FINAL REPORT

MINNESOTA DISTANCE-BASED FEES PROJECT

August 2022

DEPARTMENT OF TRANSPORTATION

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Richard Baker, Mike Warren, Markell Moffett, Kenny Fennell, Jason Stribiak	

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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).

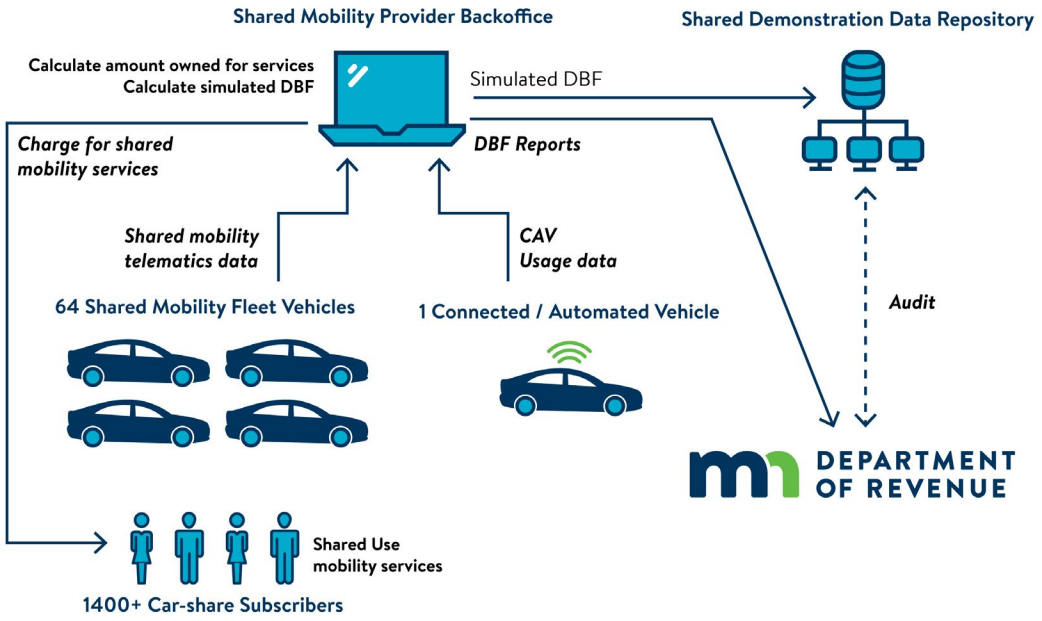

Figure 1: Minnesota Distance-Based Fees Demonstration Functional Architecture

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]

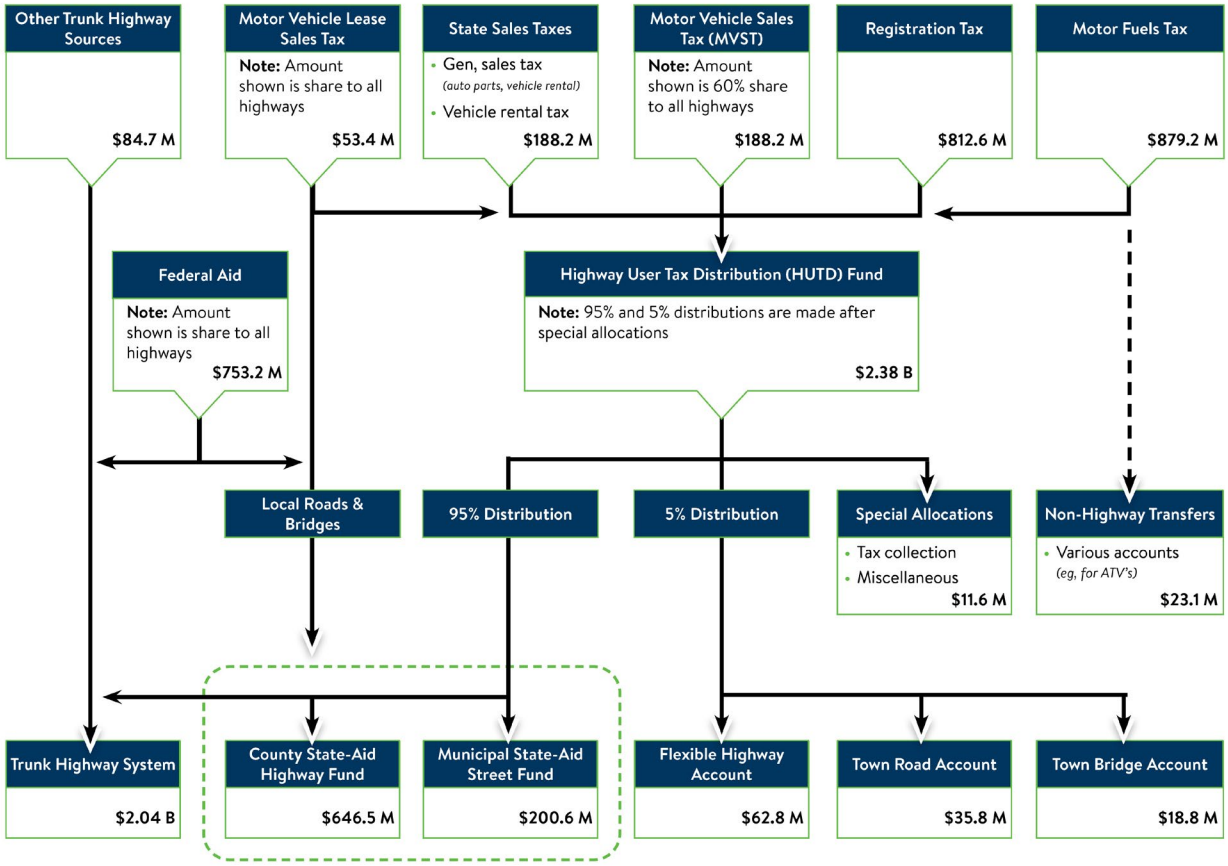


Figure 2: Overview of Minnesota Transportation Funding[4]

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.

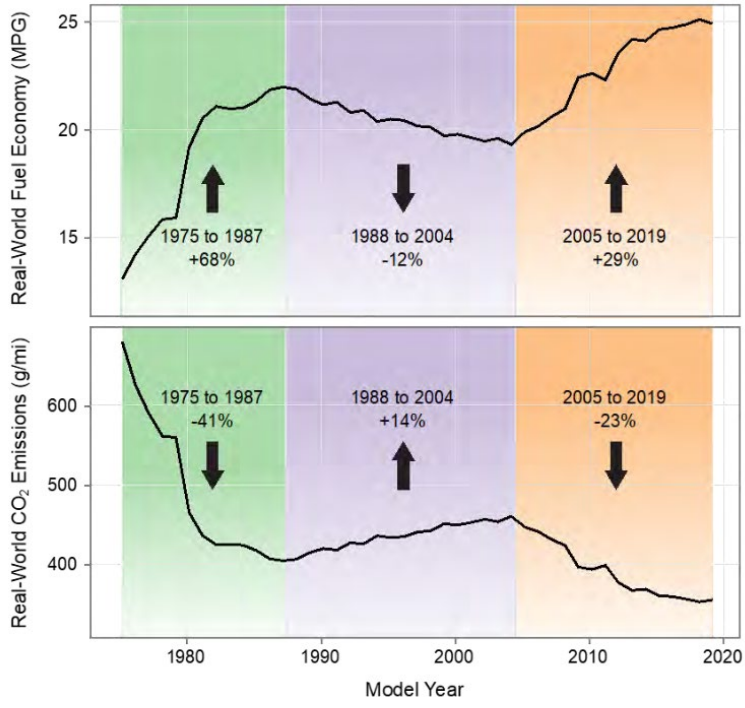
One potential rate adjustment shown above is the vehicle-weight adjustment, to account for heavier vehicles contributing more wear and tear to a roadway per mile driven relative to lighter vehicles.[7] With a vehicle-weight rate adjustment, a heavier vehicle would pay a higher rate than a lighter vehicle 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.

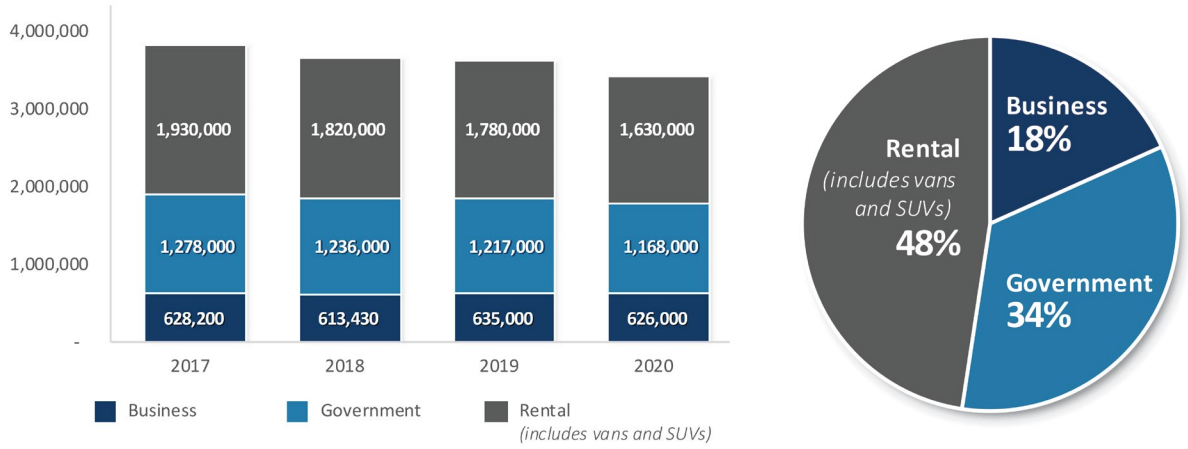


Figure 5: Automobile Fleet Vehicles by Type

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.

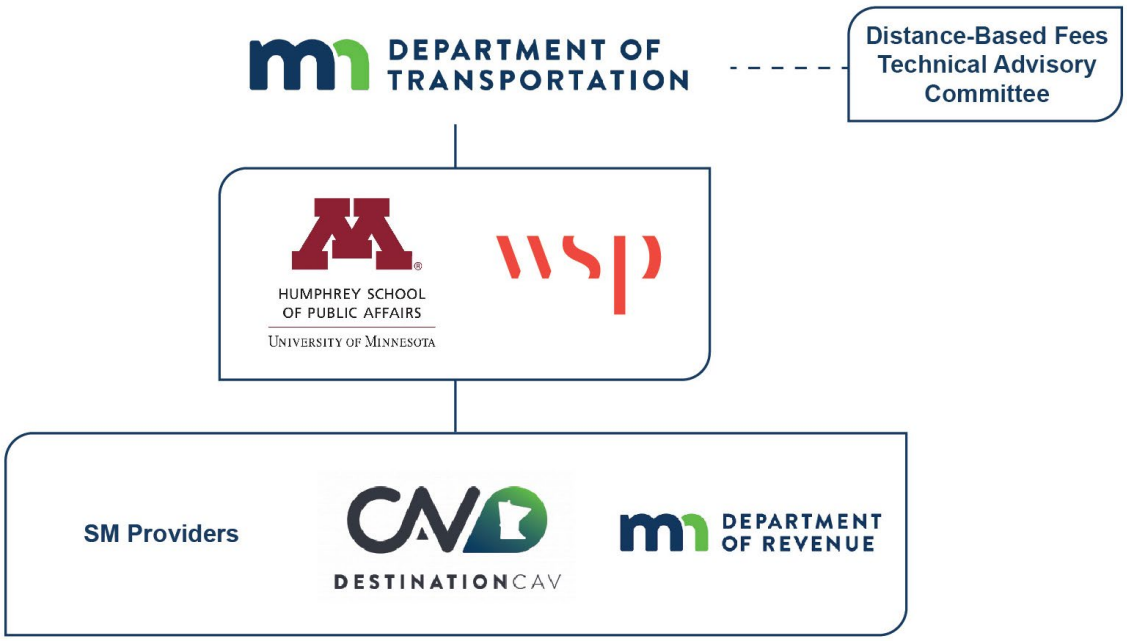


Figure 6: Project Team

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.

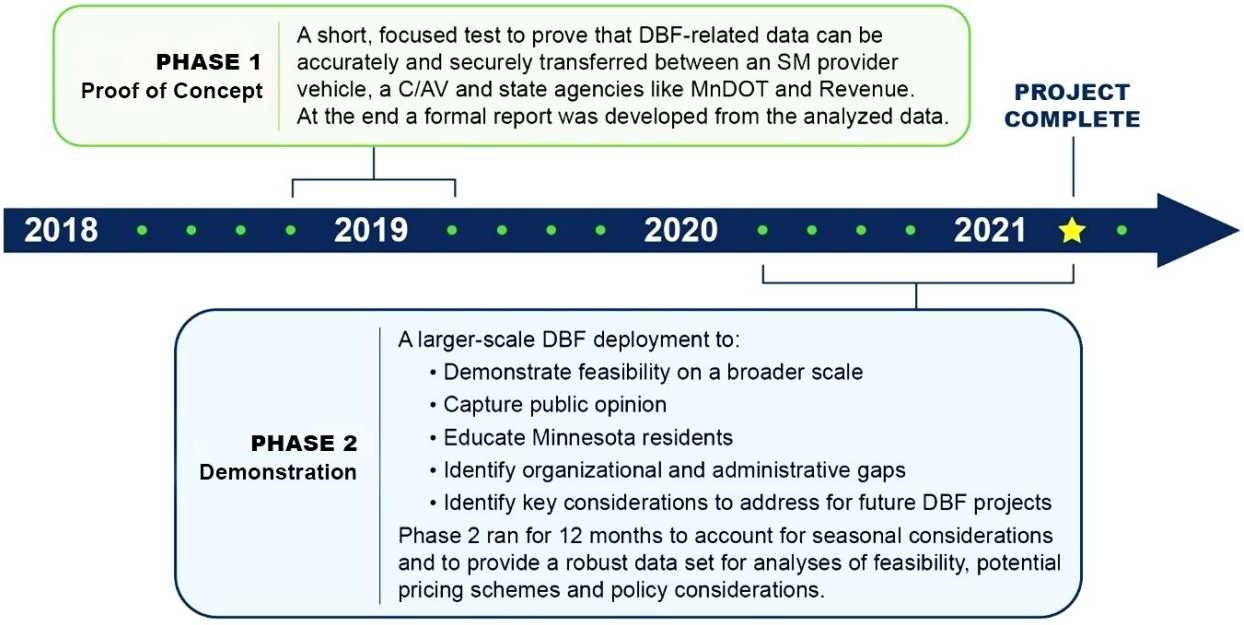


Figure 8: Project Phasing

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.

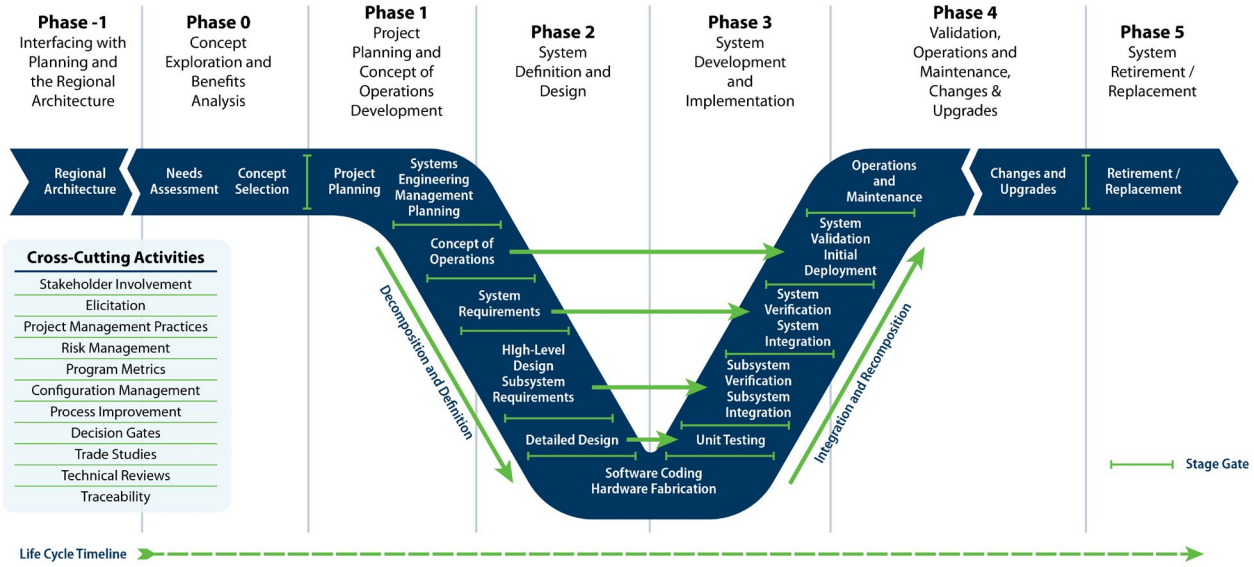


Figure 9: Systems Engineering V-Diagram

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.

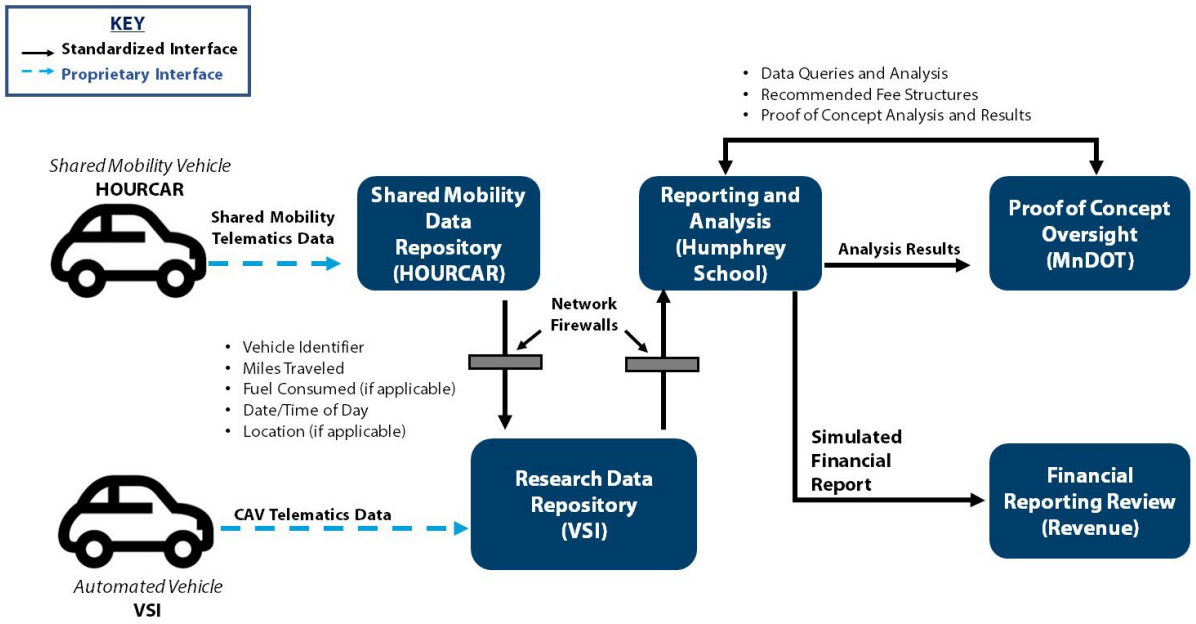


Figure 10: Functional Architecture for the Proof-of-Concept

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.

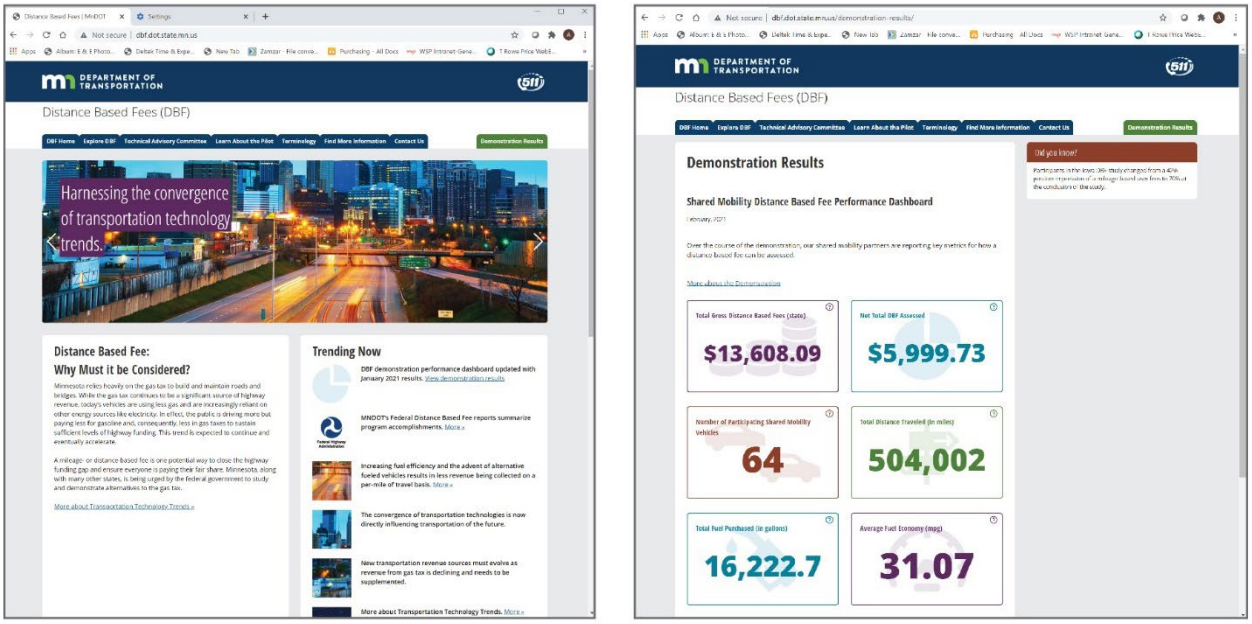


Figure 12: Minnesota DBF Website

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.

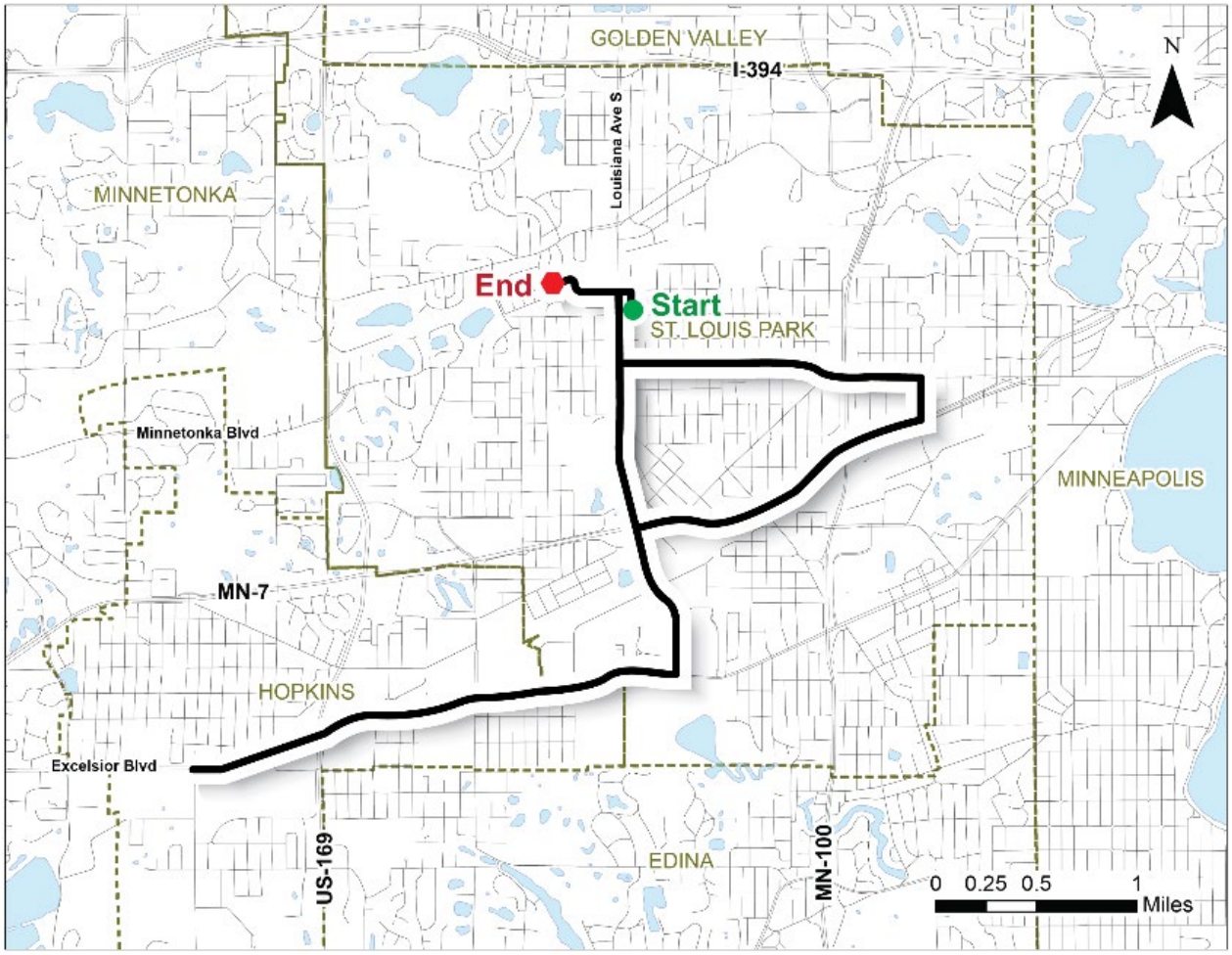


Figure 13: CAV Live Data Polling Test Trip Map

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.

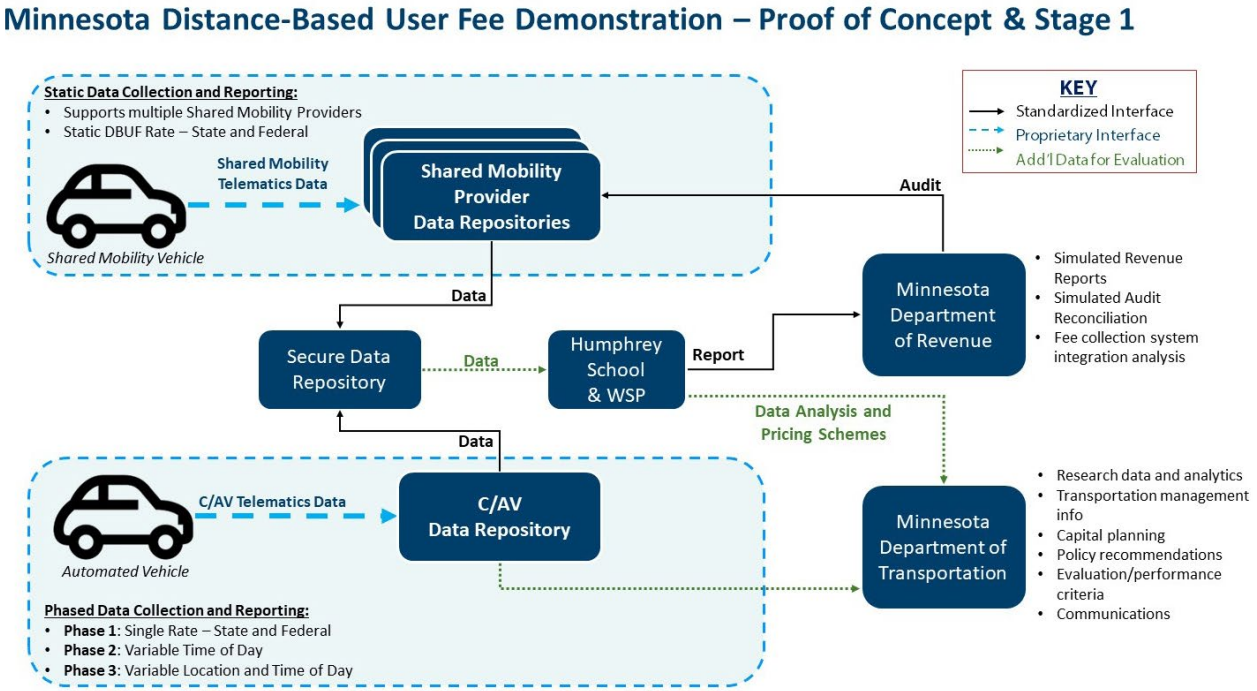


Figure 15: Minnesota DBF Staged Demonstration Architecture – Stage 1 Supervised Reporting

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.

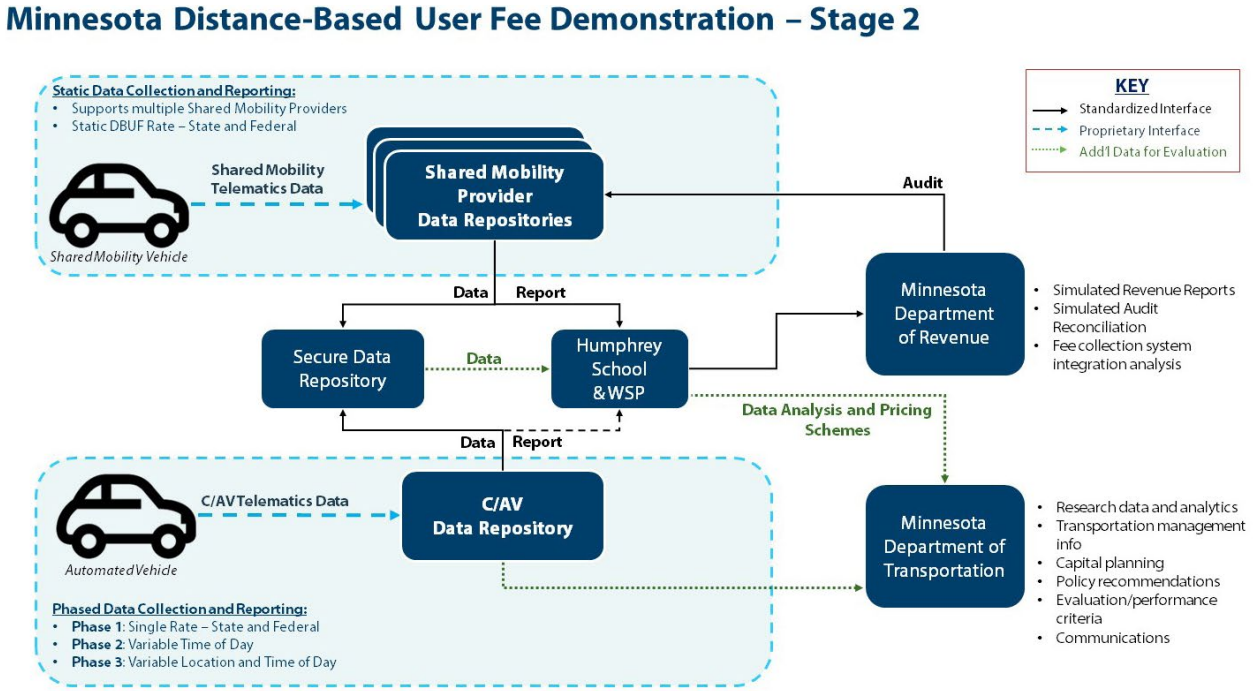


Figure 16: Minnesota DBF Staged Demonstration Architecture – Stage 2 Supervised Reporting

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.

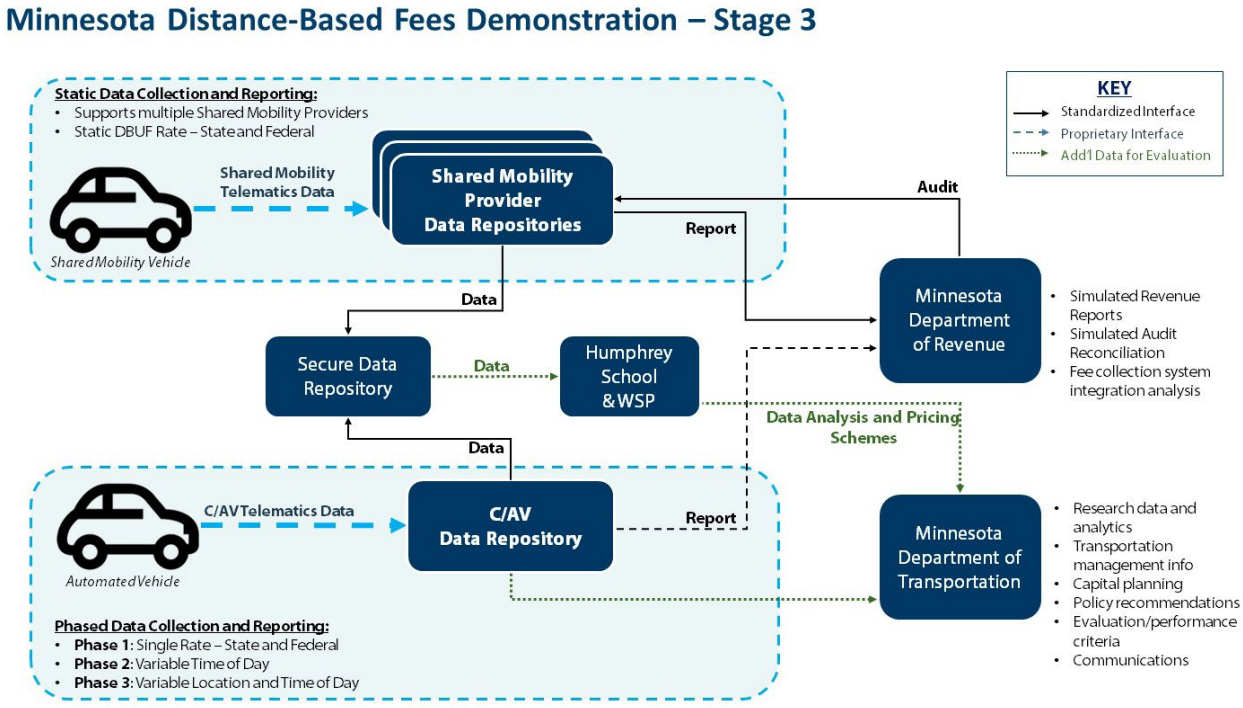


Figure 17: Minnesota DBF Phased Demonstration Architecture - Stage 3 Formal Revenue Reporting

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

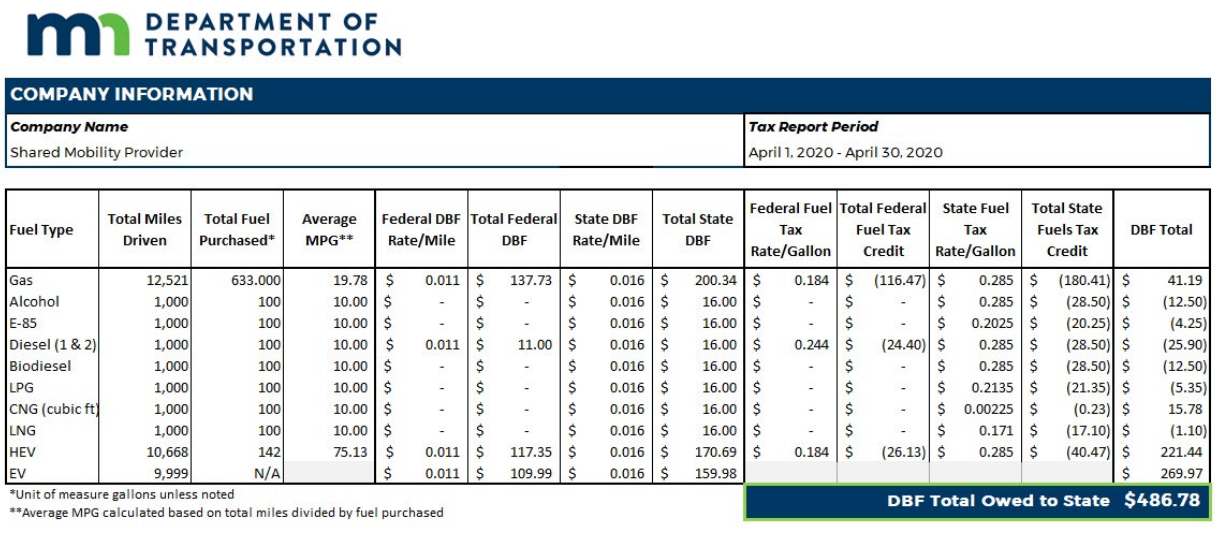
4.4 OPERATIONS

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.

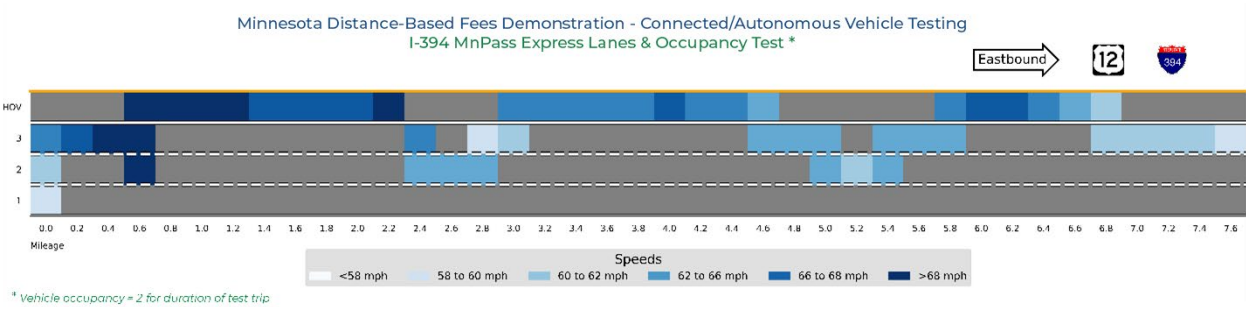


Figure 19: CAV Lane Detection Test Graphic

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

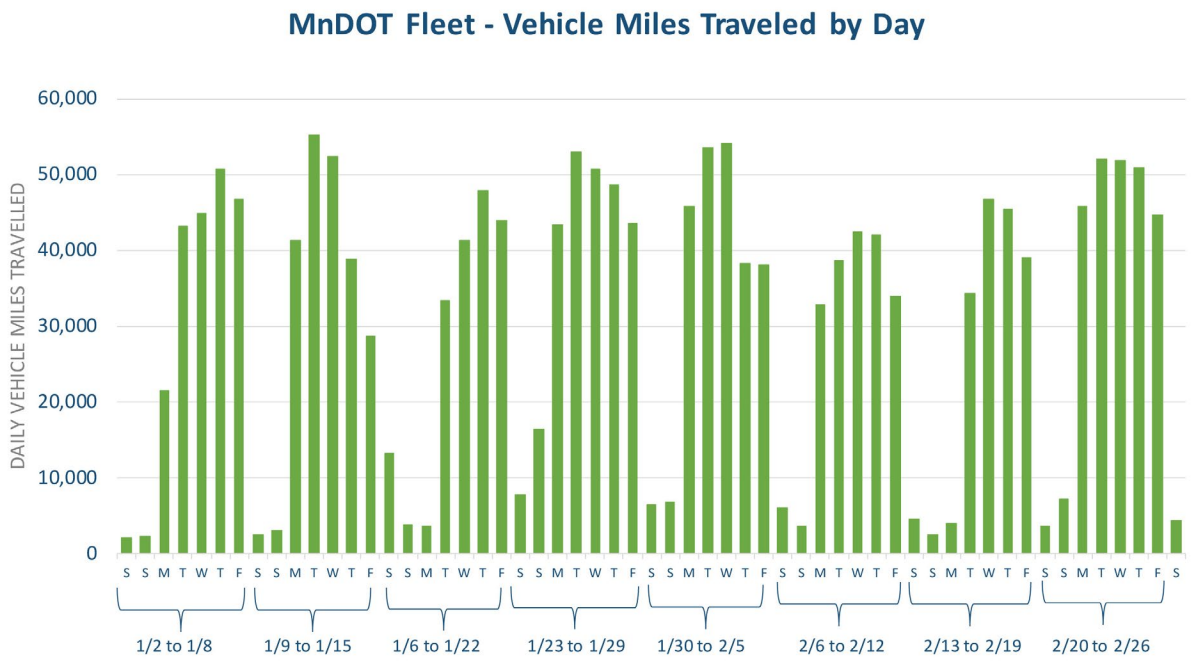


Figure 21: Vehicle Miles Traveled per day for MnDOT fleet vehicles

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.

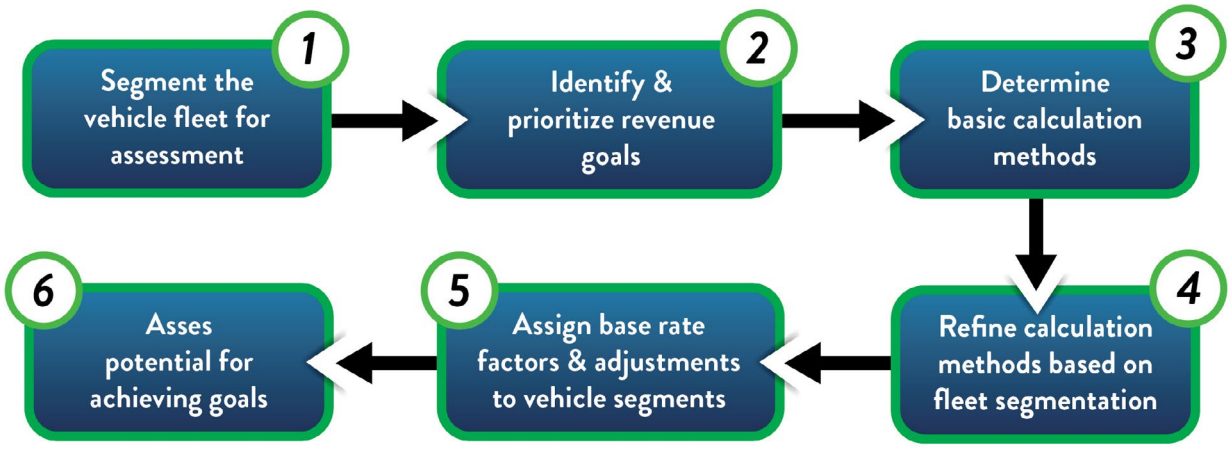


Figure 22: DBF Framework Development Process

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.

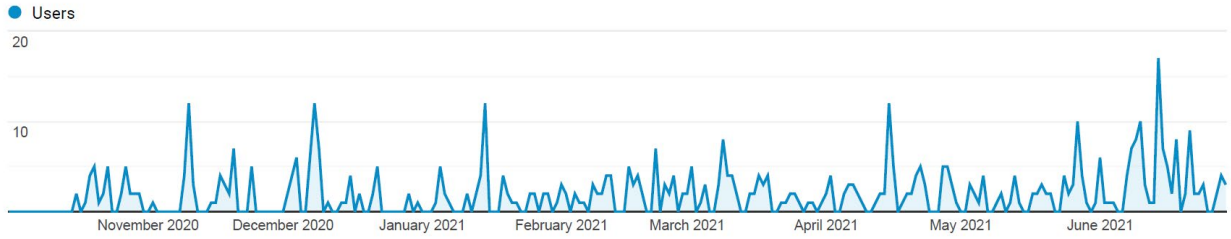


Figure 23: Website Analytics - Visitors per Day

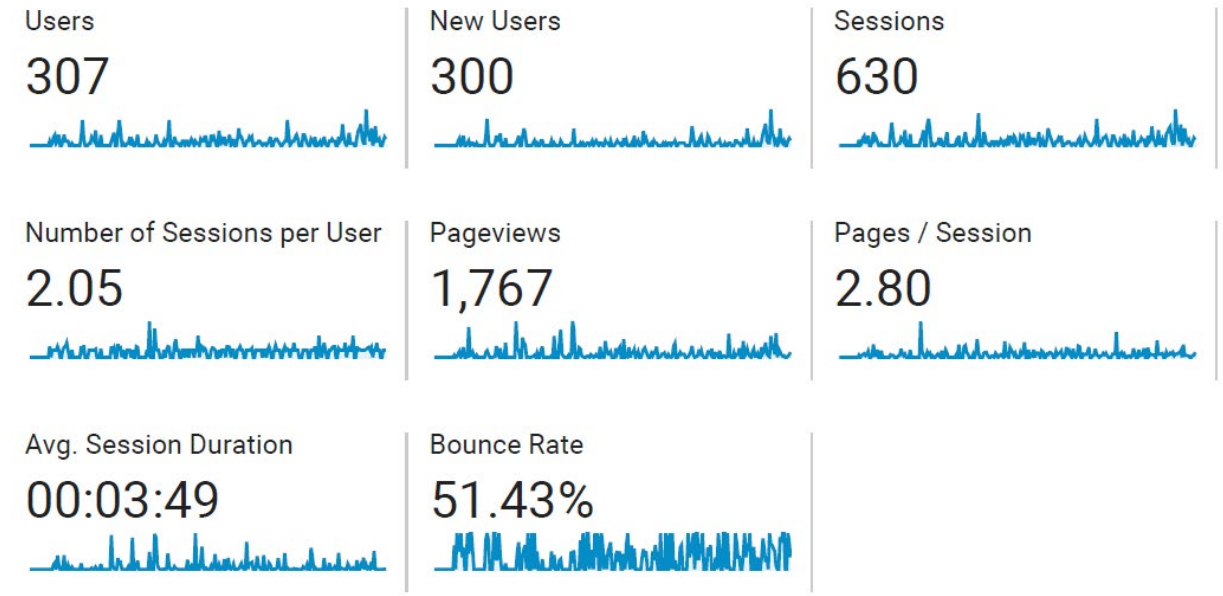


Figure 24: Website Analytics - Breakdown of Website Visits

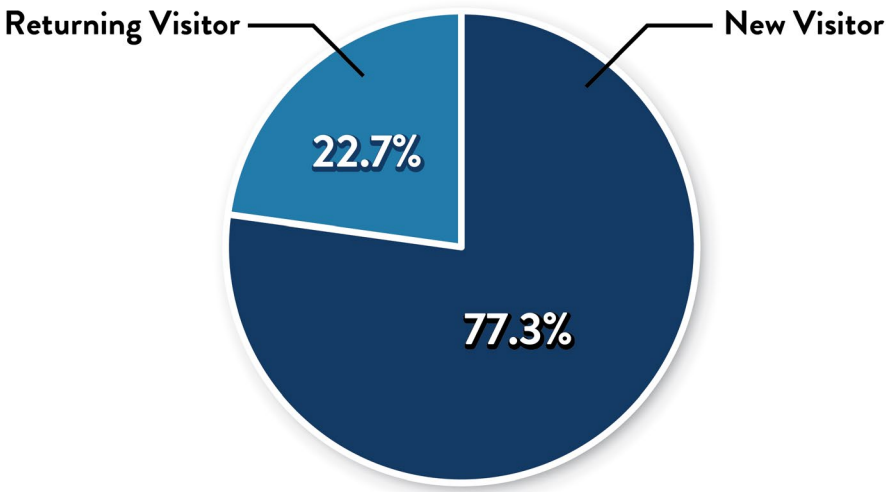


Figure 25: Website Analytics - Breakdown of New and Returning Visitors

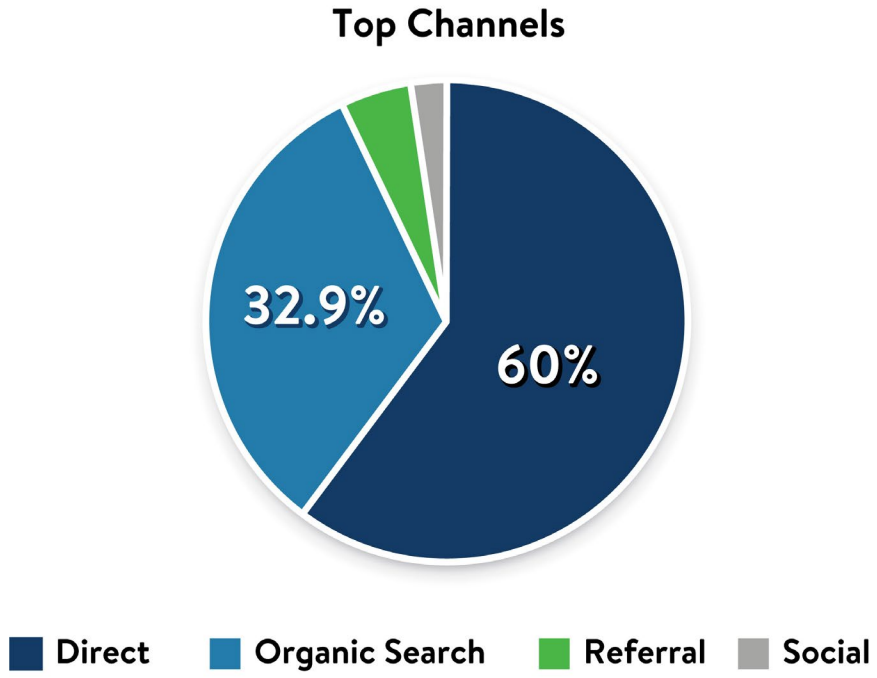


Figure 26: Website Analytics - Top Channels to Website

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).

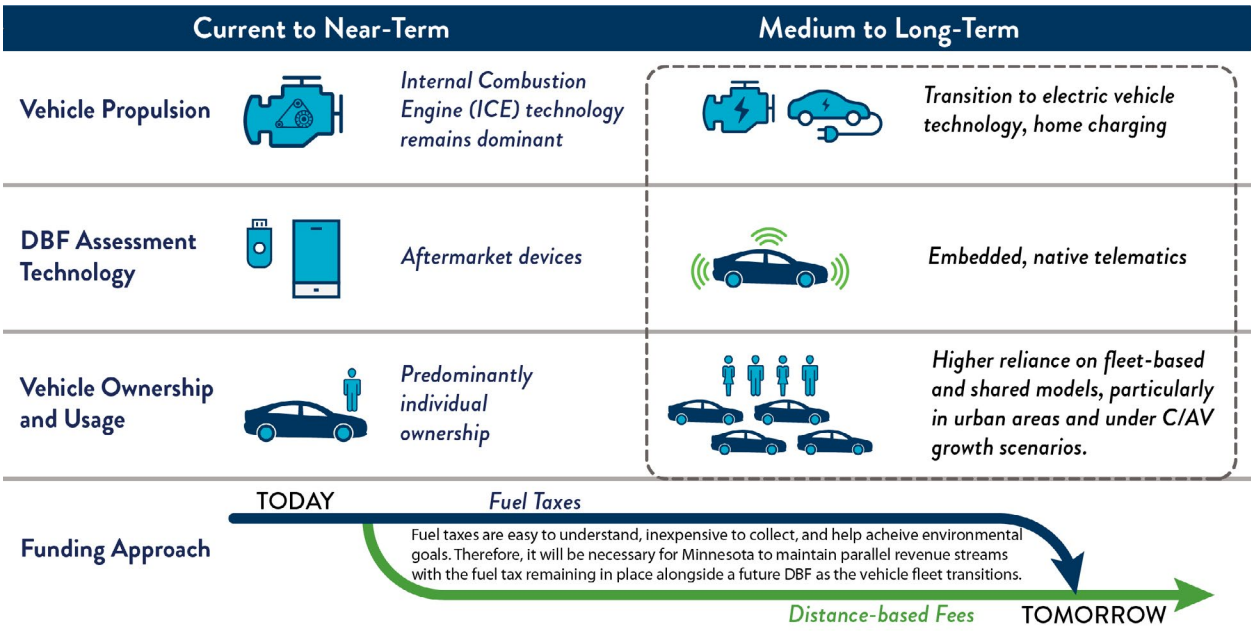


Figure 27: Charting a Path Forward for Minnesota DBF

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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