freight infrastructure and funding conjure up images of heavy-duty

Table 65. Economic impacts of tax scenarios as lost 2021 GDP ($m2012).

Industry Group	Diesel Tax	Diesel/Gas Tax	VMT Fee	Registration Fee
Agriculture and Forestry	3	3	3	2
Mining	50	53	59	45
Utilities	0	0	0	0
Construction	80	86	96	80
Manufacturing	147	155	171	129
Wholesale Trade	24	27	30	30
Retail Trade	14	15	17	15
Transportation and Warehousing	27	31	35	40
Services	121	132	147	133
General Government*	0	0	0	0
TOTALS	**466**	**501**	**558**	**475**

*Does not include net tax revenue.

trucks; in reality, the truck population includes a wide range of vehicles used for many purposes. This issue is treated at greater length in Appendix B.

Figure 15 illustrates the problem graphically. Class 4–8 medium- and heavy-duty trucks are a subset of all Class 1–8 trucks. Diesel trucks are also a subset of the Class 1–8 trucks. Freight trucks (defined either as freight body types or trucks used in goods movement applications) are another subset of Class 1–8 trucks, and most are a subset of Class 4–8 medium- and heavy-duty trucks. The intersection of these three subsets is medium- and heavy-duty diesel freight trucks—about 3.1 million vehicles, or 3.8% of the 2002 VIUS total for Class 1–8 trucks. A diesel fuel tax surcharge would affect the 7.4% of the fleet that uses diesel, about 6.1 million trucks, but only about half of them haul freight.

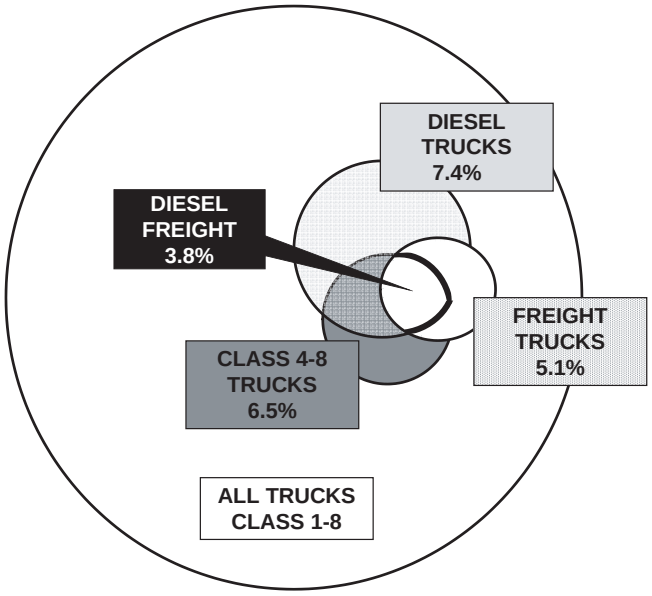


Figure 15. Truck population segments.

For the fuel tax surcharge and VMT fee alternatives, a substantial part of the implementation, compliance, and collection costs would be incurred in identification of freight vehicles. As shown in Table 66, however, a large portion of the medium- and heavy-duty trucks in use do not haul either freight or passengers, but are used in the provision of services. The majority of the U.S. fleet, about 60%, is in mixed-use sectors, notably construction.

In many instances, the use of diesel fuel is implicitly equated with freight transportation. As Table 67 shows, however, even in the heaviest classes of trucks, other fuels account for about 9% of the vehicles. In medium and light-heavy vehicle classes, which together account for about the same number of vehicles as the heavy-heavy class, only about half of the vehicles use diesel fuel. A diesel fuel tax, therefore, would cover only part of the freight trucking industry.

A tax or fee focused on a subset of the whole Class 4–8 medium- and heavy-duty truck fleet would therefore raise serious equity concerns. The most pragmatic approach, which would also yield the highest revenue, would be to apply the tax or fee to all Class 4–8 medium- and heavy-duty trucks, with the understanding that freight and service vehicles of similar sizes have similar infrastructure requirements and would benefit similarly from infrastructure improvements.

Appendix B discusses freight and truck fleets in more detail.

Electric Vehicles

Fully electric or plug-in, hybrid, heavy-duty freight or service vehicles are likely to be uncommon in the near future, but could eventually become a factor. Electric freight or

Table 66. Uses of medium- and heavy-duty trucks.

Sector	Total	Share
Freight	**4,330**	**34%**
For-hire Transportation & Warehousing	1,280	18%
Retail Trade	1,531	7%
Wholesale Trade	736	5%
Manufacturing	783	4%
Mixed Freight/Service	**12,526**	**60%**
Construction	4,541	19%
Agriculture, Forestry, etc.	2,240	14%
Not Reported/Not Applicable	3,286	11%
Vehicle Leasing or Rental	859	6%
Waste Hauling, Landscape, Admin/support	743	5%
Utilities	679	3%
Mining	178	2%
Service & Personal Transport	**68,318**	**6%**
Other Services	2,127	3%
Accommodation & Food Services	284	1%
Information Services	377	1%
Personal Transportation	65,343	1%
Arts, Entertainment, Recreation	187	0%
Total	**85,174**	**100%**

Source: 2002 VIUS (U.S. Census Bureau, 2004).

service vehicles have been used in the past for urban delivery and will likely become a practical possibility with continued advances in battery technology.

Applying fuel taxes to electricity is difficult. Power consumption would need to be tracked at either the point at which vehicles were charged or on the vehicle itself. Electric vehicles can be charged from almost any conventional electric power outlet with appropriate converters or on-board equipment, so metering at the point of charging would likely be impractical. On-board metering or tracking, like VMT fee systems, would require some means of reporting use and calculating fees. Most electric vehicles have regenerative braking, so while going downhill they "make" fuel. Electric power use, therefore, is not an accurate proxy for electric vehicle impact on infrastructure.

VMT fees are a logical way of assessing electric or partially electric vehicles for infrastructure impacts. On-board OBUs and self-reporting options would both be applicable.

An annual registration fee system would apply equally well to electric or partially electric vehicles. Since the registration fee could vary by vehicle, it would be possible to create incentives for electric vehicle ownership and use or higher fees to offset loss of fuel tax revenue.

International Trucking

There is a substantial volume of cross-border trucking activity that may pose problems in some fuel tax, VMT fee, or registration fee systems. At present, U.S. and Canadian trucks move freely across the border. The situation at the Mexican border is much different and highly controversial. The predominant pattern is relatively short shuttle movements across the border between factories, distribution centers, or drop lots. Longer trips to and from U.S. inland points are typically handled by U.S. truckers operating to and from border drop lots rather than crossing the border. Longer

Table 67. Truck classes and fuel used.

	Medium (GVW Class 4-5)	Light-Heavy (GVW Class 6)	Heavy-Heavy (GVW Class 7&8)	Total
Fuel Share of Truck Type				
Gasoline	54.6%	40.1%	8.5%	30.0%
Diesel	44.8%	57.5%	90.9%	69.1%
Alternative	0.6%	2.4%	0.6%	0.9%

Source: 2002 VIUS (U.S. Census Bureau, 2004, Table 5).

trips within Mexico are a mirror image, handled by Mexican truckers to and from drop lots south of the border. Under the North American Free Trade Agreement (NAFTA), Mexican truckers were to have been permitted to operate in the United States beyond the border zone. That permission has been withheld, however, and operation of Mexican trucks in the United States remains an industry and political hot button.

The infrastructure needs along both borders are already substantial and will increase as trade with both partners grows. If VMT became the primary basis for infrastructure finance, border states could be expected to demand that Canadian and Mexican trucks pay their fair share. When and if Mexican trucks handle more trips north of the border, there will be a corresponding loss of fuel tax revenue unless Mexico is brought into the IFTA system.

Most Canadian provinces are partners to IFTA. Fuel taxes paid by U.S. trucks operating in Canada and Canadian trucks operating in the United States are therefore already allocated between states and provinces based on VMT. Mexican states are not yet parties to IFTA, and there is little reason for them to join while Mexican trucks are prohibited from operating in the United States beyond the border area. An extension of IFTA to Mexican states and truckers would be a logical step when and if the NAFTA logjam is broken.

It would be difficult to justify a U.S. mandate to equip foreign cross-border trucks with VMT-compliant OBUs or EOBRs. Some firms specialize in cross-border trips while others rarely or never make such trips. Moreover, such a requirement could violate the terms of NAFTA or other cross-border agreements.

Direct fuel tax revenue from Canadian and Mexican trucks is likely to be minimal. The heavy-duty Class 7 and 8 vehicles that are likely to be used in cross-border shipping typically have large fuel tanks holding up to 250 gallons, or enough fuel to travel 1,000–1,200 miles. U.S. and Canadian trucks moving between border and near-border states would rarely need to refuel in the other country (but might do so if diesel is cheaper across the border). Diesel fuel is much cheaper in Mexico, so Mexican truckers avoid buying fuel in the United States. Mexican diesel can have higher sulfur content and damage U.S. fuel systems, so U.S. truckers rarely buy fuel in Mexico. U.S. state and federal governments do, however, receive a prorated share of Canadian fuel tax revenue according to the miles traveled south of the Canadian border. There is no comparable revenue stream from Mexican trucks.

Some alternatives for addressing the problems that may arise with some fuel tax, VMT fee, or registration fee systems in international trucking would include the following:

- Requiring cross-border trucks to install VMT-compliant OBUs and report U.S. mileage separately.
- Requiring cross-border trucks to be enrolled in IFTA.
- Requiring a manual log and VMT fee payment for travel in the U.S.

VMT-compliant OBUs capable of tracking and reporting U.S. mileage separately would have to be GPS-enabled, or they would have to be units of the kind required for time/location VMT as opposed to mileage-only units sufficient for distance/vehicle VMT. The need for more elaborate OBUs would greatly increase the compliance cost for cross-border truckers, particularly if U.S. truckers did not need them. If this were the case, it would tend to perpetuate the cross-border shuttle system prevalent in Mexican trade and perhaps encourage such a system for Canadian trade as well. There would be an unknown but probably significant increase in border area congestion, VMT, and emissions, and a corresponding loss of efficiency.

Canadian trucks regularly engaged in cross-border moves are normally enrolled in IFTA. These vehicles could convert to distance/vehicle VMT fees at little or no cost. Extension of IFTA to Mexico would involve up-front political and institutional investments and possibly protracted negotiations, but cost would be minimal and compliance cost very low (as little as $25 per month for IFTA filing). Non-IFTA trucks could have an option of a one-time fee at the border or could interchange the shipment with an IFTA-enrolled trucker.

Manual filing of VMT fees for border crossings would be cumbersome, costly, and unreliable. The audit and enforcement capability would be very limited. One workable alternative might be a one-time payment in lieu of OBU installation or IFTA enrollment.

Federal registration fees would not apply directly to Canadian or Mexican trucks, but an apportionment plan along the lines of the IFTA or UCRP system would appear to be applicable.

Exemptions

New funding mechanisms offer an opportunity to eliminate or phase out current fuel tax exemptions and promote equity among classes of vehicles and users. Certain users are exempted from paying federal excise taxes on motor fuels for on-highway use, including vehicles that fall into the following categories:

- Vehicles exclusively used by federal, state, county, or local government.
- School buses.
- Qualified intercity and local buses.
- Vehicles used by non-profit educational organizations.

Individual states also have their own categories of exempt highway users. If these exemptions are not eliminated, they will have to be accommodated within the new system.

Table 68. Total annual federal and state fuel tax exemptions.

Sector	Federal Exemptions	State Exemptions	Total
Government Use Vehicles	$ 363,000,000	$ 155,000,000	$ 518,000,000
School Bus Use	$ 146,000,000	$ 126,000,000	$ 272,000,000
Transit Use	$ 61,000,000	Unknown	$ 61,000,000
Federal Use	N/A	$ 29,000,000	$ 29,000,000
U.S. Postal Service	N/A	$ 27,000,000	$ 27,000,000
Charitable Organizations	Unknown	Unknown	Unknown
Total	**$ 570,000,000**	**$ 337,000,000**	**$ 907,000,000**

In 2007, ATRI estimated an overall fuel tax revenue loss of $900 million annually due to these exemptions, as shown in Table 68. The federal portion was $570 million.

The exemption issue affects all three of the leading candidate mechanisms identified in this study. Increasing or surcharging current fuel taxes would not affect exempt vehicles or users. VMT fees could potentially be assessed on vehicles and users that do not now pay fuel taxes. The barriers would be political and institutional. Registration fees could likewise be extended to the full range of vehicles if politically and publicly acceptable.

Many off-road and non-vehicle operations, including railroads, barges, machinery, stationary engines, electric generators, and so forth would be easier to segregate in a VMT system because VMT for that equipment would not be tracked. It is likely that there would be no VMT fees for farm equipment, for example, as any on-road travel would be ancillary to routine operation.

Off-road highway vehicle travel poses a challenge to potential VMT systems. Currently, vehicles that operate off road can use untaxed fuel. Untaxed fuel is either bought in bulk or delivered to jobsites using mobile equipment. Closing this exemption would reduce the current evasion problem, but would create other difficulties. Many off-road vehicles (e.g., construction equipment) do not have odometers and lack the electronic systems that would be used to connect OBUs. It is also a conceptual leap to apply infrastructure taxes or fees to vehicles that spend their time operating off the infrastructure that the fees are designed to support.

Exemption of government use vehicles currently reduces net federal fuel tax revenue by an estimated $363 million annually. Slightly more than 2% of the trucks in 2008 were owned by public agencies (see Table 69).

Most of the medium-duty, public-sector trucks are owned by county and local agencies (see Figure 16).

For those public-agency fleets that use fuel cards to obtain gas or diesel at commercial gas stations or card-lock facilities, the withdrawal of the exemption could be accomplished via procedural and accounting changes. If third-party VMT tracking via commercial OBUs becomes common practice, there would be multiple options for public-sector vehicles:

- They might not be tracked.
- They could be tracked but their VMT and TDM fees reported at zero (no payment). This option would have the distinct advantage of generating VMT and TDM data for private-sector vehicles.
- They could be tracked and their VMT fees reported and paid at a different (presumably lower) rate.

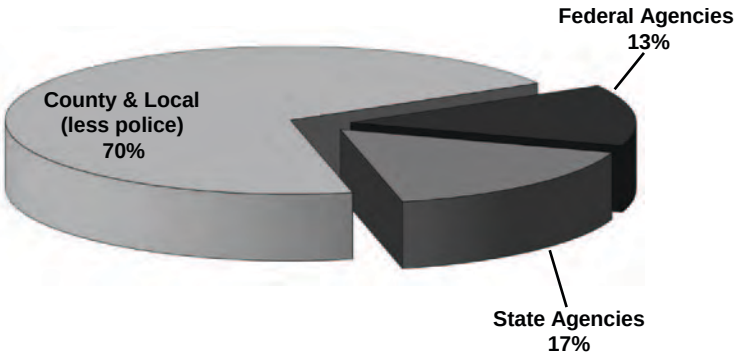
Public agencies that purchase fuel in bulk could either report fuel use or VMT and calculate fees manually or use OBUs for that purpose. There are also commercial automated and manual systems that can track vehicle mileages in conjunction with bulk fuel use. If both VMT and fuel usage were reported, discrepancies could again trigger audits.

Trucks and other vehicles owned by public agencies are registered, but public agencies do not pay the same registration fees as owners of private vehicles. Assessing federal excise taxes or registration fees on these vehicles would be relatively simple and would not have extensive technology or reporting requirements.

Application of fuel taxes, VMT fees, or registration fees to government vehicles, however, would be a transfer between government entities and would by itself bring no more funds into the public sector. To pay fees while retaining their same net budget level, government agencies would have to increase revenue from other sources by the same amount. For federal

Table 69. Truck fleet composition—2008.

DECEMBER 2008 REGISTRATIONS	PRIVATE & COMMERCIAL	FEDERAL	STATE, COUNTY, & MUNICIPAL	TOTAL TRUCKS	TRUCK TRACTORS	FARM TRUCKS	OTHER MEDIUM & HEAVY	PICKUPS VANS & SUVS	OTHER LIGHT
TRUCKS	107,964,897	379,373	1,897,317	110,241,587	1,930,378	1,908,943	6,831,934	99,122,567	447,765
SHARE	98%	0%	2%	100%	2%	2%	6%	90%	0%



Source: *Automotive* Fleet 2009

Figure 16. Public-sector Class 1–5 trucks in service—2009.

agencies, funding fees would presumably entail offsetting increases across the whole mix of federal revenue sources. Unless federal agencies accepted a net budget loss, the impact of federal agency freight fees would be spread across the general population.

Taxes or fees paid by state and local government agencies would presumably be funded by increases in their current mix of revenue sources. The increased expenditures on transportation infrastructure would likely pass through state governments, principally the state highway departments. The amounts may not balance, however, which would result in friction between state and federal levels (just as there is now friction over "donor" and "donee" states under the Highway Trust Fund). Within a state, the effect would be to transfer funds from other state agencies and their revenue sources to the state Federal-Aid highway and infrastructure program. On the local and regional level, taxes or fees would be paid from the existing spectrum of revenue sources, which can include state and federal funds.

In effect, subjecting public vehicle fleets to fees would thus result in passing the fees through to the general public. To the extent that there is a net increase in federal revenue from extending a freight fee to public agencies that are exempt from the fuel tax, the burden will thus ultimately be transferred to the existing mix of non-fuel-tax revenue sources. The economic impact is likely to be roughly the same as transferring General Fund revenue to the Highway Trust Fund and increasing the General Fund tax burden accordingly.

Public and Industry Acceptance

Overall Indications

There is limited information on the overall acceptance of freight-focused revenue mechanisms. Most of the studies and surveys have focused on public acceptance of taxes or fees on passenger vehicles. Explicit linkage to environmental issues tends to increase support for any type of fee or tax. It also appears that public acceptance may vary greatly with the details of implementation.

The ATA, and other industry organizations, and most likely their members, are concerned that VMT fees or other proposals do not address one of their greatest concerns over the existing fuel tax: diversion to non-highway uses (American Transportation Research Institute, May 2007). The industry is very unlikely to support any revenue mechanism that does not incorporate funding dedication to highway infrastructure. The Associated General Contractors of America, on the other hand, has voiced their concern over the rising costs of infrastructure coupled with the decline in effective funding and endorsed the whole range of potential solutions (Statement of James D. Waltze, National Surface Transportation Policy and Revenue Study Commission Field Hearing, Los Angeles, CA, February 22, 2007).

There is little support in the literature for applying new revenue mechanisms to non-highway modes. The ATA supports inclusion of other modes in Highway Trust Fund revenue collection if those modes are eligible for Highway Trust Fund spending. Yet, there appears to be little support for using Highway Trust Fund revenue for other freight modes. The ATA also supports development of a multimodal funding mechanism for multimodal freight projects.

Fuel Taxes and Surcharges

The National Surface Transportation Infrastructure Financing Commission noted strong public opposition to motor fuel tax increases as one of the problems associated with the fuel tax. As of mid-2010, the current administration had eliminated fuel tax increases from consideration.

There are, however, specific proposals and indications of support for fuel tax increases. The Freight FOCUS Act of 2010, described earlier, would raise the diesel tax by $0.12 per gallon and index the tax for inflation to fund a Goods Movement Trust Fund. The proposal did not pass in 2010, but can be regarded as an initial placeholder for more serious efforts in 2011 and beyond. The measure is supported by the

trucking industry, whose members would bear the brunt of the increase. ATA has also proposed an increase in the diesel tax and tied it to proposals to reduce diversion, reduce evasion, and narrow exemptions. The AASHTO proposal to convert the fuel tax to a sales tax would effectively increase the tax rate because fuel prices are expected to rise.

VMT Fees

Studies and surveys to date suggest that the public is very skeptical regarding VMT systems. There is a range of concerns, with privacy being the most prominent and consistent. The potential use of GPS in connection with VMT fees is apparently a cause for great concern.

Acceptance of VMT fees within the freight and service trucking industry will depend on the amount of the fees and the means of implementation. The principle concerns of truck owners and operators will be the following:

- The base per-mile rate as applied to trucks.
- The graduation of fees with increasing truck weight or GVW class.
- The higher capital, collection, compliance, and enforcement costs of VMT fees compared to existing fuel taxes.
- The potential need for VMT-compatible technology investments that may duplicate or make obsolete commercially justified systems.
- The higher potential for evasion.

The ATA remains strongly opposed to weight-distance taxes of any kind, and a distance/vehicle VMT fee would be a form of weight-distance tax. The analysis of VMT fee structures opens the possibility of large annual fee increases for the larger truck classes. Experience with weight-distance taxes in Oregon, New York, New Mexico, and Kentucky leads to legitimate concerns over record-keeping and compliance costs, as well as over the expense of the tax itself.

Acceptability within the industry would also depend on the revenue collection mechanism. About 25% of the 9 million medium- and heavy-duty trucks in the United States are enrolled in IFTA, for which the owners are already recording and reporting VMT. Another significant but unknown percentage of trucks are equipped with commercial or proprietary telematics or EOBR systems that are probably capable of recording and reporting mileage. Truck owners would quite reasonably object to VMT implementation plans that duplicated existing capabilities at additional cost.

Acceptance of VMT fees by other modes is very unlikely. The application of VMT fees to railroads or coastal and inland waterways vessels would be awkward at best and is hard to justify.

Registration Fees

Registration fees and excise taxes are not popular in the trucking industry. When business conditions are difficult, marginal operators sometimes cannot make the annual HVUT payment. Tire taxes and sales taxes on new trucks are, with some justification, criticized for discouraging new investments that could advance safety and environmental objectives. At present, the three federal excise taxes are assessed on the heaviest trucks, but the revenue is not dedicated to trucking infrastructure.

The literature reviewed for this study had relatively little coverage of non-fuel excise taxes or registration fees. The exceptions are testimony on behalf of the Associated General Contractors of America, which mentions a vehicle sales tax as an alternative to motor fuel taxes, and the work of the Mineta Institute, discussed below (Waltze, February 22, 2007).

The acceptance of a federal registration fee might be more widespread if the fee were paid quarterly or at some other interval rather than an annual lump sum. Shifting from an annual basis, however, would likely eliminate the potential for piggybacking on state registration fee collection. Public acceptance of a broader federal truck registration fee might also be greater if the truck tire and truck sales taxes were allowed to expire. Such an option, however, would result in a major loss of Highway Trust Fund revenue.

Survey Results

The Mineta Transportation Institute at San Jose State University has conducted a series of surveys to explore public opinion regarding a range of revenue-generating options.

A 2005 white paper summarizes Mineta Institute survey findings in which three alternatives stand out: tolled highways (treated in this study as a project-specific option); higher fuel taxes; and registration fees tied to emissions and fuel use (Weinstein and Dill, February 22, 2007). While the survey mainly concerned passenger vehicles and their owners, the results (see Table 70) indicate stronger support for fuel taxes than many observers had expected and weak support for mileage-based (VMT) fees.

A subsequent June 2010 report by the Mineta Institute reviewed surveys to date and conducted a new survey of attitudes toward transportation tax increases (Agrawal and Nixon, June 2010). Table 71 shows the study's findings regarding previous surveys. Most surveys found the percentage of respondents favoring a mileage tax to be quite low. The most favorable result was the most recent (HNTB in 2010), but that survey apparently phrased the question to refer to a "mileage use tax" without specifying a mile-by-mile VMT fee. The 2009 California survey found that responses were more favorable when the proposal was linked to vehicle

Table 70. 2005 Mineta Institute survey findings.

Revenue Option	Description of Option from Questionnaire	% of Respondents Supporting the Option
Truck-only toll (TOT) lanes	There were proposals in some congested regions to build new toll lanes for trucks right next to existing freeways. Trucks would be required to use these toll lanes instead of the regular freeway. (Survey 2)	**64**
High-Occupancy/Toll (HOT) lanes	Open underused carpool lanes to solo drivers who were willing to pay a toll. (Survey 1)	**55**
Toll roads	One option for building new highway projects without increasing taxes is to borrow money to build the road, charge tolls for driving on the new highway, and use the money collected to pay back the loans and maintain the highway. (Survey 2)	**47**
Environmental vehicle registration fees	Increase the vehicle registration fee to an AVERAGE of $62 per year for all vehicle owners, but vary the fee according to how much pollution the vehicle emits and how much gas mileage it gets. Vehicles that emit more pollution or get lower gas mileage would pay HIGHER fees and those that emit less pollution or get better gas mileage would pay LOWER fees. (Survey 1)	**44**
Express toll lanes	Building new freeway lanes alongside existing highways and charging a toll to drivers who use those NEW lanes. (Survey 2)	**44**
Gas tax	Increase the 18-cents-a-gallon state gas tax by one cent per year for ten years. (Survey 1)	**40**
Sales tax	Adopt a half-cent increase in the statewide sales tax. (Survey 1)	**40**
Vehicle license fee	Raise the vehicle LICENSE fee to 1%. The vehicle license fee is currently 0.65% (point six-five percent) of your vehicle's value, so the new fee would be 1%, with the additional revenue dedicated to transportation purposes. (Survey 1)	**40**
Tolls on new highway lanes	One way to pay for new highway lanes is to charge tolls for using them. (Survey 1)	**40**
Registration fees	Increase the vehicle REGISTRATION fee to $62 per year per vehicle, from its current level of $31.	**32**
General obligation bonds	One proposal is for the state to pay for new freeways and transit programs with general obligation bonds. These don't require a tax increase. But paying off the bonds from the state's general fund over 30 years would use money that otherwise might be spent for other programs and services.	**30**
Indexed gas tax	Index the gas tax to inflation. Under this proposal, the gas tax could increase slightly each year based upon inflation. For example, in 2004, inflation in California was about 3%, so the tax would have gone up by about a half cent per gallon. (Survey 1)	**27**
Mileage fee	Eliminate the 18-cents-a-gallon gas tax altogether and replace it with a so-called "mileage fee" based on the number of miles a vehicle is driven. Each driver would pay a fee of one cent per mile for every mile driven within the state. For example, every 100 miles driven would incur a mileage fee of $1. Each vehicle would be equipped with an electronic means to keep track of miles driven and the fee would be paid at the pump when drivers buy gas. (Survey 1)	**22**
N: Survey 1: 2705; Survey 2: 815		

Table 71. Mineta Institute study summary of mileage tax survey results.

Sponsor (and Author, if Different)	Survey Data	Sampling Frame	Findings
HNTB Corporation (Kelton Research)	2010	U.S. residents	39% of respondents agreed with the statement "the U.S. should try to reduce transportation greenhouse gas emissions by reducing the number of miles that vehicles travel through a mileage use tax."
Mineta Transportation Institute (Agrawal et al.)	2009	California residents	28% of respondents "supported" replacing the state gas tax with "a fee of 1-cent per mile for every mile driven within the state." Respondents were informed that "vehicles would be equipped with an electronic means to keep track of miles driven, and the fee would be paid when drivers buy gas." Support for the proposal increased to 50% for a variation in which "vehicles that pollute the least would pay less, and vehicles that pollute the most would pay more per mile."
Mineta Transportation Institute (Weinstein et al.)	2006	California likely voters	23% of respondents "would vote for" replacing the state gas tax with a mileage fee where "each driver would pay a fee of 1 cent per mile for every mile driven within the state." Respondents were informed that "vehicles would be equipped with an electronic means to keep track of miles driven, and the fee would be paid when drivers buy gas."
Rasmussen Reports	2009	U.S. residents	18% of respondents "favored" some form of mileage tax "to help fund the building and repair of roads and bridges."
Civitas Institute	2009	North Carolina registered voters	12% of respondents "would view favorably" a switch to "a plan that would charge all drivers based on the number of miles they drive in North Carolina." (The question did not specify what the "current system" was.)

pollution. Ironically, the fuel tax is linked much more closely to vehicle pollution than VMT fees.

Figure 17 shows the results of the Mineta Institute survey for 2010 and 2011 (Agrawal and Nixon, June 2011). A mileage tax of $0.01 per mile was the least popular option, with 21–22% respondent support. Gas tax variations were generally more popular than VMT fees. As the report notes, support increased with linkage to specific environmental issues and benefits.

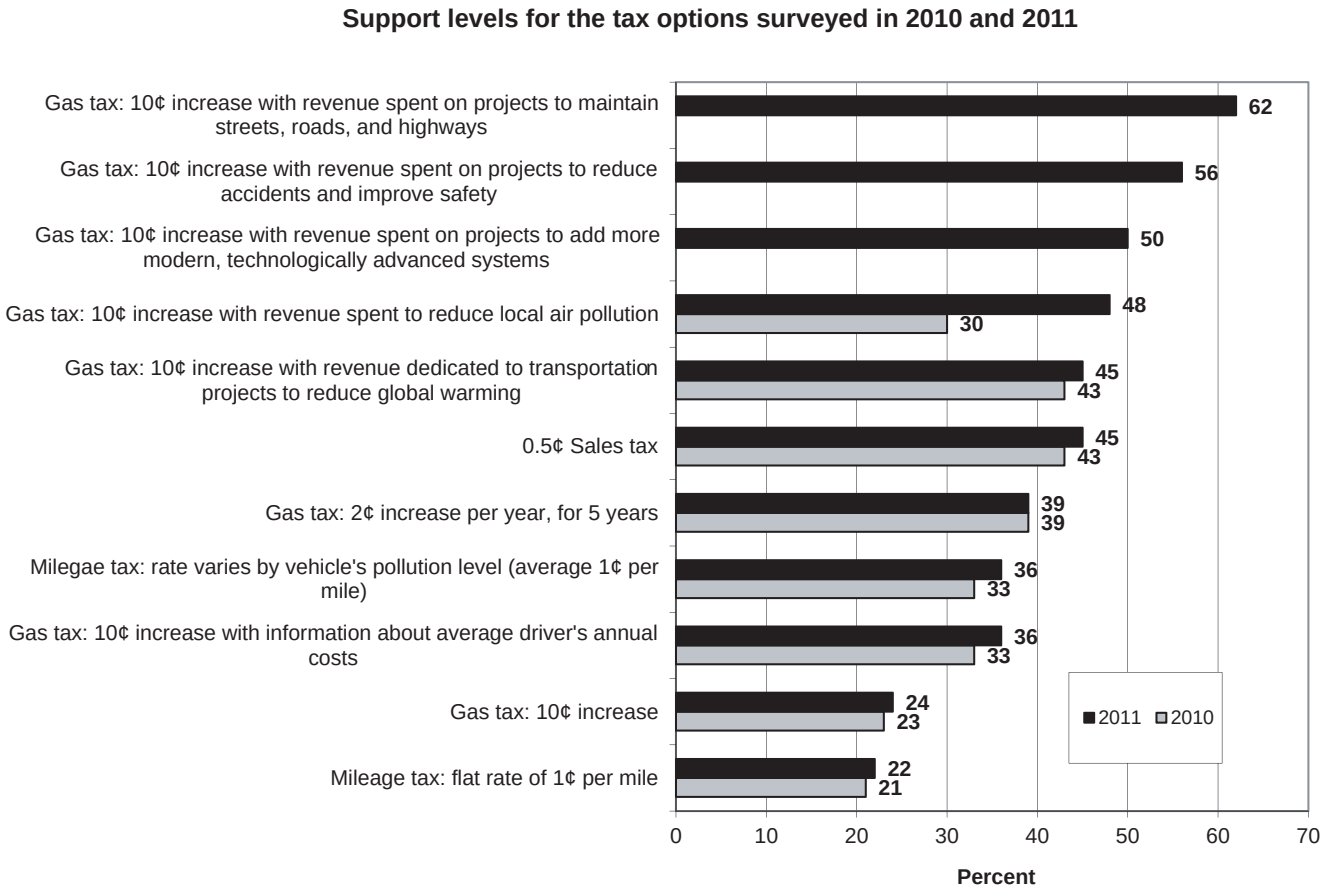
Figure 18 shows the actual question asked regarding a "mileage tax" and the responses in the 2010 Mineta Institute survey (Agrawal and Nixon, June 2010). The responses were in fact highly negative, with over 60% strongly opposing a mileage tax.

A public outreach effort in connection with the Nevada DOT VMT fee study (Rawlins, April 20, 2010) found that following a public meeting, there was this response from attendees:

- 68% indicated that the public meeting helped address their concerns.
- Areas that were designated as needing more attention were privacy (37%) and policy (28%).
- 515 indicated "Yes" or "Maybe" on a question asking about their willingness to participate in a pilot study.
- 58% indicated that they would not be willing to have VMT technology in their vehicle.

Table 72 summarizes results from a Minnesota DOT survey of public options regarding VMT fee or MBUF systems. Respondents were presented with a high-tech approach involving GPS-based OBUs and a low-tech approach that did not involve GPS. The results show a much stronger concern for privacy with the high-tech GPS approach. The author of the presentation described GPS as a "deal breaker" (Buckeye, April 20, 2010).

Respondent opinions of VMT fees are indeed generally more favorable after they participate in pilot programs. Figure 19 shows opinions shifting from negative towards positive from screening (start of pilot program) through baseline (during pilot) to exiting (after pilot). Their concerns regarding privacy tend to diminish, and they are more willing to accept less detailed statements in return for greater privacy as their trust in the system increases.



"Support" is the sum of those who said they strongly or somewhat strongly supported the tax option.

Figure 17. Results from Mineta Institute survey.

8a. One idea (a DIFFERENT idea) is to adopt a new tax based on the number of miles a person drives. Each driver would pay a tax of 1 cent for every mile driven. For example, someone driving 100 miles would pay a tax of 1 dollar. Vehicles would have an electronic meter to keep track of the miles driven, and the tax would be paid each time drivers buy gas. Would you strongly support, somewhat support, somewhat oppose, or strongly oppose this new mileage tax?

	Unweighted	Weighted
Strongly support	6%	9%
Somewhat support	14	12
Somewhat oppose	15	15
Strongly oppose	64	61
Don't know (volunteered)	2	3

Figure 18. Mileage tax (VMT) question from Mineta Institute survey.

Table 72. MBUF public opinion study results.

Approach	Least Liked		Most Liked		MBUF Preference
High Tech	Loss of privacy	2%	Base for fees	24%	8% extremely positive
	Costs	31%	Easy to use	16%	
	Base for fees	6%	Fairness	14%	
	Uncertainty of outcomes	8%	Collection method	9%	56% extremely negative
	Inconvenience	6%	Lower costs	4%	
	Enforcement issues	5%			
Low Tech	Inconvenience	25%	Base for fees	34%	18% extremely positive
	Costs	22%	Fairness	16%	
	Base for fees	16%	Lower costs	11%	
	Uncertainty of outcomes	11%	Easy to use	11%	35% extremely negative
	Loss of privacy	11%	Collection method	8%	
	Enforcement issues	7%	Less invasive/more private	6%	

Source: Buckeye, April 20, 2010.

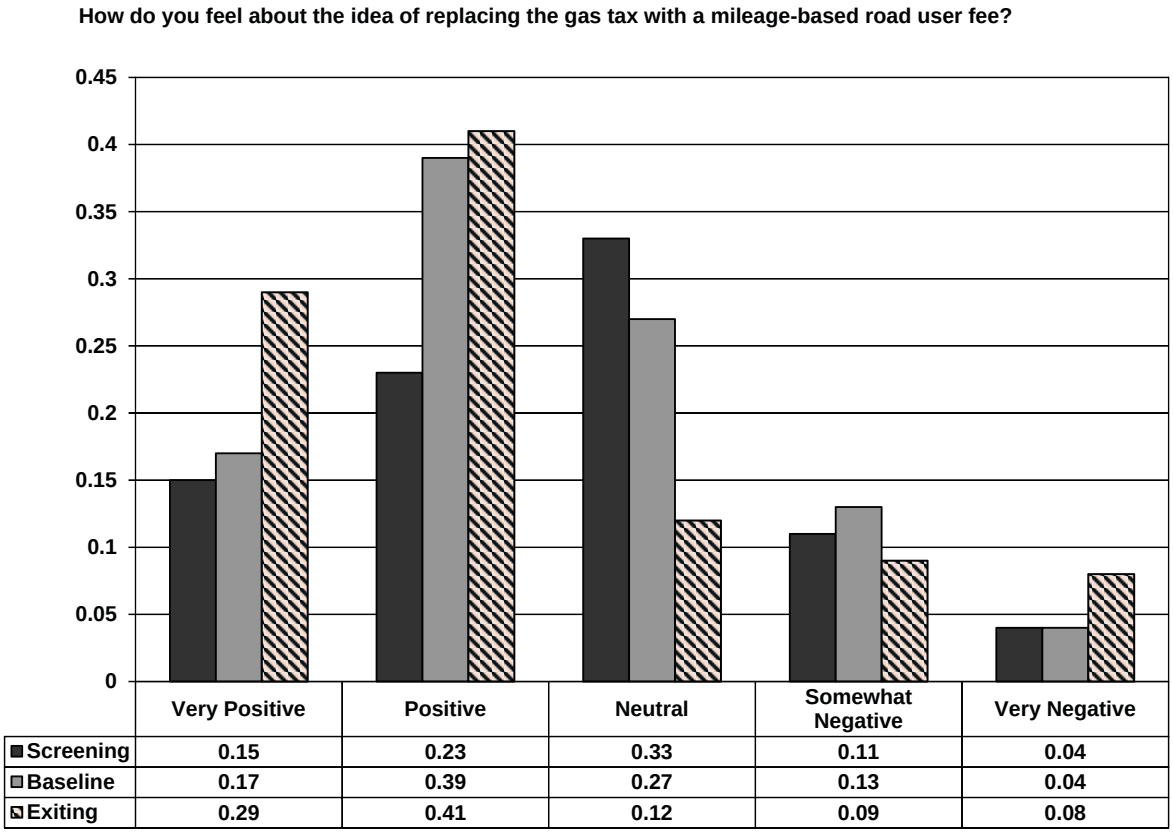
All of the pilot tests to date, however, have been tax-neutral to the participants in that none have paid more in VMT fees than they would have in fuel taxes. The attitude of the public toward VMT fees *in addition* to fuel taxes has not been tested in pilots, nor have surveys to date addressed the issue.

Figure 20 provides results from the 2009 Mineta Transportation Institute survey indicating greater support for registration fees than for mileage-based fees (VMT fees) (Agrawal, Dill, and Nixon, June 2009). A survey on "green" taxes and fees in California found that 41% supported an increase in vehicle registration fees. That support rose to 63% for "green" registration fees linked to vehicle emissions.

Table 73 provides additional survey results, which tend to support inclusion of fuel consumption and emissions factors in registration fees.

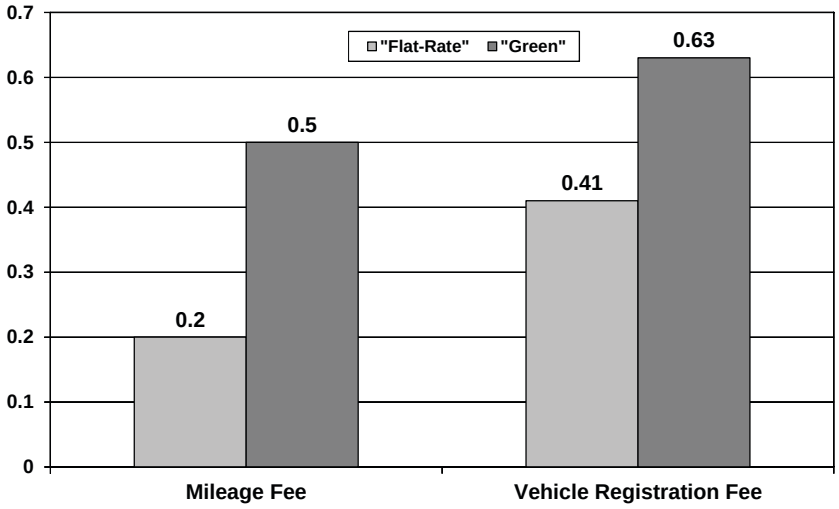
Implications

The limited amount of information available on acceptance by the public and by industry suggests that VMT



Source: Hanley and Kuhl, April 20, 2010.

Figure 19. VMT pilot project survey results.



Source: Agrawal, Dill, and Nixon, June 2009.

Figure 20. Support for VMT fees versus registration fees.

fees face a number of obstacles, notably the privacy issue. The public is generally more comfortable with fuel taxes or registration fees, particularly when these fees are linked to "green" initiatives. Industry acceptance appears to parallel public acceptance, although for slightly different reasons. The details of implementation matter a great deal to both groups.

Summary Comparisons

Table 74 summarizes and compares the leading revenue options based on key evaluation criteria. The ratings are relative, rather than absolute. Moreover, many of the rankings depend on the details of revenue mechanism design rather than fundamental characteristics.

Technical feasibility per se is not an issue for the leading options. The significant difference is in the degree to which each alternative relies on technology, with the more technology-intensive options being costlier and taking longer to implement. The potential for evasion varies; tax surcharges or VMT fees that vary between vehicles or depend on technology are more vulnerable to evasion than fuel taxes or registration fees that use existing systems.

The three leading options all have the potential to yield substantial revenue to fund freight infrastructure. There are no inherent limits, so the revenue potential is primarily an issue of political, industry, and public acceptance of appropriate taxes or fees. The sustainability of fuel tax revenue over time in the freight sector is higher than in the passenger sector, but still subject to diminishing growth. VMT fee revenue will grow as VMT continues to grow. Truck registration fees vary with the size of the fleet, which tends to diminish or not grow as quickly during economic slowdowns.

Table 73. Support for vehicle registration fees.

Opinions	Strongly Support (%)	Somewhat Support (%)	Somewhat Oppose (%)	Strongly Oppose (%)	Don't Know (%)	n
All respondents	18	23	16	39	5	1494
State/local government has adequate funding for the transportation system?						
Yes	11	19	17	51	3	475
No	24	25	15	32	4	733
Don't know	15	22	17	37	9	279
Should vehicle registration fee rates take gasoline mileage into account?						
Yes	24	27	15	29	5	847
No	9	18	15	56	2	503
Don't know	18	10	21	41	11	137
Should vehicle registration fee rates take pollution emissions into account?						
Yes	22	26	16	30	5	1005
No	9	16	14	61	1	393
Don't know	10	14	15	45	16	87

Note: Percentages may not total to 100% due to rounding.
Source: Agrawal, Dill, and Nixon, June 2009.

Table 74. Revenue mechanism comparison matrix.

Screening Criteria	Fuel Tax Surcharge	VMT Fee	Federal Registration Fee
Revenue			
Revenue potential	High	High	High
Stability/sustainability of revenues over time	Moderate	High	Mixed
Need for indexing	High	High	High
Implementation and Costs			
Time to implement	Moderate	Long	Short
Federal implementation cost	Low	High	Very Low
Recurring collection and enforcement cost	Low	High	Low
Industry implementation cost	Low	High	None
Industry compliance cost	Moderate	High	Low
Revenue Efficiency			
Collection cost efficiency	High	Low	High
Net federal revenue/net industry cost	High	Low	High
Scale economics	Potential	High	Low
Technical Feasibility			
Technical feasibility	High	High	High
Potential for evasion	Moderate	High	Low
High vs. low tech	High/Low	High	Low
Multimodal Application			
Coverage of multiple modes	Potential	Low	Potential
Modal neutrality	Potential	Low	Potential
Linkage between Use and Payment			
Emphasize user fees over taxes	Moderate	High	Low
Proportional to truck size and weight	High	Potential	High
Incentives and Impacts			
Incentives for productivity gains	Low	Low	Low
Incentives for user behavior	Low	Low	Low
Transportation system impacts	Low	Low	Low
Modal shift (e.g., from truck to rail)	Moderate	Low	Low
Environmental impact	Low	Low	Low
Economic impacts	Low	Low	Low
Equity			
Between payers, users, and beneficiaries	Moderate	Potential	Moderate
Between public- and private-sector users	Low	Potential	Potential
Between freight, passenger, and service users	Potential	Potential	Moderate
Political and Public Acceptance			
Likely legal challenges	Low	Likely	Possible
Legislative feasibility	Low	Low	Moderate
Freight stakeholder positions	Moderate	Adverse	Moderate
International legality	High	Questionable	High
Public and commercial privacy issues	None	Serious	None

There are marked differences in implementation time and cost, with the high-tech variations on VMT fees and fuel tax surcharges taking longer and costing more. A federal registration fee would be the quickest and least expensive option.

The differences in cost translate into differences in revenue efficiency. The low-tech variation on fuel tax surcharges and the federal registration fee yield the greatest net federal revenue at the lowest industry cost and are therefore the most efficient. VMT fees would likely show the greatest scale economies, with efficiency rising as the fee rises.

The potential of fuel taxes and registration fees to cover multiple modes depends on system design and policy choices. Trucks and inland waterway vessels use public infrastructure and pay both fuel taxes and registration fees. Railroads use private infrastructure and pay neither (except in a few states that assess fuel taxes on railroads), but there are no technical barriers to federal taxes on railroad fuel or fees on equipment. VMT fees, however, would not be practical for rail or waterborne transportation.

As with other factors, the degree to which each option is a "user fee" depends on system design. Fuel taxes reflect both vehicle mile and vehicle weight because fuel consumption varies with both. VMT fees reflect vehicle mileage by definition, but would need to vary by vehicle class or weight. Registration fees do not reflect mileage, but can vary by weight, class, axle loading, or other impact variables.

The tax and fee rate levels contemplated in this analysis would not create strong incentives for change in freight industry operations. The changes in overall cost structure would be minor—far less than the fuel cost variability that

the industry has recently experienced. Freight and service truck operators already have stronger cost incentives to minimize mileage and fuel use, so any new incentives would be slight. The transportation system impacts, environmental impacts, and economic impacts would all be modest. The exception would be a diesel tax surcharge that widened the cost gap between diesel fuel and gasoline, thus encouraging the substitution of gasoline-powered trucks for diesel trucks.

Equity among users, vehicle types, and industry segments is likewise a matter of system design more than an intrinsic feature of each option. One serious issue is the definition of "freight vehicles" and the choice of fuels to tax. There is no straightforward, unambiguous way to classify vehicle types or industry segments as "freight," and medium- and heavy-duty trucks use gasoline as well as diesel. Each option, if implemented, would also have to cope with exemptions for off-road and public-sector uses, electric and hybrid vehicles, and international trucking. Combining revenue sources (for example, using registration fees to cover electric vehicles that would not pay fuel taxes) may be a more effective strategy than attempting to adapt one option for all applications.

Public acceptance is problematic. The current administration has indicated its opposition to higher fuel taxes, but multiple industry associations have supported fuel tax increases. Planners and policy makers tend to favor VMT fees, while the industry and the public tend to oppose them. Of the three options, VMT fees may face the greatest barriers due to the perception of a privacy problem, even if the privacy issue can be resolved legally and technologically.

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Acronyms

ARTBA	American Road and Transportation Builders Association
ATRI	American Transportation Research Institute
AVL	Automatic vehicle location
BCI	Building Cost Index
BHWY	Bureau of Labor Statistics Producer Price Index for the highway and street construction industry
BLS	Bureau of Labor Statistics
BPI	Bid-Price Index
BTU	British thermal unit
CCI	Construction Cost Index
CPI	Consumer Price Index
CVET	Commercial Vehicle Excise Tax
DOT	Department of Transportation
DSRC	Dedicated short-range communications
EHUT	Equalized highway use tax
EOBR	Electronic on-board recorder
FAF	Freight Analysis Framework
GDP	Gross domestic product
GIS	Geographic information system
GPS	Global positioning system
GVW	Gross vehicle weight
HTF	Highway Trust Fund
HVUT	Heavy Vehicle Use Tax
IFTA	International Fuel Tax Agreement
ITMS	Inland Marine Transportation Systems
IRP	International Registration Plan
IRS	Internal Revenue Service
ITC	Investment tax credit
LPR	License plate recognition
LTL	Less-than-truckload
LUST	Leaking Underground Storage Tank
MBUF	Mileage-based user fee
MCI	Materials Cost Index
NAFTA	North American Free Trade Agreement
NHCCI	National Highway Construction Cost Index
NPV	Net present value
OBD	On-board diagnostics
OBU	On-board unit

OCR	Optical character recognition
ODOT	Oregon Department of Transportation
OEM	Original equipment manufacturer
PCE	Passenger car equivalent
PIN	Personal identification number
PPI	Producer Price Index
PPP	Public-private partnership
PwC	PricewaterhouseCoopers
RFID	Radio frequency identification
TDM	Transportation demand management (or travel demand management)
TRUE	Truck Road Use Electronics
UCR	Unified Carrier Registration
UCRP	Unified Carrier Registration Plan
VIN	Vehicle identification number
VIUS	Vehicle Inventory and Use Survey
VMT	Vehicle miles traveled

APPENDIX A

Literature Review

Introduction

The study team reviewed existing literature and domestic and international experience to facilitate the preparation of an annotated list of potential freight funding and financing mechanisms to be considered.

The literature review is organized into five sections:

- Infrastructure Funding and Program Needs
- Existing Revenue Sources and Proposed Changes
- Major Financing Sources
- Specific Revenue Proposals
- Public-Private Partnerships

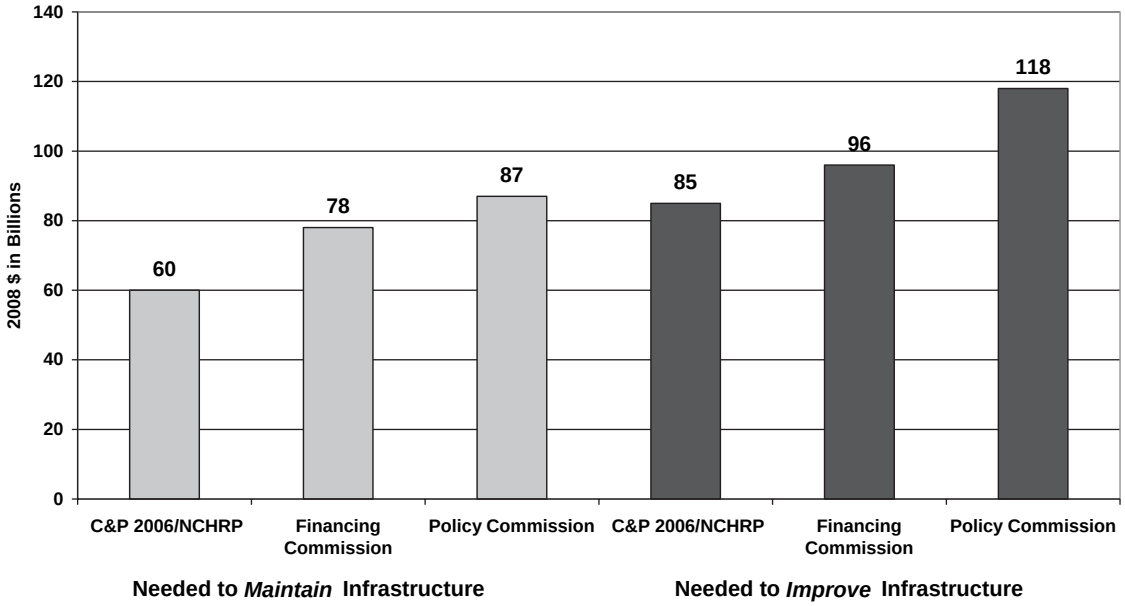
Infrastructure Funding and Program Needs

To provide some perspective on the deficiencies in real investments in highways overall, it is useful to refer to the facts presented in a U.S. Senate hearing on "Tax and Financing Aspects of Highway Public-Private Partnerships," before the Subcommittee on Energy, Natural Resources, and Infrastructure of the Committee on Finance (2008).

> What we have seen during that period [1960 through 2006] in terms of real investment is a decline of 44 percent, and at the same time we have seen a 66-percent increase in our population inside this country.

There is also widespread agreement in the literature regarding the large volume of freight moved in the United States every day, the significant increases in volume that are expected in the long run, the inadequacy of existing infrastructure to manage the throughput, as well as the lack of specific programs to address and fund future infrastructure requirements. An example is the U.S. DOT's *2006 Conditions and Performance* report to Congress, which highlights the continuing deficiencies: "Supplemental analysis conducted since the release of the 2000 report indicated that approximately one-third of the connector system is in need of additional capacity" (U.S. DOT, Jan. 2007b). Numerous reports cite high growth in the last two decades in vehicle miles traveled (VMT) on the National Highway System (NHS), as well as in freight transportation. AASHTO, in *America's Freight Challenge* (AASHTO, 2007a) and the more recent *Unlocking Freight* (AASHTO, 2010), provides detailed assessments of the growth in traffic overall and in freight transportation on the Interstate highways both from a historical perspective and future projections on the traffic conditions:

- Between 1980 and 2006, traffic on the Interstate Highway System increased by 150%, while Interstate capacity increased by only 15%.
- In 40 years, overall freight demand will double, from 15 billion tons today to 30 billion tons by 2050. Freight carried by trucks will increase 41%; by rail 38% from today's quantities. The number of trucks on the road compared to today will also double.
- On average, 10,500 trucks a day travel some segments of the Interstate Highway System. By 2035, this will increase to 22,700 trucks for these portions of the Interstate, with the most heavily used segments seeing upwards of 50,000 trucks a day.
- The amount of traffic experiencing congested conditions at peak hours in the nation's most urban areas on the Interstate system doubled from 32% to over 67%.
- Nineteen states see the heaviest use; 88% of all these truck miles occur in six states—California, Arkansas, Georgia, Tennessee, Texas, and Pennsylvania.
- Estimates of the truck hours of delay for the worst freight-truck bottlenecks show that each of the top 10 highway interchange bottlenecks cause over a million truck hours of delay per year, costing $19 billion overall.



Source: National Surface Transportation Insfrastructure Financing Commission, 2009.

Figure A-1. Estimates of infrastructure funding needs.

Questions such as how much money is needed and what is the believed magnitude of funding shortfalls compared to the physical capacity needed to move future traffic flows expeditiously are addressed by various studies, and their main findings in this regard are summarized in Figure A-1 from the National Surface Transportation Financing Commission Report (2009). The evidence presented in Figure A-1 suggests that the United States is spending only half or less of what it needs in capital expenditures.

Existing Revenue Sources and Proposed Changes

Existing Fuel Taxes

Receipts from gasoline taxes are the single largest source of revenue for transportation infrastructure investments in the United States. These taxes are largely earmarked revenues for the federal Highway Trust Fund. While the federal Highway Trust Fund contained sufficient revenues at its inception in 1956, presently it is facing difficulties in adequately funding highway infrastructure needs in the United States and in meeting its current obligations. In this section, various factors affecting the solvency of the federal Highway Trust Fund are discussed as well as the main considerations for the Obama Administration in the reauthorization of the Federal Highway Act later this year. The section also describes a parallel stream of more localized funding provided by tolling and more recent state and local efforts at using value or congestion pricing. Alongside these sources, this section describes a variety of fees—driver license fees, inspection fees, truck registration fees, and container entry fees—as well as vehicle sales taxes that are also used by state and local governments for transportation and freight infrastructure funding.

Background on the Federal Highway Trust Fund

The federal Highway Trust Fund was established in 1956 to provide a dedicated source of federal funding for highways. In 1983, the federal Highway Trust Fund was divided into two accounts—the Highway Account and the Mass Transit Account. Periodically, Congress enacts multiyear legislation, such as SAFETEA-LU, authorizing federal spending for the nation's surface transportation programs—including highway, transit, highway safety, and motor carrier programs—and setting overall funding for these activities (U.S. GAO, Apr. 2006). Funding for the Federal-Aid Highway Program is provided through the federal Highway Trust Fund, a "pay-as-you go" system that uses receipts from highway user excise taxes to fund various surface transportation programs (U.S. GAO, Apr. 2006).

Receipts for the Highway Trust Fund are derived from two main sources—federal excise taxes on motor fuels (gasoline, diesel, and special fuels taxes) and truck-related taxes (truck and trailer sales, truck tires, and heavy-vehicle use taxes). Oil companies, tire manufacturers, truck and trailer retailers, and owners of heavy highway vehicles (trucks weighing 55,000 pounds and over) pay the excise taxes directly to the Highway Trust Fund (U.S. GAO, Apr. 2006). The highway user pays the other taxes indirectly, since these taxes become part of the purchase price of the taxed item.

Table A-1. FHWA summary of user fee structure.

Tax Type	Tax Rate
Gasoline and gasohol	18.4 cents per gallon
Diesel	24.4 cents per gallon
Special Fuels:	
General rate	18.4 cents per gallon
Liquefied petroleum gas	18.3 cents per gallon
Liquefied natural gas	24.3 cents per gallon
M85 (from natural gas)	9.25 cents per gallon
Compressed natural gas	18.3 cents per 126.67 cubic feet
Tires: (maximum rated load capacity)	
0 - 3,500 pounds	No Tax
Over 3,500 pounds	9.45 cents per each 10 pounds in excess of 3,500
Truck and Trailer Sales	12 percent of retailer's sales price for tractors and trucks over 33,000 pounds gross vehicle weight (GVW) and trailers over 26,000 pounds GVW
Heavy Vehicle Use	Annual tax: Trucks 55,000 pounds and over GVW, $100 plus $22 for each 1,000 pounds (or fraction thereof) in excess of 55,000 pounds (maximum tax of $550)

Source: FHWA, March 2007, p 33.

Highway Fee Structure and Revenues

Table A-1, from FHWA, summarizes the existing federal user fee (tax) structure for fuels, tires, sales, and use taxes (FHWA, Mar. 2007, p. 33).

Receipts from the gasoline tax constitute the single largest source of revenue for the Highway Account, and approximately 84% of the receipts from the gasoline tax go to this account. Overall, the Highway Account receives the majority of the tax receipts for the Highway Trust Fund, including all receipts from truck-related taxes.

Table A-2 summarizes 2010 and 2015 revenue sources for highway transportation and transit.

Factors Affecting the Solvency of the Highway Trust Fund

Perhaps the most detailed analysis of the solvency of the Highway Trust Fund, based largely as it is today on fuel taxes, comes from the American Transportation Research Institute (ATRI). This analysis lists multiple factors that have adversely affected federal and state-to-state highway trust funds in

Table A-2. AASHTO summary of current revenue sources.

Revenue Mechanism	Description	Revenue Generation 2010	Revenue Generation 2015
Federal Gasoline and Gasohol Tax	18.40 cents/gal, with 15.44 cents going to the Highway Account, 2.86 cents going to the Transit Account, and 0.10 cent going to the Leaking Underground Storage Tank Trust Fund	$26.9 billion ($22.7 billion Highway Account/$4.2 billion Transit Account)	$28.0 billion ($23.6 billion Highway Account/$4.4 billion Transit Account)
Federal Diesel Tax	24.40 cents/gal, with 21.44 cents going to the Highway Account, 2.86 cents going to the Transit Account, and 0.10 cent going to the Leaking Underground Storage Tank Trust Fund	$10.1 billion ($8.9 billion Highway Account/$1.2 billion Transit Account)	$10.8 billion ($9.5 billion Highway Account/$1.3 billion Transit Account)
Federal Vehicle Taxes	Includes a tax based on tire weight, a retail tax on trucks weighing more than 33,000 pounds, and a heavy vehicle use tax	$7.2 billion	$10.1 billion
General Fund	Appropriations of General Fund dollars for public transportation purposes (assumes it grows with inflation)	$1.9 billion	$2.2 billion

Source: AASHTO, 2007b, p.51.

addition to tax rate stagnation. The four categories below have direct relevance to changes that the ATRI study suggests in the Highway Trust Fund as well as the choice of alternative revenue options for freight infrastructure (ATRI, 2007).

Exemptions

ATRI found the following two losses to the federal Highway Trust Fund from exemptions, totaling $570 million:

- Government use vehicles—$363 million
- School buses and transit—$146 million
- Qualified transit—$61 million

For state highway trust funds, ATRI found the following four losses, totaling $337 million:

- Government use vehicles—$155 million
- School—$126 million
- Federal—$29 million
- USPS—$27 million

Total losses from exemptions were $907 million per year in 2007 (ATRI, 2007).

Diversions from the Federal Highway Trust Fund

The largest diversion is the loss of 11.1% to mass transit, estimated at a cumulative $50 billion from 1994 through 2005. Interest earned on federal Highway Trust Fund investments diverted to the General Fund is estimated at $2.0 billion/year, and loss to the Environmental Protection Agency for leaking fuel storage tanks is $70 million (ATRI, 2007). Legislation H.R. 2847, passed by Congress in March 2010, would restore $19.5 billion to the federal Highway Trust Fund from the General Fund as compensation for the loss of interest over many years (Bill Summary, 2010). Work actually stopped on some federally funded highway and bridge projects on Monday, March 1, 2010, demonstrating the precarious condition of the federal Highway Trust Fund.

Tax Evasion

Estimates range from $1 billion to $9 billion/year, and ATRI calls for greater penalties and enforcement.

Inflation

Based on the Consumer Price Index, ATRI estimates a 28% decrease in buying power from 1993 to 2006 (ATRI, 2007).

Legislative Safeguards

Two existing fiduciary mechanisms are intended to safeguard the solvency of the federal Highway Trust Fund: the Byrd Rule (or Byrd Test) and Revenue Aligned Budget Authority, or RABA. Under the Byrd Test, dating to 1956, the U.S. DOT must compare existing and projected unpaid authorizations to the states with current and projected resources and then reduce the former to match the latter if needed. Reapportionments were triggered in 1961 and 2004. Under SAFETEA-LU, however, instead of a 24-month window, U.S. DOT was given a 48-month window, thus rendering the test essentially meaningless; the federal Highway Trust Fund would have failed the test in all years following 2004 under the old standard. Likewise, under TEA-21 in 1998, the U.S. DOT was to undertake essentially the same comparison as part of its annual budget submission to RABA. However, SAFETEA-LU negated that obligation unless the federal Highway Trust Fund balance fell under $6 billion. Testimony by the U.S. Government Accountability Office (U.S. GAO) to the House Ways and Means Subcommittees on Oversight and Select Revenue Measures in June 2009 detailed how Congress has drifted away from its earlier prudential enactments when faced with the real-world consequences of underfunding the federal Highway Trust Fund (U.S. GAO, 2009).

Earlier work by TRB (2006) assessed the state and the future of the federal Highway Trust Fund and took a relatively sanguine view: "The risk is not great that the challenges evident today will prevent the highway finance system from maintaining its historical performance over the next 15 years; that is, it should be able to fund growth in capacity and some service improvements, although not at a rate that will reduce overall congestion." That said, "[T]ravelers and the public would benefit greatly from a transition to a fee structure that more directly charged vehicle operators for their actual use of roads" (TRB, 2006, pp. 2–3). The TRB committee highlighted the exemptions and diversions that weaken the system for attention by Congress (TRB, 2006, p. 5).

Reauthorization

Current federal highway funding is authorized by SAFETEA-LU, which has been extended through March 31, 2012. President Obama's administration has developed a proposal for the reauthorization that makes mention of a VMT tax (discussed at more length in the next section), but more recent statements from the administration have claimed that the tax was only part of a draft proposal (Laing, 2011). Barbara Boxer, chair of the Senate's Environment and Public Works committee, has stated that, as of June 2011, the upcoming surface transportation reauthorization bill will include the following key considerations:

- Consolidation of numerous programs to focus resources on key national goals and reduce duplicative and wasteful programs.
- Consolidation of numerous programs into a more focused freight program that will improve the movement of goods.
- Expansion of the TIFIA (Transportation Infrastructure Finance and Innovation Act) loan program, which helps states finance transportation projects of national and regional significance.
- Expediting of project delivery without sacrificing the environment or the rights of people to be heard (Boxer et al., 2011).

Other Existing Taxes and Fees

Tolling

The concept of tolling as a source of revenue generation has a long history in the United States (FHWA, 2010a). Tolling (for highways as well as for bridges, tunnels, and other long-lived public infrastructure with high up-front costs and a sustainable stream of benefits) has been considered as a funding mechanism to support long-term borrowing to finance such facilities because it offers a potentially steady stream of revenue (if demand and tolls are properly forecast and set) that can be used to underwrite long-term debt. For a variety of reasons, including the assumption that revenue recovery using tolled facilities would not meet debt servicing requirements when free alternatives were available, the acquisition of "excess lands," and the subsequent recapture of improved post-construction land value were initially favored over tolls to finance the Interstate system (FHWA, 2010b). The fundamental arguments supporting this choice of funding for public roads can be traced back to an influential report to Congress written by Herbert Fairbank (Bureau of Public Roads, 1939). (Also see the National Surface Transportation Policy and Review Commission's web page at http://www.transportationfortomorrow.org/final_report/historical_documents.aspx for access to historically relevant documents in electronic form.)

In the post-World War II years, the idea for an Interstate system matured, and funding discussions became more clearly focused on immediate revenue requirements. Reliance on fuel-based taxes as a source of financing, rather than longer term and more speculative land value capture, emerged as the most feasible and equitable method to pay for and rapidly deploy federally sponsored highway construction. Prior to the passing of the Federal-Aid Highway Act of 1956, which established the foundations of the U.S. Interstate system, five states developed intercity highways financed by toll revenues (Lewis, 1997). However, as national policy on intercity highways began to be shaped by the Eisenhower administration, a series of studies and recommendations emerged emphasizing use of fuel-based taxes, rather than toll-based revenues, to underwrite construction. Tolling as a source of revenue was only permitted for states with elements of the Interstate system already in place and on a case-by case basis thereafter for significant bridge and tunnel construction on the Interstate system (U.S. GAO, Jun. 2006).

Due in part to the methods chosen to finance the Interstate system and the historic rise in both VMT and overall fuel consumption patterns in the 40 years following the adoption of fuel-based taxes as a financing mechanism, tolling as a source of revenue generation to support capital investment in highways has not been widely adopted. States, including Massachusetts, have eliminated tolls on portions of their Interstate system (I-90 west of I-495). Other states have considered tolling portions of their Interstate systems heretofore supported by state and federal fuel taxes (e.g., Pennsylvania's I-80 and portions of New Jersey's I-95), and other states, including Texas and Indiana, have proposed using concessions to grant limited tolling privileges to private operators to maintain and upgrade the capacity of portions of their existing Interstate system.

The National Surface Transportation Policy and Revenue Study Commission (Dec. 2007) estimated that there were only 5,100 miles of tolled highway facilities (including bridges and tunnels) in the 50 states as of 2004. An assessment of overall highway revenues suggested that only 4.5% ($7 billion) of the $145.3 billion of all government-generated funds used for highways and bridges was attributable to toll revenues in 2004 (National Surface Transportation Policy and Revenue Commission, Jan. 2007). (Note that in other technical papers produced for the National Surface Transportation Policy and Revenue Commission, the revenues from tolling were estimated at $6.6 billion and 7% of all highway revenues (National Surface Transportation Policy and Revenue Study Commission, Jan. 2007.) Our own review of the Highway Statistics (Table HF-10) for 2004 through 2007 shows toll revenues at $6.57 b (4.46%) in 2004 and $9.04 billion (5.27%) in 2007.) As of 2007, toll revenues collected by all state and local authorities derived directly from road and crossing tolls (tunnel and bridge as reported in Tables SF-3B and LGF-3B) amounted to $10.2 billion (of a total of $22.6 billion in all receipts, which include concessions, bond proceeds, etc.) (FHWA, 2009). Yet, even with the relatively low level of reliance on tolling as a revenue source, as recently as 2006, 23 states were considering adding toll-supported highways to their non-Interstate networks, and six states were planning to build toll roads for the first time (U.S. GAO, Jun. 2006).

In a series of technical papers assessing the role of tolling in future transportation finance, research undertaken for the National Surface Transportation Policy and Revenue Study Commission identified several important aspects of current and future policy and technology issues (both positive and negative) that could affect the role of tolling in generating revenues

(National Surface Transportation Policy and Revenue Study Commission, Jan. 2007). Among those listed in their report, the following are most appropriate to tolling issues:

- Use of electronic toll collection methods and interoperability of toll collection methods (E-ZPass and FasTrak, for example) have reduced the costs of toll collection and made toll collection financially feasible from an operations perspective (manual toll booth operations have historically consumed up to 30% of gross toll revenues).
- Advances in electronic tolling technology make open road tolling and other time- and location-sensitive tolling (options that have been impossible to date) possible and technically feasible.
- Institutional and legal precedents in the United States and abroad have demonstrated the feasibility of leveraging private funding; financial management; and long-term participation in constructing, operating, and maintaining highway infrastructure through the use of committed toll revenues.

These reviews and the commentary that accompanied them pointed out that there are likely to be serious issues and impediments to the use of tolling as a substitute for broader-based fuel taxes. One of the primary issues is the legal restriction on using tolls to finance Interstate highways (and, in several states, any public roads). These laws, at both the federal and state levels, would have to be amended.

In addition, a practical aspect of tolling revisits the early debate about funding the Interstate system. In rural states, where free and relatively uncongested alternative roadways are available, diversion from tolled roadways and the resulting poor revenue performance will likely make tolling less feasible in these states. This is seen as a major issue for many Midwestern and non-coastal Western states where highway demand is characterized by low traffic density, long distances, and free alternative routes. Even in relatively dense urban areas like Orange County, California, and Washington, D.C., tolling is not an unqualified success when measured by revenue generation. The Dulles Greenway (to the airport) was unable to sustain forecast revenues in the short term. However, the Dulles Toll Road, serving a high-density area east of the airport, continues to operate profitably and successfully, even helping to support an extension of the Washington Metro.

Finally, the public perception is that tolls and fuel taxes are substitutes for each other. Also, federal law relative to Interstate funding has seemed to support this view through the prohibition on the use of tolls on any federally funded portions of the Interstate system (with a few exceptions). Therefore, using tolls to finance repair and replacement, much less operations and maintenance, of existing federally financed highways is seen as "double taxation."

The general conclusion from reviewing these series of reports is that tolled facilities are a very small percentage of total miles and total revenues on the current highway system. Additionally, the length, density of traffic, and financial requirements to replace, rebuild, and otherwise maintain the existing system are likely too great to finance using tolls for most projects. Tolls will likely only be able to finance a relatively small number of urban capacity expansion and congestion management projects or to replace key bridges and tunnels where free alternatives are limited or too distant to be economically feasible to use.

Value pricing (also known as congestion pricing) is a subset of tolling that is focused on using tolls (pricing) to charge for the use of available highway capacity during periods of peak demand. Unlike a fixed price (flat rate) toll, value pricing involves adjusting the price charged to use a roadway based on the level of congestion; the more congested the roadway, the more expensive the toll. Prices can range from a fixed charge for use during the peak hour(s) of operation to a dynamically adjusted toll based on minute-by-minute tracking of congestion. In the latter case, computation of tolls is designed to establish and maintain free-flow on a highway segment or a network of tolled highways. Therefore, an important distinction exists between tolling, which is primarily revenue-driven to pay for construction and/or operation of a transportation facility, and value pricing, where tolls are set (either statically or dynamically) to manage the demand for access to the available capacity of the transportation facility. The former is directly tied to the costs of building and operating the facility; the latter is not. Several states are proceeding with implementation and testing of the value-pricing concepts, including (but not limited to) California, Texas, Minnesota, Oregon, and Washington. Literature describing the issues involved in implementing and evaluating value pricing are described by Schrank and Lomax (2009), the Washington State Transportation Commission (2006), and the Oregon Department of Transportation (2007 and Nov. 2009).

Recent federal highway legislation has begun to offer both justification and limited support for using tolls to provide specific capacity enhancement and demand management options for federally funded highways. Value pricing can be applied in a number of ways, and, under SAFETEA-LU and its predecessors, there has been an ongoing effort to fund value-pricing studies and demonstration projects (see: http://ops.fhwa.dot.gov/tolling_pricing/value_pricing/index.htm). SAFETEA-LU authorized both high-occupancy toll (HOT) lanes and also pilot projects for using tolls to rehabilitate and reconstruct existing Interstate highways, bridges, and tunnels (the last previously permitted under 23 U.S.C. 129). Currently, there are 72 active toll facility agreements under Section 129 in 24 states, with the earliest such agreement in 1961. Over 60% of these agreements have been negotiated since the Intermodal Surface Transportation Efficiency Act (ISTEA) was enacted in 1991 (FHWA, Oct. 2010). Florida has

the most tolling agreements (18), with Texas at 11 and California with 5. Most of Florida's agreements were put into place in the 1990s, and most of Texas' agreements date from 2002 to 2007. The remaining states have fewer than three facilities listed under Section 129.

The U.S. DOT released its *Congestion Pricing: A Primer* in December 2006. This document contains a detailed description of existing authorities and programs related to congestion pricing. In addition, there are three programs or provisions within the Federal-Aid Highway Program that support tolling for the purpose of highway financing (see the last three items in the list of existing authorities and programs related to congestion pricing that follow):

- **Value-Pricing Pilot Program.** This program, initially authorized in ISTEA as the Congestion Pricing Pilot Program, encourages implementation and evaluation of projects encompassing a variety of strategies to manage congestion on highways, including both tolling of highway facilities and other pricing strategies not involving tolls. This is the only program that provides funding. The Value-Pricing Pilot Program does currently extend to a fairly broad array of projects, many of which are operational but with some limited to studies. For additional information on the Value-Pricing Pilot Program, visit http://www.fhwa.dot.gov/tolling_pricing/. The U.S. DOT/FHWA value pricing website maintains a full list with details about each of the 73 demonstration projects. While there is no current summary overview of overall program progress, a number of studies on HOT lane pilot projects that are of the most interest to the states have been developed (FHWA, Dec. 2008).
- **High-Occupancy Vehicle/Toll (HOV/HOT) Facilities.** This program allows states to charge tolls to vehicles that do not meet the established occupancy requirements to use an HOV/HOT lane. The state establishes a program that addresses the selection of vehicles allowed in such lanes and procedures for enforcing the restrictions.
- **Express Lanes Demonstration Program.** This program permits tolling on 15 selected demonstration projects to manage congestion, reduce emissions in a non-attainment area, or finance new and existing Interstate lanes for the purpose of reducing congestion. Tolls charged on HOV facilities under this program must vary according to time of day or level of traffic; variable pricing on non-HOV facilities is optional (U.S. DOT, Dec. 2006).
- **Interstate System Construction Toll Pilot Program.** This program authorizes up to three facilities on the Interstate system to be tolled for the purpose of financing the construction of new Interstate highways.
- **Interstate System Reconstruction and Rehabilitation Pilot Program.** This program allows up to three existing Interstate facilities (highway, bridge, or tunnel) to be tolled to fund needed reconstruction or rehabilitation on Interstate corridors that could not be adequately maintained or functionally improved without the collection of tolls.
- **Title 23 United States Code Section 129 Tolling Agreements.** Section 129 allows tolling of non-Interstate highways as well as Interstate bridges and tunnels. There is no limit to the number of agreements that may be executed.

Congestion pricing projects involving tolls are categorized according to the extent of their application, as follows (U.S. DOT, Dec. 2006):

- **Priced lanes.** For priced lanes, pricing is applied on a limited number of lanes of a roadway.
- **Priced roadways.** For priced roadways, pricing is applied on all lanes of a roadway facility.
- **Zone-based pricing.** For zone-based pricing, pricing is applied within a limited zone involving several roadway facilities.
- **Systemwide pricing.** For systemwide pricing, pricing is applied within an entire metropolitan region, state, or country.

Truck-only toll projects to date have been studies that have not reached real-world fruition. Three studies have been sponsored by the Value Pricing Program:

- **California: PierPASS:** PierPASS is a system developed to provide incentives to shift cargo movements from peak daytime hours to night and weekend hours in order to reduce congestion and air pollution associated with port operations. The program charges a fee for accessing the port during peak daytime hours, encouraging traffic to shift to nighttime hours. The program was intended to reduce queuing at the gates and therefore reduce emissions from idling trucks. The program has been implemented in LA/Long Beach, and the OffPeak and PierPASS programs have exceeded expectations in terms of diverting truck traffic from daytime to evening hours. By 2006, PierPASS had diverted 2 million truck trips (Business Wire, 2006).
- **Georgia: I-75 South Truck-Only Toll (TOT) Study in Atlanta (Parsons, Brinckerhoff, Quade & Douglas, Inc., 2005):** In 2005, the State Road and Tollway Authority commissioned a study on the potential for the implementation of TOT facilities in the Atlanta region. The study covered three TOT lane alternatives. While not an exhaustive list of the possibilities, the three alternatives were chosen to provide regional results illustrative of the potential benefits of TOT. The report measured long-term performance of each selected scenario to determine whether there were any serious flaws in the TOT concept. The study found that TOT lanes can provide significant time savings to commercial

vehicles willing to pay a fee and that the implementation of TOT lanes could provide potentially significant congestion reduction in the region. The report also identified some difficulties implementing TOT lanes, including possible difficulties with construction and challenges with public perception, particularly for the scenarios where HOV lanes are converted to TOT lanes. The study recommended a more in-depth analysis as a next step to developing TOT lanes in the Atlanta area.

- **Georgia: Northwest Truck Tollway (Cambridge Systematics, Inc., 2009):** The Northwest Truck Tollway was originally proposed as part of the Savannah Metropolitan Planning Commission Long-Range Transportation Plan and is located between Effingham County, a suburb north of Savannah, and downtown Savannah. In 2009, Cambridge Systematics completed a report summarizing the feasibility of developing the project as a toll road and analyzing whether TOT lanes would be a viable solution to congestion in the area. The study documented the current situation and provided analysis of three possible alternatives for the construction of the road. Ultimately, the proposed model was a toll road for use by cars and trucks, which was aimed at separating through traffic, including traffic from the port of Savannah, from local traffic. The study found that an elevated alignment with one access point in the middle would provide the greatest benefit to both truck and automobile needs in the region. As next steps, the report suggests an investment grade traffic and revenue study, a detailed financial study, a detailed engineering design, coordination of efforts between local and federal stakeholders, and outreach to the general public regarding the use of tolls in roadway development.

Other states, most recently, Oregon, have assessed the feasibility of TOT facilities and found them to be difficult, if not impossible, to justify (ODOT, Feb. 2009). The primary issue is that for these facilities to be used, the increased productivity due to avoided congestion and improved travel time must exceed the cost(s) charged for using them and that these differences must take into account the availability of free alternative routes.

One noteworthy toll project is the new, interconnecting set of lanes between Tampa's two major parallel highways—Interstate 4 and the Seldon Crosstown Expressway. Construction started on March 1, 2010, and the project will have 13 lanes, all electronically tolled. The project, costing almost $400 million, will open in 2012. While there are some dedicated truck-only lanes elsewhere in the United States, this will apparently be the first TOT facility in the country (*My TBI,* no date).

Driver's License Fees

FMCSA currently collects about $75 million in unified carrier registration fees, leaving it about $30 million short compared to state entitlements. FMCSA has published a notice of proposed rulemaking in the Federal Register to address the issue (Federal Register/Vol. 74, No. 170/Thursday, September 3, 2009/Proposed Rules 45583). By all appearances, this is a limited proceeding geared toward maintenance of current program levels and not toward generation of any contribution to capital needs.

No survey of state licensing fees was undertaken, but the most populated state, California, has an initial $94 fee for a 5-year commercial driver's license (CDL). Significant differences in CDL license fees can lead trucking companies to simply register their vehicles in another state. Therefore, coordinated action among states would be necessary for generating additional revenue from this source.

Inspection Fees

The Obama Administration's proposed budget for FY11 contains a proposal for the FRA to impose a new safety inspection fee. The FRA establishes and enforces safety standards for U.S. railroads. FRA's rail safety inspectors work in the field and oversee railroads' operating and management practices. The Obama Administration proposed that, starting in 2011, the railroads cover the cost of FRA's field inspections because railroads benefit directly from government efforts to maintain high safety standards. The proposed fee would have been similar to existing user charges collected from other industries regulated by federal safety programs (Obama Administration, 2010). Collections from the first year would have totaled $50 million, rising to $80 million in FY12 and slowly thereafter. There was no suggestion that the fee would be imposed for any purpose other than cost recovery. If adopted as proposed, the base would only have risen to the same approximate magnitude as FMCSA's licensing fees. An example of how this would affect trucks at the state level can be seen by looking at California. California assesses its truck inspection fee per terminal, starting with $270 for one vehicle and reaching a maximum of $1,870 at 91 or more vehicles. Congress did not adopt this proposal, and the Obama Administration did not repeat it in its FY12 budget submission to Congress.

Truck Registration Fees

Truck registration fees are widespread and have been continuously and successfully imposed by all states. Fee structures vary widely, typically varying with the weight of the truck. In some cases, states charge a flat fee, while in others they use a flat fee along with a weight-based fee. For example, California charges a flat fee plus a fee on unladen weight and number of axles. The weight fee ranges from $8 to $1,039 (U.S. DOT, 2008a). The fees defray the costs of operating the state police and department of motor vehicles.

Container Entry Fees

Although widely discussed, there are no container fees in place to generate infrastructure revenue. Port authorities and the marine terminals that operate under their jurisdiction assess a mixture of tariff-based and negotiated fees for handling marine cargo. Ports typically charge a mixture of "wharfage" (assessed against the volume of cargo passing over the wharf) and "dockage" (assessed against the vessel for the use of the dock) or a fee that combines both. Marine terminal operators (stevedores) charge their ocean carrier clients for handling cargo and other services. Ports also typically lease marine terminals to the operators (the stevedores) and receive a stream of rent payments. These and other fees support port and marine terminal operations and capital expenditures.

There have been proposals for separate fees on containerized cargo to support infrastructure development and other cargo-related needs outside the port itself. The best known of such fees is the Cargo Infrastructure Fee, approved by the Ports of Los Angeles and Long Beach in 2008. The initial fee was set at $15 per loaded 20-foot equivalent unit (TEU), or $30 for a loaded 40-foot container (the most common size). The fee was to match funds from California's "infrastructure bonds." Implementation of the fee, however, has been postponed indefinitely due to declining cargo volumes and the threat of diversion to other ports.

The Ports of Los Angeles and Long Beach assess a separate fee for the Clean Truck Program, and similar fees have been considered in Oakland and New York and New Jersey. The PierPASS OffPeak program at Los Angeles and Long Beach assesses a fee for delivery of loaded containers to port terminals during the day shift. Revenue from these two fees, however, is used only to support the two specific programs. None of these fees are used for infrastructure funding.

Another fee is charged for use of the Alameda Corridor, the dedicated railroad between the ports of Long Beach and Los Angeles. Just under half of the $2.4 million project cost—$1.165 billion—is covered by revenue bonds. These bonds are to be repaid through a user fee that the railroads serving the harbor area have agreed to pay to the Alameda Corridor Transportation Authority (ACTA), the designated administrator and bond issuer. As of November 24, 2006, railroads pay ACTA a uniform fee of $40 per loaded 45-foot container, $36 per loaded 40-foot container, and $18 per loaded 20-foot container, with reduced fees for empty containers and non-waterborne domestic containers moving between the harbor and inland rail ramps. In turn, the railroads pass these charges on to their shipper and carrier customers, including ocean carriers. Since April 15, 2002, Transpacific Specialization Agency lines have implemented a pass-through of Alameda Corridor charges to their shipper accounts at the same revenue-neutral levels as those charged to them by the railroads (Transpacific Stabilization Agreement, no date).

Given the Alameda Corridor's funding success, one might wonder why it has not been replicated elsewhere. The literature does not answer that question directly, but apparently it has not been possible to assemble all the necessary ingredients in the Alameda Corridor's winning formula. There is no existing directly targeted federal program, and there is no existing directly targeted funding source. The local partners must assemble their own program, and federal assistance will probably come in the form of a loan guarantee.

Broadly based container or other port fees explicitly received support as a freight infrastructure financing mechanism in a submission to the National Surface Transportation Infrastructure Financing Commission by the California Association of Councils of Governments (CALCOG, September 7, 2007).

Vehicle Sales Tax

Today, new truck sales incur a federal tax of 12% in addition to any applicable state sales taxes, which are typically in the 5% range.

New truck sales are currently depressed. According to the Truck and Engine Manufacturers Association, Original Equipment Manufacturers (OEMs) faced the following losses in sales from 2006 to 2009 (TMA, 2009):

- Class 6: 70,000 down to 22,000.
- Class 7: 91,000 down to 39,000.
- Class 8: 284,000 down to 95,000.

The general economic downturn has hit construction and heavy equipment harder than any other part of the economy. The mandatory inclusion of diesel engines in emissions standards has also led to declines; while the engines are a major environmental improvement, they have also increased purchase prices and fuel consumption.

The sales base for any new revenue stream will presumably recover over time to sustainable, fleet-replacement levels somewhere between the apparently unsustainable peak of the last expansion and the current trough. Any proposal to impose a new tax on purchases will be sure to elicit strong opposition from an already depressed industry. Additionally, any such revenue source will likely receive cyclically dependent revenues over time, as evidenced by the current economic situation.

Major Financing Studies

Deficits in the funding of U.S. transportation infrastructure needs have led to several major studies examining the limitations of existing sources of funding as well as the advantages and disadvantages of new and modified sources of funding. Major contributions to our understanding of the current

funding issues and concerns for the future have come from AASHTO and the U.S. Chamber of Commerce, via its affiliated publishing entity, the National Chamber Foundation (NCF). Two National Surface Transportation Commissions were authorized by Congress with the purpose of developing a vision for the U.S. surface transportation system for the 21st Century. The two main contenders that emerge from these studies as sources of revenue with potential for meeting the funding needs of the next century are a modified fuel tax and VMT fees.

Alongside these national studies, there are two recent studies specifically focused on freight infrastructure financing, one by FHWA (FHWA 2007) and the other by TRB (TRB 2009). Both reiterated the importance of a user-charge-based system of financing for freight infrastructure. Additionally, an extensive national public opinion survey about federal transportation tax options is described. The overall findings of these reports, the national public opinion survey, and the evaluations of specific revenue options for freight infrastructure funding are examined in more detail in this section.

AASHTO calls for $3 billion a year for freight needs, to come from existing federal Highway Trust Fund sources, as well as a new program with funding sources yielding $6 billion a year from sales tax on motor fuels. Table A-3 captures the estimated revenues associated with various options, mostly short-run changes designed to bolster the federal Highway Trust Fund (AASHTO, Mar. 2007, p. 65). The additional revenue sources recommended by the AASHTO report include diversion of existing customs duties and VMT fees. AASHTO's representation of the revenue amounts that various options would yield for plausible specified values of tax rates, fee rates, duties, and so forth, are shown in Table A-4. The potential for revenue in 2010 and 2015 are the greatest from VMT ($0.01 per mile) on Interstate highways, other than NHS and Federal-Aid Highways, and VMT on Federal-Aid and Non-Federal-Aid Highways. The federal fuels tax indexed to capture the buying power from inflation since 1993 is a close third.

The NCF, as early as 2005 and drawing on work by Cambridge Systematics, published its list of candidate funding options, shown in Table A-5 (NCF, 2005a, p. 5). Three sets of options are considered: (1) increases in existing sources of revenue for the Highway Trust Fund; (2) new federal revenue from customs duties at ports and for intermodal imports; and (3) other revenue sources that state and local governments and the private sector could use to stimulate investments in transportation infrastructure such as tolls, Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA) credits, bonds, and investment tax credits (ITCs). The NCF report, like the AASHTO report, finds that the federal fuel tax indexed to

Table A-3. AASHTO revenue source recommendations.

Revenue Mechanism	Description	Revenue Generation 2010	Revenue Generation 2015
Potential Federal Revenue Options			
Federal Fuels Tax Increase	Across the board increase in cents/gallon tax on gasoline, diesel, gasohol, and specialty fuels	1 cent/gal = $1.9 billion	1 cent/gal = $$2.0 billion
Index Federal Fuels	Annually adjust cents/gallon fuels tax rates by an inflation index such as the CPI (approximately 0.49 cent/gallon each year)	$0.9 billion	$6.2 billion
Sales Tax on Motor Fuels	Percentage charged on sales revenues for gasoline, diesel, gasohol, and specialty fuels	1 percent = $3.5 billion to $5.5 billion (depends on how tax is imposed)	1 percent - $3.9 billion to $6.0 billion
End Revenue Loss from HTF Exemptions	Eliminate or finance from the General Fund Federal fuels tax exemptions for state, municipal, and certain agricultural vehicles	$1.2 billion	$1.3 billion
Recapture Interest on HTF Balances	Reinstate interest earnings on HTF balances (assumes minimum combined $10 billion balance and 5 percent interest rate)	$0.5 billion	$0.5 billion
Alternative Longer-Term Federal Revenue Options			
Sales Tax on Motor Fuels	Percentage charged on sales revenues for gasoline, diesel, gasohol, and specialty fuels	1 percent = $3.5 billion to $5.5 billion (depends on how tax is imposed)	1 percent = $3.9 billion to $6.0 billion
Customs Duties	Allocates a percent of current U.S. Customs duties for port, transportation, and intermodal freight investments	5 percent = $1.6 billion	5 percent = $2.0 billion
Vehicle Miles Traveled - User Fee	1 cent per mile traveled on Interstate, other NHS, and Federal-Aid highways	1 cent/mile = $25.7 billion	1 cent/mil = $28.3 billion
Vehicle Miles Traveled - User Fee	1 cent per mile traveled on Federal-Aid and Non-Federal (local) highways	1 cent/mile = $30.2 billion	1 cent/mile = $33.4 billion

Source: AASHTO, Mar. 2007, p. 65.

Table A-4. Surface transportation funding options matrix.

Funding Mechanisms	Mechanism Yield 2011 (millions)	Illustrative Rate	Revenues 2011 (millions)	Average Revenues 2011-2016 (millions)	Total Revenues 2011-2016 (millions)
Annual Drivers License Surcharge	$1.00 Surcharge = $222	$ 5.00	$ 1,110	$ 1,165	$ 6,993
Annual Highway Miles Traveled Fee (All Light-Duty Vehicles)*	1c/VMT = $6,538	$ 0.02	$ 13,075	$ 13,474	$ 80,843
Annual Highway Miles Traveled Fee (All Trucks)*	1c/VMT = $977	$ 0.03	$ 2,931	$ 3,020	$ 18,120
Annual Registration Fee (Light-Duty Vehicles)	$1.00 Fee = $261	$ 10.00	$ 2,613	$ 2,741	$ 16,448
Annual Registration Fee (Trucks)	$1.00 Fee - $4.4	$ 15.00	$ 66	$ 66	$ 399
Container Tax	$1 per TEU = $605	$ 15.00	$ 9,076	$ 10,658	$ 63,946
Dedicated Income Tax-Personal	1% of current taxes = $1,130	1.00%	$ 11,301	$ 11,881	$ 71,285
Dedicated Income Tax-Business	1% of current taxes = $383	1.00%	$ 3,832	$ 4,029	$ 24,172
Diesel Tax Revenue	1 cent/gal = $386	$ 0.15	$ 5,794	$ 6,052	$ 36,309
Gas Tax Increase	1 cent/gal = 1,379	$ 0.10	$ 13,795	$ 14,030	$ 84,183
Harbor Maintenance Tax	0.1% Tax - $1,236	0.50%	$ 6,181	$ 6,581	$ 39,485
HVUT Increase	10% Increase = $97	15.00%	$ 146	$ 169	$ 1,017
Imported Oil Tax	$1.00/Bbls = $4,217	$1.00	$ 4,217	$ 4,356	$ 26,138
Sales Tax on Auto-related Parts & Services	1.0% of Sales = $2,567	1.00%	$ 2,567	$ 2,823	$ 16,938
Sales Tax on Gas	1.0% of Sales = $2,987	8.40%	$ 25,091	$ 30,945	$ 185,671
Sales Tax on Diesel	1.0% of Sales = $868	10.60%	$ 9,198	$ 11,484	$ 68,903
Sales Tax on New Light-Duty Vehicles	1.0% of Sales = $2,337	1.00%	$ 2,337	$ 2,571	$ 15,427
Sales Tax on New and Used Light-Duty Vehicles	1.0% of Sales - $3,515	1.00%	$ 3,515	$ 3,837	$ 23,021
Share of US Customs Revenue	1% of Receipts - $333	1.00%	$ 333	$ 381	$ 2,288
Tire Tax on Light-Duty Vehicles	$1.00 Fee = $1,960	$3.00	$ 5,880	$ 6,168	$ 37,009
Ton Freight Charge - All Modes	1 cent/ton = $164	$ 0.25	$ 4,111	$ 4,432	$ 26,592
Ton Freight Charge - Truck Only	1 cent/ton = $113	$ 0.25	$ 2,835	$ 3,057	$ 18,340
Ton Mile Freight Charge - All Modes	1 cent/ton mile = $43,497	$ 0.05	$ 21,748	$ 23,446	$ 140,678
Ton Mile Freight Charge - Truck Only	1 cent/ton mile = $12,731	$ 0.05	$ 6,365	$ 6,862	$ 41,174
Truck/Trailer Sales Tax Increase	1% of Sale = $219	5.00%	$ 1,095	$ 1,529	$ 9,174
Truck Tire Tax Increase	10% Increase = $33	10.00%	$ 33	$ 48	$ 286
US Freight Bill - All Modes	1% of Sales = $7,612	1.00%	$ 7,612	$ 8,206	$ 49,236
US Freight Bill - Truck Only	1% of Sales = $6,608	1.00%	$ 6,608	$ 7,124	$ 42,745
Total Revenues			$ 173,465	$ 191,137	$ 1,146,819

*VMT fee estimates refer to miles traveled on Interstate System.

Source: AASHTO, 2011.

retroactively capture the increase in fuel costs since 1993 is the most remunerative revenue option. The revenue estimates are different in the two reports, primarily due to the differences in the time period considered for revenue generation and slightly different assumptions underlying the estimates. The National Surface Transportation Policy and Revenue Study Commission in its report, *Transportation for Tomorrow* (Dec. 2007) also called for a variety of measures to boost the solvency of the Highway Trust Fund.

The National Surface Transportation Infrastructure Financing Commission in its final report, *Paying Our Way* (2009), employed a weighted multiattribute utility analysis to come up with its evaluation of what it saw as the range of revenue options ranked based on their strengths and weaknesses

Table A-5. NCF summary of financing options.

Options to Close Funding Gap	Potential to Close Federal Share of Funding Gap 2005-2015	Potential to Close Non-Federal Share of Funding Gap 2005-2015	Comments
Federal Revenue Options to Increase Highway Trust Fund Revenues			
Index Federal fuel taxes starting in 2005	$62 billion		Index fuel tax rates to CPI starting in 2005.
Index Federal fuel taxes retroactive to 1993	$211 billion		Would result in 6.2 cent gas tax increase in 2005 with indexing to CPI thereafter
Eliminate HTF exemptions	$13 billion		As proposed in President's 2006 budget
Recapture interest on HTF balances	$9 billion		Declining source as HTF balances are reduced
Other Federal Revenue Options			
Utilize 5 to 10 percent of current Customs duties for port and intermodal improvements	$17 billion at 5 percent* $34 billion at 10 percent*		These funds would be set aside for port and intermodal purposes and mostly distributed back to Customs districts of attribution
Federal Policy Options to Enable and Stimulate Greater Investment by States, Local Governments, and the Private Sector			
Authorize flexible tolling provisions		$12 billion	Rough estimate based on extensive and increasing use of tolling and pricing
Enhance TIFIA credit instruments		$3 billion	Estimated additional private investment induced
Authorize private activity bonds (assume $15 billion nominal authorization as proposed by Administration and Senate)		$2 billion	Estimated additional private investment induced
Authorize tax credit bonds (assume $30 billion not bond proceeds authorization as in Senate-proposed "Build America Bonds")		$30 billion available for surface transportation grants through 2010; General Fund supported	Debt-oriented financing technique that leverages a Federal tax subsidy to generate new transportation funding.
Authorize freight/intermodal ITCs (assume $500 million annual limit on 20-year tax credits that are monetized over a 5-year period)		$6 billion available for freight/intermodal projects through 2009**	Equity-oriented financing technique that leverages a Federal tax subsidy to generate new transportation funding

Notes: *Only 30 percent of these amounts are estimated to fund highway-related needs such as intermodal connectors.
**These funds would not address the surface transportation needs normally included in the FHWA and AASHTO Needs Reports; however, they would address needs identified in the AASHTO Freight-Rail Bottom Line Report (American Association of State Highway and Transportation Officials, Freight-Rail Bottom Line Report, Washington, D.C., 2003).

Source: NCF, 2005a.

(see Table A-6) based on an evaluation using weighted criteria (see Table A-7). The Commission found VMT as a top federal revenue option and facility level tolling and pricing as the best state and local revenue option. Other options—classified as strong, moderate, or weak—are listed in Table A-6.

The Mineta Institute (MTI), in its report on a national survey of public opinion, asks the question: "What Do Americans Think About Federal Transportation Tax Options?" The preliminary results from Year 2 of this national survey were made public in May 2011. The survey results show:

- A majority of Americans would support higher taxes for transportation—under certain conditions. For example, a gas tax increase of $0.10 per gallon to improve road maintenance was supported by 62% of respondents, whereas support levels dropped to just under half if the revenues were to be devoted to reducing local air pollution or global warming. For tax options where the revenues were to be spent for undefined transportation purposes, support levels varied considerably by what kind of tax would be imposed, with a sales tax much more popular than either a gas tax increase or a new mileage tax.
- The poll also asked respondents about their priorities for government spending on transportation in their state. Over two-thirds of respondents felt that governments should make it a high priority to maintain streets, roads, and high-

Table A-6. National Surface Transportation Infrastructure Financing Commission summary of financing options.

Strong	Moderate	Weak	Not Applicable/Seriously Flawed*
Federal Options			
Vehicle miles traveled fee	Freight waybill tax	Freight ton-mile tax	Vehicle inspection and traffic citation surcharge
Automobile tire tax	Vehicle sales tax	Driver's license surcharge	Vehicle personal property tax
Motor fuel tax	Harbor maintenance tax	Bicycle tire tax	Windfall profits tax
Carbon tax/cap and trade	General fund transfer	Dedicated income tax	Petroleum franchise tax
Customs duties		Auto-related sales tax	Minerals severance tax
Truck/trailer sales tax		Freight ton-based tax	Federal tax on local transit fares
Vehicle registration fee		General sales tax	Federal tax on local parking fees
Heavy Vehicle Use Tax			
Container fee			
Tariff on imported oil			
Sales tax on motor fuels			
Truck tire tax			
State and Local Options Benefiting from Federal Action			
Facility level tolling and pricing	Proceeds of asset sales, leases, and concessions	Cordon area pricing	Development and impact fees
		Passenger facility charges	Tourism-related taxes
			Tobacco, alcohol, and gambling taxes

For revenue options that are dependent upon utilization of a targeted investment fund as a basic premise for feasibility; such a fund is assumed for evaluation purposes (e.g., for all freight-related funding mechanisms and more specifically those more narrowly targeted to intermodal port and harbor-related investment).

* State and local options in this category may have applicability but there is no relevant federal action or role.

Source: National Surface Transportation Insfrastructure Financing Commission, 2009.

Table A-7. Criteria for evaluation and weighting.

Criteria	Weighting
Revenue Stream Considerations	
Revenue potential	14.0%
Sustainability	8.0%
Flexibility	4.5%
Justification for dedication	4.5%
Implementation & Administration	
Public acceptance/political viability	9.0%
Appropriateness for federal use	7.0%
Ease/cost of implementation & admin.	7.0%
Ease/cost of compliance	4.5%
Economic Efficiency/Impact Considerations	
Promotion of efficient investment	7.0%
Promotion of efficient use	14.0%
Creates/mitigates side effects	3.5%
Equity Considerations	
User/beneficiary equity	10.0%
Equity across income groups	3.5%
Geographic equity	3.5%

Source: National Surface Transportation Infrastructure Financing Commission, 2009.

ways, and almost two-thirds said the same about reducing accidents and improving safety. By contrast, not quite half of respondents placed a high priority on reducing traffic congestion or expanding public transit service.

- The survey questions replicate those from a similar survey that MTI conducted in 2010 to establish how public views may have shifted over the past year. The only substantial change in support levels over the 2 years was a jump in support for a gas tax with revenue spent to reduce local air pollution. In 2011, the tax had 48% support, compared to 30% in 2010.

TRB issued a major report in 2009 entitled *Funding Options for Freight Transportation Projects,* with the following main findings:

- Present financial arrangements are inadequate for maintaining and improving freight transportation system performance.
- Finance reforms should be designed to promote productivity gains.
- Finance reform options differ in their probable impacts on freight system performance.

To finance new programs, the TRB report expressed a preference for projects with user charges: "A project's ability to generate revenue from its users is evidence of economic benefit to users and helps ensure that it will be sustainable in operation" (TRB, 2009, pp. 5–6, 9).

The National Surface Transportation Policy and Revenue Study Commission, in *Transportation for Tomorrow* (Dec. 2007), after considering a variety of options specifically for freight transportation funding, suggested a federal freight fee—not specified as a container charge or waybill charge—giving the example of the existing $45 charge imposed by the Port Authority of New York and New Jersey. The report also suggests that an unspecified portion of customs duties would likewise be deposited into a new Surface Transportation Trust Fund, and an ITC for facilities owners would promote expansion (National Surface Transportation Policy and Revenue Study Commission, Dec. 2007, pp. 42–43). FHWA, in *Financing Freight Improvements* (2007), provides detailed information about both the existing federal funding program structure and operations and the corresponding freight application as well as case studies to show how a variety of intermodal freight facility projects have been funded.

To sum up, the NCF led the way with the earliest discussion regarding broad revenue options, and AASHTO fleshed out the basic revenue options outlined in NCF with specific yield estimates. While the national expert studies on transportation support the VMT fee or a modified gas tax, public opinion survey results show that a majority of voters prefer a tax to fee increase, but this depends on how the tax increases are used. While the highway authorization situation has struck most as highly regrettable, perhaps the delay offers one last opportunity for an authorization in anticipation of a major future effort. At the same time, nothing prevents Congress from creating a new program after the omnibus reauthorization.

Specific Revenue Proposals

Vehicle or Axle Weight Tax

According to the U.S. DOT and as cited by the Congressional Budget Office, the current fuel taxes result in an inequity between smaller trucks and larger ones: "[A]ccording to DOT's most recent calculations, the revenues generated from federal fuel taxes levied on smaller trucks with weight less than 25,000 pounds cover 150 percent of their cost impact, but larger trucks weighing over 100,000 pounds pay only 40 percent of their costs" (U.S. GAO, 2008, p. 16). The wear and tear imposed by vehicles is exponential, and it has been known for decades that the effect is extreme, such that a 10% increase in axle weighting would yield a 46% increase in wear and tear (Luskin and Walton, 2001, p. 2). Requiring the purchase of overweight permits could roughly capture excessive costs from these vehicles. This permit's cost could be increased over time and tied more closely to wear and tear.

The conceptual case in favor of a highly progressive vehicle weight tax therefore seems to be strong. The question of behavioral response would have to be addressed, however. To what extent would loads in the largest trucks be split up into two to avoid vehicle weight taxes? The relationship between weight and wear and tear refers to the axle weight, not the total vehicle weight, so an increase in axles could offset the increase in total weight. Therefore, a tax should address weighting per axle rather than the weight of the whole vehicle, providing incentive to move less weight per axle.

Dedicated Customs Duties

Both diversion of customs fees and a surcharge to custom fees have been proposed as freight infrastructure revenue sources, and a critical distinction must be made between the two approaches. Diversion would add no new revenue to the federal budget. Diversion of a portion of customs duties to fund freight-related infrastructure was proposed by Hicks (2003) and recommended by the National Surface Transportation Policy and Revenue Study Commission in their *Transportation for Tomorrow* report (Dec. 2007). The National Surface Transportation Infrastructure Financing Commission recommended a related 3.5% surcharge on customs duties and fees. AASHTO estimated that if a 5% rate were in effect today, it would yield $1.6 billion in 2011 (See Table A-3).

Hicks (2003) envisioned diverted customs revenue as a funding source for maritime infrastructure projects, not as a replacement or supplement for fuel taxes. In contributing to the 2006 California Marine and Intermodal Transportation System Advisory Council (CALMITSAC) report, however, Hicks changed his position. The CALMITSAC report recommends that public policy makers "[a]bandon efforts to secure a 'Customs carve-out, including proposals to capture an increment of growth' in customs duties" (CALMITSAC, 2006, p. xiv). The CALMITSAC report goes on to note that due to multiple trade agreements, including The North American Free Trade Agreement and The Jamaican Republic–Central America–United States Free Trade Agreement, customs duties have not grown with the volume of trade and were not expected to do so in the future. The same report notes that about 30% of customs duties are used to support farm subsidies, making the agricultural sector a potential opponent of customs revenue diversion for other purposes. The CALMITSAC report sums up the reasons for its policy position that "Customs carve-out proposals are clearly a futile exercise, considering that:

- U.S. trade negotiations are whittling away at this source of revenue.
- There is no reliable pattern of growth in customs duties.
- All previous legislative carve-out proposals have failed.
- U.S. farmers are trying to hold on to this important source of agricultural subsidies.

- Importers and the White House Office of Management and Budget continue be opposed to customs carve-out" (CALMITSAC, 2006, p. 49).

Also, in the context of broad infrastructure funding, there is no connection between the customs duties on various international trade flows and the impact of trade on the maritime, highway, air, or rail transport systems, i.e., custom duties do not meet the user benefit criterion.

Customs duties have always been general purpose revenues, going back to the founding of the American Republic. Indeed, in the earliest years, customs duties were the *only* source of revenue for the federal government; there was no internal revenue at all until the first whiskey tax in the Washington Administration. Customs duties do not go to U.S. Customs and Border Protection (CBP), whose budget consists of about $10 billion in appropriated general funds and $1.4 billion in fees. Given CBP's many duties, the huge throughput it must manage, and the demand for increased port security, it is unlikely that any money could be removed from its budget to sustain capital expenditures.

Diverting custom duties to a freight infrastructure fund would impoverish the General Fund to the extent that any new special fund would be enriched. Although the amount seems small in relation to the size of the federal General Fund, a key question would be whether federal appropriators, faced with a reduction in their allocations, would object.

Moreover, with trade tariffs being reduced, there would be the long-term problem of a declining tax base and consequent conflict with U.S. trade policy. Passage of the three free trade agreements—with Panama, Columbia, and South Korea—would reduce customs revenue. Even more so, a successful completion of the admittedly struggling Doha Round would produce declining customs revenues over time across a very broad range of companies. For any given amount of revenue raised, the percentage dedicated to freight infrastructure would have to rise each year to maintain revenue from this source for the freight infrastructure fund.

Freight Tonnage Tax

Total freight tonnage for all modes increased slightly in 2007 to more than 880 million tons. While the 2007 data do not reflect ongoing economic trends, in 2008, all freight modes showed the effects of the continued economic downturn. Nationally, reported freight transport rates are down from between 11 and 40%. However, the rate of decline is decreasing, and there is some hint of a rebound in some sectors of manufacturing and logistics. Motor carrier data may not directly reflect exact industry tonnage amounts and should only be used to indicate general industry trends. In 2008, motor carrier tonnage was off nearly 20% while truck numbers increased slightly. Rail freight tonnage decreased to slightly less than 10% in 2007, which is again likely related to the overall economic downturn (Missouri Department of Transportation, 2010).

The literature does not contain a detailed proposal for a freight tonnage tax, and the interaction of federal and state agencies has not been specified in this regard. Additionally, it is unclear whether there will be self-reporting. If so, how would carriers be audited?

At the state level, the record-keeping required to administer a tax can be seen from a discussion by the Missouri Department of Transportation, which tracks freight tonnage by mode annually. Port tonnage is reported to the Missouri Department of Transportation from public ports and the Army Corps of Engineers. Air cargo data are collected via mail survey of commercial airports with known cargo activity. Rail tonnage is obtained from the Association of American Railroads. The Missouri Department of Transportation calculates motor carrier freight movement using commercial vehicle miles traveled, trip length per shipment, and average truck cargo weight.

Freight Weight-Distance/Ton-Mile Tax

A weight-distance or ton-mile tax can be seen as a variation of a tonnage tax. The definition of the tax is as follows:

> A ton-mile tax is one method for a government to generate funding for road construction and maintenance. This would be levied based on the actual weight being carried for each trip and the number of miles traveled. The taxes are set based on the weight of the truck, and for larger trucks, the number of axles is also taken into account. It attempts to allocate the costs based upon the wear and tear that the vehicle puts on the road since a heavier vehicle will cause a road to deteriorate faster. Proponents argue that such a tax gives drivers incentives to drive vehicles that are lighter or spread the weight over more axles. The administrative costs of these taxes appear to be quite high, and some states that previously used ton-mile taxes have repealed them. (USLegal, no date)

Multiple proposals have considered assessing a highway user tax based on ton-miles. A ton-mile is the activity involved in transporting one ton a distance of one mile and is a common unit of freight transportation. The tax base options discussed in the literature include gross ton-miles (which include the empty weight of the vehicle); net ton-miles (which include only the weight of the lading and do not include miles traveled empty); and revenue ton-miles (activity for which a for-hire carrier was paid) for different purposes.

The State of Oregon uses this tax, but it appears to be a sore point for the trucking industry. The American Trucking Associations has detailed its objections, considering the following criteria for evaluating business taxes:

- **Efficiency** here stands for the notion that a tax should have a low ratio of administrative cost to the revenue it brings in.

- **Equity** means that a tax should be structured so as not to unduly discriminate among segments of the industry, large and small carriers, interstate and intrastate operations, or modes of transportation. A relatively objective test for the equity of a proposed tax, however, is whether it discriminates against a part of the industry in favor of another part, or against trucking as opposed, say, to rail.
- **Effectiveness** goes to the ability of a tax to raise, with reasonable rates, the amount of money needed for its purpose. Whether the rates of a tax are reasonable or not may appear a subjective question, but when tax rates are so high as to make a tax uncompetitive or unenforceable, the tax ceases to be effective. Oregon's weight-distance tax, at more than 13 cents per mile at 80,000 pounds declared weight, seems clearly ineffective by this measure.
- **Enforceability** means that a tax is structured and administered in such a way as not to invite evasion. Structure matters a great deal to enforceability. A tax that depends on self-assessment by a multitude of taxpayers, for example, will not be readily enforceable. The enforceability of the personal income tax, both at the state and federal level, depends absolutely on the mechanism of tax withholding. The fuel tax is enforceable in large part because it depends on compliance by a small number of fuel suppliers both to collect the tax from their customers and to remit it to the state. A weight-distance tax, on the other hand, and, perhaps to a lesser extent, a general sales or gross receipts tax, are not readily enforceable. Weight-distance tax regimes commonly feature not only burdensome audit and reporting requirements, but they vary by ports of entry as well.
- **Competitiveness** stands for the idea that a tax should not disadvantage businesses located in the taxing state *vis a vis* out-of-state competitors or motor carriers *vis a vis* other modes of transportation.
- **Neutrality** means that a tax is structured in such a way that it does not unduly influence business investment decisions or run counter to important state policies. It might be noted that this criterion involves two conditions that may sometimes conflict, since state policies may well run counter to neutrality in business investment decisions, and *vice versa.*
- **Non-intrusiveness** in a tax means that it does not unduly create concerns over privacy, either personal or corporate. For the most part, this criterion has become more important as automated databases have become more widespread, allowing government, on the one hand, to manipulate masses of data not otherwise available to it and, on the other, to lose, sell, or otherwise mishandle that data. The income tax, however, both individual and corporate, has always been a relatively intrusive tax—whether unduly so depends on one's point of view.

In the highway tax area, it might be stated as a general rule that a tax that relies for its enforcement on keeping detailed records of the travels of at least personal passenger vehicles is, at least currently, unacceptably intrusive. It might be suggested that a tax that requires government to keep either intimate personal data or proprietary business data without the most rigorous safeguards violates this criterion (Pitcher, 2010).

Weight-distance tax regimes in the German-speaking countries are described by the NCF in Appendix D of *Future Highway and Public Transportation Financing, Phase II* (pp. 114–115). The German Toll Collect truck toll system applies to vehicles heavier than 12 metric tons and only to the use of motorways—other roads are exempt. The price varies by distance traveled, the number of axles, and the emissions class of the vehicle. The overall fee structure is designed to recoup direct capital and operating costs to the motorway system imposed by truck traffic. The technology supporting Toll Collect involves an OBU equipped with a GPS to determine motorway entry and exit and distance traveled and also a global system for mobile communications (GSM) to communicate billing data to the central computer system. Toll Collect is administered by a private consortium that collects the tolls on behalf of the German government (NCF, 2005b).

Switzerland launched its heavy goods vehicle fee (HVF) in January 2001. The HVF applies to all vehicles with a maximum laden weight in excess of 3.5 metric tons. The fee is based on the distance driven (on all Swiss roads, not just the highways), as well as the maximum laden weight and emissions class of the vehicle. The price structure is designed to account for both direct and external costs of trucking and to encourage a freight mode shift from road to rail. The supporting technology includes an on-board unit (OBUs, mandatory for all Swiss vehicles and optional, though encouraged, for foreign vehicles) featuring GPS and a DSRC system, as well as a connection to the vehicle's tachometer (which includes odometer information). DSRC signals from overhead gantries at border crossings (in the case of primary arteries) and GPS position signals (in the case of smaller roads without DSRC gantries) are used to record the status of the OBU (within Switzerland or traveling abroad), and odometer information is used to register miles driven on Swiss roads. DSRC stations mounted throughout the network are also used to verify the correct functioning of passing trucks as a means to prevent toll evasion (NCF, 2005b, pp. 114–115). By way of comparison, Swiss registrations of trucks in 2009 were about 326,000, while a comparable figure for the United States, based on the 2002 VIUS, is in excess of 85 million (NCF, 2005b).

The domestic literature on ton-mile taxes, weight-distance taxes, and variations is largely conceptual. The weight-distance taxes previously tried by individual states predated OBU/GPS technology and relied heavily on manual record keeping. More recent discussions of ton-mile taxes have largely been subsumed by the broader VMT tax concept.

The available discussions of ton-mile and weight-distance taxes generally do not delve into distinctions between empty

and loaded vehicle miles, the differences between actual vehicle tire weight and vehicle weight class, the treatment of government and service vehicles, or the carriage of lading that is not weighted. Furthermore, a freight ton-mile tax raises significant modal equity questions that are not addressed by the current literature in any detail. If applied only to for-hire and private freight trucking, such a measure would ignore the substantial impacts of non-freight vehicles of all kinds.

In 2003, the last year for which Bureau of Transportation Statistics (BTS) data are uniformly available, the average freight revenue per ton-mile was 13.36 cents for truck, 2.28 cents for rail, and 1.77 cents for barge (BTS, 2010). A nominal 1 cent per ton-mile fee would therefore increase average truck rates by around 8%, average rail rates by around 44%, and average barge rates by about 56%. Clearly, a multimodal ton-mile tax would require much more detailed investigation than the current literature reflects.

Congestion Pricing and Road Pricing

"Road pricing" is generally envisioned as being applied to chronically congested urban routes, but the term also sometimes includes broader user fee concepts. "Congestion pricing" is typically proposed as a traffic demand management (TDM) strategy, for which revenue generation is of secondary importance. For this project, the concept of selectively pricing road segments with or without a time dimension is relevant both as a revenue-generation mechanism and as a potentially desirable option for VMT fees or other use fees. In urban areas, the cost of passenger vehicles' contribution to congestion is about 10 cents per mile, representing one of the largest sources of external costs of motor vehicle use (CBO, Jan. 2011).

In 2007, the U.S. DOT released its *National Strategy to Reduce Congestion on America's Transportation Network* (U.S. DOT, Jan. 2007a). Then-Secretary Mineta observed, "Congestion is not a fact of life. It is not a scientific mystery, nor is it an uncontrollable force. Congestion results from poor policy choices and a failure to separate solutions that are effective from those that are not" (U.S. DOT, Jan. 2007a). The document lays out a plan to address congestion, including implementing a broad congestion pricing or variable toll demonstration project.

Actual congestion pricing and road pricing demonstrations have been very limited, and there is very little experience with implementation in the United States. Examples are so far largely limited to varying tolls on existing toll roads, bridges, and tunnels, and some experience with variable parking fees (e.g., downtown New York City).

An academic article on road pricing puts this tension in a pithy fashion: "Although the idea wins intellectually, political acceptability remains a great challenge, and diverse attempts to introduce road pricing have failed politically. The classic tension between the desirable and the politically acceptable is particularly relevant for highways, as we find ourselves in a freeway status quo that is difficult to undo" (Lindsey, 2006, p. 95). Moreover, the article also points out that on various aspects of the implementation of road pricing, "economists disagree over how to set tolls, how much to cover common costs, what to do with any excess revenues, whether and how 'losers' from tolling previously free roads should be compensated, and whether to privatize highways" (p. 96).

Resources for the Future modeled the Washington, D.C., metropolitan area with a view towards a single inner cordon for the District of Columbia itself, an outer cordon at I-495/Beltway, or both; distance- and time-sensitive charges on either freeways or roads generally; and a VMT tax (Safirova, Houde, and Harrington, 2007). Researchers considered not only congestion costs but also social costs such as pollution, accidents, climate change, oil dependency, and noise. They found that "comprehensive variable time-of-day pricing on the entire road network turns out to be by far the most effective and efficient policy when it comes to reducing congestion alone. However, when other social costs are factored in, the performance of the VMT tax is almost as efficient" (Safirova, Houde, and Harrington, 2007, p. 21). The VMT tax had earlier been estimated at 14–15 cents per mile (p. 17). Full social cost pricing would call for cordon entry fees of $3.34 at the Beltway and $5.80 for downtown (Washington D.C. area). In their abstract, Safirova, Houde, and Harrington acknowledge, "We also find that full social cost pricing requires very high toll levels and therefore, is bound to be controversial" (Safirova, Houde, and Harrington, 2007, abstract).

A sharp illustration of the disagreement in the literature regarding the benefits of road charging is encapsulated by "War of Words," a magazine article about a debate between anti-London cordon pricing activist Peter Roberts and pro-pricing Canadian columnist Bern Grush. Roberts asserts that "road-user charging is a tax too far. It has been exposed as intrusive, expensive, inefficient and authoritarian. We do not want it and no amount of propaganda or heavy-handed persuasion can change our minds" (Cassini, 2008, p. 57). Grush counters with his conclusion: "To fix funding, congestion and emissions: a) remove registration and fuel taxes; b) charge for road use by time, place, and distance; c) provide better roads and; d) provide better public transport" (p. 57).

In the United States, resistance is indicated in the claim made by ATRI that "in cases where research has included a consideration of system end-user interests, findings suggest that system end-users do not typically support alternative financing approaches" (ATRI, 2007, p. 2) to the existing fuel/gas tax.

A different analytical perspective, considering freight specifically, comes from Rensselaer professor Jose Holguin-Veras, who studied truck deliveries into Manhattan in light of proposed London-style cordon entry pricing. He found freight road pricing of limited effectiveness in reducing urban truck traffic because "the decision about delivery time is made jointly

between the carrier and the receiver; the carriers have great difficulties passing toll costs to receivers; and, in the few cases where toll costs could be passed, the pricing signal reaching receivers is of no consequence compared to receivers' incremental costs of off-hour deliveries" (Holguin-Veras and Silas, 2008, p. 2). Instead, tax deductions to receivers willing to do off-hour deliveries, such as restaurants, would work better to reduce congestion. His simulation showed that a $10,000 tax deduction to receivers could stimulate a 20% shift in deliveries to off hours (p. 12). ATRI echoed this point of view: "Price changes, however, may not have any effect; a Georgia study showed that delivery time, and thus the time at which trucking operations occur are strongly driven by shipper/manufacturer requirements. Consequently, the attempt to 'price' trucks (that have no choice in delivery schedules) out of the commuter traffic mix becomes regressive and inflationary" (ATRI, 2007, p. 14).

Perhaps the most practical perspective of all on the cost of congestion comes from the Texas Transportation Institute's *Urban Mobility Report,* which estimates the total national congestion costs for 437 urban areas in 2007 at a total monetized cost of $78 billion due to a loss of 4.2 billion hours and 2.9 billion gallons of fuel (Schrank and Lomax, 2007, p. 1).

Freight Transportation Services/Waybill Tax

A tax on freight transportation services would be modeled after the existing air cargo tax of 6.25% and is also sometimes referred to as a bill of lading tax or a waybill tax. A report (prepared by PricewaterhouseCoopers) of the American Road and Transportation Builders Association (ARTBA) contains by far the fullest treatment (ARTBA, 2009). Table A-8 contains the specifications of this proposal.

PricewaterhouseCoopers puts the gross yield for a 1% tax at $65 billion; taking into consideration deductions for taxes paid from the corporate income tax, the net yield would be $49 billion. Critically—and unlike the air cargo tax—the IRS would have to issue regulations, under Section 482 of the Internal Revenue Code, upon which private trucking fleets would calculate a taxable basis. Today there is no explicitly stated market value.

Rep. Adam Smith of Washington previously introduced H.R. 2707 to establish the National Freight Mobility Infrastructure Fund. In 2011, the bill was reintroduced as H.R. 3607. According to this proposal, the U.S. DOT would establish a Freight Mobility Infrastructure Improvement Program to award competitive grants to improve the efficiency of freight. The bill would impose a tax on taxable ground transportation equal to 1% of the fair market value (with some exceptions for federal, state, and local government transportation and transport within a local geographic area) and would require deposits into the new fund of amounts equivalent to the new tax. The Coalition for America's Gateways and Trade Corridors supports the Smith proposal as the broadest-based proposal that has been made to support an overall freight program (www.tradecorridors.org). The Waterfront Coalition previously registered its objections to the difficulty of complying with the proposed new tax, which would not, as Pricewaterhouse Coopers detailed, apply to private fleets. Some of the objections voiced by the Waterfront Coalition in a hearing before the Ways and Means Committee are the following:

> . . . While the tax attempts to fairly capture each and every user of the system, the mechanism still exempts a large segment of highway users.
>
> . . . Almost half of all truck moves occur by way of internal trucking or private fleets. Assessing a transaction fee on internal trucking moves would be quite difficult given the fact that a shipping document or purchase order is not generated. It is our belief that private fleets should not be exempt from the fee.
>
> . . . Establishing a fee collection system that takes into account modern logistics practices could be quite difficult and costly to establish and administer. Today, many domestic moves involving consumer products are originated by electronic interchange between business partners that does not involve a paper shipping document. Often retailers and product suppliers communicate by way of electronic transmission of inventory control data. Shared logistics software then notifies a contracted trucking company to move product to a retailer's store or consolidation center. This electronic interchange does not generate any shipping document and the information shared between motor carrier, product supplier and retailer is often proprietary. It would be quite difficult for an agency of the government to tap into this electronic interchange for the purpose of collecting a transaction fee. It is even more difficult to determine which entity in this transaction remains the party responsible for paying and collecting the fee (Waterfront Coalition, 2009).

To date, proposals for transportation services taxes or fees do not include methodologies for including the value of transportation provided by private or contract carriers. The proposal outlined in Table A-8 exempts government-provided transportation services, thus failing to address one of the major "holes" in the current fuel tax system. The proposal does not address the highway impacts of service vehicles, construction equipment, and so forth. It is mode-specific and does not address rail, marine, or inland waterway modes. Perhaps most critically, the available literature makes no connection between the monetary value of transportation services and the impact of those services on the highway system.

Vehicle Miles Traveled (VMT) Fee

A fee on vehicle miles traveled (VMT) is the leading candidate to replace or supplement the highway fuel tax system. VMT is a direct reflection of vehicle activity on streets and roads. VMT user fee variations include the following:

Table A-8. Specifications for highway transportation services tax.

Issue	Explanation
Administration	The tax would be enacted as part of the Internal Revenue Code and administered by the IRS under Code provisions relating to federal excise taxes.
Application of tax	The tax would apply to the value of highway transportation services.
Liability for tax	The purchaser of the highway transportation services would be liable for the tax.
Collection and remittance responsibility	The tax would be collected and remitted to the U.S. Treasury by the provider of taxable highway transportation services.
Taxable highway transportation services	In general, taxable highway transportation services would be defined as the movement of property within the United States in a truck with gross vehicle weight rating over 26,000 pounds (Class 7 and Class 8 trucks). Transportation that occurs outside of the United States (the 50 States and the District of Columbia) is not subject to tax. An amount would be treated as paid for taxable highway transportation services if it is directly related and integral to the cost of providing such services, including separately stated charges for fuel and other items.
Self-provided and related-party transportation services	If taxable highway transportation services are self-provided or provided to a related party, the tax would be imposed on the value of the services.
Accessorial services	In general, accessorial services, such as warehousing and storage, packing and unpacking, sale of insurance coverage, and rental of containers, would not be subject to tax if separately stated, unless the services can only be provided by the carrier, either directly or subcontracted, and all who use the service are directly or indirectly charged for it.
Freight forwarders and shipping agents	Amounts received by freight forwarders and shipping agents that arrange but do not provide taxable highway transportation services are not subject to tax. Amounts such persons pay for taxable highway transportation services are subject to tax under the general rules.
Multimodal transportation services	If an amount paid for transportation services includes both taxable highway transportation services and other modes of transportation, the tax would be imposed only on the value of the taxable highway transportation services.
Exemption	Transportation services provided by federal, state, and local governments and instrumentalities thereof would be exempt from the tax unless the transportation services are provided for hire, such as by the United States Postal Service.
Filing requirement	IRS Form 720, Quarterly Federal Excise Tax Return, would be revised to include the new highway transportation services tax.

Source: ARTBA, 2009.

- VMT fee on all roads or only on Interstates and NHS routes.
- VMT fees with or without congestion pricing or other Traffic Demand Management (TDM) options.
- VMT fees adjusted by weight class or axle count to reflect the greater impact of heavier vehicles.

However, the effect of VMT taxes on overall efficiency also would depend on how much it costs to put the taxes in place and to collect the taxes.

Estimates of what it would cost to establish and operate a nationwide program are rough (CBO, Mar. 2011). The most comprehensive reference is *NCHRP Web-Only Document 143* (Sorenson et al., 2009). Nine VMT fee variations were considered by this study:

- **Self-reported odometer readings.** For this option, drivers would report their current mileage each year as part of the annual registration process.
- **Annual odometer inspections.** Similar to the prior option, the key distinction here is that drivers would submit to periodic (likely annual) odometer readings at certified stations as the basis for assessing mileage fees.
- **Assumed annual mileage with optional odometer inspections.** With this approach, vehicle owners would be assessed

an annual VMT fee based on the estimated mileage for the vehicle class (e.g., passenger vehicles vs. commercial trucks).

- **Fuel consumption–based mileage estimates.** Under this approach, fuel consumption would serve as the basis for estimating travel distance. All vehicles would be equipped with some form of automated vehicle identifier, or AVI, device (likely a radio frequency identification, or RFID, tag embedded in the license plate or registration sticker).
- **On-board diagnostics (OBD) II-based mileage metering.** For this approach, vehicles would be equipped with an on-board unit (OBU) that serves as the mileage metering device. The OBU would be connected to the on-board diagnostics port (with a second generation, or OBD II, available on vehicles manufactured since 1996), providing data on vehicle speed that can be integrated over time to compute travel distance.
- **OBD II/cellular-based mileage metering.** Like the previous approach, this would rely on an OBU connected to the OBD II port to meter mileage. The OBU would also be equipped with cellular communications, and this would make it possible to determine, with rough accuracy, the location of travel.
- **Coarse-resolution GPS-based mileage metering.** From the perspective of metering capabilities, this option, employed in the Oregon trials, is identical to the previous approach. The only difference is that the OBU would rely on a coarse-resolution GPS receiver, rather than cellular-based location, to identify the jurisdiction or area of travel.
- **High-resolution GPS-based mileage metering.** This option is similar to the prior approach, but would rely on differential GPS for sufficient accuracy to determine the specific route of travel.
- **RFID-based tolling on a partial road network.** With this option, all vehicles would be equipped with AVI devices featuring RFID tags. These would communicate, via DSRC technology, with gantries set up along the most heavily traveled segments of the road network to support facility-based tolls—either flat tolls or tolls that vary by time and location.

In briefly evaluating each of the metering mechanisms described above, the goal of the study was to distinguish a smaller set of options offering the greatest potential for near-term implementation. These judgments were based on several criteria:

- **Full road network metering.** The system should be capable of metering VMT across the entire road network.
- **Cost vs. metering capabilities.** If a system offers limited metering capabilities (that is, the ability to vary rates by vehicle characteristics but not by time or location of travel), then it should also be low cost.
- **Enforceability.** The system should allow for at least reasonably effective enforcement, both to protect against revenue loss and to avoid resentment among law-abiding citizens.
- **Minimal required state support.** The system should allow for state participation in cases where states would like to levy their own VMT fees; it should not require excessive effort for states not interested in this policy.
- **Minimal burden on users.** Gaining public acceptance for the transition from fuel taxes to VMT fees will likely be difficult in its own right. Increasing the burden on users—for instance, by requiring regular odometer inspections—will make this even more difficult.

Three options appeared to offer the greatest promise for implementing a national system of VMT fees; each has its own set of advantages and limitations:

- **Mileage metering based on fuel consumption.** Although offering limited metering flexibility, this option would likely prove the least expensive to develop and operate, given the low cost of RFID technology and the ability to expand the existing fuel tax system to encompass fuel retailers rather than developing an entirely new revenue system. The existing fuel taxes could also provide a fallback revenue system—to charge vehicles lacking the required AVI device for road use. Finally, the pay-at-the-pump model could still be used to collect fees for most vehicles if a transition to more sophisticated metering equipment were pursued over the longer term.
- **OBD II/cellular-based metering.** While the technology remains to be demonstrated in the context of road pricing, this option could provide significant metering flexibility at lower cost than the GPS option.
- **Coarse-resolution GPS-based metering.** This option also provides flexible metering options, and the technology has been demonstrated in real-world trials. If the price of the equipment can be reduced through large-scale production and if current privacy concerns associated with the use of GPS can be overcome, this would be a promising option (Sorenson et al., 2009, pp. xix–xxii).

Minnesota is beginning technical research into a mileage-based user fee, testing equipment that could eventually be used to implement a VMT tax structure. The study began in July 2011, and a final report is expected in December 2012 (Minnesota Department of Transportation [MnDOT], 2011). Previously, MnDOT has convened focus groups to better understand public understanding of and enthusiasm for mileage-based taxes; the results indicated that most were in favor of a clear pay-for-use type of funding structure, but were concerned about the privacy implications of such a tax (MnDOT, 2008).

During 2006 and 2007, the Oregon Department of Transportation (ODOT) conducted a pilot project in the Portland area, funded by the state, of the first of the three types of VMT fees (mileage metering based on fuel consumption) (ODOT, no date). The project involved about 300 drivers and their passenger vehicles, as well as two retail service stations, and treated the state as consisting of two zones, the Portland area and everywhere else. Drivers were paid about a dollar a day to participate.

When a car equipped for the VMT pulled up to a fuel pump at a service station with the proper VMT equipment, the equipment on the pump read, from the car's equipment, the number of miles the car had driven since it was last fueled at a pump equipped for the tax. For the study, the mileage was determined either by GPS or by on-board computer directly from the car's odometer. The pump equipment automatically applied a cent-per-mile to this mileage figure and subtracted the per-gallon gasoline tax that would have been due on the sale if the VMT had not applied to it. In the pilot, the driver got a bill that showed the VMT and the amount of the subtracted fuel tax separately from the price of the fuel.

At the end of the month, the gas station remitted to the state its VMT collections during that period, settling up with ODOT for the difference between that amount and the gas tax it had paid to the wholesaler.

The official report noted repeatedly that more development of the equipment and of the details of VMT implementation is needed. Mileage readings were apt to be highly inaccurate. The equipment for both the cars in the study and the service stations had to be specially designed for the pilot; it is unclear how much either would cost if it were mass produced. Adapting cars may cost hundreds of dollars, and retrofitting gas stations thousands of dollars. ODOT concluded that it would be more than 20 years before a VMT tax on cars could be implemented fully in the state. It apparently has no plans to supersede its current system of taxing trucks.

Energy Use Tax

The Howard H. Baker Jr. Center for Public Policy at the University of Tennessee–Knoxville has proposed an energy user fee instead of a gas tax or VMT fee. Such a tax would cover all forms of energy used to move vehicles with a user fee per unit of energy (such as megajoules). No exceptions would be made for electric, hydrogen, or any other vehicles. The user fee would initially be set at a level that is equivalent to the current gasoline tax (0.15 cents per megajoule). It would then be indexed to both the average energy efficiency of all vehicles (in miles per megajoule) and to an "appropriate index of inflation for surface transportation construction and maintenance" (Greene, 2011). Such a tax would continue to encourage users to seek more efficient means of transportation, regardless of the exact energy source powering the vehicle. The tax would also result in the same level of revenues as a VMT tax.

Oil Tax

A percentage tax on crude oil and refined petroleum products could replace the current taxes on gasoline and diesel fuel, with revenues used to fund highways, public transit, and aviation. Such a tax would simplify the current taxing system by replacing the variety of existing transportation taxes with one single upstream tax. It could be adjusted independently of inflation and would have the benefit of transferring external costs of producing and consuming oil to the producers and consumers of oil instead of the general public. Additionally, while increased taxes are generally considered very unfavorably in the eyes of the public, the current political and environmental climate may make raising taxes on oil instead of motor fuel much more politically feasible (Crane et al., 2011).

Carbon Cap and Trade

In 2010, Congress was seriously considering a cap-and-trade regime to reduce carbon, which would produce substantial revenues, some portion of which could then be dedicated to freight transportation improvements. This approach would have the additional benefit of spurring a reduction in carbon emissions from congestion or otherwise. No source provided any details as to how such designation might happen, either in percentage amounts or how projects would qualify for such funding. Even so, no source disagreed with the concept.

Since the surveyed literature was written, the House of Representatives in 2009 passed legislation to create a carbon cap-and-trade system (H.R. 2454, the American Clean Energy and Security Act or ACES), which died in the Senate. No similar major legislation has been reintroduced in the 112th Congress While the legislation made provision for various designated uses, transportation efficiency was not one of them. To quote and digest from the summary provided by the office of the speaker:

> ACES required that major U.S. sources of emissions obtain an allowance for each ton of carbon or its equivalent emitted into the atmosphere. CBO projects that allowance prices in 2005 dollars were expected to be $16 in 2015 and increase to $36 by 2030. At these allowance prices, the total value of the allowances created under the legislation ranged from roughly $70 to $80 billion in 2015 to $90 to $120 billion in 2030 (Offices of Speaker Pelosi et al., 2009).

For the period from 2012 through 2025, 55% of the allowances were to be used to protect consumers from energy price increases; 19% to assist trade-vulnerable and other industries make the transition to a clean energy economy;

13% to support investments in clean energy and energy efficiency; and 10% for domestic adaptation, worker assistance and training, prevention of deforestation, and international adaptation. The remainder (3% of allowances) was to be used to help ensure that ACES is budget neutral (Offices of Speaker Pelosi et al., 2009).

While the concept of designating some portion of carbon allowance fees to freight transportation improvements seems valid, it had no political currency in Congress. The legislative history makes clear that there are numerous other valid uses for the new revenue to be derived from carbon allowances as well. Some freight projects may be able to qualify as investments in energy efficiency, although that would not be definitely known until new programs were established and eligibility rules published. However, the last seemingly realistic chance of passing a carbon allowance and trading based regulation ended in the failure of the Senate to pass similar legislation in July 2010 (Hulse and Herszenhorn, 2010).

Investment Tax Credits

Contrary to the politically weak possibility of carbon cap-and-trade charges, a railroad ITC enjoys considerable popularity. Indeed, the Internal Revenue Code contained a temporary measure, Section 45G, which expired on December 31, 2009. Section 45G created an incentive for short line railroads to invest in track rehabilitation by providing a tax credit of 50 cents for every dollar that the railroad spent on track improvements up to $3,500 per mile of owned or leased track. The credit was capped based on a mileage formula. The bipartisan tax agreement of December 2010, enacted as The Tax Relief, Unemployment Insurance Reauthorization and Job Creation Act of 2010, retroactively extended numerous provisions, such as that for short line railroads, that had expired almost a year before and granted a year forward until December 31, 2011. As of late 2011, despite the introduction of S. 1801 by Sen. Snowe of Maine to extend numerous provisions, a substantial possibility exists of another lapse of numerous expiring provisions on January 1, 2012.

Rep. Earl Pomeroy of North Dakota, Rep. Jerry Moran of Kansas, Sen. Blanche Lincoln of Arkansas, and Sen. Mike Crapo of Idaho have introduced companion legislation, H.R. 1132 and S. 461, to extend the provision through tax year 2012 and strengthen the short line railroad tax credit, supported by the American Short Line and Regional Railroad Association. The proposed legislation increases the per mile credit limitation from $3,500 to $4,500 to account for increased construction costs since 2004. However, neither of these bills became law (TCU Legislative Watch, 2011).

Two House bills would create a new credit applicable to all railroads, with the principal effect of pertaining to the major Class I carriers. H.R. 1806, introduced by Rep. Kendrick Meek along with 47 cosponsors and referred to the Ways and Means Committee, would create (1) a tax credit for 25% of the cost of new qualified freight-rail infrastructure property and qualified locomotive property and (2) a taxpayer election to expense the cost of qualified freight-rail infrastructure property (i.e., deduct all costs in the current taxable year) with a 2015 sunset. An earlier Meek bill, H.R. 272, had a 2012 sunset and 70 cosponsors. The Association of American Railroads is supporting the later Meek bill. Another bill, H.R. 1789, introduced by Rep. Corinne Brown, also of Florida, and without any cosponsors, added to the Meek bill the element of track maintenance as a qualifying expenditure, in effect attempting to unify the pieces of legislation.

Initial support for a credit for the large railroads grew out of AASHTO's *Freight-Rail Bottom Line Report* (AASHTO, 2003). State highway officials were concerned that, although railroads might be able to invest enough to increase capacity somewhat in coming years, they would not be able to keep pace with growing throughput and would lose overall market share to trucks, with resulting increased highway congestion. AASHTO sees that result as increasing the demand on highways beyond what could possibly be managed. As evidence for its initial conclusions and its concern, AASHTO pointed to two principal pieces of evidence: freight revenue per ton-mile has steadily decreased since deregulation in 1980, and railroads' cost of capital, at about 12%, exceeds return on investment of about 8% in the late 1990s (p. 40). At the same time, Class I railroads faced capital expenditures of 17.8% of revenue, as opposed to 3.7% for a composite of manufacturing segments (p. 35). Moreover, since deregulation, the proportion of value of rail stocks in the Standard and Poor's 500 has declined from 2% to 0.5% (p. 42). In other words, investors are looking for better returns elsewhere. AASHTO saw an unfunded annual investment need of between $2.65 billion to $4.15 billion (p. 45) and concluded, "If improvements are not made in the freight-rail system, the nation's freight transportation system will weaken and shippers, highway users, and communities will pay the social, economic, and environmental costs" (p. 52).

The Congressional Budget Office has done a series of three studies on freight transportation (CBO, 2003, 2006, and 2007), the second of which concentrated on rail. Looking at the same evidence and taking note of the AASHTO report, CBO said, "Recent activity suggests that the railroads will continue to expand capacity. Whether growth in supply will keep pace with growth in demand is an open question. It appears that railroads have been able to generate enough profits to finance some investments and attract new capital. The prospect of future profitability is an open question, however" (CBO, 2006, pp. 9, 16). Rather than an ITC, however, CBO looked first to increased charges on trucks and barges for their use of publicly provided facilities and after that at federal assistance in the form of loan guarantees (p. 22).

Tolls

One of the most detailed discussion of tolls in the surveyed literature is also the most negative in its implications for congestion, pollution, and accidents (ATRI, 2007). An illustration of this is the New Jersey E-Z Pass System. As much of a technical improvement as it represented, it generated a $469 million deficit owing to high extra interest on bonds not paid off on time and operating expenses at 37% over budget. Even more surprisingly, ATRI cites an FHWA 2005 survey of state toll administrations showing that many of them were operating at a loss (ATRI, 2007, p. 13). The ATRI report goes on to conclude, "Based on available public financial data, tolling appears to be a far less efficient means of raising transportation revenue than motor fuel taxes" (p. 14).

The concept of "[n]ew toll roads, bridges, and lanes on the Interstate system" explicitly received support in a brief submission by the California Association of Councils of Governments to the Financing Commission in 2007 (CALCOG, September 7, 2007).

A fuller treatment came from Washington, where the State Transportation Commission reported to Governor Gregoire that a "key recommendation of this study is the need to implement non-stop, highway-speed electronic toll collection on any new or enhanced facility. . . . In addition to the Tacoma Narrows Bridge and State Route 167 HOT Lanes Pilot Project already in development, the study identifies the 520 bridge, Snoqualmie Pass and the Columbia River Crossing in Vancouver as other possible projects statewide" (WSTC, 2006).

Public-Private Partnerships

Rationale and Definition of Public-Private Partnerships

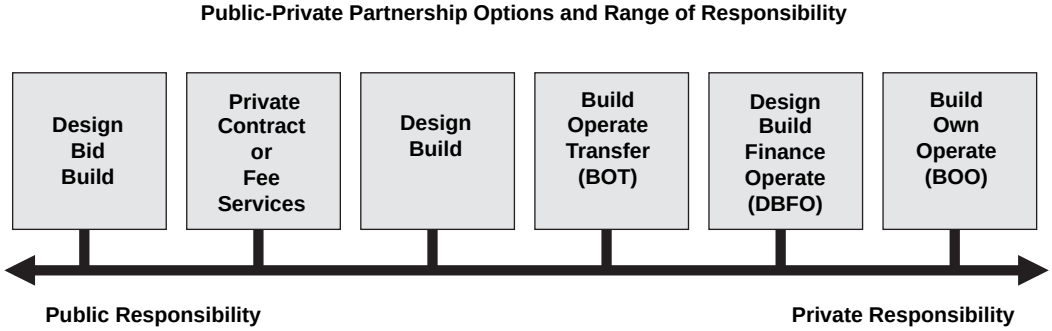
PPPs introduce private capital for public construction and maintenance purposes. Private financiers are able to render predictable future revenue streams into current value and hence to commit private equity in lieu of publicly raised capital. Two reports and numerous case studies have also found that PPPs can save from 6 to 40% of the cost of construction and significantly limit the potential for overruns (U.S. DOT, Dec. 2006).

The private sector has traditionally been involved as contractors in the design and construction of highways and in construction and management of railroads. Marine ports have historically been operated by private operators across the country as well. However, most of this involvement has been either through traditional design-bid-build contracts or fully private operations. PPPs—as defined by U.S. GAO (1999) and the definition adopted by U.S. DOT (2004)—refer to nontraditional contractual agreements formed between public-agency and private-sector entities that allow for greater private-sector participation than do traditional methods of private procurement by the public sector. The agreements can involve a public agency contracting with a private entity for any one or more of the following project-related activities: planning, construction, delivery, operation, maintenance, toll collection, management, and financing of projects. Various types of contractual agreements are discussed later in this section. PPPs are used widely in many infrastructure areas and are composed of varying combinations of public (federal, state, and local government) and private resources (Deloitte Research, 2007). In its 2006 *Conditions and Performance Report* to Congress, the U.S. DOT offered a spectrum as a way to conceive of increasing private responsibility across an ordered series of options (see Figure A-2).

The next few paragraphs provide a brief description of the historical developments in PPPs across the world, some basic facts about PPPs, and a discussion of the main federal and some significant state policies for promoting PPPs. The benefits and limitations of PPPs (keeping a focus on freight transportation wherever the authors could find relevant cases to illustrate issues raised in the literature) are then discussed.

Origin Of PPPs in the United States and Europe

Contemporary PPPs (as defined by GAO above) originated in the United States in the 1980s, when seven states adopted



Source: U.S. DOT, 2006.

Figure A-2. PPP options.

legislation to allow private investments in highway projects. In 1987, Congress approved a pilot program authorizing (approximately) 35% federal funding of government-sponsored toll roads (Perez and March, 2006). Wider use of PPPs in the United States emerged in the 1990s when states experienced severe budget constraints, particularly in funding transportation projects, due to the limitations of the mainstay of their revenues—the fuel tax. Twenty-one states and one U.S. territory have since passed legislation enabling the use of PPPs for transport infrastructure projects (U.S. DOT, 2008b).

Internationally, particularly in Europe, PPPs date back to the 1960s and 1970s (Spain and France), with their widespread use emerging after the Maastricht Treaty (1992) and the need to integrate the various countries newly introduced into the European Union. Once again, strict deficit control regulations pushed European nations, who were seeking integrated road infrastructure to realize the economic benefits of their Union, to make a big push toward PPPs. This push was facilitated by supportive policies of the European Commission's European Investment Bank and various other European structural funds (Perez and March, 2006; U.S. GAO, Feb. 2008).

Early history of PPPs in the United States included several failed projects, but over time, experience with PPPs has improved results in transportation projects. Significant development in public policy was necessary (more details to follow) to streamline the contract processes that are critical for the success of these arrangements and improve PPP outcomes in transportation projects.

Types of PPPs

PPPs may either be a brownfield project or a greenfield project. Brownfield projects involve the operation or maintenance of an existing infrastructure asset. Most PPP projects for brownfield assets are long-term lease or concessions of existing infrastructure projects (for example, long-term concessions on the Chicago Skyway and the Indiana Toll Road both use existing facilities—See Table A-9). Greenfield projects are those involving the development of a new infrastructure asset (for example, Miami Port Tunnel, a long-term concession to design, build, finance, operate, and maintain a tunnel providing access from the Port of Miami to the Florida mainland). Primary forms of innovative contracting for PPPs are design-

Table A-9. Advantages of PPPs—selected projects.

Project	Description	Advantages
Missouri Safe and Sound Bridge Project	Concession to upgrade, finance, operate, and maintain more than 800 bridges in Missouri	Leveraged the private sector's ability to raise money Reduced costs over time by competitively bidding the work
Chicago Skyway	Long-term concession to operate and maintain 7.8 mile toll road in Chicago	Up-front payment for concession of the toll road provided funding for other projects and made up for funding shortfalls
Indiana Toll Road	Long-term concession to operate and maintain 157 mile toll road in northern Indiana	Long-term concession provided up-front payment to cover debt and make up for funding shortfalls
Miami Port Tunnel	Concession to design, build, finance, operate, and maintain a tunnel providing access from the Port of Miami to the Florida mainland	Cost savings half the original costs projected by Florida DOT by relying on the private sector to construct the project, the state transferred the risk of cost overruns during construction and cost overruns in the long-term operation and maintenance
Northwest Parkway	Long-term concession to operate and maintain 11-Mile toll road outside of Denver and funding commitment for future expansions	Costs $189 million less than originally estimated
Virginia Pocahontas Parkway	Long-term concession to operate and maintain 14 mile toll connector outside of Richmond and to build Richmond Airport Connector	Actual cost came in $10 million below estimated costs Eliminated a potential delay of up to 15 years to raise public funds by relying on private capital

Source: U.S. DOT, 2008b, and Deloitte Research, 2007.

build contracts, design-build-operate-maintain contracts, cost-plus-time bidding, construction manager-general contractor, and construction-manager-at-risk (Fishman, 2009). Innovative financing used in PPPs includes project delivery structures occurring when the private sector provides some debt or equity financing. Examples of innovative financing techniques include design-build-finance-operate, build-operate-transfer, and long-term-lease-concessions (Fishman, 2009).

Federal and State Policies

Several federal programs have been enacted to promote PPPs. SAFETEA-LU amended Section 142 of the Internal Revenue Code to permit the issuance of private activity bonds to finance privately developed and operated highway and freight transfer facilities. This change in code allows for the maintenance of tax-exempt status of bonds for projects developed, designed, financed, constructed, operated, and maintained by private entities. By providing private capital with access to tax-exempt interest rates, private sources of capital are better be able to compete with public sources of capital (U.S. DOT, 2008b).

Another federal program that has provided aid to PPPs is the Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA). TIFIA provides federal credit assistance to major transportation investments of national importance. TIFIA credit assistance can take the form of a direct loan, a loan guarantee, or a line of credit. TIFIA credit assistance is available for as much as 33% of total project costs. For direct loans through TIFIA, loan maturity can be as long as 35 years, and the U.S. DOT has significant flexibility to allow for payment deferrals if revenues generated by the project are insufficient to cover the loan repayments (U.S. DOT, 2008b). Because the demand for assistance has exceeded the funding provided by TIFIA, the awarding process has become very competitive (CBO, Jan. 2011).

Federal legislation also provided credit assistance for state infrastructure banks (SIBs). SIBs offer low-interest loans and loan guarantees for Federal-Aid highway projects. SAFTEA-LU allowed states to establish infrastructure revolving funds capitalized with federal transportation funds. Federal legislation also provides for public benefit corporations. The establishment of a 63-20 public benefit corporation allows a private company and private project developers to issue tax-exempt debt. SAFTEA-LU also added several programs to promote tolling. Tolling provisions, although not exclusively for PPPs, have aided the ability of private capital to invest in infrastructure projects (Fishman, 2009).

Yet another federal program advancing the use of PPPs is Special Experimental Project Number 15 (SEP-15). SEP-15 allows states to identify impediments to their use of PPPs in federal statutes, regulations, and policies governing the highway program and request exceptions in order to test alternative project delivery mechanisms (U.S. DOT, 2008b).

In 2007, the U.S. DOT announced the six Interstate routes to participate in the Corridors of the Future Program, aimed at improving freight movement and reducing congestion. A main objective of the program is to demonstrate the benefits of financing models that include private-sector capital (U.S. DOT, 2008b).

SAFETEA-LU created the Public-Private Partnership Pilot Program (Penta-P) to showcase the advantages of PPPs for new fixed-guideway capital projects funded by FTA. The object of the program is to reduce risks, accelerate project delivery, improve reliability of projections of project costs and benefits, and enhance project performance (U.S. DOT, 2008b). SAFETEA-LU also created a variety of programs authorizing tolling on Interstate highways. These programs are not specific to PPPs but have facilitated the use of PPPs to implement tolling (U.S. DOT, 2008b).

In addition to existing toll facilities, several states have adopted PPPs as a preferred approach for delivery of new transportation capacity and capital improvements. At the state level, there is broad variation in the legislation that states have adopted to authorize PPPs. Currently, 25 states have statutory authority to enter into highway or transit PPPs. The extent and type of legislation enacted "varies from state to state . . . in the types and amounts of projects that are authorized and in the breadth of the authorization delegated by the legislature to state or local transportation agencies" (U.S. DOT, 2008b, p. 28). States with broad-based legislation enabling PPPs include Colorado, Georgia, Florida, Mississippi, Oregon, South Carolina, Texas, Utah, and Virginia. Other states have limited enabling legislation, and some states have legislation enabling only non-highway PPPs (not described here) (U.S. DOT, 2008b).

State legislation that enables PPPs accomplishes the following (Deloitte Research, 2007):

- Public entities are given considerable flexibility in the types of agreements they enter into and the specific procurement process.
- Contracts are awarded according to a best-value determination, not just low price.
- Authority is given to use a mix of public and private dollars.
- Authority is given to have "mixed concessions" (the reconstruction or expansion and long-term operation of existing facilities).
- Allowance is given for the long-term lease of existing assets.
- Authorization is given for procedures to receive and consider solicited and unsolicited proposals.
- Provisions that would require further legislative action for a project to be authorized or financed, franchise agreement executed, or toll rates changed are avoided.

Advantages of PPPs

The motivation for use of PPPs has consistently been a desire to benefit from the efficiencies from private-sector competition and to enlarge the funding for increasing the supply of public infrastructure. Also, where technology permits, PPPs allow a fee-for-service mechanism to make users pay for this infrastructure as they use it in the form of tolls (partially or fully privatizing public infrastructure). The role of PPPs in freight transportation projects is motivated by a number of factors, each of which is discussed below.

Assistance in Filling Public Funding Gaps

Public support can be difficult to obtain for freight-specific projects because of their indirect benefits. While freight projects can help to grow the economy by providing more efficient transport of goods, this is an indirect benefit to many users, which can make such projects difficult to justify to voting constituencies (Hillestad et al., 2009). A long-term concession for Missouri's Safe and Sound Bridge Project, covering 800 bridges in mostly rural areas, allowed leverage of private capital in a situation where the project could not provide its own revenues via tolling (see Table A-9). Another successful example of a revenue-generating project is the Alameda Corridor, a relatively unique project serving the high-volume ports of Long Beach and Los Angeles. Most recently (2010), the project called the Crescent Corridor, a 2,500-mile rail route stretching across 13 states from New Jersey to Tennessee and Louisiana, would offer significant economic and environmental benefits by creating tens of thousands of jobs and moving trucks off crowded highways such as I-81. Five states have joined together in a public-private partnership to apply for $300 million in federal funding to develop the corridor, which would dramatically increase rail capacity along the route and represent one of the largest additions of freight transportation capacity since the Interstate Highway System in 1956. The federal money would leverage more than $140 million in state investment and the $264 million that Norfolk Southern Corporation, whose freight trains operate along the route, has committed to the project (Riley et al., 2010).

Availability of Private Capital—Domestic and Foreign

There is an unprecedented interest among global investors in the potentially stable and long-term returns offered by transport infrastructure projects (HM Treasury, 2006). As of 2007, the total magnitude of PPPs worldwide is $572 billion (U.S. DOT 2008b). Reports by the *Financial Times* have estimated that private equity has already raised somewhere between $50 billion and $150 billion (U.S. DOT, 2008b). A *McKinsey Quarterly* report from February 2008 estimated that the world's 20 largest infrastructure funds at that time had nearly $130 billion under private management (U.S. DOT, 2008b). By leveraging this capital, even at a relatively conservative leverage, significant investments in infrastructure could be made (U.S. DOT, 2008b).

Reduction of Costs through Greater Efficiencies

This is particularly important on large, usually very complex freight mobility projects with multimodal (cross-modal) links that are well suited for PPPs (Coalition for America, Nov. 2007). In most cases, a private role is also necessary for the supply chain in freight transportation (highway, ports, marine terminals, rail, and so forth). In general, there is potential for greater efficiencies, as compared to purely public-sector provision, because private-sector actors are concerned with return on investment and therefore have a greater incentive to deliver infrastructure projects on time. Also, long-term concessions, investment, and maintenance decisions are likely to be based on consideration of life-cycle costs versus initial costs of projects (Mayer, 2006). The public sector could also benefit from these cost savings via competitive bidding for projects. Competitive bidding saved Missouri money over time in the Safe and Sound Bridge Project, as did Florida in the Miami Port Tunnel concession, Denver in the E-470 Toll Road, Virginia in the Pocahontas Parkway, and South Carolina in the Eastern Toll Corridor (see Table A-9).

Avoidance of Public-Sector Debt Limitations

The use of private-sector funding also helps jurisdictions that are limited by the amount of debt they can incur. Because, in some cases, the private sector assumes the risk of a project, debt limits are not applicable to certain PPPs, allowing more infrastructure to be developed more quickly than if only public-sector funding was used (Deloitte Research, 2007). The cost of municipal public debt in the United States could be as much as 30–35% lower due to the tax exemption of municipal debt in federal income tax filing (most investors benefiting from such tax exemption have marginal income tax rates in the highest federal income tax bracket). Nonetheless, the gap between the costs of borrowing for the public and the private sectors has narrowed since the onset of the new millennium. This is probably more true in other parts of the world than in the United States, as will be explained further in the discussion on limitations of PPPs.

Transportation Services Charging

The ability to charge for freight transportation infrastructure across different modes is important for the more expansive private-sector engagement required by PPPs and for benefiting from the PPP. However, it is not required, as seen in the case

of Missouri's Safe and Sound Bridge Improvement Program. Charging for services is now more feasible for roads than it has ever been historically, particularly with technologies for vehicle tracking and automated billing, including fees tied to VMT, type of vehicle, type of roadway, and time of use (Hillestad et al., 2009). In terms of value pricing for freight, by charging more per axle, toll roads can recoup some of the cost of additional wear and tear on the road caused by heavy trucks that regular roadways cannot. PPPs have also facilitated the use of technology, such as the PrePASS weigh stations for trucks that use weigh-in-motion technology for weight-based charges.

Risk Sharing

The private sector can provide important risk mitigation and risk sharing for projects. Risks of major infrastructure projects are associated with the design, regulatory requirements, financing, and construction of the project. After construction, risks are associated with the generation of traffic and revenue for financial viability of the project. Private capital, for a price, can assume the debt for such projects and also the risk of cost and schedule overruns, barring certain circumstances, such as changes requested by the public agency (U.S. DOT, 2008b). In many cases, the private sector will assume the risks associated with financing over the life of the project while the government still maintains a residual right of ownership. The private sector may also have a greater ability to diversify risks, such as across projects in varying locations (Buxbaum and Ortiz, 2009). There is also the possibility of packaging various risk return profiles in a single PPP. Use of equity finance could potentially increase risk taking but, to the extent that this risk is borne by the private entity in the PPP, public resources will not be exposed to added risk.

Return on Investment as Funding Basis

Since private investors are concerned with returns on their investment, there is a greater incentive to carefully consider a project's costs and benefits (U.S. DOT, 2008b). Unfortunately, this is not always the case with public funding; political factors often take precedence over economic and broader social criteria. For example, earmarked funding, allocated to specific congressional districts in the federal highway bills, can sometimes misallocate resources. The number of earmarks in transportation infrastructure funding has grown significantly, from 10 in 1982 to more than 6,000 in 2005 (National Surface Transportation Policy and Revenue Study Commission, 2007).

Limitations of PPPs

The most common failure of PPP projects lies in the overestimation of potential demand for the transport service, resulting in overpricing. Delivery of efficient services to users at affordable prices is key to the success of such ventures. Competition at various stages of the project, therefore, is important, typically taking the form of competitive bidding in various stages of the process of PPP award and in the final transfer of rights to the awardees, sale of assets, and so forth. Additionally, legal issues in the process—including various government clearances (environmental, right-of-way, and so forth), contract terms and finally transparency to the public, and public perception of the agreements with the private sector—can become pitfalls for PPP arrangements for providing infrastructure services.

Monopoly Pricing by Toll- or Charge-Setting Private Entity

One benefit of PPPs is moving the issue of fee increases away from the political realm to the market. However, there is a concern that since infrastructure facilities are often monopolies, the private sector can charge unreasonably high fees. Therefore, PPP contracts could be used to limit fee increases to the rate of inflation or some other predetermined rate, or the government can retain the power to set rates based on a similar objective criterion (Deloitte Research, 2007). There are several types of PPPs that do not require the implementation of tolls (for example, design-build, maintenance contracts, and agreements with availability payments/shadow tolls). Shadow tolling involves the government paying the private sector based on traffic flows, while the consumer is not charged directly. This is one method for alleviating public objections to tolling. Whatever the method of revenue generation in the PPP, tolling policy and other types of revenues generated/disbursed to the private entity participating in the PPP are an important public responsibility that should be clearly articulated in contracts (Buxbaum and Ortiz, 2009).

Hazards of Non-Compete Clauses

A non-compete clause provides the concessionaire with monopoly power and prevents creation of competing capacity within a specific distance from the facility, or the public sector is required to pay the concessionaire (private entity in the PPP) for the lost revenues on the facility with the concession. In reality, after the experience with strict non-compete clauses in the 91 Express Lanes PPP in California, most PPP deals have included "limited-compete" clauses (Buxbaum and Ortiz, 2009).

Higher Cost of Capital

The cost of municipal public debt in the United States could be as much as 30–35% lower due to the tax exemption (most investors benefiting from such tax exemption have marginal income tax rates in the highest federal income

tax bracket). This argument contains some truth, but the criticism overlooks the difference between cost of capital and cost of debt (Deloitte Research, 2007). While the cost of municipal, tax-exempt debt is lower in the United States, the private sector is able to combine equity with debt, and private corporate debt is also cheaper than private project debt (Mayer, 2006). Additionally, PPPs leverage creative financing using credit guarantees in which the government provides funds to PPP projects through cash advances and loan agreements, and the private sector pays back these loans to the government after completing the project. Selected private-activity bonds also enjoy tax exemption from federal income taxes (but might still be exposed to the Alternative Minimum Taxes). Additionally, private-sector efficiencies provide risk reduction that lowers the effective cost of capital in PPPs.

Valuation of the Public Facilities

Valuation of the public facilities involved in the PPP is a critical component. Public-sector experience in valuing public assets is limited, but recent accounting regulations have pushed governments to value their capital assets, providing a baseline for estimation. *NCHRP Synthesis 391: Public Sector Decision Making for Public-Private Partnerships* (Buxbaum and Ortiz, 2009) highlights the need for public-sector personnel with skills including value engineering, business modeling, risk transfer assessment, capital budgeting, traditional financial problem-solving methodology, and performance auditing.

Inadequate Transparency and Public Participation

According to *NCHRP Synthesis 391,* "[t]he Chicago Skyway and the Indiana Toll Road concessions are particularly noted as examples in which transparency was lacking from the public perspective (as reported through the news media), even though public officials involved in these deals believed the process to be transparent and both transactions were subject to legislative review and approval of final terms" (Buxbaum and Ortiz, 2009). The perception of a lack of transparency has plagued other recent PPP deals (e.g., the SH-130 in Texas), but after the public backlash, some PPP proponents and decision-makers took notice and are making an effort to communicate and involve the public in the process. In New Jersey, the governor began to explore the feasibility of leasing public assets, including toll roads, eventually moving to pursue an asset monetization through the creation of a public corporation. Both solicited and unsolicited PPPs have some conflict of interest (Buxbaum and Ortiz, 2007). There are also the related issues raised in the literature about public perception of foreign investments and control of public infrastructure and national security issues in PPPs for public infrastructure projects.

PPP Revenue Not Always Directed to Transportation Needs

Questions have been asked about the use of the money raised through PPP deals. For example, in the $1.8 billion Chicago Skyway project, the revenue was used partly to pay off the City of Chicago's $200 million debt. Twenty-five percent of the revenue from Texas toll roads goes into general funds instead of back to transportation-specific projects, and Indiana's $3.8 billion toll road has provided a great deal of general government funding to surrounding counties (See Appendix E).

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APPENDIX B

Defining Freight Vehicles

Which Vehicles Do We Tax?

It is common to divide transport activities into "freight" and "passenger." For purposes of this analysis, "freight," or "goods movement," is defined as trips undertaken to move goods that are or could be routinely accomplished by a for-hire carrier. "Goods" in this sense is broadly defined to include waste products, recyclables, empty containers and pallets, returned merchandise, equipment, by-products, and similar commodities being transported. Vehicle movements that do not involve loading or unloading goods would not be freight trips. This definition leaves some unavoidable ambiguity, especially in agriculture, construction, and related services.

As shown in Table B-1, a large portion of the medium and heavy trucks in use do not haul either freight or passengers, but are used in the provision of services. The majority of the U.S. fleet, about 60%, is in mixed-use sectors, notably construction. Not only is there a mix of freight and service vehicles in these uses, but there are many multipurpose vehicles, such as flatbed trucks, whose use can vary from day to day. The Greyhound Bus Company, whose vehicles are not classified as trucks, offers package service on some of its routes and thus could be considered a freight carrier.

For the fuel tax and VMT fee alternatives, a substantial part of the implementation, compliance, and collection costs would be incurred in identifying freight vehicles. Most highway projects that would benefit freight-hauling trucks, however, would likely also benefit service and mixed-use trucks that may actually constitute the majority of medium- and heavy-duty vehicles. Examples include bypass or climbing lanes for trucks, rail grade crossing separations, and truck rest stops.

Non-highway modes do not entail the same level of complexity. On inland and coastal waterways, some ferries carry both passengers and their vehicles. There are also a very few coastal vessels that routinely carry both passengers and cargo, but their impact is likely to be negligible. On the railroads, the only significant operations that mix passengers and freight are Amtrak trains. Some long-distance Amtrak trains carry express shipments, and the Auto Train carries both passengers and their automobiles. Although a large portion of air cargo moves on passenger planes, there is already an air cargo excise tax that is independent of aircraft type.

Freight Truck Types

There are a number of vehicle classification systems in use. The most universal is the GVW system shown in Table B-2.

Commercial truck use and the working definition of "truck" for planning and policy purposes usually begins with Class 3 vehicles, which are those with gross (vehicle plus load) weights of 10,001 to 14,000 lb (see Figure B-1).

Class 1 and 2 vehicles are primarily pickups, vans, and SUVs used for personal transportation or the very lightest service and delivery purposes (e.g., a landscaper's pickup or a florist delivery van). Many light-duty "step vans" used for local delivery are actually Class 2 vehicles. Class 3 vehicles include the largest pickups and vans ordinarily used for personal transportation and the smallest trucks routinely used to carry goods, supplies, and equipment. Classes 4–6 are considered medium-duty trucks and, while predominantly used to provide services, also encompass step vans, flat beds, small dump trucks, and other trucks used to move freight. Classes 7 and 8 are heavy-duty trucks predominantly used to move freight, but these classes also include concrete pumpers, well-drilling units, and other large service vehicles.

Classes 4–5 are typically considered light- and medium-duty trucks and encompass larger "step van" delivery vehicles and a wide variety of other applications. In particular, Classes 4–5 include a very large proportion of trade, construction, and service vehicles that do not ordinarily haul freight in significant quantities, but which use the same infrastructure. Discussions of freight user fees and freight infrastructure tend to ignore

Table B-1. Uses of medium- and heavy-duty trucks.

Sector	Total	Share
Freight	**4,330**	**34%**
For-hire Transp. & Warehousing	1,280	18%
Retail Trade	1,531	7%
Wholesale Trade	736	5%
Manufacturing	783	4%
Mixed Freight/Service	**12,526**	**60%**
Construction	4,541	19%
Agriculture, forestry, etc.	2,240	14%
Not Reported/Not Applicable	3,286	11%
Vehicle Leasing or Rental	859	6%
Waste hauling, landscape, admin/support	743	5%
Utilities	679	3%
Mining	178	2%
Service & Personal Transport	**68,318**	**6%**
Other Services	2,127	3%
Accomodation & Food Services	284	1%
Info Services	377	1%
Personal Transportation	65,343	1%
Arts, Ent., Rec.	187	0%
Total	**85,174**	**100%**

Source: U.S. Bureau of the Census, "Vehicle Inventory and Use Survey", 2002

the very large population of medium-duty trucks and service vehicles.

Class 6 is an overlap category, encompassing large trade and service vehicles, many straight truck freight vehicles, and the smallest tractors routinely used to haul freight in semi-trailers. In most states, Class 6 vehicles are the largest that can be driven without a CDL, making them popular for local trucking. Properly configured Class 6 vehicles can accomplish many of the tasks assigned to Class 7 and 8 vehicles. Where trailers are partially loaded or loaded with very light goods, the full gross vehicle weight rating of Classes 7 and 8 may not be required. Classes 6 and 7 include heavy-duty service vehicles as well as freight trucks, a fact often ignored in discussions of "freight" infrastructure needs.

Class 8 trucks (33,000 lb and over) are heavy-duty vehicles by any definition. Class 8 includes both straight trucks, and tractors for use with semi-trailers. Although primarily populated by freight vehicles, Class 8 also includes very heavy service vehicles, such as concrete pumpers, cranes, and drilling equipment.

Table B-3 displays the distribution of annual VMT for trucks other than pickups, vans, and SUVs from the 2002 Vehicle Inventory and Use Survey (VIUS) database. These data suggest that freight and goods movement activities account for about 61% of the total medium-duty and heavy-duty truck VMT, with service sector activities accounting for 39%. The division is not precise, as sectors such as retail trade and agriculture likely have an unknown mixture of freight and service uses. The split may have changed somewhat since 2002, but there is no more recent data of this type and any overall changes are probably not dramatic.

State truck registrations typically include body type information, which could be used to distinguish trucks whose intended use or capability is transporting freight from those whose intended use is providing a service of some kind. As an illustration, Table B-4 displays body type data from the 2002 VIUS sorted into freight, mixed freight/service, and service categories. Among these medium- and heavy-duty trucks, 75% are identifiable as being freight haulers. Another 12%, mostly smaller vans, could be used in either freight or service applications. It is likely that these trucks could be further sorted into freight and service types by weight class.

As Table B-5 shows, freight transportation dominates the uses of tractor-trailer combinations.

Table B-6 confirms that essentially all tractor-trailer combinations are used in moving freight of some type.

Table B-2. Truck classifications.

Weight Class	Minimum GVW (lb)	Maximum GVW (lb)	VIUS Category	Common Category
Class 1		6,000	Light-Duty	Light-Duty
Class 2	6,001	10,000	Light-Duty	Light-Duty
Class 3	10,001	14,000	Medium-Duty	Light-Duty
Class 4	14,001	16,000	Medium-Duty	Medium-Duty
Class 5	16,001	19,500	Medium-Duty	Medium-Duty
Class 6	19,501	26,000	Light-Heavy	Medium-Duty
Class 7	26,001	33,000	Heavy-Duty	Heavy-Duty
Class 8	33,001	80,000	Heavy-Duty	Heavy-Duty

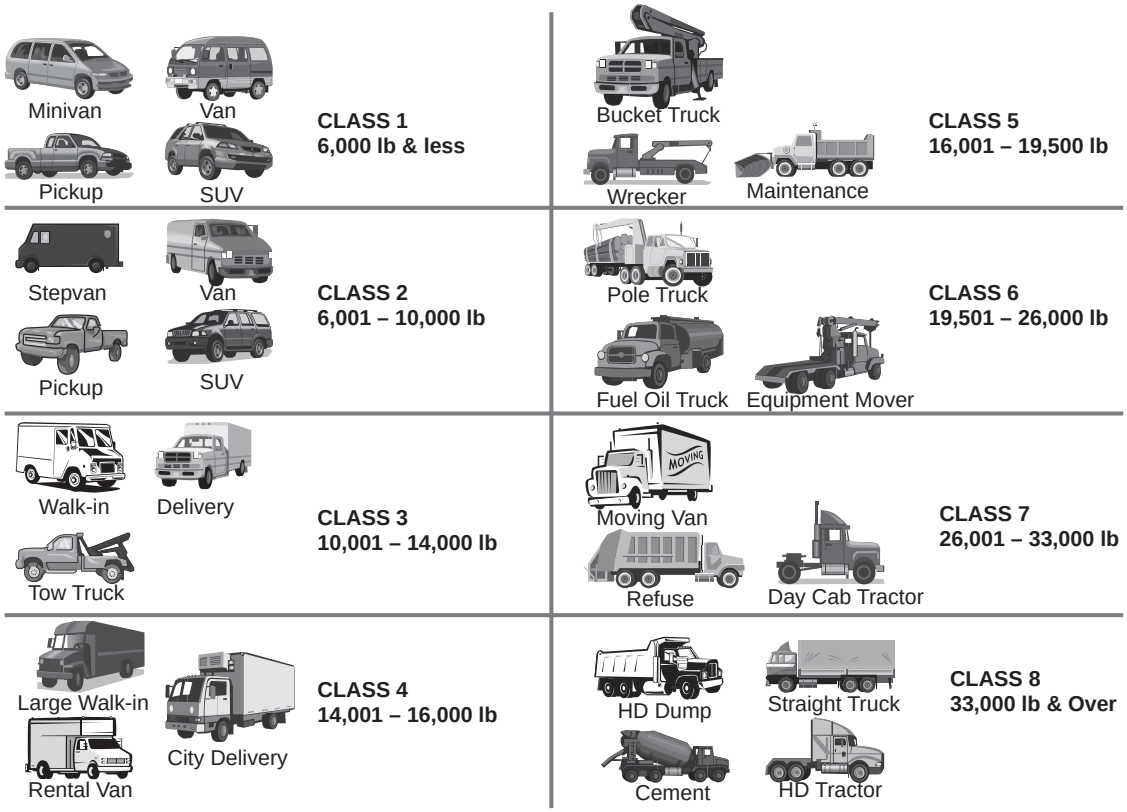

Figure B-1. GVW truck classes.

Table B-3. Freight versus services share of truck miles.

Millions of Annual Truck Miles Excluding Pickups, etc.		
Sector	**Miles (000)**	**Share**
Freight/Goods Movement	**88,129**	**61%**
For-hire Transportation or Warehousing	65,350	45%
Manufacturing	5,509	4%
Wholesale Trade	7,784	5%
Retail Trade	9,486	7%
Services & Other	**57,043**	**39%**
Vehicle Leasing or Rental	10,693	7%
Agriculture, forestry, fishing, or hunting	7,797	5%
Mining	1,981	1%
Utilities	2,498	2%
Construction	14,998	10%
Information Services	560	0%
Waste management, landscaping, or administrative/support services	5,101	4%
Arts, entertainment, or recreation services	201	0%
Accommodation or food services	2,402	2%
Other services	2,208	2%
Personal transportation	311	0%
Not reported	8,143	6%
Not applicable	150	0%
Total	**145,172**	**100%**

Source: VIUS 2002, Table 3a

Table B-4. Medium- and heavy-duty single-unit truck body types.

Type	Trucks (000)	Share
Single-unit trucks	**4,110**	**100%**
Freight	**3,087**	**75%**
Beverage	42	1%
Concrete mixer	77	2%
Curtainside	4	0%
Dump	727	18%
Flatbed, stake, or platform	948	23%
Low boy	4	0%
Pole, logging, pulpwood, or pipe	18	0%
Tank, dry bulk	26	1%
Tank, liquids or gases	178	4%
Tow/Wrecker	128	3%
Trash, garbage, or recycling	96	2%
Van, basic enclosed	583	14%
Van, insulated nonrefrigerated	19	0%
Van, insulated refrigerated	86	2%
Van, open top	152	4%
Mixed Freight/Service	**483**	**12%**
Van, step, walk-in, or multistop	413	10%
Van, other	69	2%
Other	1	0%
Service	**540**	**13%**
Armored	11	0%
Concrete pumper	6	0%
Crane	18	0%
Service, utility	262	6%
Service, other	222	5%
Street sweeper	6	0%
Vacuum	15	0%

Within the mixed freight/service sector, the use of tractor-trailer combinations is most common in construction and in agriculture, forestry, and so forth, where it is reasonable to assume that those combination vehicles are primarily used to move goods or equipment in freight service. The majority (77%) of trucks in freight service, however, are single-unit vehicles, as are the majority of service and mixed-use vehicles. These data, therefore, suggest that a higher VMT fee on tractor-trailer combinations would indeed be incurred primarily by freight haulers. However, it would cover only a small portion of all freight trucks.

Table B-6. Medium- and heavy-duty tractor-trailer types.

Type	Trucks (000)	Share
Truck-tractors	**1,422**	**100%**
Automobile carrier	13	1%
Beverage	34	2%
Curtainside	4	0%
Dump	129	9%
Flatbed, stake, or platform	194	14%
Livestock	15	1%
Low boy	58	4%
Mobile home toter	5	0%
Open top	64	5%
Pole, logging, pulpwood, or pipe	22	2%
Tank, dry bulk	28	2%
Tank, liquids or gases	81	6%
Van, basic enclosed	593	42%
Van, drop-frame	14	1%
Van, insulated nonrefrigerated	15	1%
Van, insulated refrigerated	120	8%
Other	1	10%
Not applicable	34	2%

The distinction between freight and service trucks can be complicated by the use of service trucks to pull trailers loaded with goods. Examples include the following:

- Utility company service trucks pulling trailers loaded with cables, poles, or other supplies.
- Heavy-duty pickups with bed-mounted fifth wheels used to pull commercial vehicle or livestock trailers.
- Construction vehicles used to tow other equipment to a work site.

These practices would likely increase if "freight" vehicles paid higher taxes than "service" vehicles.

Table B-5. Truck types and sectors.

Sector	Single-Unit Trucks and Tractors w/o Trailers	Single - Unit with Trailer	Tractor with Single Trailer	Tractor with Double Trailers	Tractor with Triple Trailers	Total
Sector Composition						
Freight	**77%**	**2%**	**19%**	**1%**	**0%**	**100%**
Mixed Freight/Service	**91%**	**6%**	**4%**	**0%**	**0%**	**100%**
Service & Personal Transport	**99%**	**1%**	**0%**	**0%**	**0%**	**100%**
Total	**96%**	**2%**	**2%**	**0%**	**0%**	**100%**
Sector Share						
Freight	**4%**	**6%**	**63%**	**73%**	**100%**	**5%**
Mixed Freight/Service	**14%**	**42%**	**35%**	**25%**	**0%**	**15%**
Service & Personal Transport	**82%**	**52%**	**3%**	**1%**	**0%**	**80%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: 2002 VIUS, Table 5

Table B-7. Truck classes and fuels used.

	Light (GVW Class 1- 3)	Medium (GVW Class 4-5)	Light-Heavy (GVW Class 6)	Heavy-Heavy (GVW Class 7&8)	Total
Truck Count by Fuel Type (000)					
Gasoline	74,765	1,013	342	215	1,570
Diesel	2,513	832	490	2,291	3,613
Alternative	597	12	20	14	46
Total Reported	**77,875**	**1,857**	**852**	**2,520**	**5,229**
Fuel Share of Truck Type					
Gasoline	96%	55%	40%	9%	30%
Diesel	**3%**	**45%**	**57%**	**91%**	**69%**
Alternative	1%	1%	2%	1%	1%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Source: 2002 VIUS, Table 5.

Diesel versus Other Fuels

In many instances, the use of diesel fuel is implicitly equated with freight transportation. As Table B-7 shows, however, even in the heaviest classes of trucks, other fuels account for about 9% of the vehicles. In medium and light-heavy vehicle classes, which together account for about the same number of vehicles as the heavy-heavy class, only about half of the vehicles use diesel fuel. A diesel fuel tax, therefore, would cover only part of the freight trucking industry. Moreover, a tax that raised the price of diesel relative to the price of gasoline or other fuels would encourage the use of gasoline-powered vehicles to avoid the tax burden.

The connection between fuel type and truck type is also complex. As data from the 2002 VIUS (see Table B-8) show, tractor-trailer combinations use diesel almost exclusively. Single-unit trucks with or without trailers, however, mostly use gasoline. Moreover, most diesel trucks (77.5%) are in the single-unit categories.

Table B-8. VIUS data on truck type and fuel used.

	Single-Unit Trucks and Tractors w/o Trailers	Single - Unit with Trailer	Tractor with Single Trailer	Tractor with Double Trailers	Tractor with Triple Trailers	Total
Truck Count by Fuel Type						
Gasoline	75,092,000	1,235,400	7,100	-	-	76,334,600
Diesel	4,283,700	463,200	1,311,400	66,500	1,500	6,125,400
Alternative	260,600	377,700	-	-	-	643,400
Total Reported	79,636,300	2,076,300	1,318,500	66,500	1,500	83,103,400
Share of Trucks	**95.8%**	**2.5%**	**1.6%**	**0.1%**	**0.0%**	**100.0%**
Truck Share of Fuel Type						
Gasoline	98.4%	1.6%	0.0%	0.0%	0.0%	100.0%
Diesel	69.9%	7.6%	21.4%	1.1%	0.0%	100.0%
Alternative	40.5%	58.7%	0.0%	0.0%	0.0%	100.0%
Fuel Share of Truck Type						
Gasoline	94.3%	59.5%	0.5%	0.0%	0.0%	91.9%
Diesel	5.4%	22.3%	99.5%	100.0%	100.0%	7.4%
Alternative	0.3%	18.2%	0.0%	0.0%	0.0%	0.8%

Source: 2002 VIUS, Table 5.

APPENDIX C

On-Board Devices in Trucking

Overview

Electronic on-board data recorders (EOBRs) and associated communication systems (telematics) are possible implementation tools for VMT fees. The use of such devices is limited at present, however, and the future requirements and applications are only now being developed. The surge of interest is in part attributable to the expectation that motor carriers will gravitate to some sort of EOBR for the benefit of their own operation or in response to government mandate. When supplemented by global positioning system/automatic vehicle location (GPS/AVL) capabilities (often called "telematics"), EOBRs become multipurpose devices capable of supporting time/location VMT options. EOBRs would not ordinarily have dedicated short-range communications (DSRC) or radio frequency identification (RFID) functions to communicate with roadside readers or toll systems.

EOBRs are primarily intended to record data on vehicle operations and driver hours of service to meet the company's need for management information and regulatory compliance. EOBRs can record miles traveled, as well as hours operated, fuel consumption, and so forth. EOBR mileage data, remotely accessed or downloaded, could be used to calculate or assess VMT fees without adding any new equipment to the vehicle. To the extent that EOBRs are adopted by the industry for other reasons and can be used successfully in VMT implementation, marginal implementation time and cost would be reduced.

Development of the devices is not yet mature. The requirements for the devices are not yet fully developed, particularly those that might be mandated by federal regulations. Development of supporting software is evolving rapidly. For larger fleets with many drivers, the existing devices and application support is performing as anticipated, thereby encouraging adoption by others. Some specialized applications are already in operation and working successfully. For many motor carriers and drivers, particularly for a very small fleet (e.g., one to five trucks/tractors, which is the majority of commercial trucks), the value of such devices, the supporting software, and the supplemental administration of the data are still debatable.

A minority of the approximately 10 million medium- and heavy-duty trucks and the approximately 3.0 million drivers with a commercial driver's license will be involved in most of the pending FMCSA regulations. In particular, the scope of the pending, revised Hours of Service Regulations is likely to cover only a minority of commercial trucks.

Technology

Electronic on-board (data) recorders and telematics systems include various devices used to communicate data among the truck, its driver, and a home base. These devices come in many forms and have evolved significantly. All current devices require applications software to convert the data to actionable information, alerts, and a permanent record, and to integrate with trucking company information and accounting systems. Applications include the following:

- Customer service, shipment status reporting, contingency planning.
- Dispatch instructions, equipment utilization.
- Time of day, location, mileage readings, routings, vehicle miles, and estimated times of arrival (ETAs).
- Fuel consumption and fuel tax reporting.
- Driver comfort/convenience, phone calls, text messaging, and Internet access.
- Document transmission, order management, and signed delivery receipts.
- Hours of service and electronic logging.
- Vehicle maintenance, service due, parts and components used, warranty support, and engine diagnostics.

In private trucking, the justification for most installations has been a combination of customer service and fuel

consumption considerations. In for-hire trucking, the justification for most installations has been single entry of data to avoid clerical mistakes, customer service considerations, and engine diagnostics.

These devices typically connect to the "engine bus" within the truck's factory electronic system to obtain data on vehicle operation, fuel consumption, and engine performance. They can use either GPS or global system for mobile communication (GSM) cellular technology for vehicle location and movement information. The EOBRs themselves can be relatively small, such as a one-way tracking or more elaborate, such as a comprehensive two-way system.

Suppliers

There are many vendors of the devices, applications, and systems integration. Commonly known device vendors include Qualcomm, XATA, NAVTEQ, Sprint Nextel, and AT&T. Applications software vendors include FleetMatics, SkyBitz, Cheetah, PeopleSoft, IBM, Comtech, Manhattan, Innovative, and RASTech, as well as engine manufacturers such as Cummins or Daimler Benz and fleet operators such as UPS Technologies and Ryder Systems. Systems integrators include TMW Systems, Oracle, McLeod, and IBM, as well as niche integrators such as Internet Truckstop.

Some suppliers tend to concentrate on for-hire trucking; others concentrate on private trucking or trucking that does not involve intercity freight such as service, work, or vocational trucks.

Hours of Service (HOS) Regulations

Part 395 of the Code of Federal Regulations (CFR) governs the Hours of Service (HOS) for a commercial vehicle driver. These rules govern the driver's duty status 24 hours per day and 7 days per week in four categories. Drivers must keep a Daily Driver's Log to record each change of duty status and the duration in the status category.

In CFR Part 395.1, however, there are exceptions (b) through (q) that relieve some drivers of requirements either all or part of the time. *The net result of these exceptions is that over 50% of commercial truck drivers do not have to comply with HOS regulations.*

CFR Part 395 also provides certain regulations in Part 395.15 governing automatic on-board recording devices to record the driver's hours of service. The data that must be kept include total miles driven each day; however, that mileage does not have to be detailed by state or by vehicle when more than one vehicle is driven in a day. The existing regulations in Part 395.15 imply, but do not specify, that a given EOBR is permanently installed in a specific truck.

Pending Developments

As of October 2010, there are five pending legislative and regulatory developments, which, until firm, make the outlook for EOBRs very uncertain. Most of these developments focus on the responsibilities of the FMCSA.

Effective June 2012, companies that historically have had compliance issues with the federal Hours-of-Service (HOS) regulations were going to be required to equip their trucks with an EOBR that reports hours of service by individual driver. In August 2011, however, the U.S. Court of Appeals for the Seventh Circuit vacated the rule and sent it back to FMCSA for review on the grounds that the agency did not provide enough detail on how it intends to prevent carriers from harassing drivers through the use of EOBRs. As of January 2012, the future of the rule is still unknown.

A new Hours-of-Service (HOS) Final Rule was issued by FMCSA on December 22, 2011. The new rule makes a number of detailed changes to HOS regulations, but does not otherwise materially change the implications for EOBR use.

The new Compliance, Safety, Accountability program (CSA, previously "Comprehensive Safety Analysis") promulgated by FMCSA is being progressively implemented in 2011 and 2012. These rules and procedures, enforced by FMCSA in cooperation with state police, create new measurement systems for both drivers and motor carriers. The FMCSA has announced rules and procedures for this implementation. The goal is to score each driver and each company based on performance. One of the performance metrics is HOS compliance.

A planned "Use of Advanced Information Technologies to Monitor Compliance" protocol to be issued by the FMCSA would effectively require any GPS tracking and dispatch system information to be made available for HOS compliance audits. Such audits are one of the processes embedded in the CSA.

A current research initiative by the FMCSA called "Wireless Roadside Inspections" (WRI) will be voluntary for carriers that have demonstrated effective safety and compliance management capabilities, presumably by virtue of the CSA analysis. The WRI will serve to automate safety inspections covering carrier and driver credentials, electronic driver logs, and selected vehicle safety systems status. The goal of WRI is to automate inspections and avoid time lost where noncompliance is a minimal risk, thereby enabling law enforcement to better leverage roadside resources toward higher risk carriers, vehicles, and drivers. It will enable participating carriers to minimize time lost with roadside inspections while also getting positive credit in their CSA safety performance ratings.

The expected congressional legislation to renew the Federal Highway Program, including new funding of the Highway

Trust Fund, could include a mandate for use of EOBRs for HOS compliance and vehicular accident prevention. That mandate could extend to vehicles and driving situations presently exempted from HOS regulations.

Carrier Motivation

There is substantial industry interest and action in EOBRs for cost and service reasons. In for-hire trucking, the justification for most installations has been single entry of data for service planning (avoiding clerical time and cost), customer service considerations, and engine diagnostics. In private trucking, the justification for most installations has been a combination of customer service and fuel consumption considerations.

Larger fleets have achieved productivity gains that have justified such investments. In doing so, trucking management has had to overcome the risk of alienating drivers who may dislike the idea of a recording device installed in the truck cab. It is not yet clear whether smaller fleets (e.g., less than 10 trucks) can get sufficient payback on what, for them, are substantial capital and operating costs. Somewhat ironically, some drivers now have become so adjusted to having such communication devices with them at all times that sometimes they will not work for a trucking company that does not provide the "right kind" of communication technology and operations support systems.

Cost

The overall cost of EOBRs depends on initial acquisition and installation costs, servicing and maintenance costs, the costs of acquiring and operating the necessary software and communications links, and the costs of integrating the system with others used by the motor carrier. The unit cost is affected by the state of development and number of sales of the devices and software. At least in theory, the price charged by each of the suppliers involved should be declining as market penetration increases. On a unit basis, this has been occurring, and discounts from list price have been significant, particularly when a large fleet decides to start installing units.

Cost estimates vary significantly. A survey published in 2006 by the American Transportation Research Institute (ATRI) reported "purchase costs" (however defined) by interviewees that had installed EOBRs as shown in Table C-1. Causes of the wide variance in costs were not reported, but are likely to include differences in hardware specifications and software applications.

In addition, reporting carriers stated that, "on average," monthly maintenance costs were $21.41 per truck, monthly wireless subscriptions (when applicable) were $33.71 per truck, and annual software updates were $33.86 per truck. The annual total operating costs would be $695.30 per truck/unit. Three-quarters of the respondents indicated that it took less than 3 years to achieve the expected return on the investment. Respondents estimated the life span for the device at approximately 8 years (although, apparently, no units had yet been installed for that long).

Table C-1. Reported cost of truck EOBRs.

Reported Price Range	Percentage of Responses	
	Motor Carriers	Device Vendors
Less than $500	7	33
$500-$999	15	25
$1000-1499	15	17
$1500-1999	26	8
$2000 or more	37	17

Source: ATRI.

Benefits and Impacts of Installation

The ATRI report stated that 93% of respondents indicated some benefits to tracking HOS via EOBRs compared to other methods. Benefits reported include regulatory compliance (46% of respondents), safety (34%), and productivity (20%). Other positive impacts were also included. Seventy-six percent reported improved driver morale, 62% reported that driver retention was not impacted, and 78% said that use of EOBRs improved company productivity.

Of the motor carriers responding that were not using EOBRs (81% of respondents), the primary reasons for not using EOBRs were as follows:

- 24% currently in compliance,
- 22% concerned about privacy/ownership/security,
- 22% concerned about impacts on driver retention, and
- 20% no government mandate.

When asked about additional features that might be of interest should the use of EOBRs for HOS record-keeping be required, 63% selected management of International Fuel Tax Agreement (IFTA) regulations, the most of any response category. As compared to other carriers, owner-operators were less likely to want features of vehicle operating cost, business management, or real-time communications. Private fleets were more likely to want IFTA compliance functions. Truckload

carriers were more likely to want real-time communications functions.

EOBR Market Penetration

There is no known public data on market penetration for EOBRs or telematics systems. Private parties that sell the devices may have internal, confidential estimates. No public survey or research on the size of the market is known to exist. Market penetration would increase if HOS regulation mandated EOBRs on all vehicles or on all vehicles used in categories other than those exempted in CFR 395.1 (b) through (q).

In the mid-2000s, ATRI stated that only 1 or 2% of new trucks and tractors were being built with some sort of EOBR installed at the factory. That is not a good indicator because retrofitting tractors (even brand new tractors) is the dominant method of installation now and for the foreseeable future.

Historic rates of penetration would be meaningless if the federal government issued a mandate to use EOBRs in some applications. This may occur sometime after 2010 for carriers with deficient compliance scores in CSA, hazmat carriers, new carriers, and carriers that fail a FMCSA audit. However, that is not likely to be more than 100,000 trucks in total.

Common wisdom in the industry is to wait to see what federal agencies mandate and not to do anything immediately. The economy has been so bad that truckers are not investing in accessorial equipment and new software.

Cycle and Lead Times

The lead time for installation of devices, software, communications capability, training of personnel, and acceptance by all involved is substantial in either the simple or the complex case. This lead time would be controlled by the rate of attrition of older power units whether by wear and tear, technological obsolescence, or government-mandated obsolescence.

Like all capital equipment, trucks and tractors have a life cycle controlled by the owner and the service in which the equipment is operated. Life cycle is measured in miles or hours of operation (useful life), not in months since manufacture. Trucks can and do last 20–30 years, although the majority are retired in 15–20 years. Class 7 and 8 tractors tend to be cascaded down through applications that are progressively less stressful, with less justification for after-market installation of EOBRs. Some tractors cascade into local or seasonal use in one-driver "fleets." Other reasons for not installing EOBRs include unwillingness by a new owner to make the investment and use in an HOS-exempt service. EOBRs would have to penetrate the applicable truck population for other reasons, usually service performance and cost reduction, which are internal to the trucking company and/or owner-operator. Such justification would not be the same for a smaller fleet, particularly a one-truck operator, as it is for a larger fleet. However, if either technological or government-mandated obsolescence were to occur, the governing conditions would likely be the maximum output of the equipment manufacturing sector and the ability of truck owners and operators to cope with the new requirements.

APPENDIX D

Privacy Issues

Overview

The proposed approaches to assessing VMT fees involve using on-board units to record, store, and transmit road use data. These proposals have raised privacy concerns regarding the government's ability to track the movements of individuals. Whether these concerns are legitimate as a practical matter depends on the nature and specificity of the data recorded.

In designing a VMT fee system, there is generally a tradeoff between privacy and auditability. If the system is designed to be highly auditable, the government will gain access to a certain degree of information regarding individuals' movements. However, even if a high degree of auditability is sought, there is no need to design a system that provides the government with a virtual map of an individual's movements as feared by privacy groups. Below that level of detail, it may be possible to allow each individual to choose the tradeoff between privacy and auditability that he or she thinks is optimal.

As a legal matter, virtually any system design would comply with existing constitutional and statutory privacy protections. It is possible that a system that provides detailed route information regarding all of an individual's movements could raise constitutional concerns. However, as noted, an effective VMT fee program would not require the recording or transmitting of this level of detail.

This appendix will begin by discussing the various options for implementing a VMT fee system and the tradeoff between auditability and privacy involved with each. It will then proceed to discuss the legal issues relevant to these options.

Road User Fee Design Options

The option most protective of privacy (Option 1) eliminates the collection of road user data altogether. Under this option, VMT fees could be estimated based on the amount of fuel purchased and the EPA miles per gallon (mpg) estimate for the particular vehicle model. The EPA mpg data for a vehicle would be stored on a radio frequency identification (RFID) tag. RFID readers located at service station fuel dispensers would automatically read the EPA mpg data stored on the RFID tag as a vehicle is fueling. Unlike other options that are highly protective of privacy, this option allows for easy auditability. However, it only provides a rough estimate of miles traveled. Furthermore, the fees would fall disproportionately on those who do most of their driving in congested areas since mpg falls considerably under congested driving conditions.

Another option, similarly protective of privacy (Option 2), would collect a limited amount of road user information and transmit only a subset of that information to the government. Under this option, often called a "thick-client" system, a GPS system would identify the jurisdiction in which the vehicle is traveling and a separate device connected to the vehicle's speed sensor or odometer would record the miles traveled. An on-vehicle computer would combine this information and record the miles traveled in each jurisdiction and calculate the corresponding VMT fees.

Thus, in Option 2, no information regarding routes traveled would be recorded or stored. Even the location information regarding the jurisdictions in which a vehicle traveled need only be stored long enough for the computer to calculate the proper fees. The only information that would be transmitted to the government would be the accumulated total of user fees owed by a given vehicle during the billing period. The government would therefore not even be able to determine the jurisdictions through which a given vehicle has traveled. While this system is highly protective of privacy, it provides a low level of auditability. If individuals receive a billing statement that only lists the total fees owed, users will have difficulty verifying that this information is correct.

A similar system that allows for more auditability, but is somewhat less protective of privacy (Option 3) would use the same technology as Option 2, but instead of only transmitting total fees owed, it would transmit total miles driven in each jurisdiction and total fees owed by jurisdiction. The state of Oregon and the University of Iowa, in conjunction with

the FHWA, have conducted pilot programs using this type of system. Depending on the mix of privacy and auditability sought, the information could be recorded by day, week, month, and so forth. In other words, at the end of a billing cycle, the system could transmit the miles accumulated in each jurisdiction for each day, each week, or each month. The shorter the period of time, the easier it is for individuals to determine whether the fees are being assessed accurately. However, shorter time periods also provide the government with more detailed information regarding an individual's movements. Another possibility for this system would be to record and transmit the amount of fuel purchased each time a user visits a gas station. The fuel volumes purchased could be compared to miles driven and used as another check on the accuracy of the system.

An extension of Option 2 and Option 3 described above in a time/location VMT system would be to record not only information regarding road use by jurisdiction, but also to record use of toll roads, bridges, and tunnels. Under this scenario, the GPS component would identify when a vehicle travels on certain toll facilities. The information transmitted to the government could still be limited to the total fees owed, as under Option 2. However, if more auditability is sought, information regarding the number of times a particular toll facility was used each day, week, or month of a billing cycle could be transmitted to the government and provided to users. Of course, this increased level of detail would provide the government with some information regarding particular routes traveled by individuals.

The option least protective of privacy (Option 4) is a "thin-client" time/location system based entirely on GPS data that records and transmits detailed route information. This system is highly auditable since users can review and verify each individual trip taken in their vehicles. The detailed information would also allow the user to engage in a more careful examination of the financial consequences of his or her driving behavior. However, such a system would provide the government with a highly detailed record of the movements of users that could reveal personal information such as political affiliations, medical treatments, and so forth. As discussed below, government collection of this level of data could raise constitutional issues.

As the discussion above indicates, there is generally a tradeoff between privacy and auditability. The government could decide the balance for everyone by requiring that the system provide a certain level of information. Alternatively, the government could establish the minimum level of information it would require and allow each individual to choose the balance between privacy and auditability that he or she finds optimal. For example, the government could require that all users submit information regarding total fees accumulated during a billing cycle and allow individuals to determine whether they want to provide information regarding total miles driven in each jurisdiction to allow for increased auditability. A framework involving such consumer choice could be established by allowing for an open system in which the private sector develops various products corresponding to different levels of privacy. The government would simply certify these technologies as complaint with the road user fees system. Alternatively, a single technology could be developed that enables users or certified technicians to make adjustments to the privacy settings.

Third-Party Option

A variation on Options 2, 3, and 4 that some may view as increasing the level of privacy protection without reducing individual auditability is to have the relevant road use data collected by a private third party. Under this scenario, the data collected by the on-vehicle system would be transmitted to a private company. The company would bill the individual and pass the fee revenue along to the government. Thus, the only information the government would receive would be the total fees paid for a given billing period. This feature could be integrated into Options 2 through 4 described above.[1] Under Option 2, total user fees owed would be transmitted to the third party. The third party could then provide the fees it collects to the government without tying a particular amount of fees to a particular user. Alternatively, the third party could provide the government with the amount of fees associated with each user. However, this would not increase the level of privacy under Option 2 since, even without third-party involvement, Option 2 would provide the government with the total fees associated with each user. Under Options 3 and 4, the mileage and jurisdiction/detailed route information could be recorded and transmitted to the private third party, who would bill the individual based on this data and pass the funds collected along to the government. Again, the fees transmitted to the government could be associated with individual users or provided only as an aggregate amount for all users.

Placing a third party between the information and the government could arguably provide some additional privacy since the government would only receive either aggregate fees for all users using a particular third party or fees associated with each individual user. This purported increase in privacy would not come at the price of individual auditability since the individual could be provided with the more detailed information collected by the third party. However, depending on how the legislation is drafted, the government may reserve the right to access the detailed information for various purposes, including audits.

[1]Under Option 1, a third party is already involved. Under that option, the gas station would collect the road user fees just as it currently collects the gas tax.

Further, federal statutes requiring government agencies that collect and maintain personal information to implement data security measures and to limit the use and disclosure of personal information would not necessarily apply to private third parties. Thus, private third parties might engage in acts that violate individuals' privacy, such as selling personal information, or fail to adequately protect personal information unless the legislation establishing the system or contracts with users require these third parties to maintain the security and confidentiality of the data. Even if the government does not have regular access to the data and third parties are required to maintain the confidentiality and security of the data, those who are concerned about their privacy may not see third-party intermediaries as a substitute for limiting the amount of information actually collected or transmitted by the on-vehicle devices. After all, they will still be required to provide information regarding their movements to another party. Those who trust private corporations less than the government may actually view this alternative as less protective of privacy.

Legal Issues

The Fourth Amendment

The Fourth Amendment prohibits unreasonable searches.[2] A "search" occurs under the Fourth Amendment when the government violates a subjective expectation of privacy that society recognizes as reasonable.[3] Thus, a road user fee system would involve a "search" if individuals have an expectation of privacy in the type of information transmitted by the system to the government. However, there is no reasonable expectation of privacy in the type of information that would be provided by the options described above, with the possible exception of the detailed information provided under Option 4.

Option 1, in which only the amount of fuel purchased and the EPA mpg are provided to the government, does not infringe on any expectation of privacy. There can be no expectation of privacy in EPA mpg data since this information is publicly available. Nor can there be an expectation of privacy in the amount of fuel one purchases. The Supreme Court has held in various other contexts that there is no expectation of privacy in information voluntarily conveyed to businesses. For example, in *Smith v. Maryland,* the Supreme Court held that there is no expectation of privacy in the dialing information sent to a phone company when a person dials a phone.[4] The Court reasoned that there can be no reasonable expectation of privacy in information voluntarily conveyed to the phone company, which was free to record the information and share it with others.[5] Similarly, in *California v. Greenwood,* the Court held that there is no reasonable expectation of privacy in garbage left on the curb for pickup by trash collectors. According to the court, there could be no reasonable expectation of privacy in the garbage because it was left in an area exposed to the public and put at the curb for "the express purpose of conveying it to a third party, the trash collector, who might himself have sorted through [it] or permitted others, such as the police, to do so."[6] When one purchases fuel, the amount of fuel purchased is intentionally and voluntarily shared with the provider of the fuel and the amount purchased is exposed to the public on the display of the gas pump. Thus, there can be no reasonable expectation of privacy in that information.

Under Option 2, the only information that would be provided to the government would be the total road user fees owed. This information essentially provides the government with a rough estimate of the number of miles driven during a given period. There can be no reasonable expectation of privacy in such information for two reasons.

First, as with dialing information sent to the phone company and garbage left on the curb, mileage information is voluntarily conveyed to service providers on a regular basis. When an individual takes his or her car in for maintenance, the owner of the car voluntarily conveys the mileage driven since the previous visit to that service provider. Thus, according to *Smith* and *Greenwood,* there can be no reasonable expectation of privacy in this information.

Second, the mileage driven by an individual is a subset of the information regarding that individual's movements in public, in which there can be no reasonable expectation of privacy. The Supreme Court, in *United States v. Knotts,* established that electronic monitoring of an individual's movements does not violate the Fourth Amendment where it reveals no information that could not have been obtained through visual surveillance.[7] The court reasoned that such monitoring was analogous to following someone on public streets, where there is no expectation of privacy.[8] In contrast, the Supreme Court held in *United States v. Karo* that electronic tracking of a device does violate the Fourth Amendment if the device is located in a private area out of view from the public, such as a home.[9] The Court reasoned that tracking the device while it is in a private residence is analogous to entering a residence to verify that the device is inside the residence,

[2] U.S. Const. amend. IV ("The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated . . .")

[3] *See, e.g., Kyllo v. United States,* 533 U.S. 27, 33 (2001).

[4] 442 U.S. 735, 742–745 (1979).

[5] *Id.* at 745; *see also United States v. Miller,* 425 U.S. 435, 443 (1976) (holding that there is no reasonable expectation of privacy in information transmitted to a bank because the information was voluntarily conveyed and exposed to the banks employees in the ordinary course of business).

[6] *California v. Greenwood,* 486 U.S. 35, 41 (1988)

[7] *United States v. Knotts,* 460 U.S. 276, 282 (1983).

[8] *Id.* at 281.

[9] *United States v. Karo,* 468 U.S. 705, 715–17 (1984).

a place which the Fourth Amendment protects from government intrusion.[10] Taken together, these cases establish that warrantless tracking of an individual's movements violates the Fourth Amendment when it provides the government information regarding an individual's location within an area, such as a private residence, where he or she has a reasonable expectation of privacy, but not when it reveals information regarding an individual's movements in public. Since the Fourth Amendment permits monitoring an individual's movements in public, it must also permit monitoring the number of miles driven by an individual in public. Put another way, since the number of miles driven by an individual could be obtained by visual surveillance, there can be no expectation of privacy in that information.

Option 3 would not only provide information regarding the number of miles driven but also the jurisdictions, and possibly the toll facilities, where those miles were accumulated. With regard to the Fourth Amendment, however, this amounts to a distinction without a difference. Because there is no reasonable expectation of privacy in one's movements in public, government access to information regarding which jurisdictions an individual traveled through and what toll facilities an individual used does not implicate the Fourth Amendment. Indeed, state governments already collect a subset of this information. Through the use of cameras and devices such as E-Z Pass at toll facilities, states collect information regarding the roads used by individuals and, in some instances, the distances traveled on such roads.

Option 4 would provide detailed information regarding the routes traveled by individuals. Requiring individuals to provide this level of detailed location information to the government conceivably could be found to be inconsistent with the Fourth Amendment. As discussed above, the Supreme Court has held that the Fourth Amendment does not prohibit electronic monitoring of one's movements in public. However, that decision long predates GPS devices that allow for the constant collection and recording of highly detailed information about an individual's movements, which can reveal personal information such as political affiliations, medical treatments, personal relationships, and so forth. A court may find such a situation distinguishable from the cases where an electronic beeper provided the police with information regarding an individual's location for a short period of time.

Indeed, some state courts have found that the use of GPS devices to track an individual's movements violates state constitutions. In finding that the use of a GPS device to track a vehicle's movements violated the state constitution of New York, the court in *People v. Weaver* distinguished the use of a GPS device from the "primitive" beeper used to track individuals in *Knotts.* It found that, unlike the beeper in *Knotts,* which facilitated surveillance during a single trip, a GPS device allows the "whole of a person's progress through the world . . . [to] be charted and recorded over lengthy periods" yielding "a highly detailed profile, not simply of where we go, but by easy inference, of our associations—political, religious, amicable and amorous, to name only a few—and of the pattern of our professional and avocational pursuits."[11] In holding that use of a GPS device to track a vehicle's movements violated the state constitution of Washington, the court in *State v. Jackson* similarly noted the fact that GPS tracking allows for constant surveillance and "can provide a detailed picture of one's life."[12] Because these decisions were based on state law, they would not prohibit the operation of a federal, GPS-based system (although they could limit the ability of states to collect state taxes through such systems).

Federal courts that have directly addressed the issue of GPS tracking of vehicles have generally found it to be consistent with the Fourth Amendment.[13] However, the Court of Appeals for the D.C. Circuit recently held that GPS tracking over an extended period of time is a search within the meaning of the Fourth Amendment and therefore requires a warrant.[14] As explained above, the Supreme Court in *Knotts* found that there can be no reasonable expectation of privacy in one's movements that are exposed to the public. The D.C. Circuit, however, interpreted *Knotts* as being limited to the tracking of someone "during a discrete journey," and as leaving open the question of whether sustained surveillance for an extended period might cross the line and become a Fourth Amendment "search."[15] According to the court, the reasoning in *Knotts* is not applicable to prolonged surveillance because the aggregate amount of information that such sustained surveillance reveals about a person is, in effect, not exposed to the public even if the individual bits of information are.[16] It stated, "[T]he whole of one's movements over the course of a month is not actually exposed to the public because the likelihood anyone will observe all those movements is effectively nil."[17] The

[10] *Id.* at 715.

[11] *People v. Weaver,* 909 N.E.2d 1195, 1199-00 (N.Y. 2009).

[12] *State v. Jackson,* 76 P.3d 217, 223 (Wash. 2003). More specifically, the court stated that GPS information "can provide a detailed record of travel to doctors' offices, banks, gambling casinos, tanning salons, places of worship, political party meetings, bars, grocery stores, exercise gyms, places where children are dropped off for school, play, or day care, the upper scale restaurant and the fast food restaurant, the strip club, the opera, the baseball game, the "wrong" side of town, the family planning clinic, the labor rally." *Id.*

[13] See, e.g., *United States v. Garcia,* 474 F.3d 994, 998 (7th Cir. 2007); *United States v. Marquez,* 605 F.3d 604, 610 (8th Cir. 2010); *United States v. Burton,* 2010 WL 996487 (N.D. Fla. 2010); *Morton v. Nassau County Police Department,* 2007 WL 4264569 (E.D.N.Y. 2007); *United States v. Moran,* 349 F.Supp.2d 425 (N.D.N.Y. 2005); *U.S. v. Williams,* 650 F.Supp.2d 633 (W.D. Ky. 2009).

[14] *United States v. Maynard,* No. 08-3030 (D.C. Cir. Aug. 6, 2010).

[15] *Id.* at 17–18.

[16] *Id.* at 22.

[17] *Id.*

court also found that the sum of a person's movements over an extended period is not "constructively exposed" to the public by virtue of the fact that his individual movements are, because the "whole reveals far more than the individual movements it comprises."[18] According to the court, detailed GPS records indicating who a person visits and how often can reveal an intimate picture of an individual's life, which is not revealed by observing a person for a short period of time.[19]

Because detailed records regarding one's movements over an extended period can provide such an intimate picture of one's life, the court found that individuals have a reasonable expectation of privacy in that information, which is protected by the Fourth Amendment.[20] Thus, the court's holding relied on the fact that the tracking at issue provided detailed route data to the government. The only option above that would transmit such information to the government is Option 4. The information provided by the other options, such as total miles driven or miles driven in a particular jurisdiction, hardly provides an intimate picture of one's life.

A few other federal courts of appeals have noted that constant, indiscriminate GPS surveillance could raise Fourth Amendment concerns. For example, in *United States v. Garcia,* the Seventh Circuit noted that use of the device was limited and stated, "Should government someday decide to institute programs of mass surveillance of vehicular movements, it will be time enough to decide whether the Fourth Amendment should be interpreted to treat such surveillance as a search."[21]

In short, although mass GPS tracking of detailed vehicular movements appears to be consistent with the Fourth Amendment under existing Supreme Court precedent, some courts have indicated that they view such tracking as distinguishable from the type of tracking approved by the Supreme Court. Thus, it is advisable to design a VMT fee system in a way that provides general information regarding the aggregate movements of individuals rather than detailed information regarding particular routes or destinations.

As discussed above, VMT fee system options can be designed such that a private third party receives the data and only provides the government with the fees it collects. This feature does not change the constitutional analysis. Because the private third party will be collecting the data on behalf of the government, the third party cannot be distinguished from the government for purposes of the Fourth Amendment.[22] Thus, the Fourth Amendment limits described above would be equally applicable to a third-party collecting the data.

Statutory Law

There are statutory provisions dealing with the installation of "tracking devices." In particular, Section 3117 of Title 18 defines "tracking device" as "an electronic or mechanical device which permits the tracking of the movement of a person or object."[23] It also states, "[i]f a court is empowered to issue a warrant or other order for the installation of a mobile tracking device, such order may authorize the use of that device within the jurisdiction of the court, and outside that jurisdiction if the device is installed in that jurisdiction."[24] Another provision, Federal Rule of Criminal Procedure Rule 41 (Rule 41), authorizes courts to issue warrants for tracking devices upon a showing of probable cause.[25] These provisions, however, do not limit the ability of the government to implement a VMT fee system for several reasons.

First, it is not clear that most of the VMT-compatible OBU systems described above would constitute a "tracking device." A system that provides detailed GPS route information would clearly fit within the statutory definition. As noted elsewhere, distance/vehicle VMT systems do not require GPS capability. A system that merely informs the government of the total

[18] *Id.* at 28.
[19] *Id.* at 29–32.
[20] *Id.* at 32.
[21] *United States v. Garcia,* 474 F.3d 994, 998 (7th Cir. 2007); *see also United States v. Marquez,* 605 F.3d 604, 610 (8th Cir. 2010) ("It is imaginable that a police unit could undertake 'wholesale surveillance' by attaching such devices to thousands of random cars and then analyzing the volumes of data produced for suspicious patterns of activity. Such an effort, if it ever occurred, would raise different concerns than the ones present here."); *United States v. Pineda-Moreno,* 591 F.3d 1212, 1216 n. 2 (9th Cir. 2010) ("We, like the Seventh Circuit, believe that '[s]hould [the] government someday decide to institute programs of mass surveillance of vehicular movements, it will be time enough to decide whether the Fourth Amendment should be interpreted to treat such surveillance as a search.' ") (quoting *United States v. Garcia,* 474 F.3d 994, 998 (7th Cir. 2007)). Viewed out of context, these statements could arguably be read to suggest that the mass collection of more general data, such as miles driven by jurisdiction, raises potential constitutional concerns. However, these statements were made in the context of decisions regarding the use of GPS devices to obtain specific route and location information and referred to the possibility of police conducting such surveillance on a widespread basis. Thus, these cases do not shed light on how the courts might view the collection of much more general information regarding vehicular movements. As noted above, states already collect a substantial amount of general movement information, such as which vehicles use which toll facilities. In any event, these cases merely suggest that the Fourth Amendment implications of widespread tracking of vehicular movements should be carefully considered; they say nothing about how the issue should ultimately be decided.

[22] See *Skinner v. Railway Labor Executives Association,* 489 U.S. 602, 614–15 (1989) (holding that searches by private parties are governed by the Fourth Amendment where the search is required by law or where the government encourages, endorses, and participates in the search).
[23] 18 U.S.C. § 3117(b).
[24] 18 U.S.C. § 3117(a).
[25] More specifically, Rule 41(d)(1) states, "After receiving an affidavit or other information, a magistrate judge—or if authorized by Rule 41(b), a judge of a state court of record—must issue the warrant if there is probable cause to search for and seize a person or property or to install and use a tracking device."

miles accumulated during a particular period cannot be said to "permit the tracking of the movements of a person" since it does not even reveal general information about the locations an individual has visited or routes traveled. A system that also provides information on the jurisdictions in which an individual has traveled arguably does fit within the definition since it can reveal that an individual moved between one particular jurisdiction and another particular jurisdiction. Indeed, courts have described the definition of "tracking device" as "striking for its breadth" and noted that it does not specify how precise a device must be.[26] On the other hand, some courts have suggested that a device is not a "tracking device" if it merely reveals that an individual has visited certain locations (e.g., a credit card is not a tracking device even though it reveals that an individual visited various stores).[27] According to this theory, a device must provide information regarding how an individual moves from place to place rather than just providing a list of places he or she has been. However, as explained below, even if the VMT fee system chosen does fit within the definition of a "tracking device," its use would not be limited by statutory provisions regarding tracking devices.

Second, although several magistrate judges have held that use of a "tracking device" requires a warrant supported by probable cause in certain instances, those decisions are not applicable to the road user fee context. In those cases, the government sought information regarding the location of a cell phone subscriber from the phone company. The courts held that using cell phone data to locate a subscriber transforms the phone into a "tracking device," as defined by 18 U.S.C. § 3117(b), and that the government must therefore obtain a warrant pursuant to Federal Rule of Criminal Procedure 41 (Rule 41).[28] However, courts that have taken this position have done so in the context of a complex web of statutory provisions that are not applicable to a VMT fee system. Specifically, these decisions have focused on a provision of the Communications Assistance for Law Enforcement Act (CALEA) restricting access to "call-identifying information" about a telecommunication subscriber's location obtained "solely pursuant" to a pen register order (a "pen register order" allows law enforcement to use a device that records the phone numbers associated with incoming and outgoing calls).[29] These courts have found that the additional authority needed to obtain location-related "call-identifying information" is a warrant issued pursuant to Rule 41.[30] Thus, these holdings appear to be irrelevant to a situation where the government does not seek "call-identifying information," as would be the case in a road user fee program.[31]

Nonetheless, several opinions speak broadly about the use of tracking devices and suggest that a warrant supported by probable cause is necessary whenever the government seeks to use a tracking device. For example, one magistrate judge, in finding that a cell phone was being used as a tracking device, stated that probable cause is "the standard which the Government has long been required to meet in order to obtain Court approval for the installation and use—by law enforcement agents—of a device enabling the Government to record, or 'track,' the movement of a person."[32] Other

[26]See, e.g., *In re Application of the U.S. for an Order Authorizing the Installation and Use of a Pen Register Device, a Trap and Trace Device, and for Geographic Location Information,* 497 F.Supp.2d 301, 310 (D.P.R. 2007) (opinion of a magistrate judge) [hereinafter *D.P.R. 2007*]; *In re Application for Pen Register and Trap/Trace Device with Cell Site Location Authority,* 396 F. Supp. 2d 747, 753 (S.D. Tex. 2005) [hereinafter *S.D. Tex. 2005*].

[27]See, e.g., *S.D. Tex. 2005* at 756 ("[L]earning a credit card user's location at the point of purchase is far different from continuously monitoring a person's movement from place to place in real time. Section 3117(b) covers only those devices which permit the 'tracking of the movement of a person or object.' Cell site data allows continuous tracking of actual movement, i.e., change of location over time; the examples cited by the government do not."); *In re Application of the U.S. for an Order Directing a Provider of Electronic Communication Service to Disclose Records to the Government,* 534 F. Supp. 2d 585, 603 n.47 (W.D. Pa. 2008) (opinion of a magistrate judge) [hereinafter *W.D. Pa. 2008*] ("Location is static; movement is change in location. There is, thus, a temporal element inherent in the term "movement"; one can only "track" location over time . . . Indeed, the apparent origin of the term "track" derives from looking at the physical manifestations of the prior presence of the subject being tracked to reconstruct or trace a course of movement.").

[28]See, e.g., *W.D. Pa. 2008; In re Application of the U.S. for an Order (1) Authorizing the Use of Pen Register and a Trap and Trace Device and (2) Authorizing Release of Subscriber Location and/or Cell Site Information,* 396 F. Supp. 2d 294 (E.D.N.Y. 2005) (opinion of a magistrate judge) [hereinafter *EDNY 2005*]; *S.D. Tex. 2005; In re Application of the U.S. for an Order Authorizing the Installation and Use of Pen Registers and Call Identification Devices,* 416 F. Supp. 2d 390 (D. Md. 2006) (opinion of a magistrate judge); *In re Application of the U.S. for an Order Authorizing the Installation and Use of a Pen Register,* 415 F. Supp. 2d 211 (W.D.N.Y. 2006) [hereinafter *WDNY 2006*]; *D.P.R. 2007.*

[29]See, e.g., *W.D. Pa. 2008* at 609 ("As noted above, a significant majority of Courts have rejected the Government's contention that real-time, or prospective, movement/location information may be obtained under a hybrid theory which purports to combine the authorities of the [Pen Register Statute] and the [Stored Communications Act] by seizing upon the term 'solely' in a provision of the CALEA."); *WDNY 2006* at 215 ("I share the concerns expressed by some of my Magistrate Judge colleagues as to the wisdom and logic of predicating Congress's intent to combine statutory provisions separately enacted over a fifteen year period to create a new and independent hybrid authorization mechanism on the use of the word 'solely' in the exception clause.").

[30]See, e.g., *D.P.R. 2007* at 311; *EDNY 2005* at 321; *W.D. Pa. 2008* at 616.

[31]The term "call-identifying information" is defined as "dialing or signaling information that identifies the origin, direction, destination, or termination of each communication generated or received by a subscriber by means of any equipment, facility, or service of a telecommunications carrier."47 U.S.C. § 1001(2).

[32]*W.D. Pa. 2008* at 592.

judges have said, "A Rule 41 probable cause warrant was (and is) the standard procedure for authorizing the installation and use of mobile tracking devices."[33]

These broad pronouncements, however, seem to be based on Fourth Amendment concerns regarding the potential tracking of individuals in private areas.[34] For example, one of the cases holding that cell phone tracking requires a warrant acknowledged that cell phone tracking would not be objectionable under the Fourth Amendment if it could be limited to an individual's public movements.[35] Nonetheless, it held that a warrant supported by probable cause was required because it would be impossible to know beforehand whether an individual would enter a private place while being tracked. This would not be an issue with the road user fee systems described above, with the possible exception of Option 4, because they would not reveal anything to the government regarding an individual's location in a private area. The on-vehicle devices could be active while a vehicle is located in a private space, such as an enclosed garage. However, the information transmitted to the government would not allow the government to determine whether an individual is or was in such a space at a given time, which is the key to the Supreme Court's tracking analysis.[36] A system, such as Option 4, that provides detailed GPS information could, in rare instances, reveal information regarding an individual's location in a private area. This is yet another reason not to use such a system as the basis of a road user fee program.

Finally, absent Fourth Amendment concerns, the statutory provisions regarding tracking devices, 18 U.S.C. § 3117 and Rule 41, cannot serve as independent grounds for requiring a warrant. As courts have noted, unlike other provisions governing electronic surveillance, 18 U.S.C. § 3117 provides no standard for obtaining permission to install and monitor a tracking device.[37] Furthermore, Rule 41, which authorizes courts to issue warrants for tracking devices, does not establish such a standard. As the notes to Rule 41 state, the amendment to Rule 41 regarding tracking devices "[did] not resolve this issue or hold that such warrants may issue only on a showing of probable cause."[38] "Instead, it simply provides that if probable cause is shown, the magistrate judge must issue the warrant. And the warrant is only needed if the device is installed . . . or monitored . . . in an area in which the person being monitored has a reasonable expectation of privacy."[39] In other words, as explained by one magistrate judge, "[t]he only limit on such devices is the Fourth Amendment."[40]

Some states have enacted legislation generally prohibiting electronic tracking by anyone except when a court order is obtained or the device is lawfully used for law enforcement purposes.[41] It is not clear whether most of the on-vehicle

[33] *In re Application of the United States for an Order Authorizing the Disclosure of Prospective Cell Site Information,* 2006 U.S. Dist. LEXIS 73324, at *16 (E.D. Wis 2006) (quoting *S.D. Tex.* 2005 at 752).

[34] See, e.g., *S.D. Tex.* 2005 at 752 (citing *Karo,* a case which required a warrant for tracking in private residences but not in public spaces, for the proposition that a probable cause warrant is the standard for the use of a tracking device).

[35] See, e.g., *W.D. Pa. 2008* at 613.

[36] The Supreme Court, in *Karo,* held that electronic tracking of a device inside a private residence was inconsistent with the Fourth Amendment because it told "the agent that a particular article [was] actually located at a particular time in the private residence and [was] in the possession of the person or persons whose residence [was] being watched." *United States v. Karo,* 468 U.S. 705, 715 (1984). Put another way, it "reveal[ed] a critical fact about the interior of the premises that the Government [was] extremely interested in knowing . . ." *Id.* Conversely, when the beeper in *Karo* was tracked to a public warehouse, but could not be tracked to the defendant's particular storage locker, a location in which the defendant had a reasonable expectation of privacy, the Court found that there was no Fourth Amendment violation. *Id.* at 721. Thus, the key is not whether a tracking device is active while it is in a private location but whether it reveals to the government that an individual or object is actually in a private location.

To the extent that the cell phone tracking cases are based on the notion that the Fourth Amendment always requires a warrant to use a tracking device regardless of whether it is located in private or in public, they are wrongly decided. This much is clear from *Knotts* and *Karo.* Moreover, the only federal court of appeals to have considered the issue has found that using a cell phone to track an individual's movements in public does not violate the Fourth Amendment. *United States v. Forest,* 355 F.3d 942 (6th Cir. 2004). *See also United States v. Marquez,* 605 F.3d 604 (8th Cir. 2010) (no warrant required for installation and use of tracking device); *United States v. Pineda-Moreno,* 591 F.3d 1212 (9th Cir. 2010) (same); *United States v. Garcia,* 474 F.3d 994 (7th Cir. 2007) (same).

[37] See, e.g., *United States v. Forest,* 355 F.3d 942, 950 (6th Cir. 2004) ("[I]n contrast to other statutes governing electronic surveillance, § 3117 'does not prohibit the use of a tracking device in the absence of conformity with the section . . .' ") (quoting *United States v. Gbemisola,* 225 F.3d 753, 758 (D.C.Cir.2000)); *In the Matter of the Application of the United States for an Order Authorizing the Installation and Use of a Pen Register and a Caller Identification System on Telephone Numbers [Sealed] and the Production of Real Time Cell Site Information,* 402 F.Supp.2d 597, 603, 604 (D. Md., 2005) (opinion of a magistrate judge) ("Unlike other provisions in the ECPA, 18 U.S.C. § 3117 articulates no standard for obtaining permission to install and monitor a tracking device.")

[38] Notes to 2006 Amendments to Fed.R.Crim.P. 41.

[39] *Id.*

[40] See Section II.A above for a discussion of the legality of road user fee systems under the Fourth Amendment.

[41] See, e.g., Minn Stat §§ 626A.35 (prohibiting the use of tracking devices without a court order); Haw. Rev. Stat §§ 803-42 (same); California Penal Code § 637.7 (generally prohibiting the use of tracking devices except for the "lawful use of an electronic tracking device by a law enforcement agency"). Other states have enacted legislation specifying the standards law enforcement must meet to obtain a court order (e.g., reasonable suspicion) before using a tracking device but these statutes do not impose a general prohibition on the use of tracking devices. *See, e.g.,* Utah Code Ann. § 77-23a-15.5; S.C. Code Ann. § 17-30-140; 18 Pa. Cons. Stat § 5761; Tex. Code Crim Proc. art. 18.21 It is not clear that these statutes even require law enforcement to obtain a court order in all instances since they do not state that a law enforcement officer must obtain a court order but state that an officer may obtain a court order or that the judge may issue a court order in certain circumstances.

road user fee systems would fit within the state definitions of "tracking device." Even if they did, state laws would be preempted to the extent that they conflict with a federally mandated VMT system. These laws could potentially restrict states from using a VMT system to collect state road user fees if the federal legislation does not implicitly or explicitly address the use of tracking devices for state fee collection purposes. However, if states choose to establish a VMT system, they could simply amend these laws.

California has also recently enacted a law prohibiting state transportation agencies, including contractors hired by these agencies, from sharing personally identifiable information collected from electronic toll collection systems.[42] Again, to the extent that this law conflicts with a federally mandated VMT system, it would be preempted. In addition, it would not prohibit California from using a VMT system to collect fees; it merely prohibits California agencies from sharing certain information with others. However, if left unamended, this law could conceivably limit data sharing between a California VMT system and a federal VMT system.

Conclusion

There are numerous design options for a road user fee system. In general, the more a particular design option protects privacy, the less auditability it provides. Fortunately, under existing law, virtually any design option would be consistent with constitutional and statutory privacy protections. Thus, the decision regarding how to strike the balance between privacy and auditability can be based primarily on practical and political considerations.

[42]Cal. SB 1268 (2010). This law also prohibits providing this information to law enforcement absent a warrant unless delay in obtaining the information would cause an adverse result.

APPENDIX E

Public-Private Partnerships and Investment Tax Credits

Public-Private Partnerships

This section describes the different types of public-private partnerships (PPPs) used in transportation infrastructure projects and evaluates the potential opportunities to leverage public funding. When private funding through a PPP can be used for an infrastructure project, it is expected to reduce the requirement for public funding. Thus, the use of PPPs and associated private funding might reduce the need to raise public funds through other mechanisms.

There are several types of PPPs. It appears that the term "public-private partnership" is being applied in a very broad sense to just about any project that has both public and private participation. In reviewing existing projects described as PPPs, five categories of PPPs were selected for analysis.

Concession Agreement PPPs

Concessions are contractual long-term agreements between a public agency and a private-sector entity or concessionaire that allow the concessionaire to participate in the development or operation of a transportation infrastructure project. This study considered two types of concessions, (1) the long-term lease of an existing facility and (2) the development and operation of a new facility. In each case, the concessionaire provides up-front funding or development commitments in exchange for the ability to receive payments over the term of the agreement. These payments can come from highway user tolls, shadow tolls, facility availability payments, or facility sublease payments. Shadow tolls are payments by the public agency that are based on use of the road. Availability payments are payments made by the public agency for availability of the highway facility, and they can be compared to lease payments for availability of the road.

In a simplified view of typical PPP financing, the concessionaire funds the project with a blend of equity and debt financing. The projection of the expected payment stream is used to secure debt financing and estimate return on equity. With a PPP in the form of a long-term lease of an existing facility, the concessionaire provides an up-front concession payment and takes on the obligation to operate and maintain the highway or port facility. In exchange, the concessionaire collects the facility tolls or tenant lease payments to amortize debt and provide return on equity. The concessionaire takes on the risk of the maintenance and operating cost as well as the risk of the revenue stream.

Long-Term Lease PPP Concessions

In the long-term lease of an existing toll road or port facility, the public agency receives an up-front concession payment and possibly a commitment to provide additional development of highway or port infrastructure. The concessionaire also operates and maintains the facility. In return, the concessionaire receives the toll payments for the toll road. With a port concession, the concessionaire receives lease payments from port tenants or stevedoring and operational service fees from port operations.

The primary attraction of the long-term lease toll road concession is that the public entity can receive a large up-front payment. Because of the long-term nature of these concessions, this up-front payment can be quite substantial. The first toll road concessions of this type were for the Chicago Skyway and the Indiana Toll Road (ITR). The Chicago Skyway concession was completed in 2005. It had a 99-year term and produced a concession payment of $1.8 billion for the City of Chicago. The ITR 75-year concession agreement was completed in 2006 and produced a concession payment of $3.8 billion for the State of Indiana.

To what extent did these concession payments reduce the need for alternative sources of funding for transportation infrastructure?

In the $1.8 billion Chicago Skyway concession payment, there was no commitment to utilize any of the funding for

new transportation infrastructure. About $463 million (25.3%) was used to retire existing Skyway debt. This can be viewed as an exchange of public debt for private debt with no increase in transportation funding. About $392 million (21.4%) was used to retire City debt and pay for other City obligations. The remaining $975 million (53.3%) was placed into three City reserve funds: a long-term fund ($500 million), a mid-term fund ($375 million), and a neighborhood human infrastructure fund ($100 million). With the exception of the original deposit in the long-term fund, it appears that all of the concession payment expenditures and earnings are being used to cover City operating expenses. Although use of the concession money to fund city operations may have freed up other City money for transportation infrastructure, there appears to be no clear increase in transportation funding from the Skyway concession payment.

The ITR concession will result in a significant increase in transportation infrastructure funding. The first use of concession funds was the retirement of $750 million of ITR bonds. The remaining $3.1 billion was allocated to fund transportation infrastructure projects through the Indiana Major Moves plan, a 10-year, $12 billion transportation plan established in 2005. It appears that the ITR concession created $1.9 billion more than would have been available with the state-operated toll road. In addition, the concession payment allowed advancement of the Major Moves plan and created other cost savings resulting from the early retirement of the remaining toll road bonds.

In these two case studies, the analysis shows that the concession agreements did produce higher net present value than the tolling agencies own value estimates. However, the focus of this analysis is how much of the concession payment and increased value was actually applied to transportation infrastructure investment. In the case of the ITR, virtually all of the concession payment, net of toll road debt retirement, was applied to highway improvements. However, in the case of the Chicago Skyway, little to none of the payment was directly allocated to highway infrastructure.

There can be significant benefits to privatization of an existing toll road. Clearly, the up-front concession payment provides the driving benefit to a long-term concession agreement, especially for cash-strapped public entities. There can also be operating efficiencies and service improvements that result from private-sector management of these facilities. However, the privatization of an existing toll road has run into political opposition. Five key factors driving this opposition were identified:

- Future toll road increases are controlled by a concessionaire that is not responsible to the public.
- Disagreement with the proposed uses of the concession payment.
- Loss of control of toll road operations to a private toll road operator that is not responsible to the public.
- Fear of the inherent uncertainty of an extremely long-term lease of 50 to 99 years.
- Political opposition from the existing toll road agency that would be displaced by the concessionaire.

Design-Build-Finance-Operate-Maintain PPP Concessions

With a PPP that is set up to develop and operate a new facility, the concessionaire is usually expected to design, build, finance, operate, and maintain (DBFOM) the new facility. Financing of the project can be more complex, using a combination of equity, bank debt, government loans, and public-sponsor payments. The concessionaire takes the risk of on-time, on-budget project delivery in the construction phase of the project. As with the long-term lease, the concessionaire also takes on the risk of maintenance and operating cost. The concessionaire's revenue stream can come from tolls, shadow tolls, or availability payments. Shadow tolls and availability payments would have lower revenue risk as they may be agreed to up front. The concessionaire's payments may also be tied to performance requirements to ensure standards of maintenance and operation.

The primary purpose of the DBFOM concession is to utilize private-sector sponsorship and investment to develop large-scale highway infrastructure. The primary advantage is completion of projects sooner without the need to use public funding sources. In many cases, projects that have been delayed due to a lack of public funding can be advanced with private capital under a PPP.

Most of the highway projects involve tolling in order to provide the necessary return on invested private capital. Reliance on tolls usually places the concessionaire at risk to achieve the projected revenue. In some cases, the concessionaire is paid availability payments or shadow tolls by the public partner, thereby mitigating the concessionaire's revenue risk. In either case, the highway facility is paid for over the life of the concession.

Another potential benefit of a DBFOM PPP is on-time, on-budget project delivery. Private-sector partners take on the risk of meeting the project cost and delivery schedule. The profit motivation is an effective driver for project delivery performance. Most concessions have a long term, exceeding 35 years. Since the private-sector partner is responsible for long-term operations and maintenance, it considers long-term project life-cycle costs in making investment decisions. The concessionaire can thus make the tradeoffs between short-term cost savings and long-term value.

Since DBFOM concessions are project-specific, private funding of project construction costs can represent a well-

defined increase in funding for transportation infrastructure. However, private investment will only be made when the risk and return projections are attractive to the private investor and can be financed with debt. Therefore, DBFOM concessions will only be available for projects where the revenue stream can be reliably projected.

In the case of the Pocahontas Parkway, the actual revenue stream was less than half of that projected, putting the bonds in danger of default. In the case of the Florida I-595 project, the toll revenues were not sufficient to attract the needed investment and the Florida Department of Transportation (FDOT) had to commit to acceptance and availability payments to enable the necessary financing. In the case of Texas SH-130, the revenue projections were investment grade and enabled $1.1 billion in debt and $210 million in private equity funding.

Port Long-Term Lease PPP Concessions

Long-term lease concessions for U.S. port facilities are quite different from toll road lease concessions. Ports do not have the quasi-monopoly competitive market positions that toll roads have and must compete with other ports for ocean carrier business. Port authorities operate as businesses investing in port facilities and generating income from facility leases and port operations. Most ports are owned by public port authorities that are controlled by a local or regional government entity. Ports are often viewed as generators of economic activity that create jobs and economic development for their communities. As such, ports can receive public funding to support their activities and infrastructure investments.

A port authority can function as a landlord, a port operator, or a combination of both. A landlord port authority develops and leases its terminal facilities to ocean carriers or terminal operating companies that operate these leased port facilities. Port authorities can also have operating capability to provide services to their ocean carrier customers with their own employees. A third option is to lease certain facilities and operate others. Port income is generated from facility leases as well as port operating services. It is this lease and operating income that supports investment in port facilities.

Ports are capital intensive. Securing the necessary funding for port modernization and capacity expansion is always an issue for public port authorities. Port financing can come from revenue bonds secured by port income or from public funding. The downturn in the economy in 2008 and 2009 led to reduction in port volume and difficult economic conditions for ports. Declines in port revenue reduced coverage on fixed debt obligations and also limited public funding availability for port development projects. As a result, there has been an increasing interest in developing PPPs to secure private funding for port facilities through long-term lease concessions.

Ports have historically leased their port facilities to ocean carriers and terminal operating companies. These leases typically ran for 10 to 15 years. However, in the case of long-term concessions, the concessionaire is looking for very long terms, exceeding 50 years, to provide the incentive to make large investments in port infrastructure. These long-term concessions are more than just facility leases. They also provide the ability to operate a business on the port facility. These concessions also require the concessionaire to invest in terminal facility upgrades and cover all of the operating and maintenance expenses of the terminal. The concessionaire also takes the business risk associated with the volume and revenue stream and receives the income from its port business. In exchange, the port authority will receive concession payments and possibly commitments to make investments in port facilities. These concessions may be considered as an alternative source of funding for port infrastructure.

Three U.S. port concessions (Oakland, Baltimore, and Portland) were completed in 2009 and 2010 and a number of others are in various stages of development.

In Oakland and Baltimore, the 50-year port concessions were driven by the need to secure private capital for near-term terminal facility development. The 50-year term gives the concessionaire sufficient time to earn an adequate return on any long-term investments that are made in port facilities. A second benefit for the ports was the reduction of long-term business risk related to lease and volume-related revenue streams. In each case, the selected concessionaire was a major marine terminal operator that could operate its business for the long term on the port property.

The situation in Portland was different from that of Baltimore and Oakland. In Portland's case, the primary driver for the concession was development of container volume growth. The concession period was shorter—25 years—and the concession did not develop any significant new capital investment. However, the port appeared to achieve its objective of getting a private operator that was focused on new business development. The Portland concession may be viewed as a model for small ports that wish to get a private operator interested in partnering with their port.

Railroad Grant Agreement PPPs

There are a number of private freight railroad projects that have been funded in part by state and federal grants. These projects have been referred to as PPPs because of the combined application of public and private funding. Grant-based railroad PPP projects are generally major railroad infrastructure improvements that are believed to have significant public-sector benefits. These large projects would

not go forward without some element of public participation due to inadequate rail carrier return.

The funding objective is to prorate the project cost on the basis of the projected benefits. The public-sector contribution is based on the public benefits, and the rail carrier contribution is based on the private benefits. Public benefits from a rail infrastructure project can come from a variety of sources. Several types of public benefits have been identified including the following:

- Economic impact and job creation
- Reduced highway congestion and enhanced mobility
- Environmental benefits from reduced greenhouse gas emissions
- Improved railroad at-grade crossing safety
- Improved passenger rail service on the freight-rail system

The objective of the public-private partnership analysis conducted under NCFRP Project 29 is to determine the extent to which the public grant funding provided to the PPP has been leveraged by the private-sector investment that would not have otherwise been committed to the project. In addition, the analysis will consider the extent to which the projects themselves may reduce the need for publicly provided freight infrastructure.

The following four major railroad infrastructure PPP grant projects were reviewed in detail:

- The Chicago Region Environmental and Transportation Efficiency Program (CREATE), a multicarrier upgrade of rail infrastructure in the Chicago region.
- The Heartland Corridor, a Norfolk Southern (NS) double stack clearance and terminal development project running from Norfolk to Columbus and Chicago.
- The National Gateway, a CSX double stack clearance and terminal development project running from North Carolina through Washington, D.C., to Chicago.
- The Crescent Corridor, a NS capacity expansion project from New Orleans and Memphis to New Jersey.

In the projects reviewed, the rail carriers were able to gain the support of the public entities that stood to benefit from the project. In each case, a large number of component projects were assembled to make the overall project program large enough to be considered politically significant. Principal public benefits included economic impact, job creation, emissions reduction, and improved safety. The apparent strategy for the rail carriers in each case was to secure the financial, as well as political support, of the states and communities involved in the project. Political support to apply for and secure federal grant funding appears to be a key benefit in the formation of a coalition of public stakeholders. In each case, the federal SAFTEA-LU and TIGER grant funding provided a significant portion of the public funding.

The funding theory advocated for these PPPs is that the public sector pays for the public benefits and the private sector pays for the private benefits. From a political perspective, it appears that the PPP projects are very attractive and warrant funding support. From the private-sector perspective, many of the component projects in the overall program would not have gone forward without public funding support. However, it is likely that some of the component projects would have gone forward separately without the formation of the PPP. Overall, the PPPs are enabling funding of significant rail freight transportation infrastructure. However, it remains undetermined just how much private capital was leveraged by the public capital that was committed in the projects reviewed. In some instances, it may have been quite low. Additionally, each PPP is unique, and continued incoming private funding cannot be achieved without new agreements continuing to be reached.

Use of PPPs for Financing Freight Infrastructure

The analysis and case studies described below identify four types of PPPs: concession PPPs for existing infrastructure, DBFOM PPPs for new infrastructure, port lease PPPs for operation and improvement of infrastructure, and grant agreement PPPs for public participation in private infrastructure projects (e.g., railroads).

Concession PPPs

In selling concessions to operate existing infrastructure and collect future revenues, public agencies are essentially monetizing the expected future net revenue stream from existing infrastructure. The public agency gains access to the net present value of the expected net revenue less the return (profit) obtained by the private concessionaire. The direct benefits could include the following:

- Earlier access to the cash, enabling the agency to fund other projects.
- Access to more cash if the private concessionaire is more optimistic about the future revenue stream.
- A lower financing cost if the private concessionaire can place debt at a lower interest rate.

Concession PPPs are therefore a means of extracting the net present value of a future income stream as cash for near-term use. Whether that cash is used for other infrastructure projects depends on case-by-case political outcomes.

DBFOM PPPs

In DBFOM PPPs, the public agency is offering the right to build an infrastructure project and collect the ensuing revenue stream. There are several types of revenue streams—tolls, shadow tolls, availability payments, and acceptance payments.

DBFOM PPPs are essentially a means of purchasing infrastructure on the installment plan. Where the concessionaire collects tolls that would otherwise have been collected by a public toll road authority, users (e.g., drivers) are paying the installments directly. If the installments come in the form of shadow tolls, availability payments, or acceptance payments, the public agency is paying for the infrastructure on behalf of the users.

DBFOM PPPs can be compared with the lease of the APM Portsmouth container terminal by the Virginia Port Authority. The APM terminal was built as a private-sector facility for private-sector use. In this case, the *private*-sector owner (APM Terminals) found itself cash poor and leased the terminal to a *public* agency in return for a future revenue steam (the lease payments). Economically, this process is equivalent to a DBFOM PPP in which a private concessionaire builds a facility in return for annual availability payments.

Port Lease PPPs

Port lease PPPs can be considered a subset of concession PPPs. They tend to differ from ordinary port terminal leases in the length of the agreements, the presence of up-front cash payments, and lessee commitments to infrastructure investments. Ports typically lease terminals for 5 to 10 years, with 20 years being an exception, and tenants are not usually committed to dredging, terminal expansion, or major capital investment. The combination of a longer term lease and an up-front payment gives the lessee a long-term investment and profit opportunity and provides the port authority with cash for other projects.

Grant Agreement PPPs

Grant agreement PPPs, which have so far been mostly rail projects, can be viewed as expanding private projects to include public benefits or facilitating the implementation of projects that generate public benefits (e.g., jobs, economic development, congestion relief, and emission reductions) but would otherwise not pass private funding hurdles. The amount of private funding being leveraged may be relatively small, and the public participation is mainly justified by the secondary benefits rather than by the direct transportation capacity increase. Grant agreements appear, then, to be an effective means of achieving public goals, but are not a promising avenue to significant increases in infrastructure funding. If grant agreement PPPs follow the guideline of public funding for public benefits and private funding for private benefits they become financially neutral instruments for facilitating project development and implementation rather than revenue-generating mechanisms.

Sources of Funds

Investment funds typically consist of a mix of the following: senior private debt (e.g., higher-rated bonds); subordinate private debt (e.g., lower-rated bonds); TIFIA bonds; public agency funds or grants (however sourced); and private equity.

Of the five types of capital, all but the private equity are accessible via revenue bonds or comparable public-sector instruments backed by future tolls or other fees. The concession approach may be faster, easier, less costly, or a way to sidestep bonding capacity limits.

The influx of private equity is usually the focus of interest for PPPs. As the case studies conducted in this project suggest, private equity is usually the smallest funding component. One question for NCFRP Project 29 is how much private equity PPPs attract that could not have been obtained by some other means.

Although in the near-term private equity is a net increase in infrastructure investment, in the long term the concessionaire is expecting a return on that investment. Bond holders invest capital in return for a fixed revenue stream, with the level of investment (the bond price) determined by the terms and the credit rating. Equity investors, in contrast, provide capital in return for an expected but uncertain revenue stream as well as (usually) a measure of control in the enterprise. Public agencies cannot ordinarily tap equity capital.

The balance between various debt and equity instruments is a major strategic issue in most private-sector financing efforts. Debt-heavy financing is typically regarded as riskier for potential investors, and the bond portion is likely to be saddled with higher interest rates or greater discounts. An appropriate proportion of equity signals the strength, faith, and commitment of the organization itself and should result in more favorable debt terms. The inclusion of private equity in PPP financing may thus reduce the overall financing cost.

The buying power of debt and equity capital are the same. In principle, access to both types of capital should result in lower funding costs than relying on debt alone. Given the relatively small role that equity has played in the PPPs examined, it appears likely that debt financing could have been expanded to cover the whole need, but at some small incremental financing cost.

Higher Private Value

Both the concession and DBFOM PPPs may entail higher up-front concession payments than the public agencies expected, indicating that the concessionaires had higher expectations of net revenue in the future. Ironically, the greatest short-term public benefit from differing public/private traffic growth expectations is likely to occur when the concessionaire is overly

optimistic and pays too much. However, under those circumstance (which occurred in the Pocahontas Parkway project), financial failure of the concessionaire may leave the public agency with a serious dilemma. This is one of the underlying risks of PPPs: the reliability of revenue forecasts over the long duration of the project life.

Greater efficiency is anticipated from a private concessionaire than from a public agency. Whether the manifestation is lower operating and maintenance costs, lower administrative overhead, lower wages and head count, or simply a profit incentive, the greater expected efficiency of private-sector operation may be a contributing factor to the higher-than-anticipated concession bids. Whether or not such efficiencies are achieved and sustained is a matter for future research. The issue is clouded by the scarcity of truly comparable public and private operations. There is, however, an alternate means of achieving private-sector efficiencies—outsourcing. Private-sector efficiencies may be realized by putting an operating and maintenance concession up for competitive bid, without giving potential bidders a lease on the facility or a right to the revenue stream. In this respect, PPPs might be regarded as an easier means of achieving the same end, with the difference coming down to the details or the contract and the bid/offer process.

Another possible reason for higher private than public valuations—access to lower interest rates—is a function of current markets. In some cases, such as in the Pocahontas Parkway Association PPP, private concessionaires are able to issue tax-exempt revenue bonds, which should yield similar rates to public-sector, tax-exempt revenue bonds (such as those issued by ports, airports, or transit authorities). There may be a benefit, however, to any ability of private concessionaires to obtain higher credit ratings and thus more favorable bond terms than their public-sector counterparts.

Part of the willingness of private concessionaires to pay high up-front payments may be due to the handling of risk. As the case studies conducted under this project reveal, the degree of risk being assumed by concessionaires varies widely. Some PPPs appear to place almost all the risk on the concessionaire. Realistically, however, financial failure of a carefully structured joint venture, such as the ones created for the Chicago Skyway and the Indiana Toll Road, is unlikely to have repercussions for the parent organizations beyond the loss of their private equity. If the concessionaire for a vital piece of infrastructure is failing, the public agency involved will have no alternative to rescue or replacement, as was demonstrated in the Pocahontas Parkway case. This is another inherent risk: the lock-in effect, wherein long-term contracts written as part of PPPs could tie the hands of government in making future decisions.

Overall Value of PPPs

This discussion suggests that the major value of PPPs is not in providing capital that would otherwise be inaccessible, but in facilitating more rapid capital investment at a comparable or even lower financing cost. The sources of PPP funding can, for the most part, be accessed through revenue bonds or other instruments. The efficiency attributes of private-sector development and operation are, theoretically, accessible through outsourcing and design-build contracts without private financing. PPPs, however, may prove to be a quicker and more flexible means of tapping those funding sources and efficiencies. In that respect, the true function of PPPs may be more institutional than economic. This conclusion also suggests that PPPs are not a substitute for revenue-generation mechanisms, but a complement that can make other mechanisms more effective by giving public agencies more choices over the timing of investments. The most important impact of PPPs may thus be decoupling the timing of capital investments from the timing of revenue—at a cost.

Not all states have legislation in place to encourage or allow PPPs, so there is a near-term limit on their usefulness. Yet the popularity of PPPs and the widespread funding shortfalls of public agencies suggest that enabling legislation is likely to emerge in most states.

The long-term limitation of PPPs is the need for a secure revenue stream from infrastructure projects. So far, PPPs have been limited to toll roads, port terminals, and other facilities for which tolls or user fees are in place or acceptable. It is conceivable that PPPs could be used to build locks, airports, new marine terminals, bridges, and tunnels. In essence, if it is possible to charge a fee for a facility's use, a PPP might be able to build it.

The use of shadow tolls or availability payments sidesteps this limitation and might enable the use of PPPs for non-toll and non-fee facilities. This is a promising option—allowing public agencies to contract for the construction of infrastructure they cannot presently fund and pay for the infrastructure over time. This option also bypasses the limitation of revenue bonds, which must ordinarily be tied to a specific source of revenue. A DBFOM PPP using shadow tolls or availability payments is the rough equivalent of financing transportation infrastructure with general obligation bonds, where debt service does not come from a specific source. That strategy was used in California for the so-called Infrastructure Bonds (Proposition 1B), but was stymied in part by poor bond markets. The shadow toll or availability payments strategy, in contrast, does not require the public agency to either issue bonds or identify a specific source for the revenue. It is conceivable, however, that a public agency could over commit its future revenue from taxes or other sources and find itself unable to meet commitments to shadow tolls or availability payments.

PPPs and VMT Fees

The concept of shadow tolls raises the possibility of coupling VMT or road pricing fees with DBFOM PPPs to finance infrastructure and then service the debt. VMT fees are, effectively,

non-specific tolls that could be used to fund all or part of shadow toll payments for non-toll facilities. Shadow tolls are payments to the concessionaire based on vehicle counts. A concessionaire could be assigned all or a portion of the VMT fees generated by the facility, or there could be some mix of VMT fees and other funds. Such a strategy would offer a middle ground between revenue bonds tied to tolls and shadow tolls or availability payments without a specific revenue source. If the VMT concept is extended to enable road pricing, every road could become a toll road and therefore a candidate for PPP funding.

It is also conceivable that the technical infrastructure for highway user fees, area tolls, or other financing mechanisms could be developed through PPPs, as has been done with some highway and bridge toll systems. In that respect, PPPs could become part of an implementation strategy for VMT fees, congestion fees, or other financing initiatives.

Investment Tax Credits

Investment tax credits (ITCs) have been proposed as economic incentives for increased private investment in transportation infrastructure for railroads and potentially for other modes. The key issues are understanding the extent to which ITCs actually leverage additional private capital beyond that which would have been invested anyway and determining the potential role for ITCs in a long-term revenue-generation strategy for freight transportation infrastructure.

A tax credit is generally calculated as a percentage of the private investment that meets eligibility requirements of the applicable tax law. The *net* increase in infrastructure funding would be additional private-sector capital investment *induced* by the availability of ITCs over the amount that would have been invested without ITCs. The *direct* funding for ITCs would come from the federal General Fund, because the use of ITCs will result in a *corresponding reduction in federal corporate income taxes.* Where transportation firms do not have enough income in a given year to use all the ITCs that are available, ITC rules may allow them to carry the credit forward or back to another taxable year or transfer the credit to an entity that can use it.

The amount of investment that may occur in response to ITCs is difficult if not impossible to predict. ITCs are necessarily imprecise in both the kind and amount of investments induced. ITCs typically specify a category of eligible investments, not a case-by-case review. The accuracy of such categorization is limited. A somewhat narrow categorization will diminish the response, as was reportedly the case with the original short line railroad ITC. A broad or loose categorization may elicit investments in marginal projects. The literature on ITCs located and reviewed in this project is generally focused on the efficacy of the measures in achieving increased investment or completed projects, rather than on the dollar amount of investment induced.

Overall, ITCs are probably best viewed as policy tools rather than as revenue-generating mechanisms. ITCs have been used with success to encourage private investment in alignment with clear policy directions. The effectiveness of ITCs as part of a freight infrastructure strategy will depend on how well the policy goals can be articulated and how well they can be expressed as infrastructure investment objectives.

ITC Background

An investment tax credit has been, on and off, a part of the Internal Revenue Code (the "Code") for almost 50 years. Congress and a number of administrations have believed the credit to be an effective way to direct investment. In 1962, the Kennedy Administration and Congress determined that the economy would benefit from increased investment in industrial capacity, and Congress enacted a credit for investment in tangible personal property and other tangible property, not including buildings or structural components thereof.[1]

ITCs have not been permanent. For example, while the Revenue Act of 1962 did not contain a sunset date for the ITC, the credit was suspended in 1966, reinstated in 1967, repealed in 1969, reenacted in 1971, modified substantially in 1975, expanded in 1978, adjusted significantly in 1981, readjusted in 1982, and repealed generally in 1986. The changes were generally in response to perceived differences in economic activities and budgetary constraints (Rosacker and Metcalf, 1992). Other tax credits have also shown this on-again/off-again behavior, which some observers have noted as limiting the impact of ITCs.

Since 1986, a large number of different credits have been enacted for particular types of investments. Some of these have been ostensibly permanent; others have had sunset dates.[2] The rules applicable to these credits vary widely in terms of the following:

- Qualifying investment or production; the taxes against which they may be credited.[3]
- The percentage limits of the taxes that may be credited.
- The percentage of qualifying basis for which a credit is allowed.
- Whether the basis must be reduced by a portion of the credit.

[1]The Revenue Act of 1962, P.L. 834, adding, *inter alia,* sections 38, 46 and 48 to the Code.

[2]Changes in Congressional budgeting rules over the years have made permanent credits difficult to enact, even when Congress intends to reenact the credit. The best example may be the credit for increasing research activities, section 41 of the Code, which has been extended no fewer than 10 times.

[3]Regular tax only, regular tax and alternative minimum tax, essentially refundable in 1981 and 1982 under the period of safe harbor leasing provisions of section 168(f)(8).

- The degree of government review.[4]
- Whether the credits are essentially unlimited (as was true of the traditional tax credit).
- Whether they are subject to a statutory maximum for all taxpayers (e.g., the Section 48A and 48B credits) or per taxpayer (as in the case of the Section 45G credit for certain railroad maintenance).
- Whether the taxpayer has an option to claim credits computed in multiple fashions (e.g., a choice between the production tax credit of Section 45 or the energy credit of Section 48).

The history of the investment tax credit points out the flexible manner in which this statutory tool has been used. There is precedent in the current Code, or in provisions that are no longer effective, for almost any form of incentive for investment or production that Congress deems worthy of additional investment.[5] The key nexus appears to be between the structure of an ITC and the national freight transportation infrastructure policy that it should support.

ITCS and National Freight Transportation Policy

An investment tax credit is primarily a *policy instrument* rather than a revenue-generation mechanism. The use of ITCs to promote infrastructure investment is conceptually linked to elements of freight transportation policy. Unlike most other proposed tools to increase freight transportation infrastructure spending, ITCs would require an initial implicit or explicit policy decision on what kind of investments would qualify and should be encouraged. Other revenue mechanisms (such as fees and taxes) generate revenue first, and have a separate process for choosing and funding infrastructure projects. ITCs would require legislators or the IRS to create rules for firms to follow, but would not ordinarily give public agencies any voice in the actual choice of projects. There are, however, grant programs that allow project review and then deliver the grant in the form of a tax credit. There are also grants "in lieu of tax credits" such as Section 1603 of the American Recovery and Reinvestment Tax Act of 2009, which applies to investments in renewable energy sources.

ITCs have been used to influence the direction of private investment (e.g., more for capital goods, less for real estate), or to encourage specific social goals (more coal gasification plants, more preservation of historic buildings). Their success has been judged on progress toward those goals rather than on the net new investment induced. ITCs implemented to date have been temporary, in line with their use to promote specific goals. In essence, Congress has decided from time to time that the nation needs more investment of some kind (e.g., research and development, short line railroad maintenance, and so forth) and has used an ITC to encourage private investment in that field. When the ITC expires, there is an implicit or explicit choice made between renewing the ITC (because there is not yet enough of the desired outcome) or not renewing the ITC (because there is now enough of the desired outcome or private investment can now be expected to provide enough without further incentives).

The effectiveness of an ITC depends critically on the precision with which relevant policy can be articulated. Policy direction can be relatively clear in fields such as coal gasification and preservation of historic buildings. At present, national policy regarding freight transportation infrastructure is far less clear. Alignment of a freight transportation infrastructure ITC with uncertain public policy is inherently difficult.

Creating an effective ITC for rail infrastructure, for example, would require answering some basic questions:

- What national freight transportation objectives would be served by railroad capital investment?
- What type and amount of rail infrastructure is required to achieve those national freight transportation objectives?
- How much of that infrastructure are the railroads likely to build and maintain on their own initiative with existing capital resources?
- What is the gap between "normal" railroad investment and the policy-dictated investment level?
- How can an ITC be structured to induce railroads to fill the gap?

Railroad capital investment might serve one or more of the following conceptual policy objectives:

- Maintain railroad network capacity for efficient movement of current and expected rail freight.
- Expand the capacity of railroads to accommodate new types of rail freight or an increased market share.

[4]Simply claimed on a tax return and subject to normal audit procedures, as was the case of the "traditional" investment credit, or requiring an application to be reviewed and particular projects selected by the Department of Energy and the Internal Revenue Service as in the case of the advanced coal project and coal gasification credits of sections 48A and 48B.

[5]In addition to tax credits, similar types of benefits, i.e., reductions in the cost of capital, have been provided to railroads through the depreciation rules. As the Third Circuit explained in Armstrong World Industries, Inc., v. Comm'r, 974 F2d 422 (3rd Cir., 1992), before the enactment of Economic Recovery Tax Act of 1981, Pub. L. 97-34, section 167(r) permitted common carriers to compute depreciation on railroad track and related items using the Retirement-Replacement-Betterment method. Under this method, the cost of new rail lines and the cost of improvements to existing lines were generally capitalized over a period of many years (e.g., 36 or 50 years), but the cost of replacing original rail lines ("replacement property") could be deducted in the year the expense was incurred.

- Improve the future efficiency of railroads to move freight, thereby promoting environmental goals.
- Increase railroad capacity and efficiency as a complement to port development strategies.
- Enable railroads to attract freight from other modes, thereby reducing congestion and investment needs for highways and waterways.

These different objectives would imply different ITC formulations. An emphasis on overall capacity and efficiency might lead to a broad definition of eligible projects while an emphasis on alleviating highway congestion might better be served by a narrower focus on intermodal terminal facilities.

In this respect, ITCs have much in common with PPPs. PPPs tend to be more project-specific, but would nonetheless be more effective in promoting long-term strategic goals if the strategy were clear.

ITCs and Capital Investment Decisions

The investment choices made by private firms are influenced by far more factors with far more variability than have apparently been addressed in econometric studies to date. The response of the private sector in general to an ITC will depend on, among other factors:

- The overall investment climate, access to capital, and current interest rates.
- Competing capital investment needs and opportunities.
- The tax situation facing the potential investor.
- The flexibility of the ITC in terms of credit transfers, rollovers, and so forth.
- The expected life and availability of the ITC.
- The relative attractiveness of eligible investments with and without the ITC.

Based on the experience of study team members who have participated in freight carrier capital investment planning, the process tends to be sequential. Carriers (e.g., railroads) begin with the capital requirements of sustaining existing business: maintenance, renewal, repair, or replacement of existing physical plant and rolling stock. Such needs are usually but not inevitably funded before expansion projects are considered. Capital investments for capacity expansion are typically prioritized on financial grounds (e.g., internal rate of return [IRR]). Within that process, an ITC would improve the IRR for eligible projects by reducing the carrier's out-of-pocket cost. The carrier could respond in any one of several ways:

- By funding more capacity expansion projects that would not have otherwise been justified.
- By funding the same expansion projects and using the net ITC benefits to increase spending on non-eligible projects.
- By funding the same capital program at a lower cost and retaining the ITC benefit in the form of retained earnings, wages, dividends, or perhaps reduced prices.

Projects that do not meet IRR standards or rank near the top of the IRR scale, even with the ITC contribution, are unlikely to be funded. This may well be the case with projects that serve social goals but do not generate internal returns, such as increased passenger service or short haul intermodal service to divert trucks from highways.

By lowering the cost of capital investment relative to other uses for funds, ITCs could introduce market distortions. It is possible that an ITC might encourage overinvestment in capital. The result could be operations that are too capital intensive, or "gold plating" of infrastructure. This distortion is likely to be smaller when private companies are making long-run decisions that capture full life-cycle costs of the infrastructure, including operating and maintenance costs, and comparing those costs with the long-term revenue stream.

Section 45G Railroad Maintenance Tax Credit

Section 45G of the Internal Revenue Code of 1986, as amended, originally adopted as part of the American Jobs Creation Act of 2004, provided a tax credit for track maintenance expenditures of Class II and Class III short line railroads. The tax credit was 50% of qualified expenditures, capped at $3500 per mile for the railroad's total rail miles. This tax credit will expire at the end of 2011, and the short line rail industry continues to work to ensure the continuity of the Section 45G incentives. It is instructive to note that the stated purpose of the tax credit was to promote short line railroads as an alternative to highways.

The railroad maintenance tax credit for short line and regional rail carriers was in place for expenditures from 2005 through 2009. The 50% tax credit was available for eligible capital and maintenance expenditures on railroad track and structures and was capped at $3500 per mile for a carrier's total rail miles, which include yard track as well as main line track. As an example, if a railroad had 300 miles of track, its tax credit would have been capped at $1.05 million. With the 50% tax credit, it would take about $2.1 million of spending to utilize the maximum tax credit on those 300 miles of track.

It does not appear possible to establish a direct year-to-year comparison of capital expenditures before and after the inception of the section 45G tax credit or to determine how much investment was induced. There are no comprehensive data on capital investment in the short line rail industry. An immediate increase in capital investment, carefully and

appropriately defined, would indeed provide evidence of the provision's efficacy. Lacking access to actual taxpayer data, the study team had to rely on survey data voluntarily submitted to the American Short Line and Regional Railroad Association (ASLRRA), which has been helpful. At the same time, in addition to the data limitations noted, the association has only the data submitted by voluntary participants, well under half of the industry for any one survey.

Since the IRS does not release data, it is not possible to know the actual amount of the tax credit that is received. According to a source at ASLRRA, the Joint Committee on Taxation of the U.S. Congress estimated the maximum qualifying tax expenditure for the railroad maintenance tax credit to be $165 million per year. That is, taxpaying short line entities could have claimed that much credit in total in a given year if they used the tax credit to the maximum extent possible. The means by which this estimate was derived are not documented.

Table E-1 provides an estimate of eligible section 45G short line maintenance expenditures from ASLRRA. The figures are somewhat higher than the $330 million that would be implied by the Joint Committee estimate of a maximum of $165 million in tax credits. Private spending usually exceeds the stated 1:1 ratio of private spending to tax credit since not all spending will qualify and not all qualified spending will actually be used to obtain credits.

The ASLRRA source interviewed provided an estimate of $140 million for the tax credit amount actually claimed. That estimate, as well as estimates of the actual capital expenditures, were derived from surveys of ASLRRA members. While ASLRRA represents a large part of the industry, not all short lines are members, so the estimates had to be extrapolated from the survey results. The estimated $140 million in tax credits used implies a corresponding private investment of at least $280 million up front, half of which would be refunded. The data in Table E-1 imply that, for example, short line railroads spent $365.9 million on maintenance in 2008 and received (according to the ASLRRA estimate) $140 in tax credits. The net private expenditure was thus $225.9 million, with the other $140 million coming from the public sector.

Given the history of deferred maintenance typically inherited by cash-poor short line operators, there seems to be little doubt that the section 45G program has achieved its intended purpose of encouraging and accelerating short line maintenance.

Table E-1. Estimated short line maintenance expenditures.

Year	45G Eligible Expenditure (millions)
2006	$349.40
2007	$362.30
2008	$365.90

Source: Adam Nordstrom, Washington Representative, ASLRRA, Chambers, Conlon and Hartwell, LLC, email dated August 20, 2009.

Legislative Proposals

Several bills have been introduced in Congress to provide ITCs for railroad infrastructure investment.

Section 45G Extension

The first set of bills, H.R. 1132 and companion bill S. 461, would extend section 45G through 2012 and increase the cap from $3500 to $4500 per mile. As of September 2010, the legislation had not advanced beyond its initial referral to committee. Targeted tax legislation on this topic and others was subsumed into the giant, end-of-the-year tax package passed by the House and Senate in mid-December 2010, retroactively extending numerous expired provisions and reinstating them through 2011.

The Freight Rail Infrastructure and Expansion Act of 2010

H.R. 1806 was introduced on March 29, 2009. Its companion bill, S. 3749, was introduced on August 15, 2010. Although neither bill advanced beyond committee in the 111th Congress, Rep. Leonard Boswell of Iowa reintroduced the legislation as H.R. 2091 in the current Congress. The key provision of these bills is the 25% tax credit for capacity expansion of qualified freight-rail infrastructure and locomotives. The legislation is designed to ensure that the tax credit applies only to new infrastructure that increases freight-handling capacity. Locomotive additions must provide a net addition of total locomotive fleet horsepower over the previous year to be eligible. This tax credit is also intended to apply to shippers and any other entity that invests in rail capacity expansion. For port authorities or public agencies that do not have a tax liability to receive the benefit of the tax credit, credit transfer provisions would need to be added to the legislation.

If H.R. 2091 were passed as currently worded, investment in new rail infrastructure and locomotives would receive a 25% tax credit. The Association of American Railroads (AAR) estimates this tax incentive would cost the U.S. Treasury about $300 million per year[6]. The AAR estimate was based on con-

[6]Statement of Charles W. Moorman, Norfolk Southern, on behalf of the Association of American Railroads before the House Committee on Ways and Means Subcommittee on Select Revenue Measures July 23, 2009.

tinuation of Class I railroad capacity expansion investments, which run between $1 billion and $1.5 billion per year. For Class I railroads to claim $300 million in tax credits, they would have to invest $1.2 billion in spending on new infrastructure capacity.

This tax credit would apply to any entity that invests in the qualifying rail infrastructure. The Class I rail carriers will be the most likely prospects to take advantage of the tax credit. If tax credit transfer provisions are included in the legislation, the benefit may also be applied to customers with rail-served facilities, port authorities, and other entities that can expand freight-rail capacity.

In terms of leveraging private capital, the legislation would require a minimum of $3.00 of private funding for each $1.00 of federal tax credit. It is difficult to assess the ability of a future tax credit to leverage more than the minimum 75% private funding requirement. The 25% tax credit may serve to reduce after-tax cost to the point where a given project exceeds its return requirement. The improvement in project returns should increase the number of eligible projects by lowering the cost threshold, thereby encouraging a higher level of investment.

The FREIGHT Act

In July 2010, Senators Lautenberg, Murray, and Cantwell introduced S. 3629, the Focusing Resources, Economic Investment, and Guidance to Help Transportation Act of 2010 (the FREIGHT Act). This bill seeks to establish a comprehensive, multimodal, national freight transportation policy. Companion legislation has been introduced in the House. To the extent that the FREIGHT Act succeeds in establishing a coherent national freight transportation and infrastructure policy, such a policy statement would also facilitate the establishment of corresponding ITCs.

Temporary versus Permanent ITCs

If ITCs are to be part of a long-term infrastructure financing strategy, they may need to be made permanent. Numerous federal tax incentives live a precarious life as temporary measures with a given expiration date. In the worst case, an incentive can be allowed to lapse, only to be renewed prospectively at a later date.

Perhaps the most notable such provision is the overall corporate research and development tax credit, which has expired for the 14th time. The stop-start syndrome has hampered attempts to prove the net value of any of the provisions so affected. With the research and development tax credit, for example, attempts have been made to model, econometrically, the net additions to corporate research and development and ultimately to national output, *if only* the provision were made permanent. Under the circumstances, however, demonstrating specific examples of multiyear projects not otherwise undertaken has remained daunting.

The need for an enduring, if not permanent, ITC is even more apparent if the goal is to encourage freight infrastructure investment. While private firms are often faster at planning and completing projects than public agencies, a deliberate network expansion strategy would likely span multiple fiscal and calendar years. Critical facilities such as intermodal terminals at ports (e.g., BNSF's Southern California International Gateway project) or serving metropolitan areas can require years of planning, permitting, and environmental review that a prudent private-sector firm would not be likely to undertake for a tax credit of limited or uncertain duration. The same observation would apply to truck terminals or investment in waterway facilities and domestic vessels.

Contribution of ITCs to Infrastructure Funding

The potential of ITCs for infrastructure funding depends in large part on alignment with a national freight transportation policy that is not yet fully articulated. Unlike other kinds of financing mechanisms, ITCs require that the nation make a decision on what kind of infrastructure and how much of that infrastructure it wants to encourage before the revenue is available. In essence, the ITC rules would specify what kinds of investments would be eligible and then turn the choice of actual investments over to the private sector. The benefits of the ITC will depend in large part on the rules and how the affected industry responds.

ITCs can contribute to net infrastructure funding when they induce greater net private investment in beneficial infrastructure than would otherwise have taken place. If ITCs merely reduce the cost of investments that the recipients would have made anyway, they become a subsidy with no *net* revenue devoted to transportation infrastructure.

If ITCs *accelerate* the stream of capital investment so that railroads or others expand beneficial capacity sooner, the benefits depend on how soon the capacity is used. While there is a economic benefit to reserve capacity (related to the concept of option demand), the benefits become more concrete and the expenditure becomes easier to justify when the new facilities fill with traffic.

Another possibility is that ITCs might induce railroads (or other carriers) to cooperate with public-sector initiatives to use some of the added capacity for passenger service or other public purposes by lowering the threshold for capacity investment decisions. Public agencies might thus share in both capacity funding and capacity use. Response of the industry to such proposals in the past has been mixed. In California, Caltrans has a history of successful cooperation with BNSF on

publicly funded capacity increases to handle Amtrak or other regional passenger trains. In sharp contrast, Union Pacific (UP) withdrew its application for $47 million in "Infrastructure Bond" proceeds to increase clearances over Donner Pass because the state government made accepting more passenger trains a condition of the grant. (UP completed the project with its own funds instead.)

From a national policy perspective, it might seem ideal if railroads would use ITCs to add capacity for truck-competitive services that could relieve the pressure on highways (e.g., intermodal capacity). In this respect, rail ITCs could reduce the need for highway investment by prolonging the life of existing road capacity. (This concept supports the use of public funds for the Heartland Corridor and I-95 Corridor rail capacity.) The same argument might be made for rail services that offer a competitive alternative to inland waterways, if such alternatives would reduce the long-term need to invest in those waterways.

If railroads invest instead in capacity for rail-dominant freight flows (such as coal from captive shippers), the public benefit would depend on how much of the long-term cost savings (if any) were passed onto the customers or the ultimate consumers.

Investment Eligibility

The history of the short line ITC and the current legislative proposals raises the question of what railroad investments should be eligible for ITCs. Adding or rebuilding capacity is unquestionably an infrastructure investment. Railroad track and right-of-way maintenance (also known as maintenance of way), however, could be regarded as an ordinary operating expense conceptually similar to maintenance performed on highways or maintenance dredging at ports.

Tax credits reduce the level of private investment required for a given project. This reduction in the private cost increases the effective rate of return on the private investment and makes an individual project more attractive. In the capital budgeting process, carriers will select the best projects from the portfolio of available investments.

There is an open question regarding the use of ITCs for locomotives, rolling stock, or other non-track rail capital needs. Rail network capacity depends on track capacity as well as on related factors such as signaling and communications. Making such expenditures eligible for ITCs would be consistent with an emphasis on physical network infrastructure. Locomotives, however, are more akin to trucks or vessels and are not, in most people's minds, part of "infrastructure." Moreover, the railroads enjoy many more choices when it comes to acquiring locomotives and cars, including financial and operating leases for both new and used equipment and pooling options, so there is less concern over an investment shortfall. Railroad rolling stock is also highly interchangeable and very durable, so there is a strong resale market that reduces investment risk.

Net Fiscal Impact

Solid evidence on the net benefits of ITCs is sparse. There have been a number of different ITCs offered at the federal and state levels. The economic literature includes many studies of their impacts, but most such studies are focused more on the specific goals of the ITC (e.g., preservation of historic buildings) than on the net investments made. Hungerford and Gravelle (2010) observe that "[d]espite attempts to analyze the effect of the investment tax credit, considerable uncertainty remains. Time series studies of aggregate investment using factors such as the tax credit (or other elements that affect the tax burden on capital or the 'price' of capital) as explanatory variables tended to find little or no relationship" (p. 8).

ITCs appear to be generally efficacious in inducing the kinds of investments desired. For example, Massachusetts has provided businesses with an ITC for tangible property investments since 1970. Ernst & Young (2004) found that

> The ITC is a very effective tax incentive. Massachusetts gains $7.00 of additional net personal income for each dollar of net costs to the state. This is a significant long-run return in terms of new jobs and higher incomes as a result of the state's investment. In the aggregate, the ITC added $314 million to the state's personal income. (Executive Summary)

There are also doubts, however, regarding the long-term economic efficacy of ITCs. Goolsbee (1997) argued that much of the benefit of an ITC for capital goods is actually captured by capital suppliers in the form of higher prices (and higher wage payments to capital workers), finding that a 10% ITC increases equipment prices 3.5 to 7.0%. Chirinko and Wilson (2008), in an examination of state ITCs, found that the result may be a "zero-sum game," with increases in investments that qualified for ITCs in one state offset by reductions in non-qualified investments in other states.

To the extent that the investments themselves can reduce costs and increase income, increased future cash flows will enhance a carrier's ability to make future infrastructure investments. In other words, the returns on the tax credit spending can be used for future investment. This observation suggests the possibility of a multiplier effect coming from the public investment in private facilities. However, there is no requirement that the private returns from the public investment be plowed back into additional infrastructure investment. Supporters of the Manufacturing Extension Program have noted such an effect from that federal program, in which funds of about $100 million are matched by state funds and then supplemented by fees

charged to small and medium-sized companies receiving technical assistance (Selko, August 31, 2007).

Potential Application of ITCs to Non-Rail Modes

ITCs are most often discussed in application to railroads because railroad infrastructure itself is privately funded. As noted below, the application of ITCs to other modes appears to have very limited potential.

Highway

The possibility of application of an ITC for motor carrier infrastructure was also considered by the study team. An ATA representative confirmed that there was at present little or no private road infrastructure financed by motor carriers.[7] Although the addition of motor carrier tractors can be considered an increase in transport capacity, the tractors are considered rolling stock and not infrastructure. The only infrastructure assets that might be considered infrastructure would be buildings, primarily truck terminals. It was noted that the trucking industry currently has an adequate supply of truck terminals, so an ITC for construction of truck terminals would not be a meaningful use of federal incentives.

Some motor carriers and equipment manufacturers have expressed interest in ITCs for costs associated with federal- or state-mandated safety, emissions, or fuel conservation rules. While ITCs could encourage faster replacement or expansion of legacy fleets with newer, cleaner, safer equipment, those would not be infrastructure investments.

Based on this assessment, there does not appear to be any real opportunity to use an ITC to leverage trucking industry investment in infrastructure. A multimodal ITC strategy might include trucking, but it is doubtful that such a program would add significant infrastructure or funding.

Ports and Waterways

As a general rule, the only privately owned or funded infrastructure at ports or on the inland or coastal waterways is in proprietary terminals. Many, if not most, marine terminals handling bulk materials (crude oil, minerals, and so forth) are privately built, owned, and operated. The owner and operator is typically the shipper or the receiver, so such terminals are not usually accessible other users or for other uses. It is conceivable, however, that investment in additional bulk terminal capacity could enable the user to divert business from highways or railroads, thus increasing total available infrastructure capacity in the same way that ITCs for railroads might.

Most marine container terminals are built and owned by port authorities, which are public agencies. A very few such terminals (notably the APM Portsmouth terminal) have been built as private initiatives.

A crucial question for a national freight transportation policy is whether the domestic inland and coastal marine transportation industry is being held back by lack of investment in vessels (tugs, towboats, barges, and seagoing ships). Much of this industry is subject to the Jones Act (dealing generally with coast-wise trading), notably the need to use U.S.-built vessels. Industry spokesmen have pointed to the high relative cost of U.S.-built vessels as an industry handicap in expanding and competing with other modes. If this factor is limiting the industry's ability to handle cargo and freight for which it would otherwise be suitable and efficient, then there may be a logical application of an ITC for U.S.-built vessels.

The Maritime Administration (MARAD), however, already has the Capital Construction Fund (CCF) program, created to assist owners and operators of U.S. flag vessels in accumulating capital for the modernization and expansion of the U.S. merchant marine. The program encourages construction, reconstruction, or acquisition of vessels through the deferment of federal income taxes on monetary deposits of money or other property placed into a CCF. MARAD also administers the Construction Reserve Fund (CRF), which provides tax deferral benefits to U.S. flag operators. The primary purpose is to "promote the construction, reconstruction, reconditioning, or acquisition of merchant vessels which are necessary for national defense and to the development of U.S. commerce." Eligible parties can defer gains from the sale or loss of a vessel, provided the proceeds are used to expand or modernize the U.S. merchant fleet. Finally, MARAD oversees the Title XI Federal Ship Financing Program, which provides U.S. Government credit guarantees for debt issued by (1) U.S. or foreign ship owners to finance U.S. flag vessels or eligible export vessels constructed, reconstructed, or reconditioned in U.S. shipyards and (2) U.S. shipyards to finance advanced shipbuilding technology.

Air Cargo

Air cargo infrastructure can be divided into those facilities that are built as parts of municipal airports and those facilities that are built by major air cargo carriers such as UPS, FedEx, or DHL. The privately built facilities tend to be sorting or maintenance centers off the airport property and would not ordinarily be considered part of the transportation infrastructure system. The use of ITCs to encourage development of air cargo infrastructure would thus be extremely limited.

[7]Robert Pitcher, American Trucking Associations, telephone interview September 2, 2010.

Key Findings

ITCs appear to be a potentially valuable part of a comprehensive freight transportation financing package, but can do only part of the job by themselves. Their usefulness is particularly limited until the nation decides what kind and how much freight infrastructure to build. It seems clear that the usefulness and effectiveness of ITCs for infrastructure funding will depend heavily on what projects are eligible, what the tax credit rate is, and how permanent the ITC becomes.

ITCs can provide an incentive for private-sector investment in transportation infrastructure. The tax credit is generally applied as a percentage of the value of the qualified expenditure. There is very limited evidence on the amount of new private investment that is induced by ITCs. In the case of the section 45G tax credit for short line maintenance, it was not possible to determine whether the private-sector investment was any greater than it would have been without the tax credit.

There are some fundamental differences between ITCs and grant programs. ITCs have an advantage in expediency and low administrative cost. Once passed into law, a tax credit is presumably politically neutral, as all eligible railroads have equal access to the program. In the section 45G program, the rail carrier need only select eligible projects, fund 100%, then utilize the tax credit for a 50% reimbursement. The tax credit is thus equal to the net, post-refund private expenditure. The tax credit does, however, require the railroad to fund the full expenditure up front, which may require some recipients to borrow the funds and pay interest, offsetting some of the benefits. The tax credit also lacks project-by-project control over how the money is spent. A grant program could instead provide the funds up front, but would ordinarily entail far more up-front work and time to apply for the grant and justify the specific project. The ARRA section 1603 grants, for example, are not payable until a qualifying project is placed in service.

An ITC can be effective in encouraging additional private investment of a particular type or in a general development direction. As such, an ITC can supplement the public sector's own infrastructure investment efforts. It does not appear possible, however, to predict the amount of private investment that will occur. Given an overall infrastructure investment goal of some amount, we can say that an ITC will help achieve that goal but we cannot say by how much.

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Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation