Surface Transportation System Funding Alternatives Phase I Evaluation

Road Usage Charge Enhancement to Improve Functionality, Public Acceptance, and Interoperability by the Oregon Department of Transportation

FHWA-HOP-19-043

August 2022

U.S. Department of Transportation
Federal Highway Administration

Notice

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the use of the information contained in this document. The content of this document does not have the force and effect of law and is not meant to bind the public in any way. This document is intended only to provide clarity to the public regarding existing requirements under the law or agency policies.

The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this report only because they are considered essential to the objective of the document.

Quality Assurance Statement

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

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA-HOP-19-043	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Surface Transportation System Funding Alternatives Phase I Evaluation: Road Usage Charge Enhancement to Improve Functionality, Public Acceptance, and Interoperability by the Oregon Department of Transportation		**5. Report Date** August 2022 **6. Performing Organization Code**
7. Author(s) Sonika Sethi, Ben Pierce, Justin Robbins, Drew Van Duren, Asha Weinstein Agrawal		**8. Performing Organization Report No.**
9. Performing Organization Name and Address Leidos Inc. 1750 Presidents Street Reston, VA 20190 HDR Inc. OnBoard Security San Jose State University		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** DTFH61-16-D-00053, T-0015
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration 1200 New Jersey Avenue, SE Washington, DC 20590		**13. Type of Report and Period Covered** Evaluation Report September 29, 2017–July 28, 2019 **14. Sponsoring Agency Code** HOP
15. Supplementary Notes The Government's Task Manager for this effort was Angela Fogle.		

16. Abstract

This report presents the independent evaluation results of the Road Usage Charge Enhancement to Improve Functionality, Public Acceptance, and Interoperability by the Oregon Department of Transportation (ODOT), which received fiscal year (FY) 2016 funding from the U.S. Department of Transportation's Surface Transportation System Funding Alternatives Program. ODOT is one of eight entities to engage in pilots or pre-pilot planning and development activities to explore a variety of options to demonstrate user-based alternative revenue mechanisms.

The U.S. Congress and the Federal Highway Administration (FHWA) seek to understand whether a user-based alternative revenue mechanism that utilizes a user-fee structure can help maintain the long-term solvency of the Highway Trust Fund and can be implemented nationally at some time in the future. As part of this endeavor, the FHWA is evaluating seven of the eight grantee sites that received funding in Federal FY 2016. The evaluation reports resulting from this process will make the Secretary of Transportation and U.S. Congress aware of the progress that has been made, lessons learned from initial pilot and planning efforts, the role of education and outreach, the potential for any negative impacts on constituents, and initial findings on administrative fees, among other issues.

17. Key Words	18. Distribution Statement
Road Usage Charge, Mileage-Based User Fee, Vehicle Miles Tax, Surface Transportation System Funding Alternatives	No restrictions.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	44	n/a

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 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 ABBREVIATIONS

DEQ	Department of Environmental Quality
FAST	Fixing America's Surface Transportation
FHWA	Federal Highway Administration
FY	fiscal year
GPS	global positioning system
MRD	mileage-reporting device
NHTS	National Household Travel Survey
OBD	onboard diagnostics
ODOT	Oregon Department of Transportation
RUC	road usage charge
STSFA	Surface Transportation System Funding Alternatives
USDOT	U.S. Department of Transportation

EXECUTIVE SUMMARY

This report presents the independent evaluation results of Oregon's fiscal year (FY) 2016 Surface Transportation System Funding Alternatives (STSFA) grant project to improve functionality, public acceptance, and interoperability of its existing road usage charge (RUC) program. The Oregon Department of Transportation (ODOT) received $2.1 million in FY 2016 STSFA funds from the U.S. Department of Transportation (USDOT) to enhance the capabilities of its existing RUC program. ODOT previously conducted pilots in 2007 and 2013. Since 2015, the State has operated an ongoing volunteer program called OReGO to demonstrate the functionality and scalability of RUC. ODOT is one of eight entities to engage in FY 2016 awarded funds to explore enhancements of independently funded pilots, or pre-pilot planning and development activities, to consider a variety of options to demonstrate user-based alternative revenue mechanisms. The FY 2016 funding and associated grant programs are referenced throughout this document as constituting Phase I of the STSFA Program.

BACKGROUND

As vehicles become more fuel efficient, the reliability and adequacy of the motor fuel tax as a primary source for transportation infrastructure funding continue to decline. Recognizing this trend, the Fixing America's Surface Transportation (FAST) Act[1] established the STSFA Program to provide grants to States or groups of States to demonstrate user-based alternative revenue mechanisms that employ a user-fee structure to maintain the long-term solvency of the Highway Trust Fund. The stated goals of this program are for States 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 provide information on possible approaches.
- Provide recommendations regarding adoption and implementation of user-based alternative revenue mechanisms.
- Minimize the administrative cost of any potential user-based alternative revenue mechanisms.

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

The U.S. Congress and the FHWA seek to understand whether a user-based alternative revenue mechanism that utilizes a user-fee structure could help maintain the long-term solvency of the Highway Trust Fund and be implemented nationally at some time in the future. As part of this endeavor, the FHWA evaluated seven of the eight grantee sites that received funding in Federal

[1] Public Law 114–94, H.R. 22, § 6020, H.R. 22, 114th Congress (2015).

FY 2016.[2] The evaluation reports resulting from this process will allow the Secretary of Transportation and U.S. Congress to be aware of progress, lessons learned from initial pilot and planning efforts, the role of education and outreach, and the potential for any negative impacts on constituents and initial findings on administrative fees, among others.

OREGON ROAD USAGE CHARGE PROGRAM ENHANCEMENTS

As part of the RUC program enhancement efforts, ODOT used Federal grant money to expand and improve the functionality of its RUC program, conduct outreach to further increase public awareness, provide recommendations to the Federal Government and other States about road usage charging, and streamline processes to minimize the administrative costs of its existing program. The enhancement activities were planned to prepare the State for program expansion while acting as an example for other States (as well as the Nation), and for how to implement and administer an RUC program. The program had four specific objectives:

- **Expand technology options:** In addition to testing additional technology options, ODOT analyzed how the agency addressed overcoming challenges of certifying more technical options, which require enhanced system operations and improved interfaces. This objective involved the following key activities:
  - Documenting findings and recommendations for increasing technology options in the RUC marketplace.
  - Analyzing improvements to the RUC open market.
  - Developing a manual reporting option (to accommodate users and participants who are unable to use the existing mileage-reporting technologies and/or do not have internet access).
  - Partnering with other agencies to streamline RUC services and share transportation data.

- **Increase public awareness:** ODOT pre- and post-tested public opinion on a range of road charging topics and concepts to determine whether the education program improved public acceptance.
- **Evaluate compliance mechanisms:** ODOT tested new compliance processes with current account managers as much as possible. However, it cannot implement a new compliance mechanism until State legislation passes to provide the necessary statutory authority.
- **Explore interoperability:** An RUC Summit was conducted in September 2017. ODOT summarized lessons learned and next steps.

MAJOR FINDINGS

ODOT has been running a voluntary, alternative revenue collection program since July 2015 called OReGO. After completing STSFA Phase I activities, ODOT recognized the need to decouple an RUC approach from specific technology solutions. As part of exploring new technologies, ODOT investigated the opportunities presented by emerging technologies, such as connected vehicle technology, and specifically, vehicle-to-infrastructure communication, which

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

can potentially allow vehicles to transmit large amounts of data. A major focus of these efforts was to evaluate the role of such technology in transportation funding applications.

Key findings of Oregon's Phase I efforts in accordance with relevant STSFA evaluation criteria follow:

- **Technology options:** Providing a range of technology options for mileage reporting is critical for program success. Oregon tested onboard telematics, dashboard image capture, data exchange, and paired smartphone and beacon options as part of this project. The key findings in relation to the new technologies tested are:
    - Some of the new or emerging candidate technologies are not sufficiently mature for RUC assessment: The ODOT pilot tested new technologies, specifically, cell phone and beacon pairing, cell phone imagery of odometer, and vehicle telematics data. The pilot demonstrated that these new technologies have inadequacies. Cell phone and beacon pairing and cell phone imagery of odometer resulted in poor user experience and inconsistencies in captured data. The telematics approach is reliable and simple, but is not currently available in all automobiles on the road, and will need time to mature.
    - Manual reporting options are important in a mandatory system, but are likely to be costly to implement: The general framework of the OReGO system allows States to add reporting mileage options, including a manual reporting option. While the manual reporting option was not tested as a live demonstration during Phase I, ODOT recognized the need for manual reporting within a mandatory system and developed a plan for the eventual testing of the manual option. The paper option in manual reporting, however, is expected to have high implementation and enforcement costs. When implemented program-wide, economies of scale could potentially make this option viable. Using third-party vendors to physically verify mileage could also help contain costs.

- **Data security and accuracy:** Secure and interoperable vehicle telematics access capabilities are essential for realizing end-to-end data security and privacy. While security requirements in the Oregon pilot are commensurate with the objectives of typical pilots, there is room for enhancement, particularly for a full-scale mandatory RUC program. Ease of use should be balanced with system reliability and ensuring users do not have the ability to game the system. For instance, smartphone-related technology may appear to be the easiest for the State to use, given the ubiquity of smartphones. However, there are several challenges with this technology. Smartphone applications require a vehicle-specific component so that person-miles traveled outside of the specific vehicle (i.e., in another vehicle or on another mode within the jurisdiction, or inter-jurisdictionally) are not attributed to the respective vehicle. ODOT tested a vehicle-mounted beacon to provide this functionality. Early testing results show that a beacon-like device that communicates with the smartphone application from within a specific vehicle is susceptible to interference from other, nearby vehicles.

- **Multi-jurisdictional interoperability:** ODOT's efforts to develop, test, and implement additional technologies for the existing OReGO program, consistent with those used in

the Washington and California pilots, attempt to increase interoperability opportunities. The RUC Forum in 2017 explored such opportunities.

- **System cost:** Although a full-scale program cost estimate was not part of the Phase I effort, several tasks identified efficiencies that could result in cost reductions relative to the current program:
  - The deploying agency may be able to serve as the account manager. For this to occur, business processes should be established based on the agency's objectives. Sound documentation of business processes is essential.
  - Significant savings could be realized for account manager certification efforts by streamlining business operations and aligning program requirements with existing standards. The results of process analysis tasks found potential increases to revenue through a reduction in tax evasion, and improved business efficiency of new compliance procedures.

- **Enforcement and compliance mechanisms:** Although implementing complete program enforcement is a possibility, the agency needs to make a tradeoff between the cost of the enforcement and compliance aspects, and the marginal revenue generated by more stringent enforcement.

- **Equity and fairness:** Determining both the actual burden of RUC on different households and the perceived fairness of the approach are key to the long-term success and wider adoption of a voluntary RUC program. The key issues with RUC, as identified by the focus groups conducted as part of ODOT's program, follow:
  - Several focus group participants questioned why vehicles with poor fuel economy should get a refund. They contended that the fee amounted to a disadvantage to owning and driving electric and high fuel efficiency vehicles (i.e., "being penalized for doing the right thing") and would lead to negative environmental impact.
  - Some focus group participants also contended that RUC would be unfair for low-income drivers, although they did not provide any specific reasoning for the belief.

CHAPTER 1. INTRODUCTION

As vehicles become more fuel-efficient, the reliability and adequacy of the motor fuel tax as a primary source for transportation infrastructure funding have come into question. Recognizing this trend, the Fixing America's Surface Transportation (FAST) Act[3] of 2015 established the Surface Transportation System Funding Alternatives (STSFA) Program. The purpose of this program is to provide grants to States or groups of States to demonstrate user-based alternative revenue mechanisms that employ a user-fee structure to maintain the long-term solvency of the Highway Trust Fund.

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

By funding road usage charge (RUC) pilots, the U.S. Congress and FHWA seek to understand whether a user-fee structure, such as RUC, is a system that could be implemented Nationally in the future. As part of this endeavor, the FHWA evaluated seven of the eight grantee sites that received funding in Federal fiscal year (FY) 2016, also referred to as Phase I of the STSFA grant program.[4] The evaluation reports will inform the Secretary of Transportation and U.S. Congress of the progress that has been made, lessons learned from initial pilot and planning efforts, the role of education and outreach, the potential for any negative impacts on constituents, and initial findings on administrative fees, among others.

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

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

[3] Public Law 114–94, H.R. 22, § 6020, H.R. 22, 114th Congress (2015).

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

ORGANIZATION OF THIS REPORT

Chapter 1 introduces the user-fee concept and the background and purpose of the pilot.

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

Chapter 3 presents the evaluation framework as proposed under the 2016 Notice of Funding Opportunity, the key U.S. Department of Transportation (USDOT) questions that the evaluation seeks to address, and the evaluation team's approach.

Chapter 4 provides the major findings from evaluation of Phase I activities, including lessons learned, findings and outcomes as observed by the evaluation team, and suggestions for further exploration through the course of future efforts towards an alternative revenue program.

Chapter 5 summarizes the key takeaways from Phase I activities and lessons learned that would be relevant for Nationally implementing a mileage-based fee program.

Chapter 6 presents the references used in this report.

CHAPTER 2. OREGON ROAD USAGE CHARGE PROGRAM ENHANCEMENTS

This chapter presents ODOT's RUC program enhancements, including the program objectives and a summary of activities conducted as part of Phase I of the STSFA grant program, during the FY 2016 grant cycle.

In 2001, Oregon's legislature formed the Road Usage Fee Task Force. Its mission was to find an alternative source of transportation funding outside of fuel taxes. From this legislative body, the concept of RUC—where volunteers pay for every mile they drive, rather than for every gallon of fuel their vehicles consume—came into existence. With the passage of Senate Bill 810 in 2013, ODOT was mandated to create and maintain an RUC program. The first phase of RUC program implementation began on July 1, 2015, and allowed up to 5,000 volunteer vehicles to participate. Oregon was the first State in the country to implement a Statewide program to assess RUC on a voluntary enrollment basis.

ODOT previously conducted pilots in 2007 and 2013, and since 2015, has operated an ongoing volunteer program (OReGO) to demonstrate the functionality and scalability of RUC. The program is limited to 5,000 passenger vehicles. Volunteers still pay State fuel tax at the pump, and a fuel tax credit is automatically applied toward their RUC invoices. OReGO volunteers are only responsible for the RUC. Further information about the current RUC program can be found on the OReGO FAQ webpage.

Although ODOT executed several rounds of demonstrations and evaluations prior to the proposed STSFA Phase I activities that are the subject of this evaluation report, a summary of Oregon's prior activities is beyond the scope of this evaluation. However, the reader is encouraged to review the referenced literature for a more-in-depth understanding of Oregon's RUC initiatives.

PROGRAM OBJECTIVES

As part of Phase I, ODOT planned activities 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. The RUC enhancement effort specifically targets four objectives:

- Objective 1: Expand the RUC market.
- Objective 2: Increase public awareness.
- Objective 3: Evaluate compliance mechanisms.
- Objective 4: Explore interoperability.

KEY COMPONENTS OF OREGON'S ROAD USAGE CHARGE ENHANCEMENT

Objective 1: Expand the Road Usage Charge Market

This objective encompasses four activities, as detailed below:

- Activity 1: Expand technology options for reporting mileage.
- Activity 2: Manage the open market.
- Activity 3: Develop requirements for a manual reporting option.

- Activity 4: Streamline reporting and data sharing.

Activity 1 analyzes how ODOT approached overcoming challenges of certifying more technical options, which require enhanced system operations and improved interfaces. This activity involved documenting findings and recommendations to increase technology options in the RUC marketplace. As part of this objective, ODOT planned to:

- Analyze improvements to the RUC open market.
- Develop a manual reporting option to accommodate users and participants who are unable to use the existing mileage-reporting technologies and/or do not have internet access.
- Partner to streamline RUC services and share transportation data.

The additional mileage-collecting methods (shown in Figure 1) explored as part of Phase I activities include the following:

- Dashboard image capture: This method requires the RUC payer to periodically send a photograph of the vehicle's dashboard to the account manager. It proposes using multiple photograph capture/deliver methods (e.g., using a mobile application and text messages).
- Vehicle onboard telematics: This method involves remotely reading a vehicle's odometer via a wireless connection to the vehicle. A connected car system, installed in the vehicle during manufacturing, provides functions and services that are enabled using wireless/cellular technology.
- Data exchange: This method allows a platform to receive mileage data from different companies and process it for use in the OReGO program. It emphasizes the RUC open-architecture concept. This concept helps open the market to additional companies that provide mileage collection as part of their product sets.
- Smartphone application: This method, which is a combination of a smartphone application and a wireless beacon placed in the enrolled vehicle, allows access to the smartphone's internal global positioning system (GPS) to determine location and internal phone sensors to determine mileage traveled. All vehicles can participate because they are not required to provide any functionality.

In Activity 2, ODOT recognized the need to streamline OReGO's existing processes related to account manager certification. The goal of this subproject was to identify which processes and systems ODOT would need to be its own account manager, rather than outsourcing the role to a private vendor.

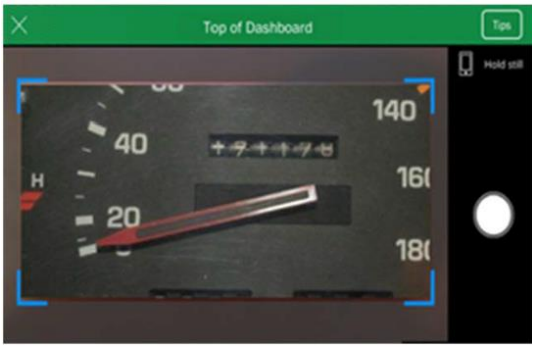
Activity 3 involved a tabletop exercise in lieu of a pilot to simulate a manual reporting option. The objectives of this project were to:

- Identify requirements for a manual reporting option, including:
  - Account management
  - Customer support management
  - Accounts receivable/payable
  - RUC payer enforcement

    - Data collection and validation
    - Other business, financial, and reporting requirements
- Develop business processes to support identified requirements
- Design a plan that outlines the scope, schedule, budget, and overall strategy to implement a manual reporting option
- Prepare a plan that outlines staffing and budget required to operate a manual reporting option

In Activity 4, the Agency Partnering project was created to ensure stakeholders understand that the data sharing and streamlining activities focus on partnering with other State entities. The overall goal of this project was to capture data points using the same technology as OReGO to streamline internal processes and participants' experiences.

Dashboard Image Capture

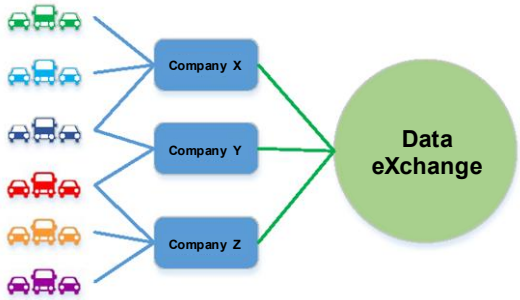


Dashboard Image Capture is a method of mileage collection where the RUC Payer periodically sends a photo of the vehicle's dashboard to the Account Manager. This method proposes using multiple photo capture/deliver methods (e.g. using a mobile app and text messages) to ensure access to this solution.

Vehicle Onboard Telematics

Vehicle Onboard Telematics is a method of mileage collection that involves remotely reading a vehicle's odometer via a wireless connection to the vehicle. A connected car system, installed in the vehicle at time of manufacturing, provides functions and services that are enabled using wireless/cellular technology.

Data eXchange



The data eXchange is a platform that receives mileage data from different companies and processes it for use in the OReGO Program. This platform emphasizes the RUC open architecture concept, and allows for multiple mileage reporting methods to send data to one common platform. This concept will help open the market to additional companies that provide mileage collection as part of their product sets.

Smartphone App and Beacon

This solution uses a smartphone app in conjunction with a wireless beacon placed in the enrolled vehicle. The app uses the smartphone's internal GPS to determine location, and internal phone sensors to determine mileage traveled. This solution provides the opportunity for all vehicles to participate, is it does not require the vehicle to provide any functionality.

Source: Oregon Department of Transportation.

Figure 1. Illustration. Technology options explored as part of Oregon Department of Transportation's 2016 Surface Transportation System Funding Alternatives-funded efforts.

OReGO partnered with the ODOT Transportation Development Division for a 6-month pilot to utilize anonymized participant travel data for traffic modeling analysis. As of this evaluation, the project had procured a contractor to implement and manage the pilot with ODOT.

OReGO also partnered with the Oregon Department of Environmental Quality (DEQ) and Azuga, a technology provider, to develop functionality for a mileage-reporting device to provide remote emissions testing for DEQ. The project team, along with DEQ and Azuga, developed a communications plan and has been involved in testing the new functionality.

Objective 2: Increase Public Awareness

ODOT planned to pre- and post-test public opinion on a range of road charging topics and concepts to determine whether the education program has improved public acceptance.

Objective 3: Evaluate Compliance Mechanisms

ODOT planned to test 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.

Objective 4: Explore Interoperability – Road Usage Charge Forum

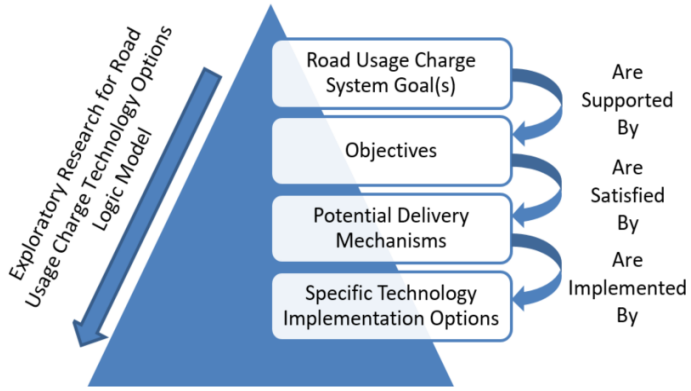
An RUC Summit was conducted in September 2017. ODOT summarized the lessons learned and next steps in an evaluation report: Oregon's Road Usage Charge: The OreGO Program Final Report (Oregon Department of Transportation 2017).

CHAPTER 3. INDEPENDENT EVALUATION METHODOLOGY

This chapter summarizes the independent evaluation approach and methodology. The study team completed this work in coordination with staff from the FHWA Office of Operations and Division office and representatives of the respective grantee sites. This chapter defines the evaluation framework and includes responses to key questions that the USDOT expressed about road usage charge RUC approaches and their viability and characteristics if implemented on a National scale.

EVALUATION APPROACH

As its name suggests, the fundamental concept of an RUC is that users pay a direct charge for the use of a roadway. However, it is important to understand that both "use" and "user" can be defined in several different ways, and the mechanism by which a charge is levied can also vary significantly. This is evident among the Phase 1 grantee agencies, all of which are using different combinations of technologies and various paradigms and mechanisms to levy charges. Often, the fundamental objective of the RUC system is a significant factor in identifying technology options, data collection, and how fees are levied. Figure 2 highlights previous research that has characterized this phenomenon through the use of an RUC logic model.



Source: HDR Inc.

Figure 2. Diagram. Exploratory research for road usage charge technology options logic model.

One essential component of this evaluation was trying to understand the fundamental objectives of the RUC systems as deployed by the grantee sites. The objectives provided overarching insight into more detailed assessments and evaluations of the efficacy, costs, and scalability of the systems at a regional or national level. Please see the discussion below (Evaluation Process section) for a summary of how the study team conducted this evaluation.

EVALUATION FRAMEWORK – U.S. DEPARTMENT OF TRANSPORTATION QUESTIONS

Table 1 presents the key questions that USDOT intends to examine as part of this evaluation. The evaluation team elaborated on the questions and defined the relevant metrics for conducting the evaluation for the specific grant site. While some questions were found to be highly applicable to Phase I activities, others were marginally applicable. Table 1 provides the assessment framework, and Table 2 provides the system attributes relevant to the evaluation.

Table 1. Assessment framework.

No.	USDOT Evaluation Question	Relevant Site Question/Metrics	Applicability to Oregon's Phase I Activities
Q1	What is the viability of RUC on a nationwide scale?	What are the lessons learned from inter-jurisdictional pilot operations?	Moderate
Q2	Would the fee assessment and collection mechanisms be scalable?	What are the results of expanding technology and manual reporting options?	High
Q3	What is the efficiency of the fee assessment and collection relative to the fuel tax?	What are the costs of RUC collection for the pilot? Have you conducted a cost estimate for operations at scale?	Marginal
Q4	What are the system attributes and characteristics of the RUC systems with respect to: privacy, security, user acceptance, ease of use, ability to audit, charging accuracy, reliability, equity, ability for a user to circumvent the charge, and other factors?	See Table 2 for detailed metrics.	High
Q5	What is the user and stakeholder perception of mileage-based user fee in general and of pilot activities?	What are some of the key inputs received from user and stakeholder surveys conducted as part of the task to increase public awareness? What was the outcome of the focus groups?	High
Q6	What changes in institutional and financial setting, frameworks, models, and elements are required?	What are the results of evaluating compliance mechanisms, managing RUC open markets, and streamlining reporting and data sharing?	High
Q7	What is the financial sustainability of each pilot deployment?	Have you evaluated the financial sustainability of the pilot deployment?	Low

Table 2. System attributes.

Functional Parameter	Description
User-Orientated Parameters	
Privacy	The nature of information being collected as opposed to the integrity of the information.
Equity	How user costs and other outcomes will impact people in different income brackets and of different races/ethnicities, gender, English proficiency level, and travel mode.
Potential for Value-Added Services	The ability to add other transportation-related applications or software to the system to enhance system performance, reduce congestion, and improve mobility.
Ability to Audit	Extent to which an individual can contest their charges and have visibility into how those charges were accrued and assessed.
Ease of Use/Public Acceptance	Degree to which the system use is straightforward and time that a participant needs to spend interacting with the installed system is minimized; the level of acceptance by the traveling public.
Transparency	User awareness, specifically in real time, of what they are being charged.
Cost to User	Cost of equipment or installation to the end-user and cost of the per-mile (or other) charge.
System-Orientated Parameters	
Data and Communications Security	Data source integrity and storage, transmission, and access.
Charging Accuracy	Ability to assess the expected charge for each use of the roadway.
Charging Precision/Repeatability	Ability to produce a consistent assessment of fees repeatedly for identical travel.
System Reliability	System up-time.
Flexibility to Adapt	Ability of the technologies and systems to be upgraded or updated.
Flexibility to Expand	Ability of the system to respond to increased demand/system capacity and add technological capabilities.
Interoperability	Ability for the system to interact and exchange information across multiple jurisdictions.
Compatibility with Low Tech	Ability of the system to accommodate users that cannot utilize the technology.
Evasion	Evaluation of how easily the system can be circumvented.

Table 2. System attributes. (continuation)

Functional Parameter	Description
System-Orientated Parameters	
System Costs	Understanding of the full spectrum of investment costs, including initial capital, operating, and maintenance costs.
Ease of Enforcement	Ability of law enforcement to identify travelers that have evaded the system.
Cybersecurity	Extent to which the system is vulnerable to a cyberattack or release of private information.
Ability to Reallocate Revenue	Extent to which the system collects information that can be used to inform allocation of revenue.

EVALUATION PROCESS

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

Kickoff Meeting

At the start of the evaluation, the evaluation team conducted 90-minute kickoff meetings with each of the grantee sites. The primary purpose was to introduce the goal and scope of the evaluation and obtain information about the pilot's Phase I goals, scope, and timeline. The evaluation team requested program documents compiled up to that point and updated project management plans.

Site Visit

In August 2018, the evaluation team, along with FHWA staff, conducted a site visit to Oregon to learn about the project progress, initial findings from the completed activities, and timeline to complete remaining activities. As part of this site visit, the evaluation team met with Oregon Department of Transportation (ODOT) staff managing the RUC pilot and, via questions and answered, learned both about the technical and business aspects of Phase I activities. At the time of this meeting, several activities were ongoing while others were completed. The evaluation team submitted a request for documentation related to completed activities.

Evaluation Report Development

This evaluation report was developed using information collected during the site visit and from Oregon's project reports, including the evaluation documents. Note that, as with the other grantee sites, ODOT's Phase I tasks did not directly address all the Federal evaluation criteria. Chapter 4 includes the major findings related to aspects that Phase I directly addressed.

CHAPTER 4. MAJOR FINDINGS

This chapter presents an overview of ODOT's RUC system and summarizes key findings and lessons learned resulting from its Phase I efforts. The findings are presented in accordance with the evaluation framework described in chapter 3. This framework is based on the STSFA grant evaluation criteria, as provided in the notice of funding opportunity.[5] Several evaluation criteria were not directly addressed within the scope of grant-funded activities. Oregon has an ongoing RUC program, but this evaluation is focused on the activities specifically funded through the Phase I STSFA funding award to ODOT.

OREGON'S ROAD USAGE CHARGE SYSTEM OVERVIEW

OReGO is ODOT's RUC program in which participants pay by the mile driven instead of by the gallon of fuel purchased. The overall OReGO system design and its utilization of third-party account managers gives considerable flexibility in the methods or technology used to capture mileage data. Account managers are the primary interface between users and OReGO (see Figure 3). They offer their own user interface and account software for tabulating mileage and fees, fee payment, and value-added services. From a user's perspective, the account manager is the main point of contact for the RUC system. Participants can choose their account manager (and associated mileage-reporting technologies and services) from the companies participating in the program.

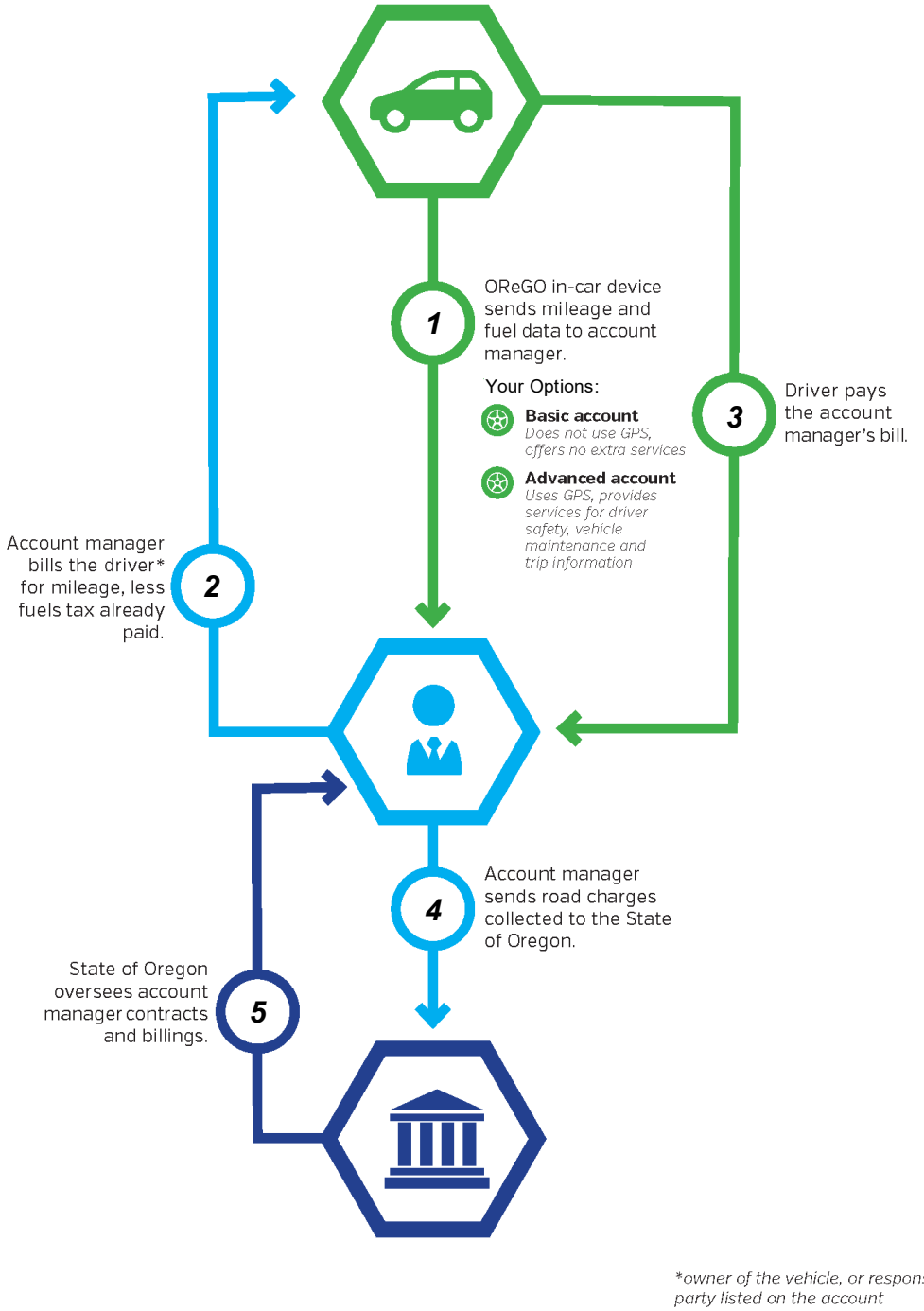
The account manager is responsible for developing, maintaining, and operating the suite of mileage-reporting technologies and the user accounts. They use the data collected from each user to calculate both the number of miles driven on public roads and the road user fee for each vehicle. These data are aggregated and anonymized for the purposes of reporting to ODOT.

The existing OReGO system can incorporate a wide array of viable technologies or approaches, as long as they are validated and authorized. The system structure allows the user to select both the account manager and mileage-reporting method they would like to use. Appendix A includes a graphic representation of OReGO's full system architecture. ODOT's RUC program uses mileage-reporting devices (MRDs) to report mileage and fuel consumption data from participating vehicles. The program's current devices plug into the vehicle's onboard diagnostic (OBD) port, capture the mileage and fuel consumption data, and report that data back to the account manager to calculate RUCs and fuel tax credits.

Two types of devices are available to OReGO program participants:

- Basic: This MRD plugs into the OBD port and captures miles driven and, when available, fuel consumption data. This device does not use vehicle location technology.
- Advanced: This MRD plugs into the OBD port and captures miles driven, fuel consumption (when available), and GPS location data. GPS allows commercial account managers to differentiate between in-State and out-of-State miles driven and also provides a number of value-added services.

[5] USDOT Notice of Funding Opportunity, number DTFH6116RA00013, issued on March 22, 2016.



Source: Oregon Department of Transportation, PRR Inc.

Figure 3. Illustration. Description of OReGO.

The system designed by OReGO allows account managers to develop innovative methods or technologies for collecting road user data. As a result, as part of STSFA Phase I, the following data-collection techniques were tested for future use in the pilot.

Dashboard Image Capture

This approach assumes use of a driver's smartphone and cellular data to transmit an image of the odometer to the account manager. Dashboard image capture utilizes technology present in almost every smartphone available on the market today, using an integrated camera to take and send an image of the dashboard to determine the current mileage of the vehicle. The process is simple and straightforward. Given its simplicity, there is little opportunity for major improvements, aside from incremental increases in smartphone capabilities or image resolution.

While the process of image-capturing an odometer leaves little opportunity for upgrade or expansion, the base technology used to capture and transmit the image does have that potential. Because smartphones typically integrate cameras, Bluetooth, cellular communications, GPS positioning, and the ability to run various applications, the presence of a smartphone for image capture opens the possibilities for incorporating other types of technologies or approaches that could be used to record and assess road user charges.

Vehicle Onboard Telematics

Using a device that connects to the OBD-II port of a vehicle (on August 9, 1995, the Environmental Protection Agency issued a final rule[6] that required manufacturers to install an OBD system), data are gathered and transmitted to the account manager through a cellular network to determine the mileage driven and fee assessed. Two base technologies are used for this fee-assessment method: the vehicle's OBD system that outputs data through the OBD-II port, and a telematics device provided by the account manager.

Data generated by vehicles using the OBD-II port are limited to static data fields that were determined when the vehicle was produced. Because the manufacturer integrates these data fields into the vehicle's sensors and software, which are generally not upgradable, the ability to expand functionality or data coming from the OBD-II port is not available. Major upgrades to vehicle diagnostics, including telematics data, will provide an opportunity to expand the functionality of the system, but these upgrades will happen on the vehicle vendor side and cannot be added later.

The telematics device uses information produced by the vehicle diagnostic system and communicated through the OBD-II port, combined with additional technologies embedded in the device such as GPS and cellular technologies. These devices have the capability to enrich the OBD-II port data with location data, allowing the ability to expand the types of data collected from standard road mileage. For example, the OBD-II data show speed and duration, allowing the account manager to calculate mileage driven. Location data are gathered from the telematics device as well and sent to the account manager, allowing them to determine how many miles were driven on public roads within Oregon, as well as where other non-fee miles were driven.

Account managers also offered extra service options in addition to the road user mileage calculations, which provide users the option to track vehicle position, map their position history, and track the speed and diagnostic information. Although users must pay a fee to use these additional services, they give the user the option to provide the account manager with an extra layer of useful information. The only data transmitted from the account manager to the OReGO

[6] "Rules and Regulations," *Federal Register* 60, no. 153 (Wednesday, August 9, 1995).

system are the account number, number of miles, and fee assessed. No telematics or diagnostic data are transferred to the OReGO program or the State Treasury.

From a user's standpoint, the telematics device is easy to upgrade, as the device is removed from the port and replaced with a different device. Additionally, account managers have the capability to push firmware updates to the devices.

A major limitation of the telematics device is the incompatibility of the device with vehicles lacking an OBD-II port. With time, the percentage of the National vehicle fleet without these ports will decrease, but legacy vehicles will remain an issue for a percentage of the Oregon population.

Smartphone Application and Beacon

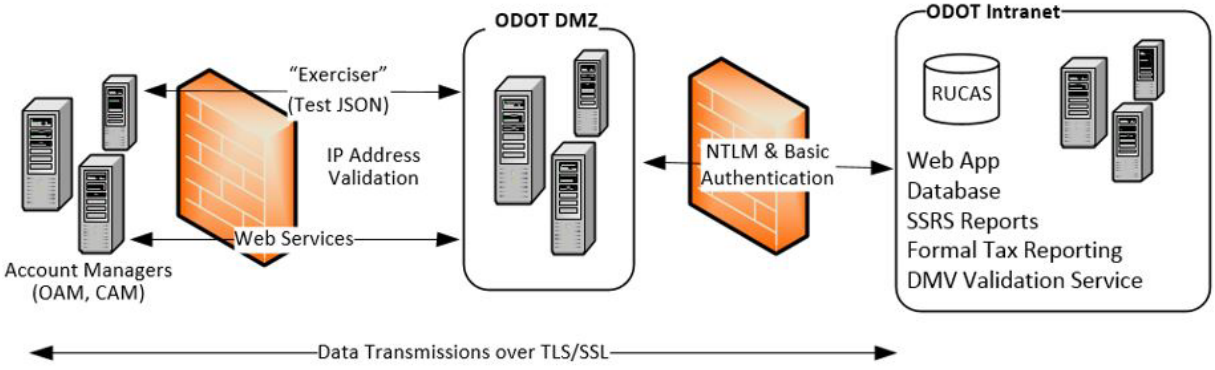
This consists of a beacon that pairs with a smartphone via Bluetooth and uses a specialized application on the smartphone to identify fee-specific travel within Oregon. The beacon allows the system to identify when a driver is in their specific vehicle.

Similar to the image-capture approach, an upgrade/update to this beacon system would be delivered via software update or an update to the smartphone's capabilities.

The pilot report concluded that this technology has inadequacies. Cell phone and beacon pairing and cell phone imagery of odometer resulted in poor user experience and inconsistencies in captured data.

Data Exchange

Data exchange is a backhaul system that allows account managers to interface with the OReGO program. As a web-based system developed with an intent to be distributed to other States upon completion, the system likely can be upgraded and expanded without significant disruption to users. Figure 4 presents the RUC system architecture.



Source: Oregon Department of Transportation.

Figure 4. Diagram. Oregon's road usage charge system architecture.

SYSTEM-ORIENTED PARAMETERS

Data Security

Data security is measured or determined by:

- The type and quantity of raw data being collected
- How the raw data are treated (i.e., sanitized, and where in the system it resides)
- The intractability of tracking the time and location of drivers (requiring collection point and account manager system anonymization and sanitization practices), as well as cybersecurity (encryption) and technology-specific properties and limitations
- The cybersecurity posture of the system and its endpoints

Raw data are stored in various locations in the Oregon pilot: (1) the smartphone MRD used in the smartphone approaches, (2) the dongle MRD, and (3) the account manager. Secure data storage necessitates encryption of data-at-rest, which was a requirement in the Oregon pilot. In the future, cryptographic module requirements pertaining to cryptographic key management and storage between the MRD (i.e., dongle) and its management platform may need to be addressed. Current security design and practices are acceptable for the early stage and small scale of Oregon's RUC deployment. As the RUC programs mature, security issues pertaining to vehicle data access controls, position spoofability, smartphone security, and detection of system misbehavior may need to be addressed.

Currently, in-house technology is developed and implemented within ODOT's Transportation Application Development methodology, which follows a strict process of system architecture mapping and ODOT review of the system requirements and implementation. The ODOT Security Unit reviews each system for potential vulnerabilities. Third-party technology used in the RUC program undergoes a certification process that involves testing and approving the technology before it is implemented. The ODOT Security Unit also reviews and approves the technology if it interfaces with any ODOT system. As part of maintaining reliable and secure technology, the RUC payer compliance mechanisms identified in the project will follow ODOT security guidelines if any new system requirements are implemented.

Relevant Activity: Account Manager Compliance

As part of this activity, ODOT 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 personally identifiable information) in transit and at rest, authentication between systems prior to transmitting data, and quality controlled data validations in each subsystem.

Key Finding: **While security requirements in the Oregon pilot are commensurate with the early status of the deployment interfaces, there is room for enhancement, particularly for a full-scale mandatory RUC program.**

Compatibility with Low-Technology Option

Currently, the OReGO system does not have the option for manual reporting by users. However, the system has flexibility to allow manual reporting as a future option. Oregon has created a framework and a plan for understanding what must be done for a manual reporting option as part of a live demonstration.

For the mileage-data-collection technologies currently in use in the OReGO pilot, certain vehicles do not meet the criteria to use an MRD for one of the following reasons:

- Vehicles manufactured before 1996 may not have an OBD-II port
- Diesel vehicles manufactured before 2006 may not have standardized OBD-II ports
- Electric vehicles are not required to follow OBD standards; therefore, some electric vehicles are not compatible with the MRD
- Prior to 2014, not all vehicles report the vehicle identification number

ODOT recognizes that, as the RUC program continues to grow, the program must research new technologies to ensure all target vehicles can participate and to provide more options in the RUC market. The OReGO program will solicit current commercial account managers to analyze the feasibility of additional mileage-reporting technologies, which could allow more vehicles in the program and provide more choice to the public.

Relevant Activity: Manual Reporting

For Phase I, Oregon worked to understand what would be required to implement a manual reporting option within the framework of its existing program. The options to participants available to date require the use of technologies (i.e., an OBD-II port, a smartphone, or a computer) for account access. A purely manual option would be necessary in a mandatory system due to the portion of Oregon's population that have vehicles without OBD-II ports, smartphones, or computers.

For the 2016 funding activities, the manual reporting option was not tested as part of the live demonstration due to financial constraints, difficulties integrating into the current pilot without significant efforts, and the potential for customer confusion. In place of a live demonstration, the OReGO team conducted a tabletop demonstration of the manual reporting option to provide an understanding of what would be necessary for it to succeed. The general approach was to use third-party vendors to record participant mileage and communicate it to the program.

As part of this task, ODOT conducted a quantitative assessment of the feasibility and fiscal impacts of such an option on the program. The assessment determined that conducting a pilot for manual reporting in the current OReGO program environment would not be feasible, as volunteers may confuse the option with a data sharing pilot that is set to be implemented around the same time.

Key Finding: **The general OReGO system framework would allow options for reporting mileage, including a manual reporting option, to be added. While ODOT did not implement a manual reporting option in its live program, the final report on the FY2016 STSFA funded program acknowledged the importance of manual reporting in a mandatory system and outlined a plan for its eventual testing.**

Interoperability

System's Ability to Interact and Exchange Information across Multiple Jurisdictions

The Phase I project explored RUC interoperability with other States by starting a conversation through an RUC forum. ODOT hosted a forum that included policy advisors, tax administrators, consultants, vendors, and representatives from all States interested in alternative transportation funding solutions. ODOT, with co-sponsors RUC West and the American Association of Motor Vehicle Administrators, held the RUC forum September 18–20, 2017, in Salem, Oregon, with over 140 representatives from 16 States and six countries in attendance. In addition to interoperability, the forum discussed privacy protection, reliability and security of technology, market-based congestion mitigation, decreased administrative costs, and the ability to audit and enforce.

The forum explored opportunities and challenges related to technical interoperability:

- Opportunities: The forum evaluated the evolution of RUC between jurisdictions, public and private markets, and technologies, and included the following key considerations:
  - Open architecture: Allows for multiple entities and systems to interoperate and evolve over time, independently
  - Concept of operations and system requirements: Enables flexibility for evolving needs of RUC entities and technological advances
  - Common administrative system: Enables RUC entities to seamlessly interoperate and handle evolving business needs (i.e., exchange of funds, data validation, compliance, etc.)

- Challenges: The forum explored challenges associated with implementing an interoperable RUC program and those related to connected and autonomous vehicle technology. Topics of discussion included how different jurisdictions handle public funds, vehicle transfers, and outsourced functions. Strategies to best position jurisdictions for success and the need for a common standard for telematics was also discussed, as was the potential intersection of these technologies with RUC policy and infrastructure needs.

ODOT's Phase I efforts did not specifically include a demonstration of interoperability. However, ODOT did participate in Washington State Transportation Commission's testing of interoperability between the States of Washington and Oregon. Enhancing interoperability was also a motivation for ODOT's Phase I efforts with developing, testing, and implementing additional technologies for the existing OReGO program.

Key Finding: **ODOT's efforts with developing, testing, and implementing additional technologies for the existing OReGO program, particularly those used in the Washington and California pilots, is an attempt to increase interoperability opportunities.**

System Costs

Several activities conducted as part of Phase I included proposed actions that address system costs, as detailed below.

Understanding the Full Spectrum of Investment Costs

Phase I did not involve a detailed exploration of administration costs. Given the voluntary nature of the OReGO program and the small number of vehicles that can participate, it is difficult to achieve economies of scale that drive down costs. It would also be inaccurate to extrapolate the program administration costs of the voluntary program to that of a full-scale mandatory RUC system without adequate adjustments.

The OReGO program collects relatively small amounts of revenue from a small number of drivers. The account manager aggregates these small amounts and remits the tax on behalf of those drivers. In a full-fledged mandated RUC program, small amounts of revenue will be collected from a large number of drivers. The current fee-collection approach can help mitigate some of the inherent inefficiencies of the RUC approach by providing larger economies of scale, and thus a lower overall collection cost as compared to a smaller pilot. However, to implement a mandatory RUC program, a full-fledged operational cost analysis would be required to determine the areas of potential inefficiencies.

Relevant Activity: Market Cycle Evaluation

As part of this activity, ODOT streamlined the certification process for account managers by redesigning documents to create cohesiveness and clarity, aligning system requirements with commonly applicable standards where possible, eliminating duplicate phases in the certification process, and better defining the overall certification process for staff training. Oregon also conducted a live recertification of an active account manager to better understand the effort needed to complete the process. Additionally, ODOT defined the process for account manager exit from the market as including development of an audit plan, a participant transition strategy that included a communication plan, and a settlement agreement template. The business requirements for a potential future implementation were also documented.

The best practices that emerged from this task that can contribute to lowering administrative costs include the following:

- Identifying allocations of projects and systems between the agency and account managers and developing a market exit procedure can reduce overheads. Market exit procedures can help streamline the exit of a specific private entity serving as the account manager from the RUC market, as and when the need arises. This can help lower agency administrative costs for managing related processes.
- Clarifying business requirements can help implementation outcomes align with the program intent.

- Optimizing the certification process to combine steps where appropriate and providing robust training to evaluation staff can streamline evaluation procedures.
- Establishing an ongoing certification process and conducting periodic compliance checks for account managers supports continued compliance.
- Aligning program requirements with commonly applicable standards, such as typical audit requirements, or State procurement laws and policies can help reduce barriers to market entry.

Key Finding: **Although a full-scale program cost estimate was not part of the Phase I effort, several tasks were focused on identifying ways to improve efficiency within the program to reduce cost. This included the option for ODOT to function as an account manager, thus streamlining business operations and compliance procedures, and aligning program requirements with common standards.**

Enforcement and Compliance

Ability of Law Enforcement to Identify Travelers Who Have Evaded the System

Compliance in the RUC program is enforced in a standard method for both RUC payers and account managers. As part of Phase I, ODOT examined both payer and account manager compliance. The key results of the efforts are described below.

> "Implementing complete program enforcement is a possibility, and it is easy to identify strict rules and policies to collect revenue and enforce penalties. There is a line that needs to be drawn regarding compliance and enforcement and fiscal impact on the program. There is a possibility that implementing particular compliance and enforcement mechanisms could cost more than the program revenue it generates. It is important to find a balance and make sure that the compliance and enforcement policies are fiscally realistic."
>
> ~ODOT, RUC Payer Compliance Evaluation

Relevant Activity: Payer Compliance and Enforcement

ODOT undertook RUC payer compliance to investigate all possible enforcement and compliance options for a mandatory RUC program. The key takeaway of this exercise was that, although implementing complete program enforcement is a possibility, the agency needs to make a tradeoff between the cost of the enforcement and the marginal revenue it generates.

ODOT's research team proposed the following best practices:

- Confirm compliance partnerships before considering options.
- Develop future program requirements and map out processes regarding a mandatory tax program, while keeping in mind that potential options would need to be approved by the legislature.
- Identify challenges to RUC payer compliance, such as vehicle transfer, sales, ownership types, fleets, and tax exempt status.
- Develop program penalties at the right level. It is easy to identify strict rules and policies to collect revenue and enforce penalties, but cost of enforcement needs to be considered.

Relevant Activity: Account Manager Compliance

Through the Account Manager Compliance project, OReGO evaluated current compliance and enforcement policies and identified potential gaps in the existing system. The resulting research paper and options analysis (*Account Manager Compliance Evaluation*) guided revisions to existing policies, processes, and contracts that can be made to enhance account manager compliance.[7] It also provided guidance and recommendations to policy makers regarding RUC program compliance and enforcement options for account managers.

Lessons learned through this effort include the following:

- Account manager certification requirements, especially those designed to ensure steady program function, should not be waived.
- Operation and test environments should be separate. Separate test and production systems help mitigate the risk of data crossover and general confusion during testing processes and ensure higher system reliability (uptime).
- It is beneficial to have internal stakeholders as testers.
- Service-level agreements should include clear and concise requirements, including the description of penalties for non-compliance.

USER-ORIENTED PARAMETERS

User Privacy

Perceived and Real

Real and perceived privacy are important factors in an RUC program. 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.[8]

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.

While not noted in the Oregon pilot, a future challenge for RUC systems, in general, may be the management of participants' privacy expectations when users migrate between account managers and when operating within different States. Participants may confuse what information 'must' be

[7] Oregon Department of Transportation, *Account Manager Compliance Evaluation*, 2016 OReGO FAST Act Grant (2018).

[8] Oregon Department of Transportation, *Market Cycle Evaluation*, 2016 OReGO FAST Act Grant (2018).

collected in their State's RUC system with what information 'is' collected by their account manager. Potential confusion in this area may lead to perceived privacy breaches when an unaware participant confuses a State's data collection privacy policy with that of their commercial account manager. States that implement RUC systems must be prepared to address and clarify potential privacy misunderstandings between the account manager and State RUC systems elements.

Data/Privacy management and data security in the MRD. Secure data management practices are necessary to ensure driver privacy and address the means by which system components, such as the dongle and centralized collection systems, collect, retain, wipe, store, and transmit data.

To reduce the exposure of driver location data in the event of a component or account manager server compromise, the Oregon pilot instituted a policy limiting retention of raw mileage and location data to a maximum of 30 days. Additionally, data-at-rest and data-in-transit encryption were employed to protect the data storage and collection processes with respect to the dongle. In practice, only secure data-management approaches that fully address device endpoint data treatment with respect to instituted privacy policies can ensure privacy. For example, good privacy practices suggest shorter retention periods for raw driver location data, but this is at odds with both the limitations on connectivity and expected frequency of data upload, and the need to ensure a driver's mileage results can be audited if questioned. Unless mechanisms other than recalculation of stored raw data are employed, the need to retain the auditable raw data for sufficient periods of time may negatively impact user privacy. Likewise, unless telematics systems and dongles provide frequent opportunities to upload mileage data, longer data retention periods associated with increased driver privacy risks may be necessary.

Privacy considerations with respect to the RUC mileage measurement methods identified in the Oregon pilot are discussed below.

Vehicle telematics. The vehicle telematics mileage-collection approach implements a dongle device connected to the vehicle's OBD-II port. The OBD-II port is typically located underneath the steering column and is used for diagnostics-related activities. Raw data, such as distance traveled (based on the integrated wheel rotation rate), is collected from the OBD-II port, stored on the dongle, and periodically uploaded to the commercial account manager for processing. Distance-traveled information may be correlated to GPS location as a function of time to allow determination of whether the miles were driven in-State (Oregon) versus out-of-State. GPS data are collected via a GPS receiver directly on the dongle, although they may be collected from another connected source.

Privacy of the vehicle telematics approach is similar to other vehicle telematics and connected vehicle systems, which depend principally on security of the MRD. In particular, the privacy and security of the MRD will depend primarily upon the following considerations: (1) physical security and overall resistance and appropriate responses to tampering, (2) use of strong cryptography, (3) employment of good, overall cryptographic hygiene and cryptographic key management, and (4) security protections and access control for MRD data.

The ODOT deployment used a commercial dongle that is used in a variety of fleet management systems. While product literature claims certain security properties of the dongle, detailed specifications and security testing were not provided and were generally out of scope of the evaluation. The assessment of the dongle's security, therefore, must be made with respect to the

use of dongles in general, and the potential vulnerabilities they may introduce alone and in conjunction with the vehicle's telematics interfaces.

Security requirements imposed on the dongle (i.e., use of encryption and implementation of basic physical security) were high-level but adequate for a pilot exercise. These requirements would leave substantial security hardness gaps in Statewide or national RUC deployments. Future RUC implementations face a significant challenge of standardizing the security of plug-in MRDs.

Dongle-type MRDs may be physically or logically attacked to obtain privacy-related data. Tamper detection and response mechanisms (e.g., notification, cryptographic key zeroization, etc.) need to be specified to prevent the disclosure of privacy-protected driver data such as historical location data. For example, future standards will need to address the assurance levels, use, and integration of the hardware security module or secure element cryptographic modules whose purpose it is to protect cryptographic keys from unauthorized use, modification, and disclosure. Without minimal mandates for hardware-based protections, the use of cryptography provides little or no benefit.

OBD-II connectivity of the MRD dongle to the vehicle's telematics system. The dongle-type MRD connects to the vehicle's OBD-II port, which is a common electronic interface to vehicles that originated in the 1990s, but was not engineered with security in mind. A man-in-the-middle attack on the OBD-II interface can easily compromise the integrity of distance-traveled information, but it will not provide driver location data unless the GPS location is also obtained from the in-vehicle network out of the OBD-II port.

In the Oregon pilot, driver GPS location data are provided by the dongle's own GPS receiver versus the vehicle telematics system. In other words, the dongle's insecure OBD-II interface to the vehicle is unlikely, by itself, to reduce driver privacy, as vehicle telematics data are not accessible through the OBD-II port. The automotive industry is subject to nearly unlimited, access-control-related cyberattacks targeting the OBD-II port, and attempts to game future RUC systems may leverage these interfaces.

Smartphone with beacon. The smartphone with beacon approach poses additional privacy concerns with respect to how drivers' smartphones may be correlated to the vehicle being driven.

The greatest challenge in this mileage-collection approach is how to correlate a given smartphone to a specific vehicle's mileage. The smartphone reports location and mileage data based on GPS tracks. However, unless the phone is attached to the correct vehicle, there is a risk of collecting and taxing mileage for a vehicle that may not have driven the reported mileage. Approaches exist to correlate a smartphone with a vehicle, the easiest being a Bluetooth beacon with a range of approximately 15 ft. If a State such as Oregon formalizes this approach and uses it at scale, it may require a mandate of using Bluetooth. Such a mandate would require the driver to always have his/her vehicle's Bluetooth beacon transmitting a static Bluetooth medium access control address. This information is easily trackable to devices other than the driver's smartphone, thus the beaconed-smartphone approach potentially introduces a privacy-violating vehicle-tracking mechanism. While many vehicles already have Bluetooth technology, it is not always activated, and it is not mandated to always be activated. Note that connected vehicle technology, such as dedicated short-range communication, based on Institute of Electrical and Electronics Engineers Standard 1609—also subject to such privacy-compromising tracking—implements countermeasures (such as frequent media access control address rotation) to thwart all but the most motivated and capable vehicle trackers. A Government mandate to use a static

beaconing address for correlating miles driven to a given vehicle introduces significant privacy concerns.

Odometer. Another option for reporting mileage in the Oregon pilot is manual odometer reading, consisting of the driver taking a digital picture of the odometer at a given time interval. This approach, while generally inconvenient and resource-intensive to the driver, best preserves actual privacy over other mileage-collection approaches. In this approach, the digital photograph consists only of snapshots in time of the odometer reading. The snapshot is taken through a smartphone application and uploaded to the account manager, along with user-provided information as to where (what State) the miles were driven. In other words, location and time data provide almost no resolution needed for privacy-violating tracking of the driver/vehicle. A consideration here is that it is imposible to verify what the RUC payer is saying about where the miles were driven.

Data/Privacy management at the account manager and State RUC reporting systems. The State of Oregon does not collect raw data; rather, it only collects processed, interface-defined data associated with a vehicle's distance traveled within the State in a given time interval. The Oregon RUC participant privacy agreement indicates adequate policies regarding the type of information that the State will collect. Inspection of the electronic interfaces (Application Programming Interface) confirm this. Raw data collection is performed by the account manager and is, therefore, differentiated from the State's RUC system.

Equity and Public Perception

Disparate Impacts Across Populations - Perceived and Real

ODOT defined equity using the American Institute of Certified Public Accountants' Tax Policy Concept Statement:

> Similarly situated taxpayers should be taxed similarly. This includes horizontal equity (taxpayers with equal ability to pay should pay the same amount of taxes) and vertical equity (taxpayers with a greater ability to pay should pay more taxes). Note: Equity is best measured by considering a range of taxes paid, not by looking just at a single tax.[9]

Relevant Activity: Focus Groups

As part of the Phase I activities, Oregon conducted focus groups designed to increase public awareness about RUC and OReGO. The goal of this activity was to provide information that leads to better understanding of public perception to inform decision-making. The exercise assisted with development of a Marketing and Communications Plan. These focus groups further explored:

- Differences in demographic and geographic perceptions of RUC
- Knowledge and attitudes about transportation funding
- Attitudes and underlying beliefs toward RUC
- Potential impact of RUC on specifically focus group participants

[9] American Institute of Certified Public Accountants, *Guiding Principles for Tax Equity and Fairness: A Framework for Evaluating Tax Proposals* (2017).

Focus group participants described the RUC program as unfair for a variety of reasons. While the reason for their opinions may not be clear, it is useful to understand how the public may view the implementation of an RUC program. Common points raised during participant feedback are provided below:

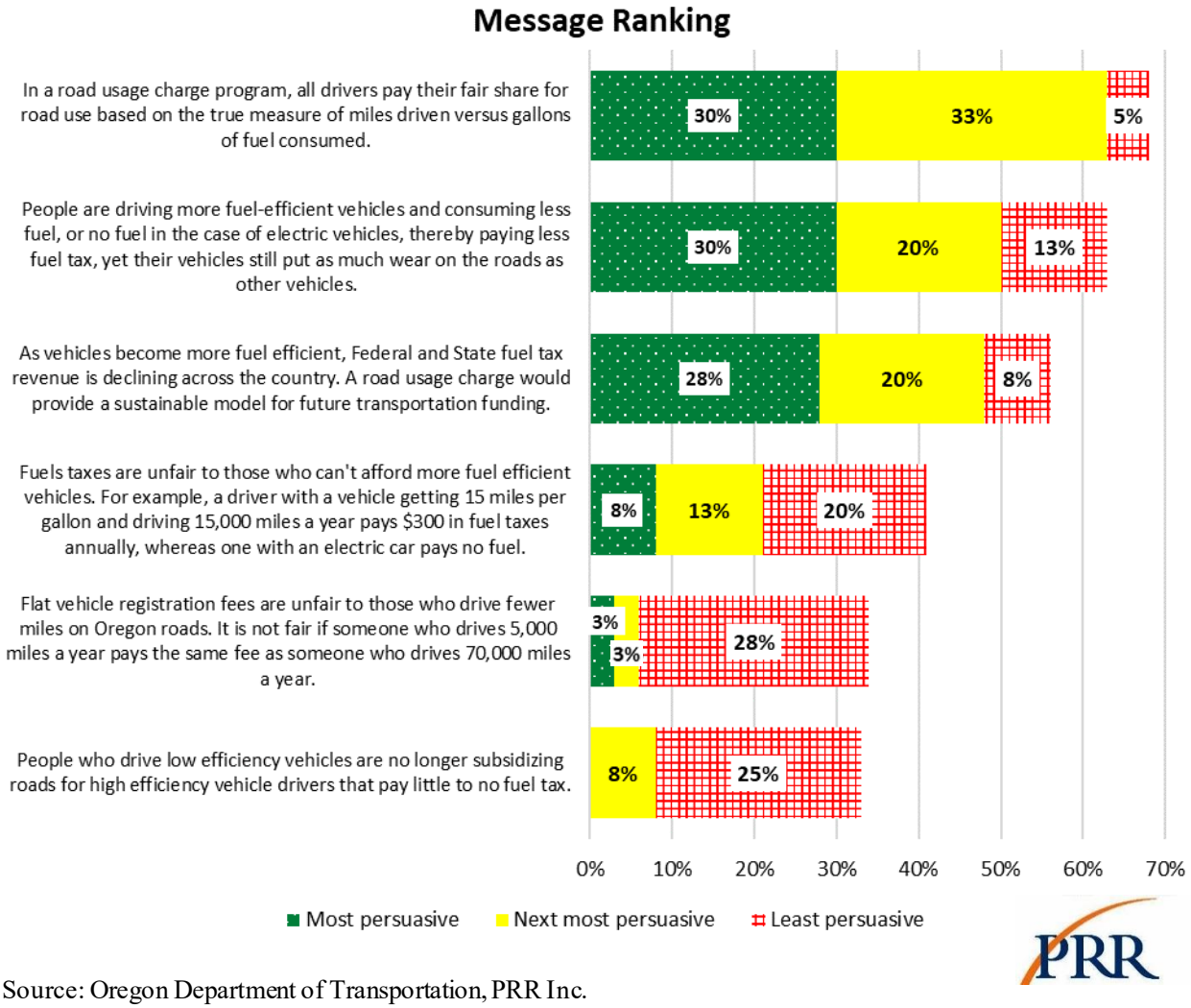
- An RUC amounts to a disadvantage to owning and driving electric and high fuel efficiency vehicles and results in "being penalized to do the right thing." This policy would lead to negative environmental impact.
- RUC would be unfair for low-income drivers.
- RUC will increase costs for transit agencies, which would pass that increased cost on to passengers.
- An RUC program could give a refund to drivers of gas guzzlers. The State refunds these drivers the difference between the RUC charges and gasoline taxes that they would have otherwise paid.

In addition to the above focus group activities, the key aspects pertaining to equity as part of this task included the following:

- Focus group participants used the online calculator to compare what they pay in fuel tax to what they would pay in RUC. All participants came to the conclusion that those who pay more would pay just a little more and those who pay less would pay just a little less. The electric/hybrid focus group, however, maintained their opposition to the RUC concept on the grounds that an RUC dis-incentivized the purchase of low-emission vehicles.
- Having participants rank the messaging that was effective in increasing support for RUC showed that the more persuasive messages were as follows (see Figure 5):
  - In an RUC program, all drivers pay their fair share for road use based on the true measure of miles driven versus fuel consumed.
  - People are driving more fuel-efficient vehicles and consuming less fuel, or no fuel in the case of electric vehicles, thereby paying less fuel tax, yet their vehicles still put as much wear on the roads as other vehicles.
  - As vehicles are becoming more fuel-efficient, Federal and State fuel tax revenue is declining across the country. An RUC would provide a sustainable model for future transportation funding.

Support for OReGO was assessed before and after the discussion of benefits and concerns with OReGO. The support remained unchanged.

Message Testing. Statements about all drivers paying their fair share and the need for a sustainable source of transportation funding were considered more effective in increasing support for road usage charge.



Source: Oregon Department of Transportation, PRR Inc.

Figure 5. Chart. Messages considered most effective in increasing support for road usage charging during Oregon Department of Transportation's focus group.

Relevant Activity: Road Usage Charge Payer Compliance

Through the RUC payer compliance task, ODOT discovered that providing an option that allows qualifying delinquent accounts to make payment through a public service option could be one way to enhance the program's equity for financially disadvantaged populations.

Key Finding: **Determining both the actual burden of RUC on different households and the perceived fairness of the approach will be key to the long-term success and wider adoption of the voluntary RUC program.**

CHAPTER 5. SUMMARY AND IMPLICATIONS FOR NATIONAL IMPLEMENTATION

Oregon Department of Transportation (ODOT) has been running a voluntary, alternative revenue collection program since July 2015. After completing STSFA Phase I activities, ODOT recognized the need to decouple an RUC approach from specific technology solutions. As part of exploring new technologies, ODOT began investigating the opportunities presented by emerging technologies, such as connected vehicle technology and, specifically, vehicle-to-infrastructure communication that can potentially allow vehicles to transmit large amounts of data. A major focus of these efforts was to evaluate the role of such technology in transportation funding applications.

Oregon's key findings of their Phase I efforts in accordance with relevant STSFA evaluation criteria are summarized below:

- **Technology options:** Providing a range of technology options for mileage reporting is critical for program success. Oregon tested onboard telematics, dashboard image capture, data exchange, and paired smartphone and beacon options as part of this project. The key findings in relation to the new technologies tested are:
  - Some of the new or emerging candidate technologies are not sufficiently mature for immediate adoption for RUC assessment: The ODOT pilot tested new technologies, specifically, cell phone and beacon pairing, cell phone imagery of odometer, and vehicle telematics data. The pilot demonstrated that these new technologies have inadequacies. The first two technologies (cell phone and beacon pairing and cell phone imagery of odometer) resulted in poor user experience and inconsistencies in captured data. The telematics approach is reliable and simple, but is currently not available in all automobiles on the road and will need time to mature.
  - Manual reporting options will be important in a mandatory system but are likely to be costly to implement: The general framework of the OReGO system allows for reporting mileage options to be added, including a manual reporting option. While the manual reporting option was not tested as a live demonstration during Phase I of STSFA, ODOT has recognized the need for manual reporting within a mandatory system and developed a plan for the eventual testing of the manual option. The paper option in manual reporting, however, is expected to have high implementation and enforcement costs. When implemented program-wide, economies of scale could potentially make this option viable. Using third-party vendors for physically verifying mileage could also help contain costs.

- **Data security and accuracy:** Secure and interoperable vehicle telematics access capabilities are essential for realizing end-to-end data security and privacy. While security requirements in the Oregon pilot are commensurate with the objectives of typical pilots, there is room for enhancement, particularly for a full-scale mandatory RUC program. Ease of use should be balanced with system reliability and ability to game the system. For instance, smartphone-related technology may appear to be the easiest to use given the ubiquity of smartphones. However, there are several challenges with this technology. Smartphone applications require a vehicle-specific component so that person

miles traveled outside of the specific vehicle (i.e., in another vehicle or on another mode within the jurisdiction, or inter-jurisdictionally) are not attributed to the respective vehicle. ODOT tested a vehicle-mounted beacon to provide this functionality; early testing results show that a beacon-like device that communicates with the smartphone application from within a specific vehicle is susceptible to interference from other, nearby vehicles.

- **Multi-jurisdictional interoperability:** ODOT's efforts to develop, test, and implement additional technologies for the existing OReGO program, consistent with those used in the Washington and California pilots, attempt to increase interoperability opportunities. The RUC Forum in 2017 explored such opportunities.

- **System cost:** Although a full-scale program cost estimate was not part of the Phase I effort, several tasks identified efficiencies that could result in cost reductions relative to the current program:
  - The deploying agency may be able to serve as the account manager. For this to occur, business processes should be established based on the agency's objectives. Sound documentation of business processes is essential.
  - Significant savings could be realized for account manager certification efforts by streamlining business operations and aligning program requirements with existing standards. The results of process analysis tasks found potential increases to revenue through a reduction in tax evasion, and improved business efficiency of new compliance procedures.

- **Enforcement and compliance mechanisms:** Although implementing complete program enforcement is a possibility, the agency needs to make a tradeoff between the cost of the enforcement and compliance aspects and the marginal revenue generated by more stringent enforcement.

- **Equity and fairness:** Determining both the actual burden of RUC on different households and the perceived fairness of the approach are key to the long-term success and wider adoption of a voluntary RUC program. The key issues with RUC, as identified by the focus groups, follow:
  - Several focus group participants questioned why vehicles with poor fuel economy should get a refund. They contended that a fee amounted to an economic disadvantage to owning and driving electric and high fuel efficiency vehicles (i.e., "being penalized to do the right thing") and would lead to negative environmental impact.
  - Some focus group participants also contended that RUC would be unfair for low-income drivers although they did not provide any reasoning for the belief.

BIBLIOGRAPHY

Dr. B. Starr McMullen, Dr., Haizhong Wang, Oregon Department of Transportation. April 2016. *Road Usage Charge Economic Analysis.* Final Report SPR 774.

Oregon Department of Transportation. 2017. *Oregon's Road Usage Charge*: *The OreGO Program Final Report.*

2017 ISO Oregon's *Statewide Information Security Standards.* March 2017.

Oregon Department of Transportation. *ODOT RUC Program Enhancements, Evaluation Plan Summary*.

Oregon Department of Transportation. *ODOT RUC Program Enhancements to Improve Functionality, Public Acceptance, and Interoperability*. 2016.

Oregon Department of Transportation, *Market Cycle Evaluation*, 2016 OReGO FAST Act Grant, 2018.

Oregon Department of Transportation, *Manual Reporting Evaluation*, 2016 OReGO FAST Act Grant, 2018.

Oregon Department of Transportation, *New Technologies Evaluation*, 2016 OReGO FAST Act Grant, 2018.

Oregon Department of Transportation, *Annual Report to the Secretary*, 2016 OReGO FAST Act Grant Fiscal Year 2016, December 2017.

Oregon Department of Transportation, *Account Manager Compliance Evaluation*, 2016 OReGO FAST Act Grant, 2018.

Oregon Department of Transportation, *RUC Payer Compliance Evaluation*, 2016 OReGO FAST Act Grant, 2018.

Oregon Department of Transportation, *RUC Forum Evaluation*, 2016 OReGO FAST Act Grant, 2018.

Oregon Department of Transportation, *RUC Payer Compliance Research Paper*, 2016 OReGO FAST Act Grant, 2018.

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

Office of Operations Web Site
https://ops.fhwa.dot.gov/

August 2022

FHWA-HOP-19-043