Surface Transportation System Funding Alternatives Phase I Independent Evaluation: Cross-Cutting Report

June 2021

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16. Abstract

The Fixing America's Surface Transportation Act of 2015 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 2016, the U.S. Department of Transportation awarded eight STSFA grants to seven lead States (California, Delaware, HawaII, Minnesota, Missouri, Oregon [project lead for two grants], and Washington) totaling $14,235,000.

This report presents cross-cutting findings from all Phase I STSFA project sites. 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.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

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

APPROXIMATE CONVERSIONS FROM SI UNITS

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

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

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

BEV	battery-electric vehicle
Caltrans	California Department of Transportation
ConOps	concept of operations
DBUF	distance-based user fee
DMV	Department of Motor Vehicles
DOT	department of transportation
FFY	Federal fiscal year
FHWA	Federal Highway Administration
FY	fiscal year
GPS	Global Positioning System
I-	interstate
MaaS	mobility-as-a-service
MBUF	mileage-based user fee
MFT	motor fuel tax
MOD	mobility on demand
MoDOT	Missouri Department of Transportation
MPG	miles per gallon
MRD	mileage reporting device
OBD-II	onboard diagnostic standard II
ODOT	Oregon Department of Transportation
PII	personally identifiable information
RUC	road usage charge
STSFA	Surface Transportation System Funding Alternative
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 that Congress is interested in identifying viable solutions. Recognizing this trend, the Fixing America's Surface Transportation Act of 2015 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 eight STSFA grants to seven lead States (California, Delaware, HawaII, Minnesota, Missouri, Oregon [project lead for two grants], and Washington) totaling $14,235,000. The types of proposals included both pre-deployment and deployment activities, and two represented multi-State partnerships. This report evaluates Phase I 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 impacts on constituents, and initial findings on administrative fees, among others.

This report presents cross-cutting findings from all Phase I STSFA project sites. The report is limited in scope to reporting key findings of 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 user based 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/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 I 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.

Towards the end of Phase I, 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 non-technology-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). These not only present new opportunities to explore a variety of scenarios, but also present challenges of uncertainty about future travel behaviors and patterns.
- While 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 I 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 towards enhancing flexibility and user choice.

The pilot sites did not significantly investigate additional attributes, like enforcement and compliance, during Phase I execution.

Table 1 presents key findings Phase I pilot sites explored regarding attributes of mileage reporting options.

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

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. • While 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 various levels of additional user effort for mileage reporting and payment as compared to 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 data set and process to simplify the data exchange and fee reconciliation.

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 I 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 I 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.

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 multi-pronged 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 **multi-pronged approach to outreach and communication**, utilizing a multitude of platforms and approaches to inform and educate the stakeholders.

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 penalize people driving longer distances, particularly low-income drivers that 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 is needed to understand the impact 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."

CHAPTER 1. ALTERNATIVE TRANSPORTATION FUNDING SOLUTIONS – AN OVERVIEW

This chapter provides an overview of the efforts of Federal and State governments and multi-entity coalitions towards 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, the Fixing America's Surface Transportation Act of 2015 established the Surface Transportation System Funding Alternatives (STSFA) Program. The purpose of this program is to provide grants to States or groups of States to demonstrate user-based alternative revenue mechanisms that utilize a user-fee structure to maintain the long-term solvency of the Highway Trust Fund.

The Fixing America's Surface Transportation Act provides 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.

"As states struggle to keep pace with increasing funding shortfalls and maintenance backlogs, lawmakers are exploring innovative approaches to increase revenues for transportation...A [road usage charge] goes one step further, potentially eliminating the need for a gas tax altogether, by charging drivers on a per-mile-driven basis. Proponents see this as a way to increase transportation revenues even as fuel purchases decrease and vehicle miles traveled increases, due to improved vehicle efficiency."

Source: National Conference of State Legislatures, "Road Use Charges (RUC)" Web page. Available at: https://www.ncsl.org/research/transportation/road-use-charges.aspx. *Last accessed March 12, 2021.*

SURFACE TRANSPORTATION SYSTEM FUNDING ALTERNATIVES PROGRAM – PHASE I

In Federal fiscal year (FFY) 2016, the U.S. Department of Transportation awarded eight STSFA grants to seven lead States (California, Delaware, HawaII, Minnesota, Missouri, Oregon [project lead for two grants], and Washington) totaling $14,235,000. The types of proposals contained both pre-deployment and deployment activities, and two represented multi-State partnerships. This constituted Phase I of the STSFA grant program.

Program Evaluation

The Federal Highway Administration (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 impacts 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 cross-cutting findings from all Phase I 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

Of the eight 2016 STSFA grantees, six grantees—Oregon, Washington, California, HawaII, Eastern Corridor 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, while 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 2.

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

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

preferentially uses the term "RUC" to present cross-cutting findings because a majority of sites use this terminology.[2]

Table 2. Preferred terminology for alternative transportation revenue approaches centered around a user-fee based on distance traveled.

Phase I Pilot Site(s)	Preferred Terminology for a User-Fee Based on Distance Traveled
Eastern Corridor 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

OVERVIEW OF PHASE I PROGRAMS AND PILOTS

This section presents an overview of the Phase I programs undertaken by the eight STSFA grantees that are the subject of this report.[3]

California

As part of the STSFA Phase I Program, the California Department of Transportation (Caltrans) conducted activities to enhance their recently completed pilot.[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,

[2] The exception to this rule are the sections where site-specific approaches are detailed. For those sections, the site-preferred terminology is used.
[3] Note that, at the time of the writing of this report, HawaII had not significantly progressed on Phase I activities due to a combination of issues. As such, this report does not include any findings from HawaII's Phase I efforts.
[4] In March 2017, California Department of Transportation (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.

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.

Delaware/Eastern Corridor Coalition

The Delaware Department of Transportation and the Eastern Corridor Coalition (hereinafter referred to as Eastern Corridor Coalition) planned and deployed a focused mileage-based user fee (MBUF) pilot in the Coalition States.[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.

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

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

- **Deployment, operation, and evaluation of State-specific focused MBUF pilots:** In addition to the planning effort and pre-deployment activities, the Eastern Corridor 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."

Minnesota

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 a mobility-as-a-service (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 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

[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.

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 their STSFA Phase I efforts, include the following:

- A DBUF should operate in parallel to 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 towards the maintenance and upkeep of the transportation system.

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 (MoDOT; 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 it does not relate to the real power or impact the vehicle has on the transportation system.

The objective of Missouri's pre-deployment STSFA Phase I 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 pre-deployment activities were completed on August 15, 2018.

As part of the STSFA Phase I Program, Missouri used the Federal grant money to conduct pre-deployment 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). While this 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 pre-deployment 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.

Oregon

As part of RUC program enhancement efforts, the Oregon Department of Transportation (ODOT; hereinafter referred to as 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.
    - Developed a manual reporting option (to accommodate users and participants that are not able to use the existing mileage reporting technologies and/or do not have internet access).
    - Explored partnerships to streamline RUC services and share transportation data.
- **Increase public awareness:** Oregon pre- and post-tested 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.

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 Phase I program, 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 I 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.

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 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 I 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.

ORGANIZATION OF THIS REPORT

Chapter 2 describes the mileage reporting approaches explored by Phase I sites and discusses their 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 I sites towards 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 I sites.

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

Chapter 8 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 Phase I Program. 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 I SITES

The mileage recording/reporting approaches explored by the Phase I 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.

- **Alternative (non-RUC) approaches:** These approaches are not focused on deploying mileage recording approaches or technology, and do not have implications for the

CROSS-CUTTING FINDINGS REGARDING MILEAGE REPORTING OPTIONS

- Several pilot sites' approach to testing both technology and non-technology-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 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. While 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.

accuracy, precision, reliability, or repeatability of mileage recording and fee reconciliation.

Table 3 provides an overview of the site-specific mileage recording and reporting approaches.

Table 3. Mileage reporting/recording approaches and options tested or explored by Phase I pilot sites.

Mileage Recording/ Reporting Approach	Mileage Recording/ Reporting Option	Description	Respective Phase I 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 taken with a smartphone application that uploads the image to the account manager.	Washington
	Hybrid	Image-based odometer reading using 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 Corridor Coalition
Location-based	Smartphone with location	Smartphone with Global Positioning System (GPS) enabled to track trip location for the driver. Phase I 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 Corridor Coalition, Oregon, Washington
	Plug-in device with location	OBD-II device to calculate 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 Corridor Coalition

Table 3. Mileage reporting/recording approaches and options tested or explored by Phase I pilot sites.

Mileage Recording/ Reporting Approach	Mileage Recording/ Reporting Option	Description	Respective Phase I Site
Alternative approaches	Fleet-based	Utilizes 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

Key Cross-Cutting 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 non-technology-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 electric vehicles. Pilot sites have the opportunity to project future scenarios with a variety of travel and vehicle ownership patterns. However, this 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 I 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 electric vehicles is likely to coincide with wider availability of onboard telematics capable of connectivity with vehicles and infrastructure. While this could significantly enhance the methods and processes for data collection and aggregation, including mileage data, it 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 deduced from an account, or even deducted from a pre-paid amount, thus reducing the actual effort needed by program participants.

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 I of the STSFA funding, primarily because full testing and demonstration of technology was not part of this phase.

Phase I 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 impacted. 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. The image is "read" by an algorithm that 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.

- **Odometer/smartphone hybrid approach with location-measuring features:** Smartphones are used to measure mileage driven out of State, but the base mileage is reported through image capture, which still relies on the odometer to measure the mileage driven.

The use of the odometer is likely to be accepted by the public, 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 impacted by a number of external factors (e.g., improper tire inflation and incorrectly sized tires). There is no national regulation regarding the accuracy/precision of odometers; rather, vehicle manufacturers adhere to a voluntary Society of Automotive Engineers standard. Federal Law 49 United States Code Chapter 327 (Public Law 103-272) does prohibit 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.

A key consideration for a national program would be enacting a national, regulatory standard. Systems based upon odometer readings cannot easily distinguish where those miles were driven (e.g., out-of-State versus in-State).

CROSS-CUTTING FINDINGS REGARDING ACCURACY, PRECISION, RELIABILITY, AND REPEATABILITY OF MILEAGE REPORTING OPTIONS

- **Odometer-based approaches. These** 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 vehicle miles traveled (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 re-establish actual miles driven with the account manager or State.

Location-based approaches. Several key components must 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 verses private, and an accurate delineation of jurisdictions.

Phase I 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 I: smartphone application with and without beacon.

    - *For the approach that uses the beacon* (as tested by Oregon), 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 impacts 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 tested by the Eastern Corridor Coalition), 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 to 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 the Phase I round of testing, 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.

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 motor fuel tax (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.

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 has occurred are all mechanisms for maintaining transparency to drivers. This section explores the capabilities of the different systems and approaches explored in STSFA Phase I 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 separate 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.

CROSS-CUTTING FINDINGS REGARDING TRANPARENCY AND ABILITY TO AUDIT

- Approaches that involve pre-payment 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 pre-paid bank of miles, and Minnesota's fleet-based approach would all require fee payment prior to or during driving activities.
- Post-trip 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 real-time, as what would happen when crossing State lines.

Table 4 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:

- **Pre-trip transparency:** In this scenario, drivers are aware of the fee, or actually pay a fee prior to the occurrence of the trip. This is divided into two data categories—fee and fee sum, which are described below.

- **Intra-trip transparency:** The system is able to communicate the fees being charged during the trip. This 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.

- **Post-trip 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. This is important for keeping track of fee accumulation prior to invoicing and for maintaining the ability to audit.

Table 4. Visibility of data by trip type.

Type of Information	Pre-Trip		Intra-Trip		Post-Trip			
	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						

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 post-trip receipt.

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:** While a per-mile fee and cumulative fee may be readily known or calculated by the driver, it is not communicated by the system.

- **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, post-trip, to the driver.

Onboard diagnostics non-location-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 post-trip, 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.

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 on the fuel efficiency of the vehicle. With this approach, mileage driven has no consequence on the fee paid. The need for intra- and post-driving 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, there are two primary interactions that 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:** The regularly occurring actions necessary for each of the concepts to function. For the purpose of this report, these are the actions that are critical to the operation of the mileage recording device/method, and the payment of fees. This list of actions is not intended to cover unplanned technology failure or other unanticipated situations.
- **Additional effort:** 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:** 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.

CROSS-CUTTING 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 the 2016 funding round of the STSFA Program and their associated, necessary user actions are presented in Table 5. 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.

Of the concepts shown in Table 5, 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 utilize 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 must 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.

Table 5. 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 Bluetooth beacon in vehicle.	Yes	Once
		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 be easier to use for 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 of the **automated and semi-automated MRDs** and mileage recording methods, the payment will typically be handled by a third-party account manager or by the State. 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.

Table 6 provides a summary of payment methods associated with each mileage recording approach and the effort and frequency of associated user actions.

Table 6. 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 cross-cutting 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 tax to the Internal Revenue Service, 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, while 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., a road usage charge [RUC]) typically comprises the following key features, contributing to relatively higher cost of collection and administration as 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 Phase I sites is likely to necessitate significant organizational and programmatic changes:

- **Evolving role of the departments of transportation (DOTs).** Several alternative transportation revenue approaches are being championed by State DOTs that have not traditionally been involved in tax revenue collection. With the shift to a user-fee system, that is likely to change as DOTs get involved with several functions associated with a RUC system, and as they begin interfacing with other existing or new entities to administer the program effectively. These entities may be DMVs, Departments of Revenues (DOR), 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 above, 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 I efforts with regard to administrative costs of collecting a user fee and potential savings or synergies explored.

KEY CROSS-CUTTING FINDINGS

The following lessons learned emerged from Phase I explorations with regard to program structure that have implications for system costs:

CROSS-CUTTING 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.

- **Explore organizational efficiencies:** Oregon's Phase I efforts were directed significantly towards 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 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 default for the organization and the driving public. This 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.

SIGNIFICANT PHASE I EFFORTS EXPLORING PROGRAM STRUCTURE AND SYSTEM COSTS

With the exception of a few grantee sites, Phase I primarily involved setting up a first pilot or conducting pre-pilot activities. Most rate-setting analyses were focused on estimating a "revenue-neutral" rate considering fuel tax collection costs (that potentially range being between 1 and 5 percent). This section details some significant efforts towards streamlining.

Eastern Corridor Coalition's Administrative Cost Analysis

The Eastern Corridor Coalition conducted a looking-ahead analysis of the two key cost components for the main organizational functional areas defined above. A previous Eastern Corridor Coalition study identified fuel tax collection cost to be an average of 0.86 percent for the Coalition States.[6] The Eastern Corridor Coalition Administrative and Compliance Issues Technical Memorandum quotes the following excerpt from a paper by Fleming, D.S. (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% 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% 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.

[6] I-95 Corridor Coalition. 2010. "Administrative and Legal Issues Associated with a Multi-State VMT-Based Charge System." Final Research Report. November 2010.
[7] I-95 Corridor Coalition. 2019. "Administration and Compliance Issues and Business Rule Considerations in a Mileage Based User Fee System." August 2019.

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.

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 is 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 I effort, several tasks were 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 best practices 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 regards 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 30 a) 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 I Program was the development of a cash-flow model. However, the model, while useful to calculate a revenue-neutral RUC rate, does not address system costs. The Final Enhancing Road Charge Pilot Program Report presents the following considerations regarding system costs:

- **Higher costs of California DMV operating as a State account manager:** California's final report for Phase I 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:

[8] Missouri General Assembly. Missouri Constitution Section: Article IV, Executive Department, Section 30a. November 14, 2016.

- 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.

CHAPTER 4. 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 inter-jurisdictional 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.

CROSS-CUTTING FINDINGS REGARDING INTEROPERABILITY

- Measuring the location of miles driven will enable accurate collection of fees for out-of-State driving.
- RUC West and Eastern Corridor Coalition have laid the groundwork for RUC systems to be regionally interoperable.
- Consistency of data and standards between States will be critical to enable true interoperability.

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 cross-cutting findings from the STSFA Phase I explorations regarding the interoperability of location-specific technologies and approaches explored by the grantees.

KEY CROSS-CUTTING 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 I grantees, the technology that is consistently used to measure location, thus enabling interoperability, is GPS. To measure the location of miles, today's mileage reporting devices (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 7 presents the ability to measure location of the mileage recording approaches explored by Phase I pilot sites.

Table 7. 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 standard 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.

Framework to Reallocate Funds

The ability to measure location is one aspect of interoperability. The other aspect needed is the framework to reallocate funds between jurisdictions from both the technical and administrative perspectives. States have explored reallocating fees based on available data estimates of mileage driven between States. While technically interoperable, it could be problematic for users who do not drive significant amounts out of State, who may be paying more per-mile based on the census estimate. Likewise, participants who drive significant amounts in other States with higher fees may not be paying an accurate amount for their road use. These issues would not be present for drivers using locational methods to track mileage.

Trade-Offs between Alternative Approaches to Achieve Interoperability

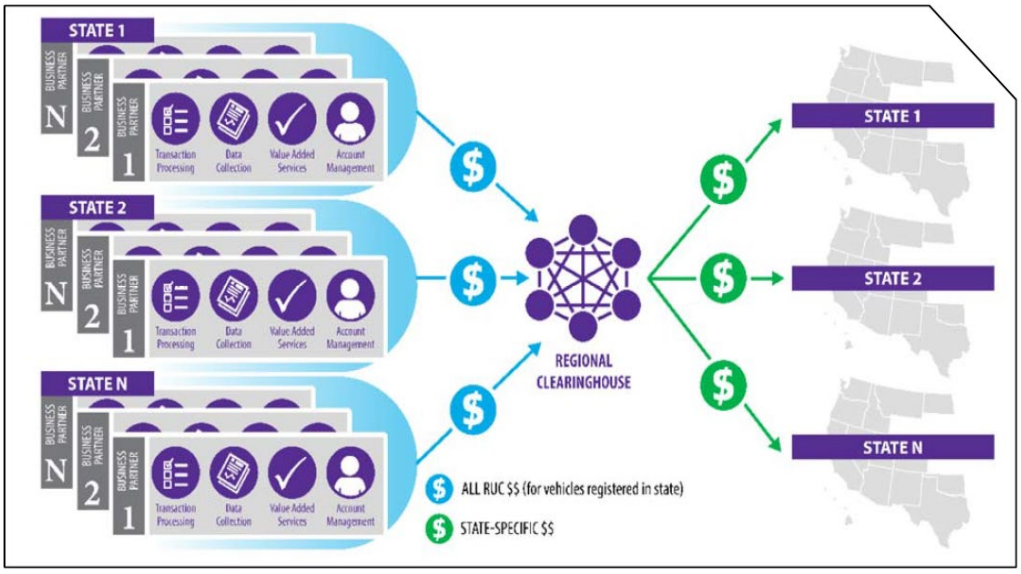
Those systems that include location-based data collection require more sophistication and complexity during the capturing of the mileage data, but enhance the ability and ease to reconcile fees between jurisdictions. They may also have associated privacy concerns. Conversely, systems where the capturing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

SIGNIFICANT PHASE I EFFORTS EXPLORING INTEROPERABILITY

Several of the 2016 funding grantees explored interoperability between States, including RUC West, Eastern Corridor Coalition, 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 of these approaches (Eastern Corridor 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 and/or private account manager 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 Corridor Coalition Pilot

The Eastern Corridor Coalition launched a pilot from May 2017 to July 2017, with 155 participants, testing a multiple technologies and approaches that enable interoperability between participating States. Technologies that enabled location measurement were tested, along with an onboard diagnostic standard II (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.

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:** This 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, non-repudiation, 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.

CROSS-CUTTING FINDINGS REGARDING DATA SECURITY AND PRIVACY

- Phase I 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.

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 I sites in the process of examining data security and privacy protections of proposed mileage recording approaches.

KEY CROSS-CUTTING FINDINGS

Data Security

The recipients of the STSFA Phase I grant 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:

- Mileage collection and reporting systems/devices.
- 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 today's best practices in network security, application/host security, data management, and privacy management typically found in most enterprises. Table 8 summarizes potential security issues on the commonly explored mileage reporting methods by Phase I sites.

Table 8. 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; therefore, access control problems raise potential data integrity and privacy problems.
Smartphone with beacon	This approach uses a smartphone application to obtain location and/or distance traveled information using the smartphone platform's GPS. A significant technical challenge of this approach is the need to associate a phone to a given vehicle.	Two significant security issues are present with this approach: • The system inherits all of 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, there is no phone/vehicle pairing technique that is reliable, secure, and convenient. Additionally, any mandate to use Bluetooth beaconing effectively translates to privacy losses due to traceability of static addresses.

Table 8. Summary of potential security issues based on mileage reporting method (continued).

Mileage reporting method	Description	Security summary
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 with regard to 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 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 geo-temporal 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.

SIGNIFICANT PHASE I EFFORTS EXPLORING DATA SECURITY AND PRIVACY

Eastern Corridor Coalition's Approach to Participant Data Privacy

Personally identifiable information (PII). High-level, access-control requirements were indicated with regard to PII data collection and storage. Specific policies are included in the participant agreement and in the account management specifications.

Mileage data. The I-95 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 9.)

Table 9. 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 Corridor 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.*[9]

Oregon's best practices towards enhancing data security and privacy, explored as part of STSFA Phase I, 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, but were not limited to: 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 was traveled in a given time interval. The Oregon RUC participant privacy agreement indicates adequate policies regarding the type of information that will be collected by the State. Raw data collection is collected by the commercial account manager and is, therefore, differentiated from the State's RUC system.

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

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 CROSS-CUTTING FINDINGS

Best practices pertaining to outreach, messaging, and communication that emerged from the Phase I sites are detailed below.

CROSS-CUTTING 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 multi-pronged approach to outreach and communications.
- Develop a framework for regional support.
- Public outreach may be impacted by local political considerations, particularly concurrent efforts around transportation funding in the States.

Recognizing the Need for Ongoing Public/ Stakeholder Education and Outreach

Implementing a RUC or another alternative form of transportation funding will require ongoing public education. Phase I 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/stakeholder concerns and develop evidence-based messaging to address those concerns.
- Multi-pronged approach to outreach and communications involving multiple media platforms.

These components are discussed in detail below.

Messaging around Key Motivators

Based upon the Phase I efforts of grantee sites, the following emerged as messages that convey the key motivator for exploring alternative transportation funding solutions (see Table 10).

- **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 impact of increasing fuel efficiency on transportation funding and how this shortfall will impact 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 can help establish the basic understanding for the message that a distance- or mileage-based charge allows States to collect enough transportation revenues to meet system needs.

- **"Fairness":** Ensuring that a 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 10. Key motivators and effective messaging in favor of exploring alternative transportation funding mechanisms.

Key motivators	Effective messaging based on Phase I 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 Corridor 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	• RUCs ensure each driver pays their fair share based on how much they use the roads (Washington, Eastern Corridor 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 I 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 a long distance and have low incomes, and it is inherently unfair because it disincentivizes fuel-efficient vehicles while giving "refunds" to "gas guzzlers." [10] In addition to the table above, Chapter 7 provides additional information on addressing some the equity related concerns through evidence-based reasoning.

- **Charging accuracy and data security:** According to Washington State Transportation Commission's (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

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

critical with respect to the reporting methods available to the public and their ability to choose between them.[11] The pilot sites have yet to develop simple and effective messaging that addresses accuracy 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 non-technical 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.[12] 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 would be likely different.

Multi-Pronged Approach to Outreach and Communication

As part of STSFA Phase I, several sites conducted limited outreach to stakeholders and the public or engaged consulting companies specializing in marketing, communications, and public outreach to recommend potential outreach approaches. Table 11 presents the approaches explored by Phase I sites or those recommended to them by their consultants for future public and stakeholder engagement.

[11] Washington State Transportation Commission. 2017. *Washington Transportation Funding Public Opinion Assessment Report*. n.p.

[12] OReGO website has an online calculator (https://www.myorego.org/how-it-works/) for users to compare what they pay in fuel tax to 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, this raised the question as to how a road usage charge could significantly increase funding for transportation.

Table 11. Multi-pronged approach to outreach explored by or recommended to Phase I sites.

Type of Outreach	Target Audience and Goals	Examples of Outreach Explored by or Recommended to Phase I Sites

Public Affairs	Educating key local- and State-elected officials, regulators, and other policy makers; 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 (FAQs) lists.
		• Pilot participation.

Stakeholder outreach	Educate stakeholders with the necessary information and materials for continued awareness around need for alternative transportation funding solutions.	• Create a stakeholder management team. • Conduct stakeholder interviews. • Involve key stakeholders in the Steering Committee. • Pilot participation.
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. • Targeted outreach to specific communities. • Conduct surveys.
Media-based outreach	Outreach to a wide audience using a variety of media platforms for marketing and messaging.	• Utilize social media platforms. • Posting fact sheets, FAQs, and promotional videos on website. • Utilize blogs, newsletters, and email blasts. • Utilize earned and donated media.

Source: FHWA, adapted from Caltrans Road Charge Communications Research STSFA Final Report 2018-2019.

Developing a Framework for Regional Communications Support

Regional coalitions (e.g., RUC West and the Eastern Corridor Coalition) provide the framework for regional communications support. For Phase I, several pilot sites engaged in outreach efforts on a regional and/or national level. The FHWA has continued to foster collaboration among the pilot sites through annual workshops conducted in Washington, D.C., 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 I and Phase II 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 impact the scope and approach of public outreach. California, Washington State, and Oregon legislatures passed gas tax increases in the recent past. This 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, prior to the vote, Caltrans contacted FHWA staff to inform them that they were asked to postpone the start date of the outreach campaign until after the vote. It was deemed risky to conduct a broad-based education and outreach campaign in the State of California regarding RUC, which was projected to be widely perceived as an additional tax.

SIGNIFICANT PHASE I EFFORTS EXPLORING OUTREACH, MESSAGING, AND COMMUNICATION

Table 12 summarizes significant outreach and communication activities that Phase I sites undertook.

Table 12. Significant outreach, messaging, and communications efforts undertaken by Phase I sites.

Phase I Pilot Site	Significant Outreach, Messaging, and Communication Efforts	Recognize Need for Public/Stakeholder Education and Outreach	Develop and Execute A Targeted Communications	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 Corridor 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 Corridor Coalition	Conducted surveys of the pilot participants to gauge public acceptance of a mileage-based fee before and after the pilot.	✓		
Washington, Oregon, California, Eastern Corridor 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.	✓	✓	

Table 12. Significant outreach, messaging, and communications efforts undertaken by Phase I sites (continued).

Phase I pilot site	Significant 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
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 12. Significant outreach, messaging, and communications efforts undertaken by Phase I sites (continued).

Phase I pilot site	Significant 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, Oregon, 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.	✓	✓	

CHAPTER 7. EQUITY AND PUBLIC PERCEPTION

Equity relates to how user costs and other outcomes will impact people in different income brackets and of different races/ethnicities, gender, English proficiency level, and travel mode. This chapter explores the cross-cutting findings of the STSFA Phase I sites with regard to equity considerations of a potential future RUC system.

KEY CROSS-CUTTING 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.

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

- Identifying, analyzing, and quantifying equity impacts.
- Developing approaches to address or mitigate inequities in proposed alternatives.
- Developing communication and messaging strategies to address concerns and educate public and stakeholders about the equitable aspects of the proposed alternative.

Project sites identified multi-pronged approaches to address equity:

1. **Identify, analyze, and quantify potential equity impacts**, which can help agencies determine the nature and extent of impacts of the proposed program across different categories of users and the potential for inequitable impacts.

2. **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.

3. **Develop and deploy appropriate communication and messaging strategies**, which helps to reach out specifically to groups who 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, non-technical terms. This outreach should highlight program details that were designed to address any equity issues identified. It is possible that some equity concerns are not adequately addressed by program design choices; in such cases, the communication approach may need to emphasize the inherent "fairness" of an RUC mechanism as compared to fuel taxes, particularly with the increasing electrification of the vehicle fleet.

Agencies need to be mindful that, even after taking the proposed steps above, some interest groups may continue to view RUC as inherently inequitable, particularly with regard to some of the common concerns discussed in this chapter.

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 (ETC) Technical Memorandum, *Equity and Fairness Considerations in a Mileage-Based User Fee System,* [13] and RUC West and Oregon's *Financial Impacts of Road User Charges on Urban and Rural Household*[14] study conducted as part of Phase I.

Fairness by Distance Driven

The Eastern Transportation Coalition 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 that "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 to other things people pay for based on usage such as electricity, water, cell phone minutes, cable channels, etc., because 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 Institute 2015 study that indicated that trends between 2000 and 2012 show a shift in minority residents towards the suburbs, thus negatively impacting job proximity.[15] 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.[16] However, this is not largely different from a fuel tax, which also places an undue burden on residents that travel longer distance 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. While the Brookings Institute 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 impacts on them would 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 would illuminate the magnitude of the RUC burden versus the fuel tax burden for individual drivers.

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[13] I-95 Corridor Coalition. 2019. *Equity and Fairness Considerations in a Mileage-Based User Fee System*. n.p.
[14] RUC West and Oregon Department of Transportation. *Financial Impacts of Road User Charges on Urban and Rural Households*. Available at: https://www.ebp-us.com/sites/default/files/project/uploads/FINAL-REPORT---Financial-Impacts-of-RUC-on-Urban-and-Rural-Households_Corrected.pdf.
[15] Kneebone, E. and N. Holmes. "The Growing Distance Between People and Jobs in Metropolitan America." Brookings Institute. April 1, 2016, n.p.
[16] Congressional Budget Office. 2011. "Alternative Approaches to Funding Highways." March 23, 2011.

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 impact 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 as compared to the current fuel tax structure based on type of vehicles owned.

Fairness by Rural Versus Urban Location

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 Phase I was the study conducted by RUC West on the financial impacts of RUC on households. This report analyzes the financial impacts 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.[17] 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 impact 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 (Figure 2), 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.

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: RUC West

Figure 2. Average fuel efficiency (miles per gallon) for vehicles in urban, mixed, and rural census tracts of project States (gas-taxed vehicles only).

To better understand the financial impact 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 National Household Travel Survey showed

[17] RUC West and Oregon Department of Transportation. *Financial Impacts of Road User Charges on Urban and Rural Households*. Available at: https://www.edrgroup.com/pdf/FINAL-REPORT---Financial-Impacts-of-RUC-on-Urban-and-Rural-Households_Corrected.pdf.

much longer trip lengths for rural households, including nearly twice as much travel for shopping trips. A key finding of the study was that, 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. Assuming that an RUC program will credit any paid fuel taxes back to the motorist, most rural drivers may see a positive impact 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.[18] Ranges reflect the differences from State to State (see Table 13).

Table 13. Percentage change in payment under road usage charge system compared to 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 Corridor 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

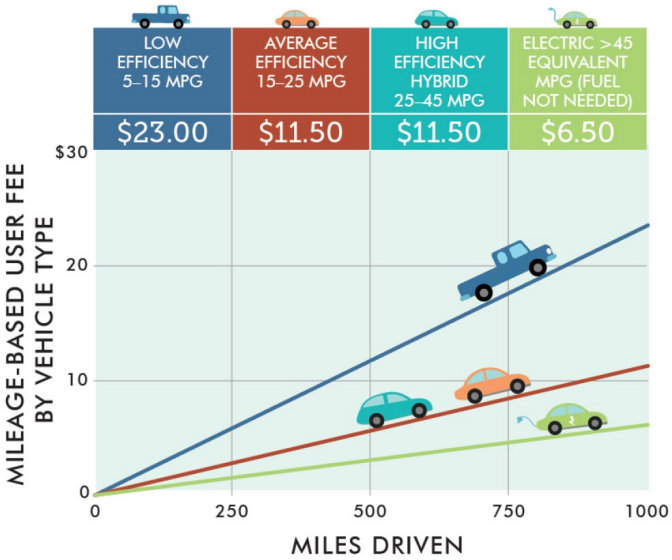
The central argument in favor of an RUC is the inherent "fairness" of a system where all drivers pay their fair share of transportation expenditures, as determined by how much they drive. Despite that fact, a persistent counter-argument that several sites have encountered in their outreach is that an 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 for this socially desirable choice with lower charges.

[18] ibid

Identification, analyses, and quantification of problem. The Eastern Corridor 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 and/or rural residents). A lower rate would be charged for those vehicles with fuel efficiencies at about the average MPG—in essence, a "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 3 shows a comparison of a mileage-based charge and the current gas tax paid by vehicle time and miles driven developed by the Eastern Transportation Coalition.



Source: Eastern Corridor Coalition

Figure 3. Graph. Hypothetical average mileage-based user fee paid by vehicles with different fuel efficiencies.

Communication and messaging. The Eastern Corridor Coalition Technical Memorandum lays out several arguments to counter the perceived unfairness of RUC to fuel-efficient vehicles, as summarized below:

- 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. [19]

[19] Union of Concerned Scientists. 2015. *Cleaner Cars from Cradle to Grave – How Electric Cars Beat Gasoline Cars on Lifetime Global Warming Emissions*. Available at: https://www.ucsusa.org/resources/cleaner-cars-cradle-grave.

- 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.[20]

SIGNIFICANT PHASE I EFFORTS EXPLORING EQUITY AND PUBLIC ACCEPTANCE

This section presents significant Phase I findings with regard to the equity implications of alternative transportation funding solutions, in addition to the RUC West study cited above.

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 being unfair to drivers who travel further on a trip-by-trip basis and who are, therefore, charged more per-trip.

The RUC West ConOps also draws 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. Assuming that an RUC program will credit any paid fuel taxes back to the motorist, most rural drivers may see a positive impact from participating in an RUC program.

- Using different rates based on income, average MPG of the vehicle, and/or classification of the driver's residence (e.g., urban, rural, mixed, or commercial) may be a future consideration.

[20] Tessum, Christopher W., Hill, Jason D., and Marshall, Julian D. 2015. "Life Cycle Air Quality Impacts of Conventional and Alternative Light-Duty Transportation in the United States;" Proceedings of the National Academy of Sciences. Available at: https://www.pnas.org/content/early/2014/12/10/1406853111.

- As RUC expands, international drivers may also be encountered. One example of this is drivers in Canada who travel along United States 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 Corridor Coalition's Pre- and Post-Pilot Surveys

The Eastern Corridor 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% at the beginning of the pilot to 38%; while the number of participants who said MBUF was "more fair" for fuel-efficient vehicles went down from 39% at the beginning of the pilot to 24% following the pilot.*[21]

[21] I-95 Corridor Coalition. 2019. *Equity and Fairness Considerations in a Mileage-Based User Fee System*. n.p.

CHAPTER 8. 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. The 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 what Federal agencies might be involved in estimating those rates.

- **Economic impact of RUC:** It is unclear what impacts RUCs might have on travel behavior.

- **RUC and tolling:** Questions remain regarding whether 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/no technology users is likely to persist in the future. While the issue may be of more significance in certain geographies like the Interstate (I) 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 would 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—mileage-based user fees (MBUFs), DBUFs, RUC, VMT tax among, and others. Using differing terminology can impact 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/State boundaries as well as the convergence of MBUF and other transportation pricing such as parking and transit.

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