Surface Transportation System Funding Alternatives Phase I Evaluation

Exploring a Mileage-Based User Fee in a Multi-State Region – Delaware Department of Transportation on Behalf of the Eastern Transportation Coalition

FHWA-HOP-19-045

January 2022

U.S. Department of Transportation
Federal Highway Administration

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16. Abstract

This report presents the independent evaluation results of Exploring a Mileage-Based User Fee in a Multi-State Region – an Eastern Transportation Corridor Coalition (TETC) initiative, which was funded through Phase I of the U.S. Department of Transportation's Surface Transportation System Funding Alternatives Program. Delaware is one of eight entities to engage in pilots or pre-pilot planning and development activities to explore a variety of options to demonstrate user-based alternative revenue mechanisms.

The U.S. Congress and the Federal Highway Administration (FHWA) seek to understand whether a user-fee structure, such as a road usage charge, is a viable substitute for the fuel tax and if such a structure can be implemented nationally at some time in the future. As part of this endeavor, FHWA is conducting evaluations of the eight grantee sites that received funding in Federal fiscal year 2016. The evaluation reports resulting from this process will allow the Secretary of Transportation and U.S. Congress to be aware of progress that has been made, lessons learned from initial pilot and planning efforts, the role of education and outreach, and the potential for any negative impacts on constituents and initial findings on administrative fees, among others.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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LIST OF ABBREVIATIONS

DMV	Department of Motor Vehicles
ECU	electronic control unit
EPA	U.S. Environmental Protection Agency
EU	European Union
FY	fiscal year
FAST	Fixing America's Surface Transportation
FHWA	Federal Highway Administration
GPS	Global Positioning System
IRB	Institutional Review Board
IVN	in-vehicle-network
MAP-21	Moving Ahead for Progress in the 21st Century Act
MBUF	mileage-based user fee
MPG	miles per gallon
MITM	man-in-the-middle
MRD	mileage recording device
MRO	mileage reporting option
OBD-II	onboard diagnostic standard II
OEM	original equipment manufacturer
PII	personally identifiable information
RUC	road usage charge
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
STSFA	Surface Transportation System Funding Alternative
TLS	Transport Layer Security
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation
UBI	usage-based insurance
VIN	vehicle identification number
VMT	vehicle miles traveled

EXECUTIVE SUMMARY

This report presents the independent evaluation results of Delaware's fiscal year (FY) 2016 Surface Transportation System Funding Alternatives (STSFA) grant project to explore the application of a mileage-based usage fee in a multi-State region. The Delaware Department of Transportation received $1.49 million in FY 2016 STSFA funds on behalf of the Eastern Transportation Coalition, formerly referred to as the I-95 Corridor Coalition (hereinafter referred to as the Coalition), from the U.S. Department of Transportation (USDOT). The Coalition is one of eight entities to engage in pilots, enhancements of independently funded pilots, or pre-pilot planning and development activities to explore a variety of options to demonstrate user-based alternative revenue mechanisms. The FY 2016 funding and associated grantee programs are referenced throughout this document as constituting Phase I of the STSFA program.

BACKGROUND

As vehicles become more fuel efficient, the reliability and adequacy of the motor fuel tax (MFT) as a primary source for transportation infrastructure funding continues to decline. Recognizing this trend, the Fixing America's Surface Transportation (FAST) Act[1] established the STSFA Program to provide grants to States or groups of States to demonstrate user-based alternative revenue mechanisms that employ a user-fee structure to maintain the long-term solvency of the Highway Trust Fund. The objectives of the STSFA program are to:

- Test the design, acceptance, and implementation of two or more future user-based alternative mechanisms.
- Improve the functionality of the user-based alternative revenue mechanisms.
- Conduct outreach to increase public awareness regarding the need for alternative funding sources for surface transportation programs and to provide information on possible approaches.
- Provide recommendations regarding adoption and implementation of user-based alternative revenue mechanisms.
- Minimize the administrative cost of any potential user-based alternative revenue mechanisms.

Staff from the Federal Highway Administration (FHWA) Headquarters in the Office of Operations have the overall responsibility for administering the program. The FHWA Division office staff provide direct support by overseeing the program in participating States.

The U.S. Congress and FHWA seek to understand whether a user-based alternative revenue mechanism that utilizes a user-fee structure could help maintain the long-term solvency of the Highway Trust Fund, and be implemented nationally at some time in the future. As part of this endeavor, FHWA evaluated seven of the eight grantee sites that received funding in Federal FY 2016.[2] The evaluation reports resulting from this process will allow the Secretary of Transportation and U.S. Congress to be aware of progress that has been made, lessons learned

[1] *Pub. L. 114-94, Section 6020, Dec. 4, 2015.*

[2] The Phase I evaluation for the eighth pilot site, Hawaii, is delayed due to a stalled pilot start.

from initial pilot and planning efforts, the role of education and outreach, and the potential for any negative impacts on constituents and initial findings on administrative fees, among others.

THE EASTERN TRANSPORTATION COALITION PILOT

As part of the Coalition's STSFA Phase I program, the Coalition planned and deployed a focused mileage-based user fee (MBUF) pilot in specific Coalition States.[3] The Coalition built upon the lessons learned from the MBUF explorations on the west coast as well as from toll interoperability experience within the Coalition States to explore potential synergies between mileage-based fees and tolling. With this focused pilot, the Coalition brought the effort to explore alternative revenue mechanisms to the east coast.

The Coalition's Phase I program identified the following key goals:

- Addressing regional issues necessary for national adoption and implementation of MBUF by:
  - Creating a low risk environment to address cross-State issues.
  - Balancing the unique needs of each State within a multi-State framework.
- Increasing public awareness of funding issues and assess the acceptance of MBUF by:
  - Educating the public about transportation revenue challenges and the MBUF solution.
  - Demonstrating the ease of use and viability of MBUF.
  - Addressing privacy concerns.
  - Addressing equity issues.
- Creating a low-cost framework to administer MBUF that would:
  - Identify cost-saving opportunities (e.g., standards) through a multi-State approach.
  - Address legislative barriers to MBUF implementation.
  - Include departments of motor vehicles (DMV) and other key stakeholders (e.g., tolling).
  - Include the private sector.

To achieve the goals, the Coalition proposed the following key activities:

Planning and pre-deployment: Activities to lay the foundation for a State to explore the MBUF concept in a low-risk environment. The scope of these planning activities was from a multi-State perspective to promote regional consistency and compatibility.

Deployment, operation, and evaluation of State-specific focused MBUF pilots: In addition to the planning effort and pre-deployment activities, the Coalition also proposed several initial MBUF pilots. These pilots were to be based on the Operational Concept Document developed as part of the planning effort. As a result of the planning effort and discussions with the partnering States, the pilot was identified as a focused pilot in Delaware with regional and national stakeholders.

[3] Coalition States include Connecticut, Delaware, District of Columbia, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Vermont, and Virginia.

MAJOR FINDINGS

The evaluation assessed the impacts of the STSFA-funded activities in a systematic manner across all sites. The key findings of the evaluation are summarized below.

Key Findings of the Eastern Transportation Coalition's Approach

The key findings of the Coalition's Phase I activities are summarized as follows:

- **Provided a range of options for mileage reporting:** The Phase I pilot included two types of technology-based options for mileage reporting. While one set of options relied on vehicle telematics using the vehicle's built-in OBD-II[4] port, the other relied on a smartphone. The approach involving vehicle telematics allowed participants to choose whether they wanted their location data to be recorded to compute the MBUF. The smartphone application required the phone's GPS to be on to record mileage. The Phase I pilot did not involve a manual reporting option.
- **Data security:** Data security aspects of the Coalition pilot are in line with the security approaches in other, similar pilots and were appropriate for this initial Phase of the project. Testing various data security measures was not a focus of the Coalition's Phase I efforts.
- **Privacy—perceived and real:** No obvious problems with data privacy were noted with the Coalition program, but as the pilot progresses to a higher number of participants, additional risks to trip data may need to be identified and addressed by incorporating improvements in system design to protect user privacy. Some of the privacy protections included in the Phase I pilot included all project team members signing a non-disclosure agreement regarding participants or the entities and States involved. Similarly, the contract with the Account Manager prevented the release or sale of any pilot data, and the destruction of all data 60 days following the completion of the pilot. The Coalition conducted participant surveys shortly after the pilot commenced and then again immediately after the pilot ended. The surveys included questions regarding privacy. The results showed that the pilot participants' concerns were mostly related to data security and privacy. However, the survey results also revealed that participation in the pilot helped reduce these concerns.
- **Flexibility to adapt and expand:** The technology options included in the Coalition pilot are generally flexible and incorporate the ability to expand to a large user base. For non-location-based mileage reporting options, the Coalition developed tables with estimated percentages for apportioning mileage between in-State and out-of-State travel. The latter approach does limit the flexibility of the system in a region where significant out-of-State travel occurs as these estimates may change both over time and with the program expanding to additional jurisdictions. It is important to note that low/ no-technology options were not included in the Phase I pilot.

[4] Onboard device systems give the vehicle owner or repair technician access to the status of the various vehicle subsystems. The OBD-II standard specifies the type of diagnostic connector and its pinout, the electrical signaling protocols available, and the messaging format. It also provides a candidate list of vehicle parameters to monitor along with how to encode the data for each.

- **Interoperability:** The Phase I pilot and the tolling proof-of-concept are an initial demonstration of the feasibility of the system, with 155 participants from 13 States. However, further demonstrations with a larger participant pool would be needed to understand the complexity of issues with interoperability at scale—both across State lines and with tolling. Differentiating between in-State and out-of-State mileage will be a key consideration for the eastern seaboard, given that 23 percent of all miles driven during the pilot occurred outside participants' home States.
- **Value-added amenities:** Amenities that the account managers were providing with the MBUF mileage reporting were a focus of the Phase I pilot. However, the pilot findings suggest that these were not as attractive to the pilot participants as the Coalition anticipated at the start of the project. Battery health and vehicle status were viewed by participants as having the highest value.
- **System costs:** Further analysis is needed to develop accurate estimates for system administrative costs as the pilot proceeds into future phases. Initial analysis shows that MBUF collection administrative costs are likely to be higher than fuel tax collection costs.
- **Equity and public perception issues:** These issues may need to be explored, analyzed, evaluated, and communicated in greater detail in future phases. The perceptions of inequity within the small participant community of the focused pilot is an indicator that the perception of inequity will be challenging in future phases as the number of participants and stakeholders increase.
- **Ease of use and public acceptance:** The Phase I pilot was successful in meeting its goal of increasing public awareness and education about MBUF and transportation funding in general. However, it is important to note that the focused pilot involved individuals and groups that could loosely be considered transportation stakeholders, and as such, their levels of acceptance of MBUF may not be considered representative of the public at large.

CHAPTER 1. INTRODUCTION

As vehicles become more fuel efficient, the reliability and adequacy of the motor fuel tax (MFT) as a primary source for transportation infrastructure funding has come into question. Recognizing this trend, the Fixing America's Surface Transportation (FAST) Act[5] of 2015 established the Surface Transportation System Funding Alternatives (STSFA) Program. The purpose of this program is to provide grants to States or groups of States to demonstrate user-based alternative revenue mechanisms that employ a user-fee structure to maintain the long-term solvency of the Highway Trust Fund.

> *"As states struggle to keep pace with increasing funding shortfalls and maintenance backlogs, lawmakers are exploring innovative approaches to increase revenues for transportation…A [road usage charge] goes one step further, potentially eliminating the need for a gas tax altogether, by charging drivers on a per-mile-driven basis. Proponents see this as a way to increase transportation revenues even as fuel purchases decrease and vehicle miles traveled increases, due to improved vehicle efficiency."*
>
> Source: National Conference of State Legislatures, "Road Use Charges (RUC)" webpage. Last accessed April 5, 2019.

By funding road usage charge pilots, the U.S. Congress and FHWA seek to understand whether a user-fee structure such as a road usage charge is a system that could be implemented nationally in the future. As part of this endeavor, the FHWA evaluated seven of the eight grantee sites that received funding in Federal FY 2016, also referred to as Phase I of the STSFA grant program.[6] The evaluation reports will inform the Secretary of Transportation and U.S. Congress of the progress that has been made, lessons learned from initial pilot and planning efforts, the role of education and outreach, the potential for any negative impacts on constituents, and initial findings on administrative fees, among others.

Staff from the Federal Highway Administration (FHWA) Headquarters in the Office of Operations have the overall responsibility for administering the program. The FHWA Division office staff provide direct support by overseeing the program in participating States. The independent evaluation of the program systematically assessed the impacts of the STSFA-funded activities conducted by each grantee across all sites. The objective of the evaluation was to document the applicability, motivation, and impediments to implementing user-based alternative revenue mechanisms as alternatives to the motor fuel tax on a nationwide level in the future. This report documents the findings of the independent evaluation of the Coalition's Phase I activities supported by the STSFA grant funds.

The evaluation team adopted the terminology used by the specific grantee sites in planning and executing their proposed programs. As such, same or similar concepts in different geographies may variably be referred to as mileage-based user fee (MBUF), distance-based user fee (DBUF), or road usage charge (RUC). Given the lack of a standard definition, these terms will be defined within the context of each grantee's program vision and activities.

[5] *Pub. L. 114-94, Section 6020, Dec. 4, 2015.*

[6] The Phase I evaluation for the eighth pilot site, Hawaii, is delayed due to delays in pilot start.

ORGANIZATION OF THIS REPORT

Chapter 1 of this report introduced the user-fee concept and the background and purpose of the pilot.

Chapter 2 details the activities planned and accomplished by the Coalition under Phase 1 of the STSFA grant program or the FY 2016 grant cycle.

Chapter 3 presents the evaluation framework as proposed under the 2016 Notice of Funding Opportunity, the key USDOT questions that the evaluation sought to address, and the evaluation team's approach.

Chapter 4 summarizes the major findings from evaluation of Phase I activities, including lessons learned, findings and outcomes as observed by the evaluation team, and suggestions for further exploration.

Chapter 5 provides a summary of the key takeaways from Phase I activities and lessons learned that would be relevant for a national implementation of a mileage-based fee program.

Chapter 6 presents the references that are used in this report.

THE EASTERN TRANSPORTATION COALITION: MILEAGE-BASED USER FEE IN A MULTI-STATE REGION

This chapter presents activities undertaken as part the Coalition's Phase I effort. The Coalition planned and deployed focused MBUF pilots in the Coalition States and, as such, introduced the exploration of alternative revenue mechanisms to the east coast. Further, the Coalition proposed to build upon the lessons learned from toll interoperability within the Coalition States and explore potential synergies between mileage-based fees and tolling. According to the Coalition's 2016 STSFA proposal. Because the Coalition crosses State lines and includes State, regional, and municipal organizations from Maine to Florida, it is well-positioned to examine the critical issues associated with a national shift in transportation funding. Given the large number of toll facilities within the Coalition States, potential synergies with tolling will also be examined. This work will build on other studies being conducted in western States.

Phase I of the Coalition's efforts involved a 3-month focused pilot to test an MBUF system and related concepts in Delaware with regional stakeholders. The pilot participants were identified by each State and included staff from State departments of transportation (DOT); project steering committee members; State legislators; local officials; and other regional stakeholders. These pilot participants did not make any actual payments; rather faux invoices, including fuel tax credits, were sent out monthly. The pilot was supposed to enhance understanding of technology issues and collect feedback from participants to help shape future exploratory efforts. The goals of the Coalition's Phase I pilot were to explore:

- Interoperability: Accurately recording out-of-State mileage for participants that chose both location-based and non-location-based mileage reporting options. The pilot also explored how MBUF funds would be transferred between States.
- Interoperability (tolling): Initial proof of concept to determine the feasibility of using MBUF technologies (with location capability) to calculate tolls on existing toll roads using the E-ZPass® toll charge structure.
- Public acceptance: Conduct education and outreach throughout the Phase 1 MBUF effort.

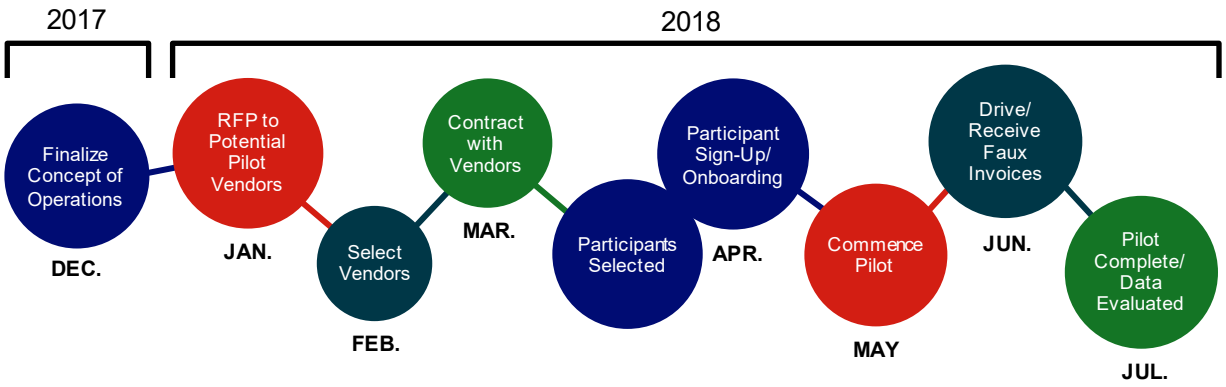
- Potential hurdles: Anticipated hurdles included privacy protection, equity concerns, ease of user compliance, flexibility and user choice, cost of administering the system, auditing, and compliance/enforcement.

SURFACE TRANSPORTATION SYSTEM FUNDING ALTERNATIVES PHASE I PROGRAM SUMMARY

The pilot ran from May through July of 2018 with a few participants continuing through August. Phase I primary activities included:

- Conducting operational concept workshops with Delaware and Pennsylvania.
- Developing operational concept documents for the Phase I pilot.
- Developing System Requirements Specification and Interface Control Documents, which were based on documents previously used in other recent MBUF pilots.
- Selecting an account manager, a process that included developing a request for proposals and evaluating the proposals submitted based on technical conformance to the specifications, ability to meet the schedule, and cost.
- Conducting system acceptance testing (in accordance with formal test plans) in early April 2018.
- Recruiting participants for the pilot: For this effort, the Delaware Department of Transportation (DelDOT) and the Pennsylvania Department of Transportation (PennDOT) took the lead in identifying participants from their States, including State DOT and department of motor vehicle (DMV) executives, legislative aids, staff from metropolitan planning organizations, and the media. The Coalition also recruited participants from other States and from national organizations with an interest in transportation funding. The recruited participants signed a participant agreement, enrolled in the pilot via a weblink, and installed the MBUF device or application for recording and transmitting mileage.
- Conducting focused pilot: The primary focus areas of the 3-month focused pilot, in addition to introducing transportation decision makers to the concept, included examining:
  - Out-of-State mileage: How will travel across boundaries be handled?
  - Tolling: What is the relationship between tolling and MBUF?
  - Amenities: Will value-added amenities help with public acceptance?
- Pilot data evaluation: The Coalition conducted participant surveys at two points during the Phase I project—shortly after the pilot commenced, and shortly after the completion of the pilot. The surveys were designed to collect information on overall participant awareness and perceptions of MBUF. In addition to direct participant feedback, other types of data that the Coalition collected during the pilot included comparisons of enrolled vehicles to vehicles reporting mileage, and comparisons of automated mileage reporting with participants' daily odometer logs.

Figure 1 shows the timeline of activities conducted by the Coalition to accomplish the Phase I tasks as well as the follow-on activities that took place later in 2018 as part of Phase II.



Source: The Coalition.

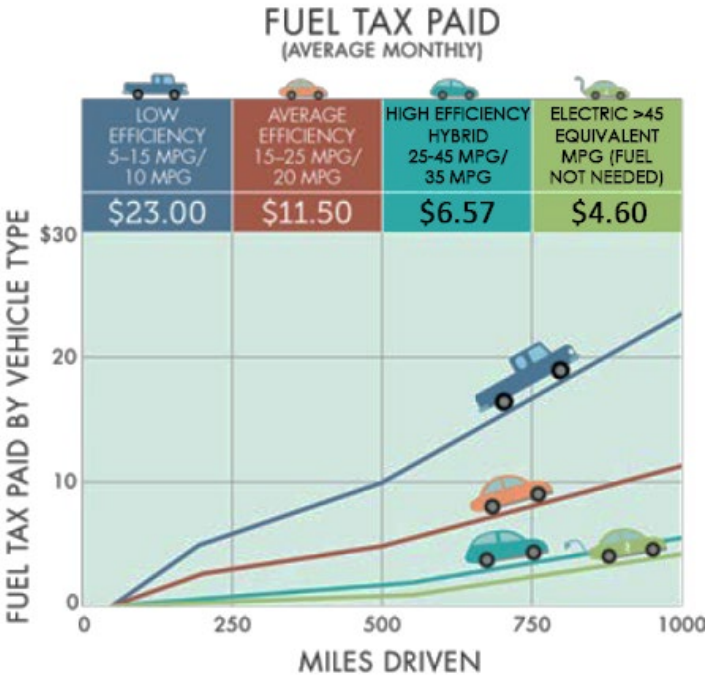
Figure 1. Diagram. Timeline for the Eastern Transportation Coalition Phase I pilot activities.[7]

Messaging to Stakeholders and General Public

Prior to and during the execution of the STSFA Phase I tasks, the Coalition messaging to stakeholders focused on the following key points:

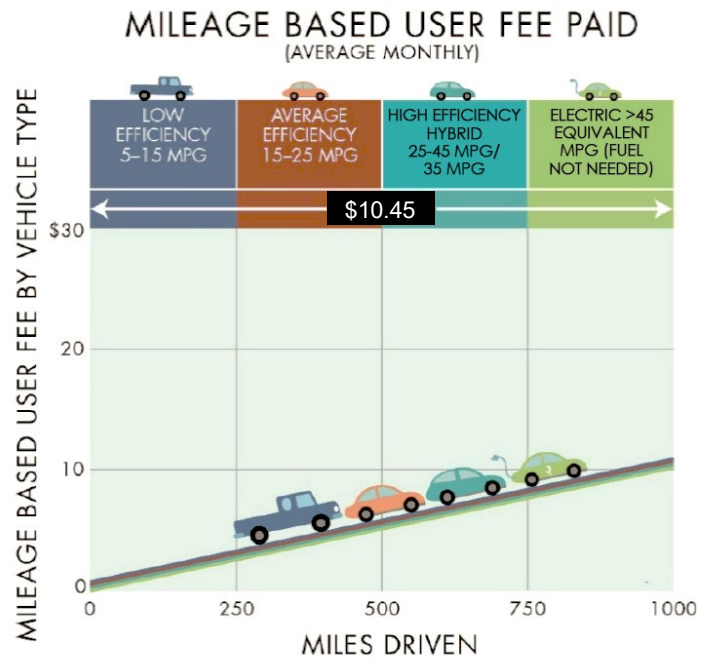
- The Coalition is neutral on the question of whether MBUF is the ultimate solution for the transportation funding shortfall faced by States across the country.
- The pilot is primarily a study designed to help the policy makers and participants understand the potential differences under an MBUF system versus the current fuel tax, and how a mileage-based revenue system will operate in real life.
- Equity is an important concern to the States(s) participating in the study. The study will explore equity across urban and rural areas. It is already known that an electric/ hybrid vehicle owner would pay more under an MBUF program, because they currently pay for only a little (or no) fuel tax. However, an owner of an older vehicle (and likely less fuel-efficient vehicle) will pay less under an MBUF program. The figures below provide some comparisons between the fuel tax and MBUF for Delaware vehicles with different average fuel economies (see figure 2).
- The study will respect the privacy of the drivers and protect personal information.

[7] Modified from I-95 Corridor Coalition's Report to USDOT on MBUF in a Multi-State Region, T201769010, January 2019.



Source: The Coalition.

A. Average monthly fuel tax paid.



Source: The Coalition.

B. Average monthly mileage-based user fee paid.

Figure 2. Diagram. Comparison of fuel tax and mileage-based user fee paid by vehicle fuel-efficiency category.

The Coalition developed an on-line calculator for drivers to compute and compare their current fuel tax burden and what they would be paying in an MBUF system.

Key Pilot Features

> ***Key Pilot Statistic***
> 20 percent of the miles driven were outside the State where the participant lived, confirming that addressing out-of-State mileage is critical to any MBUF exploration in this region.

The pilot conducted by the Coalition from May through July 2018 has the following key features:

- Participants: The pilot included 155 participants from 13 States. The recruitment was targeted towards specific individuals or groups of individuals. The Coalition assumed responsibility for recruiting other State DOT participants and national thought leaders in transportation financing.
- Key statistics: The pilot involved 459,458 miles driven, with 23 percent of those miles being outside the State where the participant lived. This confirmed that addressing out-of-State mileage is critical to any MBUF exploration in this region.
- Payments and invoicing: All MBUF payments were simulated, and no actual monies were used. Instead, faux invoices were sent out monthly showing what participants would have been charged under a mileage-based system. This structure served the main purpose of the pilot—to gain a better understanding of how a mileage-based user fee might work in real life.
- Mileage reporting: The account manager used the following technologies:
  - Plug-in device with location (State) of miles driven: A device designed to plug into a vehicle's OBD-II[8] port that automatically calculates the MBUF based on the State(s) where the vehicle was actually driven. The device combines mileage and fuel consumption data stored in the vehicle's computer with the location of the miles driven using a GPS chip. Taking the recorded mileage and location data, along with the amount of fuel consumed, drivers would pay for their miles driven based on the actual State(s) in which they drove and receive credits for fuel taxes paid. The per-mile rates and fuel tax credits used for this approach are shown in table 1. The per-mile rates were based on the concept of revenue neutral (i.e., a vehicle getting the national average of 22 MPG would pay the same in MBUF as is paid in State fuel tax).
  - Plug-in device without location (State) of the miles driven: A device designed to plug in to a vehicle's OBD-II port that automatically calculates the MBUF based on estimates of the State(s) in which the vehicle was driven. The device accesses mileage data and fuel consumption data stored in the vehicle's computer. Without location data, drivers pay for miles driven and receive credits for fuel taxes paid based on estimates of where the travel occurred, as shown in the table 2 (based on census data). The MBUF without location identification reduces privacy concerns regarding trip

[8] Onboard device systems give the vehicle owner or repair technician access to the status of the various vehicle subsystems. The OBD-II standard specifies the type of diagnostic connector and its pinout, the electrical signaling protocols available, and the messaging format. It also provides a candidate list of vehicle parameters to monitor along with how to encode the data for each.

data, but does not provide an accurate connection between the funds collected and where the road wear and tear occurs.

- Smartphone application with location: An application downloaded on the driver's smartphone that works with a credit card-sized device (beacon) to automatically calculate the MBUF. The smartphone uses GPS to measure mileage and record the State in which the miles are driven. The beacon is used to tie the smartphone application to a specific vehicle, otherwise trips taken with the smartphone via other modes or vehicles (i.e. train or in another vehicle) will be billed for that additional mileage. To work correctly, the beacon and smartphone must be in the vehicle. Combining the recorded mileage and location data with official vehicle fuel consumption ratings (as determined by the Environmental Protection Agency [EPA]), drivers pay for their miles driven based on the actual State(s) in which they drove and receive credits for fuel taxes paid.

- **Value-added services:** Value-added amenities offered to the Phase I pilot participants included trip logs, battery and vehicle health notifications, driving scores, and safe zones. Note that the widest array of value-added services was available to the participants choosing a plug-in device with location. The plug-in device without location offered less value-added services due to the absence of location technology. The smartphone application option provided the least number of additional services, because there is no connection to data stored in the vehicle's computer; therefore, several value-added amenities (e.g., vehicle health, battery performance, safe vehicle zones) were not available for drivers.

Table 1. Per-mile rates and fuel taxes used in the phase 1 mileage-based user fee pilot for location-based approaches.

State	Per-Mile Rate (Cent per Mile)	Fuel Tax Credit (Cent per Gallon)
Connecticut	1.81	39.85
Delaware	1.05	23.00
District of Columbia	1.07	23.50
Florida	1.67	36.80
Georgia	1.41	31.09
Maine	1.36	30.01
Maryland	1.52	33.50
Massachusetts	1.21	26.54
New Hampshire	1.08	23.83
New Jersey	1.69	37.10
New York	1.99	43.88
North Carolina	1.57	34.55
Pennsylvania	2.65	58.20

Table 1. Per-mile rates and fuel taxes used in the phase 1 mileage-based user fee pilot for location-based approaches. (continuation)

State	Per-Mile Rate (Cent per Mile)	Fuel Tax Credit (Cent per Gallon)
Rhode Island	1.55	34.00
South Carolina	0.76	16.75
Vermont	1.38	30.46
Virginia	1.02	22.39

Table 2. Assumed percentages of out-of-State mileage by in-State vehicles and associated out-of-State per-mile rates and fuel taxes used during phase 1 mileage-based user fee pilots for non-location-based approaches.

State	Out-of-State Mileage by Resident Drivers (%)	Out-of-State Per-Mile Rate (Cent per Mile)	Out-of-State Fuel Tax Credit (Cent per Gallon)	Out-of-State Rates and Fuel Taxes Based On
Connecticut (CT)	8	1.69	37.08	NY (50%), RI, MA
Delaware (DE)	18	2.13	46.75	PA (50%), NJ, MD
District of Columbia (DC)	30	1.27	27.95	VA, MD
Florida (FL)	1	1.41	31.09	GA
Georgia (GA)	3	1.22	26.78	SC, FL
Maine (ME)	5	1.15	25.19	NH, MA
Maryland (MD)	20	1.29	28.24	DC (35%), VA (35%), PA, DE
Massachusetts (MA)	5	1.61	35.39	CT, NH, RI, NY
New Hampshire (NH)	18	1.29	28.39	MA (50%), VT, ME
New Jersey (NJ)	15	2.32	51.04	NY, PA
New York (NY)	4	1.75	38.48	NJ, CT
North Carolina (NC)	3	0.89	19.57	VA, SC

Table 2. Assumed percentages of out-of-State mileage by in-State vehicles and associated out-of-State per-mile rates and fuel taxes used during phase 1 mileage-based user fee pilots for non-location-based approaches. (continuation)

State	Out-of-State Mileage by Resident Drivers (%)	Out-of-State Per-Mile Rate (Cent per Mile)	Out-of-State Fuel Tax Credit (Cent per Gallon)	Out-of-State Rates and Fuel Taxes Based On
Pennsylvania (PA)	6	1.56	34.37	DE, MD, NJ, NY
Rhode Island (RI)	16	1.59	34.93	CT, MA
South Carolina (SC)	5	1.49	32.82	GA, NC
Vermont (VT)	8	1.54	33.86	NH, NY
Virginia (VA)	10	1.30	28.50	DC, MD

Multi-State MBUF calculation. The Coalition calculated the per-mile fee rates developed for the Phase I pilot based on each State's fuel taxes to be revenue neutral—that is, a vehicle getting the national average of 22 miles per gallon (MPG) would pay an MBUF that is equal to the amount paid for the State fuel taxes. The per-mile fee rates for the Phase 1 pilot for each of the Coalition States are listed in the table 2.

In general, MBUF for the pilot was calculated as shown in figure 3:

(# of miles driven × per-mile rate) - State fuel tax paid = MBUF

Source: The Coalition.

Figure 3. Equation. Calculation of net mileage based user fee.

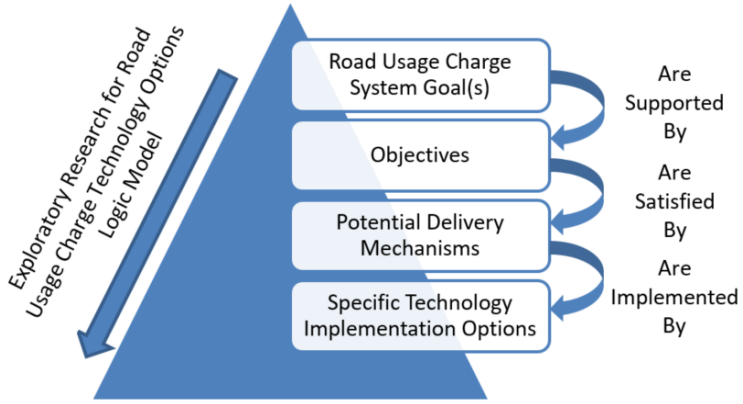
Fuel tax credit calculation. The fuel tax credit calculation varied depending upon the mileage reporting option the pilot participant chose. With a plug-in device—either with or without location—fuel usage was based on vehicle data obtained via the OBD-II port for most vehicles. For vehicles where this information could not be obtained from the OBD-II port (i.e. electric vehicles), fuel consumption was estimated based on the miles driven and the average MPG rating for the vehicle make, model, year, and engine type, as identified by the EPA. With the smartphone option, mileage was calculated based on the phone's GPS, and fuel was estimated based on the miles driven and the average MPG rating of the car make, model, year, and engine type, as identified by the EPA. This information is available at https://www.fueleconomy.gov/ by clicking on the Find a Car tab.

CHAPTER 2. INDEPENDENT EVALUATION METHODOLOGY

This chapter summarizes the independent evaluation approach and methodology employed by the study team in coordination with staff from FHWA headquarters in the Office of Operations and the FHWA Division office representatives of the respective grantee sites. The chapter defines the evaluation framework and includes responses to key questions that the USDOT expressed about MBUF approaches and their viability and characteristics if implemented on a national scale.

EVALUATION APPROACH

As its name suggests, the fundamental concept of an MBUF is that users pay a direct charge for the use of a roadway. However, it is important to understand that both "use" and "user" can be defined in several different ways, and the mechanism by which a charge is levied can also vary significantly. This is evident among the phase I grantee agencies, all of which are using different combinations of technologies and various paradigms and mechanisms to levy charges. Often, the fundamental objective of the RUC system is a significant factor in identifying technology options, data collection, and how fees are levied. Previous research[9] has characterized this phenomenon through the use of an RUC logic model, as illustrated in figure 4.



Source: HDR Inc.

Figure 4. Diagram. Exploratory research for road usage charge technology options logic model.

One essential component of this evaluation was understanding the fundamental objectives of the MBUF systems as deployed by the grantee sites. Determining the objective provided overarching insight into more detailed assessments and evaluation of the efficacy, costs, and scalability of the systems at a regional or national level. Please see the discussion in the evaluation process section for a summary of how the study team conducted this evaluation.

EVALUATION FRAMEWORK – U.S. DEPARTMENT OF TRANSPORTATION QUESTIONS

To explore the key questions to be examined as part of this evaluation within the context of the grantee site's proposed activities, the evaluation team elaborated on the question and defined relevant metrics for conducting the evaluation. While the evaluation team found some questions to be highly applicable to Phase I activities, others were marginally applicable. Table 3 provides the assessment framework, and Table 4 provides the system attributes relevant to the evaluation.

[9] HDR Inc. (2011). *Exploratory Research on Technology Options for Collection of Road Use Fees*. Unpublished technical memorandum developed under contract to the Federal Highway Administration.

Table 3. Assessment framework.

No.	U.S. Department of Transportation Evaluation Question	Relevant Site Question/Metrics	Applicability to the Coalition's Phase I Activities
Q1	What is the viability of mileage-based user fee (MBUF) on a nationwide scale?	How will mileage across multiple States be handled?	High
Q2	Would the fee assessment and collection mechanisms be scalable?	Not applicable.	Low
Q3	What is the efficiency of the fee assessment and collection relative to the gasoline tax?	What are the costs of MBUF collection for the pilot? Have you conducted a cost estimate for operations at scale? How do the costs compare with fuel tax collection in your State?	Moderate
Q4	What are the system attributes and characteristics of the MBUF systems with respect to: privacy, security, user acceptance, ease of use, ability to audit, charging accuracy, reliability, equity, ability for a user to circumvent the charge, and other factors?	See system attributes in table 4 for detailed metrics.	High
Q5	What is the user and stakeholder perception of MBUF in general and of pilot activities?	What were the key outcomes of the workshops and participant surveys?	High
Q6	What changes in institutional and financial setting, frameworks, models, and elements are required?	What organizational and administrative process changes do you anticipate for implementing a MBUF?	Moderate
Q7	What is the financial sustainability of each pilot deployment?	What are the results of the initial system cost analysis?	Moderate

Table 4. System attributes.

Functional Parameter	Description
User-Orientated Parameters	
Privacy	The nature of the information being collected as opposed to the integrity of the information.
Equity	How user costs and other outcomes will impact people in different income brackets and people of different races, ethnicities, and genders; English proficiency level; and travel mode.
Potential for Value-Added Services	The ability to add other transportation-related applications or software to the system to enhance system performance, reduce congestion, and improve mobility.
Ability to Audit	Extent to which an individual can contest their charges and have visibility into how those charges were accrued and assessed.
Ease of Use/Public Acceptance	The degree to which the system use is straightforward and time that a participant needs to spend interacting with the installed system is minimized; the level of acceptance by the traveling public.
Transparency	User awareness, specifically in real time, of what they are being charged.
Cost to User	Cost of equipment or installation to the end-user and cost of the per-mile (or other) charge.
System-Orientated Parameters	
Data and Communications Security	Data source integrity and storage, transmission, and access.
Charging Accuracy	The system's ability to assess the expected charge for each use of the roadway.
Charging Precision/Repeatability	The system's ability to produce a consistent assessment of fees repeatedly for identical travel.
System Reliability	System up-time.
Flexibility to Adapt	Ability of the technologies and systems to be upgraded or updated.
Flexibility to Expand	Ability of the system to respond to increased demand/system capacity and add technological capabilities.
Interoperability	Ability for the system to interact and exchange information across multiple jurisdictions.

Table 4. System attributes. (continuation)

Functional Parameter	Description
System-Orientated Parameters	
Compatibility with Low Tech	Assessment based on the system's ability to accommodate users that cannot utilize the technology.
Evasion	Evaluation of how easily the system can be circumvented.
System Costs	Understanding of the full spectrum of investment costs, including initial capital, operating, and maintenance costs.
Ease of Enforcement	Ability of law enforcement to identify travelers that have evaded the system.
Cybersecurity	Extent to which the system is vulnerable to a cyberattack or release of private information.
Ability to Reallocate Revenue	Extent to which the system collects information that can be used to inform allocation of revenue.

EVALUATION PROCESS

The evaluation team devised an approach centered on periodic interfaces with the grantee agencies, including a site visit with a subset of grantees conducting pilot deployments to understand better the rationale and outcomes for Phase I activities.

Site Visit

In July 2018, the evaluation team along with the FHWA STSFA program team met with the Coalition team managing the project to discuss initial findings from the activities completed and the timeline for completing the remaining activities. The meeting included questions and answers between the evaluation team and the Coalition staff and consultant members involved with several Phase I activities. The evaluation team submitted a request for documentation related to completed activities.

Development of Evaluation Reports

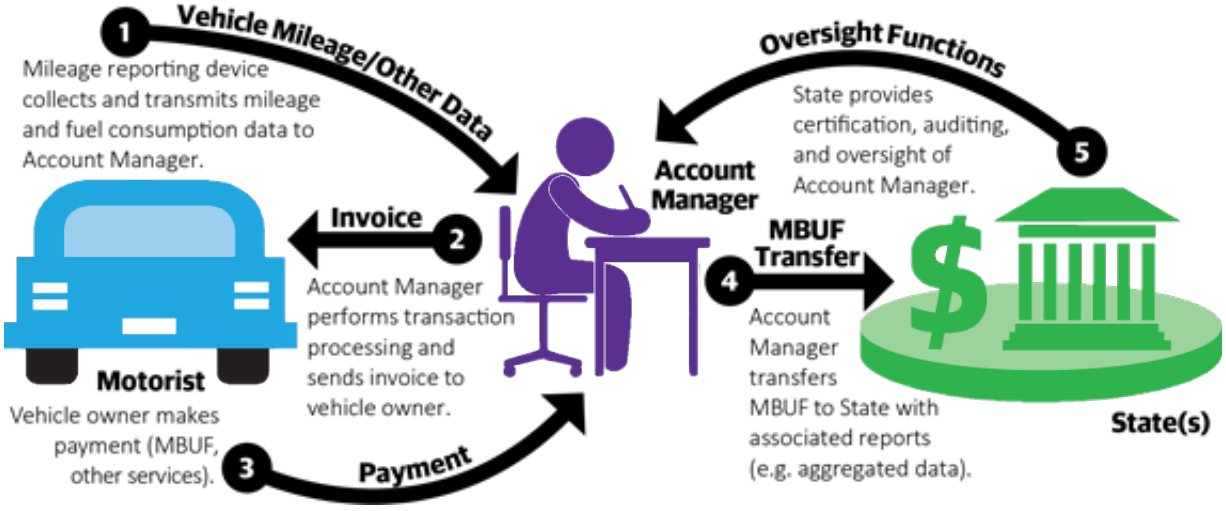
The information collected during the site visit and the Coalition's project reports were the key inputs to development of this evaluation report. Note that as with the other grantee sites, the Coalition's Phase I tasks did not directly address all the Federal evaluation criteria. Chapter 5 likewise includes the major findings related to aspects that Phase I directly addressed.

CHAPTER 3. MAJOR FINDINGS

This chapter presents an overview of the Coalition's proposed MBUF system and a summary of key findings and lessons learned resulting from their Phase I efforts. The findings are presented in accordance with the evaluation framework provided in chapter 4 that is based on the STSFA grant evaluation criteria as provided in the notice of funding opportunity.[10] It is important to note here that given the early stage and limited scope of the pilot executed by the Coalition, several evaluation criteria were not directly addressed within the scope of grant-funded activities. The Coalition may be addressing additional aspects of a MBUF system with non-Federal funds and/or may anticipate addressing some aspects in the future phases of their pilot. Given the limitations of scope of this effort, this chapter includes detailed discussion only on the attributes of the proposed system that were explored, examined, or tested during Phase I.

OVERVIEW OF THE EASTERN TRANSPORTATION COALITION MILEAGE-BASED FEE SYSTEM

Figure 5 illustrates the basic concepts, functions, and participants of a likely MBUF system—as used for the Phase 1 pilot—including the following major components and processes:



Source: The Coalition.

Figure 5. Diagram. Mileage-based user fee charging activities and functions.

- Data collection and reporting:
  - The MBUF system would likely provide multiple approaches—both automated (via technology) and manual (e.g., as part of an annual vehicle inspection process, flat fee as part of vehicle registration)—for collecting and reporting mileage and other data. It is assumed that most data collection and reporting functions will likely involve technology-based solutions—as used in the Phase 1 pilot and described in chapter 3—wherein a device and/or in-vehicle software automatically records the vehicle

[10] USDOT Notice of Funding Opportunity Number DTFH6116RA00013, issued on March 22, 2016.

identification number (VIN), measures the miles traveled, and calculates (or otherwise estimates) the fuel usage. Location and routing data may also be collected to support other in-vehicle and driver-oriented services, as well as being used to differentiate mileage by the State where the miles were driven. Information on locations, dates, and times will also be important for collecting tolls in some instances. This information would be transmitted to the MBUF account manager via wireless communications (1 as identified in figure 5).

- Account management:
  - This system feature encompasses several functions and activities starting with "transaction processing"—transforming the transmitted vehicle data into a per-mile charge through calculating and applying the appropriate fee per mile and any applicable fuel tax credits. Transaction processing may also involve using location data to allocate mileage by State or other jurisdiction where the driving occurred, and potentially to charge tolls. Other account management administrative functions include setting up accounts for payers and their respective vehicles, issuing invoices and statements (2 in figure 5), receiving payments[11] (3 in figure 5), managing accounts receivables, transmitting collected monies to the State treasury (4 in figure 5), and providing customer service activities and supporting audit activities. The account management functions may be provided by a government or private entity, or some combination thereof. For the Phase 1 pilot, a single private entity was used as the account manager.

- System administration and accounting:
  - This activity focuses on financial collection and accounting, with the primary goal that all MBUF funds—as paid by the vehicle owners or lessees—make their way into the States' treasuries. This also includes managing and reconciling any fund transfers associated with out-of-State mileage and toll collection. The State government entity (e.g., finance) receives account information and funds from the account managers (4 in figure 5). The State also provides oversight of account managers (5 in figure 5). These oversight and administrative activities may include performing auditing and reconciliation functions, ensuring that the MBUF payments are ultimately provided to the State, and certifying private entity account managers and their MBUF hardware and systems. Other system administration activities will include compliance and enforcement. Given that no funds were exchanged, the system administration and accounting functions for the Phase I Pilot were minimal.

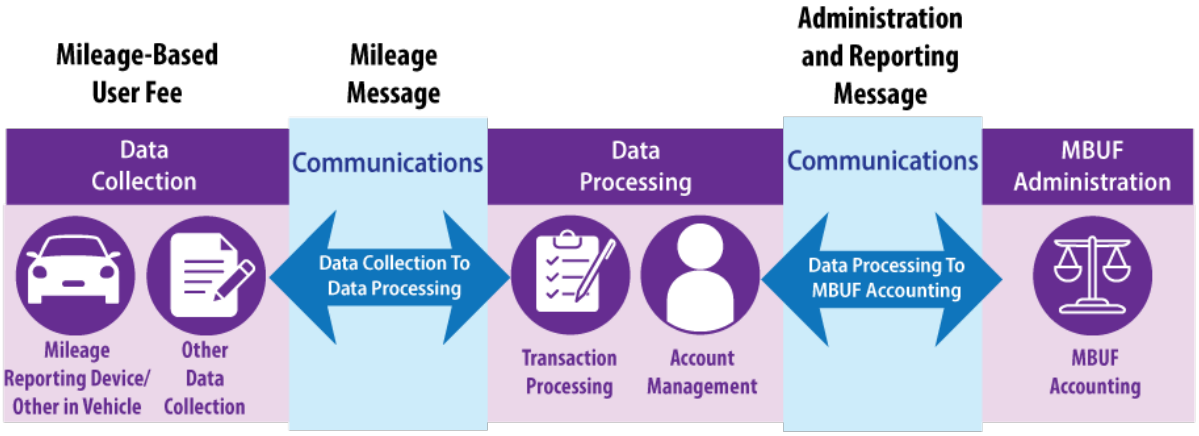
SYSTEM-ORIENTED PARAMETERS

Data Security

Figure 6 shows the high-level data flows in the Coalition's MBUF system. Notably, data security was not a major emphasis in designing this initial pilot for many reasons. Firstly, there is no financial data in the account manager database (e.g., credit card numbers) as the pilot used only faux invoices (this will also be the case in Phase 2). Another consideration was that the account

[11] All payments in the I-95 Corridor Coalition MBUF pilots are simulated. No actual funds are transferred.

manager used in the pilot was compliant with several Internal Organization for Standardization/International Engineering Consortium 27002 information security standards.[12]



Source: The Coalition.

Figure 6. Diagram. Interstate 95 Corridor Coalition high-level data flows.

Flexibility to Adapt and Expand

One of the key areas for study is the ability of the technologies and systems used in the pilot to be upgraded or updated.

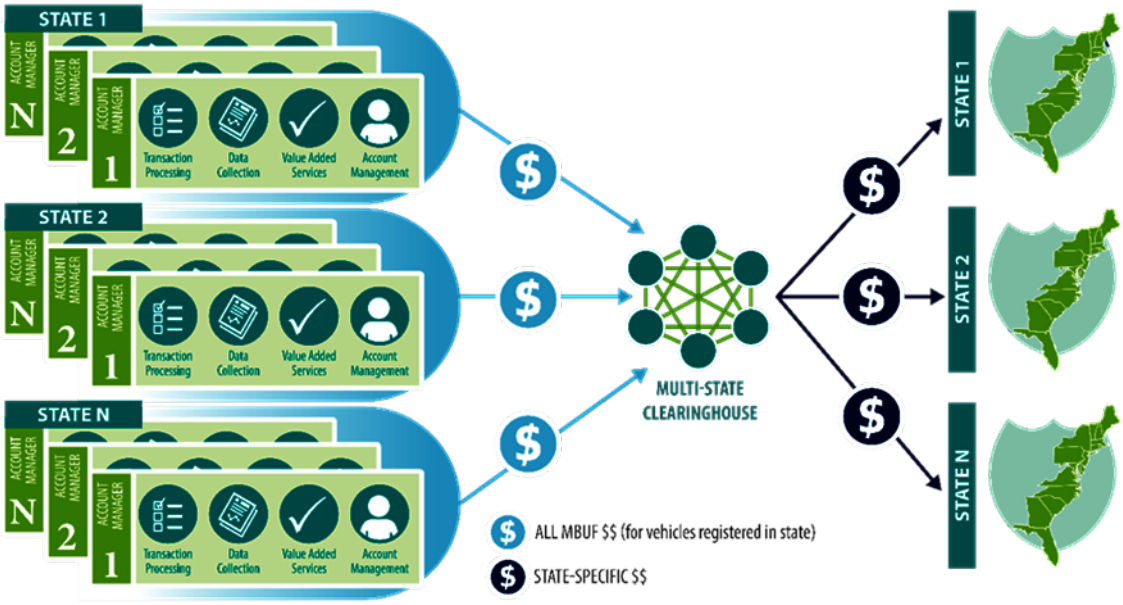
System. Like many other MBUF systems, the Coalition's MBUF program used third party account managers—one of the STSFA criteria - as the primary administrator of the mileage collection methods. An account manager system retains flexibility to add or remove the technologies used for mileage recording. Different account managers may be added into the system, each bringing different technology approaches to recording and collecting mileage while also giving options to the users in terms of value-added driver amenities.

Interoperability. Testing the interoperability of the MBUF system across State lines is one of the primary stated objectives of the Coalition's Phase I pilot. The administration subsystem is designed to account for reconciliation between different States to account for out-of-State mileage. The account managers (data processing subsystem) would be responsible for transfer of non-personally identifiable information to facilitate the reconciliation of charges between different States' participants. Technology that is not location based would rely on assumed in-State versus out-of-State mileage. For the pilot, the assumptions were based on census data. In a mandated system, results from data collected by location-based technology would likely prove valuable in developing such parameters.

The Coalition project also addressed alternative architectures in a multi-State, mandated MBUF system for managing out-of-State mileage data and the cross-State transfer of funds. This is shown in figure 7 with the establishment of a clearinghouse function that receives funds from State-specific account managers and redistributes funds between States such that each agency

[12] Standards SYS.SSD.3–SYS.SSD.21.

receives the net revenues it is owed—not unlike what International Fuel Tax Agreement[13] and International Registration Plan[14] do for heavy trucks. The multi-State MBUF clearinghouse could also perform certification and auditing functions on behalf of the States (although, the States will need to audit the multi-State clearinghouse).



Source: The Coalition.

Figure 7. Diagram. Regional clearinghouse focused with different set of account managers for each State.

Vehicle technology. Two approaches use technology that interfaces directly with the vehicle's electronic control units (ECU) to measure and collect the required travel data—one is location sensitive and the other is not. The data is collected through the OBD-II port, which is required in all post-1996 vehicles. Data is transmitted through the cell network to the account manager to determine the number of miles driven. One approach adds location data through a built-in GPS receiver in the OBD-II device, while the other does not add location data. Using vehicle telematics limits the data to the static fields already built into the vehicle's telematics system, and this data does not include vehicle location or exact vehicle mileage.[15] This data can be useful to users, but may not directly help in understanding how the vehicle is using the roadway network.[16]

[13] The purpose of IFTA is to establish and maintain the concept of a single fuel tax license for all of your qualified motor vehicles, authorizing them to travel in all FTA jurisdictions, requiring you to file only one tax return each quarter with your base jurisdiction to report your fuel usage and mileage.

[14] The International Registration Plan is a registration reciprocity agreement between the contiguous United States and Canadian provinces, which provides apportioned payments of registration fees, based on the total distance operated in participating jurisdictions.

[15] According to clarification provided by the Coalition, while mileage data are not directly provided via the OBD-II port, data are provided that the plug-in device uses to calculate mileage and estimate fuel consumption to a high degree of accuracy.

[16] See section on value-added amenities on page 39 for ways in which these data can be useful to drivers.

Ultimately, the telematics data will be transmitted to a cell network via an OBD-II device that is installed by the user. The devices themselves are not upgradable, but swapping devices or upgrading devices is quick and easy for a user to do. However, one of the security features included in the system is a VIN check. If a driver swapped a device on their own—with no communications with the account manager—the system would identify a VIN mismatch.

The OBD-II device that uses location data will add usability to the data for later analysis, in addition to providing a more accurate method for accounting for out-of-State miles. The data can indicate the travel patterns of a user, providing insight into how the road network is being used, especially when aggregated with other user location and trip data. It is possible that the value-added amenities will promote the use of location-based approaches. It needs to be emphasized that, beyond the account manager, the data used is summary-level and will not include personally identifiable information (PII).

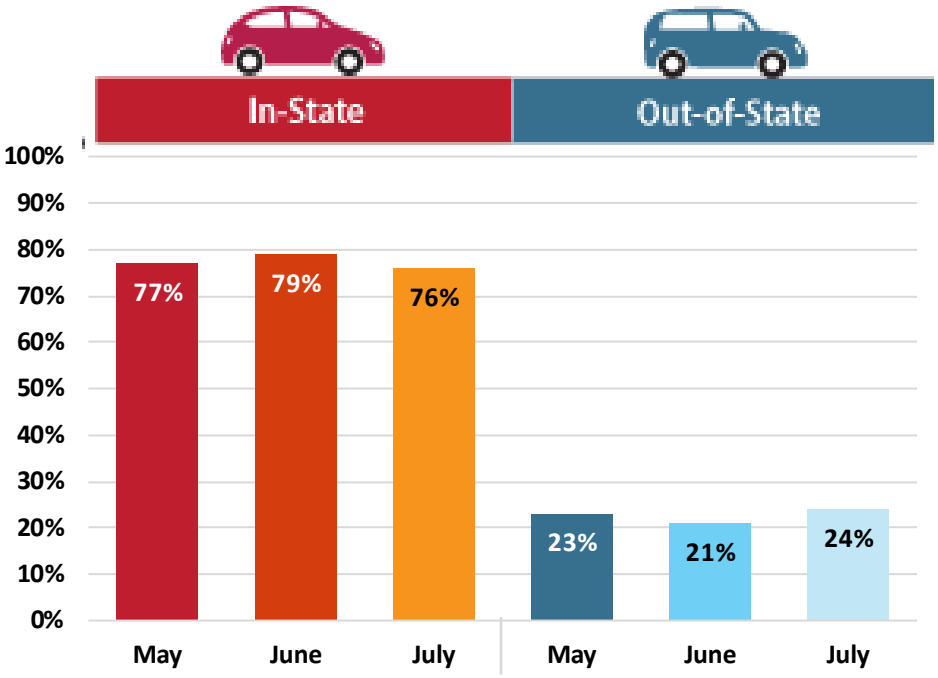
Non-vehicle technology. This approach uses a smartphone application to collect mileage data. The essential function of the application is to calculate vehicle mileage without an external dongle. The smartphone application used in the Coalition's pilot used the phone's GPS technology to determine mileage and to differentiate mileage by the State in which the mileage was accrued.

The data collected through the smartphone application is primarily location and time data, which can be useful for future travel pattern analysis. The presence of the smartphone with location features activated will lend itself to additional functionality updates to the application. Further, any updated technology incorporated into smartphones (e.g., enhanced location identification tools) may be used in future iterations of the application.

Key Finding: The technology options included in the Coalition pilot are generally flexible and incorporate the ability to expand to a large user base. However, the applicability of non-location based devices in this context where there is a significant share of out-of-State miles limits the flexibility of the system. That said, such non-location devices will likely be necessary in a MBUF system for drivers that may have privacy concerns with location-based options. The inclusion of location-based value-added driver amenities might help to increase the number of drivers adopting a location-based approach. It is important to note that low/ no-technology options were not included in the Phase I pilot.

Interoperability

The ability of the system to interact and exchange information across multiple jurisdictions is another key focus of this evaluation. Two aspects of system interoperability were examined by the Coalition in Phase I: interoperability across State lines and interoperability with tolling.



Source: The Coalition.

Figure 8. Chart. Participants' out-of-State mileage for the duration of the Coalition pilot.

Interoperability across State lines. The Coalition Phase I pilot started out with the assumption that a significant share of the residents' mileage is driven outside of their home State. This was confirmed by the data collected from pilot participants choosing location-based methods of mileage reporting (see figure 8). To ensure interoperability across State lines given such high percentage of out-of-State travel, the Coalition developed the following process:

- Computed per-mile rate for each Coalition State using the State fuel tax (refer to table 2). These rates were gross revenue neutral rates not taking into consideration the likely increased costs associated with administering the MBUF system. The Phase II rates will be net-revenue neutral for each State.
- Based on the technology for mileage reporting (location bases versus non-location based), the Coalition did one of two things:
  - Used the actual out-of-State mileage and applied the appropriate per-mile rate for States where miles were driven to compute the MBUF and the fuel tax credit.
  - Assumed a specified percentage of mileage to be driven in the participant's home State, based on census statistics on levels of work-related cross-State travel, and calculated home State MBUF using that State's per-mile rate and State fuel tax. The remaining percentage of the vehicle's mileage was assumed to have occurred outside of the vehicle's home State, with an average per-mile fee and average fuel tax for all out-of-State mileage based on the per-mile rates and State fuel taxes in adjacent States (refer to table 2).

Interoperability with tolling. A small portion of the pilot participants (10) took part in a proof of concept to demonstrate if location-based MBUF technology could also be used to calculate and assess tolls. Three tolled routes were selected, and the tolling point locations identified, with

GPS coordinates being used to alert drivers when they were entering tolled zones. The toll data collected by the MBUF account manager was compared to the participant's E-ZPass statements to confirm accuracy of the geo-location data collection.

This initial tolling proof of concept showed that using MBUF location-based technology to also calculate tolls is feasible. For example, the accuracy at the Delaware River Memorial Bridge was nearly 100 percent. However, the accuracy at the barrier toll plazas on DE SR-1 was only 64 percent, with the account manager count always lower than the E-ZPass statements. The reason for these errors is primarily due to a combination of Euclidian geometry and time-space relationships. For example, the barrier toll plazas on SR 1—Biddles Corner and Dover—include express toll lanes (i.e., full speed with a speed limit of 65 MPH) for both northbound and southbound traffic. However, these express lanes are adjacent to one another and separated by only a few feet. A 50-foot radius toll zone barely extended to the edge of the express toll lanes, and it was not possible to enlarge the zone without extending into the express toll lane of the opposite direction.

Applying a bit of geometry and algebra indicates that the length of the chord running thorough the circular toll zone at the most outer express lane is approximately 55 feet. A vehicle going through this outer lane at 100 feet per second (68 mph, and vehicles often drive through these express toll lanes at faster speeds), will be in the zone for half of a second. At a polling rate of once per second, there is a 45 percent chance that the passage thorough the zone will not be identified by the MBUF system.

Given that the estimated capture rate (based on toll zone size, location of lanes within the zone, vehicle speed, and polling frequency) was very similar to the accuracy at the various plazas, using MBUF technology to also calculate and charge tolls does appear feasible. The approach may need to be modified to use rectangular tolling zones, user-defined and variable dimensions, thereby increasing the likelihood of a vehicle being in the tolling zone during the polling period.

System Costs

A high-level financial analysis was developed as part of the project for a few different scenarios; for example, comparing MBUF and fuel tax revenues both when out-of-State mileage is included in the analysis and when it is not. The assumed costs for the financial analysis were as follows:

- Administrative costs for fuel tax collection: 2 percent of gross revenues.
- Administrative costs for MBUF collection: 18 percent of gross revenues with the following break-down:
    - Account manager costs are expected to be roughly 10 percent of gross revenues. The Coalition based this estimate on discussion with account managers that have closely investigated their system costs. The Coalition notes that this is a similar figure, albeit slightly higher, than the operating costs associated with all electronic tolling, which can be used as a proxy for MBUF in many respects.
    - State costs of 8 percent of gross revenues reflect the additional DMV effort and the need to accommodate cash payments. This figure is four times the administrative costs of the fuel tax. The Coalition used this figure as a conservative estimate based upon discussions with participating East Coast States. This increased percentage reflects the additional effort on the part of the State for MBUF in terms of education and outreach, certification and ongoing monitoring of account managers, changes to

DMV operations and software to support system enrollment and compliance efforts, payment enforcement and collection activities, and the need for the State to accommodate cash payments. As the MBUF system matured, the Coalition envisions that this percentage would decrease.

Adjusting for these estimated revenue collection costs, the Coalition estimated that the Delaware Department of Transportation per-mile, revenue-neutral rate would increase from 1.05 cents per mile to 1.25 cents per mile (i.e., 1/5th of a penny), while the Pennsylvania per-mile rate would increase from 2.65 cents per mile to 3.16 cents per mile (i.e., half a penny). Such net-revenue neutral rates will be used in Phase II. The analysis showed that when out-of-State mileage is included, some States become net gainers of revenue, while others become net losers.

The analysis also indicated another potential variable in examining the impact on State transportation revenues from moving from a fuel tax to MBUF—where fuel is purchased. It may be that out-of-State residents drive a few miles across State lines to purchase gas in another State where the price of gas in cheaper (in part due to a difference in State fuel taxes between States). If such a scenario does indeed exist – where one State is getting an appreciable amount of fuel tax revenues for miles that are predominantly driven in another State—States with lower fuel taxes could end up being net losers of transportation revenues. This will be examined further in subsequent Coalition work.

Key Finding: Further analysis is needed to develop accurate estimates for system administration costs as the pilot proceeds into future phases. Initial analysis shows that a MBUF collection administrative costs are likely to be higher than fuel tax collection costs.

USER-ORIENTED PARAMETERS

User Privacy

Perceived and real. Perceived privacy is an important factor in an MBUF program given the public's potential for pushback to the program based on perceptions of the program's privacy. The Coalition managed participants' privacy expectations using its Pilot Participant Agreement, which addressed:

- Personal information collected.
- Collection and use of non-personal information.
- Disclosure of personal information to third parties.
- Right to inspect one's information and records.
- Retention of information and records.
- Location-based approaches are purely optional.

Real (rather than perceived) privacy is measured by:

- The type and quantity of raw data being collected.
- How the raw data is treated (i.e., sanitized) and where in the system it is stored.
- The infeasibility of performing geotemporal tracking of drivers.

- The cybersecurity posture of the system and its endpoints.

Privacy is being overseen in the Coalition by the University of Maryland Institutional Review Board (IRB) whose responsibility is to protect the rights and welfare of human participants by reviewing participant agreements, invoice format, and participant surveys. While details of the processes used to develop, review, and refine the privacy agreements and other artifacts were not available for this review, the general information types protected and IRB oversight of participant privacy protections indicate privacy best practices appropriate for the scope, size, and objectives of the Coalition's pilot.

PII. High-level access-control requirements were indicated with regard to PII data collection and storage. Specific policies are included in the Participant Agreement and in the Account Management specifications. The contractor supporting the Coalition efforts developed a technical memorandum containing a review of potential privacy issues and solutions (see table 5). The structure of the memo is based on the principles identified in the European Union's (EU) General Data Protection Regulation that went into effect on May 25, 2018, which was designed to give control to EU data subjects in regards to how their data are processed, stored, or transmitted.

Table 5. Privacy approaches and potential solutions for user control over information.

Key Privacy-Related Issue	Considerations for a Mileage-Based User Fee System
Choice	Providing choices for mileage reporting, thereby providing drivers with a range of options. This would include at least one approach that does not involve any sort of mileage reporting (such as a time-based system), as well as not requiring a location-based approach, including specific origins or destinations or travel patterns.
Control and consent	Providing drivers with control in terms of how their data are collected (i.e., choice as noted above) and used. Consent means an unambiguous identification by the user signifying agreement to their personal data being collected and shared. From a MBUF perspective, this includes the ability to opt-in or opt-out of approaches that involve location information, data sharing with other entities, and/or long-term retention of the data. It also applies to other value-added amenities these individuals may be using.
Purpose limitation	The collection of data must have a specific and defined purpose.
Transparency	Developing an education and outreach program focusing on how information will be used and how privacy will be protected. A key component of such a program will be to describe why location data are important to the MBUF program (e.g., differentiating mileage by State), the associated driver amenities (and possibly MBUF-related discounts) that are linked to location information, and how this information will be protected.

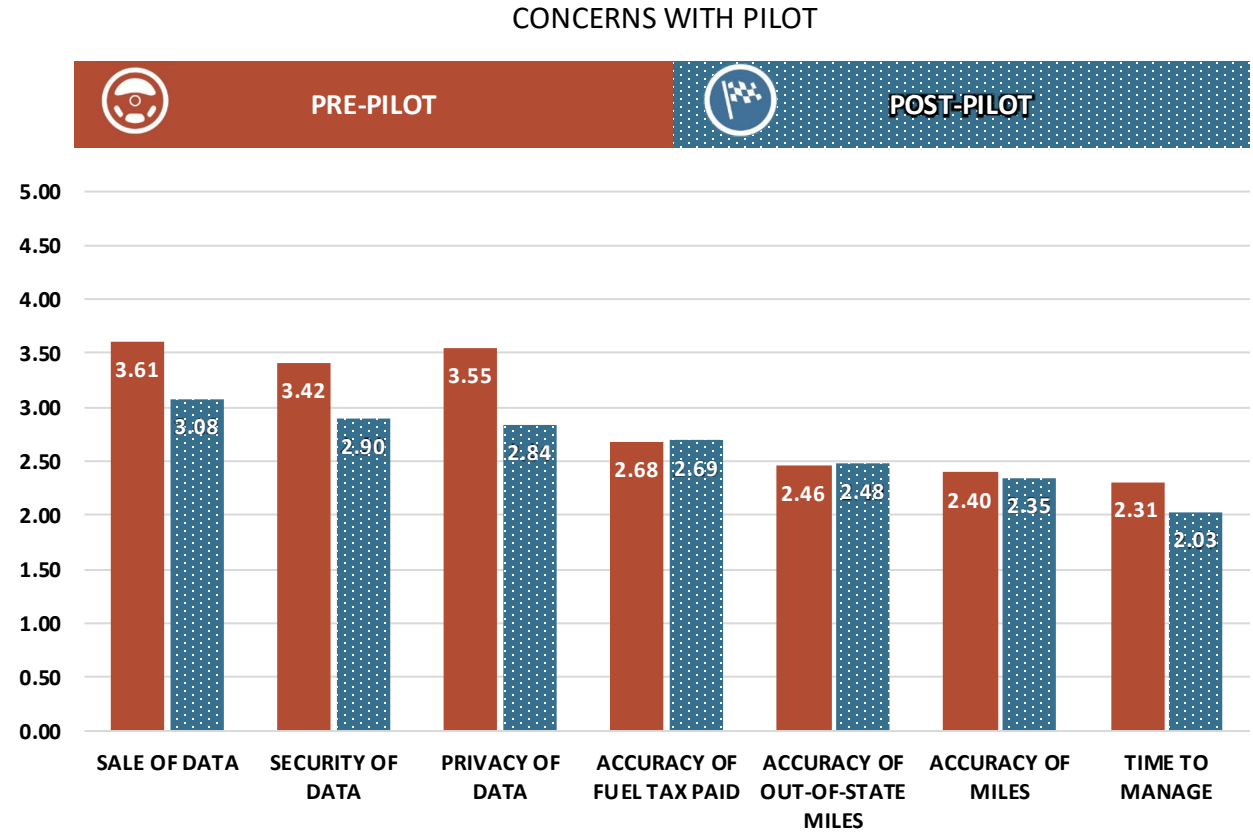
Table 5. Privacy approaches and potential solutions for user control over information. (continuation)

Key Privacy-Related Issue	Considerations for a Mileage-Based User Fee System
Data retention	Defining how long the collected data may be retained, with the goal that data should not be stored any longer than necessary.
Other use of data sharing	Defining the extent and circumstance under which private-sector providers and account managers are allowed to share (i.e., sell) collected data to other entities. This also includes protections and notifications should a Government entity request detailed data (e.g., routes by time of day) from a private sector MBUF provider.
Data anonymizing	Defining the extent to which data should be anonymized (i.e., removing personally identifiable information) and/or aggregated before providing the information to others.
Integrity and security	Defining personally identifiable information (PII) and ensuring PII and other collected data are secure from unauthorized or unlawful processing. This includes both technical and organizational safeguards (e.g., adoption of data security standards, encryption of personal data, and notification requirements should a data breach occur).

Source: Adapted from The Coalition.

Mileage data. The Coalition's pilot implemented best practices, such as limiting data retention periods and destroying data at the conclusion of those retention periods, but methods of data destruction were not specified. Mileage messages were protected in transit from the data collection to the data processing node using a Transport Layer Security (TLS) protected web service, though it was not clear whether the encrypted TLS tunnel was one- or two-way authenticated, meaning it is possible, though unlikely, that the data processing node does not authenticate the data collection mode.

Figure 9 presents the level of concerns expressed by pilot participants before and after the limited pilot.



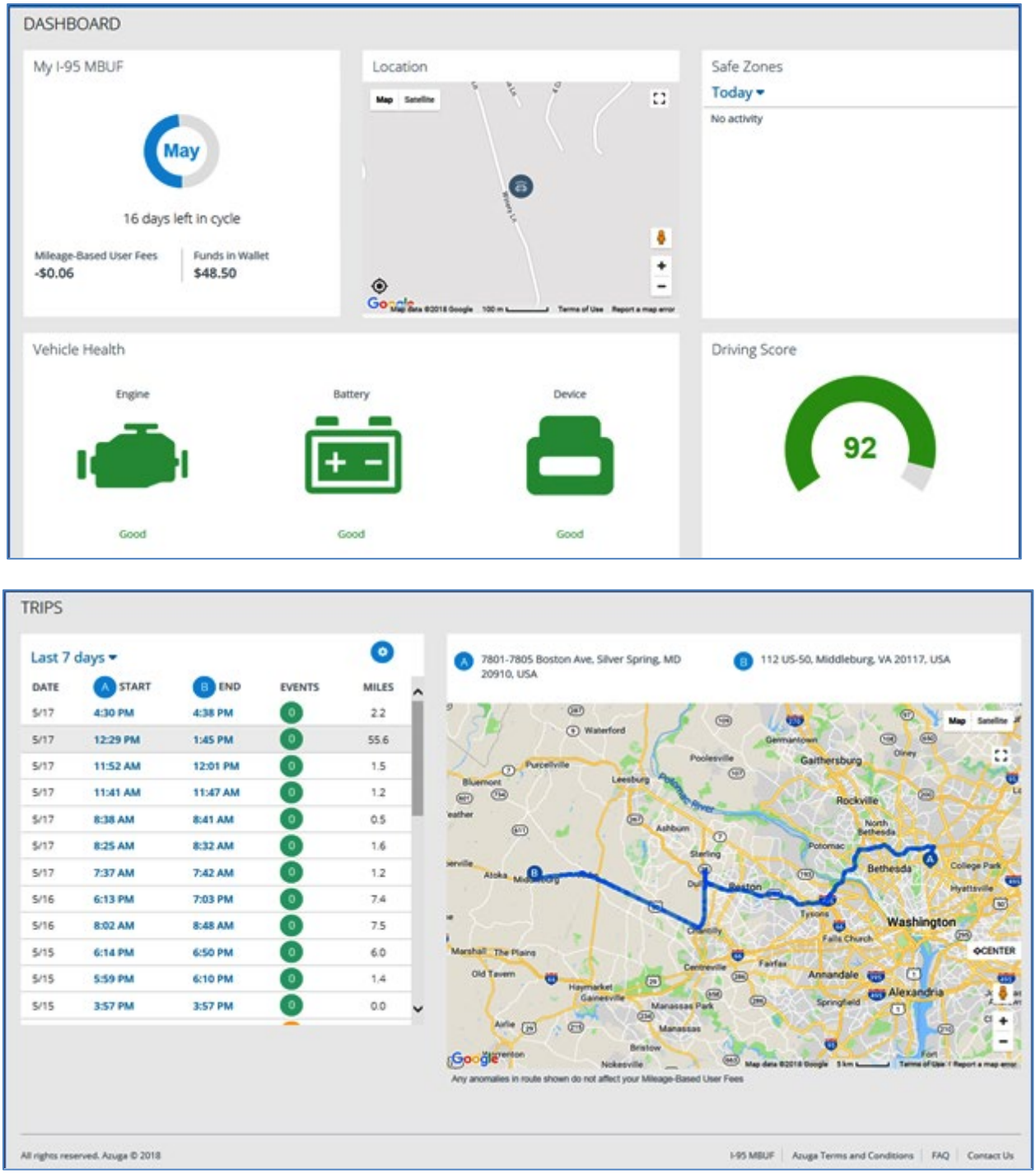
Source: The Coalition.

Figure 9. Diagram. Participants' level of concern about privacy rated from 1 (not at all concerned) to 5 (very concerned).

Key Finding: No obvious problems with data privacy were noted with the I-95 program, but as the pilot progresses to higher number of participants, additional risks to trip data may need to be incorporated into system design to protect user privacy.

Potential for Value-Added Services

As noted above, value-added amenities offered to the Phase 1 pilot participants included trip logs, battery and vehicle health notifications, driving scores, and safe zones. Examples are shown in figure 10. The widest array of value-added services was available to the participants choosing a plug-in device with location identification. The plug-in device without location identification offered fewer value-added services due to the absence of that capability. The smartphone application option provided the least number of additional services because there is no connection to data stored in the vehicle's computer; therefore, several value-added amenities (e.g., vehicle health, battery performance, safe vehicle zones) were not available.

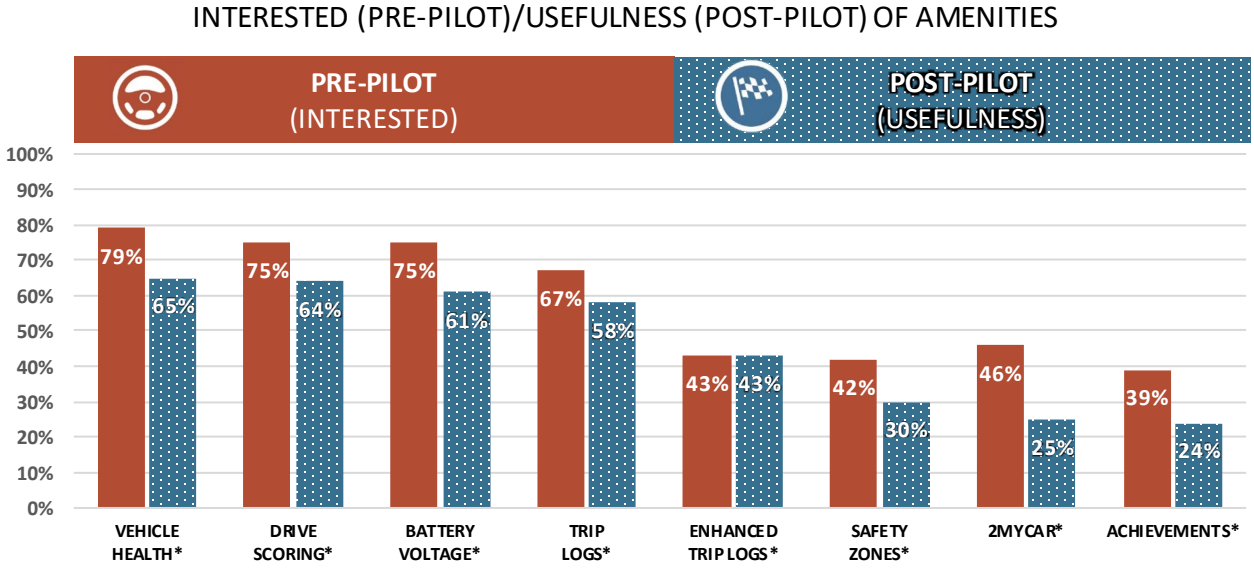


Source: The Coalition.

Figure 10. Screenshot. Examples of value-added amenities.

The Coalition envisioned that offering such amenities could increase acceptance of the MBUF approach and/or increase the number of drivers using a location-based approach. However, as shown in figure 11, there were mixed reactions to the usefulness of the value-added amenities. Of the amenities offered, participants valued those for vehicle and battery health the most. Very few participants even used the safe zone feature. All but one of the survey respondents who

chose the Smartphone with location and plug-in device without location options indicated the value-added amenities did not contribute to their selection of those options. It may be necessary to provide more information—perhaps a form of marketing—on these amenities and services.



Source: The Coalition.
Note: Chart shows ratings of 4 or higher, (Pre-Pilot: 1 - Not at all interested to 5 - Very interested, Post-Pilot: 1 - Not at all useful to 5 -Very useful). Percentages are based on availability of amenity given mileage reporting option selected.

Figure 11. Graph. Interest and usefulness of value-added amenities.

Key Finding: Value added amenities that the account managers were providing with the RUC mileage reporting were not as appealing as the Coalition initially anticipated.

Equity and Public Perception

Phase I was a focused pilot that targeted State DOT officials, legislative staff, and national thought leaders in transportation. Specific target communities that may be adversely impacted by the MBUF concept (e.g., rural communities, persons with highly fuel-efficient vehicles, low incomes) will be addressed in Phases 2 and 3 of the Coalition's effort. Figure 12 presents the Eastern Transportation Coalition pilot participant perceptions as to the fairness of the mileage-based user fee. Subfigure 12 A focused on user perceptions of reasons to support a road usage charge system while subfigure 12 B focused on user perceptions of reasons not to support a road usage charge system. The equity and perception issues analyzed in this phase led the Coalition to the conclusion that the issues are not as straightforward as they might seem. The available data may not always match perceptions. For example:

- The perception that MBUF is unfair to persons who have to drive longer distances. The Coalition contends that the whole point behind the MBUF concept is the user pays principle, whereby those who use the transportation network pay an amount proportional to how much they use it (not unlike any public utility). Moreover, in considering the fairness of MBUF on those individuals who drive long distances, it is important to note that these long-distance drivers are already paying more in fuel tax (unless they have an

electric vehicle) as compared to drivers with a shorter commute and a similar type of vehicle. However, it may be that drivers who commute longer distances do so because their lower incomes do not allow them to live closer to places of employment or various services. One possible way to mitigate potential adverse impacts on low-income families would be to tailor the MBUF system such that low-income families would receive a discount or obtain assistance from the Government in paying their MBUF. Going back to the utility analogy, such an approach would be very similar to the discounts many electric and fuel companies offer low-income customers along with government-assistance programs for lower income families.

- The perception that MBUF penalizes modern new clean hybrid and electric vehicles that pollute much less than old internal combustion engine and diesel vehicles. This again is the fundamental premise of MBUF: a revenue alternative to fuel tax given the growing number of electric and other alternative fuel vehicles that pay little no fuel tax. However, the question of disincentivizing clean energy vehicles may need to be examined with additional research and engagement with industry representatives. Any discussion of the equity and fairness of MBUF needs to be placed in the broader context of the total cost of fueling one's vehicle—be it with gas, diesel, electricity, or some combination. The Coalition performed an analysis in this regard showing that owners of electric vehicles will pay more under an MBUF system than they currently do, but they will still pay nearly $90 less per month than the owner of an internal combustion engine vehicle getting the national average of 22 MPG.
- The perception that Rural drivers may have to pay more because they drive greater distances. While the Coalition has not specifically examined this issue on the east coast geography, it cites the study conducted by RUC West (a consortium of Western States also exploring alternative transportation revenue mechanisms) on the financial impacts of road user charges on urban and rural households in eight Western States. That study concluded that the financial impacts of replacing the gasoline tax with a revenue-neutral MBUF will result in households in rural census tracts generally paying less under an MBUF than they are currently paying in gasoline taxes. In most States, households in mixed census tracts will also pay less under an MBUF. Households in urban areas in all eight States could see a slight increase in payments. A major reason for this is that rural drivers tend to have vehicles with lower fuel efficiency as compared to their urban counterparts, so the impact of a revenue-neutral rate is lower for rural drivers.[17]

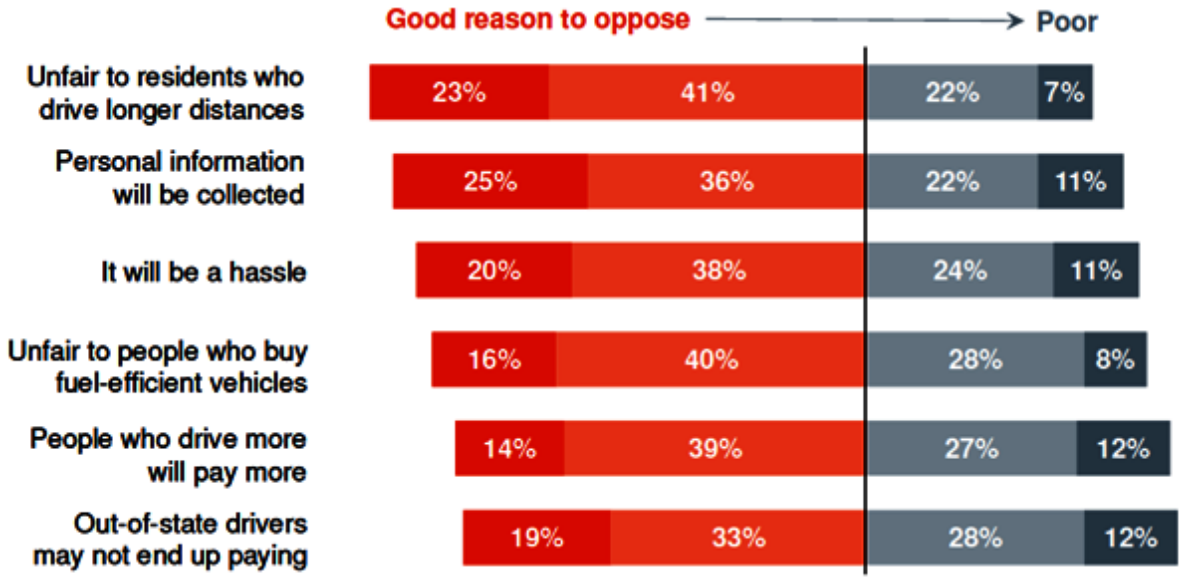
The participant surveys conducted by the Coalition at the start and at the completion of the pilot included questions about fairness and equity. Over the course of the pilot, participants' thoughts on the fairness of MBUF changed a little. The largest change in opinions on the fairness of MBUF was related to very fuel-efficient vehicles. The number of people who believed MBUF was less fair for very fuel-efficient cars increased from 27 percent at the beginning of the pilot to 38 percent. The number of people who thought MBUF was more fair at the beginning of the pilot went down from 39 percent to 24 percent. With respect to fairness for urban and rural drivers, most participants in the Phase 1 pilot believed MBUF would be the same (40 percent) for both urban and rural drivers. However, at the end of the pilot, the number of people who felt it was fairer for urban drivers compared to rural drivers increased from 30 percent to 36 percent.

[17] I-95 Coalition, Mileage Based User Fee Study, USDOT Final Report, 2019.

Key Finding: Equity and public perception issues may need to be explored, analyzed, evaluated and communicated in greater detail in future phases. The perceptions of inequity within the small participant community of the focused pilot is an indicator that the perception of inequity will be challenging in future phases as the number of participants and stakeholders increase.

Ease of Use and Public Acceptance

The Coalition's participant surveys solicited feedback on the mileage reporting options. As shown in figure 13, participants who chose plug-in device options had the highest levels of satisfaction in all categories, including ease. More than 90 percent of participants who chose the plug-in device with location would not switch mileage reporting options, compared to 57 percent who chose the smartphone with location option. Less than half of smartphone with location participants believed that option was a good choice with nearly 60 percent experiencing technical issues.



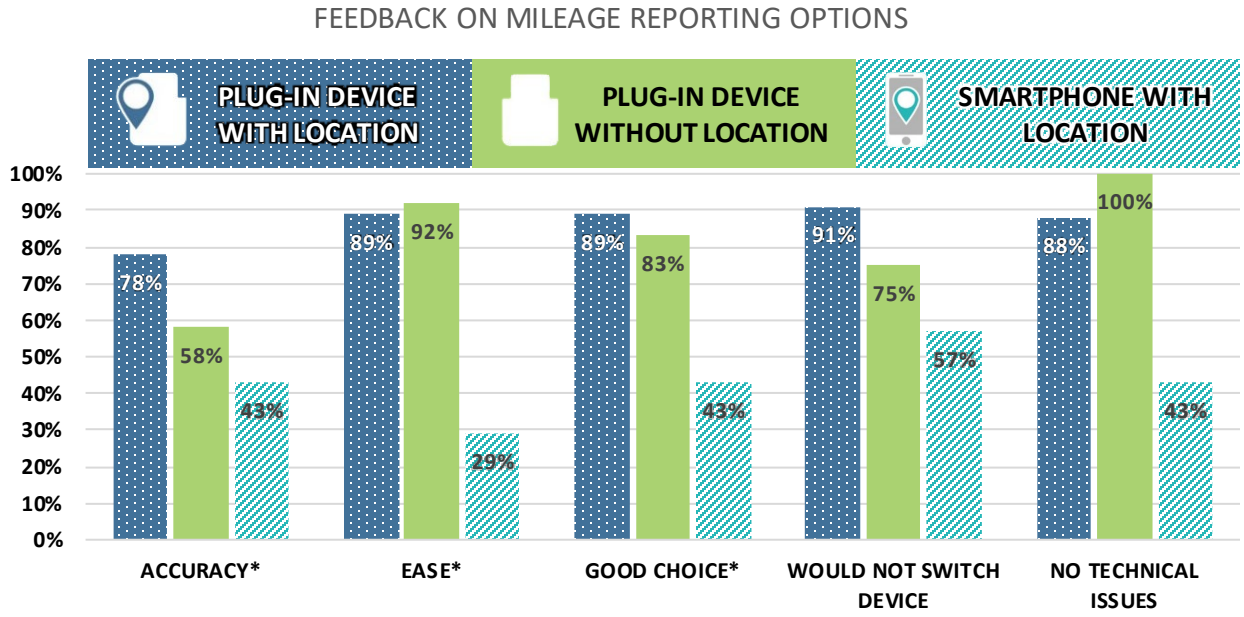
Source: The Coalition.

A. User perceptions of reasons to support a road usage charge system.

Source: The Coalition.

B. User perceptions of reasons not to support a road usage charge system.

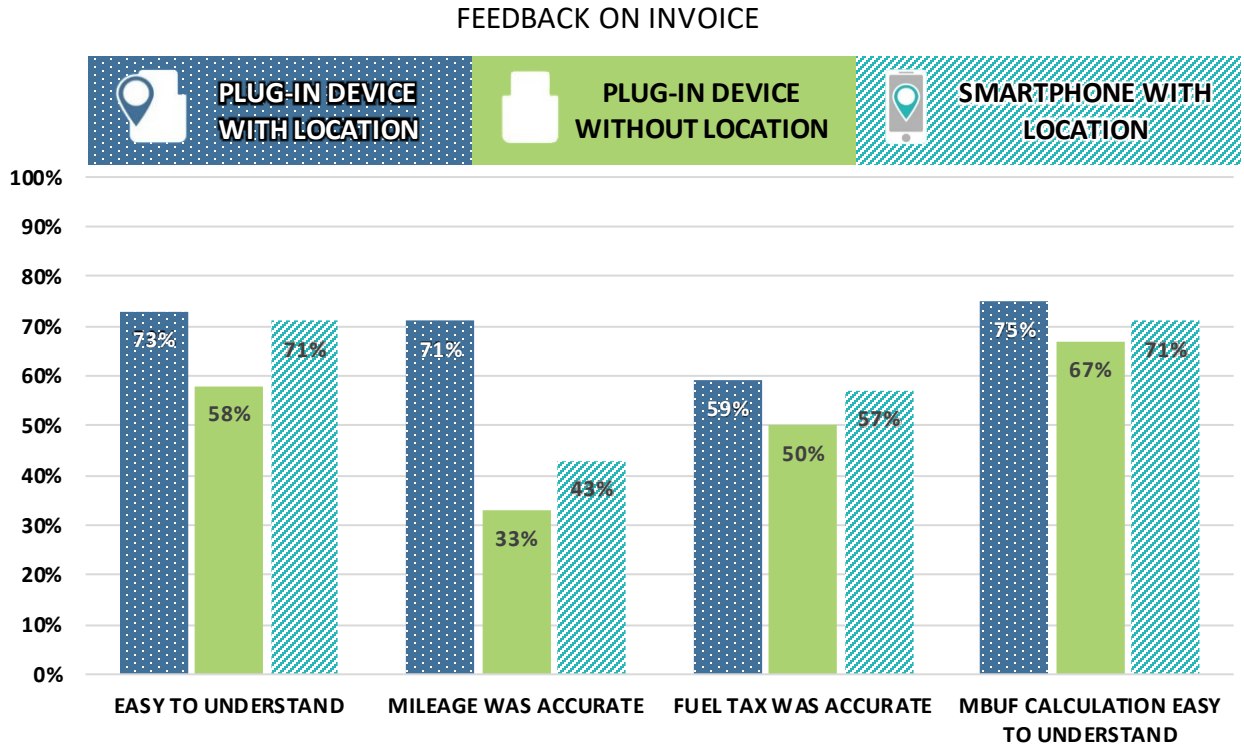
Figure 12. Charts. Eastern Transportation Coalition pilot participant perceptions as to the fairness of a mileage-based user fee.



Source: The Coalition.

Figure 13. Chart. Eastern Transportation Coalition pilot participant feedback on mileage reporting options.

An aspect of the ease of using the system also includes ease of understanding and the accuracy of the invoices. The Coalition asked the participants about invoice accuracy as part of the surveys. Figure 14 shows the satisfaction levels of mileage and fuel tax credit accuracy on invoices based on feedback from the participant surveys. Regarding data accuracy by mileage reporting option, the final pilot survey results indicated the plug-in device with location identification had the highest level of agreement (71 percent) pertaining to accurate reporting of mileage, while the plug-in device without location identification had the lowest level of agreement (33 percent), followed by the smartphone application with location (43 percent). The low level of agreement as to the accuracy for the plug-in device without location identification is likely due to a misunderstanding of the assumed out-of-State mileage included on the invoices for this option.



Source: The Coalition.

Figure 14. Chart. Eastern Transportation Coalition pilot participant satisfaction with accuracy of invoice data.

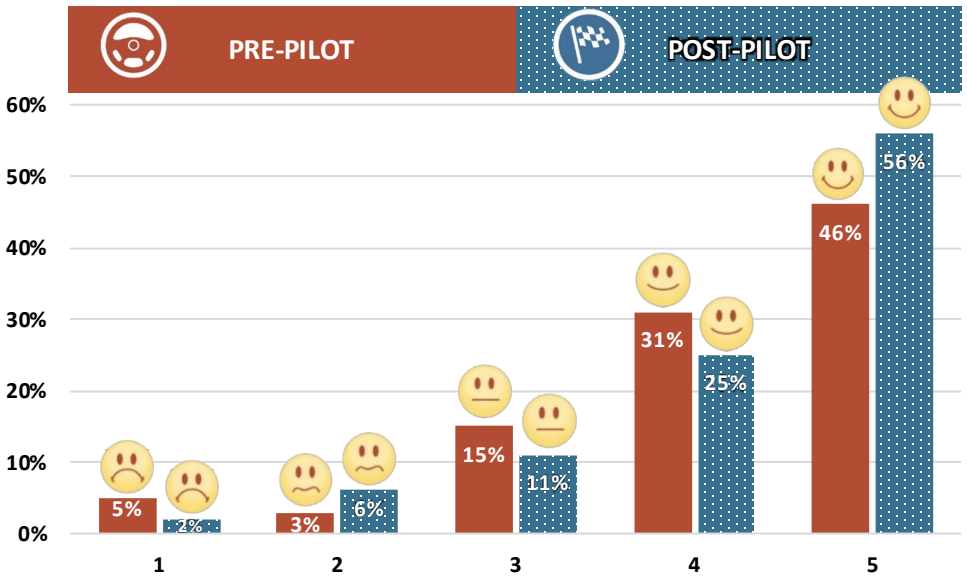
Note that per the pilot design, the non-location-based option assumed percentages of in-State and out-of-State mileage based on census statistics. Even if the participant never traveled outside their home State, a percentage of out-of-State mileage was calculated. Therefore, the Coalition expected disagreement with the accuracy of mileage for the plug-in device without location option.

As a focused pilot that did not involve monetary exchange, one of the primary goals of the Phase I effort was public education. To determine this impact, the Coalition conducted participant surveys at two points during the Phase 1 project: shortly after the pilot commenced, and shortly after the completion of the pilot. It is important to note here that the focused pilot involved individuals and groups that could loosely be considered transportation stakeholders, who were likely more informed and aware of transportation funding issues than average citizens. The survey results, hence, may not necessarily represent the public at large:

- The survey results indicated participants had an increased awareness of how much they pay in State fuel taxes. After the pilot, 65 percent of participants had a high level of agreement that they are more aware of the amount they pay in State fuel taxes to maintain and operate the roads, and 66 percent agreed the pilot increased their awareness of how much they drive.
- Participation in the pilot increased peoples' opinion of MBUF. Pilots have been shown to be an excelent mechansim to help people understand the MBUF concept. As shown in figure 15, participating in the Phase 1 Pilot increased participants' opinions of MBUF with

75 percent liking the concept at the beginning of the pilot and 80 percent at the end. Ninety-four percent of participants support doing more research on MBUF and, most participants (over 90 percent) indicated they would participate in another pilot program.

- The participant survey results showed overall satisfaction with the Phase 1 pilot was very high (90 percent), with the level of satisfaction increasing over the course of the pilot (see figure 15). The average ranking was 4.5 on a scale of 1 to 5, with 5 being very satisfied.



Source: The Coalition.
Note: Based on scale of 1 (don't like the concept at all) to 5 (really like the concept)

Figure 15. Graph. Public opinion of mileage-based user fee.

Other forms of outreach that the Coalition engaged in, to educate both the participants as well as public officials and the public at large included:

- Presentations to regional, national, and international groups and several presentations to corridor Coalition member departments of transportation.
- Two factsheets posted online and broadly distributed.
- MBUF website.
- News release and staff talking points resulting in more than 10 stories about the pilot from media outlets.
- A list of frequently asked questions for general public and participants.
- A 3-minute video describing the need for an alternative source for transportation funding, the pilot and its results, and requesting volunteers for the Phase 2 pilot.

Key Finding: The Phase I pilot was demonstrably successful in meeting its goal of increasing public awareness and education about MBUF and transportation funding in general. However, it is important to note that the focused pilot involved individuals and groups that could loosely be considered transportation stakeholders and, as such, their levels of acceptance of MBUF may not be considered representative of the public at large.

Additionally, in relation to participation in the pilot, the Coalition shared that getting recruited individuals to enroll was a challenge even though the process did not require more than 5 minutes. This challenge could have resulted from the limited nature of the pilot participants that were primarily executive-level individuals with several limitations on their time, however, the Coalition projects that:

> This could be a microcosm of a future issue in a mandated system –identifying vehicles that must be enrolled, and then ensuring that these vehicles do get enrolled.[18]

Transparency

The user experience regarding transparency of the system sharply differed in the Phase I pilot based upon the choice of mileage reporting option. For location-based options (both using vehicle plug-in device and smartphone) the account summary can be accessed any time using an online dashboard, which would provide secure information about trip taken, miles driven by State, the MBUF, and credit for fuel tax paid.

For participants choosing the non-location-based option for mileage reporting, the account of miles driven and the MBUF calculation was presented in the monthly faux invoice they received during the pilot.

[18] CH2M response to FHWA STSFA Evaluation Team's questions provided on January 16, 2019.

CHAPTER 4. SUMMARY AND IMPLICATIONS FOR NATIONAL IMPLEMENTATION

The Coalition's limited Phase I pilot demonstrated the feasibility of a MBUF system. The key findings of the evaluation of the Coalitions' Phase I program are summarized below:

- **Providing a range of options for mileage reporting:** The Phase I pilot included two types of technology-based options for mileage reporting. While one set of options relied on vehicle telematics using the vehicle's built-in OBD-II[19] port, the other set relied on a device such as a smartphone. The OBD-II plug-in methods allowed participants to choose whether they wanted their location data to be recorded. The Phase I pilot did not involve a manual reporting option.
- **Data security:** Data security aspects of the Coalition pilot are in line with the security approaches in other, similar pilots and were appropriate for this initial Phase of the project. Further pilot explorations could benefit from more extensive security requirements or measures for plugin devices, interfaces between the plugin device and vehicle, and between the plugin device (or smartphone) and account manager.
- **Privacy—perceived and real:** No obvious problems with data privacy were noted with the I-95 program, but as the pilot progresses to a higher number of participants, additional risks to trip data may need to be identified and addressed by incorporating improvements in system design to protect user privacy.
- **Flexibility to adapt and expand:** The technology options included in the Coalition pilot are generally flexible and incorporate the ability to expand to a large user base. However, the applicability of non-location-based devices in this context where there is a significant share of out-of-State miles limits the flexibility of the system. It is important to note that low/ no-technology options were not included in the Phase I pilot.
- **Interoperability:** The Phase I pilot and the tolling proof-of-concept are an initial demonstration of the feasibility of the system. However, further demonstrations with a larger participant pool, coupled with enhancements to the approach for calculating existing tolls, would be needed to understand the complexity of issues with interoperability at scale – both across State lines and with tolling.
- **Value-added amenities:** Amenities that the account managers were providing with the MBUF mileage reporting were not as attractive to the pilot participants as was anticipated by the Coalition at the start of the project.
- **System costs:** Further analysis is needed to develop accurate estimates for system administrative costs as the pilot proceeds into future phases. Initial analysis shows that an MBUF collection administrative costs are likely to be higher than fuel tax collection costs.
- **Equity and public perception issues:** These issues may need to be explored, analyzed, evaluated, and communicated in greater detail in future phases. The perceptions of

[19]Onboard device systems give the vehicle owner or repair technician access to the status of the various vehicle subsystems. The OBD-II standard specifies the type of diagnostic connector and its pinout, the electrical signaling protocols available, and the messaging format. It also provides a candidate list of vehicle parameters to monitor along with how to encode the data for each.

inequity within the small participant community of the focused pilot is an indicator that the perception of inequity will be challenging in future phases as the number of participants and stakeholders increase.

- **Ease of use and public acceptance:** The Phase I pilot was demonstrably successful in meeting its goal of increasing public awareness and education about MBUF and transportation funding in general. However, it is important to note that the focused pilot involved individuals and groups that could loosely be considered transportation stakeholders, and as such, their levels of acceptance of MBUF may not be considered representative of the public at large.

The Coalition's Phase I efforts further demonstrated that tested MBUF technologies have the capability of handling interstate travel and could also potentially capture tolls. Tolling interoperability may be feasible; however, it is still very premature, requiring, among other things, changes to how a toll zone is defined. Value added amenities that the account managers were providing with the MBUF mileage reporting were a key aspect of the program, but as some survey findings suggest, were not as appealing to participants as the Coalition initially anticipated.

The Coalition contends that it would be beneficial to develop an estimate for administrative costs. The financial tool that the Coalition developed including several scenarios and assumptions estimated a total administrative cost of 18 percent for an MBUF system including costs of an account management entity. Including the additional administrative costs in the per-mile rate—a net revenue neutral approach—would increase the per-mile rate by 1/5 to 1/2 cents. This analysis may need to be further developed in the future to include ramp-up or transition costs and considerations related to operations at scale, including organizational expansions, as well as potential efficiencies and economies that may be gained. This refinement could be informed by Phase I efforts of other STSFA grantee sites, such as Oregon and California, that are engaged in pilot enhancement initiatives.

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[20] Since July 1, 2020, the I-95 Corridor Coalition has been known as The Eastern Transportation Coalition.

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