Surface Transportation System Funding Alternatives Phase I and II Independent Evaluation

Crosscutting Report

Publication No. FHWA-HOP-21-048 May 2024

U.S. Department of Transportation
Federal Highway Administration

Notice

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the use of the information contained in this document.

Non-Binding Contents

Except for the statutes and regulations cited, the contents of this document do not have the force and effect of law and are not meant to bind the States or the public in any way. This document is intended only to provide information regarding existing requirements under the law or agency policies.

Quality Assurance Statement

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

Disclaimer for Product Names and Manufacturers

The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this document only because they are considered essential to the objective of the document. They are included for informational purposes only and are not intended to reflect a preference, approval, or endorsement of any one product or entity.

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA-HOP-21-048	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Surface Transportation System Funding Alternatives Phase I and II Independent Evaluation: Crosscutting Report		**5. Report Date** May 2024 **6. Performing Organization Code**
7. Author(s) Sonika Sethi, Ben Pierce, Justin Robbins, Drew Van Duren, Asha Weinstein Agrawal		**8. Performing Organization Report No.**
9. Performing Organization Name and Address Leidos, Inc. 11251 Roger Bacon Drive Reston, VA 20190 HDR Inc. OnBoard Security San Jose State University		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** DTFH61-16-D-00053, T-0015
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration 1200 New Jersey Avenue, SE Washington, DC 20590		**13. Type of Report and Period Covered** Evaluation Report September 29, 2017–July 28, 2019 **14. Sponsoring Agency Code** HOP
15. Supplementary Notes The Government's Task Manager for this effort was Angela Fogle.		

16. Abstract

Section 6020 of the Fixing America's Surface Transportation Act established the Surface Transportation System Funding Alternatives (STSFA) Program to provide grants to States or groups of States to demonstrate user-based alternative revenue mechanisms that utilize a user-fee structure to maintain the long-term solvency of the Highway Trust Fund. In Federal fiscal year (FFY) 2016, the U.S. Department of Transportation awarded 8 STSFA grants to 7 lead States (California, Delaware, Hawaii, Minnesota, Missouri, Oregon (project lead for 2 grants), and Washington) totaling $14.235,000. In FFY 2017, $15,502,500 was awarded under the same program. This report presents crosscutting findings from all Phase I project sites and findings from Phase II sites that have completed their respective programs at the time of writing this report. The report is limited in scope to reviewing those activities that were directly executed with STSFA funds. However, wherever relevant, references are made to how the STSFA-funded activities fit within the overall approach of the grantee site to examine alternative revenue sources.

17. Key Words	18. Distribution Statement
road usage charge, mileage-based user fee, distance-based user fee, vehicle miles tax	No restrictions.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	101	N/A

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 1,000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 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 (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	2.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BEV	battery-electric vehicle
Caltrans	California Department of Transportation
CalSTA	California State Transportation Agency
CTC	California Transportation Commission
ConOps	concept of operations
DBUF	distance-based user fee
DMV	department of motor vehicles
DOT	department of transportation
ELD	electronic logging device
EV	electric vehicle
FFY	Federal fiscal year
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carriers Safety Administration
FY	fiscal year
GPS	Global Positioning System
HOS	hour of service
ICE	internal combustion engine
IFTA	International Fuel Tax Agreement
IRP	International Registration Plan
MaaS	mobility-as-a-service
MBUF	mileage-based user fee
MFT	motor fuel tax
MOD	mobility on demand
MPG	mile per gallon
MRD	mileage reporting device
OBD-II	onboard diagnostic standard II
ODOT	Oregon Department of Transportation
OEM	original equipment manufacturer
PII	personally identifiable information
RODS	record of duty status
RUC	road usage charge

STSFA	Surface Transportation System Funding Alternative
TTETC	The Eastern Transportation Coalition
VMT	vehicle-miles traveled
WSTC	Washington State Transportation Commission

EXECUTIVE SUMMARY

As vehicles become more fuel efficient, the reliability and adequacy of the motor fuel tax (MFT) as a primary source for transportation infrastructure funding is a critical issue for which Congress is interested in identifying viable solutions. To that end, section 6020 of the Fixing America's Surface Transportation Act (Pub. L. No. 114-94) established the Surface Transportation System Funding Alternatives (STSFA) Program. The purpose of the 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.

In Federal fiscal year (FFY) 2016, the U.S. Department of Transportation awarded 8 STSFA grants to 7 lead States (California, Delaware, Hawaii, Minnesota, Missouri, Oregon (project lead for 2 grants), and Washington), totaling $14,235,000. The types of proposals included both predeployment and deployment activities, and two represented multi-State partnerships. In FFY 2017, $15,502,500 were awarded to 5 lead States (California, Colorado, Delaware, Missouri, Oregon (project lead for two grants), and Washington).

This report evaluates Phase 1 and Phase 2 of STSFA-funded projects. Staff from the Federal Highway Administration (FHWA) headquarters in the Office of Operations have the overall responsibility for administering the program and conducting the independent evaluation. FHWA Division office staff provide direct support by monitoring program activities of participating States.

The FHWA sponsored an evaluation of the work conducted by the eight grantee sites that received funding in FFY 2016. Topics addressed include lessons learned from initial pilot and planning efforts, the role of education and outreach, the potential for any negative effects on constituents, and initial findings on administrative fees, among others.

This report presents crosscutting findings from all Phase I project sites and findings from Phase II sites that have completed their respective programs at the time of writing this report. The report is limited in scope to reviewing those activities that were directly executed with STSFA funds. However, wherever relevant, references are made to how the STSFA-funded activities fit within the overall approach of the grantee site to examine alternative revenue sources.

MAJOR FINDINGS

Mileage Reporting Approaches

Of the eight 2016 STSFA grantees, six grantees—Oregon, Washington, California, Hawaii, Interstate 95 Corridor Coalition, and Road Usage Charge (RUC) West—are exploring or continuing to explore the concept of an RUC that assesses a fee based on mileage driven for individual drivers and users of the transportation system. Minnesota is exploring an approach that establishes an RUC for shared fleet vehicles, while Missouri is exploring a vehicle registration fee structure that accounts for vehicle fuel efficiency.

The mileage recording approaches evaluated by Phase 1 sites fall into the following major categories:

- Odometer-based approaches
- Vehicle onboard diagnostics-based approaches that do not include location
- Location-based approaches
- Alternative approaches, including a fleet-based approach, registration fee-based approach, and pay-at-the-pump approach

Toward the end of Phase 1, sites also began efforts to explore emerging technology-based approaches. Key findings regarding the multiple mileage reporting options follow:

- Several pilot sites' approach to testing both technology- and nontechnology-based mileage reporting methods align with the goal of providing more options to the public and enhancing the ease of use. However, these attempts are in the early phases.
- Significant future changes in transportation usage patterns are likely, given the current growth in mobility on demand (MOD) and mobility-as-a-service (MaaS). They not only present new opportunities to explore a variety of scenarios but also present challenges of uncertainty about future travel behaviors and patterns.
- Although exploring emerging technology approaches is in line with the current projection of adoption of both electric and connected vehicle technologies, data access, ownership, and privacy issues are likely to continue to pose challenges.

The attributes of the specific mileage recording approaches based on Phase 1 activities evaluated by STSFA project partners include:

- Accuracy, precision, reliability, and repeatability: These terms refer primarily to the measurement of miles driven and the system's ability to assess fees consistently.
- Transparency and ability to audit: The ability of the system to provide information on how the fee was assessed or will be assessed prior to travel; the amount assessed is the essence of transparency.
- Flexibility and user choice: From a user perspective, there are two primary interactions that occur regularly with each of the proposed systems that will influence their ease of use—mileage reporting and payment of fees. Mileage reporting includes installation, operation, and maintenance of the mileage recording method or device. For each interaction, providing more options and minimizing required actions, including the incremental effort and frequency of such actions, goes toward enhancing flexibility and user choice.

The pilot sites did not significantly investigate additional attributes, like enforcement and compliance, during Phase 1 execution. Table 1 presents key findings Phase 1 pilot sites explored regarding attributes of mileage reporting options.

Table 1. Attributes of mileage recording approaches explored in Phase 1.

Attribute	Key Reported Findings
Accuracy, precision, reliability, and repeatability	• Technology-based approaches that are installed in the vehicle and have the ability to measure and communicate directly with an account manager are likely to provide more accurate, precise, reliable, and repeatable fee assessments. • Although smartphones offer flexibility and locational measurement, the user must have them present and powered on in the vehicle while driving, potentially creating issues of reliability and repeatability. • Additional testing and pilot demonstrations are needed to establish the accuracy, precision, reliability, and repeatability of mileage recording approaches, particularly for operations at scale.
Transparency and ability to audit	• Most technologies tested or considered offer transparency comparable to the motor fuel tax. The key difference is that mileage and fee accumulation data are accessible to the driver after the trip is made in the case of road usage charge as opposed to motor fuel tax, which is paid at the time of fuel purchase. • With an active screen, cellular connectivity, and the ability to measure and display vehicle position and fee structure based on vehicle position, the transparency potential for (location-enabled) smartphone-based fee reporting is high. • The registration fee-based approach has a high degree of transparency, where the fee has no relation to a trip and, therefore, is a pay-and-forget experience for the driver. • The pilots that generated invoices (real or fictitious) largely demonstrated that transparency and ability to audit are achievable with most mileage recording approaches.
Flexibility and user choice	• Most mileage reporting options require additional user effort for mileage reporting and payment as compared with the fuel tax. • Location-enabled onboard diagnostics devices offer an easy-to-use method for mileage reporting once the device is turned on. • Odometer reading varied in its ease of use, with some approaches requiring regular images of the odometer to be captured with a smartphone, and others incorporating the odometer reading into regular vehicle inspection. • Registration-based fee, fleet-usage fee, and pay-at-the-pump strategies potentially offer a streamlined experience for the user, reducing the steps necessary to pay a fee, and reducing the complexity and actions required for the driver to manage the system. • Registration fee-based and fleet-based approaches require little effort from the driver/rider as fees are paid alongside an existing activity. • The ability to pair new activities with existing activities currently needed for driving can reduce the additional effort required of the user.

Program Structure and System Costs

As compared with the MFT, a vehicle-miles-based transportation revenue system can be associated with higher administrative costs due to a high number of (mileage) data collection points and significant front-end technology and back-end operations requirements. In addition to evaluating costs of proposed program structures, pilot sites explored a variety of options including:

- Cost savings from organizational efficiencies
- Benefits of economies of scale on system costs
- Emerging technologies for approaches that can minimize procedural overheads for collecting, storing, and processing mileage data in a secure fashion

Interoperability

Measuring the location of mileage driven is a key capability that enables accurate collection and reconciliation of fees across jurisdictional boundaries. Several pilot States and RUC West have begun developing the mechanisms to facilitate fee reconciliation between States and have worked to create a standardized dataset and process to simplify the data exchange and fee reconciliation. Washington and Oregon have tested and validated the concept of a clearinghouse entity to support interstate data and payment reconciliation. Consistency of data and standards between States will be critical to enable true interoperability.

For simpler methods of mileage reporting (i.e., odometer reading), the reconciliation of fees based on actual, measured mileage is not likely to be possible. Some pilot sites have explored methods of estimating out-of-State travel, which may address a fee imbalance between States.

Data Security and Privacy Protection

The Phase 1 grantees are generally early in their development of security-related objectives, design, and deployment; therefore, security is not yet a principal focus. Security or privacy needs in the central systems were addressed using current best practices in network security, application/host security, data management, and privacy management typically found in most enterprises.

Phase 1 sites conducted initial investigations into the following key privacy-related considerations:

- Providing choice with mileage reporting options and account managers so privacy concerns about a single option or a provider would not preclude individuals from participating in RUC
- Providing drivers with control and information about how their data are collected and used
- Limiting the purpose and retention period of the collected data and defining the extent and circumstance for sharing collected data with other entities
- Defining personally identifiable information (PII) and ensuring it is secure from unauthorized or unlawful processing

In Phase 2, Washington explored gaps in existing State privacy policies and proposed the key aspects of a model RUC privacy policy.

In addition to technical security questions is the aspect of legal implications of right to access vehicle telematics data through the use of certain technologies. Embedded within this topic is also the evolution of public perception of data security and privacy with respect to RUC data.

Public Outreach and Communication

Pilot sites that engaged in public outreach and communication activities recognized the need for ongoing public and stakeholder education, as well as a need for developing a targeted communications strategy involving:

- Messaging around key motivators
- Communicating to address public concerns
- Implementing a multipronged approach to outreach and communications

The sites also realized the need to develop a framework for regional support, including:

- Key motivators: Based on public feedback collected through surveys, focus groups, and other forms of outreach, the most effective motivators for exploring alternative transportation revenue solutions are:
  - The need to find solutions to transportation funding challenges
  - The concept of fairness; implying everyone pays their fair share of the use of the transportation system
- Communication to address public concerns: Although the above may be effective conversation starters, the messaging needs to be evidence-based and targeted to address public and stakeholder concerns about equity, privacy, and data security.
- Pilot sites also recognized a need to employ a multipronged approach to outreach and communication, using a multitude of platforms and approaches to inform and educate the stakeholders.

For pilot participant recruitment, overrecruitment (enrolling a much higher number than the target number of participants) can allow to capture a greater diversity in the participant pool.

Equity

Analysis-driven messaging around equity would first involve identifying equity concerns of the stakeholders through engagement and outreach and then analyzing impacts on target populations. Several grantee sites have begun the process of outreach through phone interviews, surveys, and focus group activities to ascertain perceptions of RUC among different demographic groups. Such outreach provides valuable insight into the potential concerns of the various stakeholders to RUC as a concept and specific approaches to fee structuring and collection.

Common themes regarding the perception of RUC being fair or equitable that have emerged with several pilot sites include the following:

- RUC may disproportionally impact people driving longer distances, particularly low-income drivers who are disadvantaged in being unable to afford to live in close proximity to work centers.
- RUC may penalize highly fuel-efficient vehicles, ignoring the environmental benefits such vehicles provide.
- RUC may penalize rural drivers who tend to drive longer distances than urban commuters.

To date, individual studies and analyses conducted by some of the pilots indicate that more data are needed to understand the effect of RUC. Additional studies could help demonstrate how an RUC can be designed to be an equitable form of transportation tax that puts into practice the principle of user pays.

It is important to note here that in both phases, the pilots explored equity, primarily with respect to two dimensions: people living in urban versus rural areas and people driving vehicles with different fuel efficiencies (or electric vehicles (EVs)). In neither phase did the sites conduct analysis to explore the effects on populations of special concerns as defined by factors like income, race, ethnicity, gender, or English language proficiency. Additionally, there were no reported public or participant opinion surveys or focus group activities designed specifically to examine the opinions and understanding held by members of populations of special concern, although the research was designed to permit some such analysis.

CHAPTER 1. OVERVIEW OF ALTERNATIVE TRANSPORTATION FUNDING SOLUTIONS

This chapter provides an overview of the efforts of Federal and State governments and multientity coalitions toward exploring alternative transportation funding solutions that is the subject of this evaluation report.

WHY EXPLORE ALTERNATIVE TRANSPORTATION FUNDING SOLUTIONS?

As vehicles are becoming more fuel efficient, the reliability and adequacy of gasoline tax as a primary source for transportation infrastructure funding is coming into question. Recognizing this trend, section 6020 of the Fixing America's Surface Transportation Act (Pub. L. No. 114-94) 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 utilize a user-fee structure to maintain the long-term solvency of the Highway Trust Fund.

The Fixing America's Surface Transportation Act provided that $15 million in fiscal year (FY) 2016 and $20 million annually from FY 2017 through FY 2020 be made available for grants for demonstration projects. Section 6020 provides express authority to enter into a grant with a State or groups of States, with no more than 50 percent of total proposed project costs being Federal funds and the remainder coming from non-Federal sources.

The stated goals 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.

> "Motor fuel tax (MFT) receipts are projected to decline as vehicles become more fuel-efficient and as the surge in the production and purchase of new electric vehicles continues to decrease revenues generated for state transportation systems. Given these two major pressures on the MFT, states have begun to actively study, explore and pilot road user charge (RUC) systems as the most likely long-term replacement for declining MFT revenue."
>
> *Source: National Conference of State Legislatures, "Road Use Charges (RUC)" web page. Available at: https://www.ncsl.org/transportation/ncsl-road-usage-charges-summit-report. Last accessed October 23, 2023.*

SURFACE TRANSPORTATION SYSTEM FUNDING ALTERNATIVES PROGRAM: PHASES 1–5

In Federal fiscal year (FFY) 2016, the U.S. Department of Transportation awarded 8 STSFA grants to 7 lead States (California, Delaware, Hawaii, Minnesota, Missouri, Oregon (project lead for 2 grants), and Washington) totaling $14,235,000. The types of proposals contained both predeployment and deployment activities, and two represented multi-State partnerships. This constituted Phase 1 of the STSFA grant program. The awards made under this program from FFY 2016–2020 are presented in table 2 below:

Table 2. Surface Transportation System Funding Alternatives awards from Federal fiscal years (FFY) 2016–2020 (Phases 1–5, respectively).

Grantee State/ Executing Entity	FFY 2016 Award (Phase 1)	FFY 2017 Award (Phase 2)	FFY 2018 Award (Phase 3)	FFY 2019 Award (Phase 4)	FFY 2020 Award (Phase 5)
California	$750,000	$1,750,000	$2,030,000	—	$2,150,000
Colorado	—	$500,000	—	—	—
Delaware/I–95 Corridor Coalition	$1,490,000	$975,000	$3,028,000	$3,350,000	$4,670,000
Hawaii	$3,998,000	—	—	—	$250,000
Minnesota	$300,000	—	$999,600	—	$3,250,000 (with Kansas Department of Transportation)
Missouri	$250,000	$2,772,500	$1,782,500	—	—
New Hampshire	—	—	$250,000	—	—
Ohio	—	—	—	—	$2,000,000
Oregon/RUC West	$1,500,000	$2,590,000	$950,000	$250,000	$134,875
Oregon	$2,100,000	$2,315,000	—	$5,000,000	—
Texas	—	—	—	—	$5,000,000
Utah	—	—	$1,250,000	$745,000	$1,250,000
Washington	$3,847,000	$4,600,000	—	$5,525,000	—
Wyoming	—	—	—	$250,000	—
Total awards	**$14,235,000**	**$15,502,500**	**$10,290,000**	**$11,770,000**	**$18,704,875**

—No data

Program Evaluation

FHWA worked with an independent team to evaluate the eight grantee sites that received funding in FFY 2016. Staff from FHWA headquarters in the Office of Operations have the overall responsibility for administering the program and conducting the independent evaluation. FHWA division office staff provide direct support by overseeing the program in participating States.

By supporting pilot demonstrations, the Federal Government seeks to understand whether a user-fee structure, such as a road usage charge (RUC), is a viable substitute to the gas tax, and if such a structure can be implemented nationally at some time in the future. Topics addressed include lessons learned from initial pilot and planning efforts, the role of education and outreach, the potential for any negative effects on constituents, and initial findings on administrative fees, among others.

Site-specific detailed evaluations are available as individual reports summarizing activities and detailed findings from each individual grantee site. This report presents crosscutting findings from all Phase 1 STSFA project sites. The report is limited in scope to evaluating activities that were directly executed with STSFA funds. However, wherever relevant, references are made to how the STSFA-funded activities fit within the overall approach of the grantee site to examining alternative revenue sources.

Terminology

Six of the eight 2016 STSFA grantees—Oregon, Washington, California, Hawaii, Eastern Transportation Coalition,[1] and RUC West—are exploring or continuing to explore the concept of an RUC that assesses a fee based on mileage driven for individual drivers/users of the transportation system. Minnesota is exploring an approach that establishes an RUC for shared fleet vehicles, whereas Missouri is exploring a vehicle registration fee structure that accounts for vehicle fuel efficiency. However, different pilot sites refer to the same or similar concepts by different names, as noted in table 3.

Given a lack of standard definitions, these terms were defined within the context of each grantee's program vision and activities. Please note that, while the evaluation team adopted the terminology used by the specific grantee site for the individual site evaluation reports, this report preferentially uses the term RUC to present crosscutting findings because a majority of sites use this terminology.[2]

Table 3. Preferred terminology for alternative transportation revenue approaches centered around a user-fee based on distance traveled.

Phase 1 Pilot Site(s)	Preferred Terminology for a User-Fee Based on Distance Traveled
Eastern Transportation Coalition	Mileage-based user fee
Minnesota	Distance-based user fee
Road Usage Charge West and participating States, including California, Hawaii, Oregon, and Washington	Road usage charge

[1]Formerly called the I–95 Corridor Coalition.

[2]The exception to this rule are the sections where site-specific approaches are detailed. For those sections, the site-preferred terminology is used.

STATE LEGISLATIVE ACTIONS RELATED TO ALTERNATIVE TRANSPORTATION REVENUE MECHANISMS

Since a user fee based on miles driven is not a constitutionally authorized approach for tax collection in any of the 50 U.S. States, the pilots and programs funded through the STSFA grants all require legislative authorization. The pilots that do not receive legislative authorization are either temporarily delayed or are yet to begin. Table 4 provides a summary of legislative actions in a subset of the STSFA pilot States.

Examples of pilots failing to take off after initial scoping are the cases of Wyoming (FFY 2019 or Phase 4 grant recipient) and New Hampshire (FFY 2018 or Phase 3 grant recipient). In late 2020, the Wyoming Legislature's Joint Transportation, Highways, and Military Affairs Committee sponsored House Bill 37, which, if passed, would have authorized an RUC pilot in the State and provided guidance related to fund collection, distribution, and penalties. At the time of writing, HB 37 had not been introduced in the State legislature, and Wyoming's RUC program was suspended. Similarly, New Hampshire's Phase 2 deployment of the vehicle miles-based fee cannot begin without legislative authorization, and as of January 2024, the State Legislature had not passed a bill to authorize the pilot deployment.

Table 4. Road usage charge related legislative efforts in a subset of the Surface Transportation System Funding Alternatives pilot States during Phases 1–5 (Federal fiscal years 2016–2020).

State	Bill	Status	Summary
California	CA S 339. Vehicles: Road Usage Charge Pilot Program	Enacted. Approved by the Governor on September 24, 2021	Requires the California State Transportation Agency (CalSTA), in consultation with the California Transportation Commission (CTC), to implement a pilot program to identify and evaluate issues related to the collection of revenue for a road charge program, as specified. Requires the CTC Road Usage Charge Technical Advisory Committee to make recommendations to the CalSTA on the design of the pilot program, including the group of vehicles to participate
Minnesota	MN H 523. Road Usage Charge	Pending—Carryover: House Transportation Finance and Policy Committee. Date of last action: January 20, 2021	Relates to transportation, imposes a road usage charge, requires a report, appropriates money
Minnesota	MN S 1880. Imposes a Road Usage Charge	Pending—Carryover: Senate Transportation Finance and Policy Committee. Date of last action: March 5, 2021	Relates to transportation, imposes a road usage charge, requires a report, appropriates money
Missouri	MO H 1041. Miles per Gallon Based Motor Vehicle Registration Fees	Failed—Adjourned: House Transportation Committee. Date of last action: February 13, 2021	Establishes miles-per-gallon-based motor vehicle registration fees.
Oregon	OR H 2342. Passenger Vehicles Road Usage Charges	Failed—Died. Date of last action: June 7, 2021	Imposes mandatory per-mile road usage charge for registered owners and lessees of passenger vehicles of model year 2027 or later that have rating of 30 miles per gallon or greater, beginning on a specified date.

Table 4. Road-usage-charge-related legislative efforts in a subset of the Surface Transportation System Funding Alternatives pilot States during Phases 1–5 (Federal fiscal years 2016–2020). (continuation)

State	Bill	Status	Summary
Utah	UT S 82. Road Usage Charge Program Special Revenue Fund	Enacted. Date of last action: March 16, 2021	Creates the Road Usage Charge Program Special Revenue Fund.
Washington	WA HJR 4202. Road Usage Charges	Pending—Carryover: House Transportation Committee. Date of last action: January 18, 2021	Amends the State Constitution so that road usage charges are limited in relation to how they may be implemented.
Washington	WA S 5444. Per Mile Charge on Electric and Hybrid Vehicles	Pending—Carryover: Senate Rules Committee. Date of last action: February 9, 2021	Implements a per-mile charge on electric and hybrid vehicles.
Wyoming	WY H 37. Road Usage Charge	Failed—House. Date of last action: December 30, 2020	Relates to highways, establishes a road usage charge, establishes a road usage charge program, creates road usage charge account managers, provides for contracting by the Department of Transportation with private entities to administer the program, provides for the distribution of funds, creates penalties, provides for regional or national expansion of the program, provides for a fuel tax sunset, requires reporting and recommendations, requires rulemaking.
Wyoming	WY D 104. Road Usage Charge	Failed—Adjourned: Filed as Draft. Date of last action: September 17, 2020	Relates to highways, establishes a road usage charge, provides for the distribution of funds, creates penalties, provides for a fuel tax sunset.

OVERVIEW OF PHASE 1 PROGRAMS AND PILOTS

This section presents an overview of the Phase 1 and Phase 2 programs undertaken by the 8 STSFA grantees that are the subject of this report.[3]

California

During the Phase 1 pilot, the California Department of Transportation (Caltrans) conducted activities to enhance an earlier RUC pilot program completed prior to the STSFA grant award.[4] Caltrans examined four specific program enhancements in detail:

- **Organizational structure design**: Assessing which agencies could administer a statewide road charge program
- **Cash-flow model**: Developing a road charge revenue flow model that can be used as a tool to assess costs and benefits of a new program
- **Enforcement and compliance strategies**: Identifying elements of an enforcement program and associated strategies for ensuring compliance
- **Pay-at-the-pump/charge point**: Investigating technologies for paying a road charge at gas stations or (electric) charge points

Additionally, Caltrans conducted public perception research to determine what information the public needs to better understand and make informed decisions about road funding. The research measured the level of knowledge of transportation funding, California's road infrastructure, instability of the fuel tax, and road charge as an alternative to the fuel tax. The research also tested core messaging related to these topics.

Phase 2 of the California pilot was not complete as of the writing of this report. As such, this report does not include findings from this phase.

Delaware/Eastern Transportation Coalition

The Delaware Department of Transportation and the Eastern Transportation Coalition (hereinafter referred to as the Coalition) planned and deployed a focused mileage-based user fee (MBUF) pilot in the Coalition States as part of Phase 1.[5] For this effort, 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.

---

[3]Note that at the time of the writing of this report, with the exception of Delaware and Washington, all other Phase 2 sites had not completed their Phase 2 activities or provided final reports. As such, this document includes Phase 2 findings of only those two sites.

[4]In March 2017, Caltrans completed a mileage-based revenue collection pilot known as the California Road Charge Pilot Program. The pilot included over 5,000 vehicles, focused on testing the functionality, complexity, and feasibility of a mileage-based system as a potential new revenue collection method for transportation funding.

[5]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.

To achieve their stated goals of addressing regional issues, increasing public awareness, and creating a low-cost framework to administer MBUF, the Eastern Transportation Coalition conducted the following key activities:

- **Planning and predeployment:** 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 predeployment activities, the Eastern Transportation Coalition also proposed a number of initial MBUF pilots. These focused 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.

Phase 2 of the Eastern Transportation Coalition's (TETC) program (funded by FY 2017 STSFA grant) comprised two parts:

- **An expanded passenger vehicle pilot:** This effort expanded upon the Phase 1 pilot that included participation from 155 transportation stakeholders and focused on the States of Delaware and Pennsylvania. The Phase 2 expanded passenger vehicle pilot was conducted from July to October 2019. The TETC in partnership with the Delaware and Pennsylvania Departments of Transportation executed the pilot, which included 899 participants from the general public in Delaware and Pennsylvania. A key purpose of this pilot was to bring the insights and concerns of the general public about a sustainable and equitable transportation funding approach into the national discussion.
- **A multi-State truck pilot:** Recognizing the motor carrier industry has a key role in the U.S. economy and is a heavy user and funder of the transportation system, the TETC conducted a multi-State truck pilot to include the perspective of the trucking industry into the national exploration of MBUF. This effort constitutes the first multi-State truck pilot funded by the STSFA Program.

Minnesota

During Phase 1, the Minnesota Department of Transportation along with the University of Minnesota's Humphrey School of Public Affairs (hereinafter referred to as Minnesota) proposed to design and ultimately deploy a user-based fee mechanism by partnering with an MaaS provider (e.g., car-sharing services). Minnesota's concept is based on the premise that the future of personal travel is captured in the new and evolving MaaS business model, which is rapidly redefining personal transport around the world. Embedded technology onboard these fleets is becoming the standard on new vehicles and enables the efficient administration and collection of user fees while maintaining user privacy and data security. This efficiency provides a platform to explore a practical and implementable path toward wider deployment of distance-based user fees. Additionally, this platform and model may be transferable to other fleet applications in the future.

The goal of Minnesota's distance-based user fee (DBUF) project is to design and demonstrate a viable model to collect user-based fees on shared mobility provider fleets. The project assumes

retention of the fuel tax and will demonstrate a means to backfill revenue lost due to increasing fleet efficiency.

The foundational assumptions of Minnesota's approach, as defined through its STSFA Phase 1 efforts, include the following:

- A DBUF should operate in parallel with existing surface transportation revenue collection mechanisms and not seek to replace currently efficient methods.
- The DBUF approach should take advantage of the trend toward increasingly available onboard telematics in new vehicles, which is particularly true for the shared mobility fleet of vehicles.
- Electric, hybrid, alternatively fueled, and other highly efficient vehicles should be charged a proportionate share for use of the roads. Under the current fuel tax approach, these vehicles are not paying their fair share toward the maintenance and upkeep of the transportation system.

Phase 2 of the Minnesota pilot was not complete as of the writing of this report. As such, this report does not include findings from this phase.

Missouri

Motor vehicle and driver's license fees comprise approximately 21 percent of Missouri's State funding, but many of the fee structures have not been changed or increased rates since 1984 (and in some cases 1969). Current rates do not reflect actual infrastructure needs or support sustainable programs of asset management to preserve the bridge and highway system statewide. Missouri Department of Transportation's (hereinafter referred to as Missouri) current vehicle registration fee structure is based on taxable horsepower. Taxable horsepower is computed, not from actual engine power, but by a formula based on cylinder dimensions. Missouri is the only State still using this metric to assess vehicle registration fee, and the metric does not relate to the real power or effect the vehicle has on the transportation system.

The objective of Missouri's predeployment STSFA Phase 1 project was to test the feasibility of transitioning the vehicle registration fee schedule from taxable horsepower to the combined miles per gallon (MPG) rating of the vehicle. The State considered this type of strategy to be a fairer and equitable measure to assess the fees paid to operate a vehicle in Missouri. All predeployment activities were completed on August 15, 2018.

As part of the STSFA Program Phase 1, Missouri used the Federal grant money to conduct predeployment activities, including:

- **Developing a platform for new registration fee schedules to capture fuel-efficient vehicles:** Missouri proposed a new registration fee structure based on the vehicle's estimated fuel efficiency (measured in MPG). As part of this activity, Missouri planned to work with other State agencies to develop a full-scale implementation strategy to amend the existing registration fee schedule. This new schedule was intended to capture the lost gas tax revenues of modern fuel-efficient vehicles (i.e., vehicles that average greater than 20 MPG). Although this strategy is not a fee based on vehicle-miles traveled (VMT), similar to what other STSFA pilot sites are exploring, it is an attempt to level the playing field by reducing the inherent inequity of the gas tax.

- **Education and outreach to the Missouri General Assembly regarding alternate funding and new technology for transportation infrastructure:** Missouri recognized a need for a custom-tailored approach to reach out to the State General Assembly. The predeployment activity involved a full-scale outreach campaign to educate the legislators about the need for alternative funding and new, innovative technology to advance transportation interests in the State.

Phase 2 of the Missouri pilot was not complete as of the writing of this report. As such, this report does not include findings from this phase.

Oregon

As part of Phase 1, the Oregon Department of Transportation (ODOT; hereinafter referred to as Oregon) conducted RUC program enhancement efforts. Oregon used the Federal grant money to expand and improve the functionality of its ongoing RUC program, conduct outreach to further increase public awareness, provide recommendations to the Federal Government and other States about RUC, and streamline processes to minimize the administrative costs of its existing program. These activities were planned to prepare the State for program expansion while acting as an example for other States, as well as the Nation, for how to implement and administer an RUC program. It specifically targets four objectives:

- **Expand technology options:** Including an analysis of how Oregon attempted to and succeeded in overcoming challenges of certifying more technical options, which require enhanced system operations and improved interfaces:
  - The activity documented findings and recommendations to increase technology options in the RUC marketplace.
  - As part of this objective, Oregon analyzed improvements to the RUC open market.
  - Oregon developed a manual reporting option (to accommodate users and participants that are not able to use the existing mileage reporting technologies, do not have Internet access, or both).
  - Oregon explored partnerships to streamline RUC services and share transportation data.
- **Increase public awareness:** Oregon pre- and posttested public opinion on a range of road charging topics and concepts to determine whether the education program has improved public acceptance.
- **Evaluate compliance mechanisms:** Oregon tested new compliance processes with current account managers as much as possible. However, it cannot implement a new compliance mechanism until legislation passes to provide the necessary statutory authority.
- **Explore interoperability:** The RUC Summit was conducted in September 2017. Oregon summarized lessons learned and next steps.

Phase 2 of the Oregon pilot was not complete when this report was written. As such, this report does not include findings from this phase.

Western Road Usage Charge Consortium

Founded in 2013 and previously known as the Western Road Usage Charge Consortium, RUC West has tackled many of the policy, organizational, technological, and operational challenges for finding a new way to generate and collect revenue to fund transportation infrastructure. At the time of submitting the grant application, the coalition included 14 States. As part of the STSFA Program Phase 1, RUC West planned to define a regional system to promote and establish RUC consistency, interoperability, and compatibility throughout the western United States. At the time of the grant application, four of the RUC West member States had legislative approval to conduct RUC pilot tests (Oregon, California, Utah, and Washington).

The two key project accomplishments for RUC West's Phase 1 efforts were:

- Creating a high-level concept of operations (ConOps) that all 11 participating States agreed on. The ConOps outlined the basic principles of how a regional RUC system will function for future pilots.
- Creating detailed system and business requirements based on California and Oregon pilots.

Phase 2 of the RUC West pilot was not complete as of the writing of this report. As such, this report does not include findings from this Phase.

Washington

One of the primary goals at the outset for the Washington State Transportation Commission (WSTC) was to collaborate with relevant agencies within and beyond Washington. This type of approach would be a necessary step in testing and building the organizational and operational capabilities necessary to implement an RUC system, which WSTC recognized would need to be capable of scaling to and interacting with multiple jurisdictions (e.g., local, Federal, State, and international).

The Phase 1 grant funded the following activities:

- **Final design and pilot test set-up:** Included activities such as developing the technical design, conducting testing, managing pilot participants, establishing interoperability, and developing a pilot application and other pilot resources. This activity resulted in a ConOps for the pilot and other related documents, such as the interface control document and the system requirement specification document.
- **Public attitude assessment:** Involved a statewide telephone survey and focus group meetings. This effort resulted in a public opinion summary report documenting the findings.
- **Evaluation planning and activities:** Involved developing the evaluation plans, principles, measures, and methods.
- **Recruitment and communications:** Included inviting and recruiting approximately 2,000 volunteers for the pilot test, thus ensuring geographic and demographic diversity.
- **Execution of a smartphone innovation challenge event:** Evolved into a competitive capstone course with teams of university students participating.

As part of the 2017 STSFA grant cycle or Phase 2, Washington tested key elements of an interoperable, multijurisdictional 12-month pilot. The Washington State RUC pilot was launched in January 2018. It involved more than 2,000 drivers from around Washington State and a small pool of drivers from neighboring States. The pilot simulated a real-world RUC program by:

- Providing participants with several high- and low-tech options to collect and report their mileage data
- Providing participants with access to a help desk to respond to their queries
- Issuing mock invoices that included information about miles driven (by jurisdiction if a location-based device was used), gallons of fuel consumed, RUC and gas taxes paid, and RUC and gas taxes credited back to correct for double taxation

Giving participants the opportunity to provide feedback at three points during the pilot: after enrollment, at the midpoint, and at the conclusion; this feedback, obtained through surveys and focus groups, formed the basis of analysis of public acceptance factors and a limited examination of equity concerns associated with the proposed concept.

ORGANIZATION OF THIS REPORT

Chapter 2 describes mileage reporting approaches explored by Phase 1 grantee sites and discusses attributes related to implementation by public agencies and ease of use for drivers.

Chapter 3 describes the program structure for administering RUC that is being employed by the various sites and the implications for the cost of administering an RUC.

Chapter 4 describes the interoperability potential and the efforts conducted by Phase 1 grantee sites toward achieving interoperability.

Chapter 5 describes the data security and privacy considerations of typical RUC programs.

Chapter 6 summarizes the public outreach, messaging, and communication efforts and lessons learned by Phase 1 sites.

Chapter 7 describes the typical equity considerations for an RUC program and efforts by grantee sites toward understanding public perception of alternative transportation revenue approaches.

Chapter 8 describes findings from the truck pilot conducted as part of TETC's Phase 2 program.

Chapter 9 provides recommendations for future analysis into alternative transportation revenue approaches.

CHAPTER 2. MILEAGE RECORDING APPROACHES AND THEIR ATTRIBUTES

The ability to accurately record miles is a critical component of any RUC system. This chapter explores the technologies and approaches deployed or tested as part of the STSFA Program Phases 1–2. The chapter also explores the various attributes of these mileage reporting options, including transparency, flexibility, ease of use, reliability, precision, accuracy, and repeatability.

MILEAGE RECORDING APPROACHES EXPLORED BY PHASE 1 SITES

The mileage recording/reporting approaches explored by the Phase 1–3 pilot sites fall into the following broad categories:

- **The vehicle's odometer:** These approaches use the vehicle's odometer to measure miles driven to assess a fee. The different approaches explored by the grantees use different means of measuring the odometer reading, but the odometer itself is what is measuring the miles.
- **The vehicle's onboard diagnostic data:** Testing an onboard diagnostic standard II (OBD-II) dongle that measures the speed of the vehicle against time driven to determine miles driven. Diagnostics or telematics information is periodically transmitted over cellular communications to the account manager to report mileage and fee. Unlike an odometer-based approach, because the mileage is being calculated based upon the speed pulse available from the vehicle, the actual mileage recorded on the odometer, which is not included in vehicle diagnostics data, is not transmitted.
- **Location-based technologies:** These approaches use Global Positioning System (GPS) technology to measure the location of miles driven. These approaches add a layer of information and complexity to that of a basic mileage charge, but they also offer the ability to distinguish between different political jurisdictions and mileage driven on public versus private roads. Regarding interoperability, the ability to accurately measure in which jurisdictional boundaries mileage is driven is critical to reconciling mileage and fees between jurisdictions.

CROSSCUTTING FINDINGS REGARDING MILEAGE REPORTING OPTIONS

- Several pilot sites' approach to testing both technology and nontechnology-based mileage reporting methods is in line with the goal of providing more options to the public and enhancing the ease of use. However, these attempts are in the early phases.
- Significant changes in transportation usage patterns are likely in the future given the current growth in mobility on demand (MOD) and MaaS. These services present new opportunities to explore a variety of scenarios but also present challenges of uncertainty about future travel behaviors and patterns.
- Emerging technology approaches present both challenges and opportunities. Although this approach is in line with the current projection of adoption of both electric and connected vehicle technologies, data access, ownership, and privacy issues are likely to continue to pose challenges.

- **Alternative (non-RUC) approaches:** These approaches are not focused on deploying mileage recording approaches or technology and do not have implications for the accuracy, precision, reliability, or repeatability of mileage recording, and fee reconciliation.

Table 5 provides an overview of the site-specific mileage recording and reporting approaches.

Table 5. Mileage reporting/recording approaches and options tested or explored by Phase 1 and 2 pilot sites.

Mileage Recording/ Reporting Approach	Mileage Recording/ Reporting Option	Description	Respective Phase 1-2 Site
Odometer-based	Manual odometer reading	A visual reading of the vehicle's odometer is made at the time of the annual vehicle inspections.	Hawaii, Washington
	Image-based odometer reading	Images of the odometer are taken with a smartphone application that uploads the image to the account manager.	Washington, Utah, Hawaii
	Hybrid	Image-based odometer reading is created by using a smartphone application with location detection ability.	Washington
Onboard diagnostic-based	Onboard diagnostic standard II (OBD-II) port	OBD-II dongle measures the speed of the vehicle against time driven to determine miles driven.	Eastern Transportation Coalition, Hawaii, Washington, Oregon
Location-based	Smartphone with location	Smartphone with Global Positioning System (GPS) enabled tracks trip location for the driver. Phase 1 grantees deployed or investigated several variations of this approach, including one site that was paired with image capture technology (see 'Hybrid' in the 'Odometer' approach above) and another that tested the technology with a Bluetooth® beacon. Both approaches require the driver's smartphone to be in the vehicle, powered on, and the application activated while driving.	Eastern Transportation Coalition, Oregon, Washington
	Plug-in device with location	OBD-II device calculates mileage using vehicle diagnostics and codes that data with location data provided by an on-device GPS device. The approach allows for the vehicle's mileage to be calculated and for the location of that mileage to be measured.	Eastern Transportation Coalition, Utah, Hawaii, and Washington, Oregon
	Vehicle telematics	Mileage and location data are gathered and transmitted by the existing in-vehicle telematics system.	Oregon

Table 6 describes the mileage reporting and recording options explored by Phase 1 pilot sites.

Table 6. Mileage reporting/recording approaches and options tested or explored by Phase 1 pilot sites.

Mileage Recording/ Reporting Approach	Mileage Recording/ Reporting Option	Description	Respective Phase 1 Site
Alternative approaches	Fleet-based	The shared-vehicle fleet's ability to track mileage and location is central to the ability to assess a mileage fee.	Minnesota
	Registration fee-based	This approach will not take miles driven into account but, rather, will focus on backfilling transportation funding gaps caused by shortages in the motor fuel tax with an additional graduated registration fee based on the vehicle's fuel efficiency.	Missouri, Utah, New Hampshire

Key Crosscutting Findings Regarding Mileage Reporting Options

- **Meeting the goal of providing more mileage reporting options to the public:** Several pilot sites' approach to testing both technology- and nontechnology-based options of mileage reporting is in line with the goal of providing more options to the public. Having multiple options to report mileage is likely to enhance ease of use and wider public acceptance. However, these attempts are in the early phases and benefit from a period of testing to determine their viability in a volunteer-based program before being implemented on a mandatory basis.
- **Market forces:** Significant changes in transportation usage patterns are likely in the future given the current growth in mobility on demand (MOD) and MaaS. New models for ridesharing, vehicle sharing, and vehicle ownership in partnership with automation are likely to create a greater demand for EVs. Pilot sites have the opportunity to project future scenarios with a variety of travel and vehicle ownership patterns. However, exploring this approach also poses the challenge of planning a system around a high degree of uncertainty.
- **Emerging technologies:** In addition to the options described above, some Phase 1 sites are beginning to explore emerging technologies, such as those developed under the connected vehicles initiative—specifically, the vehicle-to-infrastructure communication technologies that can potentially allow vehicles to transmit large amounts of data, including information about miles driven. Wider adoption of EVs is likely to coincide with wider availability of onboard telematics capable of connectivity with vehicles and infrastructure. Telematics could significantly enhance the methods and processes for data collection and aggregation, including mileage data, and can present both opportunities

and challenges. Data access, ownership, and privacy considerations are likely to continue to be key issues in the application of emerging technologies to estimate RUC.

- **Ability to pair new activities with existing activities currently needed for driving:** This ability can reduce the additional effort required by participants. Of the mileage reporting approaches considered, the registration-based fee, the fleet-usage fee, and the pay-at-the-pump fee offer a streamlined experience for the user, reduce the steps necessary to pay a fee, and reduce the complexity and actions required for the driver to manage the system. Approaches that rely on a smartphone require a high number of actions by the driver and require the presence of the driver's smartphone in the vehicle, powered on with the application running, to drive. The automated OBD-II approaches are less hands-on to operate, but similar to other mileage recording device (MRD) approaches, will have a separate bill to pay at the end of the billing cycle. Note, however, that the bill could be automatically deducted from an account, or even deducted from a prepaid amount, thus reducing the actual effort needed by program participants.
- **Using location data to inform fee estimates:** The TETC Phase 2 pilot explored the potential to use location-based data and travel patterns generated from the GPS-enabled OBD-II devices to inform the estimates of interstate travel patterns for participants who did not use location-enabled OBD-II devices. This approach would allow a balance between individual preference for nonlocation technologies and support for interoperability between States.

IMPLEMENTATION ATTRIBUTE: ACCURACY, PRECISION, RELIABILITY, AND REPEATABILITY

The proposed approaches for a revenue system based on miles driven should measure and report miles reliably and consistently. In other words, mileage reported should equal the actual mileage driven, and identical trips should produce the same reported mileage and fee. Note that several of these attributes were not fully or adequately explored with the activities from Phase 1 of the STSFA funding, primarily because full testing and demonstration of technology was not part of this Phase.

Phase 1 grantees have explored a number of options for measuring mileage, including using a vehicle's odometer, a vehicle's onboard diagnostic-based telematics, location-based measurements, and non-RUC approaches. This report explores some of the relevant characteristics of these approaches and how accuracy, precision, reliability, and repeatability would be affected. Note that pay-at-the-pump technology was not tested significantly enough to be able to evaluate its accuracy, precision, reliability, and repeatability.

Odometer: The accuracy or precision of the odometer-based mileage recording methods will be only as good as the reliability and functionality of the individual vehicle's odometer. Vehicles without functioning odometers or with odometers that are inaccurate will not produce accurate information from which to record miles and assess fees. Of the odometer-based approaches, grantees have explored different ways to record and communicate the mileage reading to the account manager or the State:

- Manual odometer reading: Common errors may be in taking the odometer's measurement, or a transcription error by the person viewing and reporting the odometer reading.

- Image-based odometer reading: When a driver sends an image of the odometer to the account manager, that image is matched with the account associated with the application used to take the picture. An algorithm reads the image. The algorithm codes the image into numeric data used to establish the vehicle's mileage. There could be transcription errors with the process; however, those errors would be reconciled with the next reading.
- An odometer smartphone hybrid approach with location-measuring features: Smartphones are used to measure mileage driven out of State, but image capture reports the base mileage, which still relies on the odometer to measure the mileage driven.

The public is likely to accept the use of the odometer, as this instrument has long been accepted by the public as a surrogate for vehicle condition. Capturing the odometer through manual, digital, or other mechanism is relatively straightforward, with only small margins for error introduced by the data collection mechanism. However, odometers are not a precision instrument, and they can be adversely affected by a number of external factors (e.g., improper tire inflation and incorrectly sized tires). There is no national regulation regarding the accuracy/and precision of odometers; rather, vehicle manufacturers adhere to a voluntary Society of Automotive Engineers standard. Federal law, 49 U.S.C. 32703, prohibits citizens from disconnecting, resetting, or altering a motor vehicle's odometer with intent to change the number of miles but does not provide a framework for odometer accuracy. It should be noted that errors or inaccuracies in odometer-based approaches accumulate over time. In other words, imprecision in the vehicle's odometer will continue to accrue with miles driven.

A key consideration for a national program could be use of a national, regulatory standard. Additionally, systems based upon odometer readings cannot easily distinguish where those miles were driven (e.g., out-of-State versus in-State) and need to rely on other methods to support interoperability between States, such as estimation of out-of-State mileage or smartphone applications that supplement location data.

CROSSCUTTING FINDINGS REGARDING ACCURACY, PRECISION, RELIABILITY, AND REPEATABILITY OF MILEAGE REPORTING OPTIONS

- Odometer-based approaches. These approaches will inherit any accuracy issues present with the vehicle's odometer. No national regulations on the accuracy or precision of vehicle odometers currently exist. These approaches do have the benefit of universal presence in all vehicles and the ability to measure cumulative miles.
- Onboard diagnostic-based technologies. Accuracy and precision and reliability are similar to odometer-based approaches.
- Location-based approaches. There were several reported issues with these approaches, including a lag time with starting to measure travel, low response rates, and high user involvement needed for proper system functionality.
- Non-RUC approaches. Missouri's and Minnesota's approaches would not require independent technology solutions for measuring VMT.

Onboard diagnostics-based technologies: The accuracy, precision, reliability, and repeatability of this approach is similar to that of an odometer-based approach, although the data are collected

in a different manner. The mileage is calculated using speed combined with time, rather than the total vehicle-miles, as communicated through the odometer. However, if the dongle were removed or damaged, mileage would not be measured during that period, and a manual reading of the odometer may be necessary to reestablish actual miles driven with the account manager or State.

Location-based approaches: Several key components need to be in place to ensure accuracy of location measurement, including visibility to the GPS satellite network, accurate maps that can define which roadways are public versus private, and an accurate delineation of jurisdictions.

Phase 1 site efforts uncovered several considerations related to these approaches that may affect a reliable, repeatable, and accurate recording of mileage driven:

- **Smartphone with location:** These approaches require the driver's smartphone to be in the vehicle, powered on, and the application activated while driving. Two key approaches were tested in Phase 1: Smartphone application with and without beacon:
  - For the approach that uses the beacon (as Oregon tested), there were issues with the smartphone pairing with other available beacons, or the beacons pairing with other smartphones. In each case, the issues with the smartphone approach would have effects on the system's ability to accurately record miles reliably and precisely and to garner the exact same results from a repeat of exactly the same trip.
  - For the approach that did not involve a beacon (as the TETC tested), there were reported issues with smartphone reliability and the requirements needed for the device to record miles. Specifically, the device needed to be powered on, location and data services turned on, and the application activated prior to travel. The numerous steps needed for participants to use the approach led to a low mileage reporting rate from participants (57 to 62 percent for smartphone users, compared with 93 to 97 percent for an OBD-II device with location). Additionally, they found a delay between activating the application and when mileage would start recording mileage due to location services needing to verify and validate the location.
- **Plug-in device with location:** From Phases 1–3, this approach has reported few issues with accuracy, precision, reliability, and repeatability. Like the vehicle diagnostics MRD, the mileage is calculated using speed combined with time, rather than the total vehicle-miles as communicated through the odometer. With locational data, the mileage can also be determined based on GPS data, thus offering a second method to calculate mileage, which is important for electric vehicles that do not produce OBD-II data usable for mileage calculation. The downside of using OBD-II mileage data is that they are not recorded if the device is removed, the device malfunctions, or if the vehicle's OBD-II data are not generated. Utah reported a weeklong outage of the account manager's data system, caused when an update to digital maps was conducted. This outage prevented the individual OBD-II units from transmitting data to the account manager during that period. However, when the system became functional again, each OBD-II was able to transmit the data accumulated during the period and the record of miles driven was preserved.
- **Vehicle telematics:** Both Utah and Oregon have used existing in-vehicle telematics systems to report mileage. OBD-II data and ports are required to comply with the Federal Clean Air Act Amendments of 1990, but electric vehicles may receive waivers from these

requirements due to their zero-emission status. As such, some electric vehicles do not have OBD-II ports and use existing in-vehicle telematics to report mileage to the account manager. Data are collected from manufacturers through a third-party data aggregator, who then reports the data to the participant's account manager.

Alternative approaches: These approaches are not focused on deploying mileage recording approaches or technology and, thus, do not have implications for the accuracy, precision, reliability, or repeatability of mileage recording and fee reconciliation:

- **Fleet-based:** The use of a shared-vehicle fleet's ability to track mileage and location is central to the ability to assess a mileage fee under this approach being explored by Minnesota. To some extent, the approach is technology-agnostic and will rely on the fleet operator's MRD technology to measure miles, to which a fee is then charged to the user.
- **Registration fee-based:** As explored by Missouri, this approach will not consider miles driven, but rather will focus on backfilling transportation funding gaps caused by shortages in the MFT, with an additional graduated registration fee based on the vehicle's fuel efficiency. In this scenario, driving behavior or miles driven does not inform the fee; therefore, there are no potential issues with accuracy, precision, reliability, or repeatability.

Note that the Utah system provides users a choice between paying the registration fee supplement or enrolling in an RUC that caps its maximum annual fee at the same amount as vehicle's annual registration fee.

EASE OF USER COMPLIANCE ATTRIBUTE: TRANSPARENCY AND ABILITY TO AUDIT

The ability of the system to provide information on how the fee was assessed or will be assessed is the core essence of transparency. Knowledge of what the fee for a given amount of travel will be, changes in the fee while driving, and understanding how fees were calculated after driving are all mechanisms for maintaining transparency to drivers. This section explores the capabilities of the different systems and approaches explored in STSFA Program Phases 1–3 for communicating this information to the driver.

The current MFT model is directly tied to the purchase of fuel, a necessity for the operation of almost all vehicles on the road today. As fuel is purchased prior to driving, there is no chance that a driver could accrue a tax bill for past driving. An RUC system, on the other hand, charges per mile instead of per gallon, which may lead to fees being billed well after driving has taken place. Depending on the billing cycle and number of miles driven, a driver could accumulate a relatively substantial bill to be paid separately from their purchase of fuel. The ability for a driver to understand the mileage fee and the ability for the driver to see the accumulation of those fees will be critical for maintaining transparency of the fee and how much drivers will owe.

Table 7 shows what information is explicitly available as part of the system. The information is divided into three types of trips—pre, intra, and post. A description of these trip types follows:

- **Pretrip transparency:** In this scenario, drivers are aware of the fee or actually pay a fee prior to the occurrence of the trip. This fee is divided into two data categories—fee and fee sum, which are described in the following section.
- **Intratrip transparency:** The system is able to communicate the fees being charged during the trip. It would include the per-mile fee, the trip fee, and the cumulative fee for road usage. When crossing jurisdictional boundaries with different rate structures, the system could communicate the fee structure to the driver.
- **Posttrip transparency:** A driver is able to see the history of where and when trips were made and how fees were accumulated from each of the trips. It is important for keeping track of fee accumulation prior to invoicing and for maintaining the ability to audit.

CROSSCUTTING FINDINGS REGARDING TRANPARENCY AND ABILITY TO AUDIT

- Approaches that involve prepayment or payment alongside other necessary tasks (i.e., vehicle inspection) are fundamentally more transparent. Like the current gas tax, Missouri's registration-fee based approach, Washington's prepaid bank of miles, and Minnesota's fleet-based approach would all require fee payment prior to or during driving activities.
- Posttrip transparency is feasible with an RUC system. Account managers can provide a breakdown of driving history and fee accumulation for each trip where and when mileage was driven if the user's specific MRD can generate the information. Achieving true transparency can be challenging for a complex RUC system that serves multiple purposes (e.g., tolling and congestion pricing).
- Inability to communicate changes in RUC rate. No system currently tested can alert a driver if a change in fee had occurred in realtime, as what would happen when crossing State lines.

Table 7. Visibility of data by trip type.

Type of Information	Pretrip		Intratrip		Posttrip			
	Fee	Fee Sum	Fee	Fee Sum	Fee	Fee Sum	Miles	Loc.
Motor fuel tax (for comparison)	Y	—	—	—	—	—	Y	—
Odometer (manual read)	—	—	—	—	Y	Y	Y	—
Image-based odometer	—	—	—	—	Y	Y	Y	—
Odometer/smartphone hybrid	—	—	—	—	Y	Y	Y	Y
Onboard diagnostic	—	—	—	—	Y	Y	Y	—
Smartphone with location	1	1	1	1	Y	Y	Y	Y
Plug-in device (onboard diagnostic standard II) with location	—	—	—	—	Y	Y	Y	Y
Fleet usage fee	—	—	2	2	2	2	2	2
Registration fee-based	Y	Y	—	—	—	—	—	—

Loc = location; Y = yes, information is visible or accessible as part of the system or approach.
1 = Smartphones with location have the potential capability to determine fee and sum of fees when the location is known, and software is enabled to display the data. These capabilities, however, were not specifically outlined as part of any of the 2016 grantees.
2 = Dependent upon the private fleet operator. Assuming a smartphone with trip planning functionality is used, the data may be available to passenger while driving and broken down as a posttrip receipt.
—No data

Each of the trip types is divided into data types. Not all data types will apply to each trip type. In any scenario, the driver could always use the vehicle odometer and the per-mile fee to calculate miles driven. For this evaluation, the following information should be available to the driver prior to invoicing:

- Fee: Will the incremental fee (per-unit fee) be visible to the driver? This information should consider cross-jurisdictional travel (i.e., a driver is aware of a change in fee when crossing national, State, or local jurisdictions).
- Fee sum: Will the cost of the trip or a cumulative running cost be visible to the driver?
- Miles: Will the system indicate the miles driven? (Only the odometer-based approach counts the vehicle's odometer in this category.)
- Location: Will the system indicate where, specifically, fees and miles were accumulated?

Odometer: This option communicates only the vehicle mileage to the driver, and the driver will need to either use the vehicle's trip meter or record mileage before and after a set time period to determine mileage driven:

- Manual odometer reading: Although a driver may readily know or calculate a per-mile fee and cumulative fee, the system does not communicate it.
- Image-based odometer reading: Has a slight advantage over manual reading because it has an image record of the odometer reading for later reference and audit.
- Odometer/smartphone hybrid: Provides the added measurement and reporting of out-of-State driving. Out-of-State mileage is visible, posttrip, to the driver.

Onboard diagnostics nonlocation based: Without location, the transparency of the mileage and fees of the OBD-II device is similar to an odometer reading. Drivers would have the ability to see cumulative mileage and fees posttrip, but the odometer would remain the best method of monitoring mileage while driving.

Location-Based Approaches

- Smartphone with location: The functionality of a smartphone increases with locational services activated, as it can allow the fee, the fee summary, and the location to be reported and viewed by the driver. The use of a smartphone also adds the potential to communicate information based on location (e.g., fees and total fees for a planned trip, and fees or total fees accumulated while driving).
- Plug-in device (OBD-II) with location: These devices are valuable in understanding past trips and the accumulation of fees and mileage, although the information will need to be accessed through the account manager's online dashboard. The addition of locational services adds the ability to visually map where trips were taken and when, giving a high level of transparency for how fees were calculated and where mileage was driven.
- Vehicle telematics: Using a vehicle's on-board telematics is not a single technology or approach, and the features and capabilities of the system will be unique to each manufacturer and vehicle. The same posttrip information available to the other location-based approaches through the account manager are available for vehicle telematics, allowing participants to see the location and time of all trips accumulating a fee.

Alternative Approaches

- Fleet-usage fee: This approach applies a fee to transportation fleets, such as car share or transportation network companies. These services typically rely on a smartphone to reserve a vehicle, plan a trip, monitor a trip, and manage payment and trip receipt. While the ConOps developed by Minnesota does not explicitly map out the availability of this information, and because the user interface and data will ultimately be controlled by the fleet operator, it is unknown at the time of this report what information will be available to the passenger and at what stage of the trip.
- Registration fee-based: Drivers are aware of the price prior to the trip. This approach requires a fee to be paid along with vehicle registration and based upon the fuel efficiency of the vehicle or vehicle category. With this approach, mileage driven has no consequence on the fee paid. The need for intra- and postdriving information is not apparent, as driving behavior does not influence the fee.

EASE OF USER COMPLIANCE ATTRIBUTE: FLEXIBILITY AND USER CHOICE

From a user perspective, two primary interactions occur regularly with each of the proposed systems that will influence their ease of use—mileage reporting, including installation, operation, and maintenance of the mileage recording method or device; and payment of fees. For both of these interactions, the MFT system sets a baseline for ease of use for the passenger. The payment of fuel tax process is seamless and is inseparable from the purchase of fuel. There is a direct connection between the tax and the commodity necessary to operate the vehicle. For each of these categories of user actions, three metrics are explored:

- Required actions metric: The regularly occurring actions necessary for each of the concepts to function. This report considers these actions are critical to the operation of the mileage recording device or method and the payment of fees. This list of actions is not intended to cover unplanned technology failure or other unanticipated situations.
- Additional effort metric: The required action of something that is already required of a driver, or an additional action that is required. For the purpose of this report, the comparison is between actions that are already required and will be newly required. For instance, the presence of a smartphone is necessary for several of the MRD concepts. Because a smartphone is not a requirement of driving a vehicle today, it would be considered a new requirement for the operation of the MRD. In general, actions that are already required will be more user friendly for passengers.
- Frequency of actions metric: An estimate of how often each of the actions for each of these concepts will be required by the driver. The less frequent the action, the less action required by the driver to manage the system.

CROSSCUTTING FINDINGS REGARDING FLEXIBILITY AND USER CHOICE

- The ability to pair new activities with existing activities currently needed for driving can reduce the additional effort required of participants.
- Odometer-based and smartphone-based mileage reporting approaches generally require a higher level of user effort to operate.
- Automated approaches (i.e., OBD-II), with or without location, require very little effort from users to operate.
- Unless paid alongside another required payment (e.g., fuel or vehicle registration), RUC charges will require additional effort from participants to pay the fees.
- Fleet-based and registration fee-based approaches would require no additional effort for participants to pay the fee or operate the system.

Mileage Recording

The mileage recording methods and devices explored in Phases 1 and 2 of the STSFA programs and their associated, necessary user actions are presented in table 8. For each of the concepts, the actions to operate have been outlined and are taken either specifically or inferred from the materials provided or from on-the-ground observations of the evaluation team. The intent is to

outline how much effort is required from the user for the system to function correctly outside of any normal actions typically taken.

In table 8, the only mileage recording method requiring minimal additional effort is the manual odometer reading, so long as that task is already required as part of a department of motor vehicles (DMV) inspection. Generally, those MRD approaches that use a driver's smartphone will require more actions and with a higher frequency. With the image capture, a smartphone is used monthly to capture and send an image of the odometer. For the smartphone approach with location, the presence of the driver's phone that has power and is switched on needs to be continuous, in addition to the image capture of the odometer. Of the methods that need additional effort to operate, the plug-in MRD device has a relatively low level of effort from the driver and should require only the installation of the device.

Note that the alternative methods such as fleet-based and registration-based payment require no additional effort on behalf of the user. In the case of fleet-based payment, the fee would be automatically added to the cost of the trip. In the case of a supplemental registration-based fee, the fee would be added to the existing annual registration fee payment process.

Table 8. Mileage recording methods and associated user actions, additional effort, and frequency of actions.

Method	Mileage Recording Approach	Necessary User Actions To Operate	Additional Effort	Frequency
Odometer-based	Odometer (manual)	Requires regular visits to license agency for manual odometer reading.	No	Yearly
	Image-based odometer reading	Requires user to regularly photograph their odometer and send to account manager.	Yes	Monthly
	Odometer/ smartphone hybrid	Requires user to regularly photograph their odometer and send to account manager.	Yes	Monthly
		Requires smartphone to be present in the vehicle, powered, and switched on.	Yes	Continuous
		May require a manual reading periodically to verify mileage.	Yes	Yearly
	Onboard diagnostic (OBD-II)-based	Requires installation of plug-in device into OBD-II port.	Yes	Once
Location-based	Smartphone with location	Requires smartphone to be present in the vehicle, powered, and switched on.	Yes	Continuous
		Requires installation of a wireless technology beacon in vehicle.	Yes	Once

Table 8. Mileage recording methods and associated user actions, additional effort, and frequency of actions. (continuation)

Method	Mileage Recording Approach	Necessary User Actions To Operate	Additional Effort	Frequency
Location-based	Smartphone with location	May require a manual reading periodically to verify mileage.	Yes	Yearly
	Plug-in device (OBD-II) with location	Requires installation of plug-in device into OBD-II port.	Yes	Once

Payment of Fees

The second primary touchpoint from a user's perspective is the payment of fees. In general, those actions that are incorporated into an existing payment will require less effort from the driver. Examples include California's pay-at-the-pump concept, Minnesota's fleet-usage fee, and Missouri's registration fee-based approach. In each of these examples, an existing payment is being made for fuel, rides, or vehicle registration, and the additional fee is incorporated into the payment. These approaches to payment are similar to the MFT, as the fee is being applied to an existing cost and becomes part of the cost of operation or use:

- Odometer reading through a DMV will typically occur yearly or twice per year, but payment can be estimated and broken down into smaller payments. If payment is done at the time of the reading, it would not be considered an additional effort, but if it is broken down into quarterly or monthly estimates, it would be considered an additional payment that is outside of today's system.
- For all the automated and semiautomated MRDs and mileage recording methods, a third-party account manager or the State will typically handle the payment. In each case, an invoice is generated at a regular interval after driving has occurred, usually monthly. That invoice is sent to the driver to be paid. In these cases, there is additional effort, although different account managers may offer services like automatic payment withdrawal from a bank. Utah's RUC system features a wallet that automatically withdraws a set amount from the participant's bank account when the RUC account reaches a certain threshold. Using an automatic withdrawal method keeps the payment amount relatively low while minimizing the involvement needed from users.

Table 9 provides a summary of payment methods associated with each mileage recording approach and the effort and frequency of associated user actions.

Table 9. Payment methods and associated user actions, additional effort, and frequency of actions.

Mileage Recording Approach	Necessary User Actions To Pay	Additional Effort	Frequency
Pay-at-the-pump	Paid along with fuel bill	No	Per fueling
Fleet usage fee	Paid along with ride fee	No	Per ride
Registration fee-based	Paid along with vehicle registration fee	No	Yearly
Odometer reading	Paid along with vehicle registration fee	No	Yearly
	Monthly/quarterly estimates	Yes	Monthly/quarterly
Road usage charge mileage reporting device approaches	Invoice issued	Yes	Monthly[1]

[1]Could potentially be any range of time, as specified by the account manager, State, or driver.

The approaches that minimize the amount of actions, additional effort, or frequency will be more in line with the current gas tax system, which is the commonly cited baseline of user-friendliness and ease of use.

CHAPTER 3. PROGRAM STRUCTURE AND SYSTEM COSTS

This chapter describes the crosscutting findings related to organizational structure and costs for administering a road usage-based alternative revenue mechanism.

Currently, the Federal Government and all States tax gasoline purchases. At the Federal level, the majority of the taxes are collected when the product is removed from the bulk storage terminals. The companies pay the Internal Revenue Service the tax, which is eventually deposited in the Highway Trust Fund. The States have different rules for the point of taxation, as some tax the product at the rack, which is upon removal from the bulk terminal, whereas other States impose the tax at the distributor level, from distributors who hold licenses and file regular (usually monthly) returns where the State and local taxes are paid. Notably, the method of collection of the MFT does not involve collecting tax at the point of sale from individual drivers.

By contrast, a user fee (i.e., an RUC) typically comprises the following key features, contributing to relatively higher cost of collection and administration compared with the MFT:

- A high number of data collection points if the fee is assessed for each individual vehicle.
- Significant front-end technology and back-end operations needs, including hardware, wireless communications, and data processing costs associated with using in-vehicle and aftermarket mileage reporting technologies, which an RUC often relies upon.

Additionally, collecting an RUC in the form currently being explored by the STSFA Program Phase 1 sites is likely to necessitate significant organizational and programmatic changes:

- **Evolving role of the departments of transportation (DOTs):** State DOTs that have not traditionally been involved in tax revenue collection champion several alternative transportation revenue approaches. With the shift to a user-fee system, that is likely to change. It is anticipated that State DOTs will need to begin interfacing with other existing or new entities to administer the program effectively. These entities may be DMVs, departments of revenue, private account managers, or others.
- **Need for capacity building to deliver the additional functions associated with RUC collection:** Additional functions involved with RUC collection, such as those described in the previous section, can necessitate both capacity-building efforts within a public entity through expanding existing departments or creating new ones, as well as contractual engagements with private entities to perform specialized functions. Broadly, the following are the two main organizational functional areas that are part of most programs based on the concept of mileage data collection from individual vehicle drivers:
  - Oversight and management: Responsible for overall oversight and management of an RUC program.
  - Account management: Responsible for collecting mileage data and, in some instances, payment.

The remainder of this chapter presents significant findings from Phase 1 efforts regarding administrative costs of collecting a user fee and potential savings or synergies explored.

KEY CROSSCUTTING FINDINGS

The following lessons learned emerged from Phase 1 explorations regarding program structure that have implications for system costs:

- **Explore organizational efficiencies:** Oregon's Phase 1 efforts were directed significantly toward identifying efficiencies in their ongoing RUC program, particularly in oversight, certification, and management functions that are likely to be performed by a State agency. Caltrans and Missouri also studied several approaches to streamline and build upon existing workflows in an incremental fashion. Additionally, RUC West concluded in its ConOps that, to mimic the advantages of gas tax collection, a limited number of account managers may be used over a regional geography in combination with a regional clearinghouse.
- **Explore economies of scale:** As the RUC program becomes widely adopted, the costs of the system (particularly, the fixed-cost components) would be spread over a larger taxpayer base. This taxpayer base is likely to have an effect of reducing the per-user costs. Further, the initial ramp-up costs—from the perspective of organizational capacity building (i.e., hiring and training staff) and public outreach and education—are likely to diminish over time as the new system becomes the default for the organization and the driving public. This scenario is likely to be explored in future phases of RUC explorations by pilot sites.
- **Explore the role of new and emerging technology in streamlining data collection:** As vehicle technology evolves and data ownership issues are progressively resolved, obtaining mileage data from individual vehicles may not be as onerous as it is under the currently available technology options that most pilots are exploring. For instance, Minnesota's user-fee structure is premised on the convergence of potentially disruptive technologies, specifically MaaS either in the market currently or on the horizon.

CROSSCUTTING FINDINGS REGARDING SYSTEM COSTS

- As compared with the MFT, a vehicle-miles-based transportation revenue system can be associated with higher administrative costs due to a high number of (mileage) data collection points and significant front-end technology and back-end operations requirements.
- In addition to evaluating administrative costs of a potential RUC program, pilot sites:
  - Explored cost savings from organizational efficiencies.
  - Explored benefits of economies of scale on system costs.
  - Explored emerging technologies for approaches that can minimize procedural overheads for collecting, storing, and processing mileage data in a secure fashion.

PHASE 1 AND 2 EFFORTS EXPLORING PROGRAM STRUCTURE AND SYSTEM COSTS

Except for a few grantee sites, Phase 1 primarily involved setting up a first pilot or conducting prepilot activities. Most rate-setting analyses focused on estimating a revenue-neutral rate

considering fuel tax collection costs (that potentially range between 1 and 5 percent). This section details some significant efforts toward streamlining.

Eastern Transportation Coalition's Administrative Cost Analysis

The Eastern Transportation Coalition conducted a looking-ahead analysis of the two key cost components for the main organizational functional areas defined above. A previous Eastern Transportation Coalition study identified fuel tax collection cost to be an average of 0.86 percent for the Coalition States.[6] The Eastern Transportation Coalition Administrative and Compliance Issues Technical Memorandum quotes the following excerpt from a paper by D. S. Fleming (2012), *Dispelling the Myths: Toll and Fuel Tax Collection Costs in the 21st Century*:

> The cost of collection for motor fuel tax revenues is significantly greater than the widely believed figure of 1 percent of the revenue collected. Indirect costs, such as losses incurred at several levels of the process and taxes hidden in the collection of revenues (some are even imposed on those exempt from the fuel tax program), suggest that the costs of motor fuel tax collections may well be in the vicinity of 5 percent of the revenue collected. Given this range, the costs for administering the gas tax were assumed to be 2 percent of gross revenues.[7]

This analysis did not include a true accounting of system costs of administering an RUC system because several dependencies, organizational structures, processes, and functions are still being developed.

States' oversight and management costs: Based on a high-level analysis of additional functions required to administer an RUC program, the Coalition assumed that the cost of collecting the RUC would be approximately 8 percent of the revenue receipts. The additional cost items identified included the following:

- Education and outreach, certification, and monitoring of account managers.
- Changes to DMV operations and software to support system enrollment and compliance efforts.
- Payment enforcement and collection activities, including accommodation of cash payments.

Account management costs: Based on a discussion with account management companies currently involved in RUC pilots, the Coalition estimated that commercial account management costs are about 10 percent of annual gross revenues for a system with 1 million customers.

The above analysis indicates total costs of an RUC program to be approximately 18 percent of annual gross revenues. However, this analysis is very preliminary.

[6]I–95 Corridor Coalition. 2010. *Administrative and Legal Issues Associated with a Multi-State VMT-Based Charge System*. Final Research Report.

[7]I–95 Corridor Coalition. 2019. *Administration and Compliance Issues and Business Rule Considerations in a Mileage Based User Fee System*.

Minnesota's Approach To Partnering With Shared Mobility Providers

Minnesota's proposed DBUF system is not a single technology or system, but rather a series of agreements to collect mileage fees from commercial mobility operators. The DOT assumes that RUC will not replace the gas tax; instead, it will operate as a parallel system. A Minnesota DOT project manager noted in an interview conducted on September 18, 2018, that the Minnesota DOT expects that the fuel tax, despite its deficiencies, is likely to continue for a long time, primarily because of its simplicity and efficiency. The cost of collecting the fuel tax in Minnesota is less than 0.5 percent of the fees collected. Structuring a DBUF approach around the MaaS business model may afford a comparable level of efficiency to existing tax collection systems, because onboard technology embedded in the MaaS vehicles is already used to collect trip and mileage data for the MaaS business. Minnesota aims to have costs of collecting the DBUF fall between that of the fuel tax and sales tax.

While the future of mobility remains uncertain, this approach allows for a high level of flexibility with data collection to compute an RUC. The approach leverages data that are already being collected or may be collected by intermediary entities for other purposes than assessing an RUC. As such, it minimizes the number of data collection points and the need to acquire front-end technology for collecting data. However, the approach will still need to account for incremental administrative costs of back-end operations.

Oregon's Approach to Streamlining System Costs

Although Oregon did not conduct a full-scale program cost evaluation during the Phase 1 effort, several tasks focused on identifying efficiencies that could be gained within existing program parameters that could result in cost reductions, including the option that an agency can serve as account manager to reduce costs. The role of the account manager is important because it collects the number of miles driven and whether those miles are eligible to be charged as part of a mileage fee program. The lessons learned that emerged from this task for decreasing administrative costs include:

- **Identifying allocations of projects and systems between agency and account manager and developing a market exit process**: This identification streamlines the effort for an account manager to leave the market and lowers administrative costs for the agency to manage the account manager exit, audit, and participant transitions.
- **Ensuring business requirements provide clarity:** Clarity in business requirements ensures implementations are aligned with the intent behind the requirement.
- **Optimizing the certification process with instructional steps**: Oregon revised the certification processes to combine steps where appropriate, streamline evaluation procedures, and provide more robust training to evaluation staff.
- **Ongoing certification and periodic compliance checks**: Compliance measures are for account managers. Compliance mechanisms ensure that account managers deliver specific outcomes in regard to the management of the data collected.
- **Aligning program requirements with existing standards**: Program requirements include audit requirements, as well as State procurement laws and policies to reduce barriers to market entry.

Missouri's Alternative Approach to Road Usage Charges

One of the motivations for Missouri to explore a non-RUC option was the potential for higher administrative costs for an RUC system due to the factors mentioned earlier in this chapter. A mileage-based tax will not be viable in Missouri if RUC vendor costs are above 3 percent of the total revenue, because the Missouri constitution (Article 4, Section 30a) limits the actual cost of collection of MFT to 3 percent.[8] As preliminary efforts indicate that RUC collection costs will likely be higher than 3 percent of revenues, Missouri has taken an approach that makes up for the lost buying power of the State fuel tax through a registration fee system that considers the vehicle's fuel efficiency. This approach, while not an RUC, is an attempt to address the inequitable burden that the fuel tax, in its current form, imposes on vehicles with low fuel efficiency.

California's Evaluation of System Cost Considerations

One of the key aspects of California's Phase 1 Program was the development of a cash-flow model. However, the model, although useful to calculate a revenue-neutral RUC rate, does not address system costs. The Final Enhancing Road Charge Pilot Program Report (2023) presents the following considerations regarding system costs:

- **Higher costs of California DMV operating as a State account manager:** California's final report for Phase 1 contends that the DMV may be best suited to lead the administration of a potential future road charge program because it is already performing most of the necessary functions. Road charge payment penalties could be tied to vehicle registration, and additional enforcement functions would not be required because they already exist within DMV. These approaches could significantly reduce system costs. Overall, however, California expects the costs of having the DMV operating as the State account manager to be higher than current costs of fuel tax collection. Some components of the additional costs, based on specific operational scenarios, are likely to be:
  - Allocating additional staff resources to manage the road charge program
  - Certifying the commercial account managers and administering cash payments for those who choose not to work with a commercial account manager
  - Modifying the DMV automated fee system to accommodate the RUC

- **Enforcement costs:** Road charges are anticipated to be relatively low amounts, making collective actions for nonpayment less cost effective. Several options could be considered to mitigate enforcement costs, including having the private entity (commercial account manager) take on enforcement, or keeping the fuel tax in place because it has low administrative costs. In the latter case, in the event of road charge noncompliance, the fuel tax would still be collected.

[8]Missouri General Assembly. 2016. Missouri Constitution Section: Article IV, Executive Department, Section 30a.

CHAPTER 4. INTEROPERABILITY

CROSSCUTTING FINDINGS REGARDING INTEROPERABILITY

- Measuring the location of miles driven will enable accurate collection of fees for out-of-State driving.
- RUC West and The Eastern Transportation Coalition have laid the groundwork for RUC systems to be regionally interoperable.
- Washington and Oregon have tested and validated the concept of a clearinghouse entity to support interstate data and payment reconciliation.
- Consistency of data and standards between States will be key to enable true interoperability consistency of data and standards between States will be critical to enable true interoperability.

The straightforward concept of paying a fee for using the roadway becomes more complex once jurisdictional (national, State, and local) boundaries are considered. If the fee charged to the driver is to reflect the fee structure of the various locations driven (assuming interjurisdictional travel), then the ability to measure location is a vital feature of the system. For all the STSFA grantee sites, the State where the vehicle is registered is where the fees will be collected. Interoperability will allow the home State to collect fees on behalf of other States where that vehicle has been driven and to reallocate those fees to the appropriate State.

As an example, a driver travels from State A to State B. For the system to be truly interoperable, the system would need to distinguish between the miles driven in each State and be able to apply the State's mileage fee and reallocate the fees between States. This reallocation becomes more important when crossing boundaries between jurisdictions with different fee structures, as the driver will be paying the accurate amount based on location of mileage driven, and jurisdictions will be receiving the correct amount. In situations where large populations live and work across State lines, or where significant amounts of driving occur in States other than the home State, the capability to measure location and apply the appropriate fee for mileage becomes even more important.

This chapter presents crosscutting findings from the STSFA Program Phase 1 explorations regarding the interoperability of location-specific technologies and approaches explored by the grantees.

KEY CROSSCUTTING FINDINGS

Ability To Measure Location

At its most basic level, the ability to measure a vehicle's mileage while crossing over a jurisdictional boundary would be enough to determine the mileage driven in other jurisdictions. Technically speaking, even manual odometer methods could support interoperability, but they would require vehicles to stop at any jurisdictional boundary for a reading; this approach would be very costly to administer and very inconvenient for drivers. Of the approaches explored by Phase 1 grantees, the technology that is consistently used to measure location, thus enabling interoperability, is GPS. To measure the location of miles, today's MRDs will need to be

GPS-enabled. This technology can tag each mile driven to a specific location, allowing the fees to be calculated based on the location of the miles driven and allowing the fees to be reconciled and reallocated once collected. Table 10 presents the ability to measure location of the mileage recording approaches explored by Phase 1 and 2 pilot sites.

Table 10. Mileage recording devices and their ability to measure location.

Mileage Recording/Reporting Approach	Mileage Recording/Reporting Option	Ability to Measure Location
Odometer-based	Manual odometer reading	No
	Image-based odometer reading	No
	Odometer/smartphone hybrid	Yes
Onboard diagnostic-based	Onboard diagnostic II port	No
Location-based	Smartphone with location*	Yes
	Plug-in device with location	Yes
Alternative approaches	Fleet-based	Yes
	Registration-based	No

*Smartphones typically include technology to measure location, although the particular mileage-capture software may not support its use.

Estimating Interstate Travel

States have explored the potential to estimate out-of-State travel among drivers who chose a nonlocation method for mileage reporting. For example, the TETC used census data on interstate commuting patterns to estimate the mileage driven out of State. This approach can capture revenue for out-of-State driving but may also not accurately reflect the actual driving behaviors for participants.

Travel data gathered from participants who used the location-based mileage reporting as part to pilots can be used to better estimate the interstate travel behavior for participants who did not use the location-based mileage reporting method. While not studied in the pilot, it could be a potential data source that allows a better accounting of interstate travel patterns with a much higher granularity than a statewide assumption of travel patterns.

Potential Framework To Reconcile Funds

The ability to measure location is one aspect of interoperability. The other aspect that is critical is the framework to reconcile funds between jurisdictions from both the technical and administrative perspectives. Several States proposed an interstate clearinghouse to reconcile funds between jurisdictions. This model proposed that payments and data for each driver would be collected by their respective account manager, who would then submit data and payments to the respective State and the interstate clearinghouse. The clearinghouse would then determine the gross payments between States that would be needed to reconcile interstate travel, thus simplifying the process for interstate payment reconciliation.

Trade-Offs Between Alternative Approaches To Achieve Interoperability

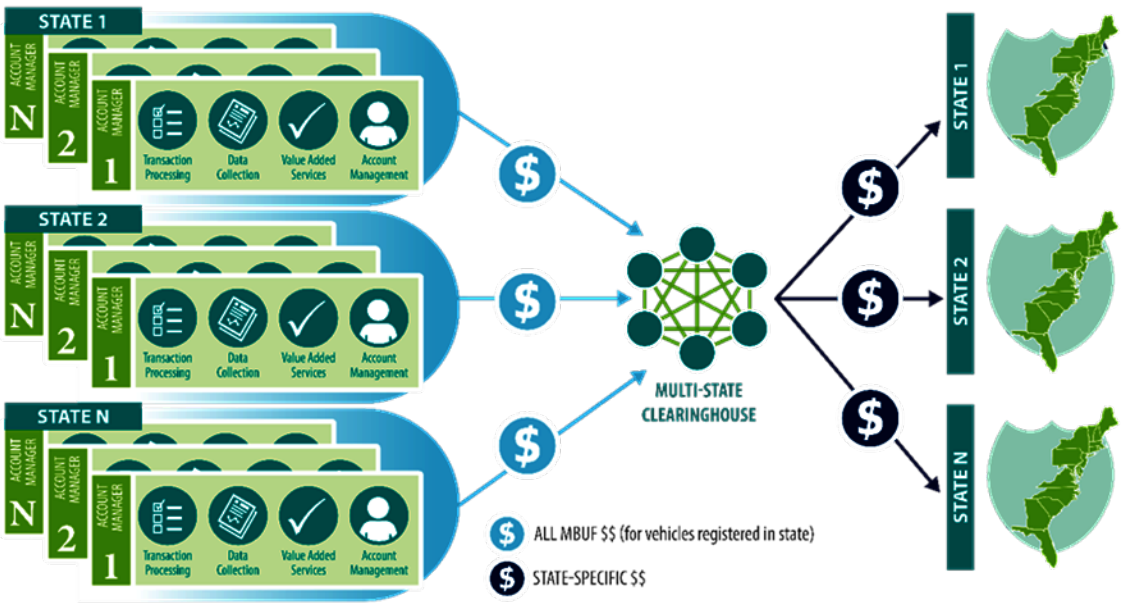
Those systems that include location-based data collection require more sophistication and complexity during the capturing of the mileage data but enhance the ability and ease to reconcile fees between jurisdictions. They may also have associated privacy concerns. Conversely, systems where the capturing of mileages are relatively simplistic (i.e., odometer readings) require more sophisticated and complex calculations and estimation for fee allocation by location.

PHASE 1 INTEROPERABILITY FINDINGS

Several of the Phase 1 grantees explored interoperability between States, including RUC West, the TETC, Washington, and Oregon. Washington and Oregon studied an approach for measuring mileage and transferring fees to reconcile out-of-State driving. Participants using location-based MRD technologies have the specific State mileage fee associated with each mile driven in that State. In both approaches (Eastern Transportation Coalition and Washington and Oregon), transfers or mock transfers of fees were both State to State and did not include a regional clearinghouse entity as suggested in the RUC West ConOps.

Road Usage Charge West Example

The RUC West consortium has established a high-level ConOps that outlines a framework for the transfer of data and fees between private account managers and States to a regional clearinghouse. This approach would allow a centralized system to settle the difference for miles driven between States and give each party a single entity to coordinate fees and data for out-of-State driving (figure 1). This approach has the benefits of limiting the number of transactions needed to reconcile fees between States. Without such a system, each State, private account manager, or both may need to reconcile data and fees between other States and account managers, generating increased complexity as more entities are involved. The RUC West ConOps offers a framework for uniform data collection and transfer, service quality, user privacy, data security, and uniformity in RUC data presentation and user controls to make interoperability as seamless and secure for the user as possible.



Source: RUC West.

Figure 1. Diagram. Regional road usage charge pilot architecture with clearinghouse, with different set of business partners for region.

Eastern Transportation Coalition Pilot

The Eastern Transportation Coalition launched a pilot from May 2017 to July 2017, with 155 participants, testing multiple technologies and approaches that enable interoperability between participating States. Technologies that enabled location measurement were tested, along with an OBD-II device that did not measure location.

Seventeen States are part of the coalition, and a mileage fee was determined for each State based upon the average MFT paid per mile by State, which was then used as a basis for fees when participants drove out of State. For the 84 percent of participants who chose a location-enabled technology, a monthly invoice was generated that provided a breakdown of miles driven per State with associated fee. For those who chose the device without location features, an invoice was generated that estimated the percentage of miles driven within the home State and estimates of miles driven in other States based on census data. Fees were then calculated using the total mileage driven with fees calculated on the estimated percentage driven in different States.

PHASE 2 INTEROPERABILITY FINDINGS

The Eastern Transportation Coalition Multi-State Passenger Vehicle Pilot

A total of 889 participants were enrolled in the Phase 2 pilot, with a majority from Pennsylvania (421 drivers) and Delaware (287 drivers). Of the two MRDs available to participants, one had the ability to measure the location of the distance traveled (GPS-enabled OBD-II), while the other did not (non-GPS OBD-II). The pilot used the existing State motor fuel tax as a benchmark for calculating the per-mile rate for each State using the national fuel economy average of 22 MPG and 19 percent of administrative costs added. Because participants would already be

paying a motor fuel tax with the purchase of fuel, the system calculated the credit that would be applied to the calculation of an MBUF. Participants using the GPS-enabled device were provided monthly statements that showed the mileage driven in each State multiplied by the per-mile fee estimated in each State, minus the fuel tax credit.

For participants who chose the non-GPS OBD-II device, the TETC estimated the proportion of total miles driven out of State using census data and calculated a blended rate that accounted for the different rates in neighboring States. The rate was calculated by applying the participant's State of residence per-mile rate and fuel tax to this estimated in-State mileage. The remaining percentage of the vehicle's mileage was assumed to have been driven in States adjacent to the participant's home State. For the mileage estimated to have been driven in adjacent States, the average per-mile fee and average fuel tax for out-of-State mileage were based on a blended or weighted per-mile rate and State fuel taxes in adjacent States.

A key issue raised in the *Mileage-Based User Fee Study: Out-of-State Mileage Technical Memorandum* was that moving from the motor fuel tax to an MBUF system could potentially cause shifts in funding for States. For example, a driver who purchases fuel in their home State would pay the motor fuel tax to that State for all miles driven with the fuel purchased. If a portion of those miles are out of State, then all the tax revenue still goes to wherever the fuel was purchased. Under an MBUF, the fees would go to whichever State the mileage was driven within, which could potentially change the revenue collected by each State. This change is summarized in the *Out-of-State Mileage Technical Report*:

> Nevertheless, the simple analysis highlighted that how MBUF is implemented could result in some States becoming net gainers in revenue, while other States could become net revenue losers from a MBUF system, depending on the levels of out-of-State mileage.[9]

Washington Funds Reconciliation Proof of Concept

Washington developed an interoperability database called the HUB to facilitate charges and payments among jurisdictions. The HUB successfully processed four quarters of multijurisdictional driving data from participants in Washington, Oregon, Idaho, and British Columbia. The pilot tested a real-money multijurisdictional reconciliation of RUC funds between the States of Oregon and Washington. Participants were required to use the plug-in OBD-II device with GPS to be eligible for the interoperability portion of the pilot, and all mileage driven was reported to WA RUC through the account manager. The mileage data collected allowed for calculation of the RUC payments due among jurisdictions based on State of residence and jurisdiction in which miles were driven.

While the OReGO is a live program involving real money transactions between volunteer participants and the State based on miles driven, the WA RUC pilot did not involve any real money transactions between participants and the State. Oregon participants who opted to participate in the WA RUC interoperability test continued their participation in OReGO without interruption but were charged for miles driven in Washington at the WA RUC rate of 2.4 cents per mile. Likewise, a select group of Washington participants opted in to pay real funds. Each

[9]I–95 Corridor Coalition. 2019. *Out-of-State Mileage Tech Memo*, 5.

month, they were charged the net RUC due for Washington miles (2.4 cents per mile) and Oregon miles (1.7 cents per mile).

The HUB received data in various formats and stored monthly aggregate travel reports from each participating jurisdiction. For Oregon and Washington, the HUB required no changes in reporting format because both States had used existing open data standards that defined jurisdictions similarly. No PII was collected in the reporting. In addition, the HUB itself was flexible to accept data, reports, and funds either directly from commercial account managers in an open system or from States. It was also designed with the capability to perform selected data management functions, and it had the potential to reduce administrative costs of participating States' RUC systems. The HUB allowed flexibility and simplified the reporting process by accommodating reporting by one or more State agencies, different RUC account managers, or any other public or private entity. Participating jurisdictions were required to report data on a monthly basis. States that plugged their RUC systems into WA RUC's HUB came to an agreement on the basic data standards, but this did not require numerous bilateral agreements.

Interoperability and reconciliation with other jurisdictions worked efficiently and effectively when using the WA RUC HUB developed for the pilot. However, a range of issues still need to be resolved for full-scale system interoperability. These issues include the legal authority for collection and remittance of other States' RUC, ownership and governance of the HUB itself, and the structure of the HUB entity so that other States also agree to use the HUB for interoperability. WSTC's Road Usage Charge Assessment Final Report (2020) concluded that with the HUB database there was no additional effort required by the participants compared with a single jurisdiction RUC, aside from educating participants on the billing statement.

CHAPTER 5. DATA SECURITY AND PRIVACY PROTECTION

One of the primary issues related to technology-based methods of collecting data required for RUC is that data about personal VMT are accurate and secure at all times. The two primary data points that are required to establish an in-State RUC are position data and distance-traveled data. State pilots determined that designing a secure RUC system would need to consider:

- Data source availability and integrity: Defines the degree to which RUC data can be trusted and, therefore, to which VMT are accurately taxed.
- Cybersecurity: Relates to the protection of information confidentiality, integrity, authenticity, nonrepudiation, and availability.
- Data storage, transmission, and access: Pilots conducted to date demonstrate that raw data may be stored in various locations and systems, specifically the smartphone MRD, which is used in the smartphone approaches, the dongle MRD, account manager Web service and database and systems, and States' RUC applications.

CROSSCUTTING FINDINGS REGARDING DATA SECURITY AND PRIVACY

- Phase 1 sites are generally early in their development of security-related objectives design and deployment; hence, security is not yet a principal focus.
- Security or privacy needs in the central systems were addressed using today's best practices in network security, application/host security, data management, and privacy management typically found in most enterprises.
- In addition to technical security questions is the aspect of legal implications of right to access vehicle telematics data using certain technologies.
- Embedded within this topic is also the evolution of public perception of data security and privacy with respect to RUC data.

Pilot sites determined that maintaining and ensuring privacy of the data collected from participants may involve several factors:

- The type and quantity of raw data being collected.
- How the raw data are treated (i.e., sanitized) and where in the system.
- The intractability of performing tracking of drivers (requiring collection point and account manager system anonymization and sanitization practices).
- The cybersecurity posture of the system and its endpoints.

This chapter presents the preliminary and high-level findings of Phase 1 sites in the process of examining data security and privacy protections of proposed mileage recording approaches.

KEY CROSSCUTTING FINDINGS

Data Security

The recipients of the STSFA Program Phases 1 and 2 grants are generally early in their development of security-related objectives, design, and deployment; therefore, security is not yet a principal focus. Architecturally, each STSFA grant recipient employs the following systems: (1) mileage collection and reporting systems/devices and (2) centralized systems. Mileage and location(s) of miles driven are collected in mileage collection reporting systems and fed to the centralized systems for account update and RUC billing purposes. The security design of the central systems generally leans on State-mandated conventional cybersecurity requirements, with little to no program-specific augmentation. Security or privacy needs in the central systems were addressed using best practices in network security, application/host security, data management, and privacy management typically found in most enterprises. The best practices used were current as of the date of this report. Table 11 summarizes potential security issues on the commonly explored mileage reporting methods by Phase 1 sites.

Table 11. Summary of potential security issues based on mileage reporting method.

Mileage Reporting Method	Description	Security Summary
Vehicle telematics using a dongle attached to the vehicle's onboard diagnostic standard II (OBD-II) port	The standardized OBD-II port obtains the vehicle's speed, which is then integrated to produce distance traveled information. This solution can either use a Global Positioning System (GPS) receiver built into the mileage recording device to obtain location data, or obtain it from another source, such as an external GPS receiver (e.g., from a smartphone application), or by entering it manually.	Vehicle telematics systems can be thwarted through man-in-the-middle attacks between the vehicle's data bus (connecting the electronic control units) and the OBD-II port, or between the OBD-II port and the connected dongle. Today, there is no secure standardized vehicle data access technology in use; access control problems raise potential data integrity and privacy problems.

Table 11. Summary of potential security issues based on mileage reporting method (continuation).

Mileage Reporting Method	Description	Security Summary
Smartphone with beacon	This approach uses a smartphone application to obtain location and/or distance traveled information using the smartphone platform's GPS. A technical challenge of this approach is the need to associate a phone to a given vehicle.	• The system inherits all the security problems of the smartphone platform—some are generally more secure than others; some are easier to root and compromise. • The beacon is necessary to correlate position/distance information with a given vehicle. Today, no phone/vehicle pairing technique is reliable, secure, and convenient. Any mandate to use wireless technology beaconing effectively translates to privacy losses due to traceability of static addresses.
Manual mileage reporting	This approach is characterized by road usage charge program participants either taking vehicle odometer pictures via a smartphone application, or uploading to an account manager, or having a recording of their odometer readings at regularly scheduled vehicle inspections.	This method is subject to integrity problems at the source if the manual reporting is made by the driver. If the manual reporting is made by a licensed technician or other third party, this method is likely the most secure.

Driver Privacy

Both perceived and real privacy are important factors in an RUC program, given the public's potential for pushback to the program based on perceptions about privacy properties and the potential for actual privacy breaches.

One of the principal challenges identified with respect to privacy is a lack of standardization concerning the data each State will collect and what different commercial account managers may collect regarding value-added telematics offerings. States that implement RUC systems should be prepared to address and clarify potential privacy misunderstandings between the commercial account managers and State RUC systems elements.

Maintaining data privacy in an RUC system is tied to the following aspects of collecting and handling participants' or drivers' data and RUC system design:

- **The type and quantity of raw data being collected:** Assessing the RUC pilots showed that, except in the cases of account manager value-added services, only minimal data were collected across interfaces. Data retention periods were minimized, and retention-related requirements were generally specific and unambiguous.
- **How the raw data are treated (i.e., sanitized), and where they are stored in the system:** Specific methods of sanitizing and scrubbing privacy-sensitive data were generally lacking in RUC pilot documentation. In addition, data aggregation rules were not clarified or standardized. This oversight is anticipated at this early stage of pilot planning and execution with relatively smaller participant pools. However, left unmitigated, aggregation of large amounts of raw or high-resolution data may lead to privacy losses, especially if comingled with identifying information. Higher resolution, position-time data collection may necessitate careful examination of data aggregation in conjunction with allowed data retention periods, especially as RUC programs begin to institute subregional, demand-based RUC designed to influence driver behavior.
- **The intractability of performing geotemporal driver tracking:** As RUC systems mature and more elaborate RUC scenarios are developed, more fine-grained location and distance information collection may become necessary. Collecting too much of these data may introduce retroactive privacy breaches (i.e., tracking one's location history). In addition to data collected, the confidentiality protections afforded the data become paramount.

Issues With Mileage Reporting Devices

There are underlying security flaws inherent with an OBD-II-based approach to collecting mileage data. Several sites concluded or assumed that read-only access on the OBD-II port and data consistency checks—e.g., between inertial sensor and odometer—were sufficient when combined with (1) regular upload intervals and (2) detection of device unplug events. Most sites' final reports indicate that custom security design and standardization for mileage reporting devices are not yet forefront in RUC pilots.

Example problems with MRD devices include:

- **Correlating mileage data with other data:** The correlation of mileage data with inertial sensor data is employed to check the plausibility and consistency of mileage information coming in through the OBD-II port. This method, however, is unreliable unless high-cost sensors and error-correction filters are employed within the MRD itself. Correlation with GPS information—assuming GPS is determined not to be spoofed—is likely to produce more reliable plausibility checks.
- **Device unplug events:** Detecting if and when devices are unplugged is a critical feature in protecting the generation, integrity, and flow of RUC data to service providers. It is noteworthy, however, that detection of device unplug events can be easily thwarted via a man-in-the-middle attack at the port interface. Between the MRD device and the OBD-II port, for example, an intermediate shim device can emulate a vehicle connection. This attacker device would be attached to the MRD, essentially forming a new physical

interface to the OBD-II port. It could be disconnected from the OBD-II port while simultaneously providing the MRD with a connected status. Furthermore, more sophisticated attacker devices could emulate legitimate driving behavior but with lower odometer readings, or entirely block the power and data interfaces of the OBD-II port when needed. Pilot results suggested that limitations in OBD-II security be offset with policy-based, occasional third-party checks of odometer values.

- **Rogue devices:** While the cost and know-how to engineer MRD OBD-II spoofing devices is beyond the capabilities or cost-benefit threshold of most vehicle owners, there is historical precedent for similar types of rogue devices to be engineered and manufactured at scale.

Future Considerations for Mileage Data Collection

The evaluation team believes that vehicle internal telematics systems and secure vehicular interfaces (not OBD-II plugin devices in the long term) are likely to be the dominant data sourcing methods for future RUC systems. Automotive cybersecurity standards are rapidly evolving as are technologies enabling applications to run on the vehicle with secure, confidential, controlled access to mileage and location data. Automotive original equipment manufacturers (OEMs) or aftermarket device providers that are given a secure interface may provide an RUC application running on the vehicle. The recently passed Right-to-Repair legislation in the State of Massachusetts could have a significant effect on how access to RUC data on future vehicle will be achieved https://malegislature.gov/Laws/SessionLaws/Acts/2012/Chapter368. At the present time, there is uncertainty about how this law may affect similar laws in other States and what solutions the industry may develop or adopt for providing secure electronic access to vehicles telematics for repair and other purposes.

Several indicators point to the possibility that today's insecure OBD-II technology will likely be replaced with more secure vehicular data access technologies either controlled by automotive OEM or aftermarket providers

PHASE 1 DATA SECURITY AND PRIVACY FINDINGS

Eastern Transportation Coalition's Approach to Participant Data Privacy

Personally identifiable information: 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.

Mileage data: The TTETC pilot implemented best practices, including limiting data retention periods and destroying data at the conclusion of those retention periods. However, methods of data destruction were not specified. The Coalition developed a Technical Memorandum containing a review of potential privacy issues and solutions (see table 12).

Table 12. Eastern Transportation Coalition's privacy approaches and potential solutions for user control over information.

Summary of Key Privacy-Related Issues and Considerations for a Mileage-Based User (MBUF) Fee System
Choice: Providing choices for mileage reporting, thereby providing drivers with a range of options. Options would include at least one approach that does not involve any sort of mileage reporting (e.g., 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. Consent 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.
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.
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 share (i.e., sell) collected data to other entities. Definition of data sharing 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 (PII)) and/or aggregated before providing the information to others.
Integrity and security: Defining PII and ensuring PII and other collected data are secure from unauthorized or unlawful processing. Security 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 Eastern Transportation Coalition.

Data Security and Privacy Enhancements in the Oregon Pilot

The Oregon pilot's *Market Cycle Evaluation Final Report* indicated that:

> …the public's perception of the program can be eroded if people do not believe the program is responsible in regards to protecting personal information. New requirements were added and existing requirements were clarified to reduce the occurrences of misinterpretation.[10]

[10]Oregon Department of Transportation. 2018. *OReGO—Oregon's Road Usage Charge Program, Market Cycle Evaluation Report*.

Oregon's best practices toward enhancing data security and privacy, explored as part of STSFA Program Phase 1, are briefly summarized below:

- **Account manager compliance:** As part of their account manager compliance activity, Oregon redefined system requirements to enhance the security and reliability of technologies offered and systems used. Refinements included encryption of level 3 data (contains PII) in transit and at rest, authentication between systems prior to transmitting data, and quality-controlled data validations in each subsystem.
- **Volunteer agreement:** The Oregon pilot provided a volunteer agreement and RUC privacy policy to clarify the rules governing the type, collection, treatment, and use of pilot participants' data. Additionally, Oregon's RUC Business Requirements documentation delineated the contractor (i.e., account manager or MRD provider) roles and responsibilities concerning privacy agreements for any value-added services or other business practices extending beyond RUC. The account manager was free to include value-added telematics offerings consistent with its State mandate to implement and socialize its privacy policy.
- **Data/privacy management and data security in the MRD:** The Oregon pilot instituted a policy requiring no more than 30 days' retention of raw mileage/location data to reduce the exposure of driver location data in the event of component or account manager server compromise. Additionally, data-at-rest and data-in-transit encryption were employed to protect the data storage and collection processes with respect to the dongle.
- **Data/privacy management at the account manager and State RUC reporting systems:** The State of Oregon does not collect raw data, only processed, interface-defined data associated with a vehicle's distance traveled and in what State it traveled in a given time interval. The Oregon RUC participant privacy agreement indicates adequate policies regarding the type of information that the State will collect. The commercial account manager collects raw data, and it is, therefore, differentiated from the State's RUC system.

PHASE 2 DATA SECURITY AND PRIVACY FINDINGS

The key aspects investigated as part of Phase 2 explorations of data security and privacy topics included:

- Identification of privacy-related RUC data collected and managed in the WA RUC pilot
- Key findings regarding public perception of RUC privacy
- Key goals for a model RUC privacy policy, including a comparison of Washington State's privacy laws with the model RUC privacy policy developed by WA RUC

Model Privacy Policy Recommendation From the Washington Pilot

A key activity of the WA RUC pilot was developing a model RUC privacy policy to address known privacy concerns. Table 13 lists the WA RUC Steering Committee's key high-level recommendations for a model road usage charge privacy policy.

Table 13. Washington State's recommendations for a model road usage charge privacy policy.

Model Road Usage Charge (RUC) Privacy Policy Aspect	Recommendation
Purpose	Clearly state the purpose of the model RUC privacy policy as protecting personal information collected under an RUC program from disclosure.
What information to protect	Identify the RUC information to be protected in the model privacy policy.
Responsibility of protecting personal information	Designate a responsible agency for protecting personal information in an RUC program. Responsibility should reside with whoever holds the information with adequate oversight for the task.
Whether responsible agency can operate as service provider	Provide drivers a government service instead of a commercial service provider choice by designating a State government agency to operate as an RUC collection provider. Surveys indicate that some individuals inherently trust commercial more than government providers, whereas others trust government more.
Nature of protection	Address the nature of the protections afforded RUC data in the State. Address the specific requirements, limitations, and prohibitions directly related to protection of personal information collected for an RUC program and direct service providers and the authorized agency to establish, publish, and adhere to an organizational usage and privacy policy available in writing.
RUC personal information as a public record	Categorize RUC information as a public record according to a State's public records laws but explicitly exempted it from disclosure.
Exceptions to nondisclosure of RUC data	Exempt from nondisclosure: Operators of the RUC and RUC payment systems, personal exemptions the RUC payer has made to his/her own data, and law enforcement activities with probable cause.

Table 13. Washington State's recommendations for a model road usage charge privacy policy. (continuation)

Model Road Usage Charge (RUC) Privacy Policy Aspect	Recommendation
Rights that should be afforded an RUC payer	Provide the RUC payer the right to access, examine, and rectify errors in personal information and the erasure of location and metered use data after the data are no longer needed after a specified period. Exceptions may include consent of the RUC payer, anonymized aggregated information used for research, and monthly summaries for accounting purposes.
Informing RUC payer of their rights	Provide payers information at first engagement about their rights and how to exercise them.
Responding to a request for exercise of rights	Mandate that service providers must never refuse a request for the exercise of one's rights.
Consent	Define consent as "freely given, specific, informed, unambiguous indication of the RUC payer's wishes." Provide for express approval for sharing of personal information. Provide for the RUC payer to be able to withdraw consent of approval.
Treatment of RUC payers	Prohibit service providers from discriminating against RUC payers when they exercise their rights. Different pricing should be allowed only when the difference is directly related to the value provided. (Note: Some service providers offer value-added services related to the telematics data collected from the vehicle.)
Security measures	Require the service provider to implement measures to protect personal information to a level commensurate with the risk of disclosure.
Security breach notices	Require the service provider to notify the authorized agency upon a breach occurring. Information should address the nature and effect of the breach.
Compliance	Require a service provider to designate a personal information officer as the contact individual for RUC payers for compliance purposes.
Certification	Require an authorized agency to establish certification mechanisms and means for service providers to demonstrate compliance.

Table 13. Washington State's recommendations for a model road usage charge privacy policy. (continuation)

Model Road Usage Charge (RUC) Privacy Policy Aspect	Recommendation
Remedies	Adopt a variety of remedies that RUC payers may use when their rights are violated. Address the nature of the remedies, including penalties.
Choice of reporting methods	There is no need to provide such a policy, as this topic should be addressed in the State's authorizing legislation for an RUC.
Preemption	Typically, in most States it is not required to include a clause about State preemption of local laws and therefore it may not be needed in an RUC privacy policy.
Anonymization of information and data	Require anonymization of location and metered use data "if an RUC payer consents to retention of the data beyond the 30-day erasure period following the later of payment, dispute resolution or noncompliance investigation."
Record of access	Ensure the policy requires service providers to maintain a record of access to personal information the service provider holds.

Analysis of Gaps in Existing State Privacy Policies in the State of Washington

The WA RUC Steering Committee identified legal protection gaps in the Washington State's current privacy laws. For instance, there is currently no exemption of RUC data in public disclosure laws. Thus, the Steering Committee suggested that RUC-related data should be afforded protections similar to tolling data in its State. The WA RUC Steering Committee performed an analysis of Washington State's existing privacy laws to determine gaps in its protection of RUC data; table 14 lists key observations and takeaways.

Table 14. Washington State's observations and takeaways about gaps in existing data privacy protections.

Topic	Observation	Takeaway
Differences in protected information	Road usage charge (RUC) data unique to RUC includes distance traveled data, travel data record, RUC account identifier (ID) information, mileage meter IDs, and RUC enforcement records. Much of the existing privacy-protected data in current State systems are not present in an RUC system.	Applying the model RUC privacy policy to Washington State would require an RUC-specific definition of personal information.

Table 14. Washington State's observations and takeaways about gaps in existing data privacy protections. (continuation)

Topic	Observation	Takeaway
Territorial scope	Washington State used only commercial service providers in the RUC pilot.	Either type of service provider (government or commercial) can be promoted; however, both must comply with privacy protection provisions.
Personal information processing principles	Protections on the disclosure of private information are different than existing Washington State Department of Licensing (DOL) systems; current law is less specific about who can use protected information.	Application of the model privacy policy should provide for specific requirements on data use, who can use it, and requirements for data security auditing.
Statutory rights	The laws governing DOL do not establish the statutory rights for data-related rights as defined in the model RUC privacy policy.	Establishment of statutory protection of data-related rights should be required before implementing an RUC program.
Data security	Current laws are less specific on security and provide flexibility for the DOL to customize such provisions in contracts.	Security provisions in an RUC system will likely need to be clarified in order to meet needs of privacy advocates.
Use of personal information officer	DOL does not currently require such an officer but could if needed.	The model RUC privacy policy is much more robust with a requirement for a personal information officer whose duties address the establishment and compliance with organizational usage and privacy policies.
Remedies available to users of RUC system	DOL only requires subsequent denial of access to personal information in case of a violation of a nondisclosure contractual requirement; Federal Driver's Privacy Protection Act of 1994 (Pub. L. No. 103-322) provides remedies for disclosure of protected information; civil cause of action remedies are available to drivers.	Model RUC privacy policy is much more specific and robust about remedies available to drivers whose private information is compromised.

Pilot Participant Perception of Security and Privacy Aspects

The Phase 2 pilots present divergent participant views on privacy. While WA RUC participants ranked RUC data privacy as the most important out of all the nine RUC defining principles,

TETC pilot participants did not consider privacy to be a highly motivating factor at the start of each pilot.

During and after pilot execution, the opinions somewhat converged with nearly half of WA RUC participants indicating that they were satisfied that information collected from the pilot would be protected from unauthorized use and a similar percentage very or somewhat satisfied with the data protections in the TETC pilot. Notably 36 percent of focus group participants in the TETC pilot did not think about privacy concerns until they were raised in the focus group.

The concern typically expressed on this topic centered around the following theses:

- Concern that automated MRDs were an invasion of privacy
- Concern about with whom the U.S. government might share private citizens' data
- Concern about data inadvertently getting into wrong hands

Overall participants, regardless of opinions about privacy, appreciated the option for nonlocation-specific approaches to report miles driven data that both pilots provided.

CHAPTER 6. PUBLIC OUTREACH, MESSAGING, AND COMMUNICATION

Outreach and communication concerning alternative transportation funding mechanisms serves two key goals—educating the public regarding transportation funding challenges and facilitating wider public and political acceptance of this approach. Additionally, it can also serve to inform the pilot sites about the types of messaging that are most effective in achieving the above goals.

KEY CROSSCUTTING FINDINGS

Best practices pertaining to outreach, messaging, and communication that emerged from the Phase 1 sites are detailed in the following section.

CROSSCUTTING FINDINGS REGARDING PUBLIC OUTREACH, MESSAGING, AND COMMUNICATIONS

- Recognize the need for ongoing public/stakeholder education and outreach.
- Develop a targeted communications strategy involving:
  - Messaging around key motivators
  - Communicating to address public concerns
  - Implementing a multipronged approach to outreach and communications
- Develop a framework for regional support.
- Public outreach may be affected by local political considerations, particularly concurrent efforts around transportation funding in the States.
- Over recruitment of pilot participants can capture a greater diversity in the participant pool.

Recognizing the Need for Ongoing Public/Stakeholder Education and Outreach

Implementing an RUC or another alternative form of transportation funding will require ongoing public education. Phase 1 sites demonstrated through their outreach efforts the variety of stakeholders that need to be informed and educated, including, among others, legislators, government officials, business and community organizations, and the general public. Educational initiatives can serve the dual purpose of increasing the level of education and support for alternative transportation funding solutions and informing the system designers about the concerns of the public and stakeholders. The lessons learned from outreach can also be applied to developing a communications strategy that focuses on appropriate messaging and approaches to reach the target audience.

Developing and Executing a Targeted Communications Strategy

An effective communications strategy involves identifying the target audience and differentiating messaging and approaches to reach them. A strong communications strategy would include:

- Targeted messaging around key motivators for exploring transportation funding alternatives
- Approaches to conduct outreach to identify public and stakeholder concerns and develop evidence-based messaging to address those concerns

- Multipronged approach to outreach and communications involving multiple media platforms.

Messaging Around Key Motivators

Based upon the Phase 1 efforts of grantee sites, the following emerged as messages that convey the key motivator for exploring alternative transportation funding solutions (table 15).

- **Transportation funding challenges:** Educating the public on how transportation funding currently works is critical to making a credible case for RUC. Once that baseline knowledge is established, it is relatively straightforward to communicate the effect of increasing fuel efficiency on transportation funding and how this shortfall will affect the general public. For instance, falling revenues can be linked to poorer road maintenance, decreased road safety, damage to personal vehicles, and increased traffic congestion—outcomes that are relevant to the driving public. This basic understanding can help establish the message that a distance- or mileage-based charge allows States to collect enough transportation revenues to meet system needs.
- **Fairness:** Ensuring that an RUC is fair is a key message that is likely to resonate with the public. The central idea supporting fairness of RUC is that, as infrastructure needs grow in the face of increasing vehicle fuel efficiency and growing market share of electric vehicles, RUC provides mechanisms for users to pay according to their usage of the transportation system. The pilot sites that conducted research into public reaction largely found that messages regarding everyone paying their fair share and sustainable funding were among the most convincing rationales for RUC. At the same time, fairness is a challenging feature to communicate because different interest groups define the term differently.

Table 15. Key motivators and effective messaging in favor of exploring alternative transportation funding mechanisms.

Key Motivators	Effective Messaging Based on Phase 1 Site's Outreach Efforts
Transportation funding challenges	• As vehicles become more fuel efficient, Federal and State fuel tax revenue is declining across the country. A road usage charge (RUC) would provide a sustainable model for future transportation funding (Oregon, Eastern Transportation Coalition). • Roads and bridges are in dire need of maintenance (California). • Transportation funding is projected to decrease because people are buying less gas due to more fuel-efficient vehicles. An RUC would provide a more stable funding stream to maintain our roadways, because it is based on usage, not fuel (Washington).
Fairness	• RUC ensures each driver pays their fair share based on how much they use the roads (Washington, Eastern Transportation Coalition). • Road charge balances the way roads are funded so that all vehicles share the cost based on how much they use the road, regardless of their miles per gallon or type of fuel (California). • People are driving more fuel-efficient vehicles and consuming less fuel in the case of electric vehicles, thereby paying less than fuel tax, yet their vehicles put as much wear on roads as other vehicles (Oregon).

Evidence-Based Messaging and Communications To Address Public/Stakeholder Concerns

It is important to develop adequate responses to concerns about privacy, data security, and the complexity of an RUC system relative to fuel taxes. The responses should aim to provide evidence-based reasoning to address public concerns. Some of the key concerns that Phase 1 sites encountered during their outreach initiatives are described below:

- **Equity:** Most resistance to RUC is due to concerns around the equity of this approach. Some of the common themes are that RUC is expensive for people who have to drive long distances and have low incomes, and it is inherently unfair because it disincentivizes fuel-efficient vehicles while giving refunds" to "gas guzzlers."[11]
- **Charging accuracy and data security:** According to WSTC's Public Opinion Report, the most critical questions about RUC pertained to system accuracy, how users would report their miles, whether it would replace a gas tax or be levied in addition to the existing tax, and whether their PII would be kept safe and not used for other—primarily commercial—purposes. System accuracy is especially critical with respect to the reporting methods available to the public and their ability to choose between them.[12] The pilot sites have yet to develop simple and effective messaging that addresses accuracy

[11]Oregon Department of Transportation. 2017. *OReGO–Oregon's Road Usage Charge Program, Focus Groups Report*.

[12]Washington State Transportation Commission. 2017. *Washington Transportation Funding Public Opinion Assessment Report*.

and data security. It may be noted that conducting pilots is one of the significant ways to both test and demonstrate the accuracy and security aspects of reporting methods.

- **Privacy:** The Minnesota Department of Transportation, in its interviews with stakeholders, found that privacy was a key concern of elected officials and advocacy organizations. These stakeholders, in turn, reflect the concerns of the general public in that tracking of individuals and their travel habits is looked upon poorly. While the sites progressing with pilots have high-level measures in place to protect drivers' location data privacy, they have yet to develop simple and effective messaging that addresses this concern. Developing messaging around this concern may involve carefully translating highly technical information regarding data-handling procedures to simple and direct messaging that is accessible to a nontechnical audience as well.
- **Why a complex system is needed if no one is significantly worse-off:** Oregon focus group participants did not see the need to implement what they saw as a complex, invasive system if it is not going to significantly increase transportation funding.[13] The ODOT Focus Group Report recommends that the sustainability and adequacy of RUC would need to be illustrated through graphics to address this concern.

Effective messaging is targeted, simple, and transparent. For instance, in the interest of transparency, messaging about pilots would make it clear that the revenue-neutral mileage rates being used during the demonstrations are for test purposes only and the actual mileage tax rates likely would be different.

Multipronged Approach to Outreach and Communication

As part of Phase 1, several sites conducted limited outreach to stakeholders and the public or engaged consulting companies to recommend potential outreach approaches. Table 16 presents the approaches explored by or recommended to Phase 1 sites.

[13]OReGO website has an online calculator (https://www.myorego.org/how-it-works/) for users to compare what they pay in fuel tax with what they would pay in road usage charge. ODOT RUC focus group participants who used the calculator all concluded that those who pay more would pay just a little more, and those who pay less would pay just a little less. However, it raised the question as to how a road usage charge could significantly increase funding for transportation.

Table 16. Multipronged approach to outreach explored by or recommended to Phase 1 sites.

Type of Outreach	Target Audience and Goals	Examples

Public Affairs	Educating key local- and State-elected officials, regulators, and other policymakers; leverage their support to continue educational efforts.	• Outreach to target audience at:
		  ○ Regional infrastructure tour.
		  ○ Conferences and seminars.
		  ○ Legislative caucus retreats.
		  ○ Local press conferences.
		• Support letters to local policymakers and stakeholders.
		• Involve target audience in steering committees.
		• Develop fact sheets, flyers, and frequently asked questions lists.
		• Participate in pilot.

Stakeholder outreach	Educate stakeholders with the necessary information and materials for continued awareness around need for alternative transportation funding solutions.	• Create stakeholder management team. • Conduct stakeholder interviews. • Involve key stakeholders in the Steering Committee. • Participate in pilot.
Public outreach	Increase the level of awareness among the general public and widespread education about transportation funding challenges and solutions through community-level engagement.	• Conduct outreach at community-based organizations and events, including youth and civic organizations, business associations, ethnic groups, faith-based organizations, educational institutions, and advocacy groups. • Target outreach to specific communities. • Conduct surveys.
Media-based outreach	Outreach to a wide audience using a variety of media platforms for marketing and messaging.	• Use social media platforms. • Post fact sheets, frequently asked questions, and promotional videos on website. • Use blogs, newsletters, and email blasts. • Use earned and donated media.

Developing a Framework for Regional Communications Support

Regional coalitions (e.g., RUC West and the Eastern Transportation Coalition) provide the suggested framework for regional communications support. For Phase 1, several pilot sites engaged in outreach efforts on a regional and/or national level. FHWA has continued to foster collaboration among the pilot sites through annual workshops conducted in Washington, DC, in 2018 and 2019 concurrently with the Transportation Research Board annual meeting. Additional collaboration is taking place outside of the STSFA Program under the RUC West umbrella between Phase 1 and Phase 2 sites and through the Mileage Based User Fee Alliance. These forums provide an opportunity to the entities engaged in pilots to share lessons learned from different approaches, improve understanding, and determine the equity concerns that will need to be addressed. They also provide an opportunity to develop common arguments and language when communicating with stakeholders.

Accounting for Political Considerations Around Transportation Funding

Political considerations, particularly concurrent actions around transportation funding such as an increase in gas tax, can affect the scope and approach of public outreach. California, Washington State, and Oregon legislatures passed gas tax increases in the recent past. This message has a specifically pronounced effect in the case of the California pilot. Senate Bill 1 passed in the California legislature in 2017, which created the Road Maintenance and Rehabilitation Program to address deferred maintenance on the State highway system and the local street and road system and was funded through an increase in the gas tax. Additionally, the bill imposed a new transportation improvement fee imposed under the Vehicle License Fee Law, with a varying fee between $25 and $175 based on vehicle value and with an inflation adjustment, and a new $100 annual vehicle registration fee applicable only to zero-emission vehicles model year 2020 and later with an inflation adjustment. Given the backdrop of this legislation and the associated increases in the current tax and fee structure, it was politically unacceptable to conduct a broad-based education and outreach campaign regarding RUC, which was projected to be widely perceived as an additional tax.

PHASE 1 OUTREACH, MESSAGING, AND COMMUNICATION FINDINGS

Table 17 summarizes significant outreach and communication activities that Phase 1 sites undertook.

Table 17. Significant outreach, messaging, and communications efforts undertaken by Phase 1 sites.

Phase 1 Pilot Site	Outreach, Messaging, and Communication Efforts	Recognize Need for Public/Stakeholder Education and Outreach	Develop and Execute a Targeted Communications Strategy	Develop a Framework for Regional Communications Support
Minnesota	Conducted extended interviews with stakeholders, including elected officials, government employees, and representatives from special interest organizations.	✓	—	—
Missouri	Supported policies that would have promoted further analysis of its registration fee structure based on a vehicles' miles-per-gallon rating.	✓	—	—
Eastern Transportation Coalition	Conducted a limited pilot with participants who could potentially become project champions: High-level executives from participating State departments of transportation and departments of motor vehicles, State legislative aids, metropolitan planning organization staff, and members of the media.	✓	—	✓
Eastern Transportation Coalition	Conducted surveys of the pilot participants to gauge public acceptance of a mileage-based fee before and after the pilot.	✓	—	—

Table 17. Significant outreach, messaging, and communications efforts undertaken by Phase 1 sites. (continuation)

Phase 1 Pilot Site	Outreach, Messaging, and Communication Efforts	Recognize Need for Public/Stakeholder Education and Outreach	Develop and Execute a Targeted Communications Strategy	Develop a Framework for Regional Communications Support
Washington, Oregon, California, Eastern Transportation Coalition	Conducted significant research into public reaction to messaging efforts, typically using more than one research method including focus groups and online and/or telephone surveys.	✓	✓	—
California	Prepared a communications strategy to support future pilot outreach efforts. These strategies identified target audiences, their key concerns and reactions to road usage charges (RUCs), and communication approaches likely to work with multiple audiences.	✓	✓	—
RUC West	Member States engaged in development and refinement of the communications resources, including subject matter folios, a communications plan, media kits, and a website.	✓	✓	✓
	Developed a communications plan focused on the goal of increasing public awareness of national transportation funding and the need for a sustainable transportation funding solution. The plan mirrored the three tiers of participation among member States, from those actively promoting road usage charging to those monitoring trends at this time.	✓	✓	✓

Table 17. Significant outreach, messaging, and communications efforts undertaken by Phase 1 sites. (continuation)

Phase 1 Pilot Site	Outreach, Messaging, and Communication Efforts	Recognize Need for Public/Stakeholder Education and Outreach	Develop and Execute a Targeted Communications Strategy	Develop a Framework for Regional Communications Support
Washington	Engaged in pilot recruitment activities, including e-newsletter blasts, website updates, earned media, paid advertising, and demographic survey. They also developed How it Works videos and frequently asked questions and used incentives as a pilot recruitment tool.	✓	✓	—
Oregon	In September 2017, Oregon Department of Transportation conducted an RUC Forum in Salem, OR, whose panelists included representatives of industry and government to provide an array of considerations about the topics, which included privacy protection, technology options, and compliance. Several pilot sites and Federal Highway Administration staff participated in the forum.	✓	—	✓
	Launched a marketing campaign.	✓	✓	-

—No data

PHASE 2 PILOT RECRUITMENT, OUTREACH, MESSAGING, AND COMMUNICATIONS FINDINGS

The communication and outreach strategies in Phase 2 were centered on pilot recruitment. Sites also continued outreach, engagement, and education activities through pilot execution.

Table 18 presents the evaluation and site-specific questions about public outreach and education.

Table 18. Evaluation and site-specific questions used to analyze road usage charge public outreach strategies.

Evaluation Questions	Site-Specific Questions and Metrics
What strategies were used to recruit participants for the pilot?	• What strategies were used to inform, educate, and build support among the general public about the pilot and the road usage charge concept? • How effectively did these strategies succeed in recruiting pilot participants and increasing public awareness and acceptance?

Outreach Strategies Used for Pilot Recruitment

Table 19 summarizes the outreach strategies and the pilot.

Table 19. Summary of outreach strategies and the pilot.

Pilot Recruitment and Participant and Public Engagement Strategy/Approach	Respective Pilot Sites
Media strategies, including creation and maintenance of pilot website, frequently asked questions and presentations and fact sheets/postcards, paid digital media, and paid social media ads	Washington, The Eastern Transportation Coalition (TETC)
Earned media strategies	Washington
Mileage-based user fee cost calculator	TETC
Over recruitment of potential participants (recruiting close to 5,000 volunteers for 2,000 spots in the pilot), which enabled a balance of participants that reflected demographics (race, ethnicity, gender, income basis) of the State and geographic and vehicle type diversity	Washington
Media engagement focused on responding to media inquiries and requests, as well as preparing for the pilot's completion	Washington, TETC
During pilot: An operational help desk staffed with individuals with knowledge of the pilot	Washington
Involvement of other State agencies (departments of transportation) to metropolitan planning organizations, industry interest groups, and academies encouraging them to sign up and invite members to participate	TETC

KEY FINDINGS ON PUBLIC OUTREACH AND COMMUNICATION

Given limited public knowledge about transportation funding topics, a multipronged approach—including broad-based media strategies, social media campaigns, and specific stakeholder outreach by State agencies for pilot enrollment—is usually needed even for small- to medium-sized pilots. Overrecruitment can be considered as a strategy to capture greater diversity in the participant pool.

Future pilots may benefit from public opinion surveying that oversamples respondents from populations of interest (e.g., by income or race), so the views of these groups can be assessed with some certainty. Similarly, future pilots may also benefit from a pilot participant recruitment plan designed to ensure inclusion of a diversity of participants across race, income, English language proficiency, and other demographic dimensions.

CHAPTER 7. EQUITY AND PUBLIC PERCEPTION

Equity relates to how user costs and other outcomes will affect people with different characteristics. With respect to RUC policy, the characteristics typically of interest for equity analysis are travel modes and basic sociodemographic factors such as household income, race, ethnicity, gender, and English proficiency level. This chapter explores the crosscutting findings of the STSFA Program Phase 1 sites with regard to equity considerations of a potential future RUC system.

KEY CROSSCUTTING FINDINGS

As discussed in chapter 6, questions regarding the equity and fairness of an RUC resonate with diverse stakeholders and community members. However, a key challenge that States implementing pilots encounter is that different interest groups define fairness differently. The key steps that agencies accomplished in Phase 1:

- Identify, analyze, and qualify potential equity effects, which can help agencies determine the nature and extent of effects of the proposed program across different categories of users and the potential for inequitable impacts.
- Develop approaches to address or mitigate inequities, which can be used to design a more equitable alternative funding program or include measures that make the original proposal more equitable for targeted groups.
- Develop and deploy appropriate communication and messaging strategies, which help to reach out specifically to groups that perceive or are likely to perceive the proposed program as inequitable. This outreach should inform community members about the outcome of the analysis in clear, concise, nontechnical terms. This outreach should highlight program details that were designed to address any equity issues identified. It is possible that program design choices do not adequately address some equity concerns; in such cases, the communication approach may need to emphasize the inherent fairness of an RUC mechanism as compared with fuel taxes, particularly with the increasing electrification of the vehicle fleet.

EQUITY CONCERNS RELATED TO ALTERNATIVE TRANSPORTATION FUNDING MECHANISMS CALL FOR A STRUCTURED APPROACH INVOLVING:

- Identifying, analyzing, and qualifying equity effects
- Developing approaches to address or mitigate inequities in proposed alternatives
- For the initial phases of exploration of alternative funding mechanisms when communications and pilot recruitment are key elements, developing communication and messaging strategies to address concerns and educate public and stakeholders about the equity aspects of the proposed alternative

In Phase 2, sites built upon the theoretical understanding of equity they had developed in Phase 1 by using surveys and focus groups to explore how both the public at large and pilot participants perceived the equity of RUC programs.

Note that in both Phases, the pilots explored equity, primarily with respect to two dimensions: People living in urban versus rural areas and people driving vehicles with different fuel efficiencies (or EVs). In neither Phase did the sites conduct analysis to explore the effects on populations of special concerns as defined by factors like income, race, ethnicity, gender, or English language proficiency. Additionally, there were no reported public or participant opinion surveys or focus group activities designed specifically to examine the opinions and understanding held by members of populations of special concern, although the research was designed to permit some such analysis.

PHASE 1 EQUITY FINDINGS

For Phase 1, project sites most commonly addressed equity concerns by collecting public opinion through surveys or focus groups. The common equity concerns raised by project sites regarding RUC and the approaches to address or mitigate the same are detailed below. This narrative significantly draws upon the Eastern Transportation Coalition (TETC) Technical Memorandum, Equity and Fairness Considerations in a Mileage-Based User Fee System and RUC West and Oregon's Financial Impacts of Road User Charges on Urban and Rural Household study conducted as part of Phase 1. [14] [15]

This section presents significant Phase 1 findings with regard to the equity implications of alternative transportation funding solutions.

Phase 1 Initiatives Examining Equity

Road Usage Charge West's Study of Equity Concerns

The RUC West explores the following chief concerns with equity related to RUC, regardless of specific State programs:

- RUC systems are likely to increase the cost of driving for the owners of electric and hybrid electric vehicles, which may be viewed as unfair to those who have made conscious decisions to reduce fuel consumption and emissions.
- RUC systems represent a highly visible new charge from the perspective of the user, particularly because fuel taxes are embedded in the retail price of motor fuel and effectively hidden from the driver.
- Because RUC systems are based on actual use, they are perceived as unfair to drivers who travel further on a trip-by-trip basis and who are, therefore, charged more per trip.

The RUC West ConOps drew from the prior experiences of member States and the Coalition to highlight the results of studies related to equity impacts, particularly the following conclusions:

- While rural drivers tend to drive slightly more miles per day than urban residents, they are generally driving older and less fuel-efficient vehicles than their urban counterparts.

[14]RUC West and Oregon Department of Transportation. *Financial Impacts of Road User Charges on Urban and Rural Households*. https://www.ebp-us.com/sites/default/files/project/uploads/FINAL-REPORT---Financial-Impacts-of-RUC-on-Urban-and-Rural-Households_Corrected.pdf, last accessed April 7, 2023.

[15]I–95 Corridor Coalition. 2019. "Equity and Fairness Considerations in a Mileage-Based User Fee System."

Assuming that an RUC program will credit any paid fuel taxes back to the motorist, most rural drivers may see a positive effect from participating in an RUC program.

- Using different rates based on income, average MPG of the vehicle, or classification of the driver's residence (e.g., urban, rural, mixed, or commercial) may be a future consideration.
- As RUC expands, international drivers may also be encountered. One example of this is drivers in Canada who travel along U.S. roadways. Further studies and demonstrations are needed.

Oregon's Focus Groups

Oregon conducted a series of focus groups in September 2017 to map the path to acceptance of RUC by identifying specific points of concern and specific points of comfort. One group consisted of people driving electric or hybrid vehicles, and these participants were especially likely to think that drivers of fuel-efficient vehicles should pay less than drivers of less efficient vehicles:

> Survey results indicated that the increased cost per month for those with fuel-efficient vehicles was seen by many as a disincentive to get such vehicles. This was especially the case in the electric/high MPG hybrid focus group, who had no problem paying for road use. They made it clear that it was not the additional amount they would pay (which was seen as insignificant), but rather the principle of a disincentive for those who made the choice to "do the right thing" by purchasing an environmentally friendly vehicle.

Other questions regarding RUCs posed by members of the focus group made up of electric and hybrid vehicle drivers included the following:

- Why should those with poor fuel economy vehicles get a refund?
- How does air quality suffer if people go back to driving gas guzzlers?

Further, over the course of the focus group, despite the participants being introduced to several persuasive messages about RUC (persuasive as graded by the participants themselves), the support for RUC among the electric and hybrid vehicle focus group decreased.

Eastern Transportation Coalition's Prepilot and Postpilot Surveys

The Eastern Transportation Coalition surveyed participants at the beginning and the end of the pilot. The Coalition noted that, the largest change in opinions on the fairness of a MBUF was related to very fuel-efficient vehicles:

> The number of pilot participants who believed MBUF (mileage-based user fee) was "less fair" for very fuel-efficient cars increased from 27 percent at the beginning of the pilot to 38 percent; while the number of participants who said MBUF was "more fair" for fuel-efficient vehicles went down from 39 percent at the beginning of the pilot to 24 percent following the pilot.[16]

[16]I–95 Corridor Coalition. 2019. "Equity and Fairness Considerations in a Mileage-Based User Fee System."

Key Equity Findings From Phase 1 Initiatives

Fairness by Distance Driven

The TETC memorandum highlights the concern that some stakeholders have shared assuming that a mileage-based fee would penalize longer commutes. The Coalition contends that the concept that a user pays based on usage is the intent of RUC. The memo explains, "Just like one pays for telephone or electricity service in proportion to usage—the greater your use of electricity, the higher your electricity bill—a transportation tax should be usage based." However, one of the key recommendations of ODOT's *Focus Group Report* was to avoid comparing RUC with other things people pay for based on usage such as electricity, water, cell phone minutes, and cable channels, because ODOT's focus group participants perceived driving vehicles to be a necessity and not easily controlled. Instead, the ODOT report recommends the emphasis of the uniqueness of driving as a resource and the importance of adequate transportation funding to ensure the roads are maintained and enhanced.

The Eastern Transportation Coalition technical memorandum further elaborates how longer commute distances correlate with lower incomes. The memorandum cites The Brookings Institution 2015 study that indicated that trends between 2000 and 2012 show a shift in minority residents toward the suburbs, thus negatively effects job proximity.[17] This trend was particularly pronounced among residents of high-poverty and majority–minority neighborhoods. However, the study also notes that these trends were not uniform across the country. In regions where this observation is true, it may be likely that RUC is, or is viewed as, a regressive form of tax.[18] However, this strategy is not largely different from a fuel tax, which also places an undue burden on residents who travel longer distances for work. The following approach may provide a roadmap to addressing some of these real or perceived equity concerns.

Identification, analyses, and quantification of problem: The Brookings Institution's 2015 study provides national trends on job proximity of low-income residents, these results may or may not be directly applicable to every State or region. Identification of potentially affected groups and analyses of RUC effects on them could help to determine the exact nature and extent of any problem, such as what the incremental tax burden is likely to be for specific income categories for a proposed RUC rate structure versus the existing fuel tax. Most critically, evaluating the incremental tax burden in itself could illuminate the magnitude of the RUC burden versus the fuel tax burden for individual drivers.

Developing approaches to address or mitigate inequities: Longer driving distances equate to a higher fuel tax burden as well. State- or region-specific analyses could also consider the types and fuel efficiency of vehicles currently owned by target groups (i.e., low-income drivers) and the effect that has on their current tax burden. As fuel tax is a more accurate proxy of transportation system usage for gas-powered vehicles, it is likely that the tax burden of low-income groups is lower or remains largely unchanged under an RUC program compared with the current fuel tax structure based on type of vehicles owned.

---

[17]Kneebone, E., and N. Holmes. 2015. *The Growing Distance Between People and Jobs in Metropolitan America*. Washington, DC: Brookings Institution.

[18]Beider, P., CBO Study Group. 2011. *Alternative Approaches to Funding Highways*. Publication No. 4090. Washington, DC: Congress of the United States Congressional Budget Office.

Fairness by Rural Versus Urban Location Geography

Another recurring criticism of RUC has been the potential for inequitable burden on rural versus urban drivers, given that the former, by reasons of geography and land use, drive longer distances on average.

Identification, analyses, and quantification of problem: The most significant effort undertaken as part of STSFA Program Phase 1 was the study RUC West conducted on the financial effects of RUC on households. This report analyzes the financial effects of a revenue-neutral RUC for drivers in urban and rural counties for eight States in the RUC West Consortium—Arizona, California, Idaho, Montana, Oregon, Texas, Utah, and Washington.[19] The analysis conducted for this study was applied uniformly to all eight participating States so that a clearer and more comprehensive assessment of the impact of RUCs could be developed and so that any differences in financial effect on a State-by-State basis could be understood. Fuel type mixtures and efficiencies were estimated with the vehicle registration data provided by the States (table 20), which indicates consistency in fuel efficiency for urban, mixed, and rural locations across all eight States, with urban areas having the highest average fuel efficiency, decreasing across mixed areas, with the lowest value in rural areas.

Table 20. Average fuel efficiency (miles per gallon) for vehicles in urban, mixed, and rural census tracts of project States (gas-taxed vehicles only).

State	Urban	Mixed	Rural
Arizona	22.7	22.1	20.9
California	27.0	26.3	25.2
Idaho	21.7	21.2	20.8
Montana	23.8	23.6	22.9
Oregon	21.3	20.3	19.9
Texas	21.6	20.5	19.9
Utah	22.8	21.8	21.1
Washington	22.6	21.5	21.2

Source: Western Road User Charge Consortium (RUC West).

To better understand the financial effect a revenue-neutral RUC would have on urban, mixed, and rural households, the report looked at driving patterns. Using *2009 National Household Travel Survey* data, the study found little difference between urban and rural households nationally in terms of trip frequencies. However, the *2009 National Household Travel Survey* showed much longer trip lengths for rural households, including nearly twice as much travel for shopping trips. A key finding of the study was that although rural drivers tend to drive slightly more miles per day than urban residents, they are generally driving older and less fuel-efficient vehicles than their urban counterparts. Assuming that an RUC program will credit any paid fuel

[19]RUC West and Oregon Department of Transportation. 2017. *Financial Impacts of Road User Charges on Urban and Rural Households*. Financial Impacts of Road Usage Charge Drivers in Rural and Urban Households | EBP | US (ebp-us.com).

taxes back to the motorist, most rural drivers may see a positive effect from participating in an RUC program. In fact, the RUC West-sponsored prior report on this issue indicates, on average, rural households will pay between 1.9 and 6.3 percent less, while urban households will pay 0.3 to 1.4 percent more State tax in an RUC system than they currently pay in State gas tax.[20] Ranges reflect the differences from State to State (table 21).

Table 21. Percentage change in payment under road usage charge system compared with gas tax.

State	Urban %	Mixed %	Rural %
Arizona	0.7	−1.7	−6.1
California	0.3	−2.4	−6.3
Idaho	1.0	−0.9	−3.1
Montana	1.4	.0.4	−1.9
Oregon	1.0	−2.9	−4.8
Texas	0.5	−1.6	−3.1
Utah	0.6	−3.4	−5.5
Washington	1.0	−3.6	−4.8

Source: Modified from RUC West by the Eastern Transportation Coalition.

Communication and messaging: As previously noted, the argument of unfairness can also be applied to the current gas tax—more miles driven equates to more gas purchased and more gas tax paid. Moreover, rural drivers tend to drive less fuel-efficient vehicles and, therefore, pay more for each mile driven.

Fairness by Fuel Efficiency and Vehicle Type

The central argument in favor of an RUC is the inherent fairness of a system in which all drivers pay their fair share of transportation expenditures, as determined by how much they drive. Despite that fact, a persistent counterargument that several sites have encountered in their outreach is that an RUC is unfair to drivers of electric/hybrid vehicles, which are more environmentally friendly than gas-powered vehicles. These constituents believe that people who purchase cleaner vehicles should be rewarded with lower charges.

Identification, analyses, and quantification of problem: The Eastern Transportation Coalition Technical Memorandum proposes the following for RUC rate structuring to address the issue of equity in this context:

> From a financial and transportation revenues perspective, consideration might be given to the concept of a variable MBUF rate structure that charges a higher per-mile rate for vehicles with lower fuel efficiencies such that these vehicles pay no less than they currently pay in gas tax (ignoring the possibility that many of these vehicles may be owned by low-income residents, rural residents, or both). A lower rate would be charged for those vehicles with fuel efficiencies at about the average MPG—in essence, a

[20]Ibid.

"revenue-neutral" rate. In this manner, there would be no reduction in transportation revenues from these vehicles relative to what is currently collected from the gas tax. Highly fuel efficient and electric vehicles would still be charged MBUF—thereby slightly increasing revenues—but at the lowest per-mile rate, recognizing their "contribution" to the environment.

Figure 2 shows a TETC-developed comparison of a mileage-based charge and the current gas tax paid by vehicle time and miles driven.

Communication and messaging: The Eastern Transportation Coalition technical memorandum lays out several arguments to counter the perceived unfairness of RUC to fuel-efficient vehicles, as summarized below:

Source: The Eastern Transportation Coalition.

Figure 2. Graph. Hypothetical average mileage-based user fee paid by vehicles with different fuel efficiencies.

- Establish that the lifecycle of a vehicle's emissions should be considered in the evaluation of environmental friendliness/burden of a vehicle type. A battery-electric vehicle (BEV) or electric vehicle also places additional environmental burden beyond that of a gasoline-powered vehicle due to pollutants created by the mining of material for batteries, during the construction of the vehicle, the production of fuel and the generation of electricity, and the operation of the vehicle. That said, the Coalition cites a 2015 study by the Union of Concerned Scientists that found that, over its lifetime, a BEV generates about 50 percent fewer global warming emissions (i.e., carbon dioxide) than a comparable gasoline car.[21]
- Further, a BEV charged with electricity generated from coal has higher lifecycle greenhouse gas emissions than an internal combustion engine vehicle, whereas the lifecycle emissions of a BEV could be almost 90 percent lower than an equivalent internal combustion engine vehicle using electricity generated from wind power. The memorandum cites a University of Minnesota study showing that electric cars are cleaner than those that rely on internal-combustion engines only, if the power used to charge them is also clean.[22]

[21]Nealer, R., D. Reichmuth, and D. Anair. 2015. *Cleaner Cars from Cradle to Grave – How Electric Cars Beat Gasoline Cars on Lifetime Global Warming Emissions*. Union of Concerned Scientists. https://www.ucsusa.org/resources/cleaner-cars-cradle-grave, last accessed April 10, 2023.

[22]Tessum, C. W., J. D. Hill, and J. D. Marshall. 2014. "Life Cycle Air Quality Impacts of Conventional and Alternative Light-Duty Transportation in the United States." *Proceedings of the National Academy of Sciences* 111, no. 52: 18490–18495. https://www.pnas.org/content/early/2014/12/10/1406853111, last accessed April 10, 2023.

PHASE 2 EQUITY FINDINGS

This section summarizes equity-related findings from the Phase 2 programs of Delaware and Washington, the two sites that had completed their Phase 2 activities as of the writing of this report. Both sites conducted pilots of a vehicle miles-based fee in this Phase. The evaluation questions used to analyze equity related findings are presented in table 22.

Table 22. Evaluation and site-specific questions used to analyze road usage charge program equity.

Evaluation Question	Site-Specific Questions and Metrics
Was there analysis conducted regarding equity considerations of the alternative revenue mechanisms?	• What types of analyses were conducted to assess equity considerations?
Was there analysis conducted regarding equity considerations of the proposed alternative revenue mechanisms?	• Do the users pay a fair share based on road usage? • How do user costs affect people in different income brackets and of different background (ethnicities, gender, English proficiency) • Does the program include measures to mitigate inequities?
What were the opinions/understanding of populations of special concern, such as low-income and minority residents?	• What opinions did minority residents hold on specific matters related to the RUC concept? • What opinions did minority residents hold on specific matters listed in above about the version of the RUC that was piloted?

Phase 2 Initiatives Examining Equity

As in Phase 1, for the most part, Phase 2 sites explored equity in just two dimensions: (1) the effects to people living in urban versus rural communities and (2) the effects on people driving electric versus internal combustion engine (ICE) vehicles, or people driving ICE vehicles with different fuel efficiencies. As in Phase 1, the Phase 2 work did not directly address equity issues related to populations of special concern defined by factors such as income, race, ethnicity, gender, or English proficiency.

- The Phase 2 sites explored the equity considerations identified in Phase 1 through (1) surveys of the general population and (2) surveys and focus groups with pilot participants. In all cases, the studies asked whether respondents felt that an RUC was fair according to the specific dimensions mentioned above.
- General population-wide surveys: Questions in population-wide surveys centered on questions of fairness of a miles-based transportation user fee scheme.
- Surveys and focus groups conducted with pilot participants at various stages of the pilot. Some survey and focus group questions delved into the aspects of fairness in general and toward specific user groups as identified above. Conducting the surveys at various stages

of pilot execution allowed sites to track participant responses over a time period and examine the effect of pilot participation on public perception.

Key Equity Findings From Phase 2 Initiatives

Based on the surveys and focus groups conducted by the TETC and WSTC, the following considerations behind participants' opinion that a mileage-based user fee transportation funding alternative was fairer than the gas tax, came to light:

- A desire for all drivers to contribute their fair share to road funding (The phrase "pay for what you use" appealed to a sense of fairness among participants in the focus group that the TETC conducted.)
- A concern about declining transportation funding and resulting negative effects on quality of life, public safety, and the health of the economy
- A desire for out-of-State drivers to pay their fair share to maintain in-State roads—particularly Delaware focus group participants who were concerned about pass-through traffic

Additionally, in the case of TETC's Phase 2 pilot focus groups, although it took some time for participants to identify the central transportation funding dilemma tied to the growing fuel economy of vehicles, once they understood the issue, sustainable funding became a high priority.

The focus groups also brought to light the following considerations behind participants' opinions that a mileage-based user fee transportation funding alternative was less fair than the gas tax:

- Concern about fees for drivers of electric and hybrid vehicles; some focus group participants suggested a slightly lower mileage rate for fuel-efficient vehicles
- Concern toward rural drivers who were assumed to drive longer distances for everyday activities

Table 23 provides a summary of equity-related findings from the Phase 2 sites included within the scope of this report.

Table 23. Summary of equity-related findings from Phase 2 initiatives.

Equity Topic	Key Finding	Respective Pilot
Overall perception of fairness of alternative funding mechanism	Paying for use and everyone paying their fair share for maintenance and upkeep of transportation assets was the most popular opinion.	TETC/WSTC
	In general equity was identified as an important topic but was not in the top three principles.	TETC/WSTC
Fairness by fuel efficiency and vehicle type	Hybrid and electric vehicle owners among focus group participants understood that while their fee would increase, they would still continue to see lower fuel costs in an alternative funding model.	TETC/WSTC
Fairness by fuel efficiency and vehicle type	RUC is fairer between gas and electric/hybrid vehicles because it separates fuel consumption from road usage. However, some participants worry that an RUC may discourage drivers from purchasing electric or hybrid vehicles because drivers would save less on gas tax.	TETC/WSTC
	The pilot did not have a significant effect on the perception of mileage-based user fee (MBUF) as fair.	TETC/WSTC
Fairness by geography	The initial assumption of focus group participants was that rural residents drive farther than other people. However, participants were able to quickly understand that an MBUF would make no financial difference to rural residents who drive long distances in low- or average-fuel-economy vehicles.	TETC/WSTC
	Rural participants were less likely to prefer the gas tax over road usage charge (RUC), and urban and suburban participants were equally likely to choose RUC.	WSTC
Fairness by distance driven	Low- and moderate-income individuals and households are priced out of certain communities and therefore drive farther for work, to reach services, and to run errands.	WSTC
Fairness by income	Providing a lower MBUF rate for low-income drivers can add complexity to MBUF administration.	TETC

CHAPTER 8. INDEPENDENT EVALUATION FINDINGS—TRUCK PILOT

The TETC was the only grantee through Phase 2 to conduct a truck pilot. These findings are presented as a separate chapter within this report because of the uniqueness of the trucking industry and the pilot.

This chapter reports findings from four main aspects of the truck pilot:

- Technical approach and system design
- Rate structure and funds reconciliation across jurisdictions
- Ease of compliance and transparency
- Stakeholder engagement and feedback

The TETC recognizes the key role of motor carriers in the U.S. economy and that a nationwide MBUF would need to address commercial vehicles driving and equitably contributing toward the maintenance of the transportation system. One of the TETC's goals under the STSFA Program was to assess how a user fee would fit into the unique operating environment, viewpoints, and regulatory environment of the trucking industry. As such, the coalition designed a truck pilot to achieve the following objectives:

- Understand the unique challenges, needs, and viewpoints of the motor carrier industry.
- Recognize and acknowledging through stakeholder outreach that not only are commercial vehicles heavy users of the transportation system, but they also pay a significant amount to help build and maintain the system.
- Understand the existing list of reporting requirements that commercial vehicles have to comply with, including the International Fuel Tax Agreement (IFTA), International Registration Plan (IRP), and electronic logging device (ELD) rules.

TRUCKS ARE NOT JUST BIG CARS. AN ALTERNATIVE FUNDING MECHANISM FOR COMMERCIAL VEHICLES SHOULD TAKE THE UNIQUE CHARACTERISTICS OF THE VEHICLES AND THE INDUSTRY INTO ACCOUNT

- The trucking industry is highly regulated. To determine a workable regulatory framework for an alternative funding mechanism applicable to trucks, it is important to understand the existing regulations and the potential interplay with an RUC or MBUF approach.
- A flat rate applied to all trucks may not be a workable solution because of the variety of vehicles and business models that comprise the trucking industry. For instance, a flat rate RUC replacement of the gas tax will be considerably penalizing for owners of highly fuel-efficient truck fleets. The compounding effect of small changes in rates on fleet owners—a common business model in trucking—would need to be a consideration in setting rates.
- Because truck mileage is largely incurred across State and jurisdiction lines as opposed to within them, an appropriate revenue reconciliation approach would also need to be a key consideration.
- It is important to engage the trucking industry and fully understanding its perspective related to an alternative funding mechanism.

The truck pilot lasted 6 months, from October 1, 2018, to March 31, 2019, with more than 50 trucks participating and traveling more than 1,430,000 miles across 27 States.

COMMERCIAL VEHICLE REGULATIONS

To understand the TETC's chosen technical approach for the truck pilot, it is important to examine the regulations and agreements involving commercial vehicles that require the collection of mileage and other driving-related information.

IFTA is a cooperative agreement between the 48 contiguous States and 10 Canadian provinces that border the United States. IFTA enables uniform administration of motor fuel taxation among member jurisdictions. A key intent of the agreement is to distribute State motor fuel taxes among States and provinces based upon where driving occurs. For example, if truck driver purchases fuel and pays motor fuel taxes in their home State but travels through neighboring States, IFTA allows those fuel taxes to be distributed among the neighboring States. The agreement consolidates and streamlines the process. It requires drivers and fleets to submit updates to their home jurisdictions that demonstrate the location and quantity of fuel purchases and the location of miles driven within participating IFTA jurisdictions. The home jurisdictions then submit records to the IFTA clearinghouse, which reconciles funds among the jurisdictions involved.

The establishment of IFTA brought several advantages to participating interstate motor carriers, including a single fuel tax license authorizing their vehicles to travel in all member jurisdictions, plus a single tax return filed each quarter with the jurisdiction where they are licensed. These returns contain mileage and fuel use information for all member jurisdictions.

The International Fuel Tax Association oversees the IFTA agreement, and each of the home jurisdictions manages taxes and reports. A carrier submits IFTA reports to the home jurisdiction quarterly, and data can be collected from driver reports or from electronic logging devices that are IFTA compliant.

IRP is an agreement among individual States, the District of Columbia, and Canadian provinces that recognizes the registration of commercial motor vehicles issued by other jurisdictions. Motor carriers register with and pay registration fees to one jurisdiction. The fee is based on the portion of distance traveled in each jurisdiction; these fees are then distributed to the relevant jurisdictions. Registered motor carriers receive apportioned plates and are able to travel through all IRP member jurisdictions. Commercial motor vehicles either alone or in combination weighing more than 26,000 pounds and traveling in two or more jurisdictions are likely registered under IRP.[23] IRP allows the use of electronic logging devices to document vehicles by jurisdiction, so long as they are IRP compliant. IRP is a separate agreement from IFTA but has a similar profile of vehicles to which the agreement is applied. The International Registration Plan, Inc., organizes and manages the agreement.

ELD rule is mandated by section 32301(b) of the Commercial Motor Vehicle Safety Enhancement Act.[24] The act requires all motor vehicles involved in interstate travel to submit an electronic record of duty status (RODS). RODS is a driver's log that identifies the operator's

[23]Definition from the International Registration Plan, Inc. https://staging-irpinc.site-ym.com/page/MotorCarrierHomepage, last accessed August 23, 2021.

[24]Commercial Motor Vehicle Safety Enhancement Act. 2012. Enacted as part of Moving Ahead for Progress in the 21st Century Act (MAP-21), Pub. L. No. 112-141, 126 Stat. 405, 786–788.

driving periods, breaks, and rest periods within a 24-hour period. It can be recorded using a manual recording device or an electronic logging device.[25] Some drivers are exempt from the ELD rule, including those who use paper RODS for 8 days or fewer of service out of every 30-day period, drivers of vehicles manufactured before 2000, and drivers who conduct drive-away-tow-away operations.

Hour of Service (HOS) regulations: The Federal Motor Carriers Safety Administration's (FMCSA) primary mission is to prevent commercial motor vehicle-related fatalities and injuries. The FMCSA dictates that all carriers and drivers operating commercial motor vehicles must comply with HOS regulations found in 49 Code of Federal Regulations Part 395.[26] HOS regulations limit maximum driving time, minimum break time, and minimum off-duty time. These regulations provide exceptions for short-haul drivers and adverse driving conditions. The driver, rather than the fleer or operator, reports HOS requirements. Drivers submit an HOS RODS through an electronic logging device installed in each vehicle.

Electronic devices and their relationship to regulations. Not all electronic devices used in the trucking industry are the same. The ELD rule requires the installation of a device to satisfy FMCSA HOS requirements. Devices that satisfy the ELD rule are intended to verify hours of operation, breaks, change in duty status, and general vehicle location. These devices may not satisfy IFTA and IRP requirements, as the data, accuracy of the data, and reporting requirements of the regulations are distinct. An electronic device that satisfies *only* the FMCSA HOS requirements will be referred to in this chapter as an HOS-compliant device.

Some devices available on the market are intended to satisfy IFTA and IRP requirements but may not be suitable for FMCSA and HOS requirements. Other devices are available that combine functionality to satisfy the FMCSA HOS requirements and also the IFTA and IRP requirements. The electronic logging device used in the TETC's Phase 2 truck pilot satisfies both FMCSA HOS and IFTA/IRP requirements. Devices that satisfy both FMCSA HOS and IFTA/IRP will be referred to as IFTA/IRP-compliant devices.

KEY FINDINGS RELATED TO SYSTEM DESIGN AND TECHNICAL ACCURACY

A key aspect of the truck pilot was to test the viability of leveraging the systems that the trucking industry already uses to record mileage, location, and trip times to satisfy requirements related to FMCSA, HOS, IFTA, and IRP.[27] The systems commonly used to meet some of the requirements of these regulations already collect the data that would be needed to calculate an MBUF. As such, no new mileage reporting methods were provided as part of the pilot outside of the methods and technologies already used to satisfy existing requirements.

Electronic logging devices are required to be installed in interstate carriers to meet the ELD rule and satisfy HOS requirements mandated by FMCSA. The TETC explored the potential to use these devices to support an MBUF. A key finding in the truck pilot is that electronic logging devices that satisfy only HOS requirement and are not IFTA compliant are inappropriate for an

[25] An electronic logging device is an in-vehicle device that keeps a log of and generates a record-of-duty status, which is then submitted to the Federal Motor Carriers Safety Administration. Electronic logging devices are self-certified and may also be used to satisfy requirements for IFTA and IRP.

[26] https://www.fmcsa.dot.gov/regulations/hours-of-service.

[27] The TETC. 2020. *Mileage-Based User Fee Study 2018-2019 Multi-State Truck Pilot Final Report*, 2-1.

MBUF, as they are not required to collect data continuously or with acceptable accuracy.[28] These devices use a 1-mile radius to identify location when on duty but a 10-mile radius off duty, which is not accurate enough for use in an MBUF. In addition, these devices are self-certified, implying that vendors themselves test the system requirements, leaving the potential for error if used in an MBUF system. The TETC concluded that electronic logging devices used to satisfy only the ELD rule (i.e., HOS-compliance devices) are inappropriate for financial transactions where location accuracy is needed because their intent is to ensure compliance with HOS requirements, not an MBUF.[29]

Truck operators and fleet companies are required to submit records at specified intervals for both HOS and IFTA/IRP. The data collected to satisfy IFTA and IRP requirements are similar to the data needed to assess an MBUF. However, neither IFTA nor IRP require the use of, or certify, in-vehicle technology. They allow carriers to manually report mileage and fuel use. HOS compliance, on the other hand, requires an electronic logging device that is certified through FMCSA.[30] A typical in-vehicle device installed in trucks to satisfy IFTA or IRP requirements uses a combination of internal and external sensors to measure vehicle driving values. Some of these electronic logging devices can satisfy both IFTA and HOS requirements, and the device used in the TETC truck pilot met requirements of both these regulations.

Devices intended to satisfy IFTA and IRP requirements may be appropriate for an MBUF. The International Fuel Tax Association does not certify devices but provides a set of requirements that devices must meet to be IFTA and IRP complaint, and the device used in the truck pilot was IFTA and IRP compliant. This compliance implies that the accuracy of the device was sufficient for tax reconciliation purposes because it was already being used for financial reconciliation among States.

An automated IFTA/IRP-compliant electronic logging device was installed in each truck enrolled in the pilot that consolidated the capture of data needed to satisfy requirements for HOS, IFTA, and IRP and to test the potential use in an MBUF system. Data from each of these devices are transmitted via cellular connection to the account manager who processes the data and prepares reports to satisfy regulatory requirements. The data the device generates include mileage driven by location, which was used to calculate the MBUF for each vehicle and fleet according to the rates established for each State based upon their diesel tax rate.

KEY FINDINGS ON EASE OF COMPLIANCE AND TRANSPARENCY

The TETC concluded that the use of a highly automated in-vehicle IFTA/IRP-compliant device that currently satisfies the existing regulatory requirements for trucking could potentially be used in an MBUF. It would streamline the collection and reporting requirements that trucks and fleets are required to follow. Using an interactive screen would allow the system to communicate information to the driver to facilitate an understanding of how fees are assessed and how mileage is accrued through different States.

[28]The TETC. 2020. *2018–2019 Multi-State Truck Pilot: Final Report*, 3–12.

[29]The TETC. 2020. *2018–2019 Multi-State Truck Pilot: Final Report*, 3–13.

[30]The TETC. 2020. *2018–2019 Multi-State Truck Pilot: Final Report*, 1–10.

Overview of Rate Structure and Funds Reconciliation

The TETC intended the rate structure of the pilot to be revenue neutral. This neutrality implied that a truck with fuel efficiency matching the national average of 6 MPG would pay the same amount in an MBUF as it would in State diesel fuel tax. Because diesel fuel tax rates differ by State, the TETC developed a per-mile rate structure based upon each State's diesel fuel tax and assuming a 6-MPG average. The respective States were not involved in setting the per-mile rates used in the pilot, and no actual funds were charged to the participants, and no funds were transferred between States. The fleets enrolled in the pilot had an average fuel efficiency of 4.1 MPG, which is 31 percent less than the national average of 6 MPG. A key finding of the pilot was that if an MBUF is to be revenue neutral when compared with the diesel fuel tax, a flat rate based off of the national fuel efficiency average would be inappropriate.

The TETC concluded that charging a flat rate for trucks would not necessarily be a revenue neutral rate in the switch from fuel taxes to an MBU. In a flat rate structure, some vehicles or carriers may end up paying more, and others may end up paying less than their current fuel tax. Notably, carriers with more fuel-efficient vehicles paid more than they had under the State fuel taxes, while carriers with less efficient fleets paid less. The report explores the potential effect of an MBUF based on the national fleet average of 6 MPG, using the fleets enrolled into the pilot as examples. The switch to an MBUF would reduce annual costs for less fuel-efficient vehicles and raise the cost for fuel-efficient vehicles. The report does this through a theoretical examination of the case of two trucks:

> …one with 3.5 MPG and one with 6.5 MPG. Assuming each truck drives 63,000 miles per year, the fuel inefficient truck would receive a "rebate" of $3,200 and the fuel-efficient truck would be required to pay a "penalty" of $400. At first, these differences may not seem large, but multiplied over a company's fleet, the costs add up quickly. For example, one company (Carrier A) in the pilot had 40 vehicles with an average MPG of 3.42. If the per-mile MBUF rate was to be set using the national MPG average, this company would receive a rebate of over $68,000 per year in State fuel taxes. The company with the most fuel-efficient fleet was Carrier D, and under the MBUF based on 6 MPG, they would be asked to pay a penalty of over $1,400 for its five fuel-efficient trucks.[31]

In sum, moving from fuel taxes to an MBUF shifts some of the cost burden from the less efficient vehicles onto the more efficient vehicles.

- **Implications of a flat rate structure:** With a flat rate structure, the financial effect of an MBUF will not be the same across all fleets and will be subject to the particular characteristics of their fleet, where and how it operates, and multiplied by the size of the fleet. Some fleets may pay more, some may pay less under an MBUF when compared with the diesel motor fuel tax. The vehicle makeup of a fleet may be a result of decisions that consider the impact of an MBUF on a business, and it should be recognized the cumulative impact that small changes in tax burden can have on a fleet.
- **Implications of a variety of business models:** The TETC pilot suggests that the variety of business models within the trucking industry indicates that an MBUF oriented toward

[31]Fuel efficiency is a factor of the vehicle characteristics plus many other factors, including driving behavior, roadway congestion, vehicle age, terrain, payload, and in-town versus long-haul driving.

trucks should not be a direct adaptation from a system designed for passenger vehicles, the majority of which are under an individual ownership model.

> "The Coalition's multi-state truck pilot clearly showed that one-rate for all trucks doesn't work due to the vast differences in vehicle operations, types, ages, performance, and mileage travelled."
>
> ~The Eastern Transportation Coalition (2020)

- **Implications of existing regulatory environment:** Trucks and fleet companies pay taxes and fees outside of the existing diesel motor fuel tax, such as the heavy-vehicle use tax; Federal excise tax (e.g., tire tax and retail truck tax); and a weight-mileage tax in Oregon, New York, Kentucky, and New Mexico. Additionally, trucks pay more at tolling locations based on characteristics such as number of axles and vehicle weight. A key finding of the truck pilot was a recognition that trucks already operate in a regulated environment and that any effort to explore an MBUF should recognize that additional requirements and regulation may become burdensome, including regulations on driver training, work hours, emissions requirements, vehicle readiness, and tax reporting.[32] A recommendation from the report was to use MBUF as a potential method to streamline the other regulatory requirements already applied to trucks and truck companies.

KEY FINDINGS ON RATE STRUCTURE AND FUNDS RECONCILIATION

The TETC found that IFTA and IRP provide a framework for developing an MBUF applied to commercial trucks that has the potential to work across State lines. However, the pilot concluded that more study is needed to understand how funds are reconciled, how rates are set, and how the system would extend beyond vehicles that are exempt from IFTA and IRP requirements. Additional effort is also needed to better understand the effects of transitioning from a diesel motor fuel tax toward an MBUF that considers the complex facets that apply to the trucking industry.

The TETC concluded that a flat rate applied to all trucks will have different effects based on several factors. The trucking industry encompasses several business models, such as over-the-road trucking, long-distance haulers, and drayage trucks, to name a few that have different load characteristics, per-mile costs, time sensitivities, and ownership models. Each of these business models may be affected in different ways by a shift from the diesel motor fuel tax toward an MBUF. An effort to make an MBUF revenue neutral will require a policy framework that recognizes those potential effects.

KEY FINDINGS ON OUTREACH, ENGAGEMENT, AND PERCEPTION

A key finding from the truck pilot was the importance of engaging the trucking industry and fully understanding their perspective related to an MBUF. The trucking industry is complex, highly regulated, and would experience an MBUF in a different way than passenger vehicles. Making sure its voice is understood and the unique challenges of the industry are incorporated in implementation design of a commercial vehicle MBUF is an important component of future MBUF exploration.

[32] The TETC. 2020. *2018–2019 Multi-State Truck Pilot: Final Report*, 3–8.

CHAPTER 9. POTENTIAL FUTURE RESEARCH

Several external groups engage RUC practitioners, including recipients of STSFA grants. Organized discussions among these practitioners have suggested gaps in current research or knowledge about RUCs. These gaps are presented below. FHWA does not endorse or verify the validity of the identified research gaps.

- **Transition to RUC:** A gap exists in identifying potential transition paths from a gas tax-based system to a mileage-based tax system and whether such transitions will involve a complete replacement of the gas tax or supplement to it. A related question is what happens when States have issued bonds against gas tax receipts.
- **RUC implementation on a national level:** Questions exist around per-mile rates to accomplish established policy goals and which Federal agencies might be involved in estimating those rates.
- **Economic effects of RUC:** It is unclear what effect an RUC might have on travel behavior, including macroeconomic effects of change to gas prices due to expiration of the gas tax, as well as individual traveler behavior with respect to mode choice and other material transportation and land use-related decisions.
- **RUC and tolling:** Questions remain regarding whether an RUC could be a disruptor to the tolling industry depending upon how tolling technology evolves and payment mechanisms converge over the coming years and decades.
- **Ongoing research on equity issues:** As discussed in chapter 6, equity issues may need to be examined and analyzed in each geography to provide clarity on actual, potential, and perceived equity issues. While national studies would be instructive, they may not be persuasive for stakeholders at the local level.
- **Best approaches to account for interstate travel:** The issue of accurately accounting for interstate travel, while meeting the needs of low- to no-technology users is likely to persist in the future. While the issue may be of more significance in certain geographies like the Interstate 95 corridor along the East Coast, interstate travel close to border jurisdictions is likely to continue into the foreseeable future.
- **Scenario planning and analysis:** Given that trends in vehicle technology and current and future travel behaviors are key influencers of potential RUC programs, agencies may benefit from evaluating different potential future scenarios. The convergence of electric vehicles, vehicle connectivity, and transportation usage patterns could be explored using the tools of scenario planning. This approach could consider emerging and potentially disruptive trends (e.g., autonomous vehicles and shared mobility) and allow States to hone in on RUC programs tailored to those potential future scenarios.

The RUC pilot partner States also identified the following needs:

- **National information repository:** The national repository should be a location where all the knowledge being created about RUC as part of the independent pilots is maintained and easily accessible.
- **Communicating progress to public officials:** States conducting pilots have identified the need to communicate progress in RUC explorations to elected officials.

- **National level forums:** Such forums would be beneficial to increase awareness about what is happening with the State pilots.
- **Standardized terminology across the country:** Terms varied across the multiple demonstration sites and approaches examined by different States—MBUFs, DBUFs, RUC, and VMT tax among others. Using differing terminology can affect the public perception and acceptance of the program and may not be ideal for interoperability between jurisdictions, particularly across State boundaries. Furthermore, in the Oregon program, the term interoperability is used to refer to both managing of operations across jurisdictional and State boundaries, as well as the convergence of MBUF and other transportation pricing such as parking and transit.

U.S. Department of Transportation
Federal Highway Administration
Office of Operations
1200 New Jersey Avenue, SE
Washington, DC 20590

Office of Operations Website
https://ops.fhwa.dot.gov

May 2024

FHWA-HOP-21-048