



TRANSPORTATION RESEARCH SYNTHESIS

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Potential Benefits to the Freight Industry of Distance-Based Road User Fees

Introduction

As vehicles become more fuel efficient, fuel taxes are producing less revenue for road construction, operations and maintenance. As a consequence, states are exploring replacing these taxes with other user-based revenue sources, such as mileage-based road user charges, also referred to as vehicle-miles-traveled fees. These approaches may also have the benefit of reducing highway congestion if pricing is varied by level of congestion. The commercial freight industry agrees that distance-based pricing, especially as it relates to congestion pricing, has system management and revenue benefits for transportation agencies but is skeptical about benefits to the industry and believes such fees will be more costly than current fuel taxes.

Mn/DOT is launching a research study to investigate potential benefits of distance-based road user fees to the Minnesota and regional freight industry. The study will assess the validity of industry concerns and provide data for initiating a dialogue with the freight industry about implementing VMT fees. Potential industry benefits to be explored relate to improved truck travel time reliability, travel time savings and better predictability of costs when compared to fluctuating fuel prices and uncertain future fuel taxes and other vehicle-related fees. Other questions to be addressed relate to the effects on trucking of variable pricing during congested periods, readiness of carriers to accept Global Positioning System-based pricing, and the relative benefits of VMT rate structures that factor in truck weight, time of day and possibly emissions as well as distance. In the end, the research will investigate ways that distance-based pricing may be superior for the trucking industry to the current system of fuel and other taxes.



In support of this research project, CTC & Associates conducted a comprehensive literature search on the issues listed above, both in the transportation industry literature and in other fields such as economics. This Transportation Research Synthesis focuses on systems aimed primarily at trucks or at both trucks and autos, with an eye to literature that describes not only the VMT pricing system itself, but also the outcomes of the system, such as cost reductions (travel time savings), improved travel time reliability and greater productivity. We have also identified relevant government and industry data sources as well as published reports and online information resources. The purpose of the TRS is to serve as a synthesis of pertinent completed research to be used for further study and evaluation by Mn/DOT. The TRS does not represent the conclusions of either CTC & Associates or Mn/DOT.

Summary

We identified research related to the following key topic areas:

- Politics and acceptability
- Assessing economic efficiency and trucking industry effects
- Privacy
- Technology and implementation
- National resources—NCHRP and TRB
- State case studies
- International case studies

Politics and Acceptability

Despite recommendations in favor of VMT pricing by the Urban Land Institute, the National Surface Transportation Infrastructure Financing Commission and current research, the trucking industry opposes a VMT fee on heavy trucks because it claims:

- It is a weight-distance tax that is cumbersome, expensive, unfair and open to evasion.
- It requires expensive and privacy-invading technologies, such as GPS systems.
- It does not return revenues to infrastructure investment, so that the cost of using the transportation system increases while the system itself deteriorates.
- It pushes vehicles into less capitalized jurisdictions.
- The fuel tax is collectable, enforceable and efficient.
- The fuel tax is socially equitable and easily adapted to alternative fuels.
- Arguments suggesting that fuel taxes can't produce enough revenue don't take into account that a recession is responsible for the current slowed growth in fuel consumption.

Increasing acceptability requires addressing these issues. One study, *The Truth, the Myths and the Possible in Freight Road Pricing in Congested Areas*, challenges a number of typical industry arguments against freight road pricing.

Assessing Economic Efficiency and Trucking Industry Effects

Some studies suggest that with VMT implementation, the trucking industry will benefit overall from improved travel time reliability and greater productivity, especially for longer trip distances. One study (see *Assessing the Influence of Distance-Based Charges on Freight Transporters*) suggests that a freight distributor should be willing to pay on average \$87 to save one hour of travel time. Other studies suggest that:

- A 2.9 cents per mile fee applied to all commercial vehicle mileage and a 0.95 cents per mile fee applied to all personal vehicle mileage will generate the same amount of revenue in 2010 as the state gasoline and diesel taxes are expected to generate.
- Carriers respond to time of day pricing on tunnels between New York and New Jersey by implementing multidimensional responses involving productivity increases, cost transfers and change in facility usage.
- The nature of these responses is determined by the balance of power between carriers and receivers.
- Carriers consider changes in facility usage to be a very disruptive alternative that forces them—and more importantly their customers—to alter their shipping and delivery patterns.
- Although carriers stand to benefit from working during off-peak hours, they could only do so if their customers are willing to work during off-peak hours.
- So far within Europe, Switzerland, Germany and Austria have implemented road pricing for commercial vehicles based on distance traveled. In all three countries, the truck tolls have increased road freight rates significantly.
- A survey of New York and New Jersey freight carriers reported that 20 percent changed their behavior in response to road pricing, with 43 percent of trips changed to increase productivity and efficiency. Carriers were able to transfer costs of road pricing to customers in only 9 percent of these trips. More than 75 percent of travelers said they had no flexibility in routes and scheduling, regardless of pricing.

Many studies in the section on **Technology and Implementation** and **International Case Studies** also address the effects of road pricing on the trucking industry and show that:

- Generally speaking, the application of weight-distance truck tolls has resulted in higher road use charges for trucks.
- If the entire road network is not priced, traffic diversion is likely.

- The recent implementation of Germany’s heavy truck charging system indicates the capability of the motor carrier industry to absorb considerably higher system costs than anticipated for passenger vehicles by passing on costs to customers.
- Distance-based user fees can alter travel demand, even absent congestion pricing. For example, the heavy goods vehicle fees in Switzerland were set deliberately to discourage truck traffic and induce a freight mode shift to rail. In the three years since the inauguration of the toll, the number of truck trips traveling through Switzerland, which had been growing at an annual rate of 7 percent, decreased by about 4 percent in 2001, by another 3 percent in 2002, and has remained stable since. However, the anticipated growth in rail freight traffic has not materialized. Instead, the principal effects appear to have been because of changes in truck configuration and delivery logistics. Specifically, larger trucks are chaining more pick-ups and deliveries together. These unintended effects are likely because of inherent logistical advantages of trucks for many shipment types and delays in rail freight improvements, such as a proposed streamlining of transnational shipping logistics.
- A Netherlands case study shows that the overall economic effect of road pricing is likely to be positive as long as the tax revenues are recycled into the economy.

Privacy

This section includes several papers on protecting privacy when implementing distance-based technologies. In general, privacy can be safeguarded via:

- On-board aggregation of all travel information and determination of the total bill owed on the on-board unit itself. With this strategy, the government never sees any of the details of the travel history for any individual, just the total amount of the bill.
- Third-party privacy agreements in which the on-board unit communicates detailed travel information to a third-party billing agent, which in turn aggregates the data and submits only the total bill to the government. As with phone companies, the third party is legally obligated to keep these data private except in the case of a court subpoena.

(See Review and Synthesis of Road-Use Metering and Charging Systems under **Technology and Implementation**.)

However, privacy is less of an issue for the trucking industry than it is for private vehicles, because the trucking industry, as a commercial enterprise, is already subject to a much stricter regulatory regime than other motorists. Government agencies monitor heavy commercial trucks for size and weight enforcement purposes. Motor carriers, therefore, surrender a certain amount of anonymity to lawfully operate on the road system. As a result, many more system options are potential candidates for application to the motor carrier industry. (See Discerning the Pathway to Implementation of a National Mileage-Based Charging System and Implementable Strategies for Shifting to Direct Usage-Based Charges for Transportation Funding: Final Report under **Technology and Implementation**; and Heavy Vehicle Tolling in Germany: Performance, Outcomes and Lessons Learned for Future Pricing Efforts in Minnesota and the U.S. under **International Case Studies**.)

What privacy concerns there are in the trucking industry have centered on preventing public disclosure of proprietary information regarding the identity of customers, prices charged to various customers, and the location and timing of particular shipments.

Technology and Implementation

This section contains papers detailing paths to implementation of distance-based charging, including ways to address concerns expressed by the trucking industry.

Results show that for the trucking industry, VMT systems could be implemented relatively quickly. According to studies cited in this section, forestalling trucking industry resistance requires the following:

- VMT systems should be structured so that they benefit the trucking industry, for example, by allowing larger truck loads in certain corridors and dedicating the resulting revenue to highway investments that benefit truckers. Successful programs typically dedicate revenues to transportation projects.
- GPS is the preferred technology for VMT implementation for heavy weight vehicles, and studies generally indicate these systems can be more than 99 percent accurate.
- A number of successful implementations of distance-based charging for heavy weight vehicles in Europe can serve as a model for the United States. (See also **International Case Studies**.)

- Advanced technologies are available for ensuring that charges are not evaded.
- Some within the trucking industry may see distance-based charges as a way to accurately collect truck travel data to satisfy requirements of the International Fuel Tax Agreement and International Registration Plan.
- The commercial trucking industry should demand assurance of data bank security and safeguards against data interception to the degree required for passenger vehicles. (See also recommendations in **Privacy**.)
- Implementation requires establishing an independent policy oversight body that includes representation from trucking industries.
- Avoiding diversion onto other roads requires that the entire network be priced.

(See especially Implementable Strategies for Shifting to Direct Usage-Based Charges for Transportation Funding: Final Report; Discerning the Pathway to Implementation of a National Mileage-Based Charging System; and Review and Synthesis of Road-Use Metering and Charging Systems.)

National Resources—NCHRP and TRB

This section contains NCHRP and TRB resources on distance pricing and other fuel tax alternatives, including:

- The TRB Congestion Pricing Committee Web site, which includes links to papers on various road pricing strategies.
- NCHRP syntheses on forecasting freight travel, taxing heavy vehicles and road pricing for congestion management.
- A TRB report suggesting that road pricing is important to targeting investment to road infrastructure in ways that cannot be accomplished by the fuel tax.

State Case Studies

This section contains accounts of VMT pricing pilot projects in the United States, although these are not generally specifically related to heavy vehicles.

- Oregon has conducted the most comprehensive pilot program to date, implementing a mileage-based road charge in Portland for 12 months. Heavy trucks did not pay this fee because Oregon's weight-distance tax for heavy trucks would be retained. Nevertheless, the Oregon Mileage Fee Concept could easily accommodate inclusion of heavy trucks if a legislature so desired.
- A New York study concludes that gaining approval of pricing will require changing how motorists view the effect of pricing on them personally.
- An Alabama paper addresses privacy issues, and a Minnesota study addresses changes in mileage by road users.

International Case Studies

This section contains accounts of VMT pricing pilot projects internationally, with many projects focused specifically on tolling of heavy vehicles, which may serve as successful models for distance-based pricing of trucks in the United States. Many papers cited in other sections of this TRS refer to these projects, especially Germany's heavy vehicle tolling. Highlights include the following:

- Researchers estimate that distance-based road user charges would reduce traffic by 14 percent in Mexico City.
- The German heavy vehicle tolling approach has largely succeeded. Critical to success was a clear articulation of a rationale to affected stakeholders and a realistic implementation schedule.
- A Netherlands case study shows that the overall economic effect of road pricing is likely to be positive as long as the tax revenues are recycled into the economy.

Politics and Acceptability

Conference Summary, *Proceedings: 2010 Symposium on Mileage-Based User Fees*, The Hubert H. Humphrey Institute of Public Affairs, University of Minnesota Center for Transportation Studies, April 20-21, 2010.

<http://utcm.tamu.edu/mbuf/>

http://utcm.tamu.edu/mbuf/2010/proceedings/documents/mbuf10_proceedings.pdf

This event brought together transportation professionals interested in advancing mileage-based user fees as an option for future transportation financing. Highlights of the proceedings relevant to the concerns of the trucking industry follow:

- Dick Mudge noted that trucks already have the technology necessary for VMT implementation, and that privacy is not as significant an issue for the trucking industry as for passenger vehicles insofar as owners have a right to know where trucks are located (page 11). Delclan's New York VMT study (see **State Case Studies**) shows that a system can be developed with a low collection cost.
- Bob Pitcher, president of the American Trucking Associations and representative of trucking industry interests, noted (page 20) that
 - Motor carriers are likely to oppose VMT fees on heavy trucks and that a VMT on cars would have to be designed so that it is difficult to evade.
 - The trucking industry has always supported a user fee system and a fair vehicle registration system that is based on weight, but not a weight-distance tax. A VMT on trucks will be rightly viewed as a weight-distance tax and opposed by trucking. More than 20 states have repealed weight-distance taxes with only four states still having them in existence today. Weight-distance taxes are cumbersome, expensive, unfair and open to evasion. The same problems undermining gasoline taxes are not present in the trucking industry as there is no satisfactory alternative to diesel fuel for heavy trucks, so there is less need to look at VMT for the trucking industry.
 - Taxes are easier to collect if collected from a small number of payers and there is something to withhold for nonpayment. The fuel tax is collectable, enforceable and efficient.
 - There are issues with VMT fees that could cause evasion problems. First, there will be several hundred million taxpayers. In addition, odometers are often off by about 4 percent and GPS can be unreliable if the conditions aren't right. Furthermore, odometer tampering does occur. Who would enforce the VMT? The Internal Revenue Services' history with excise taxes is not as good as its history with the income tax. It would be best to keep it all simple. We should keep the fuel tax as it is one of the best tax collection systems ever devised.
 - The industry is not for a highway system that is financed solely by fuel taxes. Coupling with weight-based registration fees gets us close to the point on collecting for actual costs.

See the second entry in the **Implementation and Technology** section on page 16 of this report for implementation-related conclusions from these proceedings.

"The Creative Financing Sidestep," S. Williams, D. Murray, *TR News*, Issue 267, 2010: 27-30.

Abstract: <http://tris.trb.org/view.aspx?id=919732>

This article argues that creative financing alternatives to the fuel tax are problematic and are only being considered because of a tax-averse populace and politicians. These political factors are pushing transportation agencies toward less desirable and flexible fundraising strategies as a way to sidestep public participation in the debate on fuel taxes, despite the fact that many local and national organizations—including the American Trucking Associations—support increases in fuel taxes. A few specific instruments have gained popularity, principally because of the lack of political will to support a rational U.S. transportation strategy predicated on increases in traditional funding sources, namely, taxes.

In general alternatives to the fuel tax are problematic because so-called creative financing tools raise transportation costs without a requisite increase in infrastructure investment. The net effect is that the system will continue to decline while the cost of using the system continues to increase. Several of the creative alternatives are particularly problematic:

- **Congestion pricing**, designed to raise revenue from captive users, move users to transit modes or different roads, or to shift users' daily schedules. For freight carriers, the first goal is inflationary; the second not applicable; the third creates major safety and infrastructure issues for neighborhoods and roadways not designed for heavier traffic levels; the fourth requires a complete shift in the nation's 9-to-5 economy. Meanwhile, the same total of net trips continues at some point on the system, and the infrastructure still declines.

- **Tolling**, which continues to be one of the most inefficient revenue tools available, generally spending at least 20 percent and sometimes as much as 50 percent of collected revenues on administrative costs. By contrast, 97 percent to 99 percent of fuel tax revenue returns to transportation. Further, tolls shift vehicles and costs to less capitalized jurisdictions.
- **Privatization**, which suffers from the same issues as tolls on a larger scale. Further, federal guidance for public-private partnerships lacks discrete strategies for maintaining infrastructure or safety.
- **Mileage fees**, which require GPS systems to differentiate traffic lanes, distinguish public roads from private driveways, communicate wirelessly with the gas pump and transfer electronic revenue payments from the driver's checking account to a variety of government agencies. These would cost billions of dollars to install nationwide before any revenue would go to infrastructure investment.

The authors claim that the best option is to raise the fuel tax and that its role in generating future transportation revenue has been downplayed. They make the following arguments in favor of the fuel tax:

- The fuel tax is socially equitable: Those who choose to drive large or inefficient vehicles pay more, whereas in tolling systems they do not.
- Fuel taxes can easily be adapted to alternative fuels, improvements in vehicle efficiency and changes in truck sizes and weights.

Arguments against the fuel tax use data that reflect a federal fuel tax that has not increased since 1993 and do not consider that a recession is responsible for the slowing growth in fuel consumption. These situations are not likely to be permanent.

“VMT Fee Should Replace Gas Tax, ULI Report Suggests,” *AASHTO Journal*, April 16, 2010.

<http://www.aashtojournal.org/Pages/041610uli.aspx>

Congress should consider initiating a vehicle miles traveled fee to replace the gasoline tax currently funding federal highway and transit programs, according to an infrastructure report issued by the Urban Land Institute and Ernst & Young. The report also calls for boosting transportation investment through other sources.

Infrastructure 2010: An Investment Imperative, Urban Land Institute, Ernst & Young, 2010: 87-88

<http://www.uli.org/sitecore/~-/media/Documents/ResearchAndPublications/Reports/Infrastructure/IR2010.ashx>

This report discusses the VMT on pages 87-88, advocating that it replace the gas tax and use GPS and transponder technologies similar to EasyPass to compute mileage and account for congestion, high occupancy/toll lane use and bridge tunnel fares. Trucks would be charged more based on higher emissions and greater road wear and tear. These fees would significantly reduce or eliminate reliance on income, sales and property taxes for roads and mass transit, and road users would pay fewer taxes by adopting lifestyles involving less driving. With regard to privacy, the report notes that people's movements already can be monitored via cell phones and highway cameras.

“U.S. Trucking Industry Will Not Support VMT Tax, Says ATA Vice President,” *Traffic Technology Today*, April 21, 2010.

<http://www.traffictotechnologytoday.com/news.php?NewsID=21166#loaded>

From the article: Speaking on the Political Leadership and Project Champions panel at the Symposium on Mileage-Based User Fees in Minneapolis, the American Trucking Associations' (ATA) vice president Bob Pitcher has said the trucking industry will oppose a VMT tax, suggesting they have proven costly to administer, enforce and to comply with. He added that the industry regards a VMT tax as a weight-distance tax (WDT). More than 20 states have already repealed WDTs as outdated and ineffective. All but four states currently rely on a combination of truck registration fees and fuel taxes as the most efficient, cost-effective way to raise money to build and repair roads.

“U.S. Commission Likes Idea of Mileage-Based Fees,” *Today's Trucking*, February 27, 2009.

<http://www.todaystrucking.com/news.cfm?intDocID=21286>

From the article: Calling the current federal motor fuels tax “unsustainable” over the long term, the National Surface Transportation Infrastructure Financing Commission recommended that the U.S. shift to a mileage-based usage fee by 2020. In its final report, *Paying Our Way: A New Framework for Transportation Finance*, the commission states that charging vehicle drivers a mileage fee embodies the “user pays” principle and more accurately aligns the costs and benefits of the surface transportation system to those who are using it.

Paying Our Way: A New Framework for Transportation Finance, Executive Summary, National Surface Transportation Infrastructure Financing Commission, February 2009.

http://www.vmtfeenv.com/images/NSTIF_Commission_Final_Report_Exec_Summary_Feb09.pdf

The commission claims that the transportation system is currently underpriced to yield the revenues needed to sustain its infrastructure. *From the executive summary:*

- Without changes to current policy, it is estimated that revenues raised by all levels of government for capital investment will total only about one-third of the roughly \$200 billion necessary each year to maintain and improve the nation's highways and transit systems.
- All too often the prices paid by transportation system users are markedly less than the costs of providing the transportation services they use (including pavement repair)—much less the total social costs (including traffic congestion and pollution). This underpayment contributes to less efficient use of the system, increased pavement damage, capacity shortages and congestion.

After evaluating a wide range of options to address the nation's surface transportation infrastructure, the commission endorses a transition to a funding approach based more directly on the use of the transportation system, including distance-based road user fees. *From the executive summary:*

- The current federal surface transportation funding structure that relies primarily on taxes imposed on petroleum-derived vehicle fuels is not sustainable in the long term and is likely to erode more quickly than previously thought. This is due in large measure to heightened concerns regarding global climate change and dependence on foreign energy sources, which are creating a drive for greater fuel efficiency, alternative fuels and new vehicle technology.
- The current indirect user fee system based on taxes paid for fuel consumed provides users with only weak price signals to use the transportation system in the most efficient ways. ... Fuel taxes and other direct and indirect user fees currently account for less than 60 percent of total system revenue (federal, state and local), so that users do not bear anywhere near the full costs of their travel; and fuel taxes have no direct link to specific parts of the system being used or to times of the day and thus cannot be used to affect these kinds of traveler choices.
- A federal funding system based on more direct forms of "user pay" charges, in the form of a charge for each mile driven (commonly referred to as a vehicle miles traveled or VMT fee system), has emerged as the consensus choice for the future. ... The Commission believes that such a system can and should be designed in ways that protect users' privacy and civil liberties, that incorporate any necessary cross-subsidies (for instance, to benefit the national network or to meet social equity objectives), that do not interfere with interstate commerce and that support goals for carbon reduction. Moreover, greater use of pricing mechanisms, including both targeted tolling and broad-based VMT pricing systems, may spur more efficient use of our highway network and, by shifting demand to less congested periods of the day or to other modes, may in turn enable more efficient investment, thus reducing the additional capacity that needs to be built.

The commission recommends deploying a more direct road user charge system by 2020.

"For Whom the Road Tolls: The Politics of Congestion Pricing," David King, Michael Manville, Donald Shoup, *Access*, Vol. 31, 2007: 2-7.

<http://www.uctc.net/access/31/Access%2031%20-%202002%20-%20For%20Whom%20the%20Road%20Tolls.pdf>

This article addresses the political difficulties involved in implementing congestion pricing and suggests making it politically acceptable by distributing revenues to cities with tolled freeways so that they become the champions of congestion pricing.

Mileage-Based User Fee Public Opinion Study, Robert Fichtner, Nicole Riggleman, Minnesota Department of Transportation, August 2007-December 2009.

<http://www.dot.state.mn.us/funding/mileage-based-user-fee/>

Phase I, August 2007.

<http://www.dot.state.mn.us/funding/mileage-based-user-fee/opinionstudyreport.pdf>

A panel of select key experts concluded that mileage-based fees will not be feasible for at least 10 years and recommend that a mileage-based user fee should be used to supplement rather than replace the current motor fuel tax. Researchers also conducted 10 focus groups with Minnesota road users. After discussing the current and projected funding shortfalls from the motor fuel tax and hearing a brief description of a usage tax based on mileage, participants were generally comfortable with the idea of paying their "fair share" based on how much

they use the roads. But participants were also concerned about privacy. Truckers (page 42), or those who drove high miles for work, were also seen as being hit hardest by this concept, particularly as truckers typically travel via freeway, which would be charged at a higher rate. Participants indicated that this would actually impact all consumers as the increased fee charged to truckers would be passed along to consumers in terms of higher costs for products.

Phase II, October 2008.

<http://www.dot.state.mn.us/funding/mileage-based-user-fee/MBUFPhase2FinalRpt.pdf>

The primary objective of the Phase II qualitative research was to understand the perceptions and level of acceptance among the Minnesota public regarding the implementation of a mileage-based user fee. Highlights relevant to the trucking industry follow (page 29):

Participants were provided with information about how the public is impacted by the cost of congestion in terms of the costs to transport goods via truck and how those costs increase when trucks are stuck in congestion. The following information seemed to resonate with participants, despite the fact that they asked no questions about it:

- Congestion on I-70 in Denver is costing \$839 million per year.
- In Portland, Ore., an example company hauls 25,000 tons of scrap metal across the I-5 Bridge. They make approximately 45 truckloads a day and it costs just over \$2 per minute to make the trip. When there's a traffic jam, it takes 45 minutes to get across the bridge, costing them \$140 per hour.
- In Kentucky, commuters are experiencing a commute that is on average 30 minutes longer, and traffic has doubled since 1990.
- Chicago estimates congestion costs its economy \$7.3 billion a year.

Phase III, December 2009.

<http://www.dot.state.mn.us/funding/mileage-based-user-fee/09mbufphase3finalrpt.pdf>

From the executive summary: Specific quantitative objectives of this third phase were to better understand:

- End-user reactions to informational pieces and determine whether the materials aid respondents in adequately understanding transportation issues and funding scenarios.
- Reaction to written concepts of the mileage-based user fee funding initiative, which will charge a user fee according to the number of miles driven per year, keeping attuned to potential unintended consequences.
- Quantify the barriers to a mileage-based user fee and identify potential solutions that would aid the public in acceptance of the models as presented, or perhaps enhance or remove features in the concepts.

Methodology: Respondents were screened and qualified by phone. Once qualified, they were mailed materials to review for a period of 4-5 days before being called back and interviewed. Sampling was done by RDD and an augment of hybrid drivers was added to adequately represent this unique group. Mail out packets included a cover letter, concept page detailing two potential MBUF approaches (rotated to avoid order bias), background information (half brief, half more detailed) and a 2009 MN road map as a thank-you gift. A total of 821 interviews were conducted between June 10 and August 13, 2009, for a response rate of 63 percent.

Summary of Key Findings:

- Few Minnesota drivers are concerned about current levels of funding for transportation. While acknowledging there may be funding challenges in the future, they are skeptical about the seriousness of the issue today. This skepticism may be caused by a perception that current funding levels are adequate, but mismanaged.
- Despite increasing media coverage, the concept of a mileage-based user fee remains relatively new. Once it is explained, even briefly, the public understands the idea, but remains cautious.
- Not surprisingly, the public needs different levels of information. The degree to which people understood the materials they were provided was proportional to the amount of time spent reviewing them. Also, those who reviewed more thoroughly often wanted more information.
- Initial reactions to the MBUF approaches tested were less than favorable. The higher technology approach drew stronger negative reactions, due to a concern of a loss of privacy; however, younger drivers were less adverse to the use of technology to determine the number of miles driven.

- Of the two approaches, the less technical option, relying on regular odometer checks, was preferred and considered the more “fair” and acceptable method. However, this appears to be driven less by an affinity for the less technical option and more by an aversion to the more technical option.
- Concerns of fairness were common, specifically that a MBUF would penalize those who drive more often, whether due to work or where they live, and burden lower income households. Other concerns include the added expense to implement the system, uncertainty of how out-of-state drivers would be accounted for and the accuracy of the GPS device, should it be used.
- Respondents acknowledge any funding solution will include a mix of options as opposed to a single, ultimate solution. While no one funding solution is preferred, MBUF is on par with other more familiar options such as raising fuel taxes and adding toll roads.
- A final mileage-based user fee model has yet to be developed, but this research overall suggests clear communication is one of the keys to public acceptance, not only to explain the need for a new solution, but how a MBUF will meet those needs, how drivers will be impacted and how their privacy will be protected.

In the 2010 Symposium on Mileage-Based User Fees (see the first entries in this section and **Technology and Implementation**), Ken Buckeye discussed this study (page 23), noting that winning public acceptance is one of the keys to moving forward with a VMT. Phone-mail-phone interviews were conducted with 821 Minnesota drivers and showed that few Minnesota drivers were concerned about current levels of funding for transportation. Seventy-two percent said funding will be a problem in the future. 41 percent of respondents had heard of the concept of a mileage-based user fee. Drivers believed that future funding solutions will contain a mix of options including a mileage-based user fee. However, GPS is a potential deal breaker. Higher technology approaches drew stronger negative reactions than low technology approaches. Public officials must articulate clear goals, show how the system will address these goals and make a compelling case for how mileage-based user fees will affect quality of life. A risk assessment showed that the top five risks were:

1. Increasing fees when necessary
2. Perception of privacy invasion
3. Legacy systems interface
4. Cost to implement
5. Debate on revenue distribution

The Truth, the Myths and the Possible in Freight Road Pricing in Congested Areas, José Holguín-Veras, Association for European Transport, 2006.

<http://www.etcproceedings.org/paper/the-truth-the-myths-and-the-possible-in-freight-road-pricing-in-congested-urba>

From the abstract: The paper analyzes the evidence regarding freight road pricing, complements it with game theoretic analyses, and concludes that moving trucks to the off-peak hours require comprehensive policies targeting key components of the supply chain.

The paper analyzes the evidence regarding freight road pricing, complements it with game theoretic analyses, and concludes that moving trucks to the off-peak hours require comprehensive policies targeting key components of the supply chain (i.e., receivers and carriers). The paper shows that a request from receivers asking carriers to do off-peak deliveries is likely to have an impact across the entire carrier industry; while road pricing only impacts specific industry segments. This suggests that the most efficient way to move truck traffic to the off-peak hours is to provide financial incentives to receivers in conjunction with freight road pricing. Should a sufficient number of receivers be willing to accept off-peak deliveries, the carriers will follow suit. The paper considers a toll surcharge to finance off-peak delivery initiatives. The paper highlights and rebukes a number of myths related to freight road pricing in urban areas.

Increasing the Acceptability of Road Charges for HGV Transit Traffic, Louise Stewart-Ladewig, PIARC Seminar on Road Pricing with Emphasis on Financing, Regulation, and Equity, 2005.

<http://www.etcproceedings.org/paper/download/275>

This paper summarizes the results of a key informant survey carried out among national transport organizations in the countries bordering Germany and Switzerland. The aim of the survey was to provide information about how the acceptability of distance-related charges paid while in transit through a foreign country is rated and to identify possible ways to increase overall acceptability. Key findings include:

- Distance-related road charges were considered preferable to increasing other forms of transport-related taxes and charges. Survey results show a preference for all vehicles, regardless of vehicle weight, to be included in road-charging schemes.
- Road charges were not seen to motivate an increase in the efficiency of transport companies; in fact, transport companies wish to pass additional costs caused by road charges directly to the customer. It was thought that as a method to reduce transport charges, more environmentally friendly vehicles were being purchased but no trend toward low weight vehicles was identified by those taking part in the survey.

“Freight Industry Attitudes Towards Policies to Reduce Congestion,” Thomas F. Golob, Amelia C. Regan, *Transportation Research—Part E: Logistics and Transport Review*, Vol. 36, April 1999: 55-77.
<http://www.uctc.net/papers/571.pdf>

This paper presents an analysis of the perceptions held by for-hire and private trucking company logistics and operations managers about the impacts of congestion on their operations and the feasibility and effectiveness of actual and potential congestion mitigation policies. Responses to an extensive survey of nearly 1,200 California-based or large national carriers are examined using confirmatory factor analysis. The method applied facilitates both the grouping of congestion relief policies into classes and the identification of characteristics of companies which lead them to favor one set of policies over others.

This paper identified six classes of congestion mitigation policies:

1. New dedicated truck facilities
2. Improved operational efficiency
3. Improved traffic management
4. Enhanced truck urban arterial priority
5. Increased road capacity
6. Congestion tolls and matched support for these to trucking company characteristics

The most cost-effective classes are three and four. Moreover, industry spokespersons who are in favor of either of these two classes of policies tend not to favor the policy of dedicating a single freeway lane to truck traffic, a policy that would be controversial, have potentially severe consequences for other road users and lead to increased taxation of trucking operations. The addition of another class, improved operational efficiency, would effectively guarantee a set of policies that appeal in some way to all industry segments. The other advantage of these three sets of policies is that they each encompass a set of policies that can be implemented in small pieces and targeted to severely congested regions. Possible policies that fall under freight industry perceptions of improved traffic management include first and foremost, improved traffic signal optimization. The most positive attitudes toward this class of traffic management policies are held by less-than-truckload operators and small operators in general. The most negative attitudes toward this class of policies are held by contract carriers and truckload operators.

Assessing Economic Efficiency and Trucking Industry Effects

Analysis of Operational Costs of Trucking, Todd G. Trego, Dan Murray, *Transportation Research Board 89th Annual Meeting Compendium of Papers DVD*, Paper #10-2307, 2010.

Abstract: <http://pubsindex.trb.org/view.aspx?id=910437>

This study focused on identifying current, accurate motor carrier costs that derive from transportation system operations. If the time/distance value of operating a truck is overstated, the benefits to the industry of these strategies (for example, congestion pricing) are likely overstated, too. Alternatively, programs that underestimate truck costs may also underestimate the benefits of increased program funding. There is a lack of accurate and publicly available information on the operational costs of trucking, defined as the full marginal cost of operating a truck one mile or one hour in standard operating conditions. Accurate cost figures are needed as inputs to transportation planning models to ensure that benefits to users are not overinflated or that critical investment needs are not downplayed.

Researchers distributed a survey to a cross section of for-hire motor carriers, representing the predominant industry sectors, and analyzed responses. When necessary, costs per mile were converted to costs per hour using an industry accepted average operating speed. Total marginal costs for the industry were \$1.73 per mile and \$83.68 per hour. Marginal costs were divided into vehicle- and driver-based. Top costs for carriers were diesel fuel/oil, driver wages and truck/trailer lease or purchase payments. The Specialized sector had the highest total marginal CPM, followed by the Less-than-Truckload and Truckload sectors.

A Model for Projecting Revenues from a State Vehicle Miles Traveled Fee, Richard Tremain Baker, Ginger D. Goodin, Mary Meyland, *Transportation Research Board 89th Annual Meeting Compendium of Papers DVD*, Paper #10-2606, 2010.

Abstract: <http://pubsindex.trb.org/view.aspx?id=910629>

From the abstract: Texas Transportation Institute (TTI) researchers have developed a model for estimating the revenue generating potential of a fee based on Vehicle Miles Traveled (VMT). This model was developed in response to ongoing regarding the long term sufficiency of the fuel tax as the primary mechanism for funding transportation system development. The model developed by TTI researchers was constructed on several basic assumptions: (1) The relationship between population growth and VMT growth will continue in the long term; (2) average vehicular fuel efficiency will continue to increase; (3) current legislative apportionment of fuel tax revenues to non-transportation activities will continue. The revenue model shows that a 2.9 cents per mile fee if applied to all commercial vehicle mileage and a 0.95 cents per mile fee applied to all personal vehicle mileage will generate the same amount of revenue in 2010 as the state gasoline and diesel taxes are expected to. The model also reveals that Texas state gasoline tax revenues are expected to peak in 2021 and then decline steadily, while revenues from a potential VMT-based fee will keep pace with population growth. The model allows for the input of several variables relating to fee structure and phase in strategy so as to allow for an analysis of [revenues] under numerous potential implementation and administration policies.

Quantitative Analysis of Impacts of Moving Toward a Vehicle Mileage-Based User Fee, Bhargava Sana, Karthik Charan Konduri, Ram M. Pendyala, *Transportation Research Board 89th Annual Meeting Compendium of Papers DVD*, Paper #10-2744, 2010.

Abstract: <http://pubsindex.trb.org/view.aspx?id=910711>

From the abstract: There is growing interest in the adoption of a mileage-based user fee that would involve charging road users a few cents per mile that may vary along several dimensions including vehicle body type (weight), fuel type, time of day of travel and location of travel. This concept is becoming increasingly possible due to technological innovations that allow vehicle monitoring and tracking devices along several dimensions of interest. There are several demonstration experiments that have shown the practical feasibility and benefits of implementing such pricing schemes. This paper offers a broad large scale examination of the revenue generation and social equity implications of a national level mileage-based user fee that may substitute for all or part of the current gas tax. Data from the 2001 National Household Travel Survey combined with documented elasticity values that can be used to calculate changes in vehicle fleet composition and miles of travel by time of day in response to price signals provide the basis for calculating the impacts of a mileage-based user fee system. It is found that modest mileage-based fees of just 0.5 cents per mile to 1.3 cents per mile can offer revenue streams that replace current gas tax revenue streams. In addition, the mileage-based user fee system appears to have minimal, if any, differential impacts across income classes, thus eliminating any potential equity concerns that may arise from the implementation of such a user fee system. It appears that the impediments to a mileage-based user fee system are likely to be technological and personal privacy issues, as opposed to transportation or social equity issues.

Institutional Perspectives on Road Pricing: Essays on Implementation, Response, and Adaptation, Anjali Mahendra, Massachusetts Institute of Technology, September 2008.

<http://dspace.mit.edu/bitstream/handle/1721.1/45155/3/17408656.pdf?sequence=1>

There is evidence that certain sectors, like transportation, may benefit from a road pricing policy. However, this may not be only due to increased efficiency from travel time savings, but also due to the dependence of other firms on the transportation sector. In contrast, a survey of the impacts of such pricing policies on freight carriers in the New York area concluded that trucking firms do not have the market clout to pass on increased costs due to pricing policies to the shippers or receivers of goods. This suggests that firms in the transportation sector may be worse off than other sectors when congestion pricing is implemented. The wholesale and retail sector and the construction sector may face negative impacts of higher charges because of lack of flexibility in the time during which they must transport goods. Travel times in these sectors are either dictated by customers or determined by regulatory constraints.

Highlights include:

- **Empirical studies also offer some guidance on the effects of road pricing** (page 60). So far within Europe, Switzerland, Germany and Austria have implemented road pricing for goods vehicles based on the distance traveled. In all three countries, the truck tolls have increased road freight rates significantly. However, these schemes differ from the proposed road pricing policy in the Netherlands in important ways: (1) they do not include all vehicles as the Dutch policy does; (2) the charges do not vary by time of day and location; and (3) the revenues are not used to reduce taxes for vehicle operators. From a recent comprehensive survey of freight carriers in the New York and New Jersey metropolitan area, there was a

variety of behavioral responses to the road tolls introduced at six bridges and tunnels in the area in 2001. Two hundred for-hire and private carriers were surveyed, representing 1,271 truck trips in the region. From this sample, about 20 percent of carriers changed their behavior in response to the road pricing initiative. In 43 percent of trips, these carriers implemented changes that increased their productivity and efficiency, while they were able to transfer the costs of road pricing to customers in only 9 percent of the trips. Of the 80 percent of carriers that did not change behavior, more than three-quarters mentioned that they had no choice in the matter, and they either had to use the quickest route or to adhere to schedules provided by customers.

- **Freight travel demand appears to be comparatively less sensitive to transportation costs than passenger travel demand.** Arguably, if this is the case, freight transport should benefit from the reduced congestion and gains in travel time that can be realized by a larger proportion of passengers choosing other travel options. But it appears that these gains are not being realized by all businesses in the case of London. Certain types of businesses are more likely to face negative impacts, and in sectors such as transportation, where businesses may face positive impacts, the gains are not transferred to customer firms in the form of reduced prices. Therefore, the vocal opposition of businesses will remain an obstacle unless certain policy actions are considered. These could include, for example, incentives for the receivers of goods to accept deliveries in hours outside the congestion charging window, applying the congestion charge in all locations but varying it by time of day, and ensuring that any changes in the value of the charge are based transparently and dynamically on the level of congestion, pollution and other externalities. In the absence of such measures, the institutional factors that affect the operations of most firms will make it difficult for them to realize the gains from road pricing.

Techniques for Assessing the Socio-Economic Effects of Vehicle Mileage Fees, B. Starr McMullen, Kyle Nakahara, Smita Biswas, Lei Zhang Divya Valluri, Oregon Department of Transportation OTREC 07-03, 2008. www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/2008/ODOT-VMT_Fee_Impacts.pdf

The purpose of this study was to develop tools for assessing the distributional effects of alternative highway user fees for light vehicles in Oregon. The analysis focused on a change from the current gasoline tax to a VMT fee structure for collecting highway user fees. This study did not include commercial trucks (page 16) because Oregon heavy trucks (weighing more than 26,000 pounds) already pay a weight-mile tax and thus would not face any change in user fees as a result of the policy change being analyzed. This tax provides a reasonably good approximation of the marginal damage that they do to the roads (page 3), which is exponentially and directly related to their weight. Thus, trucks operating in Oregon already pay a distance-based fee and one that carries higher tax rates for truck configurations that impose greater costs on the road system. Light vehicles (up to 26,000 pounds) in Oregon still pay road user fees through fuel taxes. Results include the following:

- Researchers confirmed the regressive nature of the gasoline tax and showed that a change to a revenue neutral VMT fee of 1.2 cents per mile would result in a very small increase in regressivity (less than 1 percent for the lowest income group) in contrast to the 5 percent increase in regressivity caused by the increase in the price of gasoline between 2001 and 2006.
- The impact of a change to a VMT fee on rural areas was found to be opposite to that suggested by conventional wisdom. On average a household in a rural location would pay less under the revenue neutral VMT fee than under the gasoline tax, whereas those in urban areas would pay slightly more.
- A change to a VMT fee is not likely to create a significant disincentive to purchase more fuel-efficient or hybrid vehicles.

See also **Oregon in State Case Studies**.

Power, Concession and Agreement in Freight Distribution Chains Subject to Distance-Based User Charges, *International Journal of Logistics: Research and Applications*, Vol. 11, Issue 2, 2008: 81-100.

Abstract: <http://tris.trb.org/view.aspx?id=851229>

From the abstract: Freight transport is an important user of the road network, yet little is understood about the potential impacts of some travel demand management strategies on freight transport activity. This arises, in part, due to the interdependent nature of decision-making within supply chains. To contribute to this shortcoming, this paper offers empirical results from a method designed to estimate attribute-specific measures of relative influence within decision-making groups. A choice modeling framework is utilized to consider the relative concession decision makers are willing to make toward the preferences of other group members when attempting to reach group choice equilibrium. The estimated influence measures highlight the relative power each type of decision maker holds with respect to each attribute within the candidate alternatives from which to choose. The alternatives represent supply chain strategies for adjusting to a hypothetical distance-based road-user charging system in Sydney, Australia. The

measures can be utilized in subsequent transport distribution models to account for the impact each decision maker may have on the decisions made at the group (i.e., supply chain) level in response to a given policy. The results are also useful in gaining a greater normative understanding of the decision-making dynamics within transporter–shipper dyads.

“Assessing the Influence of Distance-Based Charges on Freight Transporters,” D. A. Hensher, S. M. Puckett, *Transport Reviews*, Vol. 28, Issue 1, 2008: 1-19.

Abstract: <http://tris.trb.org/view.aspx?id=849749>; see [Appendix A](#) for full document. *Note that limitations of usage for this article require that Mn/DOT not post a version of this TSR to the Web that has this article appended.*

The paper investigates the potential influence of variable user charges in the freight distribution chain. A choice-modeling framework is presented that identifies potential responses from the freight transport firm to distance-based charging within the context of the wider spectrum of costs and benefits delivered in terms of travel time savings and increased trip time reliability. Results show that (pages 11-13):

- A higher freight rate lowers the marginal disutility of total cost. This makes good sense since it implies that any cost increase is passed on (to some extent if not totally) to shippers through higher freight rates.
- The chief physical influence is on marginal disutility in trip distance. As the kilometers travelled increase, the scope of travel quality gains offered to the transporter increases. Hence, longer trips may reach a sort of critical mass, at which point the time savings or reliability gains become sufficiently valuable to cover the cost of the charges.
- Decision makers who are relatively more experienced may identify benefits of paying the charges that less experienced decision makers may not identify.
- The sender of the goods may be relatively sensitive to time or reliability, placing a high priority on customer satisfaction, which in turn leads to a relatively higher net benefit for the transporter when paying the charges, through satisfying its customer’s need to provide goods promptly, reliably or both.
- A freight distributor is willing to pay on average \$87 to save one hour of travel time. The average trip time in the sample is just under four hours, although not all of it is in a congested traffic context. To illustrate how this VTTs can be used in practical applications, on average each minute saved is worth \$1.11. If it is assumed that a distance-based charging scheme is to be introduced as a charge of \$0.50/km and current average trip time is 40 minutes, and the new charged route reduces this to 20 minutes (similar to what is being observed with the Western Motorway (M7) in Sydney), then given that the 20 minutes is equivalent to 20 km (given a known speed), the charge is A\$10 and the time benefit is \$29. Clearly, anyone who values a minute in excess of \$0.50 will, all other things equal, choose to pay the charge and extract the time benefit.

“The Case for Truck-Only Toll Lanes,” R. W. Poole, Jr., *Public Works Management and Policy*, Vol. 11, No. 4, 2007: 244-249.

Abstract: <http://pwm.sagepub.com/content/11/4/244.abstract>

From the abstract: Truck traffic will grow faster than other traffic during the next 20 years, raising the need for added highway capacity. Current fuel taxes provide barely enough funding to maintain existing highways. Thus, there is growing interest in using toll finance to develop truck-only toll (TOT) lanes, generally added to existing limited-access roadways that are key trucking routes. Urban TOT lanes would provide congestion relief and better access to and from key ports and airports, whereas long-distance TOT lanes would permit longer combination vehicles that are not allowed on most interstate highways. Increased speed, reliability, and payload are reasons for trucking firms and shippers to pay tolls for superior performance. Toll lanes may do a better job than increased diesel fuel taxes of targeting investment to new capacity for goods movement. There are signs that the trucking industry is interested in TOT lanes, and federal and state policy is becoming more favorable.

“Measuring Marginal Congestion Costs of Urban Transportation: Do Networks Matter?,” E. Safirova, K. Gillingham, S. Houde, *Transportation Research Part A: Policy and Practice*, Vol. 41, Issue 8, 2007: 734-749.

Abstract: <http://www.sciencedirect.com/science/article/B6VG7-4N27665-3/2/84e58ebe4c00d40c964f5f297efd6a17>

From the abstract: In determining the marginal cost of congestion, economists have traditionally relied upon directly measuring traffic congestion on network links, disregarding any “network effects,” since the latter are difficult to estimate. While for simple networks the comparison of the network-based congestion costs with the link-based ones can be done within a theoretical framework, it is important to know whether such network effects in real large-scale networks are quantitatively significant. In this paper the authors use a strategic transportation planning model (START) to compare marginal congestion costs computed link-by-link with measures taking into account network effects. The authors find that while in aggregate network effects are not significant, congestion measured on

a single link is a poor predictor of total congestion costs imposed by travel on that link. Also, the authors analyze the congestion proliferation effect on the network to see how congestion is distributed within an urban area

“Effects of the Austrian Road Toll System on Companies,” M. Einbock, *International Journal of Physical Distribution and Logistics Management*, Vol. 36, No. 2, 2006: 152-169.

Abstract: <http://www.emeraldinsight.com/journals.htm?articleid=1545455&show=abstract>

From the abstract: Since 2004, trucks and buses in Austria have been charged per kilometer on motorways, with the amount depending on the number of axles. Therefore, enterprises whose trucks and buses use motorways are confronted with higher transport costs. These costs can be generally divided into direct and indirect ones. The main cost categories concerning indirect costs are costs for prefinancing, bad debts losses and toll-control. The paper assesses these kinds of costs and evaluates the cost effects in different branches. Further, empirical evidence based on a survey conducted in autumn 2003 is included, where enterprises were asked about their expectations concerning consequences of road pricing on their company. A major part of the paper discusses the changes in the planning system of enterprises. There exist a lot of strategies and measures reducing the total systems costs after introducing such a road pricing. Some of these strategies are presented in more detail. Besides description and evaluation, the strategies are faced with results generated by the survey. Results show that this road toll systems leads to different effects on enterprises in Austria. At first accounting is confronted with a new cost type. Toll costs can be separated into direct and indirect toll costs. Both result in an increase of transport costs depending on the industry and partly the region. Higher transport costs can have an influence on the competitive ability in Austria and in foreign countries compared to inland and foreign companies. It is a general goal to reduce the toll-based rise of logistics system costs that cannot be equated with minimizing toll costs. Enterprises can pursue strategies in the field of procurement and distribution, changing the logistics network or in the scope of transportation and packing.

“The Impacts of Time of Day Pricing on the Behavior of Freight Carriers in a Congested Urban Area: Implications to Road Pricing,” J. Holguin-Veras, *Transportation Research Part A*, Vol. 40, 2006: 744–766.

<http://www.oresund.org/ecomobility/content/download/38817/239637/file/The%20impacts%20of%20time%20of%20day%20pricing%20on%20the%20behavior%20of%20freight%20carriers%20in%20a%20congested%20urban%20area%20-%20Implications%20to%20road%20pricing%20-%20Holguin-Veras%20et%20al.pdf>

From the abstract: This paper describes the key findings from a major research project aimed at assessing the impacts of the Port Authority of New York and New Jersey’s time of day pricing initiative on the behavior of commercial carriers, and highlights key implications for road pricing policy. Results show that:

- Carriers respond to time of day pricing by implementing multi-dimensional responses involving productivity increases, cost transfers, and change in facility usage. This implies a more nuanced response than suggested by micro-economic theory, which would only predict a change in facility usage. In fact, no carrier was found to have responded by implementing only changes in facility usage, which leads to the authors to believe that this is a last resort alternative. In terms of numerical importance, three combinations of strategy groups represent almost 90 percent of the cases: Productivity increases (42.79 percent), followed by changes in facility usage and cost transfers (27.60 percent) and productivity increases and changes in facility usage and cost transfers (19.32 percent).
- Because some responses impact only the carrier (i.e., productivity increases) while others mostly impact the receivers (changes in facility usage and cost transfers), the nature of the response is determined by the balance of power between carriers and receivers. If carriers dominate the relationship, then it is likely that policies that mostly impact receivers are implemented; otherwise, the carriers have no choice but implementing strategies that help them cope with the impacts of pricing without impacting their customers, i.e., productivity increases.
- Carriers consider changes in facility usage to be a very disruptive alternative that forces them—and more importantly their customers—to alter their shipping and delivery patterns.
- Although carriers stand to benefit from working during the off-peak hours, they could only do so if their customers are willing to work during the off-peak hours. The data indicate that 36 carriers (20.2 percent) changed behavior because of the time of day pricing initiative. This number includes 17 carriers (9.0 percent) that reacted by increasing shipping charges to receivers, which illustrates the need to find out more about how receivers reacted to the time of day pricing initiative. If the carriers that only increased shipment charges are excluded, 15.3 percent of carriers changed behavior because of time of day pricing.

“How Highly Does the Freight Transport Industry Value Journey Time Reliability—And for What Reasons?” A. S. Fowkes, P. E. Firmin, G. Tweddle, A. E. Whiteing, *International Journal of Logistics: Research and Applications*, Vol. 7, No. 1, 2004: 33–44.

http://eprints.whiterose.ac.uk/2490/2/How_highly_secure.pdf

This study investigated the user valuations of three different kinds of delay:

- A delay resulting from an increased journey time, with fixed departure time
- An increase in the spread (or range) of arrival times for a fixed departure time
- A schedule delay where the departure time is effectively put back.

The study involved a survey of 40 shippers, haulers and third-party logistics operators. Respondents were asked to consider one of their freight flows on the trunk road network in detail. Various reasons why respondents value a high degree of predictability of journey times on the trunk road network are identified and discussed. The paper then moves on to present and discuss user valuations of each kind of delay. Results show that (page 9) in certain sectors of the freight transport market at least, there are relatively high valuations of all three types of delay under investigation. This reflects in part more pressure on haulers and operators to implement more efficient methods of operation.

“The Effect of Traffic Congestion on the Efficiency of Logistical Operations,” A. C. McKinnon, *International Journal of Logistics Research and Applications*, Vol. 2, Issue 2, July 1999: 111-128.

<http://www.informaworld.com/smpp/content~db=all~content=a770476601>

From the abstract: This paper presents the results of a study of the indirect effects of traffic congestion on the internal operations of seven distribution centers in the fast-moving-consumer-goods sector. In-depth interviews were held with several managers in each of these distribution centers to assess the relative importance of congestion-related delays and to examine how firms have adapted their logistical operations to the congestion problem. The research suggests that it will be very difficult to quantify at a macro level the indirect costs of traffic congestion to industry.

“Second-Best Regulation of Road Transport Externalities,” E. Verhoef, P. Nijkamp, P. Rietveld, *Journal of Transport Economics and Policy*, Vol. 29, No. 2, 1995: 147-167.

Abstract: www.jstor.org/stable/20053070

From the abstract: This paper is concerned with the welfare economic characteristics of second-best alternatives to first-best differentiated road pricing, when it is not possible to achieve optimal tax differentiation. The optimal second-best fee is found to be a weighted average of the first-best differentiated fees, the weights depending on factors such as elasticities and group sizes. The welfare effects of second-best regulation are evaluated.

“Traffic Studies and Urban Congestion,” R. J. Smeed, *Journal of Transport Economics and Policy*, Vol. 2, No. 1, 1968: 33-70.

Abstract: <http://www.jstor.org/pss/20052080>

This paper gives a quantitative analysis of capacity and congestion in real and imaginary town centers, and considers some suggested remedies. Results show that there are major questions affecting the life and welfare of the community which cannot be answered without more information, and that the universities can help to provide it.

“The Theory and Measurement of Private and Social Cost of Highway Congestion,” A. Walters, *Econometrica*, Vol. 29, No. 4, 1961: 676-699.

Abstract: www.jstor.org/stable/1911814

From the abstract: This paper attempts to apply the theory of marginal cost pricing to the services of the highways of the U.S.A. Empirical evidence suggests that “efficient prices” are generally much higher than present levels. This implies that gasoline taxes should be increased and special tolls charged in congested areas.

Privacy

“VPriv: Protecting Privacy in Location-Based Vehicular Services,” Raluca Ada Popa, Hari Balakrishnan, Andrew Blumberg, *Vehicular Services*, 2009.

<http://math.stanford.edu/~blumberg/traffic/vpriv.pdf>

From the abstract: A variety of location-based vehicular services are currently being woven into the national transportation infrastructure in many countries. These include usage- or congestion-based road pricing, traffic law enforcement, traffic monitoring, “pay-as-you-go” insurance, and vehicle safety systems. Although such applications promise clear benefits, there are significant potential violations of the location privacy of drivers under standard

implementations (i.e., GPS monitoring of cars as they drive, surveillance cameras, and toll transponders). In this paper, researchers develop and evaluate VPriv, a system that can be used by several such applications without violating the location privacy of drivers. The starting point is the observation that in many applications, some centralized server needs to compute a function of a user's path—a list of time-position tuples. VPriv provides two components: 1) the first practical protocol to compute path functions for various kinds of tolling, speed and delay estimation, and insurance calculations in a way that does not reveal anything more than the result of the function to the server, and 2) an out-of-band enforcement mechanism using random spot checks that allows the server and application to handle misbehaving users. The implementation and experimental evaluation of VPriv show that a modest infrastructure of a few multi-core PCs can easily serve 1 million cars. Using analysis and simulation based on real vehicular data collected over one year from the CarTel project's testbed of 27 taxis running in the Boston area, researchers demonstrate that VPriv is resistant to a range of possible attacks.

Congestion Pricing that Respects “Driver Privacy,” Andrew Blumberg, Robin Chase, University of Texas.
<http://www.math.utexas.edu/users/blumberg/congestion.pdf>

From the abstract: In 2003, the city of London implemented a congestion pricing policy in order to reduce traffic and raise revenues for transit improvements. The dramatic success of this system has led to widespread consideration of the adoption of such variable tolling, including road pricing, in dense urban cores around the world. While from many perspectives the broad implementation of such congestion pricing systems would be socially beneficial, the likely consequences for the privacy of motorists are extremely negative. A sophisticated congestion pricing strategy will assign a cost to a specific space-time path of a vehicle through the pricing zone. Straightforward implementations of monitoring systems to assess congestion tolls thus require detailed tracking technology to monitor the paths of each individual vehicle. In this paper, researchers introduce a novel protocol for computing congestion pricing tolls in a fashion that preserves driver privacy. The scheme uses cryptographic algorithms to guarantee that the state can collect arbitrarily nuanced congestion pricing tolls without being able to track the movements of individual drivers. That is, the system provides simultaneous guarantees that the state can correctly compute the tolls for a particular driver from the information it collects but that the state cannot reconstruct the path of the driver no matter what it does with this information. The system is built using a variant of the protocol researchers described in a previous paper to handle automated traffic enforcement (i.e., stop-light violation detection) in a way that preserves driver privacy and eliminates camera use. The protocol is relatively easy to implement with existing technology, and such implementation can be done in a fashion which is sufficiently robust to handle realistic operational requirements. In particular, researchers discuss methods for ensuring resistance to attempts to cheat and modifications to handle sporadic users (tourists).

A Proposed Architecture for Protecting Driver Privacy When Implementing Distance Based Road User Charging in Europe, 15th World Congress on Intelligent Transport Systems and ITS America's 2008 Annual Meeting, 2008.

<http://tris.trb.org/view.aspx?id=904989>

From the abstract: Thus far, solutions for distance based road user charging have typically been based on the road owner's requirements rather than those of the road users. As the techniques employed to measure road usage get more sophisticated, for example, by using satellite positioning, end user privacy is increasingly challenged. Road owners deciding on system design have to prioritize between many requirements competing for resources, and when doing so privacy is an early candidate to stand back. This paper argues that this is unnecessary, and that respect for privacy can be kept intact, without making any concessions on requirements for cost of ownership, ability to effectively enforce noncompliant vehicles, or competitive system procurement. Portions of a charging concept with high privacy standards tested by the Oregon Department of Transport is here adapted and expanded to fit regulations and typical requirements from several European cases, presenting a holistic charging scheme.

Technology and Implementation

Implementing Distance-Based User Fees as a Replacement for the Fuel Tax—FY10 TechPlan, Lee Munnich, Ferrol Robinson, Zhirong Zhao, University of Minnesota Center for Transportation Studies, in progress, start date: October 2009, end date: March 2011.

<http://www.cts.umn.edu/Research/ProjectDetail.html?id=2010069>

From the abstract: This project will develop ideas for shifting from a financing system for surface transportation based on the fuel tax to one that is based on vehicle-miles traveled (VMT), or distance-based user fees. The study will build upon research that is currently being conducted by RAND with the University of Minnesota for a National Cooperative Highway Research Program study; as well as, University of Minnesota policy development work for Congressman Oberstar. It will identify the best ways of moving toward a VMT fee system in the U.S. by examining

the current fuel-tax funding system versus a distance-based user fee system, using a set of principles that could lay the groundwork for an extensive public outreach effort.

Symposium on Mileage-Based User Fees, 2010.

<http://utcm.tamu.edu/mbuf>

In its second year, this symposium gathers professionals annually to discuss the implementation of mileage-based road user fees and sponsored several of the studies discussed in this synthesis

(http://utcm.tamu.edu/mbuf/utcm_studies.stm). See Mileage-Based User Fees, Defining a Path Toward Implementation on page 21 of this report.

VMT Primer

http://utcm.tamu.edu/mbuf/documents/VMT_Primer.pdf

The symposium Web site provides a useful primer on VMT fees.

Conference Summary, *Proceedings: 2010 Symposium on Mileage-Based User Fees*, The Hubert H. Humphrey Institute of Public Affairs, University of Minnesota Center for Transportation Studies, April 20-21, 2010.

http://utcm.tamu.edu/mbuf/2010/proceedings/documents/mbuf10_proceedings.pdf

The proceedings of the 2nd annual symposium contain the following highlights (pages 32-38) related to implementation. (See also highlights related to acceptability by the trucking industry at the beginning of the first section of this report.)

1. GPS is only feasible technology for national user-charge system and administrative costs are feasible if a thin OBU configuration is used. However, these costs are still significantly higher than the fuel tax. Collection costs could only be justified if significant benefits other than just collecting revenue (such as congestion pricing, targeted emission fees, differential rates for roads of different load-bearing capacity or better traffic data) are realized (page 33).
2. According to Ferrol Robinson (page 36), a road user charge system must:
 - a. Accommodate all vehicles regardless of propulsion system
 - b. Accommodate fuel tax collection until fuel taxes can be replaced by VMT fees
 - c. Apply to all roads and jurisdictions
 - d. Be capable of assessing higher charges to users who impose higher costs
 - e. Have technology that accurately calculates distance driven (regardless of time, road and place of travel) and allows charges based on fuel efficiency, vehicle weight and emission level
 - f. Ensure the privacy of road users, and be secure and reliable
 - g. Be flexible and accommodate future changes in technology and a variety of public policies
 - h. Generate a stable revenue stream that is able to grow as transportation needs grow
 - i. Ensure a “low” rate of evasion
 - j. Ensure that collection costs are not burdensome to agencies or users

These proceedings also include a summary of themes that emerged from the first annual symposium:

2009 Symposium on Mileage-Based User Fees Proceedings, Ginger Goodin, Texas Transportation Institute, April 2009.

http://utcm.tamu.edu/mbuf/2010/presentations/pdfs/4-20_Goodin.pdf

Eighty transportation professionals from 12 states and more than 50 organizations gathered for a day-and-a-half to hear presentations from experts on the state of the practice in mileage-based fees, also called vehicle-miles traveled (VMT) fees. Participants focused on the following questions:

1. What are the greatest challenges or barriers to transitioning from the fuel tax to a per mile fee?
2. What would the transition look like and who would lead?
3. What additional research, testing and demonstration are needed?

Themes emerging from discussions included the following:

- a. Challenges include a) public acceptance, including concerns about privacy and public trust in transportation planning; b) political leadership, including a lack of political will, the absence of an organized coalition, a need for the education of state and local

- officials, and a lack of policy definition; c) a need for standards to ensure interoperability and federal support for pilot projects.
- b. A Transition would involve federal government policies and financial support, a national consortium focused on developing a roadmap, and listening to the public in early stages to help articulate benefits.
 - c. Needed additional research includes pilot projects testing multiple technology platforms, the identification of objectives and a framework for implementation, the study of equity issues, and investigation of public acceptance issues.

Urban Mobility Report, D. Schrank, T. Lomax, March 2010.

http://mobility.tamu.edu/ums/congestion_data/tables/minneapolis.pdf

This report provides a series of tables detailing congestion data for Minneapolis–St. Paul, Minn.

Addressing Equity Challenges to Implementing Road Pricing, Brian Taylor, Rebecca Kalauskas, Hiroyuki Iseki, California PATH Program of the University of California, March 2010.

<http://www.path.berkeley.edu/PATH/Publications/PDF/PRR/2010/PRR-2010-06.pdf>

This paper examines road pricing equity from a variety of perspectives, beginning by developing an evaluation framework that defines three distinct bases for evaluating equity—free markets, equal opportunities and equal outcomes. It then uses this framework to guide a review of five case studies of road pricing—in San Diego, Minneapolis–St. Paul, Germany, Stockholm and New York—that explore how equity concerns have been raised and addressed in practice. Researchers find that equity was a central question in each case, alternatively motivating (1) the implementation of pricing (Germany), (2) the funding of alternative modes (San Diego, Minnesota and Stockholm), (3) mid-course restructuring of the pricing program (Stockholm), and (4) successful opposition to a pricing proposal (New York). Successful mitigation of equity concerns have entailed (1) careful planning of the project or program, paying attention to the dedication of toll revenues to both transit and highway improvements in and around the tolled areas to create constituents for the pricing program; (2) a limited geographic scope to central, congested zones, particular travel corridors, or particular market segments; (3) incremental implementation to allow for mid-course adjustments in project development; and (4) ongoing, substantive, and sincere public outreach and education efforts that have meaningfully influenced program design.

The report notes (page 16) that the issue of truck-weight fees provides an example of how the transportation finance system affects user decisions. Damage to pavements caused by heavy trucks increases significantly with weight per axle. Many people are surprised to learn that a relatively small share of trucks with heavy axle loads does most of the damage to roads. Yet for decades many states levied truck weight fees based on the weight of empty trucks; and toll ways frequently set rates based on the number of axles per vehicle. Both policies encourage truckers to load heavy weights onto as few axles as possible, and thereby maximize damage to roadways. Such truck fee systems increase maintenance and rehabilitation costs in comparison to jurisdictions where fees are assessed in ways to encourage truckers to reduce axle weights. Thus, changing the way that fees are levied on trucks would change truckers' behavior, and, in turn, substantially lower maintenance costs without necessarily increasing either taxes or revenues.

This report includes an appendix with five case studies, including a discussion of the German Toll Collect Program (page 46), instituted in 2005 to electronically charge trucks over 12 tons with fees that vary according to distance traveled, vehicle weight and vehicle emissions. Every truck is equipped with an on-board unit that utilizes GPS and digital road maps to track the vehicle's use of the highway network and assesses the appropriate fee automatically. Although some trucks still pay tolls manually, the German Toll Collect System is the first large-scale operation road pricing project that utilizes satellite-based electronic fee collection technology. While initially conceived of as a mechanism to more equitably distribute infrastructure costs, many within the trucking industry view the charge as unfair to the commercial freight industry. In a 2005 survey, road users reported the belief that the charges would be more equitable if vehicle related taxes were reduced or a fuel tax rebate for those paying road charges was introduced. Some users have also criticized the lack of transparency in determining the Toll Collect fees, which to the uninitiated may appear arbitrary. Furthermore, some users reported the opinion that the program would be more equitable if the truck tolls were consistent across all European countries, rather than current system whereby each country implements different road finance systems. Given that studies have repeatedly suggested that heavy trucks inflict more damage on roadways than they pay in road taxes, it is perhaps unsurprising that truckers would express dissatisfaction with a new pricing regime that explicitly and intentionally shifts more of the finance burden in Germany onto heavy vehicles. (See also **Germany** in the section on **International Case Studies**.)

Congestion Charging, Road Pricing, Travel Demand and Transport Modeling, Philipp Frohlich, Milenko Vrtic, *Transportation Research Board 89th Annual Meeting Compendium of Papers DVD*, Paper #10-3265, 2010.

Abstract: <http://pubsindex.trb.org/view.aspx?id=910977>

From the abstract: This research project developed models to establish the transport network and demand in Switzerland for the reference year 2030, then used these models to quantify the effects of six road pricing schemes on travel demand (destination, mode, route and departure time choice), and to estimate the impact of these road pricing schemes on land use, road safety and the environment.

Implementable Strategies for Shifting to Direct Usage-Based Charges for Transportation Funding: Final Report, Paul Sorenson, NCHRP, June 2009.

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w143.pdf

From the abstract: The goal in this study was to identify a range of options that might support the near-term implementation of a national system of VMT fees and evaluate their relative strengths and weaknesses. Based on the research, three options appear to offer the greatest promise: metering mileage based on fuel-consumption, metering mileage based on a device combining cellular service and a connection to the onboard diagnostics port, and metering mileage based on a device featuring a GPS receiver. While each of these approaches has its own set of advantages and disadvantages, there are also significant uncertainties that make it difficult to determine the optimal configuration at this juncture. The upcoming reauthorization of the transportation bill, however, provides the opportunity to fund a set of activities—encompassing planning, analysis, technical research and development, expanded real-world trials, and education and outreach—that could resolve the uncertainties and set the stage for implementing VMT fees beginning in 2015.

General findings include:

- **Motivations:** The motivations for transitioning to a system of VMT fees—to raise revenue and potentially to address additional policy goals—are strong.
- **Obstacles to acceptance:** VMT fees face two significant policy obstacles: first, it is not apparent that initial efforts to institute VMT fees, or subsequent efforts to increase VMT fees to keep pace with inflation, will face less opposition than increasing fuel taxes; and second, the administration of VMT fees will almost certainly be more costly and burdensome than fuel tax collection.
- **Obstacles to implementation:** Each of the options considered in this research has one or more significant drawbacks that would argue against immediate implementation for all vehicles at the national scale.
- **Implementation timing:** Many potential VMT metering and charging systems could, from a technical perspective, be implemented within a few years. Once initiated, the transition to VMT fees may occur more rapidly than expected. Transportation funding deliberations provide an opportunity to conduct activities to prepare the country for initiating a potential transition to VMT fees in 2015 or perhaps sooner.

Trucking industry-related findings include:

Motivations (pages 21-32)

- To capture and allocate the maintenance costs associated with heavy truck travel.
- Automating (streamlining) the collection of road use charges for trucks (apparent for example with Oregon’s proposal to convert its manually implemented weight-distance truck toll to an automated program leveraging current electronic tolling technology).
- Ensuring that foreign trucks pay the same road use charges as domestic trucks.
- Stimulating a freight mode shift from trucks to rail, and providing an incentive for adopting less-polluting trucks.

Effects on the Trucking Industry

- Passenger VMT may be more sensitive to changes in the price of fuel, while truck VMT may be more sensitive to changes in the economy (page 16).
- Generally speaking, the application of weight-distance truck tolls has resulted in higher road use charges for trucks.

Making VMT Acceptable to the Trucking Industry (pages 21-32)

- For weight-distance truck tolls, industry concerns center on the distribution of costs and benefits. In many cases, trucking costs would rise with weight-distance truck tolls. To forestall strong stakeholder resistance, existing weight-distance truck tolls have been structured with additional features that benefit the trucking industry—for example, allowing larger truck loads in certain corridors, leveling the playing field with

foreign competition, dedicating the resulting revenue to highway investments that will benefit truckers, streamlining burdensome regulatory compliance requirements (for example, automating the reporting of miles by state under the International Registration Plan).

- European case studies: In the Swiss case, trucks were allowed to carry heavier loads over the Swiss Alps in order to facilitate more efficient goods movement operations. In the German case, revenues were dedicated to maintenance and enhancement of the highway network, and rates were structured such that truckers could reduce the charge by up to 50 percent by upgrading to the least polluting vehicles. With the U.K. proposal, one of the pre-existing concerns for domestic truckers was that their foreign counterparts could purchase fuel in other countries with lower fuel taxes and then conduct business in the United Kingdom, gaining a cost advantage. By developing a weight-distance truck toll that would apply to both domestic and foreign truckers operating in the United Kingdom, the playing field would be leveled. It is noteworthy that even though GPS components are used in several of the existing weight-distance truck tolls, privacy issues have not emerged as a significant concern, in part because the trucking agency is already subject to a stricter regulatory regime than passenger vehicles.

GPS and Privacy

- High resolution GPS-based mileage metering is more expensive than course options but more flexible for determining specific route of travel—this additional flexibility is most useful for weight-distance truck tolls in which the per-mile rate would likely depend on the type of road on which travel occurs. If the decision is made to implement weight-distance truck tolls, then, this would be the preferred option. For a general-purpose system of VMT fees, however, the additional capabilities are not required (page xxii).
- If desired, weight-distance truck tolls could be planned and implemented now. The principal concerns limiting the deployment of GPS-based equipment for passenger vehicles in the near term—the high cost of retrofitting the existing vehicle fleet and public fears over the potential invasion of privacy—are less relevant for the trucking industry, which has a much higher cost structure and is already heavily regulated. Successful implementations already exist in Switzerland, Austria and Germany, and in each case the systems were developed in just a few years (page 6). Pages 89-90 further discuss the advantages of GPS-based weight-distance truck tolls for near-term feasibility.

Pages 21-23 cover implementation of weight-distance truck tolls specifically:

- Previous programs in states were implemented through cumbersome manual means, and only four states currently levy weight-distance road use fees. Within the past decade, though, several European nations have successfully implemented weight-distance truck charges through the use of electronic tolling technology, and this has stimulated a renewed interest in the concept (see the section on **International Case Studies**), including Austria, Switzerland, Germany and the United Kingdom.
- Pricing variations: At minimum, weight-distance truck tolling programs account for the distance of travel as well as some measure of weight (although axle-weight may be the most appropriate measure in this regard, most existing programs employ such surrogates as total laden weight or number of axles). Only vehicles above a certain weight must pay the charges (in Switzerland, for example, the lower limit is 3.5 tons; in Germany, the lower limit is 12 tons). Beyond weight class, these programs may also vary the per-mile charge on the basis of such factors as vehicle emissions class or the type of road on which travel is taking place. Note that some programs only price travel on the main highway network, while others encompass the entire road network. The German program initially priced travel just on the highway network, but has subsequently priced travel on some adjacent surface streets to eliminate the incentive for trucks to divert to local roads so as to avoid tolls.
- Technical implementation options: At the simpler end of the spectrum, the Austrian program employs an in-vehicle transponder that communicates with overhead gantries on the highway network to register the charges owed. This approach works from a cost perspective because only the highway network is subject to tolls; if the program applied to all roads in Austria, it would be prohibitively expensive to install the required infrastructure. The more technically sophisticated implementations rely on GPS. In the Swiss case, the odometer is used to measure mileage, while GPS is used to determine whether or not the travel occurs within Swiss borders. (The fees are not differentiated by road type, so greater precision is not required.) In the German case—by far the most sophisticated—GPS is used to distinguish the specific route of travel, as some roads are tolled and others are not. The German program also relies on cellular communications for uploading billing data. Note that all of the European examples also have paper-based alternatives that can be used to assess tolls for trucks lacking the necessary in-vehicle equipment. (This typically applies to foreign trucks that don't frequently travel in the country where the charge is applied.)

- Verification and enforcement options: Two common approaches have been employed to verify compliance with weight distance truck tolls. The first is to set up gantries with devices that query, via dedicated short-range communications, passing trucks to verify that their in-vehicle equipment is functioning properly. Non-compliant vehicles can either be pulled over and cited by law enforcement agents, if available, or electronically identified via automated number plate recognition systems (cameras and software capable of reading license plates) and subsequently cited by mail. The second is to ensure that the in-vehicle devices are tamper resistant—that is, that a driver will not be able to temporarily disable the device without being caught in a subsequent inspection. (Inspections might be performed during random roadside checks or on a periodic basis, for example, once per year.)
- Administrative options: Existing weight-distance truck tolls have been developed with both public and private administration strategies. In the Swiss case, the HVF program is administered by the Swiss Customs Agency, with enforcement support from the Swiss Cantons. The Oregon proposal is another case in which administrative functions would likely be supported by a public agency. In both the Austrian and German cases, in contrast, a private firm (or consortium of firms) performs, for a fee, the operational aspects of program administration.

“Policy Options for Truck User Charging,” A. Conway, C. Walton, *Transportation Research Record*, Issue No. 2115, 2009: 75-83.

Abstract: <http://pubsindex.trb.org/view.aspx?id=881877>

From the abstract: This paper provides a review of truck road user charging mechanisms employed worldwide. The purpose of this study is to identify the variables currently considered in determining user charge rates for heavy trucks within different tolling structures and to examine the relationship of these variables to policy goals.

Mileage-Based User Fees—Defining a Path toward Implementation: Identifying a Research Strategy, Richard T. Baker, Ginger Goodin, University Transportation Center for Mobility, 2009.

http://utcm.tamu.edu/publications/final_reports/Goodin_09-00-16.pdf

From the abstract: This project was the first of a two-phase research effort composed of three interrelated components: 1) a technology assessment, 2) an institutional assessment, and 3) a one-day implementation-focused symposium. Each component builds from the mileage-based user fee framework developed with funding in 2008 from the University Transportation Center for Mobility. This report documents initial progress on these three activities through February 2009.

Mileage-Based User Fees—Defining a Path toward Implementation, Phase 2, Part 1: An Assessment of Technology Issues, Matthew Bomberg, Richard T. Baker, Ginger Goodin, University Transportation Center for Mobility, 2009.

http://utcm.tamu.edu/publications/final_reports/Goodin_tech_09-39-07.pdf

From the abstract: This report reviews technology options for a mileage-based user fee system in the state of Texas. The report assesses the range of possible mileage-based user fee system architectures. These architectures are considered at the logical level (i.e., the flow and transformation of information from raw data describing roadway use to an end bill) with the goal of demonstrating how the process flow of each architecture affects its ability to meet key policy objectives. The report also explores issues related to payment, enforcement, the deployment of on-board units in vehicles, and the potential for technology enabling a mileage-based user fee to be a platform for other value-added services. Finally, the report concludes by identifying key policy questions for Texas that must be addressed before pilot programs can be developed.

Mileage-Based User Fees—Defining a Path toward Implementation, Phase 2, Part 2: An Assessment of Institutional Issues, Matthew Bomberg, Richard T. Baker, Ginger Goodin, University Transportation Center for Mobility, 2009.

http://utcm.tamu.edu/publications/final_reports/Goodin_inst_09-39-07.pdf

From the abstract: This document covers the institutional assessment portion of the research effort. It was conducted in conjunction with the technology assessment and involved the study of various user fee frameworks in place throughout the United States and an analysis of the various institutional issues to be considered with mileage-based user fee development, implementation and eventual administration. This report is meant to serve as a tool for policy makers and other interested parties who are considering mileage-based user fees as a potential means of generating transportation related funding and wish to gain a better understanding of the issues surrounding them.

While mileage-based fee systems have been tested by the Oregon Department of Transportation and the Puget Sound Regional Council, and a national assessment is currently being conducted by the University of Iowa, there has been a lack of research evaluating the potential institutional issues that would be involved in a transition to these fees as the primary source of funding for transportation development. There has also not been an evaluation of the strategies that might be employed in deploying these systems at the state and/or federal level from an administrative perspective. This report explores these issues.

Technology Enabling Near-Term Nationwide Implementation of Distance Based Road User Fees, Max Donath, Alec Gorjestani, Craig Shankwitz, Richard Hoglund, Eddie Arpin, PiMing Cheng, Arvind Menon, Bryan Newstrom, University of Minnesota, Twin Cities, Research and Innovative Technology Administration, June 2009. <http://www.its.umn.edu/Publications/ResearchReports/pdfdownload.pl?id=1166>

From the abstract: This report describes a system meant for near-term deployment that directly determines the distance traveled by a vehicle and uses this as a basis for charging a fee that reflects road use. An in-vehicle device with access to the vehicle data bus and power through a single standard connector available on all passenger vehicles since 1996, electronically calculates the distance and then securely communicates relevant information to a “back office” for processing and transferring accumulated fees from the user to the appropriate government jurisdiction. Also described are means for providing payment (and receiving credit for motor fuel use taxes paid at the pump) while also ensuring compliance, enforcement, transparency and privacy. Communication is via text messaging, available wherever cellular service is accessible. No new wireless infrastructure is needed. The in-vehicle device distinguishes distance traveled by state or by other regions of interest, e.g., rural vs. urban areas, using the same cellular technology that is used for communications. Aggregating distance based on rural vs. urban travel can facilitate different pricing policies for these different road users. Neither a GPS receiver nor longitude/latitude position data is necessary. However, higher resolution position sensing can be added to the core platform as needed based on policy objectives, e.g., to consider alternate pricing for specific road facilities.

Discerning the Pathway to Implementation of a National Mileage-Based Charging System, James M. Whitty, John R. Svadlenak, Transportation Research Board, October 2009.

Abstract: <http://onlinepubs.trb.org/onlinepubs/sr/SR299Mileage.pdf>
http://www.i95coalition.org/i95/Portals/0/Public_Files/Whats-New/SR299.pdf

This paper was commissioned to perform three tasks. First, develop and propose concepts for research and demonstration programs to test the technical and political feasibility of road use metering and mileage charging. Second, develop and expand upon the recommendations of TRB Special Report 285: “The Fuel Tax and Alternatives for Transportation Funding” for creating a structure to support the conduct of trials or pilot projects by individual states with federal leadership and funding aid. Third, develop cost estimates for the demonstrations and related research to design and implement the trials. The authors present this paper in two parts. The authors intend Part One to facilitate understanding among policymakers and researchers of the decision making necessary for constructing an acceptable mileage charging system and, further, to present the mileage charging system development already accomplished and the research in progress or completed. Part Two proposes additional research to fill knowledge gaps and obtain the data and information necessary for policymakers and researchers to reach a knowledge level for the opportunity at hand sufficient to enable legislative action.

Trucking industry-related highlights include:

Acceptability and Implementation

- Perspectives on affordability change when considering heavy commercial trucks. The recent implementation of Germany’s heavy truck charging system indicates the capability of the motor carrier industry to absorb considerably higher system costs than anticipated for passenger vehicles. A distance charging system for a regulated industry may need more sophistication and additional charging options than for light vehicles, since vehicle configuration, weight and number of axles will likely determine the rates charged. Such a system should provide improved data and communication benefits to motor carriers as well as planners and regulators (page 26).
- Other nations can serve as a model for development of heavy truck distance charging systems (pages 95-96).
- An independent policy oversight body should direct policy and system development of a national mileage-based charging system according to policy guidelines provided by Congress. Members should include representation from trucking industries (page 115). A motor carrier project team (page 116) would consult with the trucking industry and other affected stakeholders, and coordinate work on design and

implementation of an electronic weight and mileage-based charging system for heavy commercial vehicles that could replace existing diesel taxes and truck fees.

GPS and Privacy

- Protection of privacy is perhaps the most critical public acceptance factor to resolve prior to implementation. While not entirely absent, privacy protection and vehicle tracking have less political sensitivity for the motor carrier industry than for the general public. This makes sense because the government regulates the motor carrier industry as a commercial rather than personal activity. Accordingly, government agencies monitor heavy commercial trucks for size and weight enforcement purposes. Motor carriers, therefore, surrender a certain amount of anonymity to lawfully operate on the road system. As a result, many more system options are potential candidates for application to the motor carrier industry (page 29). The commercial trucking industry should demand assurance of data bank security and safeguards against data interception to the degree required for passenger vehicles (page 30 and 59).
- Departments of transportation routinely audit motor carriers for tax purposes. Allowing a collection agency to obtain the additional information required for auditing should be much less of an issue for heavy vehicles. The commercial trucking industry should demand assurance of data bank security and safeguards against data interception to the degree required for passenger vehicles (page 31).
- Some within the trucking industry may see distance-based charges as a way to accurately collect truck travel data to satisfy requirements of the International Fuel Tax Agreement and International Registration Plan (page 21).
- Pages 55-57 discuss in detail automated mileage-based charges using GPS.

Final recommendations for moving forward include (page 121) suggestions to:

- Identify and complete development of mileage-based charging collection systems for motorists fueling at commercial stations and those fueling or recharging elsewhere that can be implemented nationally or commonly by individual states.
- Design and complete system development for an electronic weight-distance tax for heavy commercial trucks for adoption nationally or by individual states.
- Engage the public throughout the development process in order to gauge public attitudes on various mileage charging system elements, including education and communication on all elements, so that a national consensus may form on the advisability of mileage charging in the United States and the most appropriate form for the new system.

Technology Options for Distance-Based Road User Charging Schemes, Diana Vonk Noordegraaf, Bjorn Heijligers, Odette van de Riet, Bert van Wee, *Transportation Research Board 88th Annual Meeting Compendium of Papers DVD*, Paper #09-2477, 2009.

<http://tris.trb.org/view.aspx?id=881759>

From the abstract: Road user charging schemes have great potential to reduce congestion and negative environmental effects. Moreover, implemented schemes are viewed as successful. Nevertheless, only a few road user charging schemes have been implemented worldwide, and they are all limited in nature. Currently, several countries are planning to implement road user charging schemes that are more ambitious in terms of geographical scale (nationwide), scope (all vehicle types) and level of differentiation (to distance, time and place). However, implementation is a cumbersome process. The technology choice is moreover a key barrier in this process, owing to the complexity of the task: technology options for road use measurement, data communication, and enforcement and inspection. To facilitate technology choices and contribute to the literature on road user charging technologies, this paper 1) describes the functional architecture, including the road user charging scheme subsystems; 2) classifies the available technologies and updates a survey of the (rapidly developing) technologies; 3) gives a comprehensive overview of appraisal criteria for technology choices; and 4) discusses the main technology-related trade-offs and synergies in terms of the functional architecture. The optimal technology option is a package of technologies that should be selected from a systems perspective, including all functional requirements, objectives, trade-offs (e.g., accurateness versus cost components) and synergies (e.g., technologies using the same infrastructure), and be flexible enough to cope with future adaptations.

New Ideas for Congestion Pricing, Patrick T. DeCorla-Souza, Matthew E. MacGregor, *TR News*, Issue 263, 2009: 39-42.

Abstract: <http://pubsindex.trb.org/view.aspx?id=900334>

From the abstract: The authors explore innovative congestion pricing approaches—such as flexible and efficient express lanes, tolled bypass lanes, priced highways, priced zones and networks, and other strategies, including

public-private partnerships to reconstruct, finance, and operate the facilities. These promising strategies—some yet untried—require creative solutions to safety and operational challenges.

Policy Options for Varying Mileage-Based Road User Charges, David J. Forkenbrock, *Transportation Research Record*, Issue 2079, 2008: 29-36.

Abstract: <http://pubsindex.trb.org/view.aspx?id=847379>

From the abstract: Particularly as more fuel-efficient vehicles, hybrids, and eventually vehicles with alternative power, such as hydrogen fuel cells, become increasingly commonplace, the motor fuel tax holds limited promise. As a possible replacement, a mileage-based road user charge has considerable potential as a means of ensuring adequate revenue with which to finance roads at the federal, state, and local levels of government. In addition to providing a stable, reliable revenue stream, a mileage-based road user charge can enable the pursuit of various policy initiatives. A key question is thus how the burden for generating the needed funds should be distributed between various classes of vehicles. The analysis concludes that if the mileage-based road user charge were structured to produce the same total amount of revenue as currently generated by the motor fuel tax, the magnitudes of incentives or disincentives that would be produced for various vehicle classes would be quite small. However, the analysis highlights that the mileage charge could be structured to substantially increase the amount of revenue generated and in the process somewhat increase the incentive to operate more-efficient vehicles. The analysis shows that considerable flexibility exists in how a mileage-based road user charge could be structured to help advance various policy choices while ensuring that the nation's road system would be adequately financed.

“How Should Heavy-Duty Trucks be Taxed,” I.W.H. Parry, *Journal of Urban Economics*, Vol. 63, No. 2, April 2006: 651-668.

<http://www.rff.org/documents/RFF-DP-06-23.pdf>

From the abstract: This paper develops and implements an analytical framework for estimating optimal taxes on the fuel use and mileage of heavy-duty trucks, accounting for external costs from congestion, accidents, pavement damage, noise, energy security, and local and global pollution. The analysis allows for endogenous fuel economy, increased auto travel (and externalities) in response to reduced truck congestion, and it distinguishes driving by truck type and region. Researchers estimate the optimal (second-best) diesel fuel tax is \$1.12 per gallon, and implementing it increases welfare by \$1.34 billion per annum. However, optimizing over both fuel and mileage taxes, and differentiating mileage taxes by vehicle type and region, yields progressively higher welfare gains. The most efficient tax structure involves a diesel fuel tax of 69 cents per gallon and charges on trucks that vary between 7 and 20 cents per mile; implementing this tax structure yields welfare gains of \$2.06 billion.

Review and Synthesis of Road-Use Metering and Charging Systems, Paul A. Sorenson, Brian D. Taylor, University of California, Los Angeles, Institute of Transportation Studies, 2005.

<http://www.trb.org/publications/news/university/SRFuelTaxRoad-MeterPaper.pdf>

From the report: Since the 1920s the motor fuels tax has been the principal user fee through which revenues have been raised for the construction and maintenance of U.S. highways (and later public transit systems). The motor fuels tax has numerous merits, and many observers believe that it will remain the mainstay of the transportation finance for years to come. Others, however, pointing to the growing political resistance to fuels tax increases, the rise of alternative propulsion vehicles, and the need for better pricing to manage road use, argue that the days of the motor fuels tax are numbered—and that new technologies now allow new and better ways to price the use of highways. This resource paper informs this debate over the future of the motor fuels tax by examining in considerable detail many of the latest efforts worldwide to develop new ways to fairly and efficiently charge for highway system use. An extensive review of innovative electronic tolling applications around the world was performed. The review included projects already in operation as well as those that have been proposed or are in the advanced stages of planning; each was evaluated in terms of policy, technology, and political acceptance issues. Case studies were selected that focus on applications involving network wide road-use metering and tolling, as these were judged to be the most relevant to the concept of distance-based user fees. A secondary focus was given to facility congestion toll projects and cordon toll projects that might be relevant from a political or technical perspective. Note: This report was commissioned by the TRB Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance.

Highlights include:

- Privacy can be safeguarded via:
 - On-board aggregation: The first approach, which is more prevalent for full-scale operational proposals, is to aggregate all travel information and determine the total bill owed on the on-board

unit itself. With this strategy, the government never sees any of the details of the travel history for any individual, just the total amount of the bill.

- Third-party privacy agreements: In this second approach, the on-board unit communicates detailed travel information to a third-party billing agent, which in turn aggregates the data and submits only the total bill to the government. As with phone companies, the third party is legally obligated to keep these data private except in the case of a court subpoena. Consumers appear to be more wary of this approach, however, and to date it has been employed only within truck tolling projects or in research trial projects.
- Pages 22-24 provide summaries of weight-distance truck tolls in other countries.
- The University of Iowa has developed (page 25) a “New Approach” proposal with pooled funding from 15 state departments of transportation and the Federal Highway Administration, for a mileage-based fee system operating across multiple jurisdictions that would serve as a long-term replacement to the fuels tax for both automobiles and trucks. The proposal includes the use of on-board units equipped with GPS and GIS maps for determining distance traveled by jurisdiction, as well as smart cards for data transfer to a billing center. In its simplest form, the proposed fee structure for automobiles would be based on the number of miles driven in each state, while for trucks it would be based on the number of miles driven by road class by state. At their discretion, individual jurisdictions also could choose to include additional fee criteria, such as congestion tolls, per-mile charges based on emissions class, and per-mile adjustments based on weight and axle configuration (for trucks). The initial feasibility study was completed and published in 2002, and efforts to develop a field trial of the proposed technology are currently under way.
- Distance-based user fees also can alter travel demand, even absent congestion pricing (page 37). For example, the heavy goods vehicle fees in Switzerland were set deliberately to discourage truck traffic and induce a freight mode shift to rail. In the three years since the inauguration of the toll, the number of truck trips traveling through Switzerland, which had been growing at an annual rate of 7 percent, decreased by about 4 percent in 2001, by another 3 percent in 2002, and has remained stable since. However, the anticipated growth in rail freight traffic has not materialized. Instead, the principal effects appear to have been because of changes in truck configuration and delivery logistics. Specifically, larger trucks are chaining more pick-ups and deliveries together. These unintended effects are likely because of inherent logistical advantages of trucks for many shipment types and delays in rail freight improvements, such as a proposed streamlining of transnational shipping logistics.
- If the entire road network is not priced, traffic diversion is likely (page 39). The tolls in both Austria and Germany charge trucks for travel on highways, but not on smaller surface streets. Forecasts of the effects of this policy suggested that significant levels of truck traffic would divert from highways to parallel streets and roads. Truck tolls were implemented a few months ago in Austria, and preliminary analyses suggest that truck traffic is being diverted onto streets and roads. In contrast, truck tolls are applied to the entire Swiss road network and, as one would expect, no diversions from highways have been observed. Like Switzerland, the proposed U.K. truck tolling system will apply to the entire road system, and forecasts project no route diversions of truck traffic.
- Immediate rollout is feasible for trucks, not for private vehicles (page 57). Immediate rollout requires that all vehicles install on-board equipment from the outset, and this can represent a considerable expense (either on the part of truckers or the government, depending on the financial structure of the program). In comparison to noncommercial vehicles, however, the magnitude of weight-distance fees applied to trucks is quite large, so the expense of the onboard equipment represents a small fraction of the overall revenue generated. Furthermore, when prices rise for all trucks, the costs generally are shifted onto customers.
- With respect to weight-distance truck tolls, privacy concerns have centered on preventing public disclosure of proprietary information regarding the identity of customers, prices charged to various customers, and the location and timing of particular shipments. However, since commercial trucking already is subject to regulation and scrutiny, such concerns have in most cases proven manageable (page 59).
- Successful programs typically dedicate revenues to transportation projects (page 63). Interestingly, opposition to using revenues collected from one mode to subsidize another is frequently voiced by modal stakeholders but far less by elected officials or the general public. For example, net revenues from the I-15 HOT lanes near San Diego and from the London congestion toll are used to support public transit, while revenues from the Swiss truck-tolling project are devoted to enhancements to the rail network.
- Successful programs tend to mitigate “losers” at least partially. Most road pricing programs reallocate the distribution of winners and losers, usually with an eye toward bringing prices paid in line with costs occasioned. While there may be sound reasons for ending the “free (or substantially discounted) rides” enjoyed by some classes of road users, some efforts to soften the blow of new pricing regimes often are politically necessary. For instance, the heavy goods vehicle fee in Switzerland, set at a level designed to

encourage a mode shift to rail freight, resulted in a significant increase in charges to the trucking industry as compared to the prior flat fee. The trucking industry generally was supportive of the measure, however, because the new program also allowed a higher maximum vehicle weight that enabled trucking companies to increase efficiency by lowering unit costs.

“Implementing a Mileage-Based Road User Charge,” D. J. Forkenbrock, *Public Works Management & Policy*, Vol. 10, No. 2, 2005: 87-100.

Abstract: <http://tris.trb.org/view.aspx?id=781048>

From the abstract: This article explores a series of issues related to implementing a mileage-based road user charge. This user charge is intended to eventually replace the motor fuel tax, which is certain to become increasingly less productive as gains in fuel mileage occur and as electric hybrid and eventually hydrogen fuel-cell vehicles enter the market. Before so great a change can occur as to how roads in the United States are financed, a series of policy and operational considerations must be addressed. The article first presents an overview of a mileage-based road user charge approach, then examines a variety of issues related to its implementation, and concludes that substantial benefits from implementing this new form of user charge are possible.

National Resources—NCHRP and TRB

TRB Congestion Pricing Committee, 2010.

<http://www.trb-pricing.org/>

From the Web site: The mission of the Congestion Pricing Committee is to foster research for a better understanding of the technological, operational, business, administrative, political and institutional aspects of pricing transportation systems and services. This includes a wide array of strategies designed to cover conventional and non-conventional approaches employed across transportation modes, including integrated transit, variable pricing coordinated across surface transportation modes, aviation pricing, parking pricing, parking “cash-out,” and road pricing mechanisms that seek to affect transportation demand and use.

Papers are available at http://www.trb-pricing.org/index.php?option=com_content&view=section&id=5&Itemid=55.

Forecasting Metropolitan Commercial and Freight Travel, J. Richard Kuzmyak, *NCHRP Synthesis 384*, January 2009.

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_384.pdf

From the preface: This report explores methods of freight and commercial vehicle forecasting currently in professional practice, along with promising methods emerging from ongoing research. The primary focus of the report is on metropolitan-level forecasting, although some consideration is given to statewide freight models.

Truck Tolling—Understanding Industry Tradeoffs When Using or Avoiding Toll Facilities, Wayne McDaniel, NCHRP Project 19-09, In Progress, Start Date December 2009, End Date June 2011.

<http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2662>

This study seeks to identify a) how goods movement businesses—including trucking companies, shippers and receivers—value the transportation roadway network and b) their willingness to pay tolls for that value. These companies are generally ardent critics of using tolls to address the nation’s congestion, environmental, and roadway transportation infrastructure needs.

To determine the willingness of the trucking industry to pay tolls, the project research team is conducting a literature search, interviewing officials from different sectors of the trucking and shipping industry, and administering an on-line survey of trucking firms here: <http://www.trucktolling.org>. Survey respondents are asked to anonymously classify their trucking business by length of haul, and by type of carrier: e.g., LTL, private, Independent Owner Operator. The project team will apply statistical analysis to the survey results to identify the factors under consideration for paying tolls and the statistical strength of those factors in a given segment of the shipping or trucking industries.

Researchers submitted a working paper on April 2010.

The Fuel Tax and Alternatives for Transportation Funding, Jens Schade, Bernhard Schlag, Special Report 285, Transportation Research Board, 2006.

<http://onlinepubs.trb.org/onlinepubs/sr/sr285.pdf>

This report examines the viability of existing revenue sources, the merits of present transportation finance arrangements and potential directions for reform of transportation finance. According to the report, fuel taxes can remain the primary funding source for the nation's highways for at least another decade, but eventually replacing them with a system for metering road use and charging accordingly could benefit travelers and the public. In addition, the committee that developed the report suggests that while the current funding system helps maintain existing highways and build new ones and ensures that users pay most of these costs, it does not help transportation agencies alleviate congestion or target investment in the most valuable projects.

Alternative Approaches to the Taxation of Heavy Vehicles, Herbert Weinblatt, *NCHRP Report 416*, 1998.

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_416.pdf

From the abstract: This report contains recommendations that are applicable to federal and state governments for evaluating alternatives to the taxation of heavy vehicles. An evaluation procedure and general assessments and recommendations on future activities are presented. The report provides guidance and resource material for use by federal and state agencies. The results will be of interest to those who deal with the identification of revenue sources for highway purposes and to the motor carrier industry. The contents are organized as follows: Summary; (1) Introduction; (2) Heavy Vehicle Taxation Systems; (3) International Experience; (4) State Taxes Paid by Heavy Vehicles; (5) Technology; (6) Evaluation Criteria; (7) Qualitative Evaluations of Generic Taxation Systems; (8) Conclusions and Suggested Research; Appendix A—Survey Responses; and Appendix B—Questionnaire Used for Survey of the States.

Road Pricing for Congestion Management: A Survey of International Practice, NCHRP, March 1995.

http://www.trb.org/Publications/Blurbs/Road_Pricing_for_Congestion_Management_A_Survey_of_154420.aspx

From the abstract: This synthesis will be of interest to transportation agency administrators and managers, state and regional transportation planners, metropolitan planning organizations, policy makers, transportation economists, traffic engineers, and others concerned with reducing traffic congestion in urban areas. The synthesis describes the experience of several foreign countries that have used road pricing, or congestion pricing, as a means to manage congestion. The synthesis contains discussions of the policy, equity, and implementation issues associated with congestion pricing. Several of the schemes described were planned or implemented as methods to increase roadway funding rather than for congestion management, but have had the effect of changing travel patterns. The case examples describe the congestion management schemes in Singapore, Hong Kong, Norway, Sweden, France, the Netherlands, and the United Kingdom. This report of the Transportation Research Board also describes the various congestion pricing schemes implemented or proposed that rely on automated or electronic vehicle use charges. The case examples include ring roads, corridors, restricted areas or zones, and area wide applications. The opportunities and cautions for implementing similar congestion pricing measures in the United States are also discussed.

State Case Studies

Minnesota

Minnesota Pay-as-You-Drive Pricing Experiment, Maya Abou-Zeid, Moshe E. Ben-Akiva, Kevin F. Tierney, Kenneth R. Buckeye, Jeffrey N. Buxbaum, *Transportation Research Record*, Issue 2079, 2008: 8-14.

Abstract: <http://pubsindex.trb.org/view.aspx?id=878499>

From the abstract: The Minnesota Department of Transportation carried out a pay-as-you-drive demonstration simulating the replacement of the fixed costs of vehicle ownership and operation with variable costs that gave drivers explicit price signals about travel decisions and alternatives. The objective was to estimate the reduction in mileage due to the mileage-based pricing scheme. The study consisted of market assessment surveys and a field experiment. The experiment is the focus of this paper. The experimental design divided participants into three groups: a control-only group, a treatment-then-control group, and a control-then-treatment group. Participants in the treatment phase were subjected to per-mile prices, and the mileage of all participants was recorded for the entire study duration. Two types of analyses were conducted. Aggregate analyses using bootstrap methods to determine groupwise changes in mileage showed that participants reduced their mileage when charged on a per-mile basis, with the greatest reduction during the summer period when trips could be more discretionary in nature. In addition, to understand better the variance in mileage sensitivity to per-mile prices, disaggregate analyses were performed by using a matching method that matched members of the treatment group to those of the control group based on the probability of participation in the experiment and their baseline mileage. The resulting percentage change in mileage

was regressed against the percentage change in price and lifestyle variables. The price elasticity of peak-period mileage was found to be negative. However, in both aggregate and disaggregate analyses, the price effect was statistically insignificant as a result of the small sample size.

Alabama

Innovative Financing Sources for State Highways: Alabama Revenue from a Vehicle Mileage Road User Fee, Johnnie C. Waid, Rod E. Turochy, Virginia P. Sisiopiku, *Transportation Research Board 88th Annual Meeting Compendium of Papers DVD*, Paper #09-3620, 2009.

Abstract: <http://pubsindex.trb.org/view.aspx?id=882376>

From the abstract: Maintaining and constructing effective highway systems is important to mobility, public safety, and economic growth. Aging infrastructure, decreased revenue and increased construction and maintenance costs burden already declining transportation funding resources. This study investigates an innovative approach to highway funding and its potential for funding. Other traditional and innovative highway financing options are also noted. While several options are addressed, this paper focuses on the vehicle mileage road user fee as an alternate financing option for highways. Revenue source evaluation is based on revenue potential, equity, efficiency, and political acceptability. Using the state of Alabama as a case study, a sensitivity analysis of road user fee rates evaluates the revenue potential of a vehicle miles traveled based fee. An overview of the fee collection system and privacy issues is addressed. Based on the findings, recommendations are offered on the road user fee and other financing solutions with the best potential for implementation.

New York

New York City's Congestion Pricing Experience and Implications for Road Pricing Acceptance in the United States, Bruce Schaller, *Transportation Research Board 89th Annual Meeting Compendium of Papers DVD*, Paper #10-0519, 2010.

Abstract: <http://pubsindex.trb.org/view.aspx?id=909511>

From the abstract: Public acceptance is widely recognized as a major barrier to widespread adoption of road pricing in the United States and internationally. Using New York City as a case study, this paper analyzes how Mayor Michael Bloomberg's 2007 congestion pricing proposal gained widespread public support while ultimately being blocked in the State Legislature. The paper assesses the implications of New York's experience for pursuing congestion pricing and mileage-based taxes in the United States. A central conclusion from this analysis is that gaining approval of pricing will require changing how motorists view the effect of pricing on them personally. Given the power of even small groups of auto users to block pricing through the political process, pricing proposals need to be perceived as benefiting drivers individually and not simply society at large. The paper discusses approaches to road pricing in light of New York City's experience.

Oregon

Oregon Road User Fee Pilot Program

<http://www.oregon.gov/ODOT/HWY/RUFPP/index.shtml>

In 2006, Oregon conducted a 12-month pilot program on a mileage-based charge for road use to explore it as a replacement for its gas tax. The gas tax has not kept pace with inflation and collects fewer revenues as vehicles become more efficient. Further, voters oppose increases in the gas tax. The program included 285 volunteer vehicles, 299 motorists and two service stations in Portland. The following reports are related to this program:

Statewide Distance-Based User Charge: Case of Oregon, Lei Zhang, *Transportation Research Board 87th Annual Meeting Compendium of Papers DVD*, Paper #08-2183, 2008.

Abstract: <http://pubsindex.trb.org/view.aspx?id=848406>

From the abstract: Concerned about the declining purchasing power of gas tax revenue due to inflation, public opposition to tax increases, and improved fuel efficiency of new vehicles, the 2001 Oregon Legislature created the Road User Fee Task Force (RUFTF) to make recommendations regarding a potential replacement for the gasoline tax. Partly funded by the Federal Highway Administration (FHWA) Value Pricing Program, the RUFTF commissioned a series of studies in the past five years exploring theoretical, technological, institutional, and practical issues involved in a vehicle miles traveled (VMT)-based revenue collection system. A pilot study is currently being conducted in the Portland region with state-wide implementation expected following the 2009 Oregon State Legislature. These past and ongoing studies have examined a range of important issues associated with this innovative revenue mechanism, including its socio-economic, regional, energy-use, and environmental impacts,

on-board VMT tracking and communication systems, data transmission options at fee collection centers, pilot study design, policy deployment and implementation, public relations, and institutional options. Estimates on the distributional impacts of a flat-rate VMT fee on Oregon households based on income and location suggest the VMT fee is slightly more regressive than the gasoline tax. However, much of the tax burden is shifted from rural to urban households. Alternative rate structures for the actual vehicle mileage fees have also been considered in Oregon, including revenue-neutral flat rate, graduated rates based on fuel efficiency, total mileage, and level of congestion, location, time of day, income, and vehicle types. This paper summarizes findings of these previous studies in Oregon as there appears to be increased interests in mileage-based direct user charges from federal and other state transportation authorities, and in the research community. Since the general rationale and theory of this innovative financing option is well-known, the discussion focuses on the political, technological, and practical hurdles and solutions with regard to vehicle mileage fees.

Technology Evaluation of Oregon's Vehicle-Miles-Traveled Revenue Collection System: Lessons Learned, James Whitty, *Transportation Research Record*, Issue 2079, 2008: 37-44.

<http://pubsindex.trb.org/view.aspx?id=848267>

The main objectives of this paper are to present the technology performance results of the VMT-based solution gathered during the pilot test in Oregon, and to share the lessons learned from its subjective evaluation.

Responses to Oregon's Experiment in Road Pricing, Anthony M Rufolo, Thomas J. Kimpel, *Transportation Research Record*, Issue 2079, 2008: 1-7.

<http://trris.trb.org/view.aspx?id=847779>

From the abstract: The Oregon Department of Transportation tested a system to collect a vehicle-based mileage fee as a replacement for the Oregon gas tax. Devices based on the Global Positioning System were installed on participating vehicles to determine the location and time of vehicle travel. The only information collected was vehicle mileage by location and time category. Midway through the study, vehicles were assigned to one of three groups: control, vehicle miles traveled (VMT), and peak hour. The VMT group was charged a flat fee per mile traveled that approximated the amount of the state gas tax then paid by the average vehicle and was given a credit for the amount of gas tax included in the purchase. The peak hour group was charged a higher mileage fee during peak periods and given a discount on the mileage fee outside the peak times or peak zones. The control group continued to pay the price, including gas tax at the pump, as before. The VMT group showed a reduction in total mileage relative to the control group, and survey responses indicated that people did change their behavior even though there was little price differential. However, this change might have developed because of being in an experiment. The peak hour group showed about a 20 percent reduction in travel during peak periods relative to the VMT group. This reduction appeared to be due to the pricing system, because factors other than the congestion price differential were likely to affect each group similarly.

Oregon's Mileage Fee Concept and Road User Fee Pilot Program, James Whitty, Oregon Department of Transportation, 2007.

http://www.oregon.gov/ODOT/HWY/RUFPP/docs/RUFPP_finalreport.pdf

This report summarizes and assesses the results of Oregon's Road User Fee Pilot Program, which concluded March 25, 2007. It also identifies lessons learned and outlines the next steps toward implementation of a per-mile charge to replace the Oregon state fuel tax on gasoline as the principal method for funding Oregon's road system. Structured as a stand-alone report, this document provides the background, rationale and policy development behind the Oregon Mileage Fee Concept so that legislators, concerned Oregonians, and observers beyond Oregon's borders can understand the context for the Road User Fee Pilot Program that tested it. They may also use this document to judge the validity of the Oregon approach. The six-year history of this program produced more technical, policy and administrative background than can be presented in this report. Interested readers are invited to refer to previous reports to the Oregon Legislature and the numerous technical documents dating back to 2001, which detail each step building the foundation for the pilot program. Authors note (page 8) that heavy trucks did not pay the mileage fee under the Oregon Mileage Fee Concept because Oregon's weight-distance tax for heavy trucks would be retained. Nevertheless, the Oregon Mileage Fee Concept could easily accommodate inclusion of heavy trucks if a legislature so desired. (See also **Techniques for Assessing the Socio-Economic Effects of Vehicle Mileage Fees in Assessing Economic Efficiency and Trucking Industry Effects** of this report.)

International Case Studies

International Scan: Reducing Congestion & Funding Transportation Using Road Pricing, Federal Highway Administration, Federal Transit Administration, American Association of State Highway and Transportation Officials, National Cooperative Highway Research Program, April 2010.

<http://international.fhwa.dot.gov/pubs/roadpricing/roadpricing.pdf>

From the report: The purpose of the International Scan was to identify new ideas and practical, workable models for integrating road pricing approaches into state, local, and regional policies, programs, and practices. The scan team focused on two primary purposes of road pricing: (1) to manage demand and (2) to generate revenue. The findings are intended to inform the U.S. road pricing research agenda and identify best practices from international experience that will assist U.S. practitioners. The scan team visited with representatives from Sweden, the United Kingdom, Singapore, Germany, the Czech Republic, and the Netherlands in December 2009. The team was composed of representatives from the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA); the Georgia, Minnesota, Virginia, and Washington State Departments of Transportation; the Port Authority of New Jersey and New York; and SRF Consulting Group, Inc. A list of scan team members is presented on the back cover.

Africa

Fuel Taxes and Road-User Charges in LDCs: Some Lessons from Sub-Saharan Africa, Reuben Gronau, *Journal of Transport Economics and Policy*, Vol. 28, No. 3, 1994: 255-273.

Abstract: <http://www.jstor.org/pss/20053045>

Congestion and road damage are the two major externalities associated with road transport. These externalities are associated, in general, with different types of vehicles: urban congestion with private cars and road damage with heavy vehicles. The experience of Sub-Saharan Africa shows that the road damage externality is much more important than the urban congestion problem in less developed countries, in sharp contrast to the experience of the developed countries. If fuel taxes are used as substitutes for more sophisticated road-user charges, there is no justification for petrol taxes to exceed the taxes imposed on diesel fuel.

Europe

A Review of European Truck Tolling Schemes and Assessment of Their Possible Impact on Logistics Systems, A. McKinnon, *International Journal of Logistics Research and Applications*, Vol. 9, Issue 3, September 2006: 191-205.

<http://www.informaworld.com/smpp/content~db=all~content=a755228890>

From the abstract: Truck tolling schemes have been introduced in Switzerland, Austria and Germany. Britain was planning to launch a lorry road user charging (LRUC) system in 2008, though this has been indefinitely delayed. This paper reviews the various schemes and reveals wide differences in their objectives, coverage, technology, procedures and toll levels. The proposed British system would have been the most complex, allowing tolls to be varied by vehicle type, class of road, geographical area and time of day. The paper also assesses the possible effects of lorry road-user charging on a range of logistical variables, including system design, freight modal choice, truck utilisation, vehicle routing and the scheduling of deliveries. It shows how its logistical effects will depend on the nature of the tolling scheme and level of charges.

Germany

Heavy Vehicle Tolling in Germany: Performance, Outcomes and Lessons Learned for Future Pricing Efforts in Minnesota and the U.S., F. O. Robinson, State and Local Policy Program, Hubert Humphrey Institute for Public Affairs, University of Minnesota, October 2008.

<http://blog.lib.umn.edu/slpp/regionalities/Heavy%20Vehicle%20Tolling%20in%20Germany.pdf>

From the report: The purpose of this report is to describe the German “Heavy Goods Vehicle (HGV)” tolling system, including the rationale for its implementation, achievement of system objectives, outcomes and political issues surrounding the project. This report draws conclusions and makes inferences from lessons learned and their applicability to pricing efforts in Minnesota and the United States. This report also describes an alternative multi-country road charge system called Euro-Vignette, and Berlin’s Low Emission Zone environmental charge and restrictions.

The German HGV tolling approach has largely succeeded in achieving its stated objectives. A brief review of steps leading to system development, deployment and operations, and outcomes, provides some useful lessons for future pricing efforts in Minnesota and the United States.

1. A clear and strong rationale is needed to create support among affected stakeholders for any proposed pricing scheme. The fact that the 35 percent foreign heavy goods vehicles using the Autobahn would have to pay their fair share under the HGV tolling scheme was instrumental in securing support. Furthermore, the fact that all HGVs were charged a predictable and documental toll meant that toll charges could be passed on to consumers, ultimately. Prior to implementation, it was estimated that toll charges would result in an increase of 0.15 percent in the price of consumer goods; however, there has been no documented increases in consumer prices as a result of tolling charges.
2. A clear statement of objectives, subscribed to by stakeholders, interest groups and political parties, is key to securing broad support and necessary for guiding system development and measuring outcomes.
3. Ensuring adherence to principles that secure pre-implementation agreements.
4. A realistic implementation schedule has to consider the magnitude and complexity of the system as well as the time required to develop and integrate complex technologies. There is no question that the German HGV tolling system is the largest in magnitude (national coverage), complexity (applicable to all domestic and foreign trucks), having multi-factor toll rate application (distance-based, specific road type, number of axles, emission level), and technologically innovative in its integration of GPS, GSM, OBU's and DSRC, to name just the key elements
5. The impact of system requirements and specifications on system implementation and operation costs need to be considered early in the process, and adequate trade-offs need to be made at that time.
6. Concerns about privacy have to be addressed. In general, the trucking industry, which has been using advanced technology to track trucks for the past two decades, does not generally have the same level of concerns as individual auto drivers do. Nevertheless, the issue of data protection and security has been addressed by the HGV tolling system. A comprehensive data protection and security system has been implemented to protect system access—registration, route booking or payment—against unauthorized access or data tampering. Data gathering is limited to what is legally approved for purposes of toll collection. Data communications are protected using an encryption system developed for that purpose. No voice telephone communications with the OBU's is possible, since the system makes use of modified SIM cards, designed exclusively for data communications.

Germany's Mileage-Based Tolling: A Model for Minnesota?, Center for Transportation Studies, November 2008. www.cts.umn.edu/Publications/CTSReport/2008/11/GermanysMileage.html

This article details reactions to Germany's mileage-based tolling by Minnesota transportation officials at a "Rethinking Transportation Finance" roundtable.

GNSS-Based Tolling in Germany: Lessons Learned after Two Years of Operation, Alain Estiot, Johannes Springer, *Tollways*, Vol. 4, No. 2, 2007.

<http://tris.trb.org/view.aspx?id=849262>

From the abstract: In 2005, a distance-based road-charging system based on global navigation satellite systems (GNSS) was introduced in Germany for trucks with a permissible total weight of 12 tons or more. This paper provides an overview of the Toll Collect (TC) system and describes some of the lessons learned from its first two years of operation. The system covers the entire German Autobahn system. In the TC system, an onboard unit stores relevant vehicle data and automatically locates the vehicle's position on motorways using signals from a global positioning satellite. The onboard unit calculates the toll by determining whether the road segment the vehicle is driving on is subject to a toll and, if so, the toll rate. The data is periodically transmitted to a central computing center that stores billing information and transmits invoices. In the first two years of operation, the TC system was found to be over 99.50 percent accurate. The assessment of the system's first two years of operation found that when comparing tolling techniques for a motorway network, the investment should be measured over many years since sections are added or modified over time. Flexibility in a tolled network also was found to be very important. The component costs of the network followed the normal pattern of a product's life cycle: expensive at first, but reducing in cost as production increased. Although the system has been successful, there is still room for improvement in cost savings.

Mexico

An Analysis of Distance-Based Road User Charges in the Mexico City Metropolitan Area, Armado Crotte, *Transportation Research Board 89th Annual Meeting Compendium of Papers DVD*, Paper #10-0432, 2010.

Abstract: <http://pubsindex.trb.org/view.aspx?id=909465>

From the abstract: This paper presents a model based on traffic count data to evaluate the potential effects of distance-based road user charges in the Mexico City Metropolitan Area. The impact of marginal social cost pricing and environmental charges is assessed for both revenue raising and revenue neutral scenarios. Four user responses are allowed in the model: changes in vehicle occupancy, time switching, mode shift, and trip suppression. The model forecasts changes in traffic flows, speeds, public transport patronage and government revenue, for different area types and different times of the day. The results suggest that marginal social cost pricing would reduce traffic by about 14 percent and the revenues from the scheme would be equivalent to about 50 percent of the total Mexico City budget.

The Netherlands

The Economic Effects of Road Pricing in the Randstad Area, Erik Verhoef, Mark Lijesen, Alex Hoen, Free University Amsterdam, 1999.

<http://www.tinbergen.nl/discussionpapers/98078.pdf>

From the abstract: This paper gives an empirical analysis of the aggregate economic impacts of the planned introduction of road pricing in the Randstad area. A model is developed that allows distinguishing between the welfare effects on various types of traffic (freight, business and commuting) for different sectors. The welfare effects on sectoral profitability considered include the full travel time gains and tax payments for business and freight transport. The results indicate that the overall economic effect of road pricing is likely to be positive as long as the tax revenues are recycled into the economy. This is, of course, what one would expect from a policy that aims at achieving increased efficiency in the use of a certain “resource,” namely road capacity. In relative terms, road pricing appears to have only limited impacts on aggregate economic indicators. The results also demonstrate that the incidence of road pricing calculated may strongly depend on the measure of incidence considered. Whereas the primary incidence presented benefits from relatively moderate data requirements and a more limited number of assumptions that have to be made, the full economic effects presented can be qualified as a probably more correct measure, which, however, will suffer from a greater degree of uncertainty. Due to the rather different patterns found, however, it seems worthwhile to accept this uncertainty in exchange for further insights into the eventual effects that can arise, after all primary impacts have fully “trickled down” through the economic system.

Sweden

Distance Based Road User Charging for Heavy Vehicles—Experiences from Sweden, Lars Kallstrom, Michael Forss, 16th ITS World Congress and Exhibition on Intelligent Transport Systems and Services, 2009.

<http://tris.trb.org/view.aspx?id=908384>

From the abstract: This paper looks at the case of introducing a distance based tax for heavy vehicles in Sweden. It describes the political process so far and the parallel system development. The discussion concludes that it is necessary to decouple the issue of tax increase from the question of how the tax could be collected. It is also necessary to further specify the system and the business model in order to be able to answer questions about the cost effectiveness of the system, which are necessary as a basis for a parliamentary decision.

United Kingdom

An Evaluation of National Road User Charging in England, S. Glaister, D. J. Graham, *Transportation Research Part A: Policy and Practice*, Vol. 39, No. 7-9, 2005: 632-650.

Abstract: <http://www.sciencedirect.com/science/article/B6VG7-4G1R3N9-1/1/1128c2bfc4b4513f30d28186c7108aff>

In this study, a model is developed to test road user charging scenarios, including revenue raising and revenue neutral charging options and economically efficient pricing. The model is used to investigate the effect of road user charges across the whole of England if they reflected marginal social costs in full. For each policy scenario the authors estimate effects on traffic volumes, user charges and fares, subsidies, environmental costs, benefits to consumers, government revenue, and overall net benefits. Findings show that appropriate charging structures coupled with compensating reductions in existing motoring taxes can make a significant difference in traffic growth,

congestion and environmental damage. Appropriate charging schemes can also relieve some of the pressure to increase road capacity.

Does Britain or the United States have the Right Gasoline Tax?, I. W. H. Parry, K. A. Small, *The American Economic Review*, Vol. 95, No. 4, 2005: 1276-1289.

<http://rff.org/Documents/RFF-DP-02-12.pdf>

This paper develops an analytical framework for assessing the second-best optimal level of gasoline taxation taking into account unpriced pollution, congestion, and accident externalities, and interactions with the broader fiscal system. We provide calculations of the optimal taxes for the US and the UK under a wide variety of parameter scenarios, with the gasoline tax substituting for a distorting tax on labor income. Under our central parameter values, the second-best optimal gasoline tax is \$1.01/gal for the US and \$1.34/gal for the UK. These values are moderately sensitive to alternative parameter assumptions. The congestion externality is the largest component in both nations, and the higher optimal tax for the UK is due mainly to a higher assumed value for marginal congestion cost. Revenue-raising needs, incorporated in a “Ramsey” component, also play a significant role, as do accident externalities and local air pollution. The current gasoline tax in the UK (\$2.80/gal) is more than twice this estimated optimal level. Potential welfare gains from reducing it are estimated at nearly one-fourth the production cost of gasoline used in the UK. Even larger gains in the UK can be achieved by switching to a tax on vehicle miles with equal revenue yield. For the US, the welfare gains from optimizing the gasoline tax are smaller, but those from switching to an optimal tax on vehicle miles are very large.

Appendix A

Note that limitations of usage for this article require that Mn/DOT not post a version of this TRS to the Web that has this article appended.