FINAL REPORT

MINNESOTA DISTANCE-BASED FEES PROJECT

August 2022

DEPARTMENT OF TRANSPORTATION

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16. Abstract

Minnesota, like many states, is exploring transportation funding alternatives to the fuel tax. Building upon previous work, the Minnesota Department of Transportation (MnDOT) demonstrated the use of fleet-based in-vehicle telematics as a mechanism for collecting and reporting travel data for the assessment of a distance-based fee (DBF). MnDOT partnered with two shared mobility providers offering car-sharing services as well as a connected and automated vehicle (CAV) research partner. The demonstration showed that the information necessary for DBF assessment can be accurately and reliably collected from telematics and CAV systems and that collection costs for DBF and usage-based fee systems overall may be lowered by using fleet-based assessment models. The project was funded with a grant from the Federal Highway Administration's (FHWA) Surface Transportation System Funding Alternative (STSFA) grant program, along with matching funds from the State of Minnesota.

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August 1, 2022

Greetings,

Minnesota recognizes that declining revenues due to increasing vehicle efficiencies are a challenge that must be addressed. Road use fees, based on distance traveled, are fundamentally fair and may one day replace the motor fuel tax or the surcharge on electric vehicle registrations.

With that challenge and favorable advances in vehicle technology, the Minnesota Department of Transportation (MnDOT) is pleased to provide this Final Report on the Minnesota Distance-Based Fees (DBF) Demonstration. This forward-looking project tested the notion of using vehicle-embedded telematics to fairly and accurately collect the data to enable charging road use fees by the miles traveled, rather than the consumption of fuel.

States have been researching and piloting the concept of distance-based fees in the U.S. for over two decades. Minnesota's Demonstration has broken new ground in the quest for an efficient, secure, and scalable alternative-fee collection mechanism.

Unique accomplishments of the project include the following:

- Assessed distance-based fees in partnership with shared-mobility providers using embedded telematics
- Captured vehicle and mileage data without installation of aftermarket technology
- Tested Connected/Automated Vehicle (CAV) telematics to report lane differentiation and occupancy
- Simulated both state and federal per-mile rates equivalent to the motor fuel tax
- Developed a rate-setting framework that considers a host of parameters to address project goals as well as social and environmental objectives
- Audited the collections and fee dissemination process to the satisfaction of the Minnesota Department of Revenue

The work of the MnDOT Project Team and our consultants at the Humphrey School of Public Affairs at the University of Minnesota, and WSP USA, is greatly appreciated by agency leadership and State and local government partners. Their research, insights, and project management skills enabled this work to be completed under the challenges presented by COVID-19.

We especially value the contributions of the shared-mobility providers at HOURCAR and Zipcar, and our CAV partner, VSI. The project specifically used the car-share model because it best exemplifies how embedded telematics, now being factory installed by most manufacturers, can enable a host of functions including vehicle maintenance, safety, and performance monitoring. We also now know that, like our research team, manufacturers envision the use of that data for road charging purposes.

The project was also guided by the DBF Technical Advisory Committee, which was established to provide guidance on policy and technical issues to the Project Team and to be an informed constituency in DBF discussions with the public and policy makers. Their contributions added greatly to the integrity of this work.

If you have comments or questions about this work, please visit the Project website at https://dbf.dot.state.mn.us/.

Sincerely,

Nancy Daubenberger

Nancy Daubenberger
Commissioner, Minnesota Department of Transportation

TERMS AND ABBREVIATIONS

ACRONYM OR ABBREVIATION	DEFINITION
AES	Advanced Encryption Standard
AV	Automated Vehicle
BRD	Business Requirements Document
CAN	Controller Area Network
CAV	Connected/Automated Vehicle
CAV Research Partner	The CAV Research Partner (VSI Labs) responsible for CAV operations across the Project
ConOps	Concept of Operations
COVID-19	A new coronavirus emerged in cases first reported in late 2019. It causes a respiratory illness now called COVID-19, which stands for coronavirus disease 2019. The ongoing pandemic has negatively affected the economy and public health worldwide.
DBF	Distance-Based Fee
Demonstration	The live operations during Phase 1 and Phase 2 within the overall Project
EV	Electric Vehicle
E-ZPass	A managed lanes system on Minnesota highways
The Project	The MnDOT DBF Project
FAST Act	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GenTax	Tax Management Software used by the Minnesota Department of Revenue
GPS	Global Positioning System
HOT Lane	High-Occupancy Toll Lane
HTTP	Hypertext Transfer Protocol
Humphrey School	The Humphrey School of Public Affairs at the University of Minnesota
HUTDF	Highway Users Tax Distribution Fund
ICD	Interface Control Document
ImpPlan	Implementation Plan
ITS	Intelligent Transportation Systems
MBUF	Mileage-Based User Fee
MN	Minnesota
MN Department of Revenue	Minnesota Department of Revenue
MnDOT	Minnesota Department of Transportation
OBD-II	Onboard Diagnostics II
PCI	Payment Card Industry
Phase 1	Phase 1 – Proof-of-Concept
Phase 2	Phase 2 – Demonstration
PII	Personally Identifiable Information

PPP	Public-Private Partnership
Project	The Minnesota Distance-Based Fees Project
Project Team	The group of organizations that implemented the Project
Revenue Report	A monthly report submitted to the State aggregating and summarizing total miles driven, fuel purchases, average fuel efficiency, and simulated distance-based fees for participating vehicles
RUC	Road Usage Charge
SM	Shared Mobility
SM Provider(s)	The Shared Mobility business partners (HOURCAR and Zipcar) responsible for SM operations across the Project
SRS	System Requirements Specifications
SSL	Secure Sockets Layer
Stage 1	Stage 1 – No Formal Reporting
Stage 2	Stage 2 – Initial Revenue Reporting
Stage 3	Stage 3 – Final Revenue Reporting
State	State of Minnesota
STSFA Program	Surface Transportation System Funding Alternative Program
TAC	Technical Advisory Committee
U.S.	United States
VCRI	Verification Cross Reference Index
VMT	Vehicle Miles Traveled

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EXECUTIVE SUMMARY

Minnesota, like many U.S. states, is exploring usage-based funding alternatives like distance-based fees (DBF) to replace declining motor fuel tax revenues. The motor fuel tax (MFT) has long been a major source of highway revenue in the U.S. but is projected to decline as gas-powered motor vehicles become much more efficient, thus generating less revenue for each vehicle mile of travel. Furthermore, the nation and the world are pivoting away from Internal Combustion Engine (ICE) technology and toward electric vehicles (EV), which use no motor fuels and thus generate no MFT revenue.

If implemented in the future, road use fees may at least partially help to address funding challenges by ensuring vehicles pay for roads based on actual travel, not fuel consumption. Although they are more complex to assess, the data needed for DBF can be obtained through simple odometer readings, aftermarket devices, smartphones, or, most recently, directly from vehicle telematics. Importantly, road use fees align with the "user pays" principle embodied in the motor fuel tax. Challenging technology issues remain, however, such as evasion, protection of personally identifiable information (PII), cost of administration, and scalability.

The Minnesota Department of Transportation (MnDOT) was among the first to begin exploring usage-based funding alternatives. In 2011, MnDOT conducted the Minnesota Road Use Test. This initial pilot relied on over five hundred participants using special global positioning system (GPS)-equipped smartphones to collect travel data and assess the road use fee. While the pilot was successful, it illustrated some of the limitations of using aftermarket devices for the collection and communication of road usage data. One conclusion was that onboard embedded technology (factory installed telematics) should be tested to enhance efficiency in administration and fee collections. To test this notion, absent the cooperation of vehicle manufacturers, MnDOT designed a road use charge pilot that leveraged fleet-based shared mobility (SM) services which already employed telematics in their business models.

In developing and designing the pilot, MnDOT considered the following DBF goals and objectives:

- **Fairness** – Ensure all road users subject to a DBF pay a fair share for their use of the roads.
- **Public Acceptance** – A DBF should be viewed as a solution with more travelers supporting it.
- **Familiarity** – Maintain the MFT systems to help with familiarity and revenue recognition.
- **Privacy Protection** – Stringent security protocols must protect personal information.
- **Ease of Payment and Collection** – A system with low administration costs that uses existing technology.
- **Transparency** – Use and fee data readily accessible as needed.
- **Low Evasion Rates** – Vehicle-embedded telematics and encrypted transmission ensures low avoidance.
- **Scalability** – DBFs incrementally implemented as data collection technology is more widely available for vehicles.

The resulting Minnesota Distance-Based Fees Demonstration Project (Project), developed with two SM providers, attempted to understand how embedded telematics might be leveraged for wider application of distance-based fees (Figure 1). The Demonstration relied on carsharing services to report distanced traveled by their fleet of vehicles within Minnesota. SM Providers collected and transmitted data from their embedded telematics systems to their respective proprietary data repositories. The SM providers then processed and aggregated the road usage data to determine the associated DBF for each vehicle. That information was then transmitted in simulated Revenue Reports that were submitted to MnDOT and the MN Department of Revenue for auditing. Additionally, a Connected/Automated Vehicle (CAV) Research Partner participated in the pilot and used its unique technology to collect and report mileage. The Demonstration's functional architecture is summarized in Figure 1. The project was funded with a grant from the Federal Highway Administration's (FHWA) Surface Transportation System Funding Alternative (STSFA) program, along with matching funds from the State of Minnesota (State).

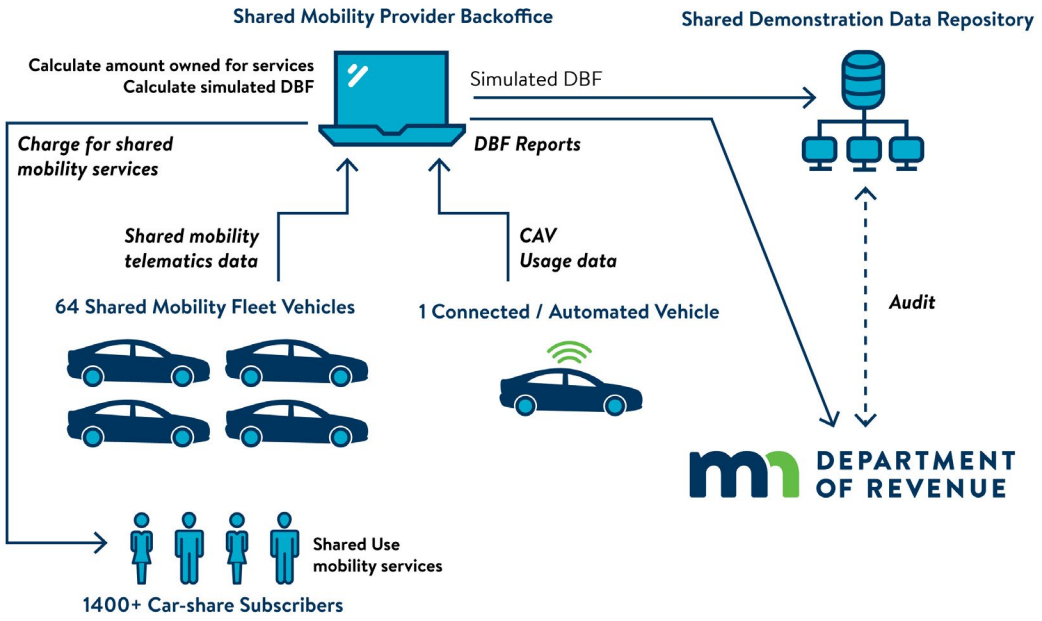

Figure 1: Minnesota Distance-Based Fees Demonstration Functional Architecture

The Project was deployed in two phases. Phase 1 took a Proof-of-Concept form, where the team designed and tested the system and performed a three-month dry run of all systems and reporting procedures. Phase 2 entailed 12 months of pilot operations with SM providers collecting road usage data, generating mock DBF invoices, and submitting reports to the State. Both phases included public communications and outreach as well as supporting research activities. Communications, research, technical specifications, and testing results are documented in separate appendices to this final report.

The Project did not require or collect any information on the individual users of the SM partner's services, and the state did not receive any location data for the SM vehicles. The SM providers were the party responsible for the fee in this model (acting as third-party account managers). The outcome of this arrangement was a reduction in the number of potential collection points, which significantly reduced administrative effort. The approach also protected personal privacy for users as no PII was collected. If such a model were implemented in the future, SM providers would collect the fee from service users as part of their existing point-of-sale processes.

In addition to the vehicles operated by the SM partners, a CAV Research Partner conducted a series of specific test cases to demonstrate the collection and transfer of data directly from a vehicle's controller area network (CAN) bus for DBF assessment. The CAV collected, aggregated, and transmitted mileage and fuel consumption information on a second-by-second basis. The CAV completed a trip to Wisconsin to test the ability of the in-vehicle systems to differentiate jurisdictional borders, which was successful. The CAV also made several trips on the I-394 E-ZPass Express Lanes to test whether the in-vehicle systems could accurately determine the lane the vehicle was travelling in and its occupancy, both of which were successfully accomplished. These are significant developments in proving DBF viability given the likely development and adoption of CAV systems for safety applications in the future as the technology for road usage charge (RUC) assessment, as well as managed lanes enforcement, will soon be standard in most new model vehicles.

Overall, a half million miles of travel was collected, processed, and invoiced in partnership with the two SM providers and the CAV Research Partner using their existing technology. The fees assessed on travel were based on an average $0.026 per mile, which accounted for both the state and federal motor fuel tax replacement costs. Testing and auditing showed that the data collected was accurate, secure, and effectively captured using embedded telematics without the need for aftermarket solutions like Onboard Diagnostics II (OBD-II) port or smartphone apps.

1. KEY FINDINGS

The design and methods of the Minnesota Distance-Based Fees Project yielded several key insights and lessons learned for the advancement of usage-based fees in Minnesota as well as the rest of the country.

Fleet-based approaches to DBF assessment are accurate and reliable. The information necessary for DBF assessment can be accurately and reliably collected from fleet-based telematics systems. The MN Department of Revenue received sufficient information to conduct an audit of assessed charges. This shows that DBF and similar systems can be implemented and operated without the need for vehicles to be equipped with aftermarket technology that can be removed or tampered with. Furthermore, the aggregation of fleet data, as opposed to collecting data from individual drivers, does not reduce the ability of the State to audit assessed charges and provides privacy to the individual users of fleet services by eliminating the need to collect PII and maintain individual user accounts.

CAV technology is likely viable as an assessment technology.
The information necessary for DBF assessments was also successfully collected from CAV systems. This is significant as future model cars are increasingly likely to have the necessary technology as a standard feature. Furthermore, next-generation traffic management applications will rely on the collection of CAV data for the provision of various roadway services such as safety. A DBF that incorporates CAV elements will therefore be able to leverage data that will be collected from the vehicle fleet as part of routine ITS offerings in the long run. Additionally, the technology deployed successfully differentiated lanes of travel and vehicle occupancy, which demonstrated their possible application within managed lanes systems. For example, a vehicle equipped with CAV systems in the future may not require a traditional toll tag or transponder to access managed lanes facilities.

Leveraging fleet-based telematics reduces complexity and improves flexibility.
Leveraging fleet SM providers' in-vehicle telematics systems eliminates the need for DBF-specific aftermarket devices to assess and collect fees. This reduces the level of effort required of vehicle owners and eliminates the risk that RUC-specific devices will need to compete for the in-vehicle diagnostic port with other devices, such as those used in usage-based insurance programs. Leveraging fleet-based telematics thus helps future proof the fee system as telematics become a standard feature in new model vehicles.

Fleet-based approaches may reduce administrative costs.
A DBF levied on fleet-based SM providers reduces the number of collection points for the State to administer, thus lowering overall system costs to the State. A total of 64 vehicles and 1,400 SM customers participated in the pilot; however, there was effectively only two primary accounts to be monitored, administered, and audited by the Project Team. Additionally, aggregated travel data from the fleet telematics systems can be audited without requiring significant effort from service providers. In subsequent interviews with the Project Team, SM partners reported that the audits were unobtrusive, with one noting they were unaware the audit had even taken place. The MN Department of Revenue reported that the information provided by the SM providers was sufficient to conduct their audit of incurred charges and that no errors were identified in submitted reports.

Fleet-based approaches can improve compliance and reduce enforcement costs.
A DBF linked to services that transportation system users already benefit from shifts the burden of compliance and enforcement to the private sector and reduces the incentives to evade the fee. In the model tested by the MnDOT team, the SM provider (as opposed to the users of their services) would be responsible for remitting the amount due for the assessed DBF. It is therefore incumbent on the provider to collect the necessary amount from their users. Much like the fuel tax, if SM providers account for the DBF in their invoicing systems, users would be unable to benefit from the service without paying the necessary DBF.

A statewide DBF could support other revenue and pricing systems.
A statewide DBF could serve as a foundation for other transportation-related fees including congestion pricing, high-occupancy toll (HOT) lanes, or local/regional fees. As noted earlier, the CAV systems tested in

the pilot were capable of differentiating lane use in addition to collecting DBF information, meaning they could be used for managed lanes operation in lieu of traditional toll tags. Additionally, the system could be configured to allow payment of other fees and taxes, essentially acting as a single platform for the payment of state and local transportation fees assessed on fleet-based service providers. The project demonstrated that incorporation with the MN Department of Revenue systems is possible, so it is likely that other transportation-related fee systems (such as those administered by departments of motor vehicles) could similarly be incorporated.

Embedded telematics, preinstalled by manufacturers in most vehicles, could be used to deploy DBF more efficiently and effectively across a range of operations and ownership scenarios.

Manufacturers have been routinely installing telematics in vehicles to monitor vehicle performance and maintenance, to update software, and for safety purposes. Data generated by the vehicle is monitored by the manufacturers and provides vehicle owners with added value and security. That data could be used to generate reports on vehicle miles of travel, which could then be used to charge DBF. Tesla is already providing that data from their vehicles to charge drivers a fee under Utah's Road Usage Charge Program.

Unique challenges remain with fleet-based DBF development implementation.

While the Project explored the contours of a new and innovative approach to distance-based fees and demonstrated several significant accomplishments, challenging questions remain. Those challenges include developing a more complete understanding of the administrative cost efficiencies that may be achievable using vehicle-embedded technology with the SM model, as well as how an embedded technology platform might be deployed under individual vehicle ownership models. Assuming the U.S. DOT would prefer to task states with collection of a federal component of distance-based fees, it is not clear how that would be executed nor how a federal motor fuel tax reconciliation or credit process would work. Additionally, significant questions remain on multi-state interoperability and how, or if, out-of-state miles would be assessed.

2. THE FUTURE OF DBF IN MINNESOTA

For DBF to truly be a scalable funding solution for Minnesota it would need to expand beyond the SM-based approach to assessment and reporting used in the Project. Ultimately, telematics data could be collected from "native" telematics systems supplied by Original Equipment Manufacturers (OEM). This represents the next step in DBF advancement and would set the stage for the evolution of DBF in Minnesota and establish a model for implementation throughout the country. Partnering with OEMs and leveraging the advanced technology likely to be embedded as a standard component in nearly all newer model vehicles will provide system flexibility for advancements in CAV technology as well as vehicle electrification; all of which use embedded telematics to convey information from vehicles to data service providers.

3. THE HUMPHREY SCHOOL OF PUBLIC AFFAIRS AT THE UNIVERSITY OF MINNESOTA

The work documented in this Minnesota Distance-Based Fees Project Final Report is supported by the work of the Humphrey School of Public Affairs at the University of Minnesota and can be found at https://dbf.dot.state.mn.us/policy-research/.

The University of Minnesota research team analyzed policy considerations and implications of DBFs on privacy, equity, and administration costs, and conducted financial analysis, outreach, and education efforts. The research team also conducted an evaluation of the Demonstration based on the administrative and political feasibility, efficiency, adequacy, and equity of DBFs. This research report also identifies challenges that must be overcome to implement DBFs and the potential to deploy this model on a broader scale.

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1. INTRODUCTION

Like many other states, Minnesota faces potential transportation funding challenges due to a confluence of several emerging trends. From a technology standpoint, an increase in vehicle fuel efficiency and a forecasted influx of electric vehicles (EV) based on the State of Minnesota's (State) goal of 20 percent EV adoption by 2030[1] could disproportionally increase wear on state and local roads and bridges relative to collected fuel tax revenues, because EVs do not pay motor fuel taxes. From an economic standpoint, a lack of consistent increases to the per-gallon state excise motor fuel tax or other revenues to keep pace with inflation could decrease purchasing power for transportation projects. Furthermore, emerging shared mobility (SM) services and Connected/Automated Vehicle (CAV) business models could impact travel behavior and thus transportation infrastructure in both beneficial and costly ways. These developments could change the way that people interact with the transportation system as well as how the Minnesota Department of Transportation (MnDOT) uses, owns, and pays for transportation infrastructure. However, these technological developments also offer benefits such as embedded technology that can safely and accurately collect, process, and share transportation-related data for use in transportation operations, planning, and finance.

In response to these emerging trends, and alongside the understanding that the motor fuel tax is likely to remain in place for years, MnDOT has taken an incremental approach to identify and implement new ways to use, own, and pay for transportation infrastructure. One of these strategies is the distance-based fee (DBF), an alternative transportation funding mechanism based on charging for actual travel, not fuel consumption. MnDOT has completed several research initiatives and demonstrations that leveraged technology innovations and facilitated this migration over the last decade. The latest of these projects was the Minnesota Distance-based Fees Demonstration Project (Project) completed in 2021. The intent of the Project was to develop and refine a pathway toward wider deployment of DBF and demonstrate how these fees can be collected efficiently and cost-effectively using reliable and secure technology already embedded in existing fleet vehicles. The Project demonstrated this sustainable transportation funding model featuring integration of DBF with SM fleets that included gasoline-powered vehicles, EVs, and CAVs. The Project achieved the following successes:

- Collecting, processing, and simulating invoices for over half a million miles of travel data using existing technology in partnership with two SM Providers and one CAV Research Partner
- Providing a positive user experience through focusing on SM providers which reduced the complexity of simulating a DBF assessment for customers and agency staff without compromising program transparency
- Demonstrating location conformance with jurisdictional boundaries showing how rate adjustments could be made based on local areas or specific boundaries
- Testing lane detection of an automated vehicle (AV) with a CAV Research Partner to determine the capability of applying rates across managed lanes

These successes are nationally significant milestones in that they are the first engagement between SM and CAV providers which produced exploratory conversations and actual learnings on how these emerging business models and technology can work with DBF systems across the United States (U.S.). This report discusses the Project from initiation to completion including the development of Project goals, design of the system, operation of the Demonstration, performance results, relevance to national efforts, and potential next steps for deploying a DBF in Minnesota.

[1] Minnesota Department of Transportation, Minnesota Pollution Control Agency, Great Plains Institute. "Accelerating Electric Vehicle Adoption: A Vision for Minnesota." 2019. https://www.dot.state.mn.us/sustainability/docs/mn-ev-vision.pdf

1.1 MINNESOTA'S SURFACE TRANSPORTATION FUNDING

The Minnesota state highway system consists of interstates, U.S. highways, state highways, county roads, and municipal roads.[2] As presented in Figure 2, funding to operate and maintain these roads is distributed through several funds including the Highway Users Tax Distribution Fund (HUTDF), which distributed more than $957 million dollars during the 2021 fiscal year.[3]

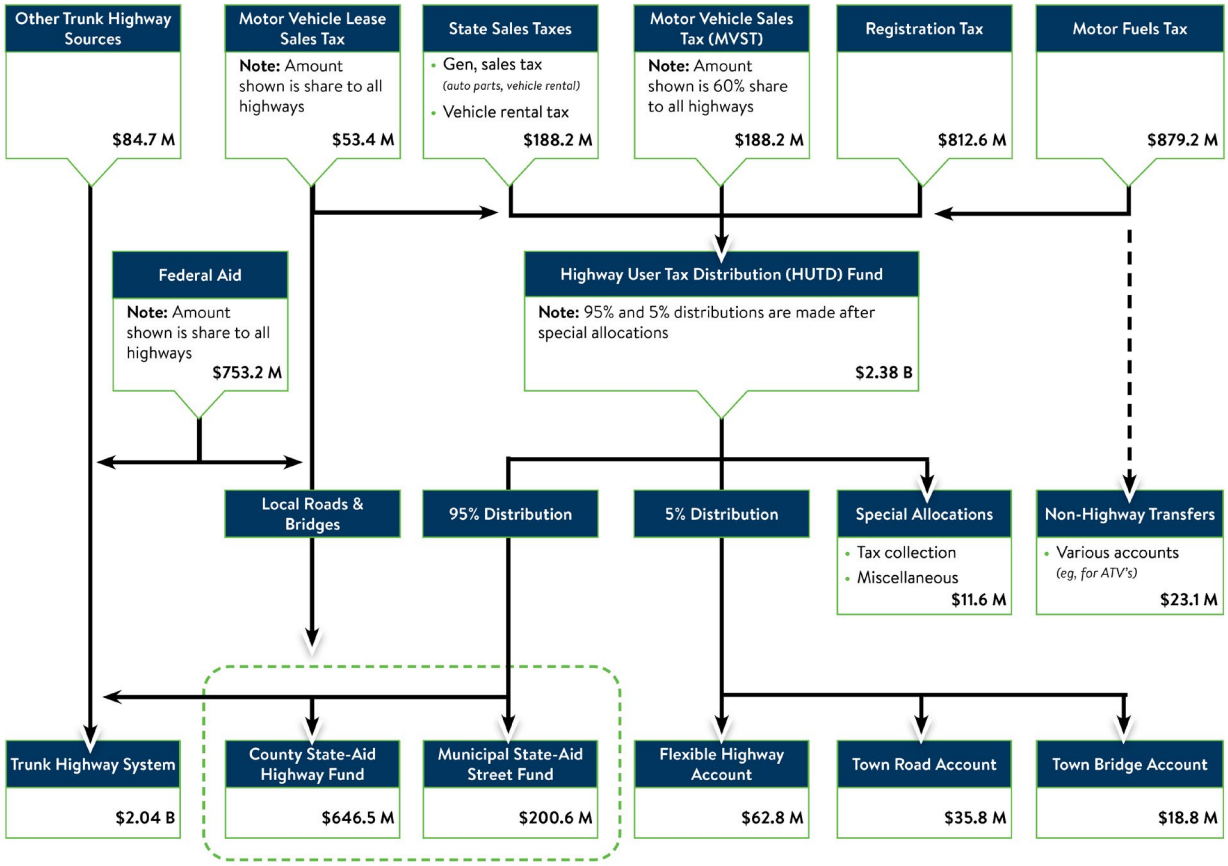


Figure 2: Overview of Minnesota Transportation Funding[4]

Revenue sources received to the HUTDF for fiscal year 2020 include the following:

- The motor fuel excise tax
- The Motor Vehicle Registration Tax (also known as Tab Fees), an annual tax based on a vehicle's value (cars, pickup trucks, vans) or weight (trucks, tractors, trailers, buses) with EVs paying a $75 surcharge
- The Motor Vehicle Sales Tax paid on the purchase price of a motor vehicle required to be registered in Minnesota
- Statutory dedication of sales tax revenue from rental vehicles and automotive repair parts
- Other revenue sources

[2] Minnesota Department of Transportation. "Roadway Data." https://www.dot.state.mn.us/roadway/data/fun-facts.html. Accessed 29 June 2021.
[3] Minnesota House Research. "Highway Finance." January 2021. https://www.house.leg.state.mn.us/hrd/pubs/hwyfin.pdf
[4] Minnesota House Research. "Highway Finance." January 2021. https://www.house.leg.state.mn.us/hrd/pubs/hwyfin.pdf

1.2 THE MOTOR FUEL TAX

One of the largest revenue sources of the HUTDF are motor fuel excise taxes. These taxes are assessed on a per-gallon basis and do not vary based on the price of the fuel being purchased. As shown in Figure 2, motor fuel taxes are collected from distributors who then pass the cost along to retailers who subsequently pass the cost along to customers who purchase fuel.[5] As such, fuel excise taxes are generally easy and efficient to collect.

These taxes are also easy to pay and are a simple experience for the customer because the tax is contained within the per-gallon cost of fuel. Motor fuel taxes must be paid to receive the fuel and the number of initial collection points is low. As such, the administrative costs of collecting the tax are relatively low, estimated to be approximately 1 percent of the revenue collected.[6]

While Minnesota understands that the motor fuel tax will likely be retained for years to come, of all the revenue sources contributing to the HUTDF, the motor fuel tax is the most likely to be affected by emerging technological, economic, and business trends. MnDOT has been exploring DBF to prepare for the future and mitigate risks associated with these trends.

1.3 WHAT IS A DBF?

A Distance-Based Fee (DBF) is a per-mile fee that a state government levies on each vehicle traveling on roadways operated by the agency. DBF's perpetuate the long-standing "user pays" policy principle, wherein those who benefit from a good or service should pay for it, that supports a fair and equitable plan to pay for infrastructure embodied in the motor fuel tax.

In seeking alternatives to fuel taxes, federal and state agencies have explored ways to implement usage-based fees for over a decade under several different names: Road usage charges (RUC), Vehicle Miles Traveled (VMT) fees, Mileage-based User Fees (MBUF), and DBF. Although the names differ, they are all fees levied per mile, per vehicle. While there are numerous ways to assess travel, no definitive method for collecting a DBF has been established. Most DBF assessment and collection methods involve a form of onboard technology to collect and transmit travel information integrated with agency back-office applications that collect other fees and taxes, as presented in Figure 3.

Technology-equipped vehicles log mileage, location, and fuel consumption.

Vehicle data is safely share with carshare provider and reviewed for accuracy.

Data is used to calculate total number of miles a vehicle travels to asses a per-mile fee.

The Minnesota Department of Revenue receives financial reports and collects charges.

Figure 3: Distance-Based Fees Collection Process

In addition to a base DBF rate, rate adjustments can be applied so that a DBF system adequately funds transportation infrastructure and achieves objectives in addition to revenue generation. Possible adjustment factors include the following:

- Vehicle weight – to account for the fact that heavier vehicles contribute more wear and tear to roadways than lighter vehicles
- Time of day and vehicle occupancy – to ease traffic congestion
- Household income and underserved populations – to ensure a fair rate for individuals given their socioeconomic status and accessibility to services
- Geography – to provide equity in rural, urban, and suburban settings
- Fuel type, engine type, and fuel efficiency – to offset environmental impacts

[5] Minnesota Department of Transportation. "Transportation Funds Forecast February 2021." 01 March 2021. https://edocs-public.dot.state.mn.us/edocs_public/DMResultSet/download?docId=12270871. Accessed 29 June 2021.

[6] Coyle, D & Baker, R, 2010, Proceedings 2010 symposium on mileage-based user fees: moving forward, 2010 Symposium on Mileage-Based User Fees: Moving Forward, Texas Transportation Institute, College Station, TX.

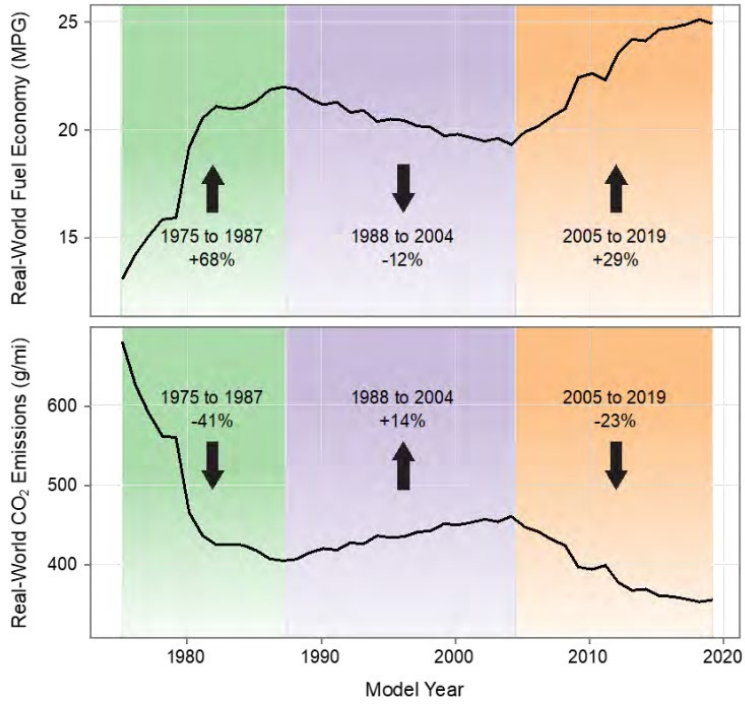
One potential rate adjustment shown above is the vehicle-weight adjustment, to account for heavier vehicles contributing more wear and tear to a roadway per mile driven relative to lighter vehicles.[7] With a vehicle-weight rate adjustment, a heavier vehicle would pay a higher rate than a lighter vehicle to ensure that each vehicle pays its fair share relative to the wear and tear they contribute to roadway infrastructure. Without such adjustments, a DBF is at risk for providing inadequate funding to maintain the transportation system.

1.4 THE NEED FOR DBF IN MINNESOTA

Minnesota's long-standing approach to transportation funding is at risk. Technological advancements in vehicular fuel efficiency, adoption of EVs and CAVs, new business models in transportation such as shared mobility, and ongoing economic trends such as inflation will all likely contribute to declines in fuel tax revenues in the long-term. This section summarizes the key trends putting Minnesota's transportation funding system at risk.

Fuel Efficiency and Electric Vehicle Trends

As presented in Figure 4, vehicle fuel economy increased by 25 percent from 2005 to 2019. With increasing fuel efficiency, vehicles can drive further on the same gallon of fuel[8] resulting in less dollars raised per mile driven. Alongside these fuel efficiency increases, EV adoption is expected to increase across Minnesota with the State setting a goal of 20 percent EV adoption by 2030.[9] In lieu of fuel taxes, EVs pay a $75 annual fee, unlike other alternative fuel-powered vehicles (such as compressed natural gas) which pay the annual $75 fee *in addition to fuel taxes as listed in* Table 1.[10]



While increasing vehicle fuel economy and the adoption of alternative fuel vehicles is a positive development for the environment and public health,[11] these trends diminish the efficacy of motor fuel tax revenue. This reduction in revenue collected per mile driven effectively reduces the funding available to operate and maintain the Minnesota transportation system (assuming no changes to the motor fuel tax are made to adjust for these fuel efficiency changes).

Figure 4: Trends in Fuel Economy and C02 Emissions since Model Year 1975[12]

[7] Comptroller General. "Excess Truck Weight: An Expensive Burden We Can No Longer Support." April 1979. http://archive.gao.gov/f0302/109884.pdf.
[8] United States Environmental Protection Agency. "The 2020 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975." January 2021. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1010U68.pdf. Accessed 01 July 2021.
[9] Minnesota Department of Transportation, Minnesota Pollution Control Agency, Great Plains Institute. "Accelerating Electric Vehicle Adoption: A Vision for Minnesota." 2019. https://www.dot.state.mn.us/sustainability/docs/mn-ev-vision.pdf.
[10] Minnesota Driver and Vehicle Services. "Motor Vehicle Fee Chart By Transaction Type." 01 September 2019. https://dps.mn.gov/divisions/dvs/forms-documents/Documents/JTF-MV-Fee-Chart.pdf.
[11] West, Jason. "Reducing greenhouse gases benefits air quality, saves live." University of North Carolina, Gillings School of Global Public Health. 23 September 2013. https://sph.unc.edu/sph-news/reducing-greenhouse-gases-benefits-air-quality-saves-lives/. Accessed 07 July 2021.
[12] United States Environmental Protection Agency. "The 2020 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975." January 2021. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1010U68.pdf. Accessed 01 July 2021.

Table 1: Current Alternative Fuel Tax Rates

FUEL	TAX RATE
Liquefied petroleum	21¢ per gallon
Liquefied natural gas	16.8¢ per gallon
Alcohol	28¢ per gallon
Compressed natural gas	0.2435¢ per cubic foot
E-85	19.8¢ per gallon
Kerosene	28¢ per gallon
Liquefied petroleum	21¢ per gallon

1.4.1 Fleet Trends

Minnesota's approach to DBF development and eventual deployment tested the use of fleet service providers as a means of assessment and collection. This anticipated reduced costs to the State by limiting the total number of collection points through shifting collection from individual drivers to their fleet providers. Importantly, it ensured the testing of fleet-embedded telematics in reducing collection costs, ensuring data security, and eliminating evasion among other benefits.

According to the U.S. Bureau of Transportation Statistics (BTS), in 2020 there were a little over 8 million vehicles within fleets out of a total of nearly 260 million registered vehicles (Table 2). Based on these numbers, about 3 percent of registered vehicles in the U.S. are associated with a fleet. Fleet-based vehicles make up an even smaller percentage of light-duty vehicles in the U.S., accounting for 1.4 percent of vehicles in 2020. Fleet-based trucks, on the other hand, account for about 35 percent of all trucks registered in the U.S. The BTS-referenced data source does not count vehicles in fleets of less than 15 vehicles as being part of a fleet.

Table 2: U.S. Vehicles Associated with Fleets

	2016	2017	2018	2019	2020
Total Registered Vehicles[13]	**268,799,083**	**272,480,899**	**273,602,100**	**276,491,174**	**275,924,442**
Light Duty Vehicles	247,644,981	250,553,248	250,709,853	253,814,184	253,121,228
Trucks	11,498,561	12,229,216	13,233,910	13,085,643	13,479,382
Other (Buses, motorcycles)	9,655,541	9,698,435	9,658,337	9,591,347	9,323,832
Total Vehicles in Fleets[14]	**9,566,200**	**8,562,900**	**8,627,630**	**8,472,000**	**8,140,000**
Automobiles in fleets	4,756,800	3,836,200	3,669,430	3,632,000	3,424,000
Trucks in fleets	4,809,400	4,726,700	4,958,200	4,840,000	4,716,000

Fleet-based vehicles make up a large percentage of trucks in the U.S. and represent a wide range of service types. *FleetOwner, a trucking industry publication, identified the largest fleets by service type in its FleetOwner 500: Top Private Fleets report as the following:*

- Utilities – AT&T (66,879 trucks), Verizon (20,000 trucks)
- Food Products – PepsiCo, Inc. (48,100 trucks), Sysco Corp. (1,600 trucks)
- Business or Home Service – Comcast Corp. (37,000 trucks), Time Warner Cable (19,879 trucks), Asplundh Tree Expert, LLC (12,837 trucks), Rent-A-Center, Inc. (6,428 trucks)
- Sanitation – Waste Management, Inc. (31,056 trucks)
- Construction – Quanta Services, Inc. (17,820 trucks)

[13] US Bureau of Transportation Statistics, National Transportation Statistics, Table 1-11: Number of US Aircraft, Vehicles, Vessels, and Other Conveyances

[14] US Bureau of Transportation Statistics, National Transportation Statistics, Table 1-14: US Automobile and Truck Fleets by Use

- Retail / Wholesale – O'Reilly Auto Parts (13,497 trucks)
- Petroleum / Gases – Crop Production Services (10,487 trucks), Baker Hughes Co. (6,985 trucks)
- Concrete – CEMEX U.S. & Operating Co. (6,600 trucks)
- Manufacturing / Processing – Weatherford & U.S. Operating Cos. (5,944 trucks)

Automobiles within fleets are classified within a much narrower band. For example, BTS breaks down fleet types for automobiles based on business, government, and rental. As Figure 5 illustrates, the largest share (48 percent) of fleet-based automobiles in 2020 were found in rental fleets, followed by government fleets (34 percent), then business fleets (18 percent). And the total number of automobiles associated with fleets has been recently declining, mostly due to declines in the number of vehicles associated with rental fleets, which declined by 16 percent between 2016 and 2020.

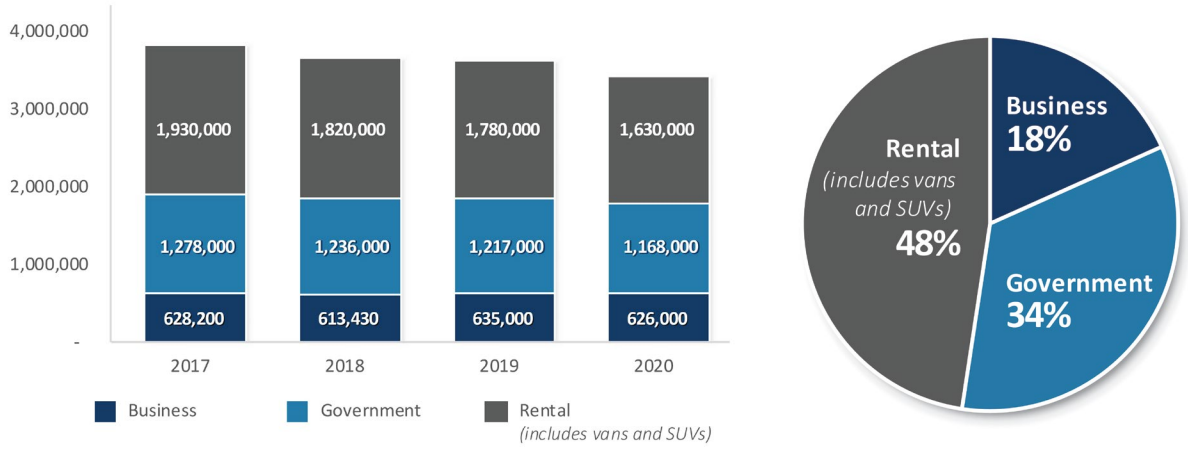


Figure 5: Automobile Fleet Vehicles by Type

These numbers account only for vehicles that are owned by the service provider, be it a business or rental company. As such, they do not include individually owned vehicles that operate in a fleet, such as transportation networking companies. More importantly, they do not include the increasing number of vehicles that are privately owned but may subscribe to services provided by their vehicle manufacturer or other original equipment manufacturer. Testing DBF integration with such native telematics systems will be part of subsequent development efforts. For this Demonstration, MnDOT elected to test integration within a smaller service fleet: shared mobility providers.

1.4.2 Shared Mobility Trends

Growth in SM fleet services, such as carshare and ride-hailing, presents both challenges and opportunities for MnDOT as well as other state, local, and federal infrastructure owners and operators. As defined by the Federal Transit Administration (FTA), shared-use mobility are "transportation services that are shared among users, including public transit; taxis and limos; bikesharing; carsharing (round-trip, one-way, and personal vehicle sharing); ridesharing (car-pooling, van-pooling); ridesourcing; scooter sharing; shuttle services; neighborhood jitneys; and commercial delivery vehicles providing flexible goods movement."[15] Table 3 further defines three forms of shared mobility that commonly use motor and alternative fuels.

[15] Federal Transit Administration. "Shared Mobility Definitions." 28 February 2020. https://www.transit.dot.gov/regulations-and-guidance/shared-mobility-definitions. Accessed on 30 March 2021.

Table 3: Overview of Shared Mobility Services That Typically Use Motor Fuel or Alternative Fuels[16]

SERVICE TYPE	DEFINITION
Carsharing	A service that provides members with access to an automobile for intervals of less than a day. Major carsharing business models include traditional or round-trip, which requires users to borrow and return vehicles at the same location; one-way or free-floating, which allows users to pick up a vehicle at one location and drop it off at another; and peer-to-peer, which allows car owners to earn money at times when they are not using their vehicles by making them available for rental to other carshare members.
Microtransit	IT-enabled private multi-passenger transportation services, such as Via, that serve passengers using dynamically generated routes, and may expect passengers to make their way to and from common pick-up or drop-off points. Vehicles can range from large SUVs to vans to shuttle buses. Because they provide transit-like service but on a smaller, more flexible scale, these new services have been referred to as microtransit.
Ridesourcing *(transportation network companies, ridesharing, ridehailing)*	Use of online platforms to connect passengers with drivers and automate reservations, payments, and customer feedback. Riders can choose from a variety of service classes, including drivers who use personal, non-commercial, vehicles; traditional taxicabs dispatched via the providers' apps, and premium services with professional livery drivers and vehicles. Ridesourcing has become one of the most ubiquitous forms of shared mobility.

Although relatively small, various forms of fleet-based SM service fleets, such as ride-hailing providers and carsharing services, are being used by Minnesotans.[17] While growth in SM providers has been challenged in 2020 and 2021 by COVID-19, it is expected to resume growth as the pandemic diminishes.18 Recent discussions with carsharing providers in the Twin Cities metro region showed that approximately 4,000 people currently subscribe to their services. This is a positive development from the perspective of enhancing access to transportation services, but it is increasingly plausible that such travel will return declining levels of revenue per-mile traveled given the trend of adding EVs and CAVs intro shared mobility fleets.

As the number of subscribers grow and SM service providers incorporate EVs and CAVs into their fleets,[19] SM services could significantly impact personal mobility by reducing individual car ownership and increasing access to a variety of vehicles and services.[20] This could, in turn, increase vehicle miles traveled by making transportation more affordable. Indeed, by some predictions, SM service fleets will account for 35 percent of all personal travel by 2030 and perhaps as much as 90 percent by 2040.[21] Regardless of the SM service fleet used, if the service provider deploys an EV, none of the miles driven by a subscriber would be paid for through a motor fuel tax. Simultaneously, many in the transportation industry expect CAVs to increase vehicle miles traveled by increasing safety and reducing the stress associated with human operation of the vehicle. If CAVs are electric powered, as expected, this would lead to more miles being driven that are not paying motor fuel taxes (barring any changes to existing fee structures).

[16] Federal Transit Administration. "Shared Mobility Definitions." 28 February 2020. https://www.transit.dot.gov/regulations-and-guidance/shared-mobility-definitions. Accessed on 30 March 2021.
[17] Bean, Xing, Zeerak, Zhao. "Regional and Statewide Shared-Mobility Funding: Recommendations for Minnesota." Institute for Urban and Regional Infrastructure Finance, Humphrey School of Public Affairs, University of Minnesota. September 2020. https://static1.squarespace.com/static/5d8a78b7362c255660b38364/t/5f6bdbba5f653c657eeabe73/1600904122750/TCSMCregionalfundingrecommendations-2020.pdf.
[18] Note: This information is based on discussion between the Project Team and the SM Providers.
[19] HOURCAR. "Electric Vehicle Pilot." https://hourcar.org/ev/. Accessed 07 July 2021.
[20] Grosse-Ophoff, Hausley, Heineke, Moller. "How shared mobility will change the automotive industry." McKinsey & Company. 18 April 2017. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-shared-mobility-will-change-the-automotive-industry. Accessed 07 July 2021.
[21] Guidehouse Insights. "Autonomous vehicles: Self-driving vehicles, autonomous parking and other advanced driver assistance systems: global market analysis and forecasts." 21 August. guidehouseinsights.com. Accessed 26 September 2018.

1.4.3 Motor Fuel Tax Developments

The quickest approach to solving the problem of diminishing revenue is to increase motor fuel taxes to levels commensurate with fuel efficiency trends. Furthermore, states might consider making necessary inflationary adjustments, recognizing that alternative energy sources require special treatment. While this has always been the prerogative of the U.S. Congress and individual states, a solution addressing the issue has eluded lawmakers due to resistance from some political leaders to raising motor fuel tax rates, despite a growing need. Although 31 states raised their fuel taxes between 2013 and 2019[22], and 22 states have variable fuel taxes that adjust to inflation or other factors[23], Minnesota has adopted neither of these two solutions.

1.5 MINNESOTA'S APPROACH TO DBF

Even with the need to explore alternative revenues sources to address long-term challenges, MnDOT recognizes the unsurpassed efficiency of the motor fuel tax and its long and durable history. Not only has the motor fuel tax has been a source of highway revenue since the 1920s, but it is also constitutionally dedicated within the State.[24]

Minnesota's approach to DBF is unique relative to other states exploring distance-based fees and RUCs in that the Project envisions the need for the State to retain its motor fuel tax and apply DBF rate adjustments to adequately fund infrastructure for years to come. Many states exploring similar concepts have the stated objective of phasing out fuel taxes in lieu of a wide scale DBF implementation. Minnesota's position hinges on the simplicity and practicality of collecting its fuel tax.

Even with ongoing technological trends, fossil fuel vehicles will still have a share of the automobile market for years to come. Coupled with the simplicity and ease of collection tied to the state fuel tax, this presents a practical argument for keeping the state fuel tax in place and then determining how a DBF can be used to either augment state fuel tax revenues or provide a revenue source for vehicles who do not pay an equitable share for their transportation use.

However, designing an alternative to the motor fuel tax that approaches its simplicity and efficiency is challenging. The cost of collecting the motor fuel tax in Minnesota is less than 0.5 percent of the fees collected.[25] By the most optimistic forecasts, the cost of operations and retrofitting vehicles with the necessary technology to assess a DBF, as well as creating the appropriate enforcement structures for a DBF, is likely to be in the range of 5 percent to 10 percent of total fees collected.[26] Furthermore, fuel taxes are embedded in the cost of fuel paid by consumers and are therefore difficult to evade. DBF, on the other hand, could present opportunities for evasion. Thus, the motor fuel tax is likely to remain in place for a long time despite ongoing technological and economic trends and given established processes and legal requirements.

1.6 A HISTORY OF DBF PROJECTS IN MINNESOTA

Over the years, MnDOT has conducted multiple research and demonstration programs leveraging technology innovations to support new ways of using, owning, and paying for transportation infrastructure. These efforts include launching one of the first-in-the-nation DBF pilots. While MnDOT's study of the DBF concept dates to 1995, only the most relevant studies since that time are discussed below.

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[22] Davis, Carl. "Most States Have Raised Gas Taxes in Recent Years." Institute on Taxation and Economic Policy. 27 June 2019. https://itep.org/most-states-have-raised-gas-taxes-in-recent-years-0419/. Accessed 01 July 2021.

[23] National Conference of State Legislatures. "Variable Rate Gas Taxes." 31 August 2020. https://www.ncsl.org/research/transportation/variable-rate-gas-taxes.aspx. Accessed 23 June 2020.

[24] Minnesota Legislative Reference Library. "State Constitutional Amendments Considered." https://www.lrl.mn.gov/mngov/constitution-alamendments#p. Accessed 07 July 2021.

[25] Coyle, D & Baker, R, 2010, Proceedings 2010 symposium on mileage-based user fees: moving forward, 2010 Symposium on Mileage-Based User Fees: Moving Forward, Texas Transportation Institute, College Station, TX.

[26] Utah Foundation. "Measuring the Miles, Road Usage Charges in Utah." March 2021. https://www.utahfoundation.org/wp-content/uploads/rr786.pdf

In May of 2007, MnDOT conducted a research study to gauge public opinion about a DBF alternative to the current motor fuel tax.27 Interviewees included transportation experts and members of the public. Eight transportation experts participated in an online discussion about the issue and 89 people provided feedback through 10 focus groups (six in the Twin Cities metro region and two each in Duluth and Mankato).

In August 2008, MnDOT conducted nine mini-focus groups with Minnesota drivers (five in the Twin Cities metro region and two each in Duluth and Mankato) to understand the perceptions and level of acceptance among participants about the implementation of a DBF.[28]

In June and July 2009, MnDOT conducted 821 phone-mail-phone interviews with Minnesota drivers selected by random sample and augmented by drivers of hybrid vehicles to better gauge their understanding of transportation funding.[29]

In May 2011, MnDOT conducted the Minnesota Road Use Test. Five hundred people from Hennepin and Wright Counties tested technology that could collect a DBF. The research provided important feedback from motorists about the effectiveness of technology in a car or truck to gather mileage information in combination with a smartphone.[30] The test results helped policy makers understand the challenges and opportunities associated with such a system.

Volunteers used a smart phone with a global positioning system (GPS) application in their vehicle. The phone was programmed for drivers to record relevant information. MnDOT used that information to evaluate whether the device provided timely and reliable travel data for a specific trip. In addition, the test examined whether other applications, such as real-time traffic alerts providing information on construction zones, crashes, congestion, and road hazards were effective in communicating safety messages to drivers. Three different groups of volunteers tested the devices for 6 months each.

The technical approach for this study recorded miles and road use while strictly protecting the privacy of participants. Participant names, vehicle identification, financial account information, travel routes, days and times of trips were classified as “not public” by the Minnesota Department of Administration to ensure the project could collect the necessary Personally Identifiable Information (PII) for the research and results to be valid. The research concluded in December 2012 and the results were made available to the public.

1.7 THE MNDOT DBF DEMONSTRATION PROJECT

The Project was informed by the earlier demonstrations in Minnesota and demonstrations in other states, almost all of which were part of the Federal Highway Administration’s (FHWA) Surface Transportation System Funding Alternative (STSFA) grant program. FHWA’s STSFA program was created in December 2015 as part of the Fixing America’s Surface Transportation (FAST) Act to identify user-based revenue sources to secure the Highway Trust Fund.[31] The STSFA program made $95 million in federal grants available over a five-year period for states (or groups of states) to research road charge programs by testing designs, measuring public acceptance, studying project implementations, improving system functionality, conducting outreach to gather and provide information, and ultimately providing recommendations regarding adoption, implementation, and minimizing administrative costs.

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[27] The Dieringer Research Group. “Mileage-Based User Fee Public Opinion Study: Summary Report Phase I.” August 2007. https://www.dot.state.mn.us/mileagebaseduserfee/pdf/opinionstudyreport.pdf

[28] The Dieringer Research Group. “Mileage-Based User Fee Public Opinion Study: Summary Report Phase II.” October 2008. https://www.dot.state.mn.us/mileagebaseduserfee/pdf/MBUFPhase2FinalRpt.pdf

[29] The Dieringer Research Group. “Mileage-Based User Fee Public Opinion Study: Summary Report Phase III.” December 2009. https://www.dot.state.mn.us/mileagebaseduserfee/pdf/09mbufphase3finalrpt.pdf

[30] Science Applications International Corporation. “Connected Vehicles for Safety, Mobility, and User Fees: Evaluation of the Minnesota Road Fee Test.” February 2013. https://www.dot.state.mn.us/mileagebaseduserfee/pdf/EvaluationFinalReport.pdf

[31] United States Department of Transportation, Federal Highway Administrative. “Fixing America’s Surface Transportation Act.” February 2016. https://www.fhwa.dot.gov/fastact/factsheets/surftransfundaltfs.cfm. Accessed 09 September 2020.

These previous projects have validated the technological feasibility of assessing DBFs while revealing major hurdles to overcome including the cost of deployment, privacy, security issues, and the complexity of national or multi-state operations. To leverage lessons learned from these previous demonstrations and design a project that addresses emerging technology and business models alongside economic trends, MnDOT ultimately selected carsharing services as the primary focus of the Project, along with the testing of a CAV. A carsharing-based DBF will not in and of itself be a viable long-term funding solution for the State. Rather, carsharing services were selected because they are fleet-based and reliant on embedded telematics; two fundamental aspects of MnDOT's long-term vision for DBF development and implementation.

Therefore, the decision to use carsharing services in the Project was informed by the following considerations:

1. **Ease of Using Embedded Technologies** – Carshare companies already use fleet-embedded telematics to report data. This approach presented a model that could greatly simplify DBF reporting and fee collection by using existing embedded technology in modern vehicles that are factory equipped with telematics that can accurately, safely, and easily report DBF data.
2. **Cost Efficiencies Achieved through Use of Existing Technologies** – Using existing technology and processes to collect and report DBF data could minimize the costs associated with procuring and installing aftermarket hardware.
3. **Increased Privacy Protection** – Leveraging existing technology and processes could build upon existing methods to minimize the risk associated with collecting PII, especially relative to DBF projects in which individuals provide information, rather than a private company.
4. **Decreased Risk of DBF Evasion** – By treating an SM provider as the collection point, the risk of evasion could be significantly reduced. The service provider, as opposed to the driver, would ultimately be responsible for remitting the fee.
5. **Leveraging Existing Fee Processes** – SM fleets already assess time and distance fees from their customers and have processes in place to calculate and collect these fees. This could reduce costs and risks associated with fee collection. Current SM fee structures are being evaluated to determine how DBFs could replace existing fees to ensure customers are not double charged for their use of the road.
6. **Potential Expansion to Additional Fleets** – Testing DBF with SM providers offered MnDOT a way to test the application of a DBF in a fleet setting using an increasingly popular mobility service. . However, if an SM-oriented DBF approach proves efficient and cost-effective; the approach could be expanded and adopted within other fleet applications that currently operate on roadways within Minnesota and across the U.S.

With these goals in mind, MnDOT initiated project development and sought funding for design and implementation. In 2017, MnDOT was awarded an STSFA program grant by the FHWA to plan and design a DBF with an SM provider. MnDOT was awarded an additional STSFA grant in 2018 to implement the 12-month DBF Demonstration planned in the previous grant award. In response to receiving the grant and in partnership with SM providers, Minnesota developed a per-mile fee mechanism that utilized technology already embedded in SM provider vehicles (i.e., no new systems were built), and MnDOT began the DBF Demonstration Project. The Project demonstrated Minnesota's vision for exploring a sustainable transportation funding model around the integration of three emerging trends with a DBF: SM service fleets (including various aspects of carsharing, ride-hailing and vanpooling services), EVs, and AVs.

2. PROJECT OVERVIEW

Through the Project, MnDOT aimed to assess a potential structural and operational approach to DBF that would address potential challenges in transportation funding related to emerging technology, such as electric vehicles (EV), and business models, such as shared mobility (SM). The Project was conducted in partnership with SM providers using existing in-vehicle telematics embedded in SM fleet vehicles that transfer data to and from existing State agency tax collection systems for automatic calculation and collection of fees. The Project addressed a range of potential administrative, technological, and operational issues including the following:

- **Pricing Framework** – Developed an affordable, feasible, and scalable per-mile rate within given constraints, for various classes of vehicles, time of day, and other variables
- **Technical Feasibility** – Confirmed the reliability and security of SM technology and the ability to integrate that technology with State fee collection systems in the Minnesota Department of Revenue (MN Department of Revenue)
- **Administrative Efficiency** – Developed a standard for highly efficient and effective collection of DBFs for the State and SM providers
- **Future Implementation** – Developed a plan that charts a path forward to validate the feasibility of DBFs, a blueprint for future projects, deployments, partnerships, applications, and other activities necessary for future DBF projects across Minnesota and the U.S.

2.1 PROJECT TEAM

To implement the Project, MnDOT formed a Project Team that included the Minnesota Department of Revenue, two SM Providers, one CAV Research Partner, the Humphrey School of Public Affairs at the University of Minnesota (Humphrey School), WSP USA (technical consultant), and a technical advisory committee formed as part of the Project. The organization of the team is presented in Figure 6.

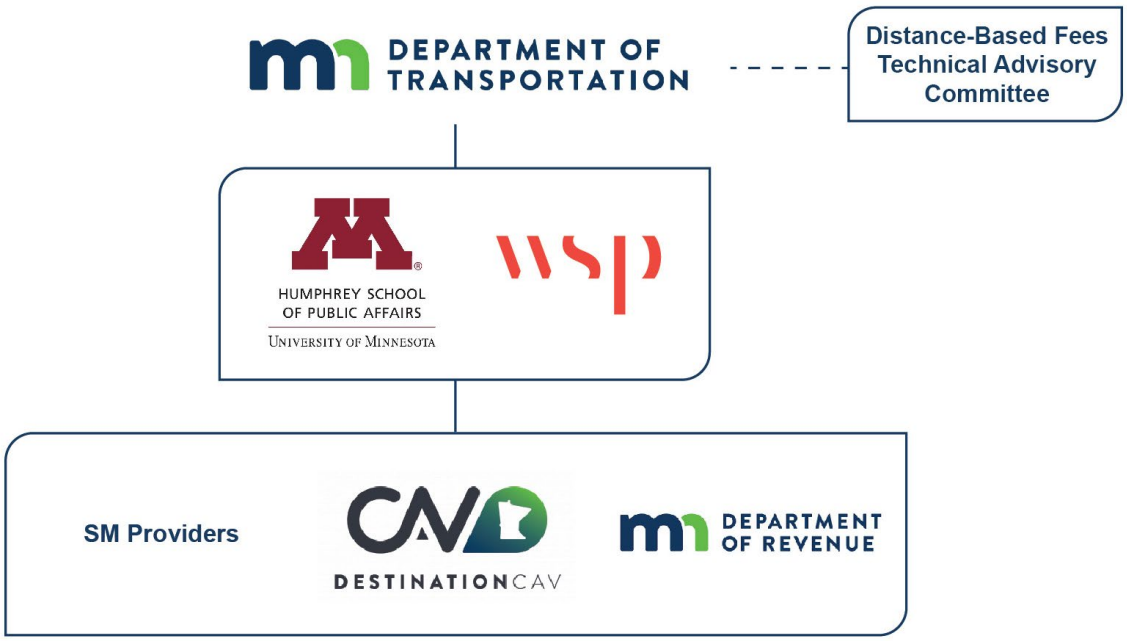


Figure 6: Project Team

Each team member had a specific role in implementing the Project:

- **MnDOT** was the Project manager responsible for overall project administration and coordination activities including convening team meetings, developing progress reports, coordinating with team members as needed, advancing the daily operations of the Project, and managing contracts with team members.
- **SM Providers (Zipcar, HOURCAR)** were responsible for running their ongoing business operations and collecting, transmitting, and processing necessary data, participating in simulated DBF invoicing and remittance, and providing feedback on the Project's impact on their operations.
- **VSI, the Connected/Automated Vehicle (CAV)** Research Partner was responsible for conducting specific tests with an automated vehicle (AV) they provided to collect travel data to evaluate pricing scenarios such as time of day pricing and location-based pricing.
- **Minnesota Department of Revenue** was responsible for simulating revenue reporting by receiving data, performing data audits, and providing feedback on the Project's impact on their administrative duties.
- **The Humphrey School of Public Affairs at the University of Minnesota** was responsible for coordinating with team members as needed to perform data analysis regarding DBF rates and administrative costs, a policy gaps analysis regarding DBF in Minnesota, a qualitative analysis of several stakeholder views on DBF, and an independent evaluation of the Project itself.
- **WSP USA**, the technical consultant, was responsible for system architecture design, technical systems integration, coordinating with SM Providers, certification and testing, operationalizing the Demonstration, and performing analyses on Demonstration results to support the Project.
- **The Distance-Based Fees Technical Advisory Committee** was responsible for providing guidance on the Project, its status, considerations for continued DBF research, and communicating with the legislature.

2.1.1 SM Provider and CAV Research Partner Recruitment

Through the early stages of the Project, several team members coordinated to recruit SM Providers and a CAV Research Partner to participate in the Project. In general, MnDOT sought partners who were naturally interested in the Project and who had existing operations, or the ability to run temporary operations, within the required geographical area. MnDOT initially engaged potential partners, developed each Partner's interest in the Project, and ultimately negotiated and agreed to partnerships with SM Providers and a CAV Research Partner.

This relationship between MnDOT and the SM Providers and the CAV Research Partner provided an opportunity for Minnesota to expand its partnerships and establish a Public-Private Partnership (PPP) that not only supported innovation research and testing, but also yielded a sound investment in local business.

INITIAL ENGAGEMENT

At first, MnDOT and the Humphrey School connected with several SM Providers and a CAV Research Partner in the Minneapolis area to present and gauge interest in the Project. MnDOT and the Humphrey School described the Project, the potential role of each partner, and the potential benefit of participation. After these introductory meetings, WSP USA joined the Project Team to act as the technical consultant and assisted with furthering the relationship with potential partners.

DEVELOPING INTEREST

At the direction of MnDOT, WSP USA held recruiting meetings with potential partners to explain the intent of the program, each partner's role, and what the Project and each partner would gain from their involvement. As part of these meetings, WSP USA developed information sheets for potential SM and CAV providers to aid in communicating these points and provide a baseline understanding amongst all the stakeholders. The sheets provided information on the Project background, the DBF concept, and the data (both required and optional) to be provided by the partner as part of the Project.

REACHING AGREEMENT

After the recruitment meetings, two SM Providers and one CAV Provider began to attend Project meetings. In the meetings, MnDOT, the Humphrey School, and WSP USA shared progress in developing the Project while the SM Providers and CAV Research Partner shared their feedback. In this feedback, the Project Team was able to address key issues that enabled SM Provider and CAV Research Partner involvement in the design of the Project and establish an agreement for the SM Providers and CAV Research Partner to join the Project.

2.1.2 Technical Advisory Committee

The Project Team formed a technical advisory committee (TAC) to engage key stakeholders to provide guidance on technical and non-technical issues throughout the Project. The TAC was issued the following charge:

> ***"The Technical Advisory Committee for Minnesota's Distance-Based Fees Demonstration is established to advise the DBF Project Team, provide guidance on policy and technical issues, and to be an informed constituency in DBF discussions with the public and policy makers. The project is federally funded and authorized by Congress and may contribute to related efforts in the State of Minnesota and to national and international research on this subject."***

As shown in Table 4, MnDOT, with support from the Humphrey School, recruited stakeholders throughout Minnesota from the public, private, and nonprofit sectors. To meet its charge, the TAC met quarterly to discuss the topics listed in Table 5. TAC documents can be found in the appendices.

Table 4: TAC Membership

MEMBER ORGANIZATION	MEMBER NAME
Minnesota Department of Transportation	Scott Peterson
Minnesota Department of Revenue	Glen Kleven
Minnesota Department of Public Safety	Tony Anderson Craig Plummer
Minnesota Management and Budget	Liz Connor Shawn Kremer
Minnesota IT Services	Paul Weinberger
Metropolitan Council	Nick Thompson
City of Minneapolis	Kathleen Mayell
City of St. Paul	Russ Stark Bill Dermody
The Transportation Alliance	Margaret Donahoe
Drive Electric (Great Plains Institute)	Brendan Jordan
Nice Ride Minnesota	Bill Dossett
University of Minnesota, Center for Transportation Studies	Laurie McGinnis Dawn Hood
Association of Counties	Emily Murray

Table 5: TAC Topics and Meeting Schedule

TAC MEETING DATE	TOPICS
April 23, 2021	• Demonstration Update • Privacy Considerations in a DBF environment • Rural Urban Considerations and Administrative Costs Survey Results
March 2, 2021	• Demonstration Update • National RUC Pilot Overview • State Overview and Plans Moving Forward • CAV Alliance Update • Review of Social Equity Surveys • Rural/Urban Equity Considerations • Administrative Cost Considerations
December 9, 2020	• Demonstration Update • Project Website Introduction • DBF Rate Setting Summary • Social Equity Policy Briefing
September 3, 2020	• Demonstration Update • Discussion of Demonstration Scope and TAC Expectations • DBF Taxation Principles • Policy Considerations in Developing a Rate Setting Framework • Modal Equity Policy Brief
June 10, 2020	• National RUC Overview • MBUF/CDBF History in Minnesota • TAC Member Expectations and Call to Action • Convergence of DBF National Trends • Issue Areas: » Social Equity » Rural/Urban Considerations » Modal Equity » Privacy Protections » Administrative Costs

2.2 PROJECT GOALS AND OBJECTIVES

The first Project Team activity was to create a set of goals and objectives for the Project. The goals and objectives focused on developing and deploying a DBF system to create an efficient and affordable path toward broader deployment. Project goals are shown in Figure 7.

Figure 7: Minnesota DBF Project Goals

The Project Team created the following specific objectives to meet these goals:

- Develop a scalable, secure, and transferable approach to DBFs that can be adopted widely and cost-effectively
- Demonstrate how a DBF program can coexist in parallel with the familiar motor fuel tax systems and processes
- Leverage partnerships with SM providers to demonstrate DBF collections with existing onboard technology that minimize collection and enforcement costs and enhance user privacy and equity
- Demonstrate how DBF accounts from SM providers could be seamlessly integrated into existing Minnesota financial reporting, auditing, and enforcement systems
- Confirm reliability and security of SM data and financial systems and integrate with State fee collection systems
- Explore ways the nexus between CAVs, EVs, and SM ownership models can be used to promote a more sustainable transportation funding mechanism
- Through targeted messaging and outreach, educate Minnesota's public and policymakers on the risk of decline in transportation funding, SM services' contribution to the problem, and how SM providers can be incorporated within a collaborative DBF solution
- Establish an appropriate pricing structure for various parameters such as vehicle classes, time of day, and other variables
- Develop a blueprint that charts a path forward to validate the feasibility of DBFs

In addition to the Project goals and objectives, as an STSFA funding recipient, the Project was also required to meet the following STSFA objectives:

- 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

Furthermore, the Project covered the following STSFA grant's required focus areas:

- Implementation, interoperability, public acceptance, and other potential hurdles to the adoption of the user-based alternative revenue mechanism
- Protection of personal privacy
- Use of independent and private third-party vendors to collect fees and operate the user-based alternative revenue mechanism
- Market-based congestion mitigation, if appropriate
- Equity concerns, including the impacts of the user-based alternative revenue mechanism on differing income groups, various geographic areas, and the relative burdens on rural and urban drivers
- Ease of compliance for different users of the transportation system
- The reliability and security of technology used to implement the user-based alternative revenue mechanism

Finally, the Project touched on the following STSFA grant's optional focus areas:

- Flexibility and choices of user alternative revenue mechanisms, including the ability of users to select from various technology and payment options
- Cost of administering the user-based alternative revenue mechanism
- Ability of the administering entity to audit and enforce user compliance

2.3 DEMONSTRATION CONCEPT

To meet these goals and objectives, the Project Team developed the following operational concept to collect travel data accurately and securely from the SM vehicle fleets and assess a DBF for use of the roads:

1. SM fleet providers collected mileage, location, and fuel consumption information from participating vehicles.

2. The SM providers sanitized and aggregated the data for each vehicle, calculated the DBF, subtracted the State and federal motor fuel tax (based on the number of gallons purchased in Minnesota), generated a series of financial reports, and produced an invoice to the State showing net DBF charges due.

3. The reports and invoices were sent electronically via a predefined format and transmission method to the MN Department of Revenue.

4. The MN Department of Revenue reviewed the documents for accuracy, assessed the simulated charges, and conducted audits as necessary to validate the information provided by the SM Provider.

All DBFs assessed were simulated over the course of the Project. SM Providers continued to collect money from their customers as part of their normal business operations. Users of the SM fleet service were not assessed any additional fees outside of what was due to the SM Provider for services rendered.

For the entire Project, vehicles, not individual customers, were considered the participating entity. This differs from similar pilots conducted in other states where the individual owners of personal vehicles are identified as the participating entity. This reflects MnDOT's intention to explore DBF assessment and collection options that can be offered at a lower administrative cost with better privacy protection. Integration with fleet-based SM services accomplishes this by reducing the total number of collection points and placing the onus for collecting and protecting travel information on the private sector.

The project also explored how detailed location-based data provided by MnDOT fleets could be collected and processed to support additional analyses to enhance the ability to account for cross-jurisdictional boundaries and potentially collect a more enhanced set of data and metrics. Such data could also support the future development and application of different pricing approaches such as congestion pricing and other local/regional fees.

During the Project, MnDOT also evaluated the feasibility of assessing a per-mile fee on miles traveled by a CAV. The CAV was used to collect CAV data for evaluation of various DBF pricing scenarios, exploring time-of-day pricing as well as location-based pricing. The CAV also provided a robust dataset that was used to explore other potential data uses, such as supporting transportation planning and modeling and overall performance monitoring and management of Minnesota's transportation network.

2.4 DEMONSTRATION PHASING

After developing the Demonstration concept, the Project Team designed a two-phase implementation process illustrated in Figure 8. Phase 1 was a three-month proof concept to transfer DBF information between one SM provider vehicle, the CAV Research Partner's systems, and the State. The lessons learned from Phase 1 informed Phase 2. Phase 2 was a 12-month Demonstration with two SM Providers and the CAV Research Partner and included communications activities to educate Minnesota residents on the DBF concept.

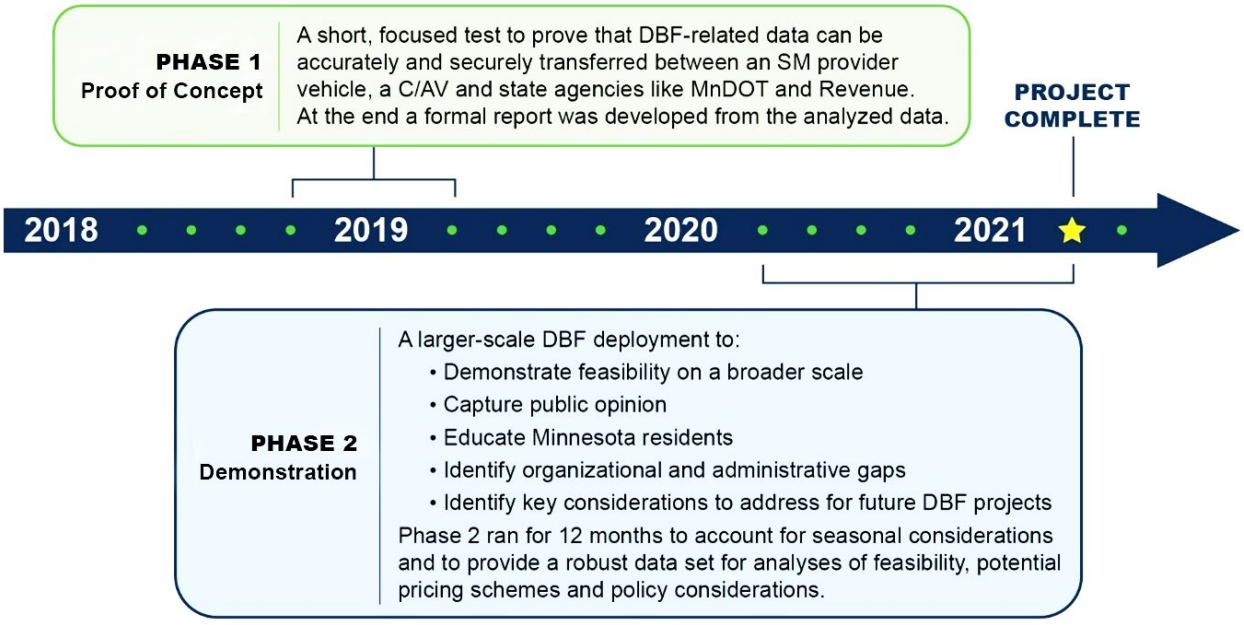


Figure 8: Project Phasing

2.5 SYSTEM DESIGN

For both Phase 1 and Phase 2, the Project Team followed the Intelligent Transportation Systems (ITS) Engineering "V" Diagram planning approach shown in Figure 9.

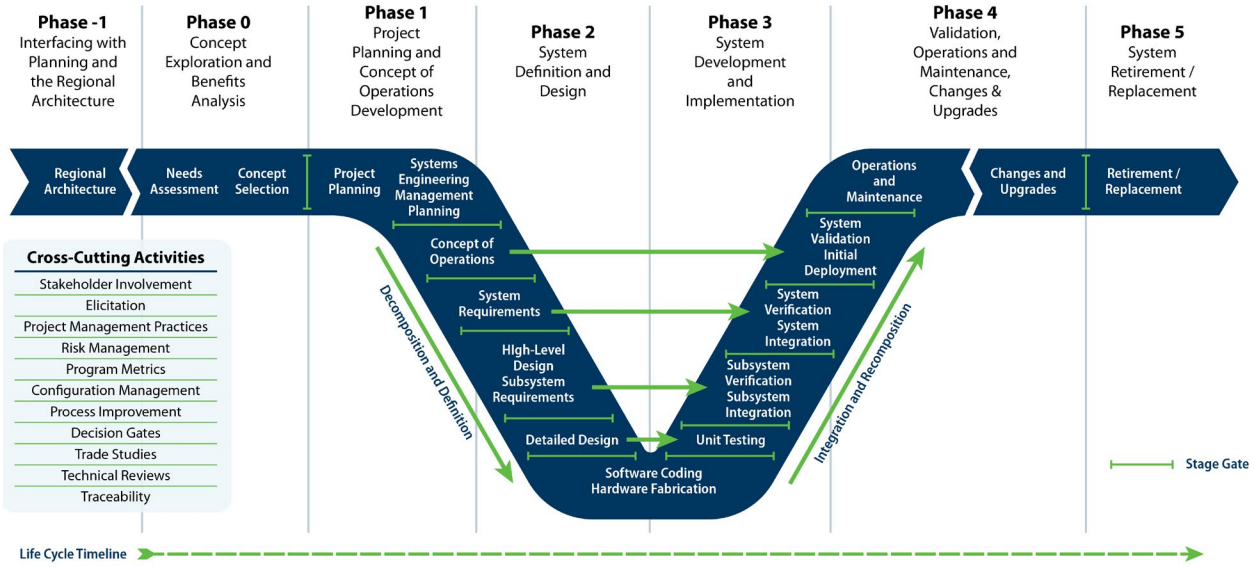


Figure 9: Systems Engineering V-Diagram

In deploying this approach, the Project Team created the following documents:

- **Concept of Operations (ConOps)** provided Demonstration needs and objectives, stakeholders, roles and responsibilities, and the operational and administrative scenarios for the Demonstration.
- **High-Level Functional Architecture Diagrams** defined key elements and functions of the system from a business perspective.
- **System Requirements Specifications (SRS)** defined the system and technical requirements for the Demonstration, as well as requirements for each subsystem, its components, and their functions.
- **System and Business Requirements Document (BRD)** defined the business and operational requirements for the Demonstration.
- **Interface Control Document (ICD)** defined how subsystems communicate with one another, including communications protocols, data fields, format, and frequency.
- **Implementation Plan (ImpPlan)** described the key tasks associated with system preparations ahead of deployment.
- **Test Plans** outlined the methodology and strategy used for evaluating all systems, processes, and interfaces needed to operate the Demonstration, to ensure alignment with requirements.
- **Verification Cross Reference Index (VCRI)** provided a template for tracking system verification and expectations for how each requirement would be validated for compliance.

3. PHASE 1: PROOF-OF-CONCEPT

The purpose of Phase 1 was the following:

- Design a feasible and affordable DBF for use during the Project
- Demonstrate the ability to accurately and securely collect and transfer DBF-related data between an SM Provider, the CAV Research Partner, and the MN Department of Revenue
- Understand how a DBF would impact an SM Provider's operations
- Establish the core systems and interfaces that would be used in the larger-scale Phase 2 portion of the Project

To accomplish these goals, Phase 1 tested two overarching scenarios that integrated DBF within the following:

- The daily operations of one SM Provider (HOURCAR)
- A CAV traveling along predetermined routes for specified periods of time operated by the CAV Research Partner

The Project Team performed the following tasks to prepare for and implement the Proof-of-Concept from 2018 through 2019:

- Stakeholder Needs and System Requirements Development
- Functional Architecture Design
- System Certification
- Communications and Outreach Strategy Development and Implementation
- DBF Rate Setting and Framework Development
- Operations
- Outreach
- Lessons Learned

Each task is described in its own section below.

3.1 STAKEHOLDER NEEDS AND SYSTEM REQUIREMENTS DEVELOPMENT

At the start of Phase 1, the Project Team defined the needs and requirements that the DBF system had to meet to be considered acceptable by each team member and project stakeholder. Although only one SM Provider participated in the operations of Phase 1, both SM Providers recruited to the Project advised on the needs and requirements of the system. Through facilitated discussion and workshops, the system needs and requirements below were developed.

3.1.1 STATE NEEDS

The overarching need for the State was that the DBF system be reliable, accurate, and cost-effective in the collection, assessment, and transfer of DBF data from the SM Providers and the CAV Research Partner. Meetings with State agency staff resulted in the following needs of the system:

- Flexible to accommodate multiple SM options (car share, ride-hailing)
- Leverage existing SM provider technology
- System and network reliability

- Accurate in the collection, processing, and transfer of data and funds
- Auditable
- Safeguards against unauthorized data dissemination
- Cost effective to administer and manage
- Increase public awareness and education on transportation funding
- Expand collaboration with SM providers
- Provide a platform that could be easily used by other states and cities

3.1.2 SM PROVIDER NEEDS

As the frontline service provider to users and the liaison to the State, the SM Providers had unique needs and goals for Phase 1, which included the following:

- Non-intrusive to current operations
- Easily integrated with existing systems
- Improved collaboration with the State
- Manage visibility to potential subscribers

3.1.3 SYSTEM REQUIREMENTS

To meet the requirements of each stakeholder, the system (i.e., all subsystems, operational processes, activities, components, and functions of the SM Providers, the CAV Research Partner, and the State) was required in its design to be the following:

- Secure
- Protective of data privacy
- Reliable and available
- Auditable
- Promotive of safe and reliable operations

System specifications to meet these needs applied to all aspects of the system and met or exceeded industry standards and applicable federal and State laws.

3.2 FUNCTIONAL ARCHITECTURE DESIGN

The Phase 1 functional architecture was designed to meet the needs and requirements of each stakeholder and successfully collect and assess a DBF as designed for the Project. As presented in Figure 10, the functional architecture collects data from the SM Provider's and the CAV Research Partner's fleet vehicles through their existing telematics systems and transfer this data to their existing data repositories. The SM Provider and CAV Research Partner then aggregated this data and calculated the assessed DBF using rates generated by the Project Team. Using the data collected from the SM Provider and the CAV Research Partner, reports were then generated and transmitted to MnDOT and the MN Department of Revenue.

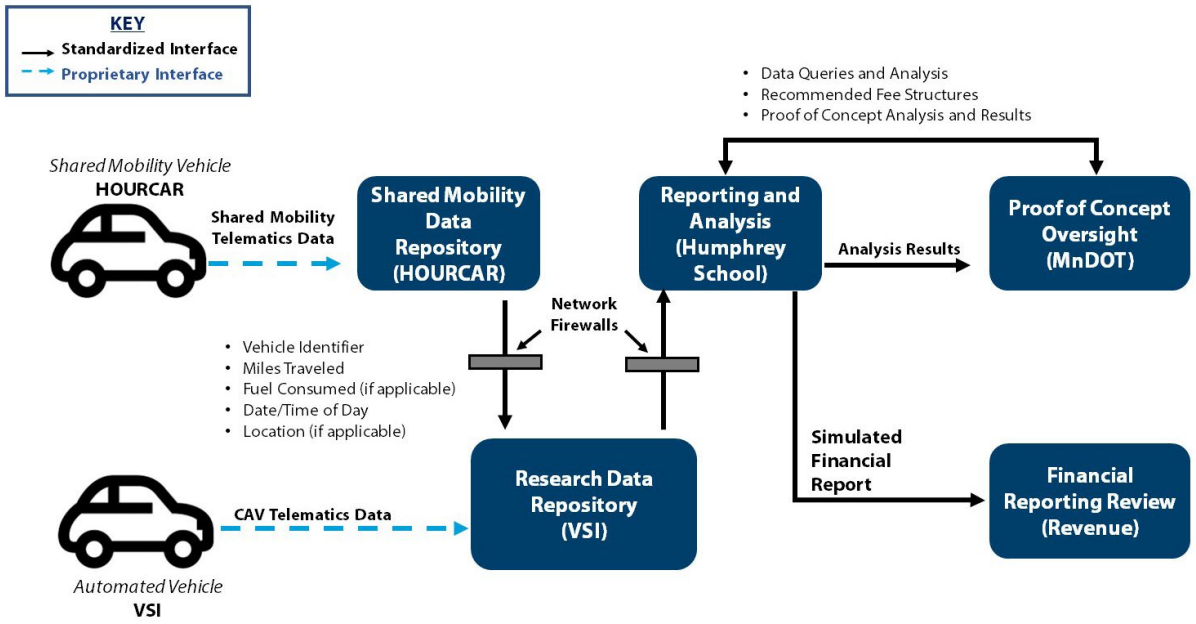


Figure 10: Functional Architecture for the Proof-of-Concept

3.3 SYSTEM CERTIFICATION

With the functional architecture set, WSP USA worked with the SM Provider and CAV Research Partner to conduct testing of the systems, processes, and components to ensure the needs and requirements of the Demonstration were met prior to launch. Testing was conducted and accepted with the full process and brief requirements described in the Proof-of-Concept Test Procedures document in the appendices.

3.4 COMMUNICATIONS AND OUTREACH STRATEGY DEVELOPMENT

Alongside the technological system development, Phase 1 included the development of communications and outreach strategies. The strategies were developed to educate Minnesota's public and policymakers as to the underlying risks of future declines in transportation funding and how SM providers could be incorporated within a collaborative DBF solution. The intention of the communications and outreach effort was for the Project Team to understand how knowledgeable stakeholders were regarding transportation funding and to collect information regarding sentiment stakeholders had regarding DBFs. Specifically, communications addressed the following topics:

- The privacy of PII with data security and privacy safeguards on all Demonstration data
- The seamlessness of data collection with little to no interaction required for SM customers
- Stewardship, as MnDOT aimed to make the Project approach the most cost-effective use of taxpayer funds to address potential funding shortfalls in the HUTDF

From these broad topics, the Project Team developed messaging materials to engage stakeholders that included the following:

- **Key Messaging** that addressed each key message and theme identified in the Communications Strategy. Calls to action may include one-pagers, brochures, videos, and emails
- **Survey Design for TAC and Existing SM Provider Customers** including frequency, key audience, scope for each survey, and desired response rates
- **Focus Group Design** including participant size, targeted messages for each session, qualitative analysis criteria, and recruitment methods
- **Direct Communication Methods** including a Project website and information hotline for general questions about the Demonstration from the media and the public

3.4.1 FACT SHEET

Ultimately, the Project Team developed messaging materials and engaged with SM customers through surveys and follow-up focus groups and Minnesota agency leaders through interviews. These messaging materials are presented in Figure 11 below and provided in the appendices.


DEPARTMENT OF TRANSPORTATION

MINNESOTA'S DISTANCE BASED USER FEE DEMONSTRATION

PHASE I PROJECT SUMMARY

July 2019

MINNESOTA DISTANCE BASED USER FEE (DBUF) DEMONSTRATION OVERVIEW

The Minnesota Department of Transportation (MnDOT) is demonstrating the feasibility of assessing a user based fee mechanism on Shared Mobility (SM) vehicle fleets. SM includes a range of new travel forms that promise greater efficiency, safety, and enhanced mobility. It also provides a platform to explore a practical and implementable path toward wider deployment of distance based user fees as a replacement for the motor fuel tax on appropriately equipped vehicles. By leveraging the advanced technology that has become a standard of SM service providers, MnDOT seeks to develop a user-based fee using existing embedded vehicle technology. This project will prepare Minnesota for the convergence of shared mobility with broad adoption of vehicle electrification as well as coming vehicle automation.

The project has two testing phases:

- **Phase I – Pre-Deployment Planning and Proof of Concept:** Pre-deployment planning and a short, focused test to verify that DBUF-related data can be accurately and securely transferred between a shared mobility provider, an Automated Vehicle, and state agencies like MnDOT and Revenue.
- **Phase II – Demonstration:** A larger-scale deployment of DBUF to demonstrate feasibility on a broader scale, capture public opinion, educate Minnesota residents, identify organizational and administrative gaps, and to identify key considerations to address moving forward.

Phase I of the project is nearing completion . The narrative below provides a summary of the primary project elements that have been completed by the project team under Phase I.

Figure 11: Proof-of-Concept Messaging Materials

3.4.2 PROJECT WEBSITE

To enhance communications and outreach activities, as well as provide a central location for project information and updates, the Project Team created https://dbf.dot.state.mn.us/. As presented in Figure 12, the public-facing website includes a performance dashboard and communicates information about the DBF concept, why MnDOT is exploring DBF, the TAC and its role, and more.

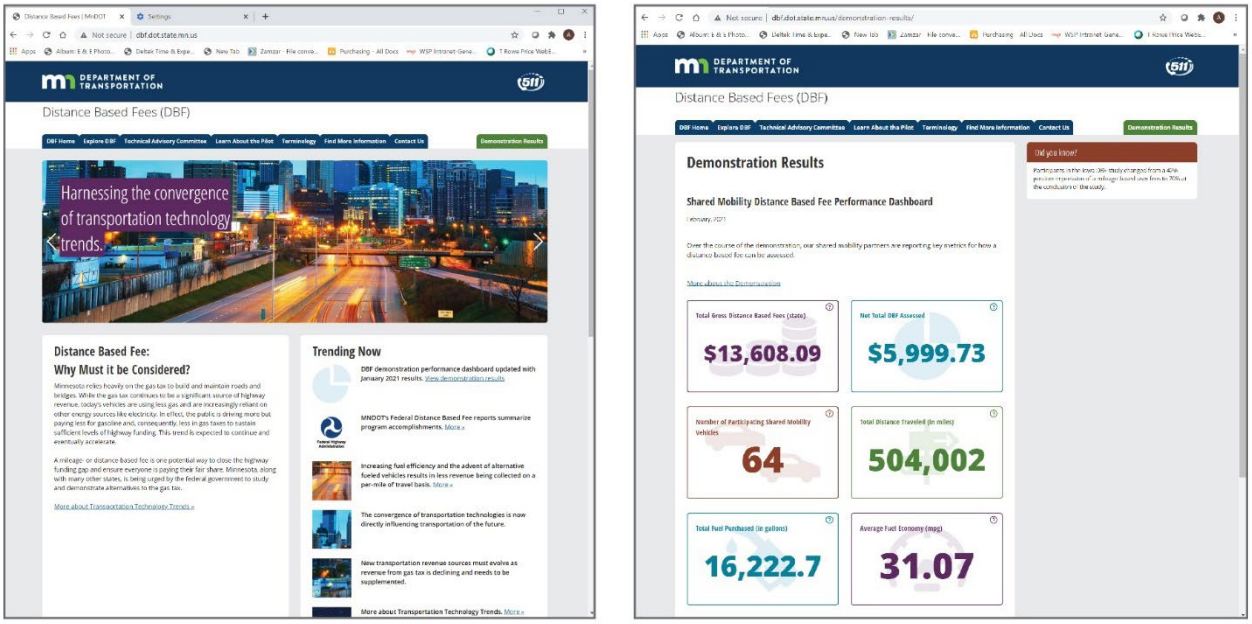


Figure 12: Minnesota DBF Website

3.5 DBF RATE SETTING

To simulate assessment of a DBF, the Project required that the Project Team develop a DBF rate formula reflecting the objectives of the Demonstration that would define the per-mile fee simulated throughout the entire Project. In setting the DBF rate for the Project, the team used the following three-step process:

1. The team developed a basic framework for potential DBF pricing schemes using an initial flat fee, calculated as follows:

$$DBUF\ Rate = S + F$$
$$S = State\ Rate = State\ Fuel\ Tax\ Revenue \div Total\ State\ VMT$$
$$F = Federal\ Rate = Federal\ Fuel\ Tax\ Revenue \div Total\ Federal\ VMT$$

2. Using both the 28.5¢ per gallon State motor fuel tax rate and the 18.4¢ per gallon federal motor fuel tax rate, the Humphrey School refined the DBF rate formula so that the SM Providers were only assessed a single DBF rate for the duration of the Project:

$$[Net\ DBUF] = [(\#\ miles\ traveled * Per\text{-}Mile\ Rate)$$
$$(\#gallons\ of\ gasoline\ consumed * motor\ fuel\ tax\ rate)]$$

3. The Project Team used data from the FHWA and MnDOT and applied the frameworks above to calculate the Demonstration DBF rate. The DBF rate calculated for the Project was 2.7 cents (1.6¢ State; 1.1¢ federal).[32]

[32] Note: This rate was developed for the sole purpose of simulating the assessment of DBF for the demonstration. As the DBF concept advances, the rate structure will have to be researched further.

Why Adjustments to the Rate?

As with any fee, a DBF must be designed to address circumstances that can negate its effect. For a DBF, these circumstances include vehicle weight, time of day and indexing as listed below.

- **Vehicle Weight and Class** adjustments ensure that each vehicle pays its fair share given that heavier vehicles wear transportation infrastructure at a higher rate relative to lighter vehicles.
- **Time of Day** allowances address travel behavior that can overly congest a transportation system.
- **Indexing** counteracts inflation's effect of diminishing the purchasing power of each dollar raised by a DBF.

The Project Team also considered rate adjustments to address circumstances that could undermine the DBF such as congestion and vehicle weight. A potential congestion fee rate and vehicle-dependent fee were also evaluated using several parameters and calculations. Analysis determined that to reduce congestion by 10 percent, an additional congestion fee of 0.9 cents per mile should be assessed during peak-hours. For the vehicle-dependent fee, the analysis determined an additional fee based on vehicle type ranging from $0.02 cents per mile for cars to $0.07 cents per mile for twin trailer semi-trucks. Ultimately, while these adjustments were researched, they were not simulated as part of the Project.

3.6 OPERATIONS

In Phase 1, the SM Provider and the CAV Research Partner accurately and securely collected, sanitized, and transferred DBF-related data using their existing systems. The data was used to create simulated invoices and simulate assessing a DBF on miles traveled with credit for federal and State motor fuels tax on gallons of fuels purchased. Then, the MN Department of Revenue reviewed the simulated invoices and related data to determine the potential for integration with GenTax, the existing tax collection systems, and existing collection processes — and to confirm auditability.

The SM Provider collected data for Phase 1 from November 2018 and into January 2019. The aggregate data collected reflected a range of reservations and trips during standard driving months and the holiday season. From the 70 participating vehicles, 4,633 unique trips were taken, totaling 103,550 miles traveled and 3,542 gallons of fuel purchased.

Between November 2018 and January 2019, the CAV Research Partner tested a CAV which automatically logged and transferred data for 43 trips. The CAV traveled 1,716 miles and consumed 79 gallons of fuel. Trip data was accurately and securely logged and transferred to the data repository.

3.6.1 DATA COLLECTION

Data was collected in accordance with the system architecture defined in Figure 5. The CAV Research Partner set up and hosted a data repository, providing access to all Team Members. The data repository required Secure Sockets Layer (SSL) over Hypertext Transfer Protocol (HTTP) as well as username/password credentials to upload or access data files. These security measures supported the secure transfer and storage of DBF-related data. The SM Provider and CAV Research Partner successfully transmitted data to the data repository throughout Phase 1.

The trip data collected and transmitted to the data repository included the necessary fields to assess a DBF on miles traveled and credit fuel taxes paid on gallons purchased. The trip and fuel purchase data files were cross-referenced to confirm miles traveled corresponded to fuel gallons purchased for each vehicle, further confirming the correct DBF and fuels tax credits were assessed for all participating vehicles.

Data was successfully sanitized of PII and aggregated prior to transmission to the repository. The SM Provider transmitted four files over the course of five months, confirming the limited effort required on the part of the SM providers to collect, aggregate, and transmit DBF-related data.

A few minor issues were identified during data collection and transmission such as the duplication of trip data and differences in the data provided by the SM Provider between reporting periods. A full accounting of these issues can be found in the Proof-of-Concept Report in the appendices. All issues identified were logged and either resolved during Phase 1 or addressed prior to Phase 2.

3.6.2 CONNECTED/AUTOMATED VEHICLE TEST CASES

For one of the logged trips, the Connected/Automated Vehicle (CAV) Research Partner deployed a CAV to conduct a live data polling test. The CAV collected, aggregated, and transmitted mileage and fuel consumption information on a second-by-second basis during the vehicle's travel using existing wireless connectivity. The 25-minute test confirmed the capability to send live data directly from a vehicle's embedded telematics systems, which can support several potential use cases, including real-time value-added services. The route of this trip is shown in Figure 13.

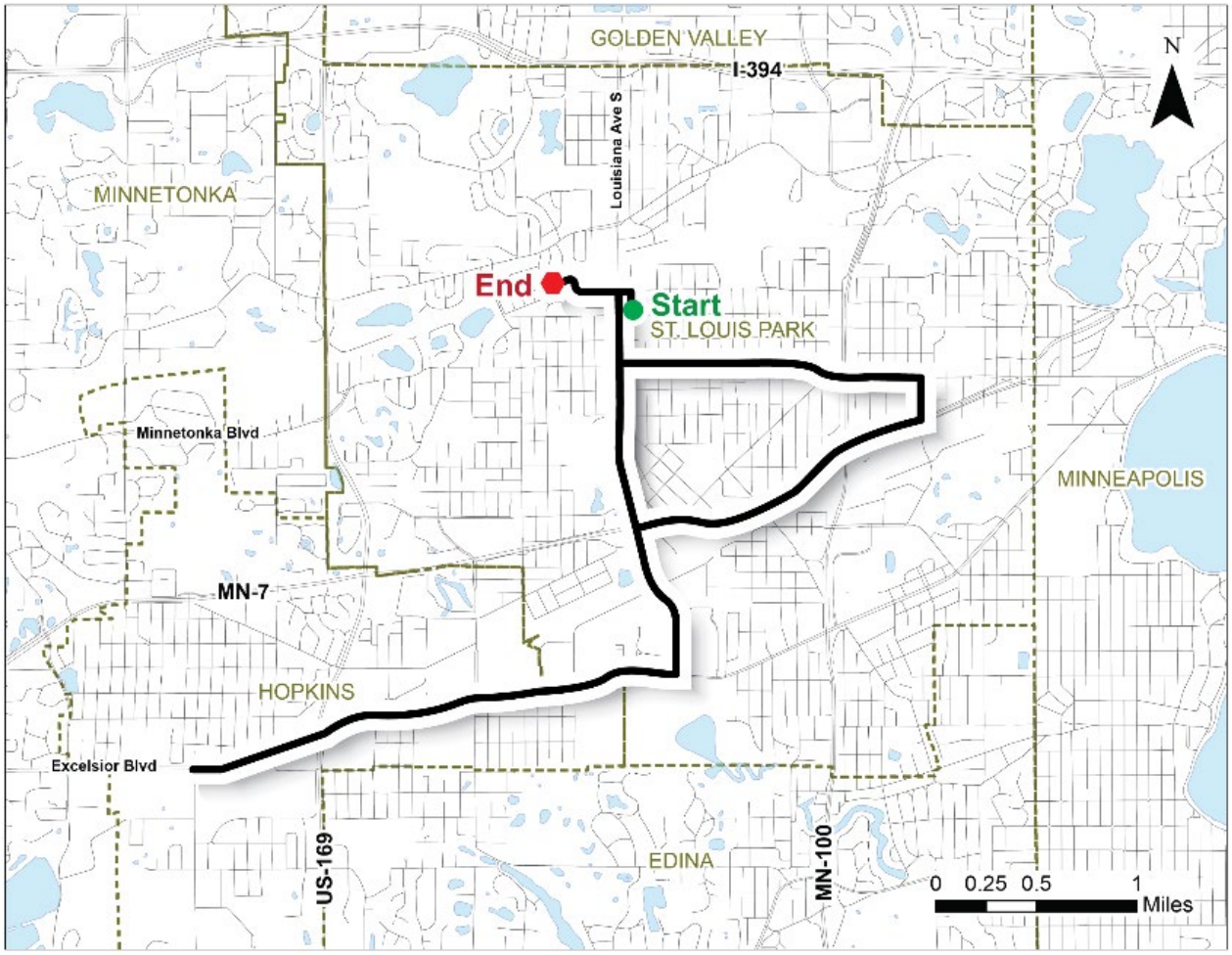


Figure 13: CAV Live Data Polling Test Trip Map

As Figure 1 shows, the Project architecture successfully collected GPS data directly from the onboard CAV systems that was sufficiently granular for the identification of routes taken and the generation of a map. During the data collection period, a small number of trips were not logged using the automated data collection system due to unrelated CAV testing that required various vehicle systems to be taken offline or reset. However, this did not affect the outcome of Phase 1 as it was still proven that data could be collected from a CAV. This issue was resolved by MnDOT and the CAV Research Partner who agreed beforehand that any DBF testing that required the dedicated use of the CAV would be scheduled in advance.

One of the major accomplishments the CAV testing achieved was that individual lane determination was verified. During the test, the CAV traveled in multiple lanes on I-394, ranging from general purpose lanes to E-ZPass express lanes (lanes in which a fee is charged for their use). The onboard technology within the CAV accurately determined which lane the vehicle was traveling, allowing the possibility to assess a variable rate for those miles traveled in express lanes.

3.6.3 DATA REPORTING

The data provided by the SM Provider was used to develop a sample financial report for the MN Department of Revenue's evaluation as presented in Figure 14. Detailed data was summarized into a sample monthly invoice, displaying monthly DBF, fuels tax credit, and net balance totals by vehicle.

DEPARTMENT OF TRANSPORTATION

COMPANY INFORMATION	
Company Name	***Tax Report Period***
Shared Mobility Provider	September1, 2018 to September 20,2018

Vehicle ID	Tax Report Period		Total Miles	Out of State	Federal DBUF*	State DBUF*	Total DBUF*	Fuels Tax Gallons	Fuels Tax Credit	Balance
IDXXXXX	6-Sep-18	25-Sep-18	100	10	$0.99	$1.44	**$2.43**	2.86	($1.34)	**$1.09**
IDXXXXY	7-Sep-18	28-Sep-18	200	5	$2.15	$3.12	**$5.27**	8.00	($3.76)	**$1.59**
IDXXXXZ	1-Sep-18	21-Sep-18	150	0	$1.65	$2.40	**$4.05**	-	($0.00)	**$4.05**
						Total	**$11.75**		**($5.10)**	**$6.64**

Notes

*Calculated based on total miles in the state

Figure 14: MnDOT DBF Proof-of-Concept Monthly Invoice Sample

A Fuel Purchase Report sample was also developed and reviewed with the MN Department of Revenue to determine the information needed to correctly associate fuel tax credits under a DBF program, and to integrate with the existing motor fuels tax collection system. Information regarding fuel type and location of the purchase were not included in the sample Fuel Purchase Report reviewed by the MN Department of Revenue, which would be incorporated into Phase 2 Revenue Reports.

As part of Phase 1, the MN Department of Revenue evaluated the potential to integrate DBF financial reporting into the existing GenTax motor fuels tax collection system. Due to the temporary and simulated nature of Phase 1, the MN Department of Revenue determined that integration with GenTax was not viable during Phase 1. As part of Phase 2, the MN Department of Revenue was tasked with further assessing the effort and potential costs associated with modifying GenTax to receive and process DBFs.

Additionally, the Humphrey School used data uploaded to the data repository to conduct analysis on trip and fuel purchase data. Analysis included verification of accuracy and reviews for data anomalies or errors. Collected data was compared against manual trip logs, confirming that the data collection mechanisms accurately captured and transmitted the appropriate travel data from the vehicle. A few data errors were identified during the analysis and resolved with the SM Provider. The errors found were related to the aggregation of data, rather than the collection of the detailed trip data itself, and were easily resolved prior to completing Phase 1.

3.7 OUTREACH

Through the communications and outreach strategy, the Project Team set out to gauge the attitudes of customers of the SM Provider participating in Phase 1. SM Providers are a logical venue for demonstrating the efficacy of implementing a DBF due to anticipated administrative efficiencies from collecting the fee at the organizational level (the SM Provider), who then pays on behalf of thousands of member drivers. This approach should also increase privacy protection since individual driving data remains in the hands of the SM Provider rather than being reported to the State.

Given these organizational efficiencies, the Project Team sought to understand the views of the customers themselves. In theory, these customers could likely be thought of as "early adopters," or at least supporters, of a DBF based on the three following hypotheses:

- Because SM customers pay for an SM service on a "per-use" basis, they would be more open to a finance system that bills them based on each trip.
- SM customers subscribing to an SM Provider's services, which itself is a relatively new trend, indicates the customer may be more likely to support new models of transportation finance.
- Given that the SM Provider involved in this discussion had plans to move to an electric vehicle (EV) fleet, their customers are more likely to embrace moving to EVs, which further emphasizes the need to develop an efficient and fair alternative to the motor fuel tax.

The research team surveyed 5,507 SM customers with 430 confirmed responses. The results revealed that while survey respondents clearly showed support for a DBF and high levels of trust of SM Providers, this support may not be very robust. Nearly all participants noted that their support of a DBF was related to other interests, such as promoting mode shift away from single occupancy vehicles or promoting increased market penetration of EVs. As such, their support was predicated upon seeing a DBF further those goals, with resulting disagreement about whether and how much an SM provider should contribute to transportation funding if they have an EV fleet, as well as whether the DBF could or should vary by time of day or location to promote other goals. At the most extreme, some participants realized during the discussion that other methods of collecting revenue from EVs, such as increased annual registration fees or an infrastructure tax paid by power utilities (passed on to users, as currently happens with the motor fuel tax), might promote their goals more effectively than a DBF.

3.8 CLOSEOUT

Closeout procedures were initiated upon completion of Phase 1 operations and simply involved notifying the CAV Research Partner and the SM Provider to stop transmitting reports. No return of devices or other closeout activities were necessary given the structure of the Demonstration. At this time, the Project Team moved to prepare for Phase 2.

3.9 RESULTS AND LESSONS LEARNED FOR PHASE 2

Phase 1 resulted in several lessons learned, the identification of leveraging opportunities, and policy considerations for the larger-scale Phase 2 DBF Demonstration. For example, Phase 1 showed the following:

- It was possible to accurately and securely collect and transmit vehicle data from SM fleet vehicles to assess a DBF.
- It was possible to accurately and securely collect and transmit vehicle data from a CAV for the purpose of assessing a DBF.
- Existing systems used to collect data and assess a DBF showed that minimal modifications were required for a larger-scale implementation.
- Revenue collection cannot integrate with GenTax until a DBF program collects actual fees. GenTax production and test environments hold live data and the level of effort needed to integrate was not conducive for the scope of the Proof-of-Concept.
- For assessing and collecting a federal DBF, it is important to align with STSFA grant objectives. Several policy considerations and Demonstration requirements related to federal DBF and crediting of federal fuels tax are still open discussion points.
- Calculating motor fuels tax credits based on fuel purchased may present obstacles when attempting interoperability with a state that calculates credits based on fuel consumed.
- Out-of-state mileage was not evaluated during Phase 1. Phase 2 evaluated how miles traveled across state boundaries may impact a DBF program from a technical and administrative perspective.
- SM vehicle fleets may have multiple reservation modes including confirmed reservation, cleaning, maintenance, and others. Which reservation modes were assessed a DBF was an open question to be further explored in Phase 2.
- A DBF on SM providers' vehicle fleet is a cost-effective model that would likely have lower administrative costs than a traditional DBF reliant on aftermarket devices.

4. PHASE 2: DEMONSTRATION

Phase 1 proved the DBF concept could be performed as designed, while Phase 2 sought to prove the concept at a larger scale. To accomplish this, Phase 2 tested the two following scenarios:

- The daily operations of the two SM Providers (HOURCAR and Zipcar)
- A CAV traveling along predetermined routes for specified periods, operated by the CAV Research Partner

The Project Team built upon the success of Phase 1 and performed the following tasks to prepare for and implement Phase 2 from 2019 through 2021:

- Stakeholder Needs and System Requirements Development
- System Architecture Design
- System Certification
- Communications and Outreach Strategy Development
- Operations
- DBF Rate Setting Framework Development
- Outreach
- Closeout

Each of these tasks are discussed in the following sections.

4.1 STAKEHOLDER NEEDS AND SYSTEM REQUIREMENTS DEVELOPMENT

To establish the operating parameters for the DBF Demonstration, the Project Team developed a series of business and technical requirements that built upon the initial set developed for Phase 1. These requirements detailed what the systems had to do and how each system was expected to perform. The requirements also provided metrics for expected service-level performance for each SM provider and the CAV Research Partner. The overarching need for the Demonstration was to establish a reliable DBF system that accurately and cost-effectively collected, assessed, and transferred DBF data from participating vehicles to the State. The Demonstration system and its partners needed to create a system that would be the following:

- Secure
- Protective of data privacy
- Reliable and available
- Auditable
- Promotive of safe and reliable operations

Based on these needs, the requirements for the Demonstration were designed to disaggregate the system into its individual components. This disaggregation simplified the verification process required to determine how each component functioned individually and interacted with other system components. Requirements were disaggregated as follows:

<operational abbreviation>.<activity abbreviation>.<requirement index>

Example: Data Collection > Trip Data > Requirement # 1 = DC.TD.1

To develop these requirements, the Demonstration was divided into the following main operational processes:

- **Data Collection** – The collection of mileage, fuel, and related travel data from participating vehicles. SM Providers were required to collect and report data no less than monthly during the Demonstration. CAV data would include additional, more detailed travel and location data for data analyses.
- **Transaction Processing** – The processing of collected mileage, fuel, and related travel data into logical transactions. SM Providers were required to sanitize and aggregate collected data prior to transmitting the data to the State (or its representatives).
- **Revenue Reporting** – Calculation of DBF and applicable fuels tax credits, net DBF owed, and formal (simulated) reporting to the MN Department of Revenue.

While a set of overarching requirements applied to all systems, subsystems, components and processes, each operational process contained its own set of activities and requirements to fulfil. Each requirement was further defined in terms of whether it applied to SM Providers, the CAV Research Partner, or both. System specifications were created to meet these requirements and applied to all aspects of the Demonstration system. These specifications met or exceeded industry standards and applicable federal and State laws. The full set of requirements can be found in the Business Requirements Document (BRD) in the appendices.

4.2 SYSTEM ARCHITECTURE DESIGN

The system architecture was designed for SM Providers to collect and transmit data to their respective proprietary data repositories, process and aggregate the data, and transmit simulated Revenue Reports to State agencies. The SM Providers also sent lower-level aggregate data to a secure data repository for analysis by the Research Partner. As in Phase 1, the CAV Research Partner conducted focused tests, collected and processed travel data from the CAV, and transmitted the data to the Demonstration's third-party data repository for analysis.

The architecture was designed for MnDOT and its partners to work with the SM Providers to advance in three stages of Demonstration operations and communications channels. This approach allowed for an iterative development of interfaces, Revenue Report design, and validation checkpoints. The stages included: Stage 1 – Report Development, Stage 2 – Supervised Revenue Reporting, and Stage 3 – Formal Revenue Reporting.

STAGE 1 – REPORT DEVELOPMENT

For the four-month Stage 1 Reporting Period, the team focused on identifying the relevant datasets necessary for DBF transaction calculation and identifying the format and structure for the monthly revenue reports. The SM Providers collected, sanitized, and aggregated monthly travel data and transmitted the datasets to the data repository. Simulated financial reporting was done by WSP USA, using aggregated mileage and fuel purchase data provided by each SM provider. WSP USA and The Humphrey School also worked with MnDOT, the MN Department of Revenue, and the SM Providers to create the template and report structure for use in subsequent stages. Figure 15 illustrates these various processes.

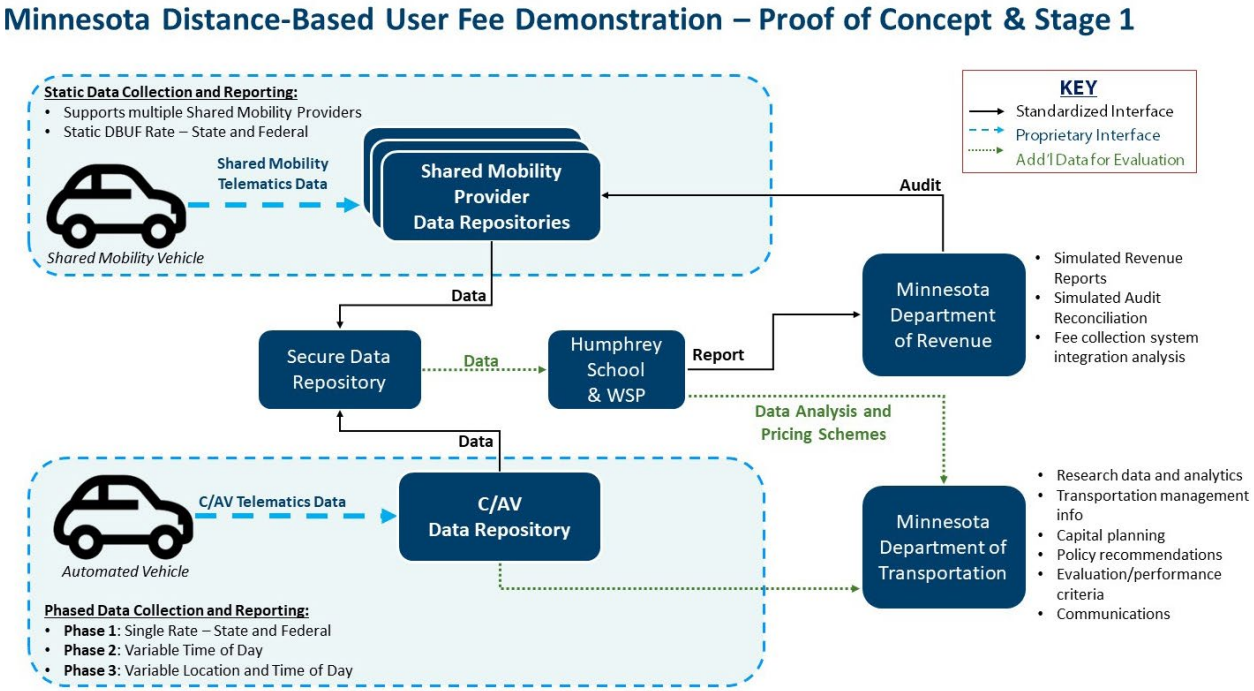


Figure 15: Minnesota DBF Staged Demonstration Architecture – Stage 1 Supervised Reporting

STAGE 2 – SUPERVISED REPORTING

In Stage 2, SM Providers collected, sanitized, and aggregated monthly travel data and transmitted the datasets to the data repository. SM Providers also calculated DBF and fuels tax rates using the collected travel data and generated a Monthly Revenue Report (using the template designed in Stage 1) which was uploaded to the data repository. Once received, the report was validated for accuracy by the WSP USA and The Humphrey School and then provided to MnDOT and the MN Department of Revenue. Any errors or omissions identified in the reports were resolved between WSP USA, The Humphrey School, and the respective SM Provider prior to transmittal to MnDOT and the MN Department of Revenue. Figure 16 illustrates this process.

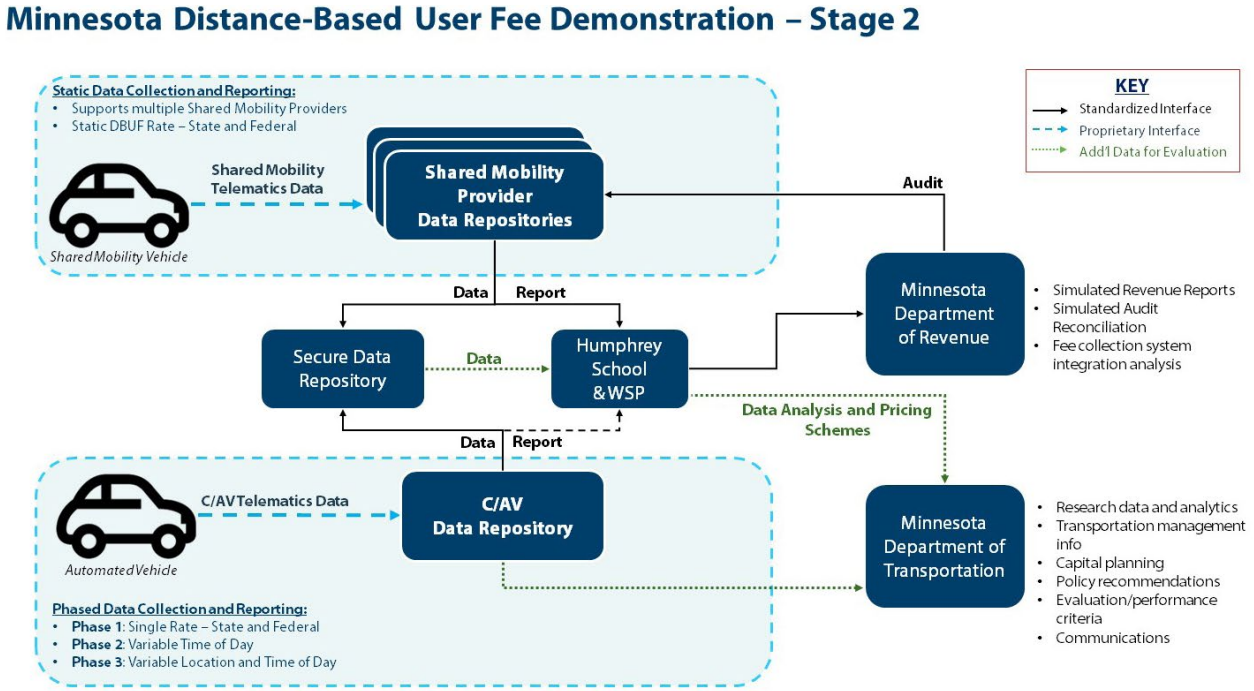


Figure 16: Minnesota DBF Staged Demonstration Architecture – Stage 2 Supervised Reporting

STAGE 3 – FORMAL REVENUE REPORTING

For the final four months of Phase 2, the SM Providers operated independently in an unsupervised reporting condition (i.e., no oversight from another team member) for Stage 3. During this stage, the SM Providers collected, sanitized, and aggregated data each month which they then used to generate their own monthly reports for upload to the data repository and subsequent transmittal to MnDOT and the MN Department of Revenue. WSP USA and The Humphrey School were not involved in these processes other than to answer questions and liaise as necessary between MnDOT, the MN Department of Revenue, and the SM Providers. Stage 3 was designed to mimic actual DBF operations where the SM Providers would collect, quality check, and aggregate their own fleet data, calculate each DBF transaction, and compile these transactions into a series of monthly reports that would be provided to MnDOT and the MN Department of Revenue for processing. Figure 17 illustrates this process.

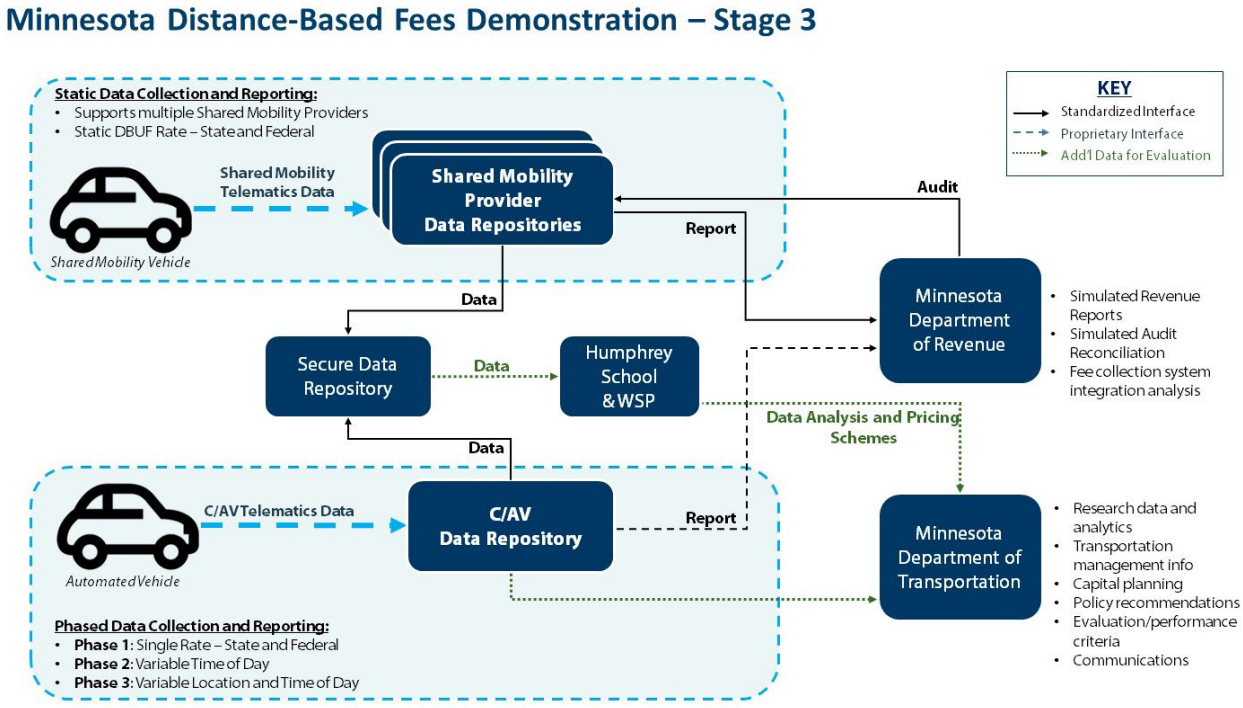


Figure 17: Minnesota DBF Phased Demonstration Architecture - Stage 3 Formal Revenue Reporting

Stage 3 also included an independent audit of the SM Providers and their self-generated reports. An independent auditor, who had limited knowledge of the DBF program and the SM Providers, reviewed a monthly revenue report, and traced the simulated financial records from the aggregated monthly report back to the individual corresponding trip data provided by each SM Provider. The auditor also evaluated the process used to calculate the transactions, the process which data was collected and uploaded, and the reporting process used by the MN Department of Revenue. The results of the audit, provided as an appendix to this document, found no major issues with the way the SM providers were collecting and reporting on their DBF data.

4.3 SYSTEM CERTIFICATION

With the functional architecture set, WSP USA worked with the SM Providers and CAV Research Partner to conduct testing on all systems, processes, and components to ensure the needs and requirements of the Demonstration were met prior to launch. Testing was conducted in three phases: Unit Testing, Integration Testing, and Dry Run (Acceptance) Testing.

- **Unit Testing** – During Unit Testing, the SM Providers and CAV Research Partner conducted internal unit and functional testing of the systems and processes that existed (or would be developed) to support the Demonstration to validate their system met all defined requirements.

- **Integration Testing** – For integration Testing, the Project Team performed connectivity tests between each SM Provider's disparate systems to verify that each system was capable of interoperability and accurate and secure data transfer. Testing also included validation of each of the reports.
- **Dry Run (Acceptance) Testing** – Acceptance Testing was a one-month dry run demonstration where end-to-end functionality of the functional architecture was tested using a controlled set of fleet vehicles. The dry run was performed in a live environment to most closely resemble how the Demonstration would operate. Once completed, all participating entities resolved identified issues, retested as necessary, and began preparing for the launch of the Demonstration.

Testing activities were directed by test documents that established the requirements, test environment, and expected pass/fail criteria: Certification Test Plan, Test Cases, and Evaluation Criteria. These documents were reviewed and approved by both MnDOT and each SM Provider prior to beginning the certification and test activities.

- **Certification Test Plan** – This plan outlined the methodology and strategy to be used for evaluating each participating entity's systems, processes, and interfaces to ensure alignment with the requirements. The Test Plan also defined details for each test phase, testing roles and responsibilities, exit criteria for each phase of testing, and potential risks and mitigation strategies.
- **Test Cases** – The Test Cases detailed how each defined requirement would be met, including inputs, conditions, test procedures/steps, and expected results for each test case. Test Cases were grouped by operational scenarios such as collecting travel data from a vehicle, assessing gross and net DBF on aggregated data, and generation of a DBF invoice.
- **Evaluation Criteria** – The criteria defined the minimum criteria required to consider one or more requirements satisfied. WSP USA used the defined criteria to evaluate test results submitted by the SM Providers and the CAV Research Partner. Evaluation criteria was required to be detailed within a requirements traceability matrix — also known as a Verification Cross Reference Index (VCRI) — for easy tracking of testing and status throughout the certification process.

WSP USA worked with the SM Providers and CAV Research Partner to conduct testing to ensure the needs and requirements of the Demonstration were met prior to launch. Testing was conducted and accepted with the full process and brief requirements described in the Test Plan document in the appendices.

Test results are provided below in Table 6, Table 7, and Table 8. Other than for one provider, all tests were found to be compliant and accepted. One SM Provider (Zipcar) was given conditional approval pending the results of 24 tests that required more time to complete. Zipcar later submitted the necessary documentation to receive full approval to participate in Phase 2 operations. Test results can be found in the Demonstration Testing Status Memo in the appendices.

Table 6: CAV Research Partner (VSI Labs) Test Results

TESTING PHASE	NUMBER OF REQUIREMENTS				
	Total	Compliant	Non-Compliant	N/A	Remaining
Unit Testing	87	72	0	15	0
Integration Testing	87	4	0	83	0
Acceptance Testing	87	53	0	34	0

Table 7: SM Provider (HOURCAR) Test Results

TESTING PHASE	NUMBER OF REQUIREMENTS				
	Total	Compliant	Non-Compliant	N/A	Remaining
Unit Testing	87	81	0	6	0
Integration Testing	87	7	0	80	0
Acceptance Testing	87	55	0	32	0

Table 8: SM Provider (Zipcar) Test Results

TESTING PHASE	NUMBER OF REQUIREMENTS				
	Total	Compliant	Non-Compliant	N/A	Remaining
Unit Testing	87	57	0	6	24
Integration Testing	87	7	0	80	0
Acceptance Testing	87	55	0	32	0

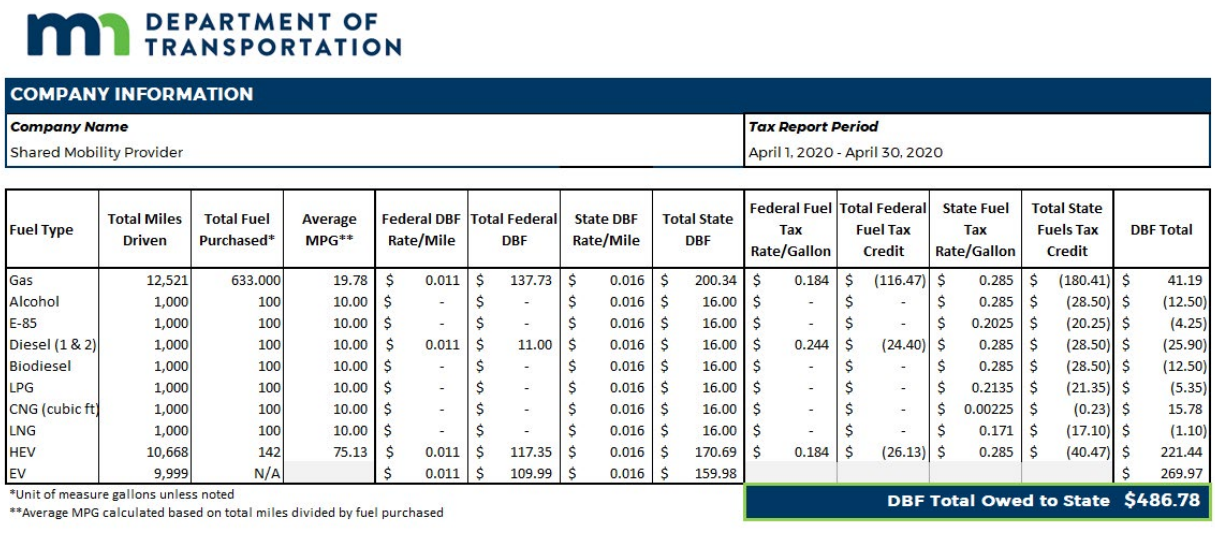
4.4 OPERATIONS

Over the twelve-month Demonstration, the Project Team collected, analyzed, and evaluated SM Provider data, prepared financial reports, maintained the Demonstration system, and liaised with the SM Providers and other Project Team members.

During Phase 2, the SM Providers collected data from 64 participating vehicles totaling 565,839 miles traveled and 18,068 gallons of fuel purchased while the CAV Research Partner tested a CAV which automatically logged and transferred data for three specific trips: A State border crossing, a lane detection test, and a lane detection test combined with a passenger occupancy detection test. Trip data was accurately and securely logged and transferred to the data repository. Operations occurred in the three stages as defined in the functional architecture.

4.4.1 STAGE 1 – REPORT DEVELOPMENT (APRIL 2020–JULY 2020)

During the first four months of the Demonstration, SM Providers collected and transmitted trip and fuel purchase data to the secure data repository each month. WSP USA evaluated this data for accuracy and completeness and coordinated with the SM Providers as needed to reconcile incomplete or inaccurate data. WSP USA then used the data to develop a Revenue Report template and send simulated Revenue Reports to MnDOT and the MN Department of Revenue as shown in Figure 18.



DEPARTMENT OF TRANSPORTATION

COMPANY INFORMATION

Company Name	*Tax Report Period*
Shared Mobility Provider	April 1, 2020 - April 30, 2020

Fuel Type	Total Miles Driven	Total Fuel Purchased*	Average MPG**	Federal DBF Rate/Mile	Total Federal DBF	State DBF Rate/Mile	Total State DBF	Federal Fuel Tax Rate/Gallon	Total Federal Fuel Tax Credit	State Fuel Tax Rate/Gallon	Total State Fuels Tax Credit	DBF Total
Gas	12,521	633.000	19.78	$ 0.011	$ 137.73	$ 0.016	$ 200.34	$ 0.184	$ (116.47)	$ 0.285	$ (180.41)	$ 41.19
Alcohol	1,000	100	10.00	$ -	$ -	$ 0.016	$ 16.00	$ -	$ -	$ 0.285	$ (28.50)	$ (12.50)
E-85	1,000	100	10.00	$ -	$ -	$ 0.016	$ 16.00	$ -	$ -	$ 0.2025	$ (20.25)	$ (4.25)
Diesel (1 & 2)	1,000	100	10.00	$ 0.011	$ 11.00	$ 0.016	$ 16.00	$ 0.244	$ (24.40)	$ 0.285	$ (28.50)	$ (25.90)
Biodiesel	1,000	100	10.00	$ -	$ -	$ 0.016	$ 16.00	$ -	$ -	$ 0.285	$ (28.50)	$ (12.50)
LPG	1,000	100	10.00	$ -	$ -	$ 0.016	$ 16.00	$ -	$ -	$ 0.2135	$ (21.35)	$ (5.35)
CNG (cubic ft)	1,000	100	10.00	$ -	$ -	$ 0.016	$ 16.00	$ -	$ -	$ 0.00225	$ (0.23)	$ 15.78
LNG	1,000	100	10.00	$ -	$ -	$ 0.016	$ 16.00	$ -	$ -	$ 0.171	$ (17.10)	$ (1.10)
HEV	10,668	142	75.13	$ 0.011	$ 117.35	$ 0.016	$ 170.69	$ 0.184	$ (26.13)	$ 0.285	$ (40.47)	$ 221.44
EV	9,999	N/A		$ 0.011	$ 109.99	$ 0.016	$ 159.98					$ 269.97

*Unit of measure gallons unless noted
**Average MPG calculated based on total miles divided by fuel purchased

DBF Total Owed to State $486.78

Disclaimer: The per-mile rates and calculated revenues reflected in this report are for demonstration purposes only and do not reflect any intent of a proposed rate structure by the Minnesota Department of Transportation.

Figure 18: Phase 2 Demonstration Revenue Report Template

4.4.2 STAGE 2 – SUPERVISED REPORTING (AUGUST 2020–NOVEMBER 2020)

In Stage 2, SM Providers continued to transmit trip and fuel purchase datasets to the data repository and generated their own simulated Revenue Reports using the template created in Stage 1. The SM Provider-generated Revenue Reports were uploaded to the data repository and WSP USA reviewed each for accuracy and completeness. WSP USA coordinated with the SM Providers to reconcile any discrepancies in the Revenue Reports and then transmitted finalized versions to MnDOT and the MN Department of Revenue for review.

During Stage 2, one of the SM Providers also started providing "breadcrumb" data along with the trip-level data they had been providing. The breadcrumb data included 30-second interval latitude and longitude geographic coordinates which the Project Team used to support enhanced analyses and evaluation of various DBF rate structures.

4.4.3 STAGE 3 – FORMAL REVENUE REPORTING (DECEMBER 2020–MARCH 2021)

During the final stage of Phase 2, SM Providers generated Revenue Reports and sent them directly to MnDOT and the MN Department of Revenue, without a review by WSP USA. This stage simulated a real-world DBF program scenario in which the SM Providers would be responsible for reporting revenues for their SM vehicle fleet directly for the purposes of assessing a DBF.

The Project Team conducted a mock audit of the SM Providers, evaluating the information provided in the submitted Revenue Reports against supporting documentation to verify the accuracy of the assessment, collection, reporting, and remittance of simulated DBF revenues during the Demonstration. The Project Team analyzed and reconciled the Revenue Reports and datasets to determine if the miles driven, fuel purchased, and calculated DBF revenues and fuel tax credits were correctly captured, calculated, and reported. The reports were validated for consistency with the associated datasets and to assess if there are overlaps, gaps, or anomalies in data. Unique vehicle IDs were randomly selected and checks and balances were implemented using complementary metrics to cross-validate the overall robustness of the reports.

The value of this audit lies in identifying discrepancies and gaps during the Demonstration and developing a plan to address those in future implementations. In aggregate, the overall data collection and financial reporting by both SM providers is accurate and follows the expected guidelines. There were some minor inconsistencies in the datasets which should be duly considered and corrected during potential future implementations.

4.4.4 CONNECTED/AUTOMATED VEHICLE TEST CASES

During the Demonstration, the Connected/Automated Vehicle (CAV) Research Partner conducted a series of specific test cases, to demonstrate the ability to collect and transfer data directly from a vehicle's controller area network (CAN) bus for the purpose of assessing a DBF. Data collected from the CAV included detailed location information for analyses of varied pricing schemes developed by the Project Research Partner. The CAV researched conducted the following key test cases:

- **State Border Crossing** – The CAV traveled a 188-mile round trip to Warren, Wisconsin on I-94 to test the detection of a State border and the ability to differentiate miles traveled in each state for potential out-of-state DBF assessment considerations.
- **Lane Detection** – The CAV traveled on I-394 for approximately 7 miles, switching between the four available lanes, detecting each lane it was in. Figure 19 shows a visualization of the test, indicating when (and for how long) the CAV was in each lane and its transition between lanes throughout the test.
- **Lane Detection with Occupancy** – The CAV duplicated the Lane Detection test, adding occupancy detection, to report how many occupants were in the vehicle when it was traveling. Occupancy sensors installed in the vehicle were used in addition to the existing seat sensors for overlapping verification. This test case could support exploration of using this type of technology to self-report occupancy when traveling in a high-occupancy toll (HOT) lane, such as the E-ZPass HOT lanes operating on I-394 in the Twin Cities metro region.

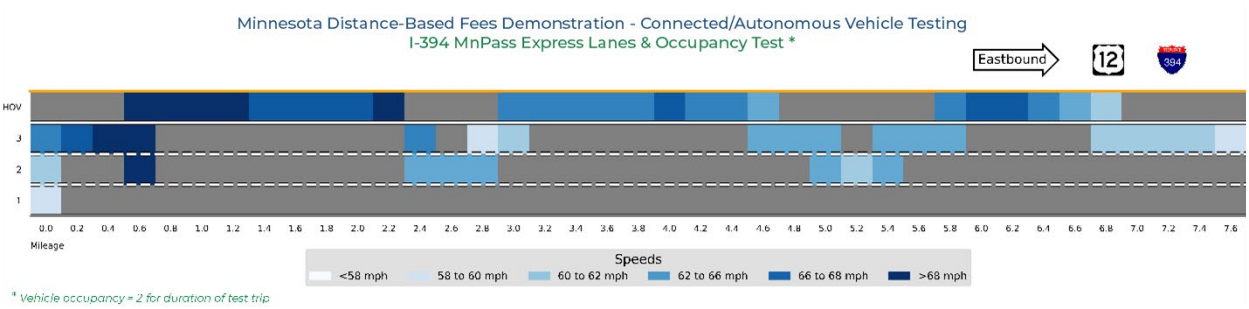


Figure 19: CAV Lane Detection Test Graphic

4.5 ANALYSIS OF MNDOT VEHICLE FLEET TELEMATICS DATA

In Phase 2, the Project Team coordinated with the MnDOT Office of Maintenance to evaluate and analyze telematics data collected from MnDOT fleet vehicles to aid in the study of how to account for cross-jurisdictional boundaries and further the future development and application of different pricing approaches. These include congestion pricing and other local/regional fees to test whether such activities could be completed using an existing set of telematics data for a large fleet.

MnDOT fleet vehicle telematics data provided a large and diverse set of approximately 1,800 vehicles and a large resulting set of data, including cross-jurisdictional travel, diverse location and time of day travel, variety in vehicle type and use. The Project Team analyzed this dataset to inform Project objectives such as ease of collection using telematics data, opportunities to reduce evasion, and scalability. Figure 20 summarizes fleet characteristics in terms of model year, fuel type, odometer reading and make, while Figure 21 summarizes daily vehicle miles traveled during the telematics data collection period.

As presented in Figure 20 and Figure 21, it was possible to characterize fleets and their trips to account for different DBF approaches using the dataset. The data shows that the MnDOT fleet is comprised mostly of vehicles from model year 2015 and later, primarily uses gasoline fuel followed by diesel, that the fleet vehicles mostly have a mileage between 5,000 and 75,000 miles, and that the top two vehicle makes in the fleet are Ford followed by Chevrolet. The data also shows the fleet mostly accrues vehicle miles of travel Tuesday through Friday in the range of 20,000 to 55,000 miles per day.

Figure 20: MnDOT Fleet Vehicle Statistics

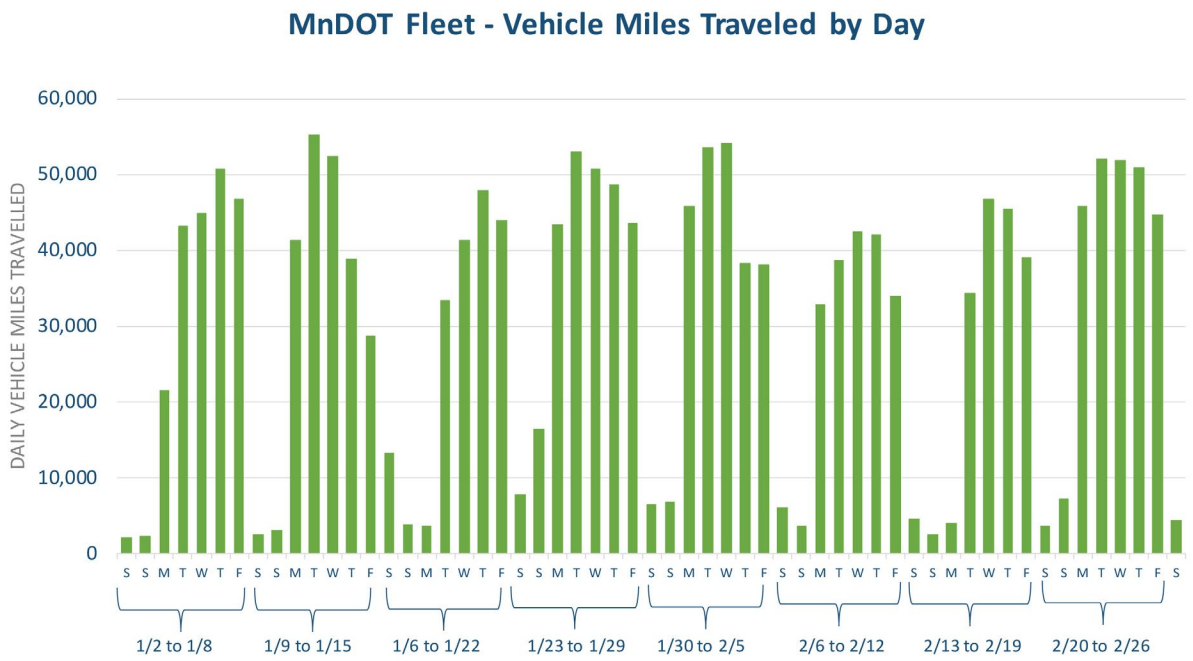


Figure 21: Vehicle Miles Traveled per day for MnDOT fleet vehicles

The size and circularity of this data proves that DBF-related information can be accurately collected using embedded telematics systems and can provide the following key conclusions to support DBF programs in the future:

- **Ease of Collection Using Telematics** – Proved that the telematics mechanism follows industry best practices to collect and transmit data from the device to the cloud. Cloud-stored data is easily retrievable and converted into usable data.
- **Scalable** – The stable, consistent dataset with a wide range of vehicle types and fuel efficiency categories can provide a clean sample set to start projecting larger scale implementations (such as a statewide or even regional program).
- **Transferable** – The telematics data collection and reporting mechanism used is a widely available, commercial offering that can transfer to larger implementations with light-, medium-, or heavy-duty vehicles.
- **Reduce Evasion** – Embedded/affixed telematics reduces the ability to evade collection and assessment of a DBF (intentionally or unintentionally).
- **Potential Reduction in Cost** – There is a potential to reduce varying program costs using telematics to collect and report data for the purpose of assessing a DBF on a fleet vehicle.
    - **Administrative** – Reduced points of collection (fleet owners rather than every individual vehicle owner/driver), lower overhead, likely less administrative efforts, reporting, and auditing.
    - **Collection** – Entity collecting the data has ease of collection with telematics that likely reduces their cost of collection.
    - **Evasion** – Data collection is automated (which reduces manual errors), mechanism is affixed (which reduces physical evasion, removing device), secure technology (which reduces hacking).

4.6 DBF RATE SETTING FRAMEWORK DEVELOPMENT

In alignment with STSFA program objectives and the need to inform future policy discussions on DBF in Minnesota, the Project Team developed a rate setting framework building on the DBF rate setting activities in Phase 1. The Project Team followed the approach shown in Figure 22.

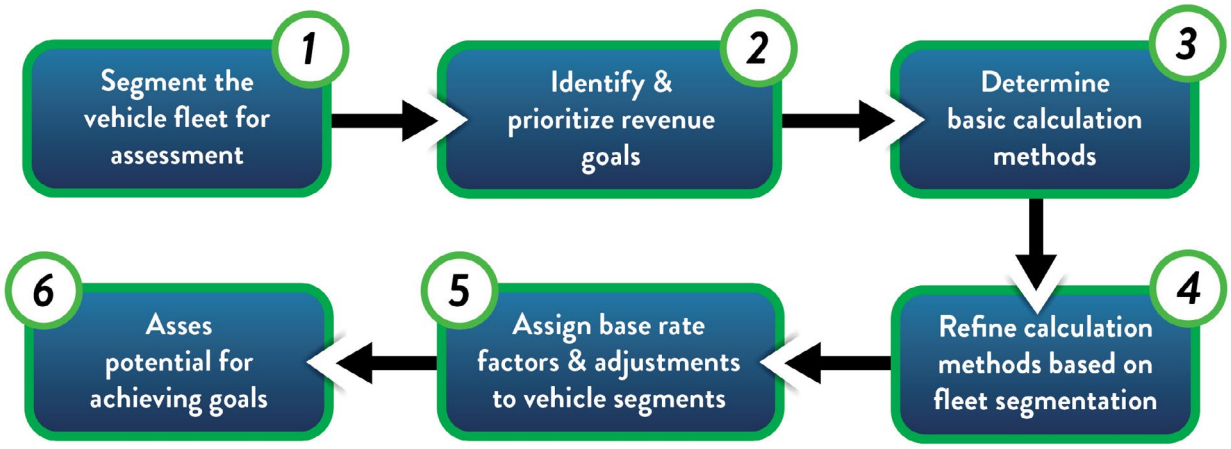


Figure 22: DBF Framework Development Process

To develop the framework through this process, the Project Team first held a series of meetings with MnDOT staff and documented several transportation policy objectives that could support future DBF deployments including those associated with revenue, system performance, and equity. The Team then identified specific rate setting methodologies and data resources associated with achieving each goal and, with guidance from MnDOT and the TAC, prioritized revenue goals. The Team then developed and refined calculation methods and associated revenue goals and rate setting approaches to different vehicle classes that might be subject to a future DBF while assessing the potential to achieve these revenue goals.

As the DBF concept advances in Minnesota and nationally, this framework can be used as a guide to empirically explore rate setting approaches.

4.7 OUTREACH

On Monday June 14, 2021, in accordance with the communications strategy, the Project Team held a roundtable with State of Minnesota leadership and interested parties titled “Rethinking Transportation Finance Roundtable, Transition to Distanced-Based Fees: Where Do We Go from Here?” The event was co-sponsored by the Humphrey School Center for Transportation Studies, MnDOT, and the Mileage-Based User Fee Alliance. The agenda can be found in the appendices.

In addition to the roundtable, the Project website was maintained through Phase 2. Figure 23 shows the approximate number of website visitors per day between October 2020 and June 2021 at a high of nearly 20 and a low of zero. Figure 24 breaks these visits down further showing a total of 307 users who visited the website approximately twice during the period for a total of 600 sessions and 1,767 page views, spending nearly 4 minutes during the visit. Figure 25 shows that approximately 77 percent of the users were new, and the remaining 23 percent were existing users. Lastly, Figure 26 shows how users navigated to the website. Direct visits (i.e., entering the website address into your browser search bar) were the most used channel at 60 percent, followed by an organic search (using a service like Google Search) at nearly 33 percent. The remaining 7 percent were composed of referrals (clicking on a link to the website while the user browses another website) at roughly 5 percent and social media (clicking through a link advertised on a social media service) at approximately 2 percent.

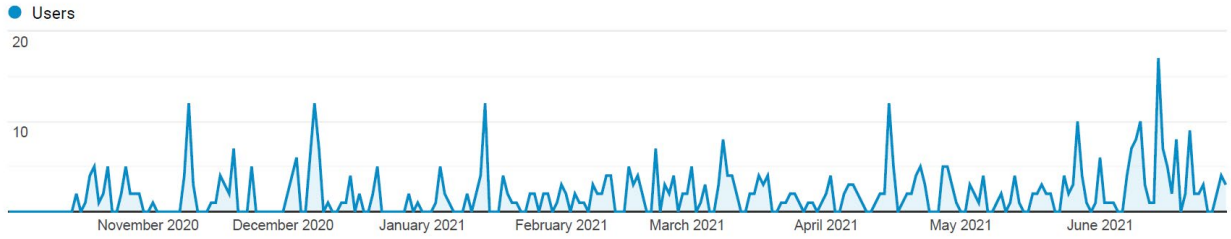


Figure 23: Website Analytics - Visitors per Day

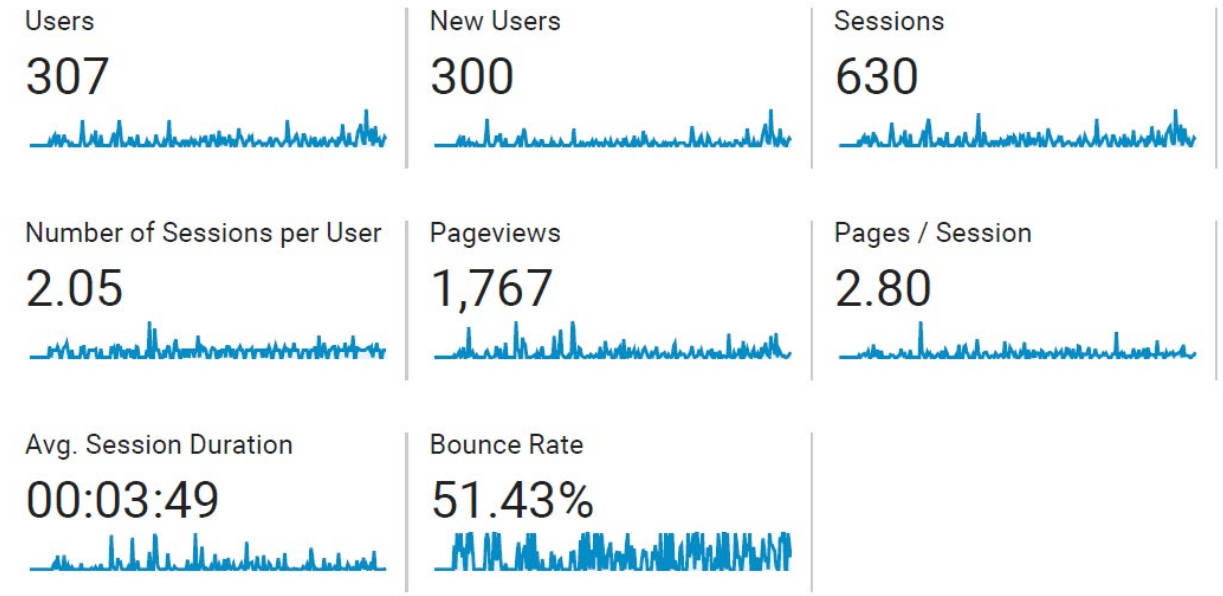


Figure 24: Website Analytics - Breakdown of Website Visits

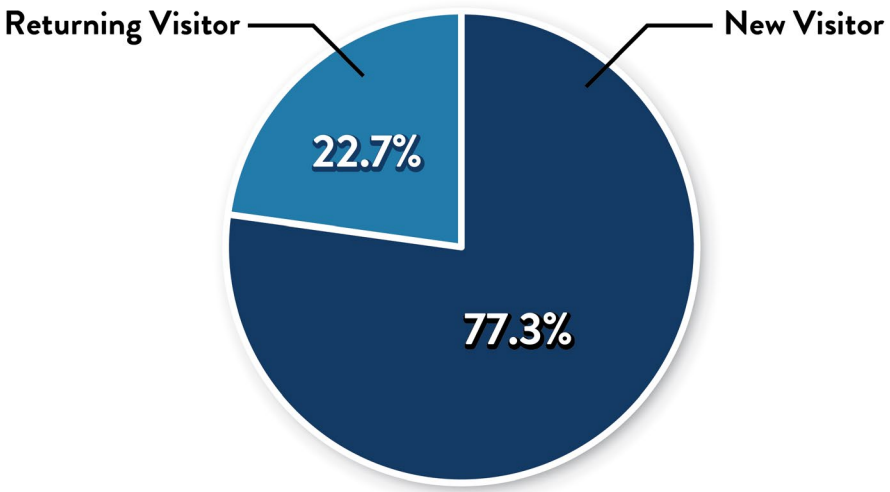


Figure 25: Website Analytics - Breakdown of New and Returning Visitors

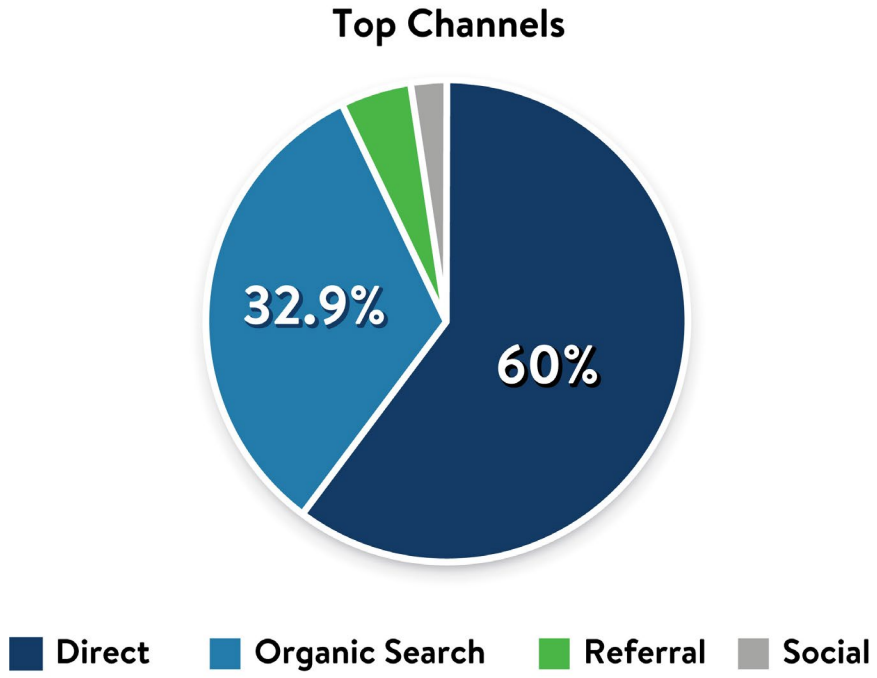


Figure 26: Website Analytics - Top Channels to Website

4.8 CLOSEOUT

Like Phase 1, upon closeout the SM Providers and CAV Research Partner were instructed to cease the transmission of all reports and resume their normal operations. No devices were required to be returned because the Demonstration used embedded vehicle technology. After closeout, the Project Team moved to administrative closeout tasks such as data analysis and reporting.

5. OVERALL RESULTS AND EVALUATION

With its two Shared Mobility (SM) Providers, the Demonstration collected over a half-million (565,389) miles in travel resulting in a net (simulated) revenues of $6,885. A total of 64 vehicles were active throughout the course of the Demonstration. Table 9 summarizes key Demonstration highlights and illustrates that a fleet-based approach to DBF operation is technically feasible in terms of collecting travel information from fleets and assessing a charge on that travel. However, the Demonstration highlighted operational, policy, and administration issues requiring further analysis.

Table 9: Demonstration Summary Statistics

TOTAL MILES TRAVELED	TOTAL FUEL GALLONS PURCHASED	AVERAGE FUEL ECONOMY (MILES PER GALLON)
565,389	**18,068.83**	**31.32**
TOTAL GROSS DISTANCE-BASED FEES (DBF) *(STATE AND FEDERAL)*	**TOTAL GROSS FUELS TAX CREDITS** *(STATE AND FEDERAL)*	**NET TOTAL DBF ASSESSED** *(SIMULATED)*
$15,358.67	**$8,474.20**	**$6,884.47**

The Demonstration was a first of its kind for assessing how a distance-based fee could be accurately and effectively assessed using SM provider fleet vehicles that included gasoline-powered vehicles, electric vehicles (EV), and Connected/Automated Vehicles (CAV). Successes of the Demonstration include the following:

- A half-million miles of travel collected, processed, and invoiced using existing technology in partnership with two SM Providers and a CAVs research partner.
- Data was accurately, securely, and effectively captured using embedded telematics without the need for aftermarket solutions like Onboard Diagnostics II (OBD-II) port or mobile apps.
- User privacy was protected and no PII was shared with MnDOT or was part of any unauthorized disseminations.
- All data systems were protected using the latest security protocols including Payment Card Industry (PCI) 3.2.1 and 265-bit Advanced Encryption Standard (AES) protocols.
- Provided a positive user experience by leveraging SM Providers' existing service models, which reduced the complexity of simulating a DBF assessment for customers and agency staff without compromising program transparency.
- Location conformance with jurisdictional boundaries was successfully demonstrated showing how rate adjustments could be made based on local areas or specific jurisdictional or geographic boundaries.
- Successful testing of lane detection of an automated vehicle (AV) with the CAV Research Partner to determine capability of applying rates within managed lanes.
- Developed a first of its kind rate setting framework that examines the basis for considering or establishing fair per-mile charges.
- Established a rational model for transaction calculation and billing using established fleet management systems that was tested, audited, and vetted with the MN Department of Revenue.
- Exponentially reduced potential points of collection and risks of enforcement by using SM Providers.
- Established several policy considerations for further research as the DBF concept advances.

5.1 A PROJECT OF FIRSTS

The Demonstration represented many accomplishments including several firsts for any DBF demonstration completed to date in the U.S. The accomplishments of the Demonstration and their national significance are summarized in Table 10.

Table 10: Minnesota DBF Demonstration Accomplishments

THE FIRST U.S. DBF DEMONSTRATION TO…	NATIONAL SIGNIFICANCE TO DBF PROGRAMS
Assess how a distance-based fee could be assessed in partnership with SM providers	Allowed for initial discussions and identification of critical issues from emerging innovative mobility providers. Leveraging fleet services for DBF assessment will reduce the potential number of collection points, thus reducing the administrative costs and potential risks of evasion and revenue leakage.
Capture DBF data directly from a vehicle's telematics system without having to rely on aftermarket hardware	Capturing data directly from a vehicle's onboard telematics systems eliminated the need for installing aftermarket devices, reduces administrative costs, increases accuracy and reliability, and reduces enforcement risk.
Successfully collect DBF data from a Connected/Automated Vehicle	Supports accurate assessment and collection of DBF from EVs and CAVs; technology likely to see widespread adoption in the vehicle fleet.
Accurately report lane differentiation and occupancy	CAV systems can be used to assess variable rates based on whether a vehicle is in a general purpose, or in an express lane. This is significant for the operators of managed lanes systems across the US, particularly given the likely incorporation of such technology as a standard feature in future vehicle models.
Successfully audit data and transactions through a U.S. State Department of Revenue	Demonstrated how DBF financial reports and associated data can be integrated into existing state financial systems accurately and efficiently.
Use a per-mile rate consisting of both the state and the federal motor fuel tax equivalents	Showed the impact that the 18.4¢ per gallon federal fuel tax has to an overall per-mile DBF rate.
Support maintaining the motor fuel tax	Facilitated integration with existing tax systems. Such an approach provides familiarity to motorists and transportation officials and promotes a more reliable funding source than one that solely relies on a per-mile fee
Developed a rate setting framework	Defined the process and considerations for properly setting a per-mile rate using key factors such as: state revenue goals, vehicle segmentation, location, powertrain, weight, emissions, vehicle purpose, administrative costs, and motorist socioeconomic factors.

In each phase of the Demonstration, the SM Providers and CAV the Research Partner accurately and securely collected, sanitized, and transferred DBF-related data in accordance with the required processes. The data was used to create simulated invoices and simulate assessing a DBF on miles traveled with credit for federal and state motor fuels tax on gallons of fuels purchased. Finally, the MN Department of Revenue reviewed the simulated invoices and related data to determine the potential for integration with GenTax, existing tax collection systems, and existing collection processes, and to confirm auditability.

The way the SM Providers reported trip data differed based on the "reservation mode" the vehicle was in – if the vehicle was offline for maintenance, a reservation may not be made and therefore not reported in the trip files submitted. The Project Team coordinated with the SM Providers to identify the parameters for what types of trips should be reported – ultimately, all trips where the vehicle traveled a distance should be reported. Regardless of the reason for a trip, if the vehicle traveled it should be assessed a per-mile DBF.

A few vehicles were damaged during the Demonstration, declared a total loss, and removed from SM Provider reporting. Final miles may not have been captured from the vehicle when the vehicle was damaged (i.e., it hadn't reached the threshold/point of reporting trip end data). Although it is likely that only a small number of miles traveled were not reported, an open consideration is whether a final odometer reading or other means of final mileage verification should be included in a future program, or if there is an acceptable margin of error for lost miles due to unforeseen circumstances, such as a damaged/totaled vehicle.

In the Demonstration, the MN Department of Revenue simulated providing a fuel tax credit based on the fuel gallons reported in submitted Revenue Reports. These simulated Revenue Reports used fuel purchase records submitted by the SM Provider for each participating vehicle. However, operational nuances of the carsharing business have posed challenges to assessing a fuel tax credit. Specific to carsharing, the customer purchases fuel for the vehicle they have rented using a charge card provided by the SM provider. During normal business operations, carshare providers will sometimes deactivate or remove charge cards from vehicles in cases of fraud, theft, or the card being lost. When carshare companies remove the charge card, a customer must use personal means to purchase the fuel required to power the vehicle and subsequently request reimbursement from the carshare provider. Generally, the only information required by the carshare provider for fuel purchase reimbursement is the purchase amount which alone does not provide the necessary information to assess a fuel tax credit in the Demonstration. There are three options for reconciling this operational issue that have different benefits and setbacks – further information on this can be found in the "MN DBF Fuel Tax Credit Assessment Options Memorandum" Appendix B.

- **Option 1** – Assess Fuel Tax Credits Using Only Reported Fuel Purchases
- **Option 2** – Assess Fuel Tax Credits Using Vehicle Miles Traveled and Reported Fuel Purchases to Fill Reporting Gaps
- **Option 3** – Assess All Fuel Tax Credits Using Vehicle Miles Traveled and the Vehicle's U.S. EPA Miles per Gallon Rating

5.2 PROJECT EVALUATION

Overall, the Demonstration proved that assessing a DBF using fleet-based telematics is technically feasible and could support a long-term transportation funding approach. The technology and systems are in place to accurately, safely, and confidently report mileage information, calculate accurate transactions, and assess and report DBF revenues from SM providers to Minnesota State agencies. Furthermore, the Demonstration proved that embedded technology in CAV can accurately report DBF data and can be used to support more granular reporting such as lane determination, vehicle occupancy, and geographic area delineation, which could be used to support congestion-based pricing if the State were to consider that approach.

The Project Team conducted a separate evaluation using criteria related to administrative and political feasibility, efficiency, adequacy, and equity of the Minnesota DBF Demonstration model. That evaluation is available as a separate appendix to this final report. The intent of this section is to show how well the Demonstration met goals and objectives associated with the Surface Transportation System Funding Alternatives (STSFA) program that supplied funding for the Project. Table 11 documents how the Project addressed the main objectives of the STSFA program.

Table 11: Attainment of STSFA Program Objectives

STSFA PROGRAM OBJECTIVES	ATTAINMENT BY THE MINNESOTA DBF PROJECT
Test the design, acceptance, and implementation of two or more future user-based alternative mechanisms	• The Project demonstrated the application of a usage-based fee system in conjunction with fleet-based SM services and CAV systems.
Improve the functionality of the user-based alternative revenue mechanisms	• The Project Team involved SM Providers and a CAV Research Partner in the development of the concept and ultimately the testing of fee collection that would integrate with their existing operations. • Communications activities tested public acceptance and uncovered other themes associated with a DBF among Minnesota stakeholders that can be leveraged for future improvements to the concept.
Conduct outreach to increase public awareness regarding the need for alternative funding sources for surface transportation programs and to provide information on possible approaches	• A key part of the Project included engagement and outreach with Minnesota stakeholders to understand their impressions of transportation funding, and DBF in particular. These communications activities acknowledge that for any DBF to be successful, stakeholders across Minnesota — from the public to state and local political and business leadership — must be aware, understanding, and supportive of a DBF.
Provide recommendations regarding adoption and implementation of user-based alternative revenue mechanisms	• MnDOT should develop a larger-scale demonstration with a more diverse array of emerging and existing fleet vehicles owners across the entire state. This includes creating the technical project documents required to procure necessary services to develop, implement and evaluate the larger-scale DBF project. MnDOT should develop a scope of work and budget that identifies funding sources, the necessary project team members, and other required components and services.
Minimize the administrative cost of any potential user-based alternative revenue mechanisms	• The concept tested in the Project — collecting a DBF through fleet vehicles — offers an opportunity to achieve greater administrative efficiency than collecting a DBF through individual vehicle owners. Rather than having to collect a DBF on every vehicle in the State, the MN Department of Revenue and MnDOT could collect DBFs on a smaller number of SM provider fleet accounts that would be responsible for aggregating and reporting the VMT of their fleet.

Table 12 summarizes the Project's attainment of objectives required of its STSFA grant application.

Table 12: Attainment of Required STSFA Grant Objectives

REQUIRED STSFA GRANT OBJECTIVES	ATTAINMENT BY THE MINNESOTA DBF PROJECT
Implementation, interoperability, public acceptance, and other potential hurdles to the adoption of the user-based alternative revenue mechanism	• Managing and lowering administrative costs is a significant challenge for road usage charge (RUC) implementation. The Minnesota DBF addresses this by leveraging existing SM service platforms for assessment and invoice generation. Furthermore, from the state's perspective, the SM fleet is essentially a single collection point, thus lowering costs relative to systems where individually owned vehicles are subject to the fee. • By levying the DBF in conjunction with SM fleet services, Minnesota's approach makes use of a growing service used by travelers across the U.S. The demonstration approach can be implemented in any area where SM fleet services are offered.
Protection of personal privacy	• The Minnesota DBF does not collect information on individual travelers. The SM fleet provider is responsible for assessing road usage, generating a fee, and collecting payment from its existing customers. By leveraging these private service platforms and only receiving aggregated data, the Minnesota DBF decreases privacy concerns.
Use of independent and private third-party vendors to collect fees and operate the user-based alternative revenue mechanism	• Third party SM Providers and the CAV Research Partner were critical in concept development of the concept and testing of fee collection that would integrate with their existing operations. The ultimate vision for DBF in Minnesota is integration with third-party service providers.
Market-based congestion mitigation, if appropriate	• While the fee was not applied in an operational setting, the Project team conducted analysis to identify likely congestion-based rates and determined that an additional fee of 0.9 cents per mile should be assessed during peak-hours could reduce congestion by 10 percent.
Equity concerns, including the impacts of the user-based alternative revenue mechanism on differing income groups, various geographic areas, and the relative burdens on rural and urban drivers	• Rates for the Minnesota DBF were set such that the revenues would be roughly equivalent to what would normally be generated in fuel taxes. As such, no additional burden is placed on the statewide traveling public.
Ease of compliance for different users of the transportation system	• The Project demonstrated a system where a DBF is assessed in conjunction with fleet-based SM services. The fee would be collected in conjunction with payment for those services. Under a future implementation, users of the service who are subject to the fee would not have to pay the fee separately or maintain a separate account (increasing compliance).
Reliability and security of technology used to implement the user-based alternative revenue mechanism	• The transmission of sensitive driver information, including PII, does not occur under the Minnesota DBF model. Such information is retained by the SM fleet provider and is not provided the administering agency. • There were no documented security breaches during the Demonstration. Information collected from the SM fleet providers was reliable and accurate.

Table 13 summarizes the Project's attainment of objectives required of its STSFA grant application.

Table 13: Attainment of Optional STSFA Grant Objectives

OPTIONAL STSFA GRANT OBJECTIVES	ATTAINMENT BY THE MINNESOTA DBF PROJECT
Flexibility and choices of user alternative revenue mechanisms, including the ability of users to select from various technology and payment options	• Minnesota's DBF approach is agnostic to in-vehicle technology insofar as vehicle telematics systems are used. Such applications are common in fleet-based SM service throughout the country. • Minnesota's approach would allow for the levying of DBF on any number of mobility services. Users are only subject to the fee when they utilize a particular service and have their choice of providers.
Cost of administering the user-based alternative revenue mechanism	• Minnesota's approach leverages existing platforms from SM providers. The state would only receive aggregated travel data from a limited number of providers, not all vehicles subject to the fee. This approach thus lowers administrative and operating costs to the state.
Ability of the administering entity to audit and enforce user compliance	• The Minnesota DBF would be collected like the fuel tax: at the time a service or good is purchased. Users would pay the fee when they use the service and would not be required to remit a separate payment. This increases compliance among users and shifts the burden of enforcement to the private sector. • The state does not require detailed information on individual trips by participating vehicles. Fees are not differentiated by type of vehicle, time of day, or any other adjustment factor. As such, aggregate information on travel within the fleet is sufficient to accomplish auditing procedures.

6. FUTURE OF DBF IN MINNESOTA

The Minnesota DBF Demonstration reflected a forward-looking perspective on transportation funding alternatives and will inform subsequent development and implementation activities within the State as well as nationwide. The Demonstration was the first pilot to successfully integrate a usage-based fee system in a fleet setting using embedded telematics exclusively for the collection and reporting of road usage. Similar pilots in other states have relied on individual vehicle owners as participants and used aftermarket devices to collect data. However, in the long-term shared vehicles are likely to be a popular alternative to individual ownership and newer model vehicles will include the necessary technologies for automatic data collection.

This section of the report provides an overview of key findings from the Demonstration as well as a summary of unresolved issues for exploration in future DBF activities within the State. The section closes by outlining a vision for the future of DBF in Minnesota that builds on lessons learned to date, addresses key knowledge gaps, and provides a summary of proposed next steps to help the State achieve this vision.

6.1 KEY TAKEAWAYS TO INFORM FUTURE EFFORTS

The Demonstration was unique in both its fleet-based telematics approach to assessment and its auditing exercise where the Minnesota Department of Revenue confirmed reporting accuracy by the private partners. It also included an automated and Connected/Automated Vehicle (CAV) component to assess the potential for DBF to be levied in conjunction with future vehicle technology. Given the scope of this effort, numerous lessons learned and key takeaways were identified.

Fleet-based approaches to DBF assessment are accurate and reliable.
The information necessary for DBF assessment can be accurately and reliably collected from fleet-based telematics systems. Furthermore, the Demonstration provided the MN Department of Revenue with sufficient information to conduct an audit of assessed charges. This shows that DBF and similar systems can be implemented and operated without the need for vehicles to be equipped with aftermarket technology that can be removed or tampered with. Furthermore, the aggregation of fleet data, as opposed to collecting data from individual drivers, does not reduce the ability of the State to audit assessed charges and provides privacy to the individual users of fleet services by eliminating the need to collect PII and maintain individual user accounts.

Connected/Automated Vehicle technology is likely viable as an assessment technology.
The information necessary for DBF assessments was also successfully collected from CAV systems. This is significant as future model cars are increasingly likely to have the necessary technology as a standard feature. Furthermore, next-generation traffic management applications will rely on the collection of CAV data for the provision of various roadway services such as safety. A DBF that incorporates CAV elements will therefore be able to leverage data that will be collected from the vehicle fleet as part of routine ITS offerings in the long run. Additionally, the technology deployed successfully differentiated lanes of travel and vehicle occupancy, demonstrating their possible application within managed lanes systems. For example, a vehicle equipped with CAV systems in the future may not require a traditional toll tag or transponder to access managed lanes facilities.

Leveraging fleet-based telematics reduces complexity and improves flexibility.
Leveraging fleet SM providers' in-vehicle telematics systems eliminates the need for DBF-specific aftermarket devices to assess and collect fees. This reduces the level of effort required of vehicle owners and eliminates the risk that RUC specific devices will need to compete for the in-vehicle diagnostic port with other devices such as those used in usage-based insurance programs. Leveraging fleet-based telematics thus helps future proof the fee system as telematics become a standard feature in new model vehicles.

Fleet-based approaches may reduce administrative costs.
A DBF levied on fleet-based SM providers reduces the number of collection points for the State to administer, thus lowering overall system costs to the State. A total of 64 vehicles and 1,400 SM customers participated in the pilot; however, there was effectively only two primary accounts to be monitored, administered, and audited by the Project Team. Additionally, aggregated travel data from the fleet telematics systems can be audited without requiring significant effort from service providers. In subsequent interviews with the Project Team, SM partners that the audits were unobtrusive, with one noting they were unaware the audit had even taken place. The MN Department of Revenue reported that the information provided by the SM providers was sufficient to conduct their audit of incurred charges and that no errors were identified in submitted reports.

Fleet-based approaches can improve compliance and reduce enforcement costs.
A DBF linked to services that transportation system users already benefit from shifts the burden of compliance and enforcement to the private sector and reduces the incentives to evade the fee. In the model tested by the MnDOT team, the SM provider (as opposed to the users of their services) would be responsible for remitting the amount due for the assessed DBF. It is therefore incumbent on the provider to collect the necessary amount from their users. Much like the fuel tax, if SM providers account for the DBF in their invoicing systems, users would be unable to benefit from the service without paying the necessary DBF.

A statewide DBF could support other revenue and pricing systems.
A statewide DBF could serve as a foundation for other transportation-related fees including congestion pricing, high-occupancy toll (HOT) lanes, or local/regional fees. As noted earlier, the CAV systems tested in the pilot were capable of differentiating lane use in addition to collecting DBF information, meaning they could be used for managed lanes operation in lieu of traditional toll tags. Additionally, the system could be configured to allow payment of other fees and taxes, essentially acting as a single platform for the payment of state and local transportation fees assessed on fleet-based service providers. The project demonstrated that incorporation with the MN Department of Revenue systems is possible, so it is likely that other transportation-related fee systems (such as those administered by departments of motor vehicles) could similarly be incorporated.

Embedded telematics — already installed by manufacturers in most of today's vehicles — could be used to more efficiently and effectively deploy DBF across a range of operations and ownership scenarios.
Manufacturers have been routinely installing telematics in vehicles to monitor vehicle performance and maintenance, to update software, and for safety purposes. Data generated by the vehicle is monitored by the manufacturers and provides vehicle owners with added value and security. That data could be used to generate reports on vehicle miles of travel, which could then be used to charge DBF. Tesla is already providing that data from their vehicles to charge drivers a fee under Utah's Road Usage Charge Program.

Unique challenges remain with fleet based DBF development implementation.
While the Project explored the contours of a new and innovative approach to distance-based fees and demonstrated several significant accomplishments, challenging questions remain. Those challenges include developing a more complete understanding of the administrative cost efficiencies that may be achievable using vehicle-embedded technology with the SM model, as well as how an embedded technology platform might be deployed under individual vehicle ownership models. Assuming the U.S. DOT would prefer to task states with collection of a federal component of distance-based fees, it is not clear how that would be executed nor how a federal motor fuel tax reconciliation or credit process would work. Additionally, significant questions remain on multi-state interoperability and how, or if, out-of-state miles would be assessed.

6.2 UNRESOLVED ISSUES FOR FUTURE EXPLORATION

The Humphrey School conducted a gap analysis to determine potential barriers to be addressed for successful implementation of DBF in Minnesota. Initiated in Phase 1, the gap analysis examined existing State legislation and policies to determine their applicability and required revisions to support a DBF program. The analysis also identified areas where new legislation would be needed to support a DBF program. These policy and legislative considerations, as well as additional research topics, are summarized in Table 14. While many of these topics were explored in Phase 2, they provide a sound launching point for subsequent DBF research.

Table 14: Potential Future Research Considerations

DESCRIPTION	CATEGORY	TERM
Administrative Costs – What are the potential policy considerations and parameters that would drive a high administrative cost?	Organizational	Short
What integration points are required with SM providers to engender continued support for the state assessing a DBF on SM vehicle fleets?	Organizational	Long
Role of the State in collection of a potential federal DBF	Organizational	Long
Data Ownership – Who owns the data?	Operational	Long
What are rational fee schedule parameters, such as fuel type, location, and time-of-day?	Economic	Long
Does the State have the right to refund federal motor fuels tax paid if the net balance of a DBF assessment is negative?	Economic	Long
Calculation of fuels tax credits based on fuel purchased vs. fuel consumed	Technical	Long
Should out-of-state miles traveled be assessed a DBF?	Social	Short
If an electric vehicle (EV) enhanced registration opt-out option is offered, does that reintroduce inequity for low-efficiency vehicles?	Social	Long

To better understand stakeholder's views on a distance-based user fee, elected officials, government employees, and stakeholders from special-interest organizations participated in interviews with Project Team members where representatives from MnDOT and the Humphrey School provided information on the Project. A script of questions guided these interviews but discussion was allowed to flow naturally. The Project Team found that stakeholders were well informed on the transportation funding issues facing Minnesota and the nation, and many of them were familiar with the concept of DBFs as well as Minnesota's past work on DBF demonstration projects and studies. All special-interest representatives agreed that the motor fuel tax may not support long-term transportation funding in Minnesota. Interviewees were informed that the Project was not intended to demonstrate a replacement for the motor fuel tax, but rather a supplemental fee that would be levied on vehicles appropriately equipped with embedded telematics capable of collecting and reporting miles driven.

An additional consideration for the Project, as well as other usage-based fee pilots conducted in 2020 and 2021, is the potential impact of COVID-19 on travel behavior and subsequent impacts to Demonstration results. Of the two SM Providers on the Project, one SM Provider noted that usage of its service was at about 40 percent of "normal" in April of 2020 and was anticipated to rebound in May. The Project team estimates that usage of the service could be up to 80 percent by the conclusion of the Demonstration. The SM Provider also noted that membership in its service offerings remained relatively stable. Applications for new memberships declined significantly in April, but new applications rebounded a little in early May. The Provider noted that the rebound of applications was not as noticeable as the rebound in usage. The Project Team speculates that users are acting conservatively and that those who have carshare memberships are not giving them up, but those who do not have them are not signing up.

6.3 SYNERGY WITH PENDING LEGISLATION AND NATIONAL DEMONSTRATIONS

Alternative, usage-based funding systems like DBF are under continual development and refinement across the country. The primary federal mechanism for these efforts has been the Surface Transportation System Funding Alternatives (STSFA) grant program. STSFA has funded most pilots to date, including this Demonstration. The federal government's commitment to usage-based funding solutions was continued with the passage of the Infrastructure Investment and Jobs Act (IIJA), which provides additional funding for state pilots and demonstrations but also directs the U.S. Department of Transportation to establish a national per-mile road usage fee pilot program. Details of the national pilot, including a possible timeline for implementation, are not yet available, but interstate issues and interoperability will likely be central topics for exploration. Furthermore, it is likely that the future national pilot will test different assessment options using

different technology and account management approaches. Minnesota's efforts to date have positioned it well to be a leader in any future national initiatives as its concept leverages embedded fleet-based telematics, emerging mobility services, and CAV systems.

6.4 OPPORTUNITIES AND SYNERGIES WITH CAV

Embedded technology outside of telematics, such as CAV systems, will be an important consideration for further exploration of the DBF concept. While such technology are not currently a standard feature in new model vehicles, they are increasingly common and will likely comprise a significant percent of the new model vehicle fleet in the coming years. In addition to improving safety, these technology systems yield a significant amount of data that can be used for DBF assessment. The Project represents an initial step in assessing how CAV systems might be integrated within a future DBF system and showed that it is technical feasible. However, private sector business models for CAV service provision are still under development. Private sector CAV services may be viable under the existing model of individual vehicle ownership, or they may be shown to be to more viable in fleet-based service approaches. Furthermore, state and local agencies are still exploring how to deploy CAV safety and system management approaches within their existing infrastructure. Given these unknowns, Minnesota's initial study of CAV systems as a potential platform for DBF implementation is fortuitous. In addition to funding usage-based pilots through the IIJA, the federal government has made several funding opportunities available for states to study and implement CAV-based systems.

6.5 RECOMMENDATIONS AND PATH FORWARD FOR DBF IN MINNESOTA

The Project demonstrated DBF feasibility within a relatively narrow range of alternative mobility service models; namely carsharing. However, there are numerous other fleet-based and telematics-based services which might eventually support DBF implementation. As a next step, MnDOT will develop a larger-scale demonstration with a more diverse range of emerging and existing fleet vehicle owners across the entire State. This is consistent with MnDOT's overall approach to developing DBF that accounts for changes in vehicle propulsion and DBF assessment technology while maintaining the fuel tax (Figure 29).

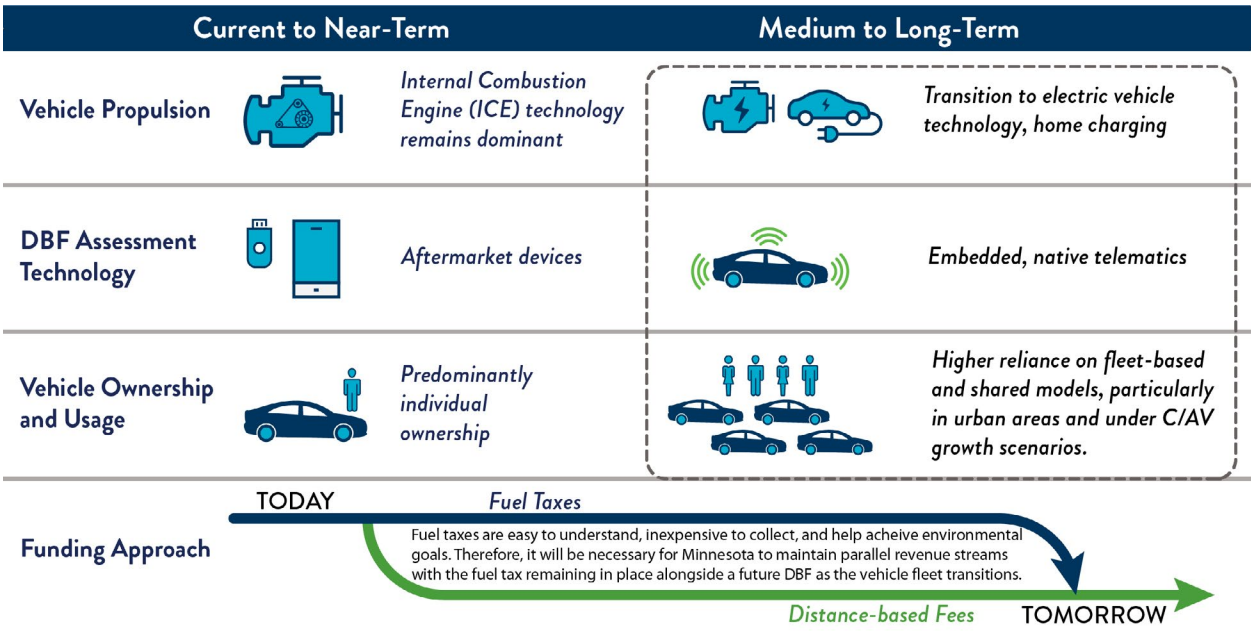


Figure 27: Charting a Path Forward for Minnesota DBF

Further, while it is possible to develop small-scale, focused projects that would address unresolved questions and issues either individually or collectively, a large-scale deployment across the State would be the best use of funding and the most effective way to mature the DBF concept both in Minnesota and nationally. Instead of answering questions piecemeal, a large-scale deployment would simultaneously address the above questions while testing issues and systems explored in the Project at a much larger scale.

For example, while a demonstration of similar scope to the Project with delivery partners such as DoorDash and Postmates would provide a use case for an additional DBF business model, it would only provide marginal learning relative to a broad deployment that includes innovative delivery services as well as municipal, freight, ride-hailing and other emerging fleet services. A broad-based approach including numerous types of fleet services allows for system testing at a scale which cannot be provided in a demonstration similar in size to the Project. Similarly, a larger-scale demonstration would yield much better insights on administrative costs and efficiency relative to smaller-scale deployments focused specifically on administrative efficiency.

At scale, an exploration of the issues discussed throughout this report would provide the most meaningful and closer-to-real-world results and lessons learned for the DBF concept both in Minnesota and nationally. To move forward with this full-scale demonstration, MnDOT will do the following:

- **Share** – Disseminate the results of the Project locally and nationally to educate and build community with relevant stakeholders.
- **Plan** – Create the technical project documents required to procure necessary services to develop, implement and evaluate the larger-scale DBF project including a scope of work and budget that identify funding sources, necessary Project Team members, and other required components and services.
- **Advocate** – Perform legislative advocacy and education to promote and fund DBF projects in Minnesota.
- **Support** – Convene state and local government, nonprofit, academic, and other interested third-party stakeholders to build community support for the DBF concept.
- **Partner** – Develop partnerships with existing and emerging vehicle fleet owners that operate in Minnesota and other organizations required to deploy the Project to engage in a larger-scale DBF demonstration.

7. CONCLUSION

The MnDOT DBF Project was created to address potential transportation funding challenges posed by emerging transportation technology and business models because of the declining revenues from the motor fuel tax. Specifically, the risk to the motor fuel tax is posed by the confluence of future developments of increasingly fuel efficient and alternative fuel vehicles such as electric vehicle (EV), automated vehicles (CAV), and emerging shared mobility (SM) business models.

Coupled with the decision to not raise the motor fuel tax despite a growing need in the face of declining purchasing power (a result of inflation), the motor fuel tax is becoming a less effective revenue source because drivers can drive more miles, and pay less per mile, due to improving fuel economy. If no adjustments are made, Minnesota's fuel tax revenues are expected to decline at least 0.05 percent per year for the next 20 years. While the motor fuel tax approach follows the original "user pays, user benefits" principle, the motor fuel tax model, as it is currently designed, can no longer provide a sustainable revenue source.

Further, as EV, CAV, and SM business models and technology continue to develop, this is expected to exacerbate the issue of people driving more miles at a lower fuel cost per mile. SM services and AV technology are expected to reduce vehicle ownership while increasing vehicle miles traveled (VMT), given the ability for more people to access transportation services. Meanwhile, EVs avoid paying a motor fuel tax altogether and are expected to be increasingly incorporated into public and private vehicle fleets.

To address these issues and achieve its goal — and building on the last several years of research and demonstration programs aimed at leveraging technology and innovation — MnDOT designed this Demonstration to continue a migratory approach towards identifying new ways to use, own, and pay for transportation infrastructure.

The Project Team developed a concept to confirm the ability to accurately and securely collect travel data from an SM provider's vehicle fleets and assess a DBF for use of the roads. During the Project, SM Providers collected mileage, location, and fuel consumption information from participating vehicles. The SM Providers then sanitized and aggregated the data for each vehicle, calculated the assessed DBF, subtracted the State and federal motor fuel tax based on the number of gallons purchased in Minnesota, and presented a series of financial reports and an invoice to the State that showed the net DBF charges due. The reports and invoices were sent electronically via a predefined format and transmission method to the MN Department of Revenue. The department reviewed for accuracy, assessed the charges, and conducted audits as necessary to validate the information provided by the SM Provider. All DBFs assessed were simulated over the course of the Project.

APPENDICES

Appendices are available online on the Minnesota Department of Transportation Distanced-Based Fees website at the links below.

Appendix A: Concept of Operations

Appendix B: Proof-of-Concept Test Procedures

Appendix C: Business and Systems Requirements Document

Appendix D: Interface Control Specifications Document

Appendix E: Test Plan

Appendix F: Test Results Memorandum

Appendix G: Proof-of-Concept Report

Appendix H: Fuel Tax Credit Assessment Options Memorandum


WSP

MINNESOTA DEPARTMENT OF TRANSPORTATION

MINNESOTA DISTANCE BASED USER FEE DEMONSTRATION PLAN

Concept of Operations

VERSION 2.2

MARCH 2020

wsp

DEPARTMENT OF TRANSPORTATION

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REVISIONS

VERSION	DATE	CHANGES
1.0	9/14/2018	Incorporated grammatical edits received after 90% ConOps workshop.
	9/20/2018	Incorporated remaining edits and addressed all comments received.
1.1	10/5/2018	Revised version submitted as final
2.0	10/24/2019	Revisions following completion of Proof of Concept and initiation of Demonstration phase
2.1	01/24/2020	Revisions following MnDOT and Revenue review
2.2	03/02/2020	Revisions to project goals language

TABLE OF CONTENTS

ACRONYMS

CAN	Controller Area Network
C/AV	Connected/Automated Vehicle
ConOps	Concept of Operations
COOP	Continuity of Operations plan
CSV	Comma Separated Value
DBUF	Distance-Based User Fee
DUA	Data Use Agreement
EPA	Environmental Protection Agency
FAST	Fixing America's Surface Transportation
FHWA	Federal Highway Administration
GAAP	Generally Accepted Accounting Principles
GPS	Global Positioning Satellite
HUTDF	Highway User Tax Distribution Fund
IGA	Intergovernmental Agreement
ISO	International Organization for Standardization
ITS	Intelligent Transportation Systems
JSON	Java Script Object Notation
MnDOT	Minnesota Department of Transportation
MOU	Memorandum of Understanding
MPO	Miles per Gallon
NDA	Non-Disclosure Agreement
PCI DSS	Payment Card Industry Data Security Standard
PII	Personally Identifiable Information
Revenue	Minnesota Department of Revenue
RUC	Road Usage Charge
SM	Shared Mobility
SSAE	Statement on Standards for Attestation Engagements
STSFA	Surface Transportation System Funding Alternatives
TAC	Technical Advisory Committee
TNC	Transportation Network Company
TPEC	Transportation Policy and Economic Competitiveness
VIN	Vehicle Identification Number
VMT	Vehicle Miles Traveled
XML	eXtensible Markup Language

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1 INTRODUCTION

Minnesota, like many other states, is at the precipice of a major transportation funding shortfall. A perfect storm of issues has created a current and projected shortfall in Minnesota's Highway Users Tax Distribution Fund (HUTDF):

- An increase in vehicle fuel efficiency and the influx of electric vehicles
- An increase of vehicle miles traveled (VMT) combined with declining purchasing power for transportation improvement projects
- A lack of consistent increases to the per gallon state excise tax to keep pace with inflation

The adoption of shared mobility (SM) services, such as car share and ride-hailing, presents both challenges and opportunities for MnDOT, as well as other owners and operators of infrastructure within the State of Minnesota. The SM business model is one that promises reduced car ownership by allowing users to pay-by-trip, a model that has been rapidly adopted by urban dwellers across the nation. This fleet-oriented business model's future is linked with electric and automated vehicles—vehicles that are highly efficient, and thereby promise to lessen revenue collected through the current gas-tax centric state HUTDF funding model.

SM provider's advancement in trip data collection and seamless, integrated payment, provides new opportunities for transportation infrastructure revenue collection. SM providers charge users a usage-based travel fee, similar to that of the Distance-Based User Fee (DBUF) concept. Many SM providers charge users a per-mile trip charge and have in-place hardware and software systems to calculate per-mile charges. Given support from SM providers, these systems could be leveraged to further evaluate DBUF feasibility and demonstrate how the use of onboard and embedded technology could greatly enhance the efficiency of DBUF collection. Thus, SM platforms pose a unique opportunity to evolve the highway funding structure in a rational, scalable, and efficient way.

Over the last several years, the Minnesota Department of Transportation (MnDOT) has conducted several research and pilot programs aimed at leveraging technology and innovation to support new ways of using, owning, and paying for transportation. This includes evaluating alternative financing and technology system solutions including launching one of the first-in-the-nation DBUF pilots; piloting rural intersection safety using connected vehicle technologies; and initiating its Connected Corridor Program.

In partnership with the University of Minnesota's Humphrey School of Public Affairs (Humphrey School), MnDOT is exploring how a DBUF, combined with SM, could be used to supplement other user taxes currently collected from drivers that use the state's roads. This work includes the compiling of a concept of operations (ConOps) and implementation of the proof of concept, which will culminate in a larger scale demonstration of the DBUF concept implemented on partner SM providers. Ultimately, the proof of concept and the larger scale demonstration could, with the proper legislative support, culminate in a highly efficient revenue collection mechanism that supports social and technological evolution, provides a more equitable and sustainable funding mechanism and can be used as a model both for deployment statewide and national consideration.

1.1 DOCUMENT PURPOSE AND INTENDED USE

This ConOps document provides a high-level overview of the DBUF demonstration proof of concept and associated larger scale demonstration. As identified within the Systems Engineering "V-Diagram" below, it is often the first engineering document produced in the systems development process. Among other items, this ConOps will identify the following:

- DBUF proof-of-concept and demonstration vision, goals and objectives
- Concept need, including related issues and needs that the demonstration concept must address
- Understanding the recommended concept
- Stakeholder oriented scenarios used to elicit the feedback required to develop the demonstration concept and gain consensus.

This ConOps also acts as the springboard for future planning, development and implementation activities and supports understanding of these activities. To this extent, this ConOps feeds into these activities and builds quality into the future system should the demonstration be proven successful.

The ConOps also provides stakeholders with a clear plan from which they can collaborate, exchange ideas, provide feedback and ultimately gain consensus on how to proceed with demonstrating the DBUF concept. Thus, the ConOps is written in a non-technical manner and focuses on clarifying stakeholder roles, responsibilities and project phases. The ConOps will establish how these stakeholders align with each phase, including roles and responsibilities in the context of implementing, operating, and maintaining the individual components of the proof of concept and demonstration system. In this manner, the ConOps helps flesh out operational needs early in the concept's design and reduces the need to revisit this stage as the concept is being designed/demonstrated, which consequently may result in cost overruns and/or schedule delays.

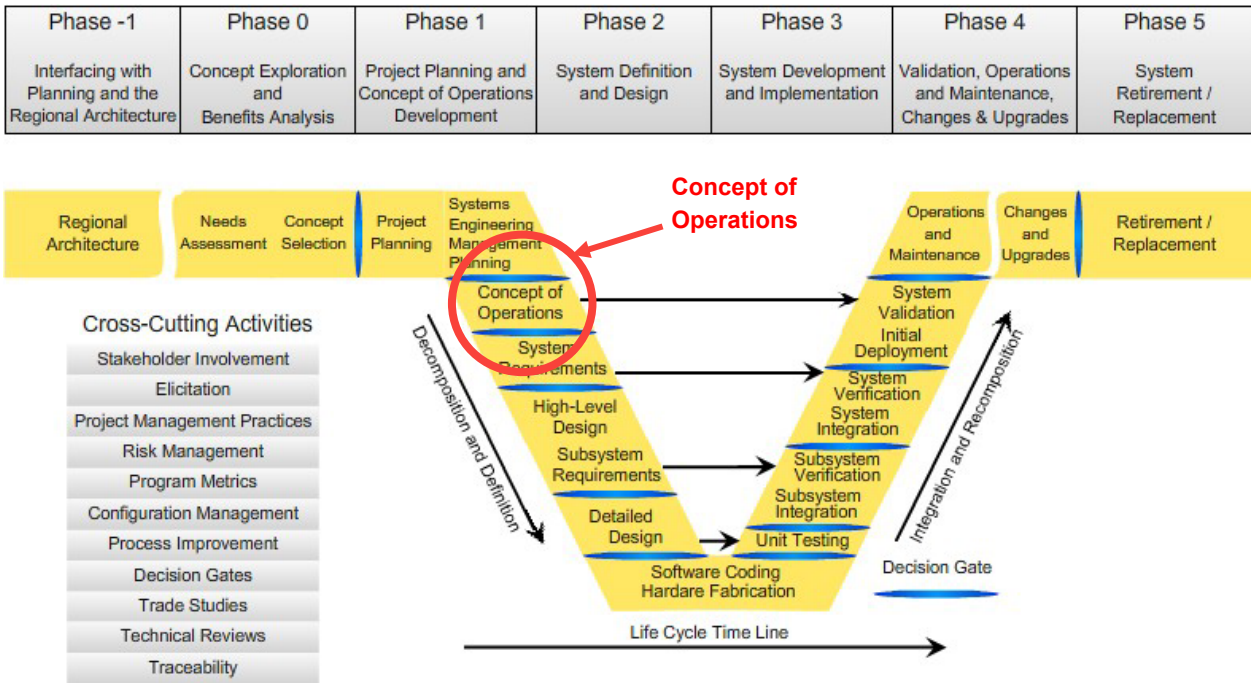


Figure 1: Systems Engineering V-Diagram

The ConOps does not describe specific technologies or technical details, many of which will be investigated as the parties move forward with the deployment phase. The ConOps is not intended to be a design document but rather addresses the high-level questions that are associated with the project that need to be answered before the concept is designed and ultimately demonstrated. To this end, the ConOps represents the transitionary step that occurs between the time the concept is proposed and when it is formally designed/demonstrated. The ConOps begins to answer the who, what, where, why and how questions that surround the DBUF concept. Because the ConOps acts as the transitionary step between concept exploration and concept design, it is important that the high-level characteristics and institutional understanding of the system are fleshed-out and that related details are communicated to all stakeholders potentially impacted by its implementation.

1.2 CONTENTS

This ConOps is organized per the American National Standards Institute standard outline for developing ConOps documents for ITS/technology projects. This outline is widely accepted by practitioners as a suitable outline for developing new systems. A brief description of each section included within this ConOps is provided below.

Section 2: Project Scope – This section provides an overview of the DBUF demonstration project. Included is a high-level description of the project, a description of its purpose, stakeholders, and geographic area to be covered.

Section 3: Referenced Documents – This section identifies and briefly describes documents that were referenced in developing this ConOps and that provides a context in the understanding of prior events leading up to the development of this ConOps and/or offer understanding of DBUF-related issues.

Section 4: Background – This section provides a brief description of existing revenue collection practices that MnDOT relies on to operate and maintain its transportation systems, as well as its limitations as a sustainable solution to adequately meet future needs.

Section 5: Operational Needs - This section identifies and describes users, state, and SM provider needs as they relate to successfully demonstrating the DBUF concept.

Section 6: Vision, Goals, and Objectives – This section provides the vision, goals, and objectives for the DBUF demonstration, as derived from the Operational Needs provided in Section 5.

Section 7: DBUF Concept Understanding – This section provides a recommended approach for collecting DBUFs and describes the operational concept for demonstrating it. It also describes the various agencies that have a stake in the concept and their roles and responsibilities with respect to design, implementation and operation of the concept.

Section 8: Operational Scenarios – This section identifies a range of possible scenarios in which the demonstration system is expected to operate, defining the sequence of events expected to occur under each scenario and the roles and responsibilities for completing activities defined from individual user perspectives.

Section 9: Operational and Support Environment - This section describes the physical environment in terms of facilities, equipment, hardware, software and personnel, operational procedures and support necessary to operate the demonstration system.

Section 10: Failure Scenarios – This section identifies potential failure scenarios for the DBUF demonstration. The scenarios captured in this section relate to the three key technology components of the demonstration system: vehicles, account management systems, and reporting.

1.3 TARGET AUDIENCE

This ConOps is primarily intended for those stakeholders who own and operate systems and equipment that will comprise either the proof-of-concept and/or the larger scale demonstration system. The primary audience that this ConOps is oriented includes:

- State of Minnesota
  - Department of Transportation
  - Department of Revenue
  - Department of Public Safety
  - Public Information Office
  - Office of Information Technology
- University of Minnesota, Humphrey School of Public Affairs
- SM providers
- Technology providers
- MnPass

In addition to the primary audience, there are several secondary entities whose interests and/or operations may be directly or indirectly affected by the demonstration. These entities include, but may not be limited to the following:

- Policymakers including State, Regional and legislators
- The Metropolitan Council and other metropolitan planning organizations within Minnesota
- Other States including other State Departments of Transportations
- Federal Highway Administration (FHWA)
- Other State of Minnesota Departments including the Department of Air Quality
- Academic institutions
- Engineering firms and consultants

Lastly, entities that are not directly involved or affected, but should be apprised on the demonstration activities include:

- The Public
- Media
- Private companies and business owners including 3M, Target, and the MAYO Clinic
- Professional organizations including the American Automobile Association

2 PROJECT SCOPE

Minnesota has a vision for exploring a sustainable transportation funding model, around the integration of three emerging trends – Shared Mobility (including various aspects of car sharing, ride-hailing, and vanpooling services), electric vehicles, and vehicle automation – with a distance-based fee. In 2017, MnDOT was awarded a STSFA grant in the amount of $300,000.00 to explore ways to plan and design for a DBUF with a SM provider. Subsequently, in 2018, MnDOT was awarded an additional STSFA grant on the amount of $999,600 to implement a 12-month DBUF demonstration. The STSFA grant requires a 50% local match, resulting in $2,599,200 in total project funding. In response to receiving the grant, Minnesota is partnering with SM provider(s) to develop a per-mile fee mechanism that utilizes telematics already embedded in SM provider vehicles (e.g., no new systems will be built, no new hardware will be needed in the vehicle).

This concept will be demonstrated to assess the feasibility of replacing and/or supplementing other user fees now collected from drivers for the use of Minnesota's roads. For example, various aspects of fee collection, including fuel taxation, registration fees, leasing, rental, insurance, and other aspects of vehicle use, may also be eligible for conversion to a DBUF under the context of SM. This concept is being pursued by MnDOT to create a highly efficient revenue collection mechanism that recognizes the future trajectory of social trends and technology, and one that can be used as a model for deployment.

It is assumed that the convergence of SM, electric and automated vehicles will profoundly affect the way Minnesotans uses, owns, and pays for transportation in the future. It is also assumed that technologies already onboard many new vehicles (or soon to be) can collect, process, and share data easily and cost effectively. This capability provides the pathway toward wider deployment of DBUFs, and importantly, will show how these fees can be collected as efficiently and cost-effectively as possible using reliable and secure technologies already embedded in vehicles.

2.1 PROJECT PURPOSE

The goal for developing this project is to design, test and prove a DBUF structure to support the sustainability and long-term solvency of the State, and possibly, the Federal Highway Trust Fund. The intent is to explore how DBUF-related data could be accurately and securely transferred between a SM provider and the Minnesota Department of Revenue (Revenue), as well as better understand how this style of fee implementation would impact SM providers.

The project will have two phases.

Phase 1 – Proof of Concept: The project will explore how DBUF-related data could be accurately and securely transferred between a SM provider and the State, and to understand how a DBUF would technically impact SM providers and if the transmission is even possible.

Phase 2 – Demonstration: The Phase 2 deployment will focus on executing a larger scale demonstration of the SM DBUF collection system proof of concept designed in Phase 1. This will also include capturing public opinion, education of residents, and identification of any organizational or administrative gaps and key considerations to address moving forward.

Ultimately, the State of Minnesota expects to use a successfully proven design to demonstrate how a SM DBUF can address administrative efficiency, privacy, technological obsolescence and other issues identified in previous pricing demonstrations and pilots.

Through partnerships with SM providers, the larger scale demonstration project will lead to:

- Confirmation of the reliability and security of SM technology and the potential for integration of that technology with state fee collection systems;
- Development of an appropriate pricing structure (within given constraints) for various classes of vehicles, time of day and other variables;
- Development of a standard for highly efficient and effective collection of DBUFs; and
- Development of a plan that charts a path forward to validate the feasibility of DBUFs, a blueprint for future demonstrations, deployments, partnerships, applications, etc.

The State of Minnesota intends to research, demonstrate and examine the necessary policy and technical considerations needed for developing a DBUF, where users would pay certain road use fees on a per-mile usage basis, as opposed to fixed fees. This project also strives to simplify the driver-technology interface and to demonstrate a significant reduction in technology costs and the cost of operations over previous user-based fee demonstrations.

2.2 PROJECT SCHEDULE AND PHASING

In Phase 1, the DBUF proof of concept was demonstrated, conducted between the fourth quarter of 2018 and first quarter 2019. During the proof of concept, data was analyzed and a formal report developed. Based on a successful demonstration of the proof of concept, the project moved to Phase 2, consisting of a larger demonstration of the DBUF proof-of-concept tested in Phase 1. The larger scale DBUF demonstration is expected to begin in Spring 2020, based on the concept's final design, and procurement and negotiations with SM providers.

The larger scale Phase 2 demonstration is expected to last 12 months, to account for a seasonal considerations and to provide a robust data set for analyses of feasibility and potential pricing schemes and policy considerations. Assuming an April 2020 launch date, the demonstration will conclude in March 2021, with an additional 1-3 months for demonstration evaluation and final reporting.

2.2.1 PHASE 1: PROOF OF CONCEPT

In Phase 1, MnDOT partnered with a SM provider to collaboratively evaluate and design the necessary supporting systems and back office protocol to support a DBUF trial that is both publicly and politically supported. Additionally, this phase involved designing a feasible and affordable DBUF focused on the future of personal travel, as well as creating and leveraging partnerships to demonstrate how existing onboard technologies can be used to collect a DBUF. Phase 1 activities were conducted in 2018 and 2019, with the proof of concept operations lasting two months. Specific activities tied to Phase 1 included:

- Recruitment of SM provider(s)
- Modeling of pricing strategies
- Design of back office operations, protocol, and software

- Stakeholder analysis and outreach
- Multi-modal pricing options
- Development and execution of legislative strategies
- Planning and design for deployment in Phase 2 demonstration

MnDOT, in partnership with the Humphrey School and WSP USA, planned the proof of concept to address the immediate goals and objectives of the 2017 STSFA grant, and preliminary needs of a larger scale demonstration. MnDOT and its partners engaged in activities to understand stakeholder needs determine direct and indirect impacts to stakeholders, and to ensure a shared understanding moving forward.

2.2.1.1 PROOF OF CONCEPT DURATION AND SAMPLE SIZE

The proof-of-concept was conducted over a 2-month period. During this time, data was constantly collected (i.e., 24 hours a day, seven days a week for a total of 14 calendar days) from SM provider participating vehicles. MnDOT coordinated with SM provider to transmit raw trip data for the purpose of data analysis and verifying that required data can be easily transferred between the SM provider and the State.

2.2.1.2 PROOF OF CONCEPT RESULTS

The Proof of Concept was successful in meeting defined goals and objectives. MnDOT partnered with a SM provider to accurately and securely collect, sanitize, and transfer DBUF-related data using existing systems. From the 70 participating vehicles, 4,633 unique trips were taken, totaling 103,550 miles traveled and 3,542 gallons of fuel purchased. The data was used to create simulated invoices, assessing a DBUF of miles traveled and crediting fuels tax on gallons purchased. Revenue reviewed the simulated invoices and related data to determine potential integration with existing tax collection systems and processes and to confirm auditability.

Tests were also executed with a connected/automated vehicle (C/AV) research partner, logging 43 trips, 1,716 miles, and 79 gallons of fuel. For one of the logged trips, the C/AV research partner conducted a live data polling test. The C/AV collected, aggregated, and transmitted mileage and fuel consumption information on a second-by-second basis during the vehicle's travel using existing wireless connectivity. This short (25 minute) test confirmed the capability to send live data directly from a vehicle's embedded telematics systems, which can support several potential use cases, including real-time value-added services.

The Humphrey School also developed a framework for DBUF pricing schemes, further defined in the Humphrey School's Pricing Schemes Task 3 Report.

2.2.2 PHASE 2: LARGE SCALE DEMONSTRATION

Where Phase 1 demonstrates the DBUF concept can be done, the Phase 2 deployment, estimated for the 2020-2021 year, explores demonstrating the system at a larger scale. Prior to beginning the large-scale demonstration, MnDOT, working in collaboration with its partners, will develop a demonstration plan that clearly defines the demonstration's scope, budget, schedule, stakeholders, procurement alternatives, necessary resources and staff, risk management plan and communication and outreach plans.

It is anticipated that the large-scale demonstration conducted under Phase 2 will require additional resource commitments, funding, and possibly legislative authorization. Possible tasks include negotiation and execution of agreements, software development and testing, and other technical support as needed. Cost estimates for the demonstration will also be developed.

2.2.2.1 DEMONSTRATION DURATION AND SAMPLE SIZE

The demonstration project is expected to capture trip data from a SM provider's local (i.e., Minneapolis) vehicle fleet and may be expanded to include other connected/automated vehicle research fleets or other SM providers. These fleets will include several different vehicle classes and fuel efficiencies. The expected vehicle fleet size could be upwards of 200.

Vehicles are considered the participating entity for the purpose of the demonstration, regardless of number of customers using a particular SM vehicle.

2.3 GEOGRAPHIC COVERAGE

DBUFs will be assessed for all vehicle miles originating in Minnesota and driven both within and outside the State of Minnesota for both the Phase 1 Proof of Concept and the Phase 2 Demonstration. Customers that use participating SM provider vehicles will not be geographically constrained in their travels; interstate travel will be possible.

It is technically possible to assess fees on miles driven only within the State, though possibly outside the goals and objectives of the demonstration. SM providers may share location data as part of their trip dataset which MnDOT can use to geofence Minnesota's state lines and assess fees on miles driven only within the State. The assignment of fees based on miles traveled within the state or total miles will be invisible to users (i.e., miles will be aggregated based on vehicle and not be individual user). Detailed location-based travel may be implemented in the proof of concept and/or demonstration to conduct location-specific analyses and pricing scheme development.

3 REFERENCED DOCUMENTS

This ConOps was developed from several meetings with Minnesota stakeholders, SM providers, and key reference documents (listed below). The reference documents listed below provide the history of DBUF in Minnesota and provide context into how the DBUF efforts in Minnesota have evolved over the course of several years. The documents used as a reference in the development of this ConOps include:

- *Report of Minnesota's Mileage-Based User Fee Policy Task Force (December 2011)* -- The Mileage-Based User Fee (MBUF) Policy taskforce report presents the agreed upon policy objectives and the 6 recommendations voted and adopted by the taskforce. The report also presents a minority opinion section.
- *Mileage-Based User Fee Policy Study: Supporting Technical Information (April 2012)* -- The document serves to complement the aforementioned MBUF Policy Task Force Report; it summarizes activity within and inputs informing all phases of the MBUF Policy Study process, including findings from Greater Minnesota listening sessions; 2011 MBUF Symposium in Breckenridge, CO; perspectives from national experts; national expert and transportation finance roundtable events; Internet panel survey of Minnesotans; and additional targeted outreach.
- *Connected Vehicles for Safety, Mobility, and User Fees: Evaluation of Minnesota Fee Test (February 2013)* – This document provides a summary of the 2011 Mileage-Based User Fee study, and evaluation of its findings, and considerations provided by the evaluation team on the effectiveness of the MBUF pilot in Minnesota.
- *Connected Vehicles for Safety, Mobility, and User Fees: Operational Summary Report (February 2013)* – This document provides a summary of the 2011 Mileage-Based User Fee study including the operational considerations, project activities, and key policy and business considerations captured during the demonstration.
- *2016 Minnesota Distance-Based User Fee STSFA Grant Application (March 2016)* – This document is the proposal developed by MnDOT to acquire federal funding to support the development and planning for this DBUF demonstration.
- *MnDOT Distance-Based User Fee Proof of Concept Report (March 2019)* – This document provides an overview of the scope, approach, results and takeaways from the DBUF proof of concept concluded in early 2019.
- *MnDOT Distance-Based User Fee Demonstration Implementation Plan (January 2019)* – This document services as the implementation plan for the 12-month DBUF demonstration, defining the goals and objectives, key milestones and deliverables, evaluation strategy, stakeholder goals, and systems and resources necessary to support the demonstration.

4 BACKGROUND

The Minnesota state highway system consists of interstates, U.S. highways, and Minnesota highways. State transportation revenues, predominantly the state gas tax which accounts for almost 45% of generated revenue, provide the largest funding source for capital, maintenance and operations activities. Federal programs are also a significant source of funding for the state system, making up about 25 percent of the funding for capital projects.

In Minnesota, as in most other states, fuel taxes are collected from distributors who then pass that cost along to retailers, and subsequently, the customers. These taxes are easy to pay and easy to collect but are largely hidden from the consumer because the tax is contained within the per gallon cost of fuel. Because fuel taxes must be paid to receive the fuel, administrative costs of collecting the fuel tax are relatively low. Despite the low administrative costs, concerns have been raised regarding the ability of the motor fuel tax to sustain and expand Minnesota's roadway transportation system. Vehicles are increasingly using less gasoline/diesel fuel, and that trend is expected to continue. Additionally, the number of vehicles that use alternative fuels, some of which are subject to lower tax rates, will also increase over time. Decreasing reliance on petroleum-based fuels and greater fuel economy is a good development for the environment. However, a diminishing use of fossil fuels combined with an increasing use of alternatively powered vehicles will inevitably result in less motor fuel tax revenue available to directly fund the preservation and expansion of Minnesota's roadway transportation system.

The HUTDF also receives revenue from the Motor Vehicle Registration Tax and the Motor Vehicle Sales Tax. The Motor Vehicle Registration Tax is an annual tax based on a vehicle's value (cars, pickup trucks, vans) or weight (trucks, tractors, trailers, buses). Electric vehicles pay a $75 surcharge. The Motor Vehicle Sales Tax is paid on the purchase price of a motor vehicle required to be registered in Minnesota. Revenues from the tax are split between the HUTDF (60%) and a Transit Assistance Fund (40%).

Born from the need to fill gaps in transportation revenue left by electric and alternative fuel vehicles, MnDOT has undertaken several studies that explore the feasibility of a DBUF. These studies, which are described at a high level in the following section, have led to the development of the DBUF concept outlined in this ConOps.

4.1 WHY USER FEES?

MnDOT recognizes the unsurpassed efficiency of the motor fuel tax and its long and durable history. The motor fuel tax has been the primary source of highway revenue since the 1920s and it continues to support roadway projects. With the advent of new sources of energy, and the increase in fuel efficiency, the long-term viability of the motor fuel tax is in question. On average, drivers can drive more and pay less per mile of travel.

The quick and rational approach to solving the problem of diminishing revenue is to increase motor fuel taxes to levels commensurate with the efficiency trends and the necessary inflationary adjustments, recognizing that alternative energy sources require special treatment. This has always been the prerogative of Congress and the States, which, some argue, have chosen to ignore or inadequately address these issues.

Political leaders have argued not to raise the motor fuel tax in the face of growing needs. This belief is that growing fuel efficiency and the emergence of alternative energy sources for motive power would

blunt any such increases, and inequities that may result. Although true, all user-based fee alternatives suffer from the same deficiencies if not designed to include sophisticated features such as allowances for vehicle weight, time-of-day, and very importantly, an inflation adjustment mechanism aka, indexing.

Minnesota's approach suggests the motor fuel tax, with all its advantages and deficiencies, is likely to continue for a long time. It is challenging to design a solution for universal replacement of the motor fuel tax that begins to approach its simplicity and efficiency. The cost of collecting the motor fuel tax in Minnesota is less than 0.5 percent of the fees collected. By the most optimistic forecasts, the cost of operations and retro-fitting vehicles with technology, as well as setting up the appropriate enforcement structures for a mileage-based fee, is likely to be in the range of 5-10 percent of total fees collected.[1] By comparison, the motor fuel tax, while imperfect, is likely to remain in place for a long time.

The approach Minnesota is taking to migrate toward user-based fees is sensible and nimble since it allows societal and technological trends to drive the change. SM is the change agent. It recognizes that a methodical migration to user-based fees will be incremental and is the path of least resistance. It will use onboard technology and communications capacity, not create new and expensive technology and back-office systems with increased administrative costs. It also recognizes that continuation of current trends in fee collection, if left unchanged, will likely be inadequate in the future. A new path toward a fair and rational user-based fee system must be charted.

4.2 PREVIOUS STUDIES

MnDOT's study of DBUFs dates back to 1995. In May of 2007, MnDOT conducted a research study to gauge public opinion about a MBUF alternative to the current motor fuel tax. Interviewees included transportation experts as well as the general public. Eight transportation experts participated in an online discussion about the issue and 10 focus groups (six in the Twin Cities Metro area and two each in Duluth and Mankato) totaling 89 people provided feedback.

In August 2008, MnDOT conducted nine mini-focus groups (five in the Twin Cities Metro area and two each in Duluth and Mankato) with Minnesota drivers to understand the perceptions and level of acceptance among participants about the implementation of a MBUF.

In June and July 2009, MnDOT conducted 821 phone-mail-phone interviews with Minnesota drivers selected by random sample augmented by drivers of hybrid vehicles to better gage their understanding of funding of transportation issues.

In May 2011, MnDOT began conducting technical research of the MBUF in a Minnesota Road Use Test. Five hundred people from Hennepin and Wright Counties tested technology that could collect a mileage-based user fee. The research provided important feedback from motorists about the effectiveness of technology in a car or truck to gather mileage information. Results helped public policy leaders understand the challenges and opportunities in such a system.

Volunteers in the study used a Smart Phone with a GPS application in their vehicle. The phone was programmed for motorists to submit information. MnDOT used that information to evaluate whether the device provided timely, reliable travel data for a specific trip. In addition, the test examined whether other

[1] Background for the Per-Mile Road Usage Charge in the USA; Presentation for the IBTTA Transportation Finance and Road Usage Charge Conference Portland, Oregon. April 26, 2015

applications, such as real-time traffic alerts providing information on construction zones, crashes, congestion and road hazards, were effective in communicating safety messages to motorists. Three different groups of volunteers tested the devices for six months each.

The technical research was designed to record miles and road use while strictly protecting the privacy of participants. Participant names, data that identifies their vehicle, financial account information, travel routes, days and times of trips were classified as not public by the Minnesota Department of Administration to ensure the research and results were valid. The research concluded in December 2012, and the results were made available to the public.

4.3 LOOKING FORWARD – THE MINNESOTA SHARED MOBILITY MODEL

By some predictions, SM will account for 35 percent of all personal travel by 2030 and perhaps as much as 90 percent by 2040[2]. Although relatively small at this time, various forms of SM are already impacting the way Minnesotans interact with the transportation system through ridesharing providers and car sharing services.

Discussions with car-sharing providers in the Twin Cities revealed that more than 2,000 drivers are already subscribers. These services are significant in their own right. However, when coupled with emerging fully automated vehicle technologies they stand poised to significantly impact personal mobility in a relatively short timeframe. This shift also offers a unique opportunity to develop a model that could positively and equitably change the user fee structure for the nation's highway system.

Currently in Minnesota, as in most other states, highway user taxes (fees) are collected from fuel distributors who pay taxes based on the number of gallons purchased by consumers at the gas pump. Based on the amount of gas purchased, the fees are easy to pay and collect but are largely hidden from the consumer. The SM model flips this paradigm and charges vehicle drivers distance-based fee for use of the roadway. This fee would be built into the provider's vehicle use fee structure that is charged to the consumer. SM providers will collect the distance-based fee portion of the charge and will pay it directly to the State of Minnesota. It essentially eliminates direct collection from thousands or even millions of drivers, as proposed for more traditional Mileage-Based User Fee (MBUF) or Road Usage Charge (RUC) programs.

Minnesota proposes to partner with SM providers to develop a per-mile road user fee mechanism that uses telematics and GPS technology. These are currently embedded in SM vehicles to automatically calculate and collect the fees. This technology has enormous capability to efficiently deliver a user-based fee system and will require virtually no driver-vehicle interface beyond what is already required of the driver. Fees charged can vary by vehicle type, roadway type, jurisdiction, and/or time of day. Because fees are collected from SM providers and not individual drivers, costs for administration, fee collection, and enforcement are substantially lower than other user-based fee models where individual vehicle owners are invoiced for miles driven.

[2] Navigant Research. Autonomous vehicles: self-driving vehicles, autonomous parking, and other advanced driver assistance systems: global market analysis and forecasts, 21 August. http://www.navigantresearch.com/research/autonomous-vehicles (2013). Accessed 26 September 2018.

5 OPERATIONAL NEEDS

This section will focus on defining the state, user, and SM provider needs. The original vision is presented, along with key goals and objectives for the demonstration.

5.1 STATE NEEDS

The overarching need for Minnesota is a reliable DBUF system that accurately collects, assesses, and transfers DBUF from SM providers accurately and cost effectively. Previous meetings with State of Minnesota staff resulted in several system considerations such as:

- Flexible to accommodate multiple SM options (car share, ride-hailing)
- Leverage existing SM provider technologies
- System and network reliability
- Accuracy in the collection, processing, and transfer of data and funds
- Auditable
- Safeguards against unauthorized data dissemination
- Cost effective to administer and manage
- Increase public awareness and education on transportation funding
- Expand collaboration with SM providers
- Provide a platform that could be easily used by other states and cities

5.1.1 FLEXIBLE TO ACCOMMODATE MULTIPLE SHARED MOBILITY OPTIONS

The DBUF system must be flexible to accommodate multiple SM options. This includes the ability to collect, assess, and process DBUF charges from car share, rideshare, and transportation network companies (TNCs). The system should support open-platforms where DBUF-related data can be collected and seamlessly shared with Minnesota state agencies without using proprietary protocols. The system should also support scalability, allowing SM providers to enter the market with little to no required customization.

5.1.2 LEVERAGE EXISTING SHARED MOBILITY PROVIDER TECHNOLOGIES

The demonstration system will leverage existing technologies, embedded within shared mobility vehicles and back office systems. No aftermarket technologies will be specifically required to support DBUF collection, as the data should be readily available from other shared mobility provider services. However, there may be rental costs if the State decides to equip vehicles within its vehicle fleet with aftermarket telematics. This decision will be dependent on the ability to partner with a SM provider for the demonstration. If the State cannot partner with a SM provider, they may opt to equip state vehicles with privately owned telematics platforms to demonstrate the DBUF concept.

5.1.3 SYSTEM AND NETWORK RELIABILITY

The fee collection system must maintain a network that supports the accurate collection and reporting of mileage and associated DBUF. This means that the SM provider's systems and hardware must remain available to support daily operations, including data reporting and account management operations, at least a certain percentage of a 24-hour per day, 365-day per year period. Generally, a common network uptime for these types of systems is 99.9% (meaning the system should be operable at least 59.94 minutes every hour of a year). This does not include system outages for regularly scheduled maintenance or situations out of the SM provider's control. Maintenance outages should be scheduled when the system is least likely to impact data collection and retention.

5.1.4 ACCURACY IN THE COLLECTION, PROCESSING, AND TRANSFER OF DBUF DATA AND SIMULATED FUNDS

The accuracy of collection, processing, and transfer of DBUF data and funds between the SM providers and Minnesota state agencies, as well as the accurate calculation of distance-based charges, is a key objective for the success of the demonstration. The ability to accurately capture a vehicle's mileage, correctly process the associated DBUF (at a predetermined per-mile rate), and transfer the data and simulated revenues to the State is paramount. Additionally, the ability to accurately credit any fuel taxes based on fuel purchased or consumed whether it be based on the miles that fuel is consumed, the average EPA miles per gallon (MPG) rating, or simply based on all miles traveled relative to the fuel tax rate is a key objective for the accurate assessment of DBUF charges.

5.1.5 AUDITABLE

The ability to easily and successfully audit a SM provider, as well as maintaining compliance with state and federal standards is another objective. This includes compliance with Generally Accepted Accounting Principles (GAAP) recommendations, policies and recommendations established by Minnesota, compliance with Statement on Standards for Attestation Engagements (SSAE) 18, and any policies required by financial institutions with whom the SM provider may transfer funds, such as Payment Card Industry Data Security Standards (PCI DSS). The ability to audit SM providers will increase the credibility of the DBUF, reducing risk of public distrust adversely impact its viability as a long-term revenue source.

5.1.6 SAFEGUARDS AGAINST UNAUTHORIZED DATA DISSEMINATION

Given the public concern over privacy protection, coupled with recent well-known instances of data network breaches (such as Equifax), the need to safeguard data and the hardware and networks that collect and transfer data from hacking and unauthorized dissemination of data will be a key objective. This includes compliance with industry standards for data storage and network security, such as the International Organization for Standardization (ISO) standard 27001 Information Security Management.

Compliance with these standards (or their equivalents), coupled with penalties for the unauthorized dissemination of data, are paramount in protecting driver and financial information. Therefore, the public needs to be confident in the systems that will house their driving and financial information. These standards should apply to both the shared mobility providers as well as Minnesota state agencies that have access to SM provider systems.

5.1.7 COST EFFECTIVE TO ADMINISTER AND MANAGE

The increased complexity of distance-based systems relative to the fuel tax model leads to concern over increased expenses needed to administer and manage the system. The current fuel tax model costs less than 0.5 percent of collected revenues to administer. Previous statewide RUC pilot projects have conducted analyses that have estimated the cost to administer a program to be between 12 percent and 25 percent of collected revenues. While leveraging a DBUF on SM providers is a specific capability which should reduce overall administrative costs, relative to other RUC programs, Minnesota should also establish a series of cost metrics that the DBUF demonstration can be compared against to determine if the program is cost-effective relative to quantifiable metrics.

5.1.8 INCREASE PUBLIC AWARENESS AND EDUCATION ON TRANSPORTATION FUNDING

The success of any DBUF program will hinge on its acceptance by the public. For the Minnesota DBUF demonstration, this is no different. The DBUF demonstration should provide a platform for educating the public on how Minnesota's transportation network is currently funded, how the HUTDF plays a vital role in ensuring reliable transportation, how the current funding model is not sustainable, and how a DBUF program with SM providers can help bridge the funding gap.

Throughout the demonstration, MnDOT plans to conduct stakeholder and public awareness and education activities. The demonstration provides an opportunity to educate SM customers, members of the public and stakeholders on how a DBUF program could alleviate potential funding shortfalls while maintaining accuracy, reliability, and confidence in technology and data protection.

5.1.9 EXPAND COLLABORATION WITH SHARED MOBILITY PROVIDERS

Given the increases in SM subscribers, and how they may change the overall vehicle ownership model, Minnesota desires to expand collaboration with SM providers operating in the state. For the purposes of the demonstration, MnDOT, the Minnesota Department of Revenue (Revenue), and other state agencies will collaborate with participating SM providers early and often, gathering their key needs and concerns, evaluating any potential risks, and ensuring they are an active partner both through the demonstration as well as for future policy discussions related to transportation funding. In return, SM providers may be compensated for time and expenses.

5.1.10 PROVIDE A PLATFORM THAT COULD EASILY BE USED BY OTHER STATES AND CITIES

As Minnesota is the first state to consider assessing a DBUF with SM providers, there is a desire to provide a model that could be easily adopted by other states and cities. Through this demonstration, the research team intends to create a series of requirements documents (including this ConOps), systems architecture diagrams, and considerations for other states and cities to easily adopt for their own uses.

5.2 SHARED MOBILITY PROVIDER NEEDS

The SM providers will also have specific needs for the DBUF demonstration. As the frontline service provider to users and the liaison to the State, each SM provider will have unique needs and goals for the success of the demonstration. Some considerations related to the needs of the SM providers include:

- Non-intrusive to current operations
- Easily integrated with existing systems
- Improved collaboration with the state
- Manage visibility to potential subscribers

5.2.1 NON-INTRUSIVE TO CURRENT OPERATIONS

The business longevity of the SM providers depends largely on the performance of their operations and customer service components. The DBUF demonstration cannot impede the SM provider's current operations and must provide a way for them to maintain current operations while improving collaboration and visibility to potentially expand their subscriber bases.

5.2.2 EASILY INTEGRATED WITH EXISTING SYSTEMS

Coupled with being non-intrusive to current operations, the DBUF demonstration system must be easily integrated with a SM provider's existing systems. Specific systems' customizations needed for SM Providers to support DBUF should be kept at a minimum and should not require new systems or software to support DBUF data collection, assessment, or reporting. Prior to deploying the demonstration, the research team should collaborate with each SM provider to identify the unique needs and interfaces needed for the demonstration. Any specific data transfers should use industry-standard protocols to prevent unnecessary software or systems customization.

5.2.3 IMPROVED COLLABORATION WITH THE STATE

SM providers also wish to improve their collaboration with the state, and the DBUF demonstration provides the perfect platform to improve that collaboration. The SM providers can leverage this demonstration to help voice their concerns about DBUF, identify any barriers to entering or expanding the SM market, and establish ways that the State of Minnesota can help streamline processes, fees, and policies that may prove cumbersome for SM market expansion.

5.2.4 MANAGE VISIBILITY TO POTENTIAL SUBSCRIBERS

SM providers want to increase their number of subscribers. As such, SM providers' involvement in the demonstration and the shaping of a potential DBUF program will need to be carefully communicated to current and potential SM subscribers to ensure it does not negatively impact SM providers. A SM provider's involvement in the demonstration may provide an opportunity to promote SM provider services and support increases in subscriptions. MnDOT and its partners will work closely with participating SM providers to craft messages about transportation funding, DBUF and the demonstration.

6 VISION, GOALS, AND OBJECTIVES

Based on the needs provided above, the following vision, goals, and objectives for the DBUF demonstration are established.

6.1 VISION

The ultimate purpose of the proof of concept is to assess whether it is possible to exchange trip data from a SM provider to MnDOT and/or other departments within the State of Minnesota. If deemed possible, the vision of the large-scale demonstration is to test and prove a user-based fee structure that will ensure the long-term solvency of the Highway Trust Fund, and evaluate the capabilities of and potential gaps in the fee collection mechanism for both the SM Providers and the State.

The Highway Trust Fund, like transportation funding in most states, is experiencing severe stress due to factors such the growing demands for resources where revenues are not keeping pace with construction costs due to inflation, and an increasing diversity of new and highly efficient power systems, among other forces. Combined, these trends along with continued technology and product and service innovations, point to great uncertainty about the future.

Minnesota's DBUF system will strive to achieve broad public and stakeholder support. Rate setting will be rational and equitable and will be capable of being adjusted to address vehicle type, roadway design, jurisdiction, time-of-day, and other factors. The model that will be designed will be scalable to multiple service segments and exportable to other agencies. Migration to the new system will be incremental, painless, and cost effective.

6.2 GOALS AND OBJECTIVES

The goals and objectives of the proof of concept and demonstration are focused on developing and deploying a DBUF system that will be focused on the future of personal travel and will create an efficient and affordable path toward broader deployment.

Specific demonstration goals:

- **Fairness**: Ensures all road users subject to a DBUF pay a fair share for use of the roads;
- **Public acceptance**: If DBUFs are viewed as a solution, more travelers will support it;
- **Privacy protection**: Stringent security protocols must protect personal information;
- **Ease of payment and collection**: A system with low administration costs that uses existing technologies;
- **Transparency**: Use and fee data readily accessible as needed;
- **Low evasion rates**: Vehicle-embedded technology and encrypted transmission ensures low avoidance; and
- **Scalability**: DBUFs should be incrementally implemented.

Specific objectives to meet this goal are:

- Develop a scalable, secure and transferable approach to user-based fees that can be adopted widely and cost-effectively;
- Leverage partnerships with SM providers to demonstrate simulated DBUF collections with existing onboard technologies that minimize collection and, enforcement costs, and enhance user privacy and equity;
- Demonstrate how DBUF accounts from SM providers could be seamlessly integrated into existing Minnesota financial reporting, auditing, and enforcement systems;
- Confirm reliability and security of shared mobility data and financial systems, and potential for integration with state fee collection systems;
- Explore ways the nexus between connected and automated vehicles (C/AV), vehicle electrification, and SM ownership models can be used to promote a more sustainable transportation funding mechanism;
- Through targeted messaging and outreach, educate Minnesota's public and policymakers as to the decline in transportation funding, shared mobility's contribution to the problem, and how SM providers can be incorporated within a collaborative DBUF solution;
- Establish appropriate pricing structure for various parameters, such as vehicle classes, times of day, and other variables; and
- Develop a blueprint that charts a path forward to validate the feasibility of distance-based user fees.

7 DBUF CONCEPT UNDERSTANDING

Working from the existing situation and associated changes inherent to transportation funding and revenue sources, Section 7 details the DBUF Concept.

7.1 OVERVIEW

The SM DBUF proof of concept and demonstration are reliant on strong public-private partnerships with SM providers. The DBUF concept will leverage the telematics platforms already installed within SM provider vehicles to calculate and collect fees. SM providers already use this equipment as part of the underlying business models but more specifically to calculate user fees for services they currently provide. Since SM providers are already calculating distances traveled for each trip and have mechanisms in place for charging their users fees based on their mileage, MnDOT will partner with SM providers to evaluate the feasibility of integrating these fees with a DBUF.

7.1.1 FEES LEVIED

The demonstration project will levy a simulated distance-based fee for all vehicles used in the demonstration. Because the primary goal is to determine if a DBUF can be levied on SM vehicles, a rate table will be used for the demonstration that allows for flexibility in rates based on variables to be explored during the demonstration (e.g. time of day, state borders, etc.). Ultimately, through future pilots and demonstrations, MnDOT may elect to vary DBUFs based on certain conditions (e.g. time of day, specific corridors/areas, congestion, fuel economy, etc.) and would need to develop a fee table for these different criteria.

7.1.2 METERING MILEAGE

The effectiveness and credibility of the DBUF concept must ensure that miles traveled can be accurately recorded and reported. For simplicity, the DBUF concept demonstration will require SM providers to provide mileage readings as reported by technologies for each of the vehicles used in the demonstration. More specifically, providers will be asked to report mileage monthly for each month the demonstration is operational.

If a DBUF is widely implemented in the future, MnDOT or other appointed state agency may need to verify the accuracy of odometer readings and determine possible other sources that could be used to report mileage. Odometer reading during the life of the vehicle may vary from the actual distance traveled based on accuracy of the instrument and circumstances out of the instrument's control (e.g. tire size). Overly estimating vehicle miles traveled may result in public distrust of DBUFs and political pressure to abandon them. Alternatively, underestimating vehicle miles may result in revenue leakage and possibly increased administrative costs.

7.1.3 BILLING AND REPORTING MILEAGE

Ultimately, a DBUF system will require a mechanism for efficient billing and reporting mileage where actions to perform these activities do not significantly increase the administrative costs of collecting fees. For the proof of concept, SM providers will be asked to electronically submit trip data to a third party where Minnesota State departments can query provided data. At a minimum, data will be able to be sorted by vehicle ID, and time/date so that the project team can easily determine the number of miles each vehicle traveled during the prior month. For the demonstration, SM providers will electronically submit trip data to a third party repository for analysis, and will compile simulated revenue reports and transmit directly to the State for evaluation.

The specific calculation for the DBUF is as follows: The number of monthly aggregated miles traveled (VMT) multiplied by the DBUF rate (Rate) minus the motor fuel tax collected for the month. The motor fuel tax is the number of gallons of fuel purchases (Gal) times the state motor fuel tax rate* (Tax) of $0.286.

Net DBUF Fee Collected = (VMT x Rate) – (Gal x Tax)

** Federal motor fuels tax credits and a related federal DBUF may also be assessed.*

7.2 PROOF OF CONCEPT FUNCTIONAL ARCHITECTURE

The proof of concept functional architecture is illustrated in Figure 2.

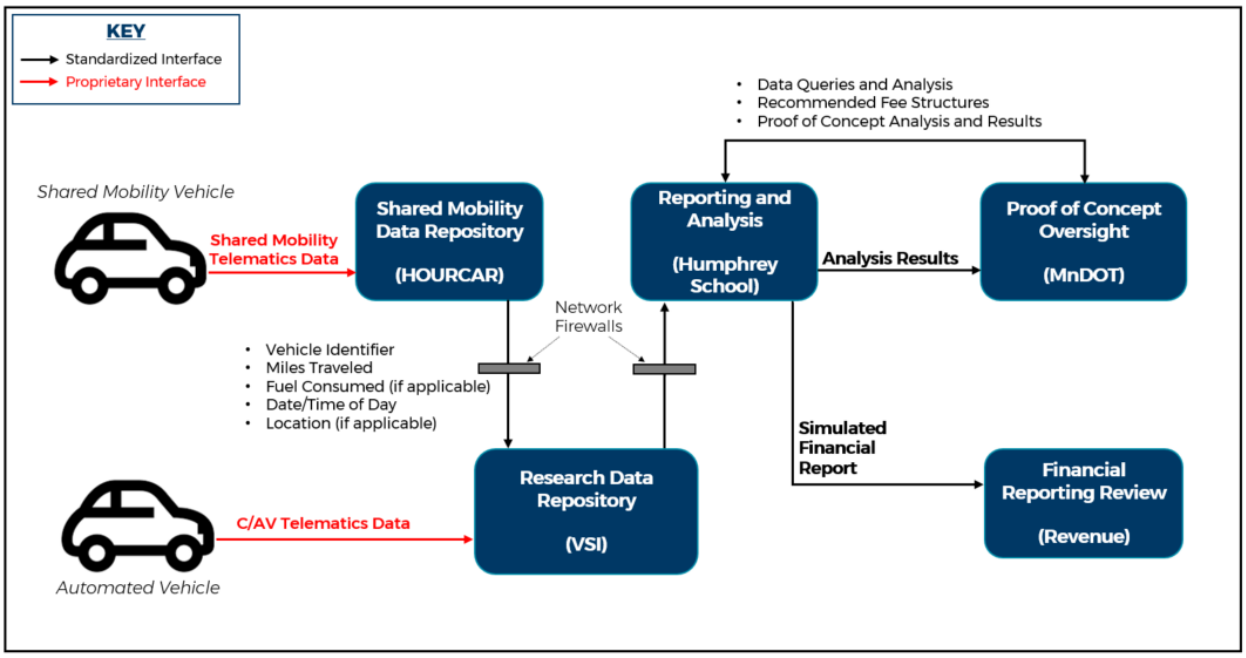


Figure 2: Minnesota Distance-based User Fee Demonstration Proof of Concept Architecture

7.2.1 SHARED MOBILITY PROVIDER INTERFACES

The SM providers participating in the proof of concept each own and operate account management systems that are currently used, in part, to receive and archive vehicle trip data. As a vehicle makes a trip, attributes of that trip (e.g. vehicle ID, time-stamped mileage, time of day, location data, and fuel consumed) are collected and stored within the vehicle's telematics platform. Trip data is locally archived within the vehicle until the time it is uploaded to the account management systems, normally through cellular network connectivity. The frequency of this communication (i.e. polling rate) varies by the provider (generally between one and three minutes).

Trip data that is archived on the account management system was sanitized of any personally identifiable information (PII) and aggregated monthly for the proof of concept. At the end of each month, the sanitized, aggregated data was pushed to a third-party research data repository The data pushed from the SM providers to the research data repository was in industry-standard data formats (e.g. eXtensible Markup Language (XML), Java Script Object Notation (JSON), or Comma Separated Variable (CSV)).

7.2.2 THIRD PARTY DATA REPOSITORY INTERFACES

A third-party data repository served as MnDOT's data archive for all trip data generated during the proof of concept. To that end, the data repository directly received sanitized, aggregated trip data from the SM provider's account management system. This communication occurred via e-mail and through industry-standard data communications protocols (XML or CSV), therefore no changes to communications were required to enable the transmission of trip data from the SM provider to the third-party data repository. The third-party data repository enabled researchers from MnDOT's partner, the Humphrey School, to query data and generate reports.

The proof of concept also included a connected/automated vehicle (C/AV) that transferred DBUF-related data to the research data repository, thus demonstrating the ability to transfer data directly from a vehicle's controller area network (CAN) bus.

7.2.3 REPORTING INTERFACES

As previously mentioned, the Humphrey School analyzed the DBUF data provided by the third-party research data repository. The Humphrey School acknowledged the successful transfer of data from the research data repository, and used the data to generate simulated revenue reports for review by the State.

7.3 DEMONSTRATION FUNCTIONAL ARCHITECTURE

The demonstration functional architecture is provided in Figure 3 below. While similar to the architecture provided for the proof of concept, the demonstration will focus on developing channels and specifications for the SM providers to have direct communication channels with Minnesota public agencies for tax reporting, auditing and administration purposes.

During the demonstration, the project team will progressively move towards this final end state functional architecture, with anticipation of three or more stages of demonstration operations and communications channels for phased development of interfaces, tax report design, and validation checkpoints.

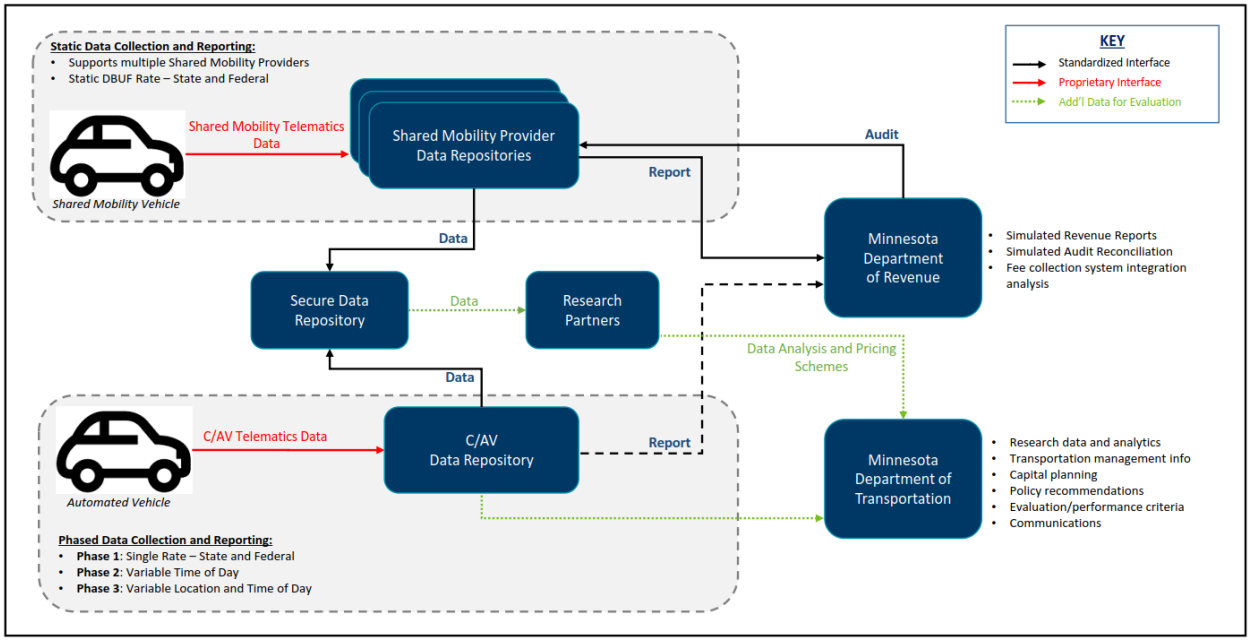


Figure 3: Minnesota Distance-Based User Fee Demonstration Notional End State Architecture

7.3.1 SHARED MOBILITY PROVIDER INTERFACES

Trip data from each SM provider's account management system will be sanitized, aggregated, analyzed, and provided to Minnesota state systems in a series of reports. It is anticipated that this data push will occur within ten days following the end of each demonstration month. As with the proof of concept, the reports provided by each SM provider are expected to be provided in XML, JSON, or CSV formats. The monthly reports anticipated to be provided by each SM provider include:

- ***Revenue Report*** – A monthly aggregate of the simulated gross and net compiled for all vehicles from each shared mobility provider (DBUF and motor fuels tax rates will include both a state and federal rate).

  Gross revenue = [(# of aggregate miles) x (per-mile rate)]

  Net revenue = [Gross Revenue] – [(# of fuel gallons consumed/purchased) x (motor fuels tax rate)

- ***Vehicle Summary Report*** – A monthly aggregate of the total vehicle miles traveled, and simulated gross, and net DBUF fees assessed per-vehicle, defined through either the VIN or through a vehicle's unique identifier.
- ***Errors and Events Report*** – A monthly report showing any data transmission errors that may affect how the DBUF is calculated.

In addition, there are reports that are not required for the demonstration, but may be relevant to future research of the DBUF concept:

- *Corridor or Area VMT Report (if available)* – A monthly report showing VMT miles for all vehicles within a SM provider's fleet, traveled within specific areas or corridors, identified by MnDOT. Note this report would use monthly aggregated data and not specific trip data.
- *Congestion and Emissions Data (if available)* – A monthly report showing the number of minutes all vehicles within a SM provider's fleet are idling and the particular timeframes where idling is at its peak. In addition, this report could identify whether vehicles are compliant with Minnesota emissions requirements, should automated emissions checks be considered a value-added benefit to the shared mobility providers.
- *Distance-Based Fee Report (if available)* – A monthly report showing how certain state or local imposed fees, levied on the SM providers, could be decomposed into a per-mile fee structure.

Each of these reports will be submitted to the State for simulated tax reporting and demonstration evaluation purposes. Network firewalls, certified to industry standards, such as the ISO 27001 family of standards for Information Management and PCI DSS (currently version 3.2), to prevent the unauthorized dissemination of data.

7.3.2 REPORTING INTERFACES

A third-party data repository will serve as MnDOT's data archive for raw data and reports generated during the demonstration. Processing and reporting of DBUF data will be conducted in three (3) stages through the demonstration (timeframes for each stage are notional and will be confirmed during demonstration design:

- *Stage 1 – No Formal Reporting (~4 months):* SM providers will sanitize and aggregate collected travel data on a monthly basis and transmit datasets to the third-party data repository. Simulated financial reporting to the State, using the information provided by the SM providers, will be conducted by MnDOT's research partners, the Humphrey School and WSP USA. During this stage, the research partners will work with the State and SM providers to develop the reporting template to be used in subsequent stages.
- *Stage 2 – Initial Revenue Reporting (4 months):* SM providers will sanitize and aggregate collected travel data on a monthly basis and transmit datasets to the third-party data repository. SM providers will also assess DBUF and fuels tax rates to the collected travel data, generate a Revenue Report (using the template designed in Stage 1) and transmit the report to the third-party data repository for validation by the research partners.
- *Stage 3 – Final Revenue Reporting (4 months):* SM providers will sanitize and aggregate collected travel data on a monthly basis and transmit datasets to the third-party data repository. SM providers will also assess DBUF and fuels tax rates to the collected travel data, generate a Revenue Report and transmit the report to Revenue directly for simulated tax reporting, mock auditing, and demonstration evaluation purposes.

Additionally, Revenue may conduct one more mock audits, evaluating the information submitted in Revenue Reports against detailed SM providers' records to validate data accuracy and integrity, and determine if the data points provided are sufficient for tax filing. During this audit, Revenue may request support from SM providers to answer questions, identify data types, and discuss the process for generating the Revenue Report.

For each data reporting stage, SM providers will produce and transmit datasets and/or Revenue Reports by the 10th of the month following the month of data collection.

7.4 STAKEHOLDERS

Agencies and entities that will have a stake in the proof of concept and demonstration are described below.

7.4.1 MINNESOTA DEPARTMENT OF TRANSPORTATION

The Minnesota Department of Transportation ("MnDOT") is the DBUF demonstration project manager. MnDOT will administer the project, establishing ongoing project coordination with partners, and convene project team meetings and other technical and policy project meetings as necessary. MnDOT will maintain a project plan and schedule, monthly progress reports, copies of project correspondence and public meeting material including presentations and displays and a final report that will be developed in collaboration with the other primary stakeholders identified herein. As project lead, MnDOT will also be responsible for coordinating with the Technical Advisory Committee (TAC), driving the day-to-day operations of the demonstration, and managing contracts with other team members.

MnDOT will be responsible for receiving information from multiple entities during the demonstration, storing and forwarding that information as appropriate, and conducting analysis on provided information to evaluate and conduct the following:

- Per-mile/per-trip fee assessment recommendations;
- Project communications;
- Research and analytics;
- Transportation management information;
- Capital planning forecasts based on DBUF data;
- Policy recommendations;
- Evaluation/performance criteria; and
- General public and legislative communications.

MnDOT will also be responsible for communicating the following types of information to the SM providers and the TAC:

- Distance-based fee analysis results and reports;
- Recommended fee structures;
- Simulated fee credit reports;
- Data use agreements and memorandums of understanding; and
- Inquiries by other state agencies and legislature.

MnDOT will be responsible for conducting certification of SM provider systems and processes, as well as functionality provided directly by Revenue, Humphrey School, and MnDOT, to ensure that all demonstration requirements are met prior to launching the demonstration.

7.4.2 MINNESOTA DEPARTMENT OF REVENUE

Revenue will coordinate with MnDOT and its partners on a desired interface with SM providers to collect the DBUFs. This includes analysis and feedback on potential interface models and their characteristics such as:

- Technology/processing needs specifications
- Ease of user compliance
- Reliability and security specifications
- Developing tests to ensure accuracy of data
- Participant account reconciliation
- Auditability
- Business rules

Ultimately, Revenue will collect revenue reports, deposit records, and audit reconciliation from SM providers. To that end, they will be responsible for financial report design, auditing and financial analysis of DBUFs. Revenue will then process this information and pass along performance information to other agencies and departments within MnDOT.

Information will be pushed via reports from each SM provider to Revenue using XML, JSON, or CSV. Reports will be automatically provided on the 10th day of the month following the data collection month. For the demonstration, simulated audits and enforcement exercises will be conducted between Revenue and each SM provider.

7.4.3 MINNESOTA STATE LEGISLATURE

Legislative support will be critical for user-based fee systems and alternative approaches to be demonstrated and ultimately implemented. The Minnesota State Legislature has previously funded research for testing mileage-based user fees (MBUF), and legislative transportation leaders participated in a Minnesota policy task force examining the policy issues related to user fees in 2010. The task force identified the challenges that would be necessary for MBUF fees to move forward, which offers a useful roadmap as this project moves forward.

While legislative action is not anticipated to be needed during the pre-implementation and implementation phases of this project, it will be important to engage legislators so they are informed and engaged on the issues and policy considerations and implications of a DBUF program. In addition, their feedback will help inform the project team on the political sensitivity toward user-based fees and the necessary outreach and education to assure a successful outcome. Minnesota's experience with priced managed lanes demonstrates the importance of engaging legislative leaders and policy makers early on as a "grass tops" approach. These leaders play a critical role in explaining what can be a very complex and challenging issue to the public, and taking the correct steps to assure public support and avoid or address organized opposition.

The Minnesota State Legislature funds a multi-year project on Transportation Policy and Economic Competitiveness (TPEC) for research by the Humphrey School on transportation finance, economic

development and new technologies. The TPEC advisory board, which meets twice a year, includes the transportation committee chairs and ranking members from the Minnesota State Legislature as well as other transportation, business and community policy leaders. MnDOT may use the TPEC advisory board as a primary approach to engage state legislative leadership on legislative strategies related to this project in the pre-deployment phase.

In addition, periodic policy briefings will be conducted for legislators, and legislators will be invited to Rethinking Transportation Finance Roundtables hosted jointly by MnDOT, the Humphrey School and the University's Center for Transportation Studies. These roundtables have typically attracted policy leaders and interested citizens, and are an effective way of keeping the transportation policy community informed on transportation finance and pricing innovations. The project team will also work closely with MnDOT's legislative liaison to assure that legislators are well informed on the progress of the project at key points and that required legislative actions are incorporated into the MnDOT legislative program and that any legislative concerns or priorities are addressed in a timely way.

7.4.4 UNIVERSITY OF MINNESOTA, HUMPHREY SCHOOL

The Humphrey School will be responsible for coordinating with and recruiting SM providers to participate in the demonstration project. This includes working with providers to determine and implement an applicable DBUF pricing scheme (i.e., rate) that these providers can use during the demonstration. Other activities the Humphrey School will be responsible for include:

- Identifying SM provider needs and policy requirements for administering a DBUF demonstration.
- Conducting customer outreach and market research with SM providers.
- Determining the data privacy, security and enforcement expectations and needs and protocols of SM providers and customers.
- Developing a range of user-based fee options with SM providers and testing the financial viability and market response to transparent DBUFs.
- Identifying a scalable approach to administer DBUFs with SM providers' vehicle fleets.
- Documenting how telematics information will be collected with the lowest administration burden.
- Developing an understanding of software requirements, support systems, and compliance tools.
- Designing supporting system and incentives concepts.
- Participating in demonstration evaluation activities.

7.4.5 SHARED MOBILITY PROVIDERS

MnDOT has held informative and productive discussions with SM providers in the Twin Cities metropolitan area. As part of their existing operations, SM providers collect a host of information that is used to monitor vehicle usage and assess fees based on trips taken. As part of the proof of concept, SM providers will be responsible for coordinating with MnDOT to establish mutually agreeable terms for sharing information and working toward a desirable concept for automatically and seamlessly transmitting desired information during normal operations. For the demonstration, SM providers will collect, aggregate, sanitize and transmit travel data to State systems for the purpose of assessing a simulated DBUF, based on agreed to terms and requirements. No changes to the SM providers'

production operations are anticipated. SM Providers will provide additional data sanitization, aggregation and reporting services for the purpose of this project.

7.4.6 TECHNICAL ADVISORY COMMITTEE

The Technical Advisory Committee (TAC) will be responsible for program status, communicating with key legislators, and setting the direction of DBUF throughout the state. The TAC is expected to include members consisting of state agencies, civil rights and community organizations, local metropolitan planning organizations, cities and counties, local transit authorities, tribes, academia, the private sector, and professional organizations. Once chartered, the TAC will focus on not only demonstration-related initiatives, but also considerations for continued research and policies related to other DBUF-type endeavors. Some of these considerations may include needed policy/legislation, social and geographic equity, rate setting determinations, privacy, enforcement & compliance, traffic implications, and freight implications.

7.4.7 USERS

Users represent the SM provider's customers (i.e., individuals that pay to reserve and use a vehicle from the SM provider's vehicle fleet that participates in the demonstration). The user will be responsible for registering with the SM provider to use the SM provider's services. This process will be no different than the process used today as part of the providers normal operating process. By registering with and paying to use the SM provider's services, the user automatically will participate in the DBUF demonstration. Users will be responsible for reserving vehicles and paying for services in the same manner they are required to do today. Except for possibly being notified about the DBUF demonstration through targeted outreach, users will experience no changes because of the demonstration.

8 OPERATIONAL SCENARIOS

This section identifies possible scenarios in which the demonstration system is expected to operate, defining roles and responsibilities from individual user perspectives.

8.1 USER ORIENTED OPERATIONAL SCENARIOS

SM subscribers will continue to interact with their SM provider for standard business operations for SM services. Users in the context of this demonstration project are the SM providers participating in the project, and are addressed in the next section below.

8.2 SHARED MOBILITY PROVIDER OPERATIONAL SCENARIOS

8.2.1 SUBSCRIBER ENROLLMENT AND RESERVATIONS

SM providers enroll subscribers into the SM provider's operations platform to register for use of services. SM providers collect certain information to enroll each subscriber, including limited PII, payment method, and other information necessary to successfully bill the user for services and manage the account. Following successful enrollment, SM providers manage reservations created by subscribers to reserve a vehicle for use during a specific timeframe. No changes to SM provider enrollment and reservation management is expected to support this project. Data related to reservations may be included in trip data provided to the State during the demonstration for the purpose of simulated tax reporting and/or audit, with any PII removed.

8.2.2 DATA COLLECTION

SM providers will collect mileage, fuel consumption (if applicable) and location data from participating SM provider fleet vehicles, using existing telematics technologies installed in the vehicle for SM operations. The data will be transmitted to the SM provider's account management system per the SM provider's business model, and will be associated with the appropriate vehicle. Fuel consumption data will be collected via fuel purchase accounts and payment cards to determine the fuel purchased for (and therefore consumed by) each vehicle in the fleet. In some cases, physical odometer readings may also be captured during mileage collection or fuel purchase transaction to validate the telematics data.

During the demonstration, data from a C/AV may also be collected to demonstrate the ability to transfer data directly from a vehicle's controller area network (CAN) bus. Data collected from a C/AV would mirror the defined data set expected from a SM vehicle, with the addition of detailed location information for analyses of varied pricing schemes developed by the project research partners.

8.2.3 DATA AGGREGATION & REPORTING

SM providers, as collectors of the trip data, will be responsible for data aggregation. Aggregation for each SM provider will occur in multiple phases – by vehicle and by reporting period at a minimum. For the demonstration, the reporting period is anticipated to be monthly. As part of this aggregation, the SM provider will also ensure that no PII is reflected in any information provided to the State.

The SM provider will aggregate raw trip data by participating vehicle. SM providers will be required to report aggregated trip data for each participating vehicle as soon as possible, but no later than at least once a month.

Once data is aggregated, SM providers will apply the appropriate DBUF and fuels tax rates to miles traveled and fuel consumed/purchased for each participating vehicle, and calculate the net DBUF owed (simulated) to the State. Data aggregation and reporting is anticipated to be reflected in the following reports that each SM provider will submit to the State on a monthly basis during the demonstration:

- ***Revenue Report*** – A monthly aggregate of the simulated gross (total VMT * DBUF rate) and net (total VMT * DBUF rate – state fuel tax rate) compiled for all vehicles from each SM provider. If available, a further delineation of federal gas tax revenues would also be provided in this report.
- ***Vehicle Summary Report*** – A monthly aggregate of the total VMT, and simulated gross, and net DBUF fees assessed per-vehicle, defined through either the VIN, or through a vehicle's unique identifier.
- ***Errors and Events Report*** – A monthly report showing any data transmission errors that may affect how the DBUF is calculated.

In addition, there are reports that are not required for the demonstration, but may be relevant to future research of the DBUF concept:

- *Corridor or Area VMT Report (if available)* – A monthly report showing VMT miles for all vehicles within a SM provider's fleet, traveled within specific areas or corridors, identified by MnDOT. Note this report would use monthly aggregated data and not specific trip data
- *Congestion and Emissions Data (if available)* – A monthly report showing the number of minutes all vehicles within a SM provider's fleet are idling and the particular timeframes where idling is at its peak. Also, this report could identify whether vehicles are compliant with Minnesota emissions requirements, should automated emissions checks be considered a value-added benefit to the SM providers.
- *Distance-Based Fee Report (if available)* – A monthly report showing how certain state or locally imposed fees, levied on the SM providers, could be decomposed into a per-mile fee structure.

Each of these reports will be submitted to Minnesota state systems, such as Revenue's tax collection system, or data repository(ies) as identified by the State during the demonstration design phase.

8.2.4 PAYMENT COLLECTION

The only payment scenarios anticipated for the DBUF demonstration will involve the current payment operations between users and the shared mobility providers at the beginning and/or the end of a vehicle's use. To demonstrate the transfer of monies, an electronic funds transfer (simulated) may be implemented,

but no specific DBUF fees are expected to be paid by users, assessed by the SM providers, or paid to the State of Minnesota. Should this be implemented, a statement of deposit will be provided to each SM provider by the state showing successful transfer and acknowledgment of the funds.

SM providers may also be expected to support periodic spot (mock) audits conducted by Revenue during the demonstration to validate Revenue Report accuracy, completeness and integrity.

8.3 DEMONSTRATION ADMINISTRATION & GOVERNANCE

8.3.1 PROGRAM MANAGEMENT

MnDOT and its demonstration partners will oversee the demonstration. MnDOT will be responsible for providing periodic project updates to interested parties including the TAC, FHWA, State of Minnesota Legislature, Governor's office, and others as needed.

In addition to MnDOT's responsibilities, a TAC will be established to guide the project and to provide expertise to ensure successful outcomes. The TAC will also be beneficial for gaining stakeholder involvement and incorporating different viewpoints.

8.3.2 SIMULATED REVENUE COLLECTION

During the proof of concept and demonstration, SM provider DBUF tax reporting will be simulated. SM providers will generate simulated tax reports, using parameters defined by the State during the design phase, and will provide to the State and demonstration partners for validation of accuracy, data integrity, and compliance with format and data requirements. The use of the current, production tax collection and reporting system(s) used by the State are not anticipated to be used for this project, due to its temporary and simulated nature.

During the demonstration, Revenue will conduct one or more mock audits, evaluating the information submitted in the Revenue Report against detailed SM providers' records to validate data accuracy and integrity, and determine if the data points provided are sufficient for tax filing. During this audit, Revenue may request support from SM providers to answer questions, identify data types, and discuss the process for generating the Revenue Report.

8.3.3 CERTIFICATION

MnDOT, or an appointed representative, will certify that each SM provider is able to meet the technical and business requirements that will be established upon completion of this ConOps and prior to the start of the demonstration. This includes conducting the required testing of SM provider systems and ensuring that each provider has met the criteria necessary to successfully collect, administer and transfer data for the purpose of assessing a DBUF.

Certification testing will encompass three phases: specific systems for each SM partner (unit testing), testing the interfaces between each SM provider and the State (integration testing), and then a 2-week demonstration dry run (acceptance testing) where full functions of the demonstration will be tested using a focused set of participant vehicles. At the completion of testing, the SM partners will resolve any identified issues, retest as necessary, and prepare for the launch of the demonstration.

MnDOT, in cooperation with its partner departments and agencies, will create the requirements and criteria with which each SM provider must comply.

8.3.4 RATE SETTING

MnDOT and its demonstration partners will be responsible for setting and adjusting the per mile rates. The per mile rate that will be used for the demonstration will be set to generate revenues that would be approximately equivalent to revenues currently generated by the motor fuel tax. The per mile rate will be a flat fee applied to vehicles of all class types, fuel efficiency, and transportation corridors.

The data collected from the demonstration, including the VMT and revenue data, can then be used to explore potential variable rates, charging per-mile fees based on vehicle class, fuel efficiency, specific corridors, or other factors.

8.3.5 EDUCATION AND OUTREACH

MnDOT will initiate efforts to educate the public and stakeholders to encourage acceptance of DBUF. This will be a multi-tiered campaign including a DBUF demonstration website with links to other studies and marketing materials and key messages that SM providers can use to educate their customer base. This effort will include the various Minnesota State Departments and SM providers to ensure the message is clearly conveyed to system users both before the demonstration begins and throughout the demonstration.

To assess the public's thoughts on the DBUF, MnDOT, the Humphrey School, and/or the SM providers may recruit SM users to participate in data gathering sessions to gain their thoughts and opinions on the demonstration and the premise of a DBUF in general. These sessions would occur at various key milestones before, during, and after the demonstration. Any changes in opinions or key themes from participants would be captured and used to show whether the demonstration led to improved public understanding and acceptance of the DBUF concept.

8.3.6 LEGISLATIVE & FHWA COORDINATION

MnDOT will be responsible for providing the Minnesota State Legislature and the FHWA with quarterly updates on project progress and results. This may include information on the number of hours used and costs incurred in demonstrating the DBUF concept, as well as general observations, risks, and results identified/observed to date. MnDOT will also present a summary of the demonstration at its conclusion via a final report and presentation.

9 OPERATIONAL & SUPPORT ENVIRONMENT

This section describes the physical environment in terms of facilities, equipment, hardware, software and personnel, operational procedures and support necessary to operate the demonstration system.

9.1 EQUIPMENT AND INFRASTRUCTURE

9.1.1 SHARED MOBILITY PROVIDERS

9.1.1.1 FLEET VEHICLES

The SM providers will provide vehicles that will host the existing telematics technologies needed to collect and send operational data for calculating the DBUF. No new vehicles are assumed, but rather the concept will rely on existing vehicles that are currently part of the SM provider's existing vehicle fleet.

9.1.1.2 VEHICLE ONBOARD TELEMATICS

All vehicles participating in the demonstration would be required to have equipment capable of accurately recording mileage by date and time. Additionally, they are expected to have onboard communications systems that can transmit this data at periodic intervals to the SM provider account management systems. While embedded GPS capabilities are not required, they are highly recommended as location-specific data could be used to delineate between zones or even specific corridors. It is anticipated that all of the SM provider vehicles have some sort of GPS system, currently used for fleet monitoring.

No new telematics hardware or software is anticipated to be needed for the demonstration. All costs associated with the procurement, installation and maintenance of the vehicle telematics will be the responsibility of the SM provider. This includes monthly expense for cellular communication services.

9.1.1.3 ACCOUNT MANAGEMENT SYSTEMS

Account management systems represent the systems that SM providers use to store data received from the vehicle telematics. Account management systems are owned and operated by SM providers.

In addition to accommodating normal SM operations, these systems may need to be modified to support data aggregation and reporting required for the demonstration. MnDOT, Revenue, and the Humphrey School will work directly with these SM providers to identify the format of the reports and may conduct testing prior to the demonstration to ensure the reports can be provided in the required formats.

9.1.2 MINNESOTA DEPARTMENT OF TRANSPORTATION

MnDOT will provide a data repository, either directly or through a third-party provider, to store demonstration data for use in analyses and demonstration evaluation. Parameters for the data repository, including security, access, and data management, will be identified in the demonstration technical requirements.

9.1.3 MINNESOTA DEPARTMENT OF REVENUE

Revenue uses a system used to administer and process taxes. Due to the temporary and simulated nature of the proof of concept and demonstration, the use of the Revenue tax collection system for SM provider tax reporting will be simulated. The project team will work closely with Revenue during the demonstration to assess the effort and potential costs associated with modifying the tax collection system to receive and process DBUF Revenue Reports in a future program.

9.1.4 COMMUNICATIONS

The DBUF demonstration will require no new communications hardware, software or infrastructure, so long as existing communications are found to be stable, secure, and reliable. The expectation is that existing communications platforms used by all stakeholders fit this category, and that the transmission of data via these existing methods will not hinder existing agency operations or data limits. Each SM provider is expected to already transmit data using cellular 3G or 4G formats, which should prove adequate for the DBUF demonstration. Cellular coverage within the greater Minneapolis/St. Paul metropolitan area appears adequate and no additional communications hardware or infrastructure is anticipated to conduct the demonstration.

9.2 FACILITIES

While facilities will be required to host servers and other hardware (i.e., computers) required for storing, analyzing and interpreting DBUF-related data, no new facilities are anticipated or will be required. It is anticipated that stakeholders will conduct and operate DBUF-related systems from existing facilities. The DBUF demonstration does not reflect a change to any current operations and as such, no additional facilities are anticipated.

9.3 HARDWARE

9.3.1 VEHICLE ONBOARD EQUIPMENT

No new onboard hardware is anticipated for the demonstration. Hardware maintenance will be conducted using the same processes currently employed by the SM providers.

9.3.2 ACCOUNT MANAGEMENT SYSTEM

Based on the existing data collection, aggregation, and reporting capabilities within each of the SM providers, additional systems may be required to sanitize and aggregate the trip data, create and disseminate the reports, and support inquiries by MnDOT, Revenue, or the Humphrey School.

9.4 STAFF

The DBUF demonstration and initial proof of concept presents additional administrative burden on MnDOT for design, development, operations and evaluations efforts. MnDOT and other participating State agencies may utilize existing staff to undertake necessary duties, procure an implementation consultant(s), leverage partners such as the Humphrey School, or a combination of all to accomplish the necessary project tasks.

9.5 FUNDING NEEDS & OPPORTUNITIES

The demonstration is anticipated to be funded through a mix of state research funds, in-kind contributions (staff time, facilities, resources, etc.), and STSFA grant dollars. Additionally, the SM providers may also provide in-kind contributions to support the demonstration activities.

9.5.1 SURFACE TRANSPORTATION SYSTEM FUNDING ALTERNATIVES (STSFA) PROGRAM

The Fixing America's Surface Transportation (FAST) Act established the Surface Transportation System Funding Alternatives (STSFA) grant 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. The objectives of the 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; and
- Minimize the administrative cost of any potential user-based alternative revenue mechanisms.

Grant award recipients must provide a 50% match, and must address the following objectives:

- The implementation, interoperability, public acceptance, and other potential hurdles to the adoption of the user-based alternative revenue mechanism;
- The protection of personal privacy;
- The use of independent and private third-party vendors to collect fees and operate the user-based alternative revenue mechanism;
- Market-based congestion mitigation, if appropriate;
- Equity concerns, including the impacts of the user-based alternative revenue mechanism on differing income groups, various geographic areas, and the relative burdens on rural and urban drivers;
- Ease of compliance for different users of the transportation system; and

- The reliability and security of technology used to implement the user-based alternative revenue mechanism. [FAST Act § 6020(d)(1)]

Recipients may also address—

- The flexibility and choices of user alternative revenue mechanisms, including the ability of users to select from various technology and payment options;
- The cost of administering the user-based alternative revenue mechanism; and
- The ability of the administering entity to audit and enforce user compliance. [FAST Act § 6020(d)(2)]

In 2016, MnDOT was awarded a $300,000.00 grant under the STSFA program to plan and design the proof-of-concept and demonstration. The award funds the design of a DBUF demonstration and conduct a proof of concept test.

In 2018, MnDOT was awarded an additional $999,600.00 grant under the STSFA program to implement, operate and evaluate the DBUF demonstration.

9.6 OUTREACH & TRAINING

MnDOT, in cooperation with its partners, will conduct public and stakeholder outreach, education, and training. Each department will be responsible for training their staff with respect to changes that occur because of the demonstration. MnDOT will be responsible for conducting general outreach activities with the following agencies as needed to communicate project progress, related activities and to solicit required input.

- Legislature
- TAC
- SM Providers
- Public
- Media
- Professional Organizations
- FHWA

SM providers will generally be responsible for outreach to their customers but MnDOT will play a pivotal role in that they will develop outreach materials that SM providers can provide or reference in their direct communications with their customers. As part of this support, MnDOT will create a project website that provides comprehensive information about transportation funding and the demonstration project.

Outreach and training is expected to occur before the demonstration begins and will continue through the end of the project.

9.7 SUPPORTING POLICIES AND AGREEMENTS

Any information provided by SM providers that is considered proprietary will be held in trust by MnDOT and their partners and not shared outside of the research team. Non-disclosure agreements (NDAs), memorandums of understanding (MOUs), and data use agreements (DUAs) will be established as necessary to limit collection and use of any proprietary information. Additionally, Intergovernmental Agreements (IGAs) may be needed between state departments prior to launch of the demonstration.

10 FAILURE SCENARIOS

The failure scenarios presented in this section represent potential issues associated with the hardware and technology systems used for the DBUF demonstration. They represent system or subsystem failure scenarios and the potential impacts of those failures. Process failures are not covered in this section but should be evaluated as administrative processes are developed over the course of the demonstration. There are three overarching categories identified for failure: Vehicles, Account Management Systems, and Reporting. Details as to each failure scenario are provided below.

10.1 VEHICLE-ORIENTED FAILURE SCENARIOS

There are several vehicle-based scenarios which could pose failure. These failures would occur primarily due to malfunctioning hardware or software, and not necessarily user interaction. Telematics systems that use wireless communications to transmit data pose a risk of loss of communication failure. This will often be a temporary failure that will remedy once the vehicle reaches an area more conducive to cellular communication. The vehicle telematics systems should be equipped with sufficient electronic storage to collect trip data for a reasonable period of time prior to transmitting to a back-office system and clearing its storage. A minimum storage of up to one week of trips is recommended and additional storage for up to a month is highly preferred. If the SM provider has not received communication from a particular vehicle for a predetermined period of time, perhaps three days, they should have the ability to “ping” the vehicle (as long as it’s in service) to verify the system is communicating properly. Should the ping be unsuccessful, the user should be contacted to assist in correcting the issue.

A second source is the loss of communications to the vehicle data connection bus. Under this circumstance, recovery may be difficult, and mileage may need to be estimated based on odometer readings upon vehicle return.

Almost all failures can be mitigated to some extent by the payment of the fuel tax, with no credit given for fuel tax payments for those miles where reporting is questionable. For this reason, it is recommended that credit for the fuel tax paid be made when miles are reported, not when fuel is purchased.

10.2 ACCOUNT MANAGEMENT SYSTEM FAILURE SCENARIOS

Account management system failure scenarios are likely to be more serious to the integrity of the overall DBUF demonstration system, but they should be easier to quickly identify that the failure has occurred so that remedial action can be taken.

As with vehicle-oriented failure scenarios, loss of communication is a potential issue. This could be due to the failure of a data communications system used by, but not associated with, the SM provider. A second form would be failure within the account management system or network. In either case, if the vehicle telematics systems have sufficient storage, as outlined in the section above, recovery from either type of communication failure, provided it is not an unusually extended failure, should not be an issue.

As with any system that stores a significant amount of financial data, the potential for hacking will also exist for account management systems. For this reason, state-of-the-art safeguards should be in place to

prevent unauthorized access to account information. ISO 27001 provides recommended safeguards to maintain data integrity.

Loss of data could be a catastrophic failure. As with data security, state-of-the-art data backup, coupled with a robust Continuity of Operations (COOP) plan should be established to prevent data loss and support data restoration in the event of a catastrophic failure. SM providers should be required to provide safeguards from all types of data loss risk.

10.3 REPORTING FAILURE SCENARIOS

Reporting failure scenarios are a combination of the failure scenarios that could be associated with the vehicles and the SM provider account management systems (network outages, system failures, lack of data, etc.). If communications are lost for whatever reason with SM providers, the systems employed should have sufficient storage to accommodate large amounts of data. Once communications are restored, data transfer can resume.

Failures can also occur through breakdowns in the Revenue or MnDOT systems hardware and software. As with monitoring of administrative systems, regular auditing, with oversight by Revenue should occur.

Distance Based User Fee Pilot Study

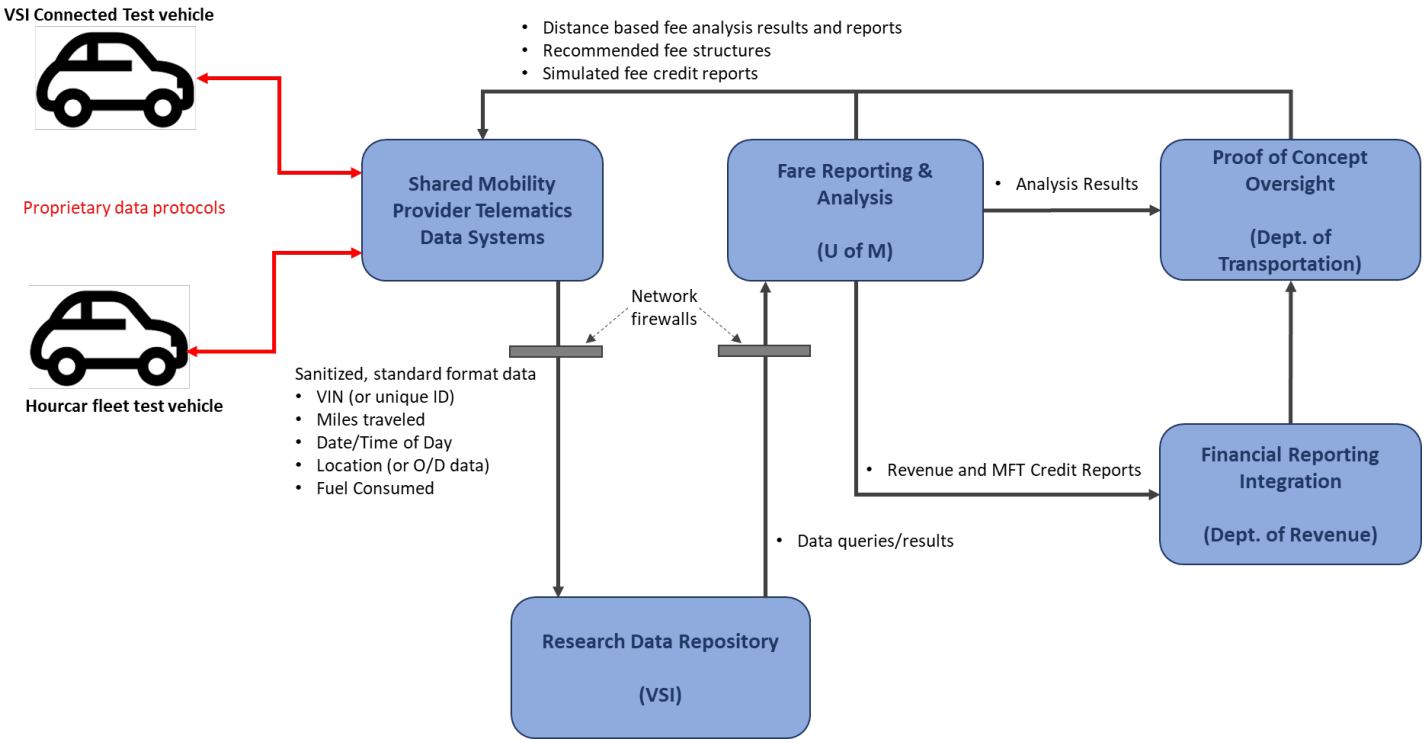
Proof of Concept Test Procedures

BACKGROUND

The Minnesota Department of Transportation (MnDOT) is partnering with shared mobility and automotive technology partners to support the research, demonstration, and examination of the necessary policy and technical considerations needed for developing distance-based user fees (DBUF), where users would pay certain road use fees on a per-mile usage basis. This project will have two phases: a proof of concept, to be conducted in 2018, and a larger-scale demonstration, expected sometime in 2019 - 2020. The document below provides the procedures and expected performance metrics associated with the proof of concept.

PROOF OF CONCEPT OVERVIEW

The MnDOT team will develop, deploy, and demonstrate the proof of concept described below. The proof of concept will test the connectivity to transfer anonymized per-trip data from a shared mobility partner and a connected vehicle to a data repository. The respository would retain the trip data which would be then transferred to a research and analysis entity who will use the data to calculate a series of revenue reports and a per-mile fee. A conceptual diagram for the proof of concept is provided below.



ENTITIES AND RESPONSIBILITIES

There are several entities involved in the proof of concept. Their roles and responsibilities are:

- **MnDOT** – Proof of Concept oversight and approval of results
- **Minnesota Department of Revenue (Revenue)** – Review of the financial reports and integration of the report information into existing Revenue data analysis systems
- **University of Minnesota (U of M)** – Data analysis and generation of the financial reports

- **Hourcar** – Shared Mobility partner providing carshare test data for the proof of concept
- **Vision Systems Intelligence (VSI)** – Establishing the data repository and provider of connected vehicle test data

ASSUMPTIONS

There are several key assumptions used for the proof of concept, described below:

- All data used in the proof of concept will be sanitized, removing any personally identifiable information.
- The shared mobility partners will be responsible for ensuring that all data provided to the research data respository is sanitized.
- The proof of concept will last for not less than two weeks.
- A minimum of 500-vehicle miles from each set of vehicles (carshare and connected vehicle).
- No customization of existing systems will be used for the proof of concept.
- Customer off the Shelf (COTS) hardware and systems shall be used to the fullest extent possible.
- Firewalls and other network protection systems shall be incorporated to ensure that all proof of concept data is safeguarded against unauthorized dissemination.
- All data provided for the proof of concept shall be in Comma Separated Values (CSV) or Excel Spreadsheet (XLS) format.
- All revenue reports provided by U of M shall be in CSV or XLS format.
- All data used for the proof of concept shall be considered research data and shall be destroyed within 30-days of the completion of the proof of concept.

PROOF OF CONCEPT PROCEDURES AND RESULTS SHEETS

This section provides the procedures, responsible entities, and anticipated success results for the proof of concept (POC). These procedures address the proof of concept setup, execution, and closeout. During the POC, the results of each step will be conducted with the results annotated by each involved entity. At the end of each section, a signature from each entity's authorized representative will be required to ensure the results provided are in-line with the expectations for the POC.

PROOF OF CONCEPT ENVIRONMENT SETUP

Step	Procedure	Entities	Performance Measure	Result
S.1	Identify carshare vehicles for proof of concept. Ensure all data points needed for POC can be captured using existing systems.	Hourcar/VSI	Accurate data provided from test vehicles with no data inaccuracies or reporting errors	
S.2	Establish networked data repository capable of collecting at least 2 Terabytes (TB) of data	VSI	Provision of data repository	
S.3	Provide data repository weblink or IP address to all entities	VSI	Weblink or IP address provided	
S.4	Ensure network firewalls are in place between systems	All	Identification of network protection	

MnDOT Representative **U of M Representative** **Hourcar Representative** **VSI Representative**

PROOF OF CONCEPT EXECUTION

HOURCAR

Step	Procedure	Entities	Performance Measure	Result
E.HC.1	Conduct normal carshare reservation and usage operations	Hourcar	---	
E.HC.2	Collect two weeks and at least 500-miles of carshare data	Hourcar	---	
E.HC.3	Determine the following data points are captured from vehicles on a per-subscription basis: • VIN or unique identifier • Trip mileage • Date/Time of Day of carshare subscription start • Date/Time of Day of carshare subscription end	Hourcar	Accurate categorization of data across the identified points	

E.HC.4	Refuel any test vehicles and record the number of gallons purchased at each refuel	Hourcar	Fuel card statements and data relative to the number of gallons purchased	
E.HC.5	Aggregate the data over the entire POC period. Remove all Personally Identifiable Information (PII) from data.	Hourcar	Inspection of start and end dates in data file equals the POC 2-week period. Inspection of data to ensure no PII exists.	
E.HC.6	Ensure data is in a CSV or XLS format	Hourcar	Identification of filename and extension	
E.HC.7	Upload aggregated data file to research data repository using the weblink or IP address provided in step S3	Hourcar	Screenshot showing successful file upload	
E.VSI.8	Send proof of successful data upload message to U of M and MnDOT	Hourcar	Email or message sent	

MnDOT Representative **Hourcar Representative**

VSI

Step	Procedure	Entities	Performance Measure	Result
E.VSI.1	Deploy Connected Test Vehicle	VSI	---	
E.VSI.2	Collect two weeks and at least 500-miles of carshare data	VSI	---	
E.VSI.3	Determine the following data points are captured from vehicles on a per-trip basis: • VIN or unique identifier • Trip mileage • Date/Time of Day of each trip • Location (provided in no less than 15 second intervals) • Fuel consumed in gallons	VSI	Accurate categorization of data across the identified points	
E.VSI.4	Aggregate the data over each 24-hour period during the POC. A day is defined as 00:00:01 to 23:59:59 Central Daylight Time (CDT)	VSI	Inspection of start and end times in data file equals a 24-hour period.	
E.VSI.5	Ensure data is in a CSV or XLS format	VSI	Identification of filename and extension	

E.VSI.6	Upload aggregated data file to research data repository using the weblink or IP address provided in step S3 at the end of each day during the POC	VSI	Screenshot showing successful file upload	
E.VSI.7	Send proof of successful data upload message to U of M and MnDOT	VSI	Email or message sent	

MnDOT Representative **VSI Representative**

U OF M

Step	Procedure	Entities	Performance Measure	Result
E.UM.1	Upon receipt of a successful file upload message, download the data from the research data respository	U of M	Successful download of POC data	
E.UM.2	Inspect uploaded data to ensure no Personally Identifiable Information (PII) exists	U of M	No PII exists on data	
E.UM.3	Create financial revenue report showing gross and net revenues calculated over the duration of the POC. The following calculation should be used in the report: Gross revenue = [(# aggregate miles) x (per-mile rate)] Net reveue = [Gross Revenue] – [(# gallons of fuel consumed/purchased) x ($0.286)] The report shall show both the calculation of gross and net revenues on a per-vehicle basis as well as an aggregate of all vehicles over the POC period	U of M	Objective evaluation of calculations and inspection of reports	
E.VSI.4	Ensure data is in a CSV or XLS format	U of M	Identification of filename and extension	
E.UM.5	Send the POC financial report to both MnDOT and Revenue using email or state-approved ftp website	U of M	Successful transfer of report to MnDOT and Revenue	

MnDOT Representative **U of M Representative**

MINNESOTA DEPARTMENT OF REVENUE (OPTIONAL)

Step	Procedure	Entities	Performance Measure	Result
E.REV.1	Inspect the provided revenue report for accuracy and auditability.	Revenue	Successfully inspection of revenue report.	
E.UM.2	Identify ways the revenue report could be safely imported into GenTax system. Attempt an integration if it is safe to conduct.	Revenue	Identified ways revenue reports could be integrated into GenTax.	

MnDOT Representative **Revenue Representative**

PROOF OF CONCEPT DISCREPANCIES AND CONCLUSIONS

This section provides a way for all POC entities to capture any identified discrepancies, the type of rework needed to resolve the discrepancy, and any conclusions noted during the POC that should be applied to the overall demonstration.

Issue	Description	Entities	Impact	Mitigation	Conclusion/Resolution

_____	_____	_____	_____
MnDOT Representative	**U of M Representative**	**Hourcar Representative**	**VSI Representative**

MINNESOTA DEPARTMENT OF TRANSPORTATION

MINNESOTA DISTANCE BASED USER FEE DEMONSTRATION PLAN

Business and System Requirements

VERSION 1.2

MARCH 2020

wsp

DEPARTMENT OF TRANSPORTATION

REVISIONS

VERSION	DATE	CHANGES
1.0	01/31/2020	Initial Draft
1.1	02/19/2020	Revisions based on project team feedback
1.2	03/02/2020	Revisions to project goals language

TABLE OF CONTENTS

TERMS & ACRONYMS

AES	Advanced Encryption Standard
C/AV	Connected/Automated Vehicle
CFR	Code of Federal Regulations
ConOps	Concept of Operations
DBUF	Distance-Based User Fee
FCC	Federal Communications Commission
GAAP	Generally Accepted Accounting Principles
Humphrey School	University of Minnesota Humphrey School of Public Affairs
ICD	Interface Control Document
MnDOT	Minnesota Department of Transportation
NIST	National Institute of Technology and Standards
PCI-DSS	Payment Card Industry Data Security Standard
PII	Personally Identifiable Information
Research Partners	WSP USA and the University of Minnesota Humphrey School of Public Affairs
Revenue	Minnesota Department of Revenue
Revenue Report	A monthly report sent to Revenue showing simulated DBUFs for SM and C/AV Providers
SM	Shared Mobility
SP	Special Publication
SSL	Secure Socket Layer
State	Minnesota Department of Revenue and the Minnesota Department of Transportation
TLS	Transport Layer Security
Trip	Operational travel of a vehicle from one geographical location to another
Waypoint	A point on a vehicle's travel route, represented in longitudinal and latitudinal coordinates

1 DEMONSTRATION OVERVIEW

The Minnesota Department of Transportation (MnDOT), in partnership with the Minnesota Department of Revenue (Revenue) and its Research Partners, the University of Minnesota, Humphrey School of Public Affairs (the Humphrey School) and WSP USA, will conduct a 12-month Distance-Based User Fee (DBUF) demonstration to confirm the ability to accurately and securely collect travel data from Shared Mobility (SM) providers' vehicle fleets and Connected and Automated Vehicles (C/AV) to assess a DBUF for use of the roads.

During the demonstration, SM Providers will collect mileage, location, and fuel consumption (if applicable) information from participating vehicles. The SM Providers will sanitize and aggregate the data for each vehicle, calculate the assessed DBUF, subtract the state and federal motor fuel tax based on the number of gallons of fuel consumed, and then present a simulated financial report to the state that shows the net DBUF charges due. The report will be sent electronically in a predefined format via a predefined transmission method to Revenue, who will review for accuracy, assess the charges, and conduct a mock audit(s) as necessary to validate the information provided by the SM Provider. All DBUFs assessed will be simulated over the course of the demonstration. SM Providers will continue to collect monies from their customers as part of their normal business operations.

The demonstration will also evaluate the feasibility of collecting DBUF-related data from a Connected/Automated Vehicle (C/AV). MnDOT and its partners will collaborate with a C/AV Researcher to conduct phased data collection for evaluation of various DBUF pricing scenarios such as time-of-day pricing and location-based pricing. The C/AV also provides a robust dataset that could be used to explore other potential uses of collected data such as supporting transportation planning and modeling and overall performance monitoring and management of Minnesota's transportation network.

An evaluation will be conducted on the 12-month demonstration to assess how well the demonstration met objectives, challenges that had to be overcome, the potential to deploy this model on a broader scale, and policy recommendations for Minnesota State Legislature to consider.

1.1 GOALS

The DBUF demonstration is intended to confirm that DBUFs can be efficiently and effectively collected using vehicle technology embedded in SM fleet vehicles and C/AVs. Successful completion of the demonstration will validate or invalidate the ability of DBUF to meet the following goals:

- **Fairness**: Ensures all road users subject to a DBUF pay a fair share for use of the roads;
- **Public acceptance**: If DBUFs are viewed as a solution, more travelers will support it;

- **Privacy protection**: Stringent security protocols must protect personal information;
- **Ease of payment and collections**: A system with low administration costs that uses existing technologies;
- **Transparency**: Use and fee data are readily accessible as needed;
- **Low evasion rates**: Vehicle-embedded technology and encrypted transmission ensures low avoidance; and
- **Scalability**: DBUFs should be incrementally implemented.

1.2 OBJECTIVES

Specific objectives to meet the goals of the demonstration are:

- Develop a scalable, secure and transferable approach to user-based fees that can be adopted widely and cost-effectively;
- Leverage partnerships with SM Providers to demonstrate simulated DBUF collections with existing onboard technologies that minimize collection and enforcement costs, as well as enhance user privacy and equity;
- Demonstrate how DBUF accounts from SM Providers could be seamlessly integrated into existing Minnesota financial reporting, auditing, and enforcement systems;
- Confirm reliability and security of SM Providers data and financial systems, and potential for integration with state fee collection systems;
- Explore ways the nexus between connected and automated vehicles (C/AV), vehicle electrification, and SM ownership models can be used to promote a more sustainable transportation funding mechanism;
- Through targeted messaging and outreach, educate Minnesota's public and policymakers as to the decline in transportation funding, shared mobility's contribution to the problem, and how SM providers can be incorporated within a collaborative DBUF solution;
- Establish appropriate pricing structure for various parameters, such as vehicle classes, times of day, and other variables; and
- Develop a blueprint that charts a path forward to validate the feasibility of distance-based user fees.

1.3 FUNCTIONAL ARCHITECTURE

During the demonstration, the SM Providers will collect and transmit data to their respective proprietary data repositories, process and aggregate the data, and transmit simulated Revenue Reports to the State. The SM Providers will also send lower-level aggregate data to a secure data repository for research partner analysis. Additionally, the C/AV Researcher will conduct focused tests, collect and process travel data from the C/AV, and transmit the data to the demonstration's third-party data repository for analysis.

During the demonstration, the MnDOT and its partners will work closely with the SM Providers to progressively move towards this final end state demonstration functional architecture, with three stages of demonstration operations and communications channels for phased development of interfaces, Revenue Report design, and validation checkpoints.

- ***Stage 1 – No Formal Reporting*** (~4 months): SM providers will sanitize and aggregate collected travel data on a monthly basis and transmit the datasets to the third-party data repository. Simulated financial reporting to the State, using the information provided by the SM providers, will be conducted by MnDOT's research partners, the Humphrey School and WSP USA. During this stage, the research partners will work with the State and SM providers to develop the Revenue Report template to be used in subsequent stages. The State may conduct initial mock audit inquiries with SM Providers, based on aggregated data transmitted. The Research Partners will conduct analyses on transmitted data. See Figure 1, Minnesota DBUF Phased Demonstration Architecture – Stage 1 No Formal Report, below for a process diagram.

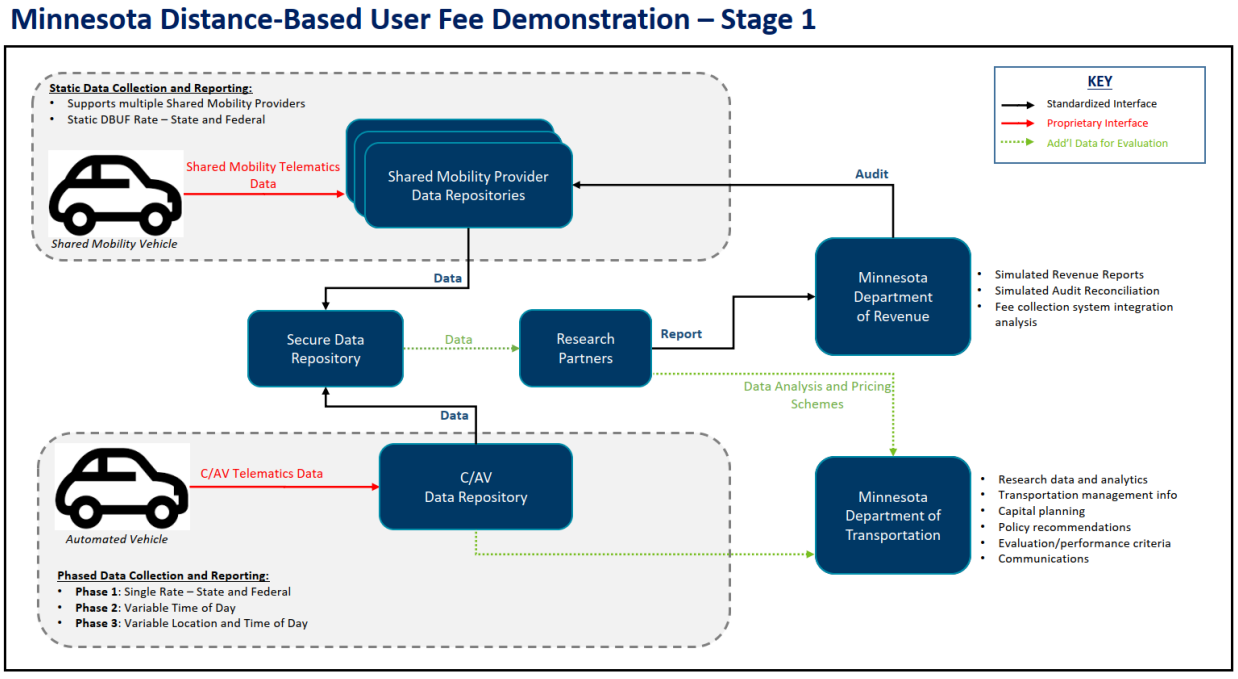


Figure 1: Minnesota DBUF Phased Demonstration Architecture – Stage 1 No Formal Reporting

- ***Stage 2 – Initial Revenue Reporting*** (4 months): SM providers will sanitize and aggregate collected travel data on a monthly basis and transmit the datasets to the third-party data repository. SM providers will also assess DBUF and fuels tax rates to the collected travel data, generate a Revenue Report (using the template designed in Stage 1) and transmit the report to the third-party data repository for validation by the research partners. The C/AV Researcher may generate datasets for use in simulated Revenue Reporting. The State may conduct initial mock audit inquiries with SM Providers, based on aggregated data transmitted. The Research Partners will conduct analyses on transmitted data. See Figure 2, Minnesota DBUF Phased Demonstration Architecture – Stage 2 Initial Revenue Reporting, below for a process diagram.

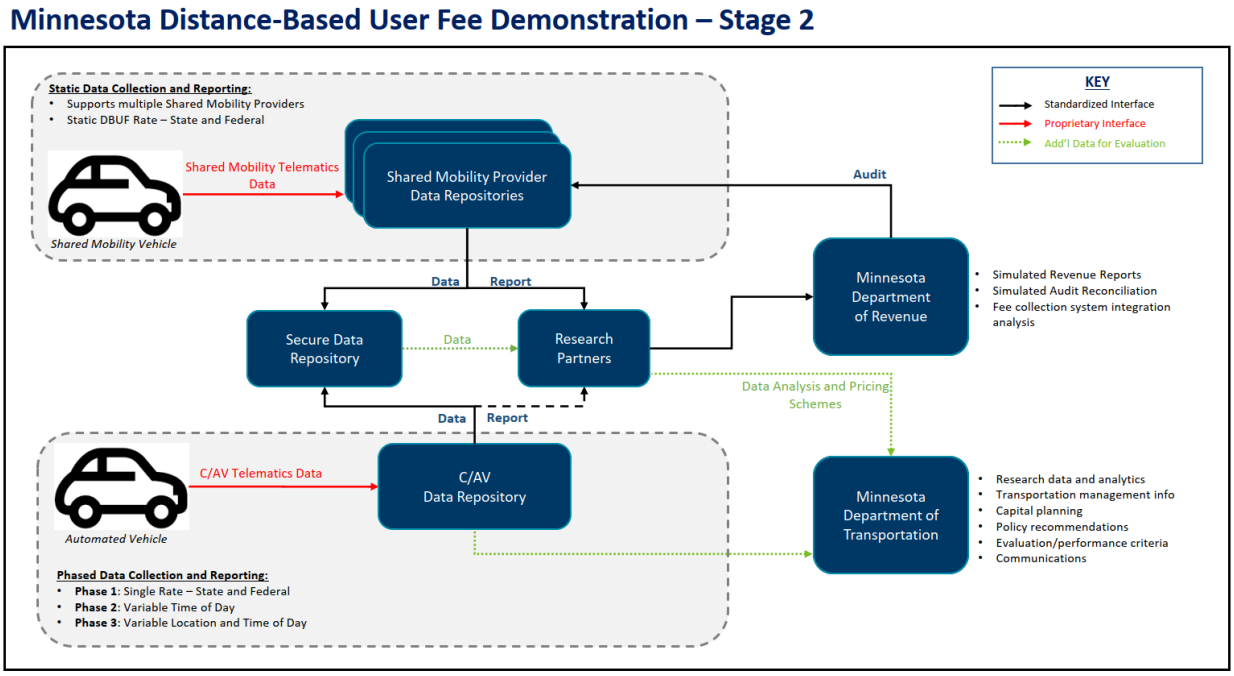


Figure 2: Minnesota DBUF Phased Demonstration Architecture – Stage 2 Initial Revenue Reporting

- ***Stage 3 – Final Revenue Reporting*** (4 months): Each month, SM and C/AV Providers will sanitize and aggregate collected travel data and transmit the datasets to the third-party data repository. SM and C/AV Providers will also assess DBUF and fuels tax rates to the collected travel data, generate a Revenue Report and transmit the report to Revenue directly for simulated tax reporting, mock auditing, and demonstration evaluation purposes. The C/AV Researcher may generate datasets for use in simulated Revenue Reporting. The Research Partners will conduct analyses on transmitted data. See Figure 3, Minnesota DBUF Phased Demonstration Architecture – Stage 1 Formal Revenue Reporting, below for a process diagram.

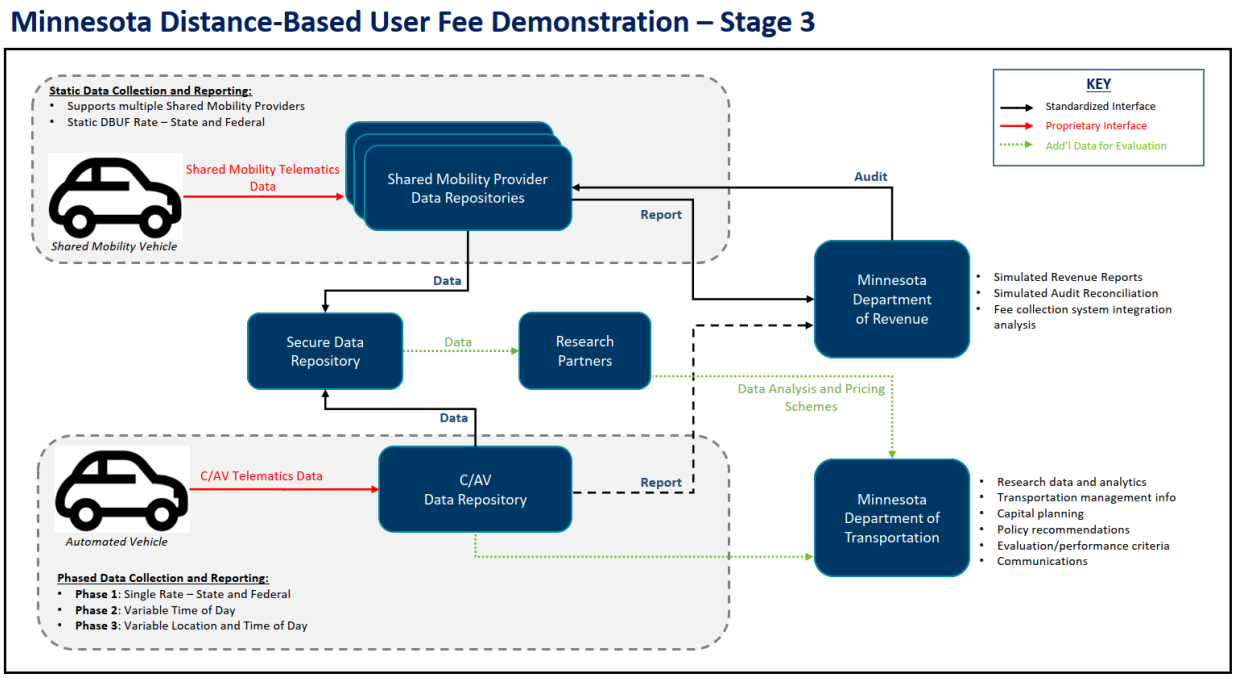


Figure 3: Minnesota DBUF Phased Demonstration Architecture – Stage 3 Formal Revenue Reporting

1.4 PROJECT DOCUMENT REFERENCES

Additional documents should be referred to for overall demonstration details:

- A Concept of Operations (ConOps) that provides demonstration needs and objectives, stakeholders, roles & responsibilities, and the operational and administrative scenarios for the demonstration.
- An Interface Control Document (ICD) which defines how demonstration systems communicate with one another, including communications protocols, data fields, format, and frequency.

2 REQUIREMENTS

Requirements detail ***what*** the system must do, and ***how*** the system is expected to perform those functions. The requirements for this project are broken down to disaggregate the system into its individual components, to support verification of how each component functions on its own as well as how it interacts with other components. Requirements will be broken down, as follows, to allow for validation at varying levels of the system:

- Operational Process
    - Activity
        - Requirement

The demonstration is divided into three main operational processes:

- **Data Collection:** The collection of mileage, fuel and related travel data from participating vehicles. SM Providers will collect and report data no less than monthly during the demonstration. C/AV data will include additional, more detailed travel and location data for data analyses.
- **Data Processing:** The processing of collected mileage, fuel and related travel data into logical transactions. SM Providers will sanitize and aggregate collected data prior to transmitting the data to the State (or its representatives).
- **Data Reporting:** Calculation of DBUF and applicable fuels tax credits, net DBUF owed, and formal (simulated) reporting to Revenue. A mock audit will be conducted on SM Provider reports by the State (or its representatives) to investigate feasibility and applicability to current or future tax system integration.

Each Operational Process will then contain its own set of activities and requirements. Overarching system specifications are also defined in this section that apply to all systems, subsystems, components and processes to be used to operate the demonstration.

Whether the requirement applies to SM Providers, the C/AV Researcher, or both is identified for each requirement.

2.1 REQUIREMENT NAMING CONVENTIONS

Each requirement is coded according the abbreviation of the defined operational process and activity, and numerical requirement index number, using the following format:

<operational abbreviation>.<activity abbreviation>.<requirement index>

Example: *Data Collection* > *Trip Data* > *Requirement # 1* = **DC.TD.1**

2.2 OVERARCHING SYSTEM SPECIFICATIONS

The system, as defined for the purposes of this demonstration, includes all subsystems, operational processes, activities, components and functions of SM and C/AV Providers, Research Partners and the State needed to successfully operate the demonstration. The overarching need for the State is a reliable DBUF system that accurately collects, assesses, and transfers DBUF from participating vehicles to the State, accurately and cost effectively. To meet this need, the demonstration system shall:

- Be secure
- Protect data privacy
- Be reliable and available
- Be auditable
- Promote safe and reliable operations

System specifications apply to all aspects of the demonstration system, and meet or exceed industry standards and applicable federal and state laws.

System Need: Security

REQ #	DESCRIPTION	SM	C/AV
SN.SEC.1	An Information Systems Management Plan shall be maintained that includes policies, processes and procedures for managing security, privacy, confidentiality, availability and processing integrity of systems and data to be used for or impact the demonstration.	X	X
SN.SEC.2	Physical security measures shall be in place to protect against unauthorized entry and/or access to demonstration data.	X	X
SN.SEC.3	Restricted level (or higher) demonstration data shall be encrypted at rest with AES 256-bit encryption or stronger.	X	X
SN.SEC.4	Demonstration data shall be encrypted in-transit with AES 256-bit encryption or stronger.	X	X
SN.SEC.5	Demonstration data stored on or made available to access using web-based methods shall secure the data using current TLS/SSL protocols (currently TLS 1.3 and SSL 3.0). This includes data upload and download; account creation, login, and maintenance; and data access using the web-based method.	X	X
SN.SEC.6	User accounts established to access demonstration data shall use, at a minimum, NIST guideline SP 800-63B (Dec 2017) for electronic authentication requirements.	X	X

REQ #	DESCRIPTION	SM	C/AV
SN.SEC.7	Systems used to collect, store, and/or transmit demonstration data shall have network security systems and processes operating and enforced. Network security systems and processes include, but may not be limited to: • Intrusion Detection Systems • Intrusion Prevention Systems • Network Firewalls • Firewall and Packet Monitoring • Anti-Virus Software • Anti-Malware Software	X	X

System Need: Data Privacy and Protection

REQ #	DESCRIPTION	SM	C/AV
SN.DPP.1	Access to demonstration data and systems storing demonstration data shall be restricted using role-based access controls, using the principle of least privilege.	X	X
SN.DPP.2	Personally Identifiable Information (PII) shall be defined in accordance with the U.S. General Services Administration Privacy Program Privacy Act. https://www.gsa.gov/reference/gsa-privacy-program/rules-and-policies-protecting-pii-privacy-act	X	
SN.DPP.3	Information Asset Classification levels shall be defined for all demonstration data, with PII classified at no less than a "restricted" level. A "restricted" level shall be defined, at a minimum, as highly sensitive or valuable information, considered proprietary and/or personal. Restricted data shall be disclosed only to authorized personnel and entities, and shall be protected using, at minimum, authentication guidelines as defined in NIST guideline SP 800-63B (Dec 2017).	X	X
SN.DPP.4	PII shall be sanitized from demonstration datasets prior to transmission to the State, including the secure, third-party data repository hosted by the State or its Research Partners.	X	X
SN.DPP.5	The system shall provide a means to detect and report unauthorized access and/or changes.	X	X
SN.DPP.6	The system shall comply with Minnesota Statute 325E.61, data warehouses; notice required for certain disclosures, subdivision 1 disclosure of personal information and notification of data breach. https://www.revisor.mn.gov/statutes/cite/325E.61	X	X

System Need: Reliability and Availability

REQ #	DESCRIPTION	SM	C/AV
SN.RAV.1	The system shall have high availability, with no less than 99.9% uptime in a given month during the demonstration. System uptime calculations do not include scheduled maintenance or situations outside the system's (or administering entity) control.	X	X
SN.RAV.2	Maintenance outages or other scheduled downtime of demonstration systems shall be scheduled when the downtime or outage is least likely to impact demonstration data collection, processing and retention.	X	X
SN.RAV.3	The system shall maintain regular backup and recovery processes to prevent demonstration data loss.	X	X
SN.RAV.4	The system shall contain redundancy where practical to prevent demonstration data loss.	X	X

System Need: Auditability

REQ #	DESCRIPTION	SM	C/AV
SN.AUD.1	Demonstration-specific data shall be retained for the duration of the demonstration for auditing purposes. *Note: Upon identification of conflict between compliance with this requirement, and compliance with data purge requirements for PII-related data and applicable laws, SM Providers shall coordinate with project team to assess to determine best course of action.*	X	X
SN.AUD.2	Demonstration-specific data shall be purged from SM Provider systems not later than one calendar month following completion of the final month of the demonstration operations period.	X	X
SN.AUD.3	Demonstration-specific data stored in the secure, third-party data repository shall be purged from the repository not later than 90 calendar days following completion of the demonstration operations period.	X	X
The following financial transaction requirements are to validate SM Provider live operations' compliance with applicable financial standards, confirming scalability for a future DBUF program handling real monies.			
SN.AUD.4	The SM Provider shall provide proof of compliance with industry security standards required for the payment options provided. *Example: Compliance with Payment Card Industry Data Security Standards (PCI-DSS) is required for credit and debit card transactions.*	X	
SN.AUD.5	The SM Provider shall prove compliance with Generally Accepted Accounting Principles (GAAP) for aspects of the demonstration system that handle financial transactions and accounting.	X	

System Need: Safe and Reliable Operations

REQ #	DESCRIPTION	SM	C/AV
SN.SRO.1	Systems and technologies used to collect demonstration data from participating vehicles shall not compromise the safe operation of the vehicle.	X	X
SN.SRO.2	Systems and technologies used to collect demonstration data from participating vehicles shall not compromise the safety of vehicle operators or passengers.	X	X
SN.SRO.3	Systems and technologies used to operate the demonstration shall not compromise SM Provider's normal business operations.	X	X
SN.SRO.4	Communications protocols used to collect and transmit demonstration data shall be compliant with Title 47 of the Code of Federal Regulations (CFR) and other applicable Federal Communications Commission (FCC) regulations.	X	X

2.3 DATA COLLECTION

The Data Collection operational process leverages the SM Provider's and C/AV Researcher's existing systems and technologies to collect relevant travel data from participating vehicles and transmit the data to the SM Provider's and C/AV Researcher's internal data repository for further processing. The Data Collection operational process includes several key activities:

- Prepare Vehicle
- Collect Trip Data
- Collect Location Data (*where applicable)*
- Collect Fuel Purchase Data (*where applicable*)
- Transmit Collected Data for Processing
- Report Errors and Events

The frequency of these activities is dependent on the SM Provider's and C/AV Researcher's individual implementation, but must occur at least monthly during the demonstration.

Activity: Prepare Vehicle

REQ #	DESCRIPTION	SM	C/AV
DC.PV.1	Each participating vehicle shall have a mechanism to collect trip data.	X	X
DC.PV.2	The vehicle, or a mechanism used to collect trip data from the vehicle, shall have storage and communications capabilities to prevent loss of trip data collected, even after periods of disrupted communications.	X	X
DC.PV.3	A unique vehicle identifier shall be assigned to each participating vehicle.	X	X

Activity: Collect Trip Data

REQ #	DESCRIPTION	SM	C/AV
DC.TD.1	Trip data shall be delineated by vehicle.	X	X
DC.TD.2	A unique trip identifier shall be assigned to the data collected on each discrete trip.	X	X
DC.TD.3	Trip data collected shall include, at minimum, the associated vehicle, the mileage travelled, and the associated trip start and end date and time.	X	X
DC.TD.4	Mileage collected for a participating vehicle shall be calculated within -/+5% of the actual miles traveled of the participating vehicle.	X	X
DC.TD.5	The amount of miles traveled shall be recorded to a precision of 1 decimal place (i.e. 4.1 miles).	X	X
DC.TD.6	The time at which the mileage measurement is captured (at the start of the trip, end of trip, or at any point during the trip) shall be captured at a minimum to the precision of minutes, with an accuracy of -/+30 seconds.	X	X

REQ #	DESCRIPTION	SM	C/AV
DC.TD.7	Trip data shall be collected for each discrete trip taken by a participating vehicle.	X	X
DC.TD.8	Trip data shall be collected at the same frequency at which location (waypoints) data is collected.		X

Activity: Collect Location Data

REQ #	DESCRIPTION	SM	C/AV
DC.LD.1	Detailed location data shall be collected to provide the specific geographic coordinates of waypoints on each trip in latitudinal and longitudinal decimal degrees to a precision of five (5) decimal places (i.e. 0.00001).		X
DC.LD.2	Waypoints shall be collected at a frequency of one point per second.		X
DC.LD.3	If location data is collected independently from the trip data, the data must be assigned appropriate identifiers to enable linkages back to the corresponding vehicle and trip identifiers.		X
DC.LD.4	Vehicle origin and destination location shall be collected for each vehicle, to include street address, city, state and postal code.	X	

Activity: Collect Fuel Purchase Data

REQ #	DESCRIPTION	SM	C/AV
DC.FPD.1	Fuel purchase data will be collected for each participating vehicle.	X	X
DC.FPD.2	Fuel purchase data must be associated with a specific vehicle participating in the demonstration, referenced through the unique vehicle identifier.	X	X
DC.FPD.3	Fuel purchase data shall include, at a minimum, the amount of fuel purchased, the type of fuel purchased, the price per gallon at the time the fuel was purchased, the total purchase price of the fuel, and the date and time at which the fuel purchase is made.	X	X
DC.FPD.4	The amount of fuel purchased shall be recorded in gallons, to a precision of 3 decimal places (i.e. 13.649 gallons).	X	X
DC.FPD.5	The price per gallon for the fuel purchased shall be recorded in dollars ($) per gallon, to a precision of at least 2 decimal places, and up to 3 decimal places where possible.	X	X
DC.FPD.6	The total purchase price for the fuel purchased shall be recorded in dollars ($), to a precision of 2 decimal places.	X	X
DC.FPD.7	The time at which the fuel purchase is made shall be recorded to a precision of minutes.	X	X

Activity: Transmit Collected Data

REQ #	DESCRIPTION	SM	C/AV
DC.TCD.1	Trip data collected from participating vehicles will be transmitted to the respective SM Provider's / C/AV Researcher's data repository.	X	X
DC.TCD.2	Fuel purchase data collected for participating vehicles shall be transmitted to the respective SM Provider's / C/AV Researcher's data repository.	X	X
DC.TCD.3	Trip and fuel purchase data collected for participating SM vehicles shall be transmitted to the SM Provider's data repository at least monthly for each participating vehicle.	X	
DC.TCD.4	Trip data shall be transmitted to the C/AV Researcher's data repository at the completion of each trip for each participating vehicle.		X
DC.TCD.5	Fuel purchase data collected for participating C/AVs shall be transmitted to the C/AV Researcher's data repository at least monthly for each participating vehicle.		X
DC.TCD.6	The transmitted trip and fuel purchase data shall be formulated/processed into logical sets of records (e.g. by vehicle, by trip).	X	X
DC.TCD.7	Transmitted data shall be delineated by vehicle.	X	X

Activity: Report Errors and Events

REQ #	DESCRIPTION	SM	C/AV
DC.EE.1	Errors or events that occur during data collection and transmission that may affect or compromise the accuracy and completeness of the data shall be documented. This may include, among others: - Data collection device malfunctioning, being disconnected, or turned off - Software updates - Anomalies in vehicle function	X	X
DC.EE.2	Errors and events reported shall include the date and time at which the incident occurred to enable validation of data records.	X	X
DC.EE.3	Errors and events reported shall indicate the specific nature of the error or event, as well as the cause of the error or event where possible.	X	X
DC.EE.4	Errors and events reported shall be associated to the appropriate vehicle and trip record according to the unique vehicle identifier and unique trip identifier.	X	X

2.4 DATA PROCESSING

The Data Processing operational process leverages SM Provider's and C/AV Researcher's existing processes to receive data from vehicles, validate and process the data into transactions, and use the transactions to sanitize and aggregate the data for transmission to the DBUF demonstration third-party repository for simulated revenue reporting and analyses. The Data Processing operational process includes the following key activities:

- Receive transmitted data
- Assign data to vehicle
- Process into transactions
- Validate data (logic checks)
- Sanitize data of PII
- Transmit detailed data to repository

The frequency of these activities is dependent on the SM Provider's and C/AV Researcher's individual implementation, but must occur at least monthly during the demonstration.

Activity: Receive Transmitted Data

REQ #	DESCRIPTION	SM	C/AV
DP.RTD.1	Collected data transmitted from the SM vehicle data collection systems will be received and stored in the respective SM Provider's / C/AV Researcher's data repository.	X	X
DP.RTD.2	The SM Provider data repository and C/AV data repository shall be configured in a manner to effectively receive the transmitted data in the appropriate formats, and with sufficient capacity to hold all data collected and processed during the demonstration.	X	X

Activity: Assign Data to Vehicle

REQ #	DESCRIPTION	SM	C/AV
DP.ADV.1	Data collected—including all trip data, location data, and fuel purchase data—must be assigned accordingly to the specific participating vehicle with which it is associated.	X	X
DP.ADV.2	A record of the unique vehicle identifiers assigned to each participating SM vehicle shall be maintained in the respective data repository.	X	X

Activity: Process into Transactions

REQ #	DESCRIPTION	SM	C/AV
DP.PIT.1	Transmitted data shall be processed into transactions that allow the SM Provider and C/AV to delineate all trips, fuel purchases and errors/events associated with a unique vehicle in a given month.	X	X
DP.PIT.2	Transmitted data shall be processed into transactions that align with discrete vehicle trips.	X	X
DP.PIT.3	SM Providers and C/AV shall maintain a record of unique transaction identifiers.	X	X
DP.PIT.4	The total number of unique transactions must align with the total number of unique trips recorded.	X	X

Activity: Validate Data

REQ #	DESCRIPTION	SM	C/AV
DP.VD.1	Reasonableness/sanity validation checks shall be performed on transactions to confirm the validity and accuracy of the data, including but not limited to:	X	X
DP.VD.1.1	Unreadable data;	X	X
DP.VD.1.2	Date/time not increasing from last trip dataset;	X	X
DP.VD.1.3	Accumulated mileage not increasing from last trip dataset;	X	X
DP.VD.1.4	Unique trip identifiers not correctly incrementing;	X	X
DP.VD.1.5	Unique transaction identifiers not correctly incrementing;	X	X
DP.VD.1.6	Duplicate trip dataset;	X	X
DP.VD.1.7	Trip data reported for vehicle not assigned to SM Provider or C/AV;	X	X
DP.VD.1.8	Fuel purchase data reported for vehicle not assigned to SM Provider or C/AV;	X	X
DP.VD.1.9	Error/event data reported for vehicle not assigned to SM Provider or C/AV;	X	X
DP.VD.1.10	Anomalies between miles traveled and fuel consumed;	X	X
DP.VD.1.11	Data reported for invalid trip type (e.g. Canceled);	X	X
DP.VD.1.12	Vehicle associated with more than one trip within the same reported time frame.	X	X
DP.VD.2	Validation checks identified shall be documented and associated with the appropriate vehicle and transaction record.	X	X

Activity: Sanitize Data of PII

REQ #	DESCRIPTION	SM	C/AV
DP.SOP.1	Processed and validated transactions shall be sanitized of any PII.	X	
DP.SOP.1.1	SM Providers shall ensure that any information related to the customer identity is removed from processed and validated transactions.	X	
DP.SOP.1.2	SM Providers shall ensure that any information related to customer billing and payment is removed from processed and validated transactions.	X	

Activity: Transmit Data to Repository

REQ #	DESCRIPTION	SM	C/AV
DP.TDR.1	Sanitized data shall be transmitted from the respective SM Provider or C/AV data repository to the shared demonstration data repository (hosted by the Research Partners) for each of the twelve months of the demonstration.	X	X
DP.TDR.2	Processed and sanitized transactions shall be transmitted to the shared demonstration data repository monthly, no later than the 10th of the month following the month of data collection.	X	X
DP.TDR.3	Processed and sanitized data transmitted to the shared demonstration data repository shall comply with data transmission protocols, data fields and formats as defined in the Interface Control Document.	X	X

2.5 REPORTING

The Reporting operational process includes applying DBUF and fuels tax rates to applicable mileage and fuel data to calculate the net DBUF owed for each participating vehicle, and for each SM Provider's entire fleet for a given reporting period. Calculated data will be processed into reports, including at a minimum, a Revenue Report for simulated tax reporting. It is also anticipated that the State (or its representatives) will conduct mock audits based on submitted simulated tax reports to investigate the feasibility of a DBUF as a revenue-generating mechanism, and the potential for integration with current or future State tax systems.

Key activities for demonstration reporting include:

- Apply DBUF rate
- Apply fuels tax credit rate
- Calculate net DBUF balance owed
- Process into monthly report
- Transmit report to Revenue
- Mock audit

REQUIREMENTS IN THIS SECTION WILL BE DEFINED DURING STAGE 1 OF THE DEMONSTRATION.

MINNESOTA DEPARTMENT OF TRANSPORTATION

MINNESOTA DISTANCE BASED USER FEE DEMONSTRATION

Interface Control Specifications

VERSION 1.1

FEBRUARY 2020

Prepared By:

WSP

Required Field:	ReportingPeriodStart	ReportingPeriodEnd	Vehicle_ID	Vehicle_Year	Vehicle_Make	Vehicle_Model	Vehicle_EngineType	Vehicle_OriginLocation	Vehicle_DestinationLocation	MilesTraveled
Description:	The date of the start of the period being reported.	The date of the end of the period being reported.	Unique identifier for participating vehicle.	Year the vehicle was manufactured.	Make / brand of the vehicle.	Name of vehicle product line.	Type of propulsion system that moves the vehicle.	Physical address of vehicle when vehicle is picked up.	Physical address of vehicle when vehicle is dropped off.	Distance vehicle traveled during reporting period, in miles.
Format:	Date	Date	String / Text	4-digit number	String / Text	String / Text	String / Text	String / Text	String / Text	Number
Special Rules:	N/A	N/A	N/A	N/A	N/A	N/A	ICE; Hybrid; PHEV; or EV	N/A	N/A	N/A
Example:	04/01/2020	04/30/2020	CARSHARE_15	2017	Kia	Niro	Hybrid	456 Street Ave., St. Paul, MN	456 Street Ave., St. Paul, MN 44444	637

OptionalField:	Trip_OdometerStart	Trip_OdometerEnd	Trip_StartTimestamp	Trip_EndTimestamp	Trip_OriginLocation	Trip_DestinationLocation
Description:	Vehicle odometer reading at start of trip.	Vehicle odometer reading at end of trip.	Date and time of trip start.	Date and time of trip end.	Physical address of vehicle at start of trip.	Physical address of vehicle at end of trip.
Format:	Number	Number	Date/Time	Date/Time	String / Text	String / Text
Special Rules:	N/A	N/A	Must be at least to a precision of minutes.	Must be at least to a precision of minutes.	N/A	N/A
Example:	31044	31052	05/01/2020 10:44:28 AM	05/01/2020 11:04:31 AM	98713 Road Ct., Minneapolis, MN 44441	54321 State St. SE, St. Paul, MN 44444

Required Field:	ReportingPeriodStart	ReportingPeriodEnd	Vehicle_ID	Vehicle_Year	Vehicle_Make	Vehicle_Model	Vehicle_EngineType	Fuel_TransactionTimestamp	Fuel_GallonsPurchased	Fuel_TypePurchased	Fuel_PricePerGallon	Fuel_TotalTransactionPrice	Fuel_TransactionState
Description:	The date of the start of the period being reported.	The date of the end of the period being reported.	Unique identifier for participating vehicle.	Year the vehicle was manufactured.	Make / brand of the vehicle.	Name of vehicle product line.	Type of propulsion system that moves the vehicle.	Date and time fuel transaction occurred.	Gallons (or units) of fuel purchased during fuel transaction for vehicle.	Type of fuel purchased during fuel transaction for vehicle.	Price of fuel purchased, per gallon (or units).	Total cost of fueling transaction for vehicle.	U.S. State where fueling transaction occurred.
Format:	Date	Date	String / Text	4-digit number	String / Text	String / Text	String / Text	Date/Time	Number	String / Text	Money (U.S. Dollars)	Money (U.S. Dollars)	2-digit String / Text
Special Rules:	N/A	N/A	N/A	N/A	N/A	N/A	ICE; Hybrid; PHEV; or EV	Must be at least to a precision of minutes.	Must be at least to a precision of 3 decimal places.	Must at least delineate between: Gasoline/Diesel; E-85; CNG; LNG *Further delineation may include unleaded, premium, super, etc.*	Must be to the precision of at least 2 decimal places, and up to 3 decimal places where possible.	Must be to the precision of at least 2 decimal places, and up to 3 decimal places where possible.	N/A
Example:	04/01/2020	04/30/2020	CARSHARE_15	2017	Kia	Niro	Hybrid	05/01/2020 05:23:55 PM	11.946	GASOLINE	$3.13	$37.39	MN

OptionalField:	Vehicle_OdometerReading	Fuel_MerchantName	Fuel_MerchantAddress	Fuel_MerchantCity	Fuel_TypeDescription
Description:	Vehicle odometer reading at time of fueling transaction; likely entered manually by customer	Name of merchant where fuel was purchased.	Physical address of fuel station / merchant where fueling transaction occurred. *If this field is included, Fuel_MerchantCity field must also be included.*	U.S. city in which fueling transaction occurred.	Description of type of fuel purchased. May provide details additional to Fuel_TypePurchased.
Format:	Number	String / Text	String / Text	String / Text	String / Text
Special Rules:	N/A	N/A	N/A	N/A	N/A
Example:	31056	SPEEDWAY 1234	789 Main Rd NE	St. Paul	Unleaded 1

MINNESOTA DEPARTMENT OF TRANSPORTATION

MINNESOTA DISTANCE BASED USER FEE DEMONSTRATION

Test Plan

VERSION 1.0

MARCH 2020

wsp

DEPARTMENT OF TRANSPORTATION

REVISIONS

VERSION	DATE	CHANGES
1.0	03/05/2020	Initial Test Plan development

TABLE OF CONTENTS

ACRONYMS

C/AV	Connected/Automated Vehicle
CSV	Comma Separated Values
DBUF	Distance-Based User Fee
MnDOT	Minnesota Department of Transportation
PII	Personally Identifiable Information
RACI	Responsible, Accountable, Consulted, Informed
Revenue	Minnesota Department of Revenue
SM	Shared Mobility
VCRI	Verification Cross Reference Index
VSI	Vision Systems Intelligence
XLS	Microsoft Excel file extension (1997-2003)

1 SCOPE

The Minnesota Department of Transportation (MnDOT), in partnership with the Minnesota Department of Revenue (Revenue) and its Research Partners, the University of Minnesota, Humphrey School of Public Affairs (Humphrey School) and WSP USA, will conduct a 12-month Distance-Based User Fee (DBUF) demonstration to confirm the ability to accurately and securely collect travel data from Shared Mobility (SM) providers' vehicle fleets and Connected and Automated Vehicles (C/AV) to assess a simulated DBUF tied to road use.

The demonstration will be conducted in three stages, each stage progressively building upon the previous. Testing will be conducted for each stage of the demonstration, focusing on the requirements for that specific stage.

The following describes how each of the 3 stages of the demonstration will operate:

- ***Demonstration Stage 1 – No Formal Reporting*** (~4 months): Monthly, SM providers will sanitize and aggregate travel data and transmit the datasets to the shared demonstration data repository. The C/AV Researcher may generate datasets for use in analyses and simulated reporting. MnDOT's research partners, the Humphrey School and WSP USA will conduct simulated financial reporting to the State, using information provided by the SM providers. The research partners will work with the State and SM providers to develop the Revenue Report template to be used in subsequent stages. The State may conduct initial mock audit inquiries with SM Providers, based on aggregated data transmitted. The Research Partners will conduct analyses on transmitted data.

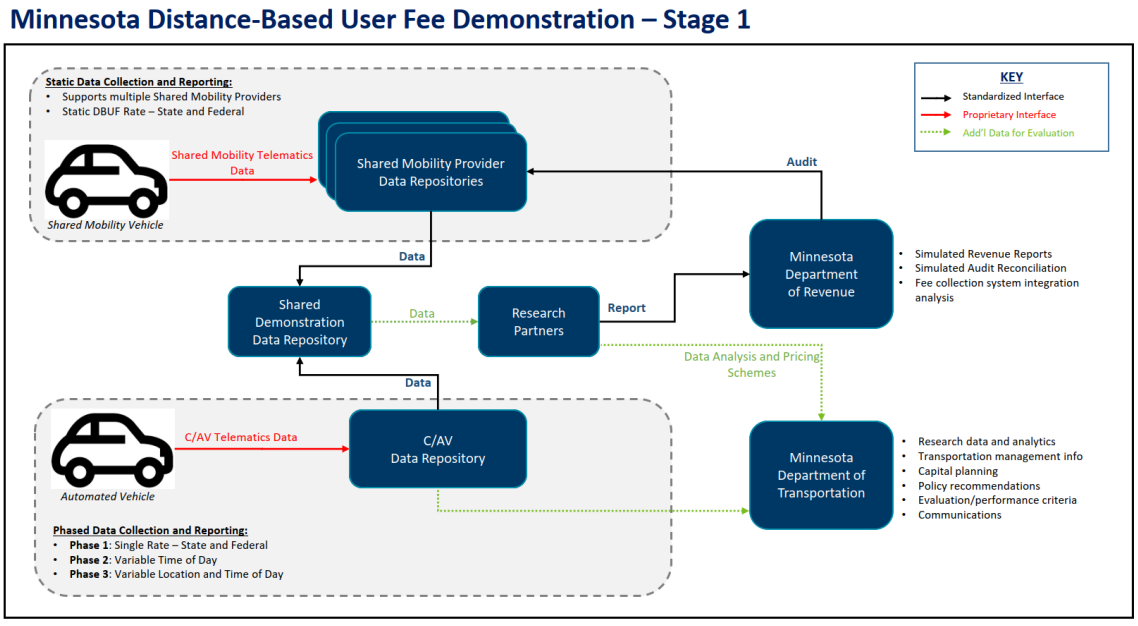


Figure 1: Minnesota DBUF Demonstration Architecture – Stage 1 No Formal Reporting

- ***Demonstration Stage 2 – Initial Revenue Reporting*** (~4 months): Monthly, SM providers will sanitize and aggregate travel data and transmit the datasets to the data repository. SM providers will also assess DBUF and fuels tax rates on the aggregated data, generate a Revenue Report (using the template designed in Stage 1) and transmit the report to the data repository for validation by the research partners. The C/AV Researcher may generate datasets for use in analyses and simulated reporting. The State may conduct mock audits with SM Providers, based on aggregated data. The research partners will conduct analyses on transmitted data.

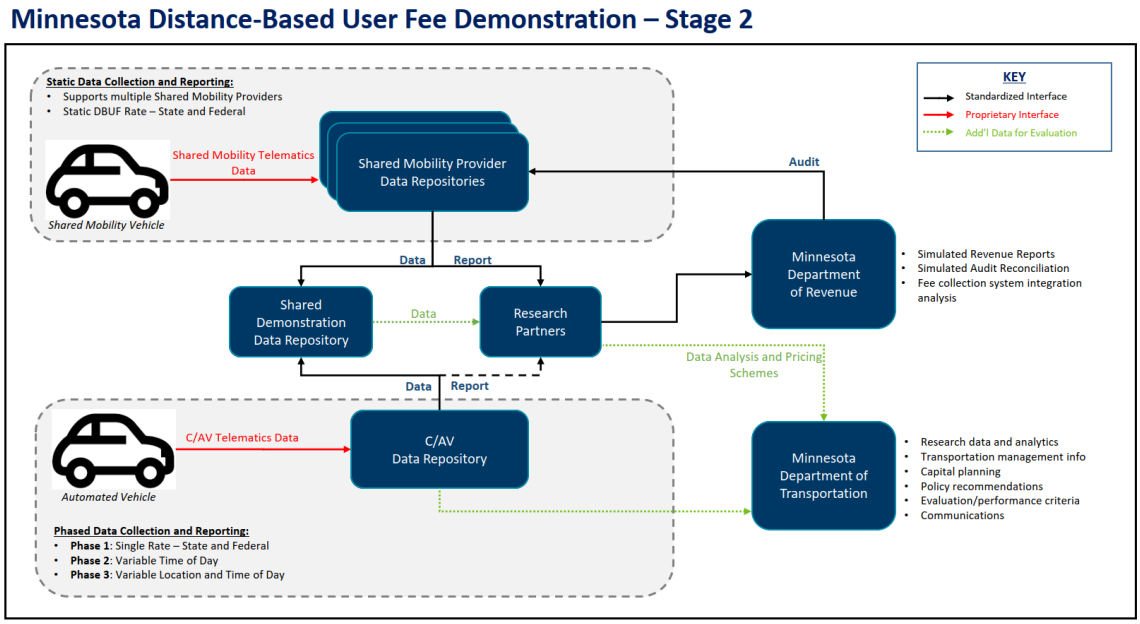


Figure 2: Minnesota DBUF Demonstration Architecture – Stage 2 Initial Revenue Reporting

- ***Stage 3 – Final Revenue Reporting*** (~4 months): Monthly, SM Providers will sanitize and aggregate travel data and transmit the datasets to the shared demonstration data repository. SM Providers will also assess DBUF and fuels tax rates on the travel data, generate a Revenue Report and transmit the report to Revenue directly for simulated tax reporting, mock auditing, and demonstration evaluation purposes. The C/AV Researcher may generate datasets for use in analyses and simulated reporting. The Research Partners will conduct analyses on transmitted data.

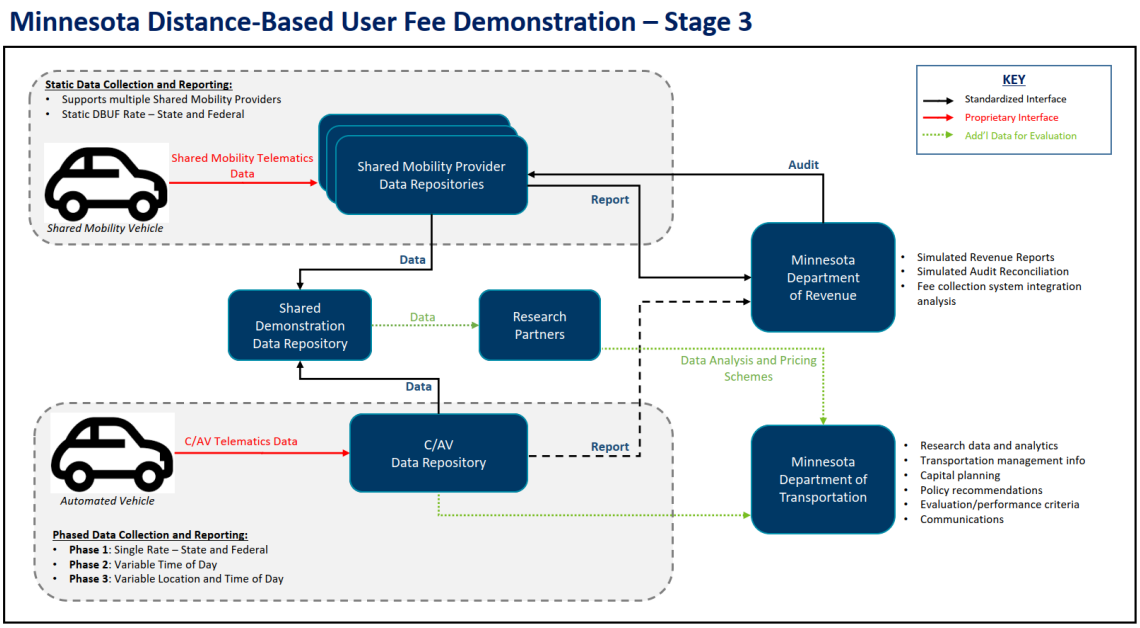


Figure 3: Minnesota DBUF Demonstration Architecture – Stage 3 Formal Revenue Reporting

2 ROLES & RESPONSIBILITIES

There are several entities involved in demonstration testing:

- **Minnesota Department of Transportation (MnDOT)**: Demonstration testing oversight and approval of results for all testing phases.
- **Minnesota Department of Revenue (Revenue)**: Review of simulated revenue reports and conducting mock audits on submitted reports.
- **University of Minnesota, Hubert H. Humphrey School of Public Affairs (Humphrey School)**: Support test case development and validation to confirm the demonstration is designed in a way to address evaluation criteria, and support data analyses activities.
- **WSP USA**: "Technical Team" – Establish and manage test plan, strategy, cases, environment and exit criteria. Review test results from SM Providers and C/AV Research Partner through all phases of testing. Coordinate Dry Run with all participating entities.
- **SM Providers (Zipcar & HOURCAR)** – Execute test cases to complete unit, integration, and acceptance testing, report results and resolve issues to confirm compliance with all SM Provider requirements.
- **C/AV Research Partner (Vision Systems Intelligence (VSI))** – Execute test cases to complete unit, integration, and acceptance testing, report results and resolve issues to confirm compliance with all C/AV requirements. VSI will also be responsible for standing up and maintaining the shared demonstration data repository, and supporting the repository during integration testing.

The following RACI table describes the responsibility of each entity during testing.

R = Responsible *A = Accountable* *C = Consulted* *I = Informed* **TESTING ACTIVITY**	**SM Providers (Zipcar & HOURCAR)**	**C/AV Research Partner (VSI)**	**WSP USA**	**Humphrey School**	**MnDOT**	**Revenue**
Conduct Unit Testing	R	R	A			
Validate Unit Testing Results			R	I	A	I
Conduct Integration Testing	R	R	A			
Validate Integration Testing Results			R	I	A	
Conduct Dry Run (Acceptance Testing)	R	R	R	C	R	C
Validate Dry Run Results			R	C	A	C
Create Punchlists	C	C	R	I	A	I
Final Testing Approval and Go/No-Go to Launch Demonstration	C	C	R	I	A	I

Table 1: Demonstration Testing Roles & Responsibilities RACI Chart

3 STRATEGY

3.1 TEST PHASES

The technical team, in concert with the SM providers and C/AV research partner, will conduct testing on all systems, processes, and components to ensure each demonstration requirement is met ("Unit Testing"). The technical team will then test the overall systems integration, validating that data can be seamlessly and securely transmitted from the SM providers and C/AV research partner to the shared demonstration data repository and the State ("Integration Testing"). The overall project team will then conduct an acceptance test ("Dry Run") to test end-to-end demonstration functionality. Each testing phase is described in more detail below.

The successful completion of each progressive test stage will serve as the entry criteria for the next stage. Only when all tests are successfully executed and MnDOT has signed off on test results will the systems, technologies, and processes for the demonstration be considered ready for launch.

3.1.1 UNIT TESTING

The technical team, SM providers and C/AV research partner will conduct unit testing of all systems and processes to be used during the demonstration, necessary to prove compliance with all demonstration system and business requirements. Unit testing will include data collection, data processing, and simulated revenue reporting.

SM providers and the C/AV research partner will provide a suite of documentation (manuals, procedure documents, data sheets, etc.) as well as conduct a series of test cases to simulate demonstration operations functionality, in order to successfully prove compliance with each of the business and system requirements defined for the demonstration.

Unit testing will occur for each of the 3 demonstration stages, to validate the requirements developed specifically for the respective stage.

3.1.2 INTEGRATION TESTING

The technical team, SM providers and C/AV research partner will conduct integration testing of all demonstration interfaces. Integration testing will include verifying connectivity of each participating entity to the shared demonstration data repository, successful upload of datasets and simulated revenue reports, and validating data and reports are correctly formatted and include all required data/fields, per the interface specifications. The technical team will coordinate integration testing activities with each provider to verify interface connectivity and compliance with interface requirements.

Integration testing will occur for each of the 3 demonstration stages, validating interfaces/reports designed for the respective stage.

3.1.3 DRY RUN

Following successful completion of unit and integration testing for each demonstration stage, the technical team, SM providers and C/AV researcher will conduct an end-to-end Dry Run test of the demonstration. MnDOT, Revenue, and the Humphrey School will also witness testing during the Dry Run and review Dry Run results. The Dry Run will validate demonstration stage 1 functionality, including data collection, data processing and aggregation, and reporting to the shared demonstration data repository. The technical team will coordinate with each provider to launch and operate the Dry Run. At the end of the Dry Run, the technical team will compile the results and conduct a “hot wash” with all entities that operated or contributed to the Dry Run to discuss outstanding issues, proposed changes and updates to meet the needs of the demonstration, and the potential impacts of any changes. The Dry Run is the final step to validate the system is ready to launch into demonstration operations.

For demonstration stages 2 and 3, unit testing results for those respective stages will be used to generate appropriate Dry Run testing and results.

3.2 PUNCHLISTS

In the event a test is not successfully executed, or a requirement is not fully met through one or more tests, the item’s level of criticality to the remainder of testing and ultimately demonstration operations launch will be evaluated. If an item is not critical to overall operation of the system, the item will be “punchlisted”, allowing the progression of testing without fully completing the testing phase the item was punchlisted in. All punchlisted items will be reviewed with MnDOT at time of assignment to the punchlist, and will be reviewed at regular check-ins with MnDOT and the providers to evaluate the progress of further testing to move the item into compliance.

3.3 TRACEABILITY

Test cases will be defined for each requirement, serving as a guideline for how each requirement is expected to be met (with either documentation or test results). The test cases are defined in a verification cross reference index (VCRI), which lists the requirement and the associated test case, and provides a mechanism to track the status of compliance for each requirement during testing.

4 TESTING SCENARIOS

The demonstration is divided into three main operational processes: Data collection, data processing, and reporting. The demonstration also includes overarching system needs that drive system security, privacy protection, and other systemwide specifications. Testing will leverage these concepts to organize testing scenarios into logical test groups and cases.

4.1 SYSTEM NEEDS

The overarching demonstration system includes all subsystems, operational processes, activities, components and functions of SM and C/AV Providers, Research Partners and the State needed to successfully operate the demonstration. The overarching demonstration system will be tested to confirm it is secure, reliable, auditable, protects privacy and promotes safe and reliable operations.

- **Security**: Verify the system applies controls and safeguards to protect the system from malicious activity and protects information and operations.
- **Data Privacy and Protection**: Validate demonstration data is protected from unauthorized access, and correctly classifies and protects personally-identifiable information (PII).
- **Reliability and Availability**: Verify the system consistently functional and that any downtime does not negatively impact to demonstration data collection, processing and retention.
- **Auditability**: Verify data retention and destruction policies to support demonstration needs, and confirm alignment with industry standards to support auditing and traceability.
- **Safe and Reliable Operations**: Confirm that systems and technologies used to operate the demonstration do not compromise the safety of participating vehicles, vehicle users, or a provider's normal business operations.

4.2 DATA COLLECTION

The Data Collection operational process leverages the SM Provider's and C/AV Researcher's existing systems and technologies to collect relevant travel data from participating vehicles and transmit the data to the SM Provider's and C/AV Researcher's internal data repository for further processing. Testing of Data Collection includes several key activities:

- **Prepare Vehicle**: Verify that participating vehicles are uniquely identified and prepared to accurately collect the required demonstration data.
- **Collect Trip Data**: Verify that trip/travel data is collected from participating vehicles in a way that supports the accurate calculation and reporting of a DBUF.

- **Collect Location Data**: Verify that SM Providers collect, at a minimum, vehicle origin and destination data for participating vehicles; Verify that the C/AV researcher collects detailed location differentiation data using geographic waypoints.
- **Collect Fuel Purchase Data**: Verify that fuel purchase data is collected from participating vehicles in a way that supports the accurate calculation and reporting of state and federal motor fuel taxes.
- **Transmit Collected Data**: Verify that the data collected from participating vehicles (miles, fuel purchase, and location) is transmitted to the respective provider's data repository / backend systems for further processing, at a frequency that supports demonstration reporting requirements.
- **Report Errors and Events**: Identity potential errors and events that may occur during the data collection process and how those errors/events are reported.

4.3 DATA PROCESSING

The Data Processing operational process leverages SM Provider's and C/AV Researcher's existing processes to receive data from vehicles, validate and process the data into transactions, and use the transactions to sanitize and aggregate the data for transmission to the DBUF demonstration third-party repository for simulated revenue reporting and analyses. The testing of Data Processing includes the following key activities:

- **Receive Transmitted Data**: Verify that data transmitted from the Data Collection mechanism(s) is received securely and is complete.
- **Assign Data to Vehicle**: Verify that the data received from the Data Collection mechanism(s) is assigned to the correct vehicle in the SM Provider's systems.
- **Process into Transactions**: Confirm that the received data is processed into logical, transaction records that are aligned with the correct vehicle and associated trips. Transactions may be grouped by trip, by reservation, by day, or another other logical grouping that is unique, traceable, and does not illogically split trips (for auditability).
- **Validate Data**: Verify that reasonableness/sanity checks are performed on transactions to confirm the validity and accuracy of the data.
- **Sanitize Data of PII**: Confirm that processed data aggregated for the demonstration do not include any personally-identifiable information (PII), including customer identity and customer billing/payment information.
- **Transmit Data to Repository**: Verify that sanitized, aggregated data is correctly transmitted to the shared demonstration data repository, in the format and frequency as defined in the requirements and interface specifications.

4.4 REPORTING

TEST SCENARIOS IN THIS SECTION WILL BE DEFINED DURING STAGE 1 OF THE DEMONSTRATION.

5 TEST PROCEDURES

The following section details procedures that serve as guidelines for successful execution and completion of each testing phase and the associated requirements.

5.1 UNIT TESTING

To successfully complete unit testing, both documentation and test results are expected to be used to verify compliance, based on the requirement being met.

Documentation will be used to verify process or policy based requirements, such as third-party compliance verification of an industry standard. Test results will be used to demonstrate how a component operates and complies with a requirement based on functionality.

Providers will submit a suite of documentation and a series of test results during the unit testing phase, clearly indicating in the VCRI which document or test case aligns with each requirement to prove compliance. See the VCRI/Test Cases document for information on the anticipated methods for compliance verification for each requirement.

WSP USA will coordinate unit testing with each provider, reviewing submitted documentation and test results to verify compliance status of all requirements. WSP USA will witness testing with each provider to verify compliance.

5.1.1 UNIT TESTING – DOCUMENTATION

SM Providers will provide copies of, or live access to (if company policies restrict providing copies), documentation appropriate to prove compliance with certain requirements. Documentation may include, but is not limited to:

- Operations Manuals
- Operations Process Documents
- Operations Procedure Documents
- Plans and Guides (e.g. Disaster Recovery Guide or Information Systems Plan)
- Specifications / Data Sheets for systems or technologies
- Production Manuals and/or Release Notes for systems or technologies
- Statements of Attestation (Provider assumes liability through contractual statement)

5.1.2 UNIT TESTING – TEST RESULTS

The following procedures serve as a guideline for providers to simulate demonstration operations scenarios, for Stage 1 of the demonstration, to generate test results appropriate to validate unit test-level compliance requirements. During each step of these unit test procedures, one or more requirements will be validated using the test results to verify compliance.

UNIT TESTING PROCEDURES – STAGE 1 "NO FORMAL REPORTING"	
Step	**Procedure**
1	Conduct normal carshare operations
2	Collect SM vehicle trip and location data • At least 4 vehicles • At least 3 trips per vehicle
3	Collect SM vehicle fuel purchase data • At least 4 vehicles • At least 2 fuelings per vehicle
4	Process and aggregate the data, per "Data Processing" requirements and interface specifications for Stage 1 datasets. Sanitize aggregated data of all Personally Identifiable Information (PII).
5	Compile aggregated datasets (mileage and fuel purchases) in a CSV or XLS format.
6	Identify and report any errors or events that occurred during data collection, processing or transmission. *Error and event reporting interface specifications to be designed collaboratively between providers and WSP USA during the unit testing phase.*

NOTE: Requirements and test cases for Stage 2 will be developed during Stage 1.

UNIT TESTING PROCEDURES – STAGE 2 "INITIAL REVENUE REPORTING"	
Step	**Procedure**
1	Obtain a copy of a demonstration aggregated and sanitized dataset (as generated by the 10th of the month following the reporting period).
2	Using the data from the dataset obtained in step 1, generate a simulated revenue report per the stage 2 interface specifications.
3	Access the shared demonstration data repository, using current credentials.
4	Access the appropriate repository folder for your organization.
5	Select the option to upload one or more files. Browse to and select the simulated revenue report generated during Step 2.
6	Verify the selected file was successfully uploaded to the appropriate repository folder.

NOTE: Requirements and test cases for Stage 3 will be developed during Stage 1 and 2.

UNIT TESTING PROCEDURES – STAGE 3 "FORMAL REVENUE REPORTING"	
Step	**Procedure**
1	Obtain a copy of a demonstration operations simulated revenue report (as generated by the 10th of the month following the reporting period).
2	Follow instructions provided in stage 3 interface specifications to transmit the simulated revenue report to the Minnesota Department of Revenue.

5.2 INTEGRATION TESTING

The following procedures serve as a guideline for providers to simulate demonstration operations interface connectivity and transmissions, for Stage 1 of the demonstration, to generate test results appropriate to validate interface requirements and specifications.

NOTE: Integration testing procedures for demonstration stages 2 and 3 are addressed as part of the unit testing procedures for those respective phases.

Step	Procedure
1	Compile aggregated datasets (mileage and fuel purchases) in a CSV or XLS format, per the interface specifications. *Compiled datasets created during Unit Testing may be used for this step.*
2	Access the shared demonstration data repository by clicking the weblink below: https://dbuf.vsi-labs.com/html/login.html
3	Log in to the data repository using your username and password. *You should have received instructions prior to this step to setup a new user account using your email address. If you have not received these instructions and/or have not setup a user account to access the data repository, please contact Markell Moffett (WSP USA) at markell.moffett@wsp.com*
4	Access the appropriate repository folder for your organization.
5	Select the option to upload one or more files. Browse to and select the compiled dataset generated during Step 1.
6	Verify the selected file was successfully uploaded to the appropriate repository folder.

5.3 DRY RUN

For the Demonstration Stage 1 Dry Run, the test procedures executed for unit and integration testing will be used or repeated to simulate the collection of SM vehicle data (trip, fuel purchase and location), processing and sanitizing the data, aggregating and compiling the data into the appropriate reporting format, and transmitting the data to the shared demonstration data repository. The Dry Run will contain no less than one week of vehicle data (trips, fuel purchases, and location).

MnDOT and its partners may choose to witness Dry Run testing and activities. This would include reserving a provider's carshare vehicle and taking one or more trips, then following those trips through the data processing, aggregation and reporting process. The technical team will work with MnDOT, its partners, and the providers to coordinate any test witnessing and evaluation during the Dry Run.

The technical team, in conjunction with providers, will compile Dry Run test results and a final Dry Run report to indicate whether the system is prepared and certified for demonstration launch.

Following successful completion of the Dry Run, and confirmation the system is approved for demonstration launch, the technical team and providers will purge systems of Dry Run data and prepare systems for demonstration launch into operations.

For demonstration stages 2 and 3, unit testing results for those respective stages will be used to generate appropriate Dry Run testing and results, to verify compliance with functionality added for stages 2 and 3, prior to launching that functionality into demonstration operations.

TO: Ken Buckeye, DBUF Program Manager, Minnesota Department of Transportation

FROM: Markell Moffett, WSP

SUBJECT: Minnesota Distance Based User Fee Demonstration – SM Provider Testing Status

DATE: March 31, 2020

The Minnesota Distance Based User Fee Demonstration is planned to launch demonstration operations on April 1st, 2020. To prepare for the April 1st demonstration operations launch date, WSP has coordinated with each Shared Mobility (SM) Provider to conduct Unit (component), Integration, and Acceptance Testing, to test all systems, processes and components needed to support data collection, processing and reporting during the demonstration.

The status of each provider's testing is detailed below, along with WSP's recommendations for continuing to move towards an April 1st demonstration launch.

VSI LABS

Status: Certified

VSI successfully completed Unit, Integration, and Acceptance Testing ("Dry Run") during the month of March 2020. The table below depicts the status of VSI's compliance for requirements under each phase of testing.

Testing Phase	# of Requirements				
	Total	Compliant	Non-Compliant	N/A	Remaining
Unit Testing	**87**	72	0	15	0
Integration Testing	**87**	4	0	83	0
Acceptance Testing	**87**	53	0	34	0

RECOMMENDATION

WSP recommends VSI be considered compliant with all demonstration requirements, completing unit, integration and acceptance testing phases, and be approved for demonstration launch and operations on April 1st, 2020.

HOURCAR

Status: Certified

HOURCAR successfully completed Unit, Integration, and Acceptance Testing ("Dry Run") during the month of March 2020. The table below depicts the status of HOURCAR's compliance for requirements under each phase of testing.

Testing Phase	# of Requirements				
	Total	Compliant	Non-Compliant	N/A	Remaining
Unit Testing	**87**	81	0	6	0
Integration Testing	**87**	7	0	80	0
Acceptance Testing	**87**	55	0	32	0

RECOMMENDATION

WSP recommends HOURCAR be considered compliant with all demonstration requirements, completing unit, integration and acceptance testing phases, and be approved for demonstration launch and operations on April 1st, 2020.

ZIPCAR

Status: Conditionally Certified

Zipcar initiated Unit Testing on March 16th, 2020, at which time 57 requirements were deemed compliant. Zipcar is working with their data science team to gather the documentation needed to prove compliance with 24 remaining systems needs requirements.

Zipcar successfully Integration and Acceptance Testing ("Dry Run") during the month of March 2020. The table below depicts the status of Zipcar's compliance for requirements under each phase of testing.

Testing Phase	# of Requirements				
	Total	Compliant	Non-Compliant	N/A	Remaining
Unit Testing	**87**	57	0	6	24
Integration Testing	**87**	7	0	80	0
Acceptance Testing	**87**	55	0	32	0

RECOMMENDATION

WSP recommends Zipcar be conditionally certified, and approved to move forward with demonstration launch on April 1st, with the following punchlist requirements and action items:

- 24 System Needs requirements – Unit Testing: Zipcar to provide proof of compliance to WSP no later than April 30th, 2020, prior to transmitting data to the shared demonstration data repository for month 1 of the demonstration (May 1-10).

WSP will monitor the status of any punchlisted requirements and completion of action items to ensure the Minnesota DBUF Demonstration is successfully deployed and operated to meet project needs.

Sincerely,

Markell Moffett
Transportation Operations Strategy Consultant
(360) 421-3638
Markell.Moffett@wsp.com

MINNESOTA DEPARTMENT OF TRANSPORTATION

MINNESOTA DISTANCE BASED USER FEE DEMONSTRATION PLAN

Proof of Concept Report

VERSION 1.4

MARCH 2019

wsp

DEPARTMENT OF TRANSPORTATION

REVISIONS

VERSION	DATE	CHANGES
1.0	12/24/2018	Initial Draft
1.1	12/26/2018	Updates from WSP internal review
1.2	01/31/2019	Addition of POC Results and Takeaways
1.3	02/22/2019	Updates from WSP internal review
1.4	03/06/2019	Updates from MnDOT review

CONTENTS

1 EXECUTIVE SUMMARY

OBJECTIVE

The Minnesota Department of Transportation (MnDOT) is partnering with shared mobility (SM) providers and connected and automated vehicle ("C/AV") research partners to support the research, demonstration, and examination of the necessary policy and technical considerations needed for developing distance-based user fees (DBUFs). The first step in this effort was to conduct a Proof of Concept ("POC"), a focused test that aimed to meet the following objectives:

- Demonstrate the ability to accurately capture and report travel data to assess a DBUF;
- Prove that DBUF-related data can be accurately and securely transferred between SM providers and state agencies without impeding motorist privacy;
- Understand how a DBUF would technically impact shared mobility providers; and
- Confirm existing systems and interfaces can be used for DBUF collection and reporting.

APPROACH

The Proof of Concept was designed using existing systems, interfaces, and processes (where possible) to demonstrate the technical feasibility and impacts that a future DBUF program could have in Minnesota. The Proof of Concept defined key roles and responsibilities, interfaces and expected data flows, and detailed test procedures needed to confirm the established objectives.

RESULTS

MnDOT partnered with a SM provider and a C/AV research partner to collect data from a variety of vehicles, sanitize and aggregate the data, and transmit the data securely to a data repository. The data was then used to create simulated invoices, assessing a DBUF of miles traveled and crediting fuels tax on gallons purchased. Finally, Revenue reviewed the simulated invoices and related data to determine potential integration with existing tax collection systems and processes and to confirm auditability.

TAKEAWAYS

The goals and objectives set forth for the POC were met. The POC demonstrated that it is possible to accurately capture and report travel data from a SM provider to state agencies without impeding motorist privacy. Collecting and reporting data for a DBUF has minimal impact to SM providers' operations. Existing systems and interfaces can be used to collect and report DBUF-related data.

There are still open policy considerations, including how to handle federal DBUF, federal fuels tax credits, and out-of-state mileage. Ultimately, the largest takeaway from the POC is that this DBUF model is viable, cost effective, and scalable for a larger implementation.

NEXT STEPS

Following the award of federal grant funding in February 2019, MnDOT can now start designing the demonstration, leveraging processes and systems used during the POC as the foundation for a broader study of how a DBUF program could be implemented in Minnesota.

2 BACKGROUND

MnDOT, along with the Minnesota Department of Revenue ("Revenue"), and the University of Minnesota Humphrey School of Public Affairs, are testing the feasibility of assessing a distance-based user fee ("DBUF") on shared mobility ("SM") and Connected and Automated Vehicle ("C/AV") partners. Through this study, MnDOT and their partners are assessing the technical feasibility, organizational and administrative considerations, capturing public opinion, and determining an acceptable per-mile fee to be potentially assessed on SM providers.

The project assesses the feasibility of replacing and/or supplementing other user fees now collected from drivers that use Minnesota's roads. For example, various aspects of fee collection, including fuel taxation, registration fees, leasing, rental, insurance, and other aspects of vehicle use, may also be eligible for conversion to a DBUF under the context of SM. This concept is being pursued by MnDOT to create a highly efficient revenue collection mechanism that recognizes the future trajectory of social trends and technology, and one that can be used as a model for deployment. It is assumed that the convergence of SM and C/AV vehicles will profoundly affect the way MnDOT uses, owns, and pays for transportation in the future. It is also assumed that technologies already onboard many new vehicles (or soon to be) can collect, process, and share data easily and cost effectively. This capability provides the pathway toward wider deployment of DBUFs and will show how these fees can be collected as efficiently and cost-effectively as possible using reliable and secure technologies already embedded in vehicles.

The project has two testing phases:

- Proof of Concept: A short, focused test aiming to prove that DBUF-related data can be accurately and securely transferred between a shared mobility provider and MnDOT.
- Demonstration: A larger-scale deployment of DBUF to demonstrate feasibility on a broader scale, and to identify key considerations to address moving forward.

This report details the Proof of Concept objectives, test procedures, and results. The report also outlines key takeaways and next steps for MnDOT and their partners as they look to further research of DBUF and explore a larger-scale demonstration effort in 2019-2020.

3 SCOPE

The Proof of Concept set out to demonstrate that travel data from a SM provider's vehicle fleet as well as an automated vehicle, can be collected by embedded telematics systems, sanitized, aggregated, and transmitted accurately and securely to state agencies for the purpose of assessing a DBUF. The project team evaluated the ability to the aggregate travel data to determine potential DBUF pricing schemes, convert the data into a series of financial reports (simulated invoices and tax returns), and determine the potential for integrating DBUF financial reporting into Revenue's existing fee collection system.

Leveraging the SM provider's direct access to its vehicle fleet data without required interaction with drivers presents a more efficient model to collect and assess distance-based user fees. Collection of data directly from a C/AV's embedded telematics further supports administrative efficiency and the minimal impact assessing a DBUF could have on the State of Minnesota and private sector partners.

3.1 GOALS AND OBJECTIVES

The POC lays the foundation for a larger demonstration effort. To ensure MnDOT and its partners are prepared to launch and operate the larger-scale effort, the POC focused on the following key goals and objectives:

- Demonstrate the ability to accurately capture and report travel data to assess a DBUF;
- Prove that DBUF-related data can be accurately and securely transferred between SM providers and state agencies without impeding motorist privacy;
- Understand how a DBUF would technically impact shared mobility providers; and
- Confirm existing systems and interfaces can be used DBUF collection and reporting.

3.2 ASSUMPTIONS

Several assumptions were identified for the Proof of Concept to ensure expectations and definition of success are aligned amongst stakeholders:

- The POC testing period shall last for no less than two weeks;
- A minimum of 500-vehicle miles from the SM vehicle fleet and C/AV must be captured;
- All data used in the POC must be sanitized, removing any personally identifiable information ("PII");

- Commercial-off-the-Shelf ("COTS") hardware and systems, including embedded telematics and existing hardware and software, shall be used to the fullest extent possible;
- Firewalls and other network protection systems shall be implemented to ensure that all POC data is safeguarded against unauthorized dissemination; and
- All data and reports provided for the POC shall be in Comma Separated Values ("CSV") or Excel Spreadsheet ("XLS") format.

3.3 ROLES AND RESPONSIBILITIES

There were several entities involved in the Proof of Concept. Their roles and responsibilities included:

Minnesota Department of Transportation (MnDOT) – MnDOT was the DBUF Proof of Concept project manager. MnDOT administered the Proof of Concept, driving test procedure execution, quality and results. MnDOT managed contracts with other team members and coordinated communications across the entire Proof of Concept team.

HOURCAR – HOURCAR, a Shared Mobility (SM) provider, provided data collection and aggregation services for its vehicle fleet. HOURCAR collected travel data from its SM vehicles, sanitized and aggregated the data on a monthly basis, and transmitted the data to a data repository hosted by VSI. HOURCAR coordinated any communications with its customers for the duration of the Proof of Concept.

Vision Systems Intelligence (VSI) Labs – VSI served a dual role in the Proof of Concept. First, VSI collected travel data from its C/AV, sanitized and aggregated the C/AV travel data on a weekly basis, and transmitted the data to a VSI-hosted data repository. Second, VSI developed and hosted a data repository that received and stored aggregated data transmitted by HOURCAR and by the VSI-owned C/AV. The data repository was made accessible to other project team members for review and analysis purposes.

University of Minnesota Hubert H. Humphrey School of Public Affairs (Humphrey School) – The Humphrey School performed analysis on data transmitted to the VSI-hosted data repository. The Humphrey School analyzed provided data to validate the accuracy and quality of the aggregated vehicle data, to establish potential pricing schemes for the demonstration's DBUF rate(s), and to generate simulated financial reports for review by Revenue.

Minnesota Department of Revenue (Revenue) – Revenue coordinated with MnDOT and other team members to evaluate financial reports and supporting audit documentation. Revenue assessed the potential for integrating financial report information into the existing Revenue fee collection system, GenTax.

WSP – WSP was the technical consultant and systems integrator for the Proof of Concept. WSP developed and validated the Proof of Concept functional and system architecture, created test procedures, and provided overall technical evaluation of the Proof of Concept structure, execution, and results.

3.4 ARCHITECTURE

The following diagram outlines the functional architecture of the Proof of Concept, highlighting key entities, subsystems, and interfaces.

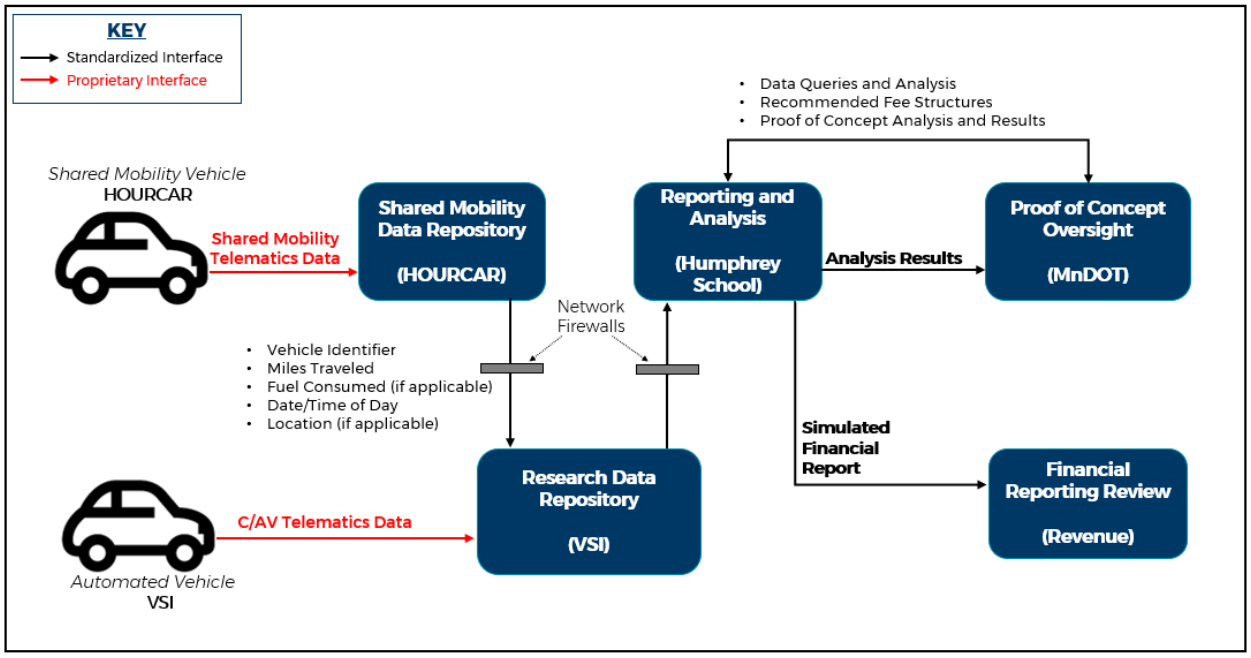


Figure 1: MnDOT DBUF Proof of Concept Architecture Diagram

3.5 CONSTRAINTS AND DEPENDENCIES

The following constraints and dependencies were identified to set clear expectations of limitations and potential barriers to success:

- SM vehicle fleet data is dependent on HOURCAR customers utilizing the participating vehicle(s) to collect at least 500 miles of travel data during the desired timeframe;
- The Proof of Concept is dependent on the HOURCAR and VSI to successfully collect, aggregate, and transmit the required data to the data repository; and
- HOURCAR and VSI are responsible for ensuring that all data provided to the research data repository is sanitized of PII.

4 APPROACH

The POC was a focused test of how DBUF can be collected from shared mobility and automated vehicles. Designed using existing systems, interfaces, and processes where possible, the POC demonstrates the minimal footprint a future DBUF program could have in Minnesota. The test was not to verify the existing functionality of involved systems or interfaces, but rather that collection of data from participating vehicles for the purpose of assessing a DBUF is feasible.

The key roles and responsibilities, interfaces and expected data flows, and detailed test procedures were defined for the POC. Each test procedure step to be conducted by the appropriate entities were defined, with the results annotated in in this POC report. An authorized representative from each participating entity approved each portion of testing to ensure the results were in line with expectations and defined measures of success.

4.1 PRE-TEST SETUP

To prepare for the POC, both HOURCAR and VSI systems were evaluated to determine the available data currently collected, and what data points should be provided for the POC. Upon that analysis, both HOURCAR and VSI leveraged their existing systems capabilities to capture the relevant data.

HOURCAR identified SM vehicles within its fleet that could capture all data points required for the Proof of Concept with no inaccuracies or errors. VSI identified a C/AV that could do the same.

VSI established a network data repository that stored aggregated data transmitted from HOURCAR, and detailed and aggregated trip data transmitted from the C/AV directly. VSI provided secure data repository access to all participating entities via a website link.

Each participating entity, as well as the project team, tested connectivity to the repository to verify data transmissions and queries functioned appropriately during the POC. Specifically, the Humphrey School tested connectivity to ensure they could download the aggregated data necessary to compile their reports and develop the per-mile DBUF rate schedule.

4.2 TEST PROCEDURES

Trip data from participating vehicles were to be transmitted to HOURCAR via proprietary protocols, on a daily basis (or at the end of each trip reservation). Trip data included a unique vehicle identifier, trip mileage, trip start and end timestamps. Trip data stored in HOURCAR's internal data repository were to be aggregated weekly and sanitized of any PII. At the end of each week, HOURCAR would then transmit the aggregated data to the data repository hosted by VSI.

HOURCAR was also to collect the amount of fuel gallons, the type of fuel purchased, and the per-gallon price of each fueling using the statements from their fleet credit

cards. This data would be used to determine how many aggregated gallons have been consumed and provide the relevant fuel tax credits.

VSI also needed collect data from a C/AV, testing the ability to receive data directly from the telematics system embedded in the vehicle. VSI was to collect detailed trip data from the C/AV, aggregating on a daily basis and transmitting to the data repository. C/AV trip data included, at a minimum: Unique vehicle identifier, trip mileage, trip start and end timestamps and locations, and fuel gallons consumed.

HOURCAR and VSI were to collect data over a minimum of two weeks, and at least 500 total miles traveled for each vehicle type (SM and automated vehicle). Additionally, VSI was to collect mileage from travel across state borders to prove the ability to differentiate location. No miles traveled across state borders were to be included as part of the DBUF assessment.

The Humphrey School was to access the VSI-hosted data repository to query aggregated trip data and generate reports. The Humphrey School would then use POC data to contribute to analysis of potential DBUF pricing schemes. The Humphrey School would also use the data to calculate gross and net revenues based on a per-mile rate (as determined by pricing scheme analysis):

> Gross revenue = [(# of aggregate miles) x (per-mile rate)]
>
> Net revenue = [Gross Revenue] – [(# of fuel gallons consumed/purchased) x (motor fuel tax rate ($0.286))]

Revenues were to be calculated for each participating vehicle individually, and as an aggregate of all participating vehicles over the POC testing period. A financial revenue report consisting of both gross and net revenues was to be generated and sent to Revenue.

Revenue would then review the financial revenue report for accuracy and auditability. Revenue was also to determine the effort required to ingest the revenue report into GenTax, a system used to administer and process taxes, with minimal modifications.

5 RESULTS

The Proof of Concept was successful in meeting defined goals and objectives. MnDOT partnered with a SM provider and a C/AV research partner to accurately and securely collect, sanitize, and transfer DBUF-related data using existing systems. The data was then used to create simulated invoices, assessing a DBUF of miles traveled and crediting fuels tax on gallons purchased. Finally, Revenue reviewed the simulated invoices and related data to determine potential integration with existing tax collection systems and processes and to confirm auditability.

5.1 SHARED MOBILITY VEHICLES

HOURCAR, the SM provider, collected data for the POC over the fourth quarter of 2018 and into January 2019. The span of data collection allowed for a range of reservations and trips during standard driving months and the holiday season. From the 70 participating vehicles, 4,633 unique trips were taken, totaling 103,550 miles traveled and 3,542 gallons of fuel purchased.

The trip data collected and transmitted to the VSI-hosted data repository included the necessary fields to assess a DBUF on miles traveled, and credit fuels tax on gallons purchased. The trip and fuel purchase data files were cross-referenced to confirm miles traveled correspond to fuel gallons purchased for each vehicle, further confirming the correct DBUF and fuels tax credits were assessed for all participating vehicles.

Data was successfully sanitized of PII and aggregated prior to transmitting to the VSI-hosted repository. HOURCAR transmitted four files over the course of five months, confirming the limited effort required on the part of SM providers to collect, aggregate, and transmit DBUF-related data.

A few minor issues were identified during the POC data collection and transmission period, including duplication of trip data and variances in data provided between reporting periods. All issues identified were logged (fault log included as Appendix B), and either resolved during the POC or will be addressed prior to launching the demonstration.

5.2 CONNECTED AND AUTOMATED VEHICLE

Between November 2018 and January 2019, the Connected and Automated Vehicle (C/AV) automatically logged and transferred data for 43 trips. 1,716 miles were traveled, consuming 79 gallons of fuel. Trip data was accurately and securely logged and transferred to the VSI-hosted data repository.

For one of the logged trips, the C/AV research partner conducted a live data polling test. The C/AV collected, aggregated, and transmitted mileage and fuel consumption information on a second-by-second basis during the vehicle's travel using existing wireless connectivity. This short (25 minute) test confirmed the capability to send live data directly from a vehicle's embedded telematics systems, which can support several potential use cases, including real-time value-added services.

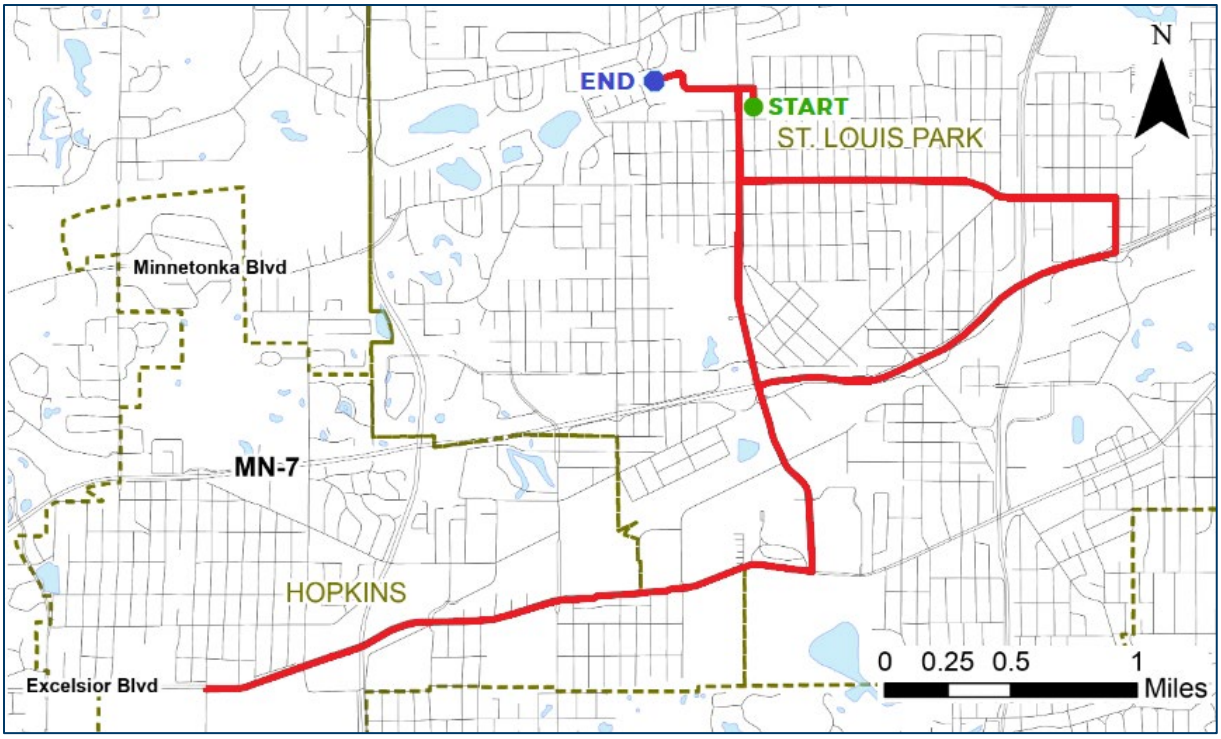


Figure 2: C/AV Live Data Polling Test Trip Map

During the data collection period, a small number of trips were not logged using the automated data collection system due to unrelated C/AV testing that required various vehicle systems to be taken offline or reset. This does not affect the outcome of the POC, as it is still proven that data can be collected from a C/AV. During the demonstration, MnDOT and the C/AV research partner will coordinate any DBUF testing to ensure that the dedicated use of the vehicle is scheduled in advance. The POC fault log included for reference as Appendix B.

5.3 DATA CONNECTIVITY AND REPOSITORY

VSI setup and hosted a data repository, providing access to all POC team members. The data repository required SSL over HTTP as well as username/password credentials to upload or access data files. These security measures support the secure transfer and storage of DBUF-related data. The SM provider and C/AV successfully transmitted data to the data repository throughout the POC. This data repository model may be leveraged during the demonstration for a secure and simple mechanism to manage demonstration data.

5.4 DATA ANALYSIS

The Humphrey School used data uploaded to the data repository to conduct analysis on trip and fuel purchase data. Analysis included verification of accuracy and checks for data anomalies or errors. Collected data was compared against manual trip logs, confirming that the data collection mechanisms accurately captured and transmitted the appropriate travel data from the vehicle. A few data errors were identified during the

analysis, and resolved with the SM provider and C/AV research partner. The errors found were related to the aggregation of data rather than the collection of the detailed trip data itself, and were easily resolved prior to completing the POC.

The Humphrey School also developed a framework for DBUF pricing schemes. A flat per-mile fee for state and federal fuels tax was developed based on the following formulas:

$$\text{DBUF Rate} = S + F$$

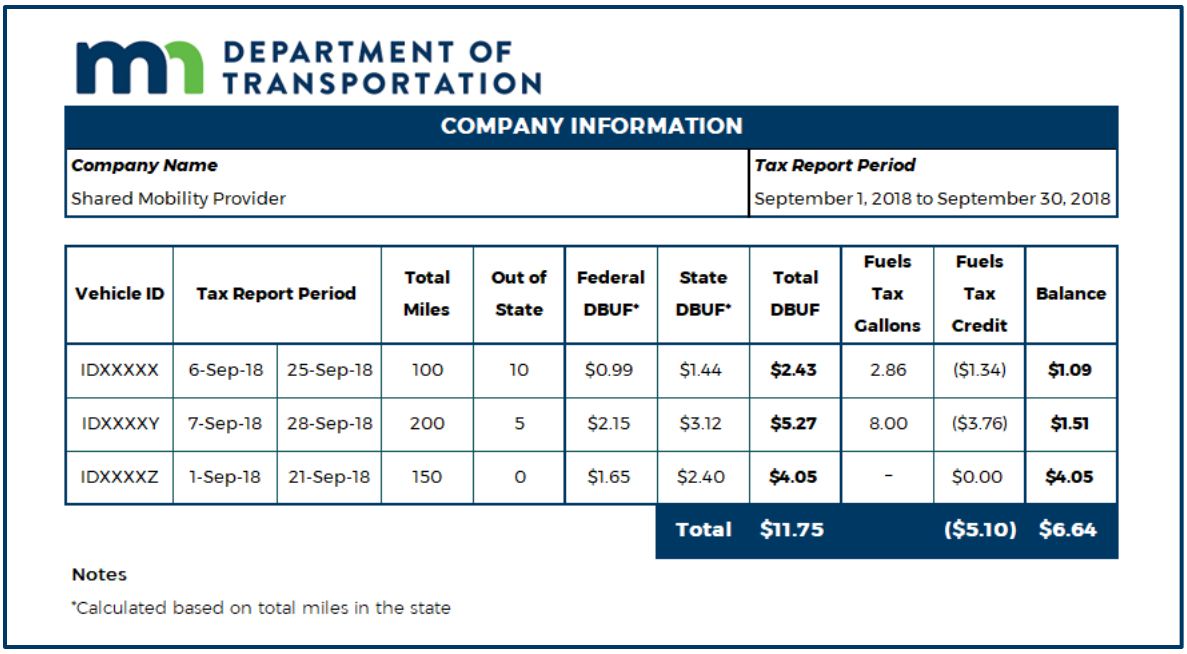
$$S = \frac{\text{state fuel tax revenue}}{\text{total state VMT}}$$

$$F = \frac{\text{federal fuel tax revenue}}{\text{total federal VMT}}$$

Data from the Federal Highway Administration and MnDOT was then used to calculate a potential DBUF rate. The DBUF rate calculated for the POC was 2.7 cents (1.6¢ state; 1.1¢ federal). A potential congestion fee rate was also evaluated, using several parameters and calculations, further defined in the Humphrey School's Pricing Schemes Task 3 Report. The analysis determined that in order to reduce congestion by 10%, an additional fee of 0.9 cents per mile should be assessed during peak-hours. Further evaluation of congestion pricing may be conducted during the demonstration, using detailed location and time-of-day information.

5.5 FINANCIAL REPORTING

The data provided by SM providers and the C/AV was used to develop financial report samples for Revenue's evaluation. Detailed data was summarized into a monthly invoice sample, displaying monthly DBUF, fuels tax credit, and net balance totals by vehicle. Detailed data was also used to create a sample Fuel Purchase Report that can be used to reconcile fuel purchases to fuel taxes credited as part of the DBUF calculations.



DEPARTMENT OF TRANSPORTATION

COMPANY INFORMATION

Company Name	***Tax Report Period***
Shared Mobility Provider	September 1, 2018 to September 30, 2018

Vehicle ID	Tax Report Period		Total Miles	Out of State	Federal DBUF*	State DBUF*	Total DBUF	Fuels Tax Gallons	Fuels Tax Credit	Balance
IDXXXXX	6-Sep-18	25-Sep-18	100	10	$0.99	$1.44	**$2.43**	2.86	($1.34)	**$1.09**
IDXXXXY	7-Sep-18	28-Sep-18	200	5	$2.15	$3.12	**$5.27**	8.00	($3.76)	**$1.51**
IDXXXXZ	1-Sep-18	21-Sep-18	150	0	$1.65	$2.40	**$4.05**	-	$0.00	**$4.05**
						Total	**$11.75**		**($5.10)**	**$6.64**

Notes

*Calculated based on total miles in the state

Figure 3: MnDOT DBUF Proof of Concept Monthly Invoice Sample

A Fuel Purchase Report sample was also developed and reviewed with Revenue to determine needed data fields to include for potential integration with GenTax, the existing motor fuels tax collection system. Fuel purchase information is needed for Revenue to correctly associate fuels tax credited under a DBUF program.

Information regarding fuel type and location of the purchase were not included in the sample Fuel Purchase Report reviewed by Revenue. Revenue requested that these data points be added to future reports, as they are needed to verify that the fuel was purchased in Minnesota, and that the correct fuels tax credit is being applied based on type. The Humphrey School confirmed that these fields are available through the SM provider's fuel purchase data files, and will be included in reports during the demonstration for full auditability validation.

As part of the POC, Revenue evaluated the potential to integrate DBUF financial reporting into the existing GenTax system. Due to the temporary and simulated nature of the POC and the upcoming demonstration, Revenue determined that integration with GenTax at this time is not viable. As part of the demonstration, Revenue will further assess the effort and potential costs associated with modifying GenTax to receive and process distance-based user fees.

6 TAKEAWAYS

There were several lessons learned, opportunities to leverage, and policy considerations to address moving forward as MnDOT looks to implement a larger-scale DBUF demonstration:

- It is possible to accurately and securely collect and transmit vehicle data from SM and connected/automated vehicles for the purpose of assessing a DBUF;
- Existing systems were used to collect data and assess a DBUF, minimal modifications would be required in a larger-scale implementation;
- Revenue cannot integrate with GenTax until the DBUF program is collecting actual fees. GenTax production and test environments hold live data, and the level of effort needed to integrate is not yet conducive;
- Addressing the assessment and collection of federal DBUF is important to align with STSFA grant objectives. Several policy considerations and demonstration requirements related to federal DBUF and crediting of federal fuels tax are still open discussion points;
- Calculation of fuels tax credits based on fuel purchased may present obstacles when attempting interoperability with a state that calculates credits based on fuel consumed;
- Out-of-state mileage was not evaluated during the POC. The demonstration will evaluate how miles traveled across state boundaries may impact a DBUF program from a technical and administrative perspective;
- SM provider vehicle fleets may have multiple reservation modes – confirmed reservation, cleaning, maintenance, etc. Which reservation modes should be assessed a DBUF is an open question to be addressed in the demonstration; and
- A DBUF program on SM providers' vehicle fleet is a cost-effective model that would have lower administrative costs than a traditional DBUF program.

7 NEXT STEPS

Conducting a POC prior to launching the demonstration allowed MnDOT and its partners to confirm base functionality, such as collecting and transmitting data, as well as resolve issues in a smaller, more controlled environment. With completion of a successful Proof of Concept, MnDOT is well-positioned to design, develop, and operate a larger-scale demonstration that addresses key policy considerations and moves the state forward in implementing a DBUF program.

Following the award of federal grant funding in February 2019, MnDOT can now start designing the demonstration, leveraging processes and systems used during the POC as the foundation for a broader study of how a DBUF program could be implemented in Minnesota.

APPENDIX A – TERMS AND ACRONYMS

TERM	DEFINITION
C/AV	Connected and Autonomous Vehicle
COTS	Commercial-off-the-Shelf: An application that does not require modification.
CSV	Comma Separated Values
Data Repository	A system that stores Proof of Concept-related data.
DBUF	Distance-Based User Fee
Firewall	A network security system that controls access to incoming and outgoing data.
GenTax	Revenue's existing fee collection system
HOURCAR	A Shared Mobility provider that provides carshare services to the greater Minneapolis/St. Paul metropolitan area, and partner to MnDOT for the Proof of Concept.
HTTP	HyperText Transfer Protocol
Humphrey School	University of Minnesota Hubert H. Humphrey School of Public Affairs: Research partner to MnDOT for Proof of Concept.
IP	Internet Protocol
MnDOT	Minnesota Department of Transportation: Project manager for the Proof of Concept.
PII	Personally-identifiable information
POC	Proof of Concept: A focused test to demonstrate the ability to collect data for the purpose of assessing a DBUF on SM vehicles in Minnesota.
Revenue	Minnesota Department of Revenue
SM	Shared Mobility
SSL	Secure Socket Layer
Telematics	System(s) embedded within a motor vehicle that controls, tracks, and reports on the vehicle. Telematics data point examples include: Miles traveled, vehicle location, and vehicle events (such as vehicle on/off).
Trip	Movement of a vehicle from one geographical location to another. A trip starts when the vehicle is "turned on" (either by motor ignition start or initiating the electric battery) and ends when the vehicle is "turned off" (motor engine disengaged, or electric battery connection terminated).
VSI	Vision Systems Intelligence: VSI Labs is a connected and autonomous vehicle research company and partner to MnDOT for the Proof of Concept.
WSP	Contracted Entity: Technical Consultant and Systems Integrator for MnDOT DBUF Program.
XLS	Microsoft Excel Spreadsheet

APPENDIX B – POC FAULT LOG

Date Identified	Source	Subsystem	Description	Recommended Resolution
12/13/2018	WSP	VSI - C/AV	VSI is using the POC-identified vehicle for other, unrelated testing. During some trips, data logging is inaccurate because of other testing occurring during that time. Automated trip logging may not be turned on, or the logging mechanism may be reset during the trip, causing errors in the trip log.	Demo testing using the C/AV will be scheduled with enough advance notice to "reserve" the C/AV to only conduct DBUF demonstration testing during that timeframe.
12/13/2018	Revenue	Revenue Reports	Fuel type and location of fuel purchase not included in Fuel Report. These data fields are needed to verify that the fuel was purchased in Minnesota, and that the correct rate is being assessed.	Humphrey School confirmed that these data fields are available in the existing fuel reports, and will be included on reports during the demonstration.
12/21/2018	Humphrey School	HOURCAR	License Plate fields empty for some vehicles (#74 and #75 in September report)	All data shall be complete and validated by SM providers prior to sending to state agencies during demonstration.
12/21/2018	Humphrey School	HOURCAR	"Canceled" column sometimes indicates a trip was taken (e.g. trip #171690 shows 8 miles traveled on a canceled trip)	All data shall be complete and validated by SM providers prior to sending to state agencies during demonstration.
12/21/2018	Humphrey School	HOURCAR	Fueling Report manual entry of current odometer readings can cause errors. Typos in manually entered odometer readings for Sept '18 transaction # 00020108 and 259001180 are creating errors in calculated mileage traveled (638036 and 706685, respectively)	Suggest SM providers ensure that electronically-captured odometer readings are collected at each fueling.

Date Identified	Source	Subsystem	Description	Recommended Resolution
12/21/2018	Humphrey School	HOURCAR	Fueling Report shows fuel added to vehicles with no change in odometer readings (indicating no miles driven). For the following Sept '18 transactions, fuel was added to some vehicles but manually entered odometer readings indicate no miles were traveled to consume those gallons.	Suggest SM providers ensure that electronically-captured odometer readings are collected at each fueling.
12/21/2018	Humphrey School	HOURCAR	Fueling Report includes field for "adjusted odometer". Unknown what drives that field. 48 of 195 records in Sept '18 report have adjusted odometer readings	SM providers to provide data dictionary for all data fields provided.
1/27/2019	HOURCAR	HOURCAR	Two vehicles included in the usage report are dummy accounts, however they have mileage/fuel associated. Dummy accounts should not have data associated in DBUF-related reports, otherwise a DBUF may be assessed on miles that were not actually traveled.	Dummy accounts should be removed from usage reports for the purpose of the demonstration.
1/30/2019	WSP	VSI - C/AV	Multi-state drive testing that occurred during the POC was not granular enough to evaluate the ability to capture travel across state lines, in order to accurately assess state DBUF. Live data polling test was done within the state on Minnesota only. Multi-state drive testing was conducted, but only trip start/end locations were captured.	Location information will be captured and analyzed during the demonstration using the C/AV only, avoiding any direct correlation of location to subscriber. There are additional considerations on the impact to subscriber privacy when determining if DBUF is to be assessed on traditional SM provider vehicle fleets.
1/30/2019	HOURCAR	HOURCAR	Due to a system glitch having to do with how members swipe in and out, there is sometimes some duplication in the trip data. This can be eliminated by de-duplicating the file using the reservation number.	For POC - files were de-duplicated by Humphrey School and WSP prior to analysis. For Demo - SM providers should confirm accuracy and integrity of data prior to sending to state agencies.

Date Identified	Source	Subsystem	Description	Recommended Resolution
1/31/2019	HOURCAR	HOURCAR	A few new vehicles were brought on to the vehicle fleet, fuel cards used in those vehicles were unknown. This caused misalignment between trips/miles and fuel purchases.	For the demonstration, SM providers to validate all vehicles in fleet, fuel cards used, vehicle ID, etc.
1/31/2019	WSP	All	Trips taken/miles traveled and fuel purchases are somewhat unaligned, as this is the first set of data being collected. Difficult to validate data. Unless all vehicles starting in a DBUF pilot/program have completely full fuel tanks on Day 1, the direct correlation between miles traveled and fuel consumed/purchased will not match for the first set(s) of data. Eventually data will catch up and correlation can start to occur.	Assume that miles traveled will not always directly correlate to fuel purchased/consumed for the demonstration - do not use as an absolute data validity checkpoint.
2/26/2019	WSP	HOURCAR	SM providers have multiple types of reservations, which may or may not be assessed a DBUF. Example of reservation types: Standard (paid), complimentary, cleaning, maintenance, dummy/testing, etc.	MnDOT and partners to evaluate types of reservations SM providers may have and determine which should be exempt from a DBUF in a live program.

To: Ken Buckeye, DBUF Program Manager, Minnesota Department of Transportation

From: Mike Warren & Markell Moffett, WSP

Subject: MN DBF – Fuel Tax Credit Assessment Options

Date: April 7, 2020

BACKGROUND

The Minnesota Department of Transportation (MnDOT) is conducting a Distance Based Fee (DBF) Demonstration to address administrative, technological, and operational issues associated with assessing and collecting a DBF. The Demonstration is in partnership with shared mobility (SM) providers, specifically carsharing providers, a service that provides customers the ability to rent a vehicle by the hour.

An overarching goal of the Demonstration is to determine whether a DBF can address funding shortfalls in Minnesota's Highway Users Tax Distribution Fund (HUTDF). These funding shortfalls are caused by:

- A lack of consistent increases to the per gallon state excise motor fuel tax, which funds 45% of the HUTDF, to keep pace with inflation;
- An increase of vehicle miles traveled combined (i.e. an increase in use and wear of transportation infrastructure) with declining purchasing power for transportation improvement projects; and
- An increase in vehicle fuel efficiency, the influx of electric vehicles and the adoption of shared mobility services such as ridehailing and carsharing which reduces fuel purchases and thus motor fuel tax revenues.

ASSESSING A DBUF AND FUEL TAX CREDIT

As part of the Demonstration, MnDOT is developing a DBF assessment mechanism that uses existing in-vehicle technologies in shared mobility fleet vehicles to send and receive data to existing state agency tax collection systems which will then assess a DBUF.

In theory, assessing a DBF is simple: A vehicle owner is charged a per-mile rate for each mile of road the vehicle travels. However, because many vehicles are powered by diesel or gasoline fuel, part of assessing a fair DBF is to credit the federal and state motor fuel taxes that are paid by the vehicle owner when purchasing fuel. Without a fuel tax credit, a vehicle owner could be overcharged through a DBF program because a vehicle owner would pay both the DBF and the motor fuel taxes for their use of the roads. In the Demonstration, the Minnesota Department of Revenue (Revenue) assesses a fuel tax credit using fuel purchase records submitted by the shared mobility provider for each participating vehicle.

However, operational nuances of the carsharing business have posed challenges to assessing a fuel tax credit. Specific to carsharing, the customer purchases fuel for the vehicle they have rented using a charge card provided by the shared mobility provider. However, in the course of normal business operations, carshare providers will sometimes deactivate or remove charge cards from vehicles in cases of fraud, theft or the card itself becoming lost. When carshare companies remove the charge card, a customer must use personal means to purchase the fuel required to power the vehicle and subsequently request reimbursement from the carshare provider. The information needed by SM Providers to reimburse the customer may not be the same information required to accurately assess a fuels tax credit in a DBF

program. Thus, the SM provider would be overcharged, by paying both the DBF and the motor fuel tax. Overcoming this operational issue is necessary to assess a fuel tax credit and a fair DBF and successfully implement a DBF program in partnership with SM providers.

Three potential options to addressing this operational nuance are presented below for consideration, each with its own benefits and pitfalls to consider based on the goals of a DBF program.

OPTION 1: ASSESS THE FUEL TAX CREDIT USING ONLY REPORTED FUEL PURCHASES

Calculate fuel tax credits based only on fuel purchase reports submitted. If a fuel purchase is not reported – either by error or because a customer used their personal payment method to purchase fuel and the fuel purchase information was not reported to the SM Provider in a way that they could use it to report fuel purchases to the State.

This would put the onus of reporting missing fuel purchases on the SM Provider. If they did not report a fuel purchase, they would not be reimbursed for that fuels tax paid.

While this method would be the simplest as it requires no estimation for missing reports, it would likely result in a lower than actual fuel tax credit and thus an overcharge in the DBF for each vehicle with missing fuel records. Although this method would put emphasis on shared mobility providers to accurately and consistently report the necessary information, this method is at odds with the goal of this Demonstration to minimize the operational burden on shared mobility providers of a DBF.

OPTION 2: ASSESS FUEL TAX CREDITS USING VEHICLE MILES TRAVELED AND REPORTED FUEL PURCHASES TO FILL REPORTING GAPS

The fuel tax credit could be estimated by using submitted fuel purchase reports to estimate the fuel tax credit for missing fuel purchase reports. Assessing the fuel tax credit in this way would be done as follows:

1. Identify submitted fuel purchase reports and associated information
2. Identify probable missing fuel purchases
3. Estimate missing fuel purchase amounts by comparing miles traveled in previous months to fuel purchases in previous months and making an assumption of when and how much the vehicle refueled based on the miles traveled until the next reported fueling
4. Based on the fuel purchase amount, calculate the motor fuel tax associated with the fuel purchase. The fuel tax credit is equal to the estimated motor fuel tax paid

While this method could be fairly accurate by using historical data, it would place an operational burden on the MnDOT and Revenue when calculating the fuel tax credit. This could increase administrative costs which is at odds with the goal of this Demonstration to minimize administrative costs and burden of a DBUF.

OPTION 3: ASSESS ALL FUEL TAX CREDITS USING VEHICLE MILES TRAVELED AND THE VEHICLE'S US EPA MILES PER GALLON RATING

The fuel tax credit for each vehicle could be assessed using the United States Environmental Protection Agency (US EPA) miles per gallon (MPG) ratings for each participating vehicle. The method for assessing the fuel tax credit is as follows:

1. Identify each vehicle's US EPA MPG rating
2. Calculate each vehicle's estimated fuel consumption by dividing each vehicle's total miles traveled during the reporting period by the US EPA MPG rating
3. Calculate the estimated fuel tax credit for each vehicle by multiplying the estimated fuel consumption by the per-gallon motor fuel tax rate. The fuel tax credit is equal to the motor fuel tax paid.

Of the options available, this method is the most accurate to assess the fuel tax credit when fuel purchase information is missing. In alignment with the Demonstration's goals, this method is also the easiest method for both MnDOT, Revenue, and the shared mobility providers to adopt.

However, this method could create confusion caused by discrepancies between vehicles that have submitted fuel purchase records and the estimated fuel tax credit for these vehicles using the above method. Second, fuels tax credits are typically assessed on fuel purchases rather than fuel consumption. Because this method uses fuel consumption, additional discrepancies could be created. Finally, there is also potential for overcharging given that actual vehicle fuel performance could be less than the US EPA MPG rating for each vehicle. Thus, more fuel would be purchased relative to the vehicle miles traveled estimated by this method which would result in an undervalued fuel credit and thus an overcharged DBF.

Given that there are similar discrepancies in all options, this method meets the goals of the Demonstration to minimalize the impact and increase administrative efficiency to State of Minnesota agencies and shared mobility providers in their daily operations.