# Data Challenges and Solutions in Implementing State-Level Mileage-Based User Fees in the United States

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**ABSTRACT**

Mileage-based user fees (MBUF) have been proposed as an alternative to the federal and state motor fuel tax for transportation funding. Multiple pilot programs have been conducted by states and have demonstrated technical feasibility. Results from pilots indicate effective data collection and MBUF calculation methods, private sector involvement via value-added services, interstate compatibility, and generation of public support through program involvement. Two permanent MBUF programs have been implemented, by Oregon and Utah. While pilots have found success on technical fronts, rate setting is an area that requires additional research. Rates need to be set correctly upon program implementation, considering factors such as anticipated administrative costs and disbursement needs. Increasing MBUF rates after implementation is expected to be met with resistance by the public and policy makers. Oregon and Utah currently use 1.8¢ per vehicle mile travelled (VMT) and 1.5¢ per VMT, respectively. This paper aims to provide a guideline for states to determine MBUF rates using existing data, so that states can set appropriate initial rates, and to address complications may arise in the process. An extensive compilation and comparison of available data on revenue, disbursements, and VMT was conducted. Three frameworks to calculate MBUFs for state administered roads are proposed, considering geographical scope, vehicle and area type, and across a range of disbursement categories. The resulting MBUF rates vary dramatically, suggesting that States need to critically explore the connection between disbursement needs and vehicle activity rates before setting rates or risk program failure.

# 1. INTRODUCTION

Transportation infrastructure funding in the USA largely comes from motor fuel taxes, which is charged per gallon purchased at the pump. As state DOT expenditures increase and the fuel tax revenue decreases, government agencies are looking for alternative methods of revenue generation. The federal government has completed studies on mileage-based user fees (MBUF)--which would replace the per gallon tax with a per-mile tax for each vehicle--but has not taken large-scale action (1). While a federal-level pilot program has yet to be established, numerous state departments of transportation (DOTs) have conducted pilot projects, and Oregon and Utah have created permanent MBUF programs. The private sector has provided technology and account management services to programs and pilots. Some of the benefits of MBUFs include increased cost recovery for new facilities, congestion management and traffic reduction, the ability to privately finance roadways, possible incentives for fuel efficient vehicles through lower rates, and a greater wealth of data for use in improving planning models (2).

This paper aims to discuss the existing literature on MBUF programs for passenger vehicles and to help states ensure they meet transportation funding needs given known data gaps, by aiding future state program implementation efforts through rate setting support. This paper also studies the available repositories of state-level data on revenue and disbursement categories of transportation funding. The paper aims to demonstrate which data may separately be needed to be collected for the design of various alternatives to the fuel tax.

## 1.1. Motor Fuel Tax Regimes and the Transportation Funding Status Quo

At present, the price of fuel paid by road-users at the pump includes state and federal fuel taxes (referred to hereafter as a 'gas tax'), as well as any associated sales tax, and is a fixed per gallon rate. This system does not require user identification or the collection of mileage data and ensures that the tax is paid with the purchase of gas. The gas tax is collected by a small number of fuel wholesalers, and is reallocated back to the respective state and federal DOTs, although states may receive slightly more or less back than they paid in (3). There are modest administrative costs associated with the collection and disbursement of gas taxes, which come primarily from implementation, operation, enforcement, and compliance costs. Gas taxes are attractive to jurisdictions as they have "low administrative and compliance costs", as well as "ease of implementation" according to the National Surface Transportation Policy and Revenue Study Commission (4). While state gas tax is intended to be used for transportation infrastructure maintenance and improvement, funds are often diverted to help with needs in other areas such as mass transit, debt service, sidewalk and pedestrian projects, school, police, or even state-level executive departments (3,5). Figure 1 summarizes the categories of inflowing revenue, and categories of disbursement outflows for various expense categories.

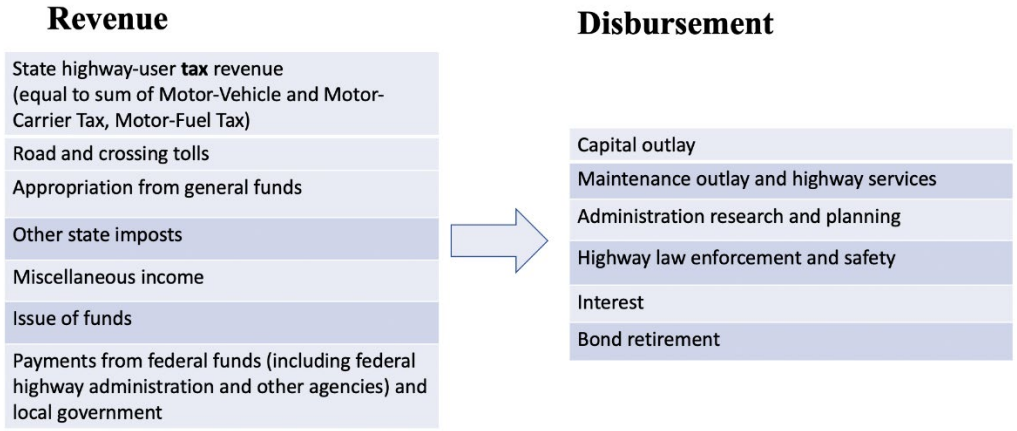


Figure 1: Typical Revenue and Disbursement Categories for Transportation Funding.

## 2. MBUF PILOTS & PROGRAMS: BACKGROUND

Before guidelines for rate setting are presented, it is important to gain an overview of the state of MBUF testing, research, and implementation. This allows for a better understanding of why rate setting is such a complex problem and how states can solve it. Given the fuel tax status quo, this section provides an overview of domestic U.S. MBUF efforts. Understanding the necessary shifts of administrative and technological requirements from the fuel tax system to a MBUF program is important for both policymakers and consumers.

### 2.1. Overview of Pilots and Programs

MBUF pilot programs and feasibility studies have been conducted throughout the United States since 2007. OReGO is an opt-in permanent MBUF program run by Oregon's DOT. Utah Road User Charge (RUC), the other permanent MBUF program in the U.S., is also opt-in but is only available to alternative fuel vehicles (AFV) (1,6,7). Pilots have primarily been conducted by state DOTs. Two state coalitions have been formed, RUC West and the Eastern Transportation Coalition (formerly known as the I-95 Corridor Coalition). These coalitions have focused on interstate compatibility, with the goal of making driving between states seamless for users of MBUF systems (8,9). All pilots have recruited participants on a volunteer basis. Some have conducted screening measures due to technical limitations (10). Table 1 shows how various pilots and programs compare. These programs were selected because they have sufficient literature available to the public.

Table 1: Categorization of Selected Key MBUF Pilots and Programs.

| Organizer | Scope (Local/State/Regional/National) | Number of Participants | Support (Y/N) | | Focus | Status | Data Collection Method | | | | Flat Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Out of state drivers | AFVs | | | Odometer Readings | GPS OBU | Non-GPS OBU | Embedded Telematics | |
| U of Iowa | National | 2650 | Y | - | Test national feasibility & assess public perception | Completed 2011 | x | x | x | | |
| OR DOT | State | >1600 (authorized for 5000) | N | Y | Permanent opt-in program OReGO | Permanent since 2015 | | x | x | | x |
| CO DOT | State | 147 | N | N | Test feasibility & assess public perception | Completed 2017 | x | x | x | | x |
| MN DOT | Regional (Wright County) | 500 | N | - | Test feasibility & assess public perception | Completed 2017 | | x | x | | |
| UT DOT | State | Unknown | N | Y | Permanent opt-in program for AFVs | Permanent since 2020 | x | x | | x | x |
| CA DOT | State/Regional | 5,129 | Y | Y | Test feasibility, complexity, security, acceptability, and interoperability | Completed 2017 | x | x | x | x | x |
| Eastern Transportation Coalition | Regional | 155 | Y | Included hybrids, no EVs | Understand what's necessary for smooth MBUF transition- focus on out of state mileage, amenities | Completed 2018 | | x | x | | |

In most MBUF pilots, users are offered multiple options to report mileage. These options correspond to the data collection methods in Table 1. Odometer readings can be reported by submitting pictures online or in person at vehicle inspections. Although this option presents challenges to the state, such as tracking out of state mileage and relying on users to provide their mileage in a timely manner, it

protects user privacy. An onboard unit (OBU) is a small device that usually plugs into vehicles' OBD-II port to track mileage and provide additional features. OBUs were the most common approach in pilot programs. Use of embedded telematics entails working with auto makers to take advantage of a vehicle's existing telematics software to track mileage without additional hardware. Embedded telematics and OBUs are accurate and effective, with the added bonus of being semi-permanent and automatic, meaning users do not have to remember to turn them on or report data manually. Use of phone apps to track mileage was also explored in pilot programs. These apps seem to be less accurate than OBUs and less reliable as they require users to remember to turn them on when they start driving (11). Flat fees allow users to participate in MBUF without submitting mileage data, instead paying to drive unlimited miles for a fixed period.

One of the draws of implementing MBUF in place of a fuel tax is that it is a more direct source of funding that fulfills the "user pays" principle. As a fee, the generated revenue will likely have restrictions on where it can be used, i.e. only for road maintenance and improvement services. Therefore, all passenger vehicle owners, including those of AFVs, would be paying for the deterioration they deal to the roads they use. MBUF has been examined in terms of equity across multiple characteristics. One study found, with a high degree of certainty, that MBUF is no more or less regressive than the fuel tax (12). However, current MBUF programs (OReGO and Utah's RUC program) require credit or debit cards as payment. This could prove to be a significant barrier to socioeconomic equity considering 25% of US households are unbanked or underbanked (13). Privacy has been identified as a concern to the public, which could be a constraint for program development. The general public remains skeptical, even if MBUF pilots and programs implement specific technical safeguards to ensure privacy, including differential rate structures for those unwilling to share location (14). While most pilots have circumvented this issue by limiting the data collected to vehicle-specific characteristics, such as mileage, fuel efficiency, and fuel consumption, it has resulted in a tradeoff between accurate location tracking, and thus rates charged, and easing the public's privacy concerns.

Pilots have found technological success and demonstrated potential to generate revenue via MBUF. They have found limited success in gaining public support. After participation, pilot participants have generally positive views of MBUF (6,10,11,15,16). Areas identified for additional research include privacy, interstate compatibility, implementation and administrative costs, and rate setting. Pilots have also begun to address how the private sector can be integrated into MBUF, a public sector project, via value-added and account management services.

### 2.2. Rate Setting Efforts

Most MBUF pilots have not attempted to determine the optimal per mile rate or rate setting structure, instead choosing to focus on studying technology, implementation, and public perception issues. In addition, most pilots have generated hypothetical revenues. Real money is not exchanged between agency and user. Programs, on the other hand, have found success in collecting revenue. Pilots have often chosen a per mile rate that aims to approximate the per mile rate that users pay under the fuel tax (6,10,11,15,16). This approximated rate is typically found by dividing the fuel tax revenue in the state by the total vehicle miles traveled by gasoline powered passenger vehicles. However, modeling a permanent rate after the existing fuel tax revenue model will carry over the deficit and prove insufficient to fund the transportation system.

Some pilots have varied their rate based on different factors (10). For example, Minnesota's pilot found its baseline rate using the same method as other states. It then created a rate schedule with rates slightly under the baseline and slightly over it to encourage certain behaviors, like keeping location tracking on (15). Programs have not placed emphasis on dividing by vehicle class. Oregon has a separate weight-by-mile tax for its freight vehicles (26,000 lbs.), and so OReGO does not charge vehicles by weight or class, citing reasons that weighing vehicles is impractical and that passenger vehicles (under

10,000 lbs.) cause less damage than freight vehicles (17). However, while pilots have not tested variable mileage rates based on vehicle class, studies have suggested increasing and varying rates as alternative solutions to decrease agency cost. States have considered a rate structure that could vary fees based on factors like location, time of day, vehicle age and fuel economy, vehicle weight, etc. (10,16,18). No program has implemented this permanently. Both vehicle registration fees and MBUF rates should be indexed to account for inflation.

The rate setup for OReGO and Utah's RUC program, the two permanent domestic programs, are similar. OReGO uses a fixed rate of 1.8¢ per VMT, which has increased from its initial rate of 1.5¢ per VMT when the program started (17). According to OReGO, this rate was set to approximate fuel tax that would be paid by a vehicle getting about 20 MPG with an administrative cost component (6). Utah's RUC program charges a fixed rate of 1.5¢ per VMT until users hit the flat annual fee limit of $120, which is equivalent to driving 8000 miles at the given rate. Utah AFV Drivers that opt out of RUC have to pay the flat fee of $120 specifically for AFVs during annual registration. As such, Utah's DOT decided to cap the program at the same flat fee (7).

## 3. INFERENCES FROM PAST MBUF STUDIES RELEVANT TO RATE SETTING

Pilot programs have demonstrated that there is no "one size fits all" MBUF solution, but that good strategies exist. Overall, more research is needed in this area to determine rates that generate the necessary amount of revenue for states and maintain a fair and straightforward system that citizens can understand. Minnesota's pilot program report states that rate setting is "probably one of the largest challenges when it comes to deploying MBUF" (15).

### 3.1. Addressing the Funding Deficit

Pilot programs' rates have been generally estimated as "revenue neutral", with the goal of generating the same revenue as the existing state fuel tax system. However, a rate set in this manner may not be enough to meet states' DOT expenditures. MBUF revenue, or any fuel tax alternative considered, should meet road capital and maintenance expenditures at a minimum. Increased revenue from MBUF may affect how much federal funding is received by the state (19). As a thought example, a state could consider that they need to generate a level of funding "X", which is inclusive of the funding available from state gasoline taxes and which is not otherwise disbursed into non-highway activities such as law enforcement or administrative costs. They could also seek to obtain additional revenue above the equivalent gas tax amount to account for alternatively fueled vehicles, or to remedy deferred maintenance after years of lower than necessary funding. But finding this amount is critical, as users will likely balk at subsequent fee increases beyond those set at the time of program initiation.

Each state has a different portfolio of revenues which needs to be considered to close the deficit gap and set the appropriate MBUF rate. For example, New York has already attempted to generate more funding through increasing motor vehicle registration and drivers' license fees, but feels that these prices are hitting the maximum value that the public is willing to pay. Therefore, short term borrowing should also be considered to close the funding gap, while investing in long term MBUF technology (20). This would facilitate a reasonable MBUF rate and decrease the funding deficit in a timely manner. An alternative solution to addressing the funding deficit is through a phased approach in introducing MBUF. In the short term, the existing fuel tax would increase, the vehicle registration fee system would be indexed, along with additional minor tax adjustments, as their planning and implementation costs are negligible in comparison. Pilots can be introduced in the medium term to help generate public awareness and support, as well as policy support. The long-term solution would remove the fuel tax and implement a permanent MBUF program (18). While setting the appropriate rate has not been the focus of MBUF studies and pilots so far, the funding deficit should not be ignored as it is inherently tied to rate setting and cost considerations.

### 3.2. Program Administrative Costs

One drawback of MBUF is that its administrative costs are higher than those of the fuel tax. The fuel tax is collected from a relatively small number of fuel wholesalers, whereas MBUF will require setup, billing, and account management for all users. If using the MBUF rate based on fuel tax revenue model, high MBUF administrative costs may cause an even larger road funding deficit. The administrative cost of MBUF is highly dependent on the type of technology employed, the number of participating drivers, total revenue, etc. While MBUF has the potential to generate much more revenue than fuel taxes, the implementation cost is anticipated to be significant and could greatly impact an already depleted transportation fund. If an MBUF program generated the same amount of revenue as the gas tax, the administrative cost of MBUF could reach almost 20% of the revenue generated. This is much higher than the gas tax's administrative costs, which are estimated to be 0.2%-1% of revenue for federal taxes, and 1% of revenue for state taxes (14).

Research and cooperation with the private sector to further develop technologies may decrease costs. Agencies should look towards short or mid-term solutions, such as those mentioned in the previous section, for solving the funding shortfall from the gas tax and the added burden of MBUF implementation costs. Adding a yearly flat rate charge for users to use the roads, adding compliance mechanisms to ensure users pay, and cooperating with other states to achieve economies of scale could also help address cost issues.

### 3.3. Logistics of Fee Assessment

Any MBUF system should be designed to replace the fuel tax in the long term to avoid double charging users. Charting a path to where state gas taxes are not being paid at the pump remains one of the main challenges in a transition to MBUF. However, near term solutions to prevent double taxing exist. OReGO demonstrates real life success of net value invoicing. Fuel consumption is reported by an OBU or is estimated by applying the recorded miles driven to the vehicle's combined EPA rating. This fuel consumption is multiplied by the gas tax and is then turned into a gas tax credit on user invoices (6). As mentioned previously, Utah has taken double taxation into consideration by capping the potential RUC charges at $120, the flat rate charged to AFV drivers who opt out of the MBUF program (7).

Going forward, for states considering MBUF/RUC programs, with respect to setting fees, three critical high-level decisions need to be made:

1. How much is highway revenue expected to be collected through fees, net of any diversions to non-highway purposes?
2. What type of fee will be set (e.g., flat fee per year, or fee per-mile driven)?
3. Will the fee vary by vehicle type, area of residence, type or location of highway traveled, etc.?

## 4. DATA SOURCES AND CASE STUDY FOR RATE SETTING

Given the overall goals and trajectories of recent MBUF/RUC programs in the US, specifically with respect to the critical task of creating fee structures and rates, the available repositories of state-level data on collections and disbursements of transportation funding were studied. This section demonstrates which sources are useful and available to states looking to set rates, as well as what data they may separately need to collect for various types of fees. One of the best-known data sources about highways and funding is US DOT's Highway Statistics (HS) series of data releases. HS has been produced on a nearly annual basis from 1992-2018, with annual reports containing information on motor fuel, motor vehicle registrations, driver licenses, highway user taxation, highway mileage, revenues, and disbursements (21). The data are collected and reported to US DOT by state DOTs.

Given that there is no central documentation of the datasets, all tables in the HS data were exhaustively studied. This included creating connections between tables to cross-validate entries (e.g., ensuring total entries in one table matched corresponding values in another, matching federal funds

distributed to those spent, etc.) and to perform other quality checks. Table counts and formats vary over time, with subsections varying from 7 to 14. Some tables (e.g., SF-12) are not reported for some years. In terms of data on revenues, disbursements, and VMT as needed for MBUF studies, four primary conclusions were made. First, it can be difficult to track from the HS data the flow between revenues such as gas taxes and disbursements, especially when concerned about specific types of roads. Second, there is bias towards collecting and reporting data for particular high-level road systems of federal interest (federal-aid highways, National Highway System, etc.). Third, it can be challenging to track revenue flows from a source through different level of roadway ownership (federal, state and local) and functional systems. Finally, connecting revenues, disbursements, and VMT at higher resolution is challenging because there is a mismatch between estimates of VMT and mileage between tables, e.g., state level disbursement for different roads exists, but not corresponding VMT at state level on different roads. Relying solely on the nationally organized HS data could be problematic for any type of detailed MBUF setting exercise.

Table 2: Available State-Level Highway Statistics Revenue, Disbursement and VMT Data (21).

| Name | Description of Table Contents and Detail |
|---|---|
| **Revenue Tables (units: thousands of dollars)** | |
| HDF | Highway-user revenue sources (e.g., federal fuel tax, state fuel tax, state, and local tolls) and their disposition (e.g., for highways, for mass transit) for all levels of government (federal, state, and local) |
| HF-1 | Disposition of highway-user revenues for highways, all levels of government |
| SF-1 | Revenues used by the state for highways, from all sources (e.g., state fuel taxes, vehicle taxes, and federal funds, etc.). |
| SF-3 | Revenues used by state for only state administered highways (same columns as SF-1) |
| **Disbursement Tables (units: thousands of dollars)** | |
| HF-2 | Disbursement (e.g., capital outlay, maintenance outlay, administration, etc.) of transportation revenues across all units of government. Capital and maintenance include the disbursement on state-administered, local-administered, and federal roads, respectively |
| SF-2 | Disbursement (e.g., capital, maintenance, administration, etc.) of state government funds on state administered highways and local roads and streets |
| SF-21 | State receipts and disbursements for highways detailed in Tables SF-1 (receipts) and SF-2 (disbursements). A key difference between state results is the presence of toll roads. |
| LGF-2 | Disbursement (e.g., capital, maintenance, administration, etc.) from local government |
| SF-4 | Disbursement (e.g., capital, maintenance, administration, etc.) of state administered highways, not including local roads and streets (SF-2 includes this). |
| SF-12 | State capital and maintenance outlays, classified by functional system and rural/urban/urbanized area |
| **VMT Tables (units: millions of miles)** | |
| VM-1 | Annual vehicle distance traveled by highway functional system and vehicle type, a national scale table |
| VM-2 | Annual vehicle traveled by functional system for each state |

Despite the data challenges mentioned above, in terms of revenue and disbursements, and VMT, there is significant detailed data already accessible by state stakeholders in the HS data to formulate revenue targets. Given the findings above related to the likely needs of states pursuing MBUFs, and the available data sources were summarized, and some example calculations were provided to help demonstrate the criticality of ex ante analysis when setting rates. *Table 2* summarizes the data of most interest to agencies considering MBUF rate setting. Additional or more detailed data may be available within state DOTs to improve upon these results but were not pursued given the intentional scope of publicly accessible data.

The two other critical needs for fee setting mentioned above were related to type of fee (flat or not), and the level of resolution of the fees (e.g., equal for all types of roads and vehicles, or varying by vehicle type, location or road type). Data available in highway statistics can support many but not all of these strategies. The most relevant data for these activities are those associated with the applicable revenue/disbursement categories within the scope of the MBUF, and the VMT. Table 3 summarizes four potential methods for estimating an exact replacement of disbursements for state administered roads using national data sources (HS), that might be useful in framing the discussions about the funds needed via MBUFs. Note that these are not necessarily "revenue neutral" from gas tax replacement because states are typically generating multiple revenue streams to pay for transportation infrastructure. These examples all solve for the MBUF rate needed to pay for the selected disbursements, regardless of the revenue categories such as driver or vehicle license fees (which could be accounted for in the rates if desired). The scope focused on state-administered roads as the financial and VMT data can be directly seen in the HS data; however, some of the funding for these roads comes from federal sources.

Table 3: Example MBUF rate policies for state-administered roads using data from year 2018 (21).

| **Calculation Method** | | **Tables Used** | **Example Calculation** | | |
|---|---|---|---|---|---|
| | | | **Location** | **Disbursement Categories Included** | **Result (¢/mi)** |
| Example 1: Total highway spending in PA / Total VMT in PA | | SF-12 / VM - 2 | Pennsylvania | Total Capital + Maintenance outlay | 4.8 |
| | | SF-4 / VM-2 | Pennsylvania | Total Capital + Maintenance outlay + service + administration + safety | 7.2 |
| | | | | Total disbursement | 10.7 |
| Example 2: Total disbursement in USA / Total VMT in USA | | HF-2 / VM-1 | National | Total Capital + Maintenance outlay | 4.9 |
| | | | | Total Capital + Maintenance outlay + service + administration + safety | 6.0 |
| | | | | Total disbursement | 6.9 |
| Example 3: Disbursement in urban or rural area in PA / Total VMT in rural or urban area in PA) | Urban Area | SF-12 / VM - 2 | Pennsylvania | Only urban area Capital + Maintenance outlay | 3.8 |
| | Rural Area | | | Only rural area Capital + Maintenance outlay | 6.8 |

In Table 3, Example 1 shows an MBUF set in Pennsylvania to pay for only capital and maintenance of highways in 2018 should be set at 4.8¢ per mile, by dividing total highway disbursements to these two categories from SF-12 by the total annual VMT on all roads in PA in VM-2. However, Pennsylvania also disburses significant funds to other categories, and the rate needed to pay for all disbursement categories (including police enforcement and others that are partly paid by fuel taxes) would be 10.7¢ per mile. An intermediate example rate is 7.2¢ per mile. Example 3, an MBUF that is tiered to urban or rural travel would yield rates of 3.8¢ and 6.8¢ per mile, respectively, which is consistent with a single overall rate of 4.8¢ per mile. This was found by dividing total annual spending on rural or urban roads by the total VMT of rural or urban roads. Nationally, Example 2 shows an MBUF parallel to those for just Pennsylvania would be priced between 4.9 and 6.9¢ per mile.

While this is a hypothetical example given an artificial constraint of state-administered roads, it demonstrates the wide range of MBUFs needed as additional disbursements are covered. Existing revenue generation comparisons are relevant in aggregate terms (total fuel taxes collected per year) to compare against these values to assess how the revenue from the MBUF would compare to that of the state gas tax. But the details of this example also demonstrate the data constraints. It is not possible, for example, to use the existing HS data to find total disbursements on Interstate highways as well as total VMT on Interstates; thus, estimating an example MBUF rate for only Interstate highways is not possible. Likewise, there is insufficient data to fully separate VMT amongst the light- and heavy-duty fleets, to create separate MBUFs for passenger vehicles and commercial trucks, as is being done through pilots.

## 5. DISCUSSION

These results demonstrate the complexities embedded in the transition from fuel taxes to MBUFs. There are various other challenges associated with setting rates, such as out-of-state drivers and privacy considerations. Even if states set rates as demonstrated above, they would be challenged to fully collect these revenues, as out-of-state vehicles under a different MBUF regime would not be paying to the State; however, out of state vehicles tend to be a relatively small percent of VMT. Only a handful of pilots have been successful in tackling the issue of out-of-state drivers. These have mostly used GPS-enabled OBUs to identify the taxing jurisdictions in which the vehicle traveled for accurate MBUF charges (10,11). On the other hand, states that choose not to collect revenue from out-of-state drivers requires in-state drivers to make up the difference.

As more states participate, presumably rates can be set and collected for each state using common technology. Experiences with multi state tolling systems, like E-ZPass and its Interagency Group (IAG), have already accomplished multi-state technology integration and implementation. The International Fuel Tax Agreement and the International Registration Plan provide other examples of cross-jurisdictional cooperation (9). Privacy is another important consideration in developing and setting rates. Location-based fee approaches have a tradeoff of providing less privacy for users by requiring location tracking. Users of any MBUF system should have options for data collection that allow them to avoid sharing their location to an agency, as demonstrated in several pilots. This can facilitate public acceptance (22). A sample program might offer users an OBU with location tracking enabled, an OBU without location tracking enabled, or a flat fee that allows users to use roads without having their mileage tracked at all for an annual price. Connecting this example to the sample calculations in Table 3, users who choose the location enabled OBU might pay the rate listed in the result column (e.g., in Example 3 a rural-urban rate of either 3.8¢ or 6.8¢ per mile). Users who are unwilling to enable location tracking would be charged the maximum (6.8¢), which assumes all of their driving is in the highest rate. Users are thus motivated to provide location data, which is synergistically valuable for state infrastructure planning. The magnitude of the flat fee could be determined by assuming that flat fee users drive significantly more miles than the average user (e.g., at the 90$^{th}$ percentile of VMT) and multiplying their assumed mileage by either the location enabled or non-location enabled rate. Setting a high flat fee ensures that users that drive many miles cannot use the flat fee to avoid paying their fair share.

## 6. CONCLUSION

MBUF pilots and studies have been carried out by state DOTs to investigate whether MBUF is a viable replacement for the fuel tax. Pilots and studies demonstrate that MBUF is technically feasible and the necessary infrastructure design exists for efficient data and revenue collection. However, there are many outstanding administrative, privacy, cost, and other policy considerations that have not been resolved by research or pilots.

A commonly stated goal of MBUF programs is to fund highways by replacing state gas tax revenues. However, various states have more complex revenue and disbursement mechanisms that would require more complex MBUF arrangements. In particular, states should be more focused on which disbursements – not revenues – they are trying to offset with transportation fees. The main issue addressed in this study is how to determine the financial viability of a MBUF program. Setting the rate requires careful consideration of anticipated administrative costs (which are not yet well understood) and disbursement goals, so rates do not need to be increased soon after implementation, undermining consumer acceptance.

While this paper provides a guideline on how states can approach the rate setting issue, it is highly dependent on the state and its unique set of circumstances (e.g. revenue portfolio, funding deficit amount). The process of analyzing current data revealed that current data does not provide full necessary visibility into the relationship between revenue generated and disbursement. Without full visibility, states may struggle to determine an optimal MBUF rate. It took an exhaustive effort to compile and cross-check the HS data. In addition, the inevitable commingling of federal and state fuel tax revenues makes it difficult to accurately assess funding needs only from state-level sources. States and the federal government need to create better datasets that more explicitly separate funding sources to aid with these considerations. To make rate setting studies more feasible, data could be organized into a single repository that builds upon the infrastructure of the Highway Statistics data but adds additional levels of detail that are likely collected by states but not reported to the US DOT.

## AUTHOR CONTRIBUTIONS

RS and SD performed MBUF pilot literature review and edited entire document. LL and CY performed the review of HS data and synthesized data opportunities and challenges into this manuscript. PA and ZF contributed to overall discussions related to the structure and message of the manuscript and edited it. HM and DM guided and supervised research, provided studies and data sources, and edited final manuscript.

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## GLOSSARY

Table 4 introduces common terminology used when discussing MBUF.

Table 4: Terminology Reference Table

| Term | Explanation |
|---|---|
| MBUF | Mileage Based User Fee |
| VMT | Vehicle Miles Traveled. Refers to the total amount of mileage traveled, not a fee unless "fee" is written after it |
| RUC | Road User Charge. Same as MBUF |
| OBU | Onboard Unit. A device placed onboard a vehicle to track mileage data. Often offers other features as well, e.g. vehicle health reports |
| OBD-II | Onboard device port. A specific port contained in most vehicles that devices such as OBUs can plug into and connect with the car. Typically found with cars manufactured after 1996. |
| CAM | Commercial Account Manager. Private company responsible for administering MBUF users' accounts, billing, and customer service. |

| | |
|---|---|
| SAM | State Account Manager. Performs the same services as CAMs for users who do not want to interact with a private company, or cannot. |
| AFV | Alternative Fuel Vehicle. Includes electric vehicles, plug-in hybrids, and gasoline hybrids |

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