Proposal to Conduct Pre-Deployment Activities for a Minnesota User Based Fee Demonstration

**By the Minnesota Department of Transportation**

**with the University of Minnesota Humphry School of Public Affairs**

May 19, 2016

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| --- | --- |
| Project Name: **Pre-Deployment Activities for a User Based Fee Demonstration in Minnesota** |  |
| Previously Incurred Project Cost | $ 0 |
| Future Eligible Project Cost | $ 600,000 |
| Total Project Cost | $ 600,000 |
| STSFA Request | $ 300,000 - $ 500,000\* |
| Total Federal Funding (including STSFA) | $ 300,000 |
| Are matching funds restricted to a specific project component? If so, which one? | No |
| State(s) in which the project is located |  Minnesota |
| Is the project currently programmed in the:* Transportation Improvement Program (TIP)
* Statewide Transportation Improvement Program (STIP)
* MPO Long Range Transportation Plan
* State Long Range Transportation Plan
 | NoNoNoNo |

**\***The budget of this pre-deployment could be expanded depending upon how many entities we partner with and upon determination of eligible in-kind contributions from our partners. For the purpose of this pre-deployment we have estimated the project cost at the lower end range.

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# The Minnesota Proposal

Minnesota proposes to partner with Mobility-as-a Service (MaaS) providers (e.g. Uber, Lyft, HourCar, Car2Go) to develop a per-mile road user fee mechanism that utilizes telematics and GPS technology already embedded in MaaS vehicles.

This proposal develops an approach that anticipates where the future of personal mobility is heading using the MaaS platform which is rapidly re-defining personal transport around the world. By 2030, MaaS will account for nearly 35 percent of all personal mobility and perhaps as much as 90 percent by 2040 (NHTSA, 2013). Minnesota’s approach to a per-mile road user fee is practical and nimble allowing powerful societal and technological trends to drive the change.



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Proposal to Conduct Pre-Deployment Activities for a Minnesota User Based Fee Demonstration

**By the Minnesota Department of Transportation**

**with the University of Minnesota Humphrey School of Public Affairs**

##

# Executive Summary

**Purpose**

The purpose of this proposal is to identify, demonstrate, and prove an alternative revenue mechanism that utilizes a user based fee structure in order to maintain the long-term solvency of the Federal Highway Trust Fund.

**Proposal**

The Minnesota Department of Transportation along with the University of Minnesota’s Humphrey School of Public Affairs (hereinafter “Minnesota”) proposes to design and develop a user based fee-per-mile revenue generator partnering with a Mobility-as-a-Service provider (e.g. Uber, Lyft, HourCar, Car2Go).

We believe the future of personal travel is captured in the new and evolving Mobility-as-a-Service (MaaS) business model. MaaS includes a range of new travel forms that promise greater efficiency, safety, and enhanced mobility. It 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.

**Minnesota MaaS Model**

Currently, in Minnesota as in most other states, highway user taxes (fees) are collected from customers buying fuel for their vehicles at the gas pump. Based on the amount of gas purchased, these fees are easy to pay and easy to collect, but are largely hidden from the consumer.

The MaaS model (Uber, Car2Go, etc.) flips this paradigm and charges vehicle drivers an explicit per-mile fee for use of the roadway. The per-mile fee is built into the provider’s vehicle use fee structure which is charged to the consumer. The road user fee portion of the charge is collected by the MaaS providers and paid directly to the State of Minnesota, essentially eliminating direct collection from millions of drivers.

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

By some predictions, MaaS will account for 35 percent of all personal mobility by 2030 and perhaps as much as 90 percent by 2040 (NHTSA, 2013). Although relatively small at this time, various forms of MaaS are already impacting the way Minnesotans interact with the transportation system through ridesharing providers (e.g. Uber and Lyft) and car sharing services (e.g. HourCar and Car2Go). Discussions with car-sharing providers in the Twin Cities have revealed that more than 30,000 drivers are already subscribers. These services are significant in their own right, however, when coupled with emerging fully autonomous vehicle technologies they stand poised to significantly impact personal mobility in a relatively short timeframe. This shift also offers a unique opportunity to develop a model that will greatly enhance safety and efficiency, and positively and equitably change the user fee structure for the nation’s highway system.

**Two-Phased Approach**

Minnesota is proposing a two-phase approach to the demonstration project. Phase I (this application) is the pre-deployment phase where the project is defined and mechanisms put in place in order to undertake Phase II of the proposal which is full deployment of the project.

**Phase I**

In Phase I we will recruit ridesharing and/or car sharing MaaS providers and collaboratively evaluate and design the necessary supporting systems and back office protocol to support a user based fee trial. Details of Phase I tasks are found in Section IV of this proposal. We estimate the cost of this pre-deployment to be in the range of $500,000 to $1 million and will take up to 18 months to complete.

**Tasks:**

* Project Management
* Recruitment of MaaS provider(s)
* Modeling of pricing strategies
* Design of back office operations, protocol, and software
* Stakeholder analysis and outreach
* Multi-modal pricing options
* Development and execution of legislative strategies
* Planning and design for deployment in Phase II demonstration

**Goals and Objectives:**

* To demonstrate that the project is both feasible and affordable.
* To complete a trial use of the Minnesota user-based fee collection demonstration.
* To illustrate the viability and probability of public and political support of the project.

**Phase II**

The Phase II deployment of this effort will focus on executing the trial designed in Phase I and will include full deployment of the Minnesota user based fee-per-mile collection system. We estimate the cost of deployment to be in the range of $600,000 to $1 million and will take up to 18 months to complete.

**Tasks:**

* Negotiation and execution of agreements
* Software development and testing
* Public outreach
* Other necessary supporting tasks.

**Partnerships and Strategies**

Minnesota has already had informative and productive discussions with MaaS providers in the Twin Cities metropolitan area including HourCar and Car2Go car-sharing services. Although no agreements have been signed yet, there is a fundamental understanding of mutual interests and needs. We are confident that further explorations and discussions can conclude with a partnership that will lead to a Phase II demonstration.

**Anticipated Outcomes**

The approach Minnesota is taking to migrate toward user based fees is sensible and nimble in that it allows powerful societal and technological trends to drive the change. MaaS is the change agent.

* Migration to user based fees will be publically and politically acceptable (no use of personal vehicles).
* Utilization of existing on-board technology and communications in MaaS vehicles will result in greatly reduced administrative costs - no need to create new and expensive technology and back office systems.
* Unlike other attempts at user-based fees, issues associated with personal privacy, data security, and enforcement disappear with Minnesota MaaS Model.
* A highly portable model will be developed that can be expanded easily and quickly around the nation and could be applied to other fleet operations.

We believe that the Minnesota Maas Model represents a unique and important opportunity for Minnesota and the nation toward development of a viable user based fee-per-mile revenue generator that will help maintain the long-term solvency of the Federal Highway Trust Fund.

# Pre-Deployment Description

## Introduction

This proposal is in response to the U.S.DOT notice of availability of funding for proposals authorized under Section 6020 of the FAST Act, Surface Transportation System Funding Alternatives. As defined in that notice dated March 22, 2016, those states applying for funding under the program but have not initiated a demonstration project, or are not prepared to advance a working alternative revenue mechanism at this time, may submit proposals to conduct the necessary pre-deployment steps to guide the development of a user based fee demonstration.

The ultimate purpose of this demonstration is to create the opportunity to test and prove a user fee structure that will ensure the long-term solvency of the Federal Highway Trust Fund and generation of adequate revenues at the state level. The pre-deployment project will introduce the user based fee pricing concept in Minnesota to a developing traveler market called Mobility-as-a-Service (MaaS). We believe that the Mobility-as-a-Service model will become increasingly important as on-board vehicle technology advances and as personal ownership expectations evolve. This project also strives to simplify the driver-technology interface and to demonstrate a significant reduction in technology costs and the cost of operations over previous user based fee demonstrations. The Minnesota Department of Transportation will lead this pre-deployment effort in partnership with the Humphrey School of Public Affairs at the University of Minnesota.

## What is Mobility-as-a-Service?

Minnesota’s proposal relies upon creating partnerships with (MaaS) providers. Society is rapidly moving towards a transportation model that provides mobility to people through services rather than direct vehicle ownership. This emerging model stands to profoundly impact the transportation system over the coming years.[[1]](#footnote-1) Various forms of MaaS are already affecting the way Minnesotans interact with the transportation system through ridesharing providers (Uber and Lyft) and car sharing services (HourCar and Car2Go). These services are significant in their own right, but when coupled with emerging autonomous vehicle technology, stand to profoundly change the way we travel. As vehicle efficiency increases and as new energy forms penetrate the personal vehicle market, a new sense of urgency arrives to replace and/or supplement the motor fuel tax. This shift also offers a unique opportunity to evolve the funding structure for highways in a rational, scalable, and efficient way.

## Collaboration with MaaS Providers

Minnesota is proposing a two phase project that will test the viability of user based fee collection systems. Phase I is to design a user based fee system in partnership with MaaS providers that will be focused toward the future of personal travel. An initial step towards that end is to foster collaboration with provider(s) to ultimately conduct a trial. Our proposal team has already had positive discussions with two car sharing providers about our concept and will continue to work with other car sharing or ride-sharing providers to evaluate and design the road user trial. A stakeholder analysis and modeling task will be conducted to thoroughly understand and develop pricing structure options and information requirements as well as evaluate impacts on travel behavior. A multi-modal option will also be assessed that may include transit or Minnesota’s successful high occupancy toll lane (MnPASS) system. In the trial, financial incentives may be necessary to gain support. These incentives might include offering motor fuel tax abatement in replacement for a distance based user fee, along with other possible tax relief or financial incentives in the demonstration phase. It should be noted that the path to full deployment of the Minnesota MaaS model will require regulatory framework, as will full deployment of all other user based fee models.

Existing telematics and GPS technology embedded in MaaS provider vehicles is robust enough (or will soon be) to collect user based fees. A prototype back office operations center will be designed in partnership with the Minnesota Department of Revenue to develop a protocol for receiving and processing MaaS user data and fees. We will also execute a legislative strategy to garner support and funding for Phase II, which will be the actual deployment of the project. Our pre-deployment will also include design and testing this concept with MaaS providers and actual drivers through personal contact, surveys and focus groups in order to understand the technical, policy and legal challenges.

We estimate that the pre-deployment work under Phase I can be completed for $600,000 to $1 million and we have assumed 50 percent federal funding in the range of $300,000 to $500,000. This range is contingent upon the number of MaaS providers we are able to recruit. MnDOT is committed to the remaining 50 percent match requirement through state funds or through eligible soft match contributions. The project will be an eighteen-month effort including project planning, data collection, analysis, modeling and evaluation. Pre-deployment will also include a robust outreach and communications effort, along with the development of legislative support. We will be prepared to apply for funding for a two year deployment within one year.

The actual demonstration conducted under Phase II will require significant additional resource commitment, and legislative authorization and funding. Under Phase II of this effort we will execute the trial designed in Phase I including negotiating agreements, software development and testing, outreach, and other tasks.

To the degree possible, this user based fee pilot project will be designed to use existing on-board telematics capacity of MaaS providers and that of auto manufacturers consistent with the needs of the transportation system. Where feasible, we will incorporate into the system design highly efficient operations, collections and enforcement protocols, as well as transparency and ease of user fee collections. A major consideration will be to exploit the potential for wider deployment in the MaaS marketplace in anticipation of a broadly maturing market in the coming years.

## What is the MaaS Market?

What is the market for MaaS and to what extent will it replace existing forms of travel? While MaaS includes a range of services, each more progressively automated and separated from personal ownership, the ultimate maturity of this concept is fully autonomous vehicles. This proposal develops an approach to testing mileage-based user fees that anticipates where the personal mobility market will be in the 15 to 25 year time horizon, using the MaaS platform that is rapidly re-defining personal transport around the world. The chart below suggests that travel by autonomous vehicles is poised to explode by the early 2030s and could account for more than three trillion vehicle-miles of travel (VMT) by 2040.[[2]](#footnote-2) A recent Morgan Stanley Research report asserted that:

*“We see today's mostly privately owned car fleet morphing into a shared electric autonomous public transport mega fleet one city at a time. We see few gating factors on the technology side and believe cost is no longer a limiting factor.”[[3]](#footnote-3)*

In addition to economic efficiency and technology readiness, driving forces behind this story include the recognition that automated vehicles are poised to serve disadvantaged populations, will significantly enhance safety, and will help to create greater equity in the transportation system.

**Source: National Highway Traffic Safety Administration, 2013**

By some predictions, MaaS willl account for 35 percent of all personal mobility by 2030 and perhaps as much as 90 percent by 2040 (NHTSA).[[4]](#footnote-4) Although relatively small, various forms of MaaS are already impacting the way Minnesotans interact with the transportation system through ridesharing providers (Uber and Lyft) to car sharing services (Hourcar and Car2Go). These services are significant in their own right, but when coupled with emerging electric autonomous vehicle technology, they stand to have a very significant impact in a relatively short time while simultaneously enhancing efficiency and greatly improving the safety of our highways. This shift also offers a unique opportunity to change the user fee funding structure for the highway system.

**Source: NHTSA, 2013**

A January 2016 report by McKinsey Consulting outlines the potential for exponential growth of MaaS and autonomous vehicle technology with the assertions that:

“*When considering the potential for industry transformation, consumer preferences and behavior are an important starting point. We believe the disruptive technology-driven trends have the potential to fundamentally change the relationship between the consumer and the automobile.*” [[5]](#footnote-5)

## Why This Approach Is Prudent

MaaS is rapidly changing expectations on how we move around and how we pay for transportation. Importantly, MaaS is also dramatically altering ownership expectations. Fundamentally, MaaS is creating a new future not bounded by the past. It is a future that promises equal or enhanced mobility for many travelers, at the same time relieving users of personal vehicle ownership burdens, enhancing safety, and perhaps reducing overall travel costs.

Most research and demonstrations of user based fees to date have focused on strategies to test the application and/or installation of devices on personal vehicles that charge for use of the transportation system by distance traveled as a replacement for the motor fuel tax. This traditional user based fee approach, however, has presented significant barriers. Individuals are being asked to accept higher fees for the system they are already using in its current form. Technology installations are costly and operations support is expensive. Most importantly, none of the previous demonstrations have charted a viable and affordable path toward wider deployment.

By combining MaaS and user based fees, transportation providers can go to where transportation *will be* going in the next few years and develop a revamped revenue structure, while recognizing the underlying way people use transportation is evolving and maturing with new technologies and applications.

## Future of the Motor Fuel Tax in the Context of User Based Fees and Maas

Minnesota’s approach recognizes the unsurpassed efficiency of the motor fuel tax and its long and durable history. The motor fuel tax has been the primary source of highway revenue since the 1920s and it continues to serve us well. That is not to say, however, that adjustments are not necessary. With the advent of new sources of energy, and the increase in fuel efficiency, the long-term viability of the motor fuel tax is in question. On average, drivers are able to drive more and pay less per mile of travel.

The quick and rational approach to solving the problem of diminishing revenue is to increase motor fuel taxes to levels commensurate with the efficiency trends and the necessary inflationary adjustments, recognizing at the same time that alternative energy sources require special treatment. This has always been the prerogative of Congress and the States, which, some would argue, have chosen to ignore or at best inadequately address these issues. Arguments that political leaders have made to not raise the motor fuel tax in the face of growing needs include growing fuel efficiency and emergence of alternative energy sources for motive power that would blunt any such increases as well as inequities that may result. Although these shortcomings of the motor fuel tax are true, all user based fee alternatives suffer from the same deficiencies if they are not designed to include sophisticated features such as allowances for vehicle weight, time-of-day, and very importantly, an inflation adjustment mechanism aka, indexing.

Minnesota’s approach suggests that the motor fuel tax, with all its advantages and deficiencies, is likely to continue for a long time. It is enormously challenging to envision a future and design a solution for the universal replacement of the motor fuel tax that begins to approach its simplicity and efficiency. The cost of collecting the motor fuel tax in Minnesota is less than 0.5 percent of the fees collected. By the most optimistic forecasts, the cost of operations and of retro-fitting vehicles with technology, and/or setting up the appropriate enforcement structures for a mileage-based fee is likely to be in the range of 5.0-10.0 percent of total fees collected.[[6]](#footnote-6) All of this is to say by comparison, the motor fuel tax, while imperfect, is likely to remain in place for a long time.

The approach Minnesota is taking to migrate toward user based fees is sensible and nimble in that it allows powerful societal and technology trends to drive the change. MaaS is the change agent. It recognizes that a migration to user based fees will be incremental and is the path of least resistance. It will utilize on-board technology and communications capacity, not create new and expensive technology and back office systems and administrative costs. It also recognizes that continuation of current trends in fee collection, if left unchanged, will likely not be adequate in the future and that we must begin to chart a path toward a fair and rational user based fee system if we are going to meet our future needs.

# Driving Forces

Around the country, sentiment is growing that the motor fuel tax is becoming outdated and will be a less reliable source of revenue in the future due to issues such as increasing efficiency of vehicles, alternative fuels, and inflation. Implementation of alternatives such as user based fees, however, have had little public and political support, are technically challenging, and early demonstrations have not charted a feasible and affordable path toward widespread implementation. Building upon the learning from Minnesota’s mileage-based user fee demonstrations, as well those in other projects around the country, we intend to develop and test a viable and efficient path for implementation of mileage-based fees with the use of the MaaS model.

## Recent Demonstrations: What Have We Learned and How Has That Learning Shaped Our Proposal

With the baseline of user based fee demonstrations well established through projects in Iowa, Minnesota and Oregon, our proposal is ready to take the next major step in demonstrating the feasibility of distance-based fee collection with the use of MaaS. Technology already embedded in the vehicles, we believe, has enormous capability to efficiently deliver a user based fee system and will require virtually no driver-vehicle interface. To date, all distance based fee demonstrations have used add-on technology requiring a significant driver involvement in turning on or off devices, plugging or unplugging, declaring or not declaring a trip, or even manually reporting miles driven. Within these demonstrations, drivers have been faced with incentives or disincentives to pay a flat per-mile fee or a variable rate by time-of-day or jurisdiction. Follow-up interviews with demonstration participants have suggested a high degree of user frustration, confusion and suspicion which has led to dissatisfaction with the experience. Ultimately, the Minnesota pre-deployment proposal will lead to a pilot with MaaS providers offering a hands-off approach to fee collection. It will test the ability of embedded technology to collect and report miles, driver’s response and satisfaction, and overall policy and legal issues. This pilot will set the stage for a new and more efficient business model for the collection of distance-based fees and will chart a path toward wider implementation.

## Summary of Market Research

Nearly every user based fee demonstration or study that has been conducted in the United States that uses a traditional approach of convincing drivers to install a transponder has engendered widespread opposition as reported in the recently completed report titled NCHRP Synthesis 487 Public Perception of Mileage-Based User Fees[[7]](#footnote-7). Drivers feel that they are already paying for the transportation system through the motor fuels tax and have significant privacy concerns with any transponder installed on their vehicle. Any user based fee deployment must overcome this significant hurdle. Minnesota’s own market research aligns with these conclusions. Four major mileage-based user fee efforts conducted in Minnesota have been completed and are summarized in Attachment 2.

## Conclusions and Experience with User-Based Fees

A number of important trials have already been conducted in Minnesota, and elsewhere, that help inform the discussion and highlight issues associated with mileage-based fees from a technology and human interface perspective as well as public acceptance. What has been learned from mileage-based user fee studies and demonstrations?

* Public acceptance of distance based fees remains a significant challenge that cannot be ignored.
* Technologies tested to date are inadequate for large-scale deployment.
* Technology costs are a significant impediment and aftermarket devices have many limitations, extra costs, and reliability issues.
* Operations costs, while scalable, must be competitive with the cost of collecting and administering the motor fuel tax.
* Customer expectations are that mileage based user fee collections should be nearly effortless for the customer.
* Cheating will be a problem unless the fee collection technology is embedded in the vehicle.
* Public acceptance of distance based fees increases when there is a direct link from the fee to the customer’s use of the system[[8]](#footnote-8).

A national technology standard for user-based fees has not yet emerged, although the connected vehicle initiative which embraces embedded technology may quickly advance the prospects for a national standard. Use and adoption of user-based fees will continue to be resisted by the public when applied to longstanding patterns of individual ownership of internal combustion engine vehicles. Instead new models should be developed using emerging approaches to shared vehicle ownership and electric vehicles. Specifically, transportation service providers should develop a user- fee based strategy for transportation based on these new emerging transportation models (e.g. shared vehicle ownership, MaaS, and autonomous MaaS). Vehicle ownership that is not attached to an individual offers a natural platform for pivoting to user-based fees. Under these models, privacy issues are resolved because reporting of travel is an inherent part of the service.

# Pre-Deployment Vision, Goals and Objectives

## Vision

The ultimate purpose of this demonstration is to test and prove a user based fee structure that will ensure the long-term solvency of the Federal Highway Trust Fund. The Highway Trust Fund, like transportation funding in most states, is experiencing severe stress due to factors such the growing demands for resources where revenues are not keeping pace with construction costs due to inflation, and an increasing diversity of new and highly efficient motive power systems, among other forces. Combined, these trends along with continued technology and product and service innovations, point to great uncertainty about the future. As the saying goes “The only thing certain is change.” Our proposal seeks to position the states and the federal government to be prepared to meet the future knowing that today’s personal transportation systems are likely to be substantially different and improved in the future.

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

## Goal:

**The goal of this pre-deployment demonstration is to design a highway user based fee system that will be focused on the future of personal travel and will create an efficient and affordable path toward broader deployment.**

## Objectives

Objectives of this system are to:

* Anticipate where technology, cooperative mobility, electrification, and computing will be in the coming decades and create partnerships to take advantage of developing opportunities.
* Design a user based fee system that utilizes existing on-board telematics, capacity of auto manufacturers and MaaS providers consistent with the needs of the transportation system.
* Incorporate into the system design efficient operations, collections, enforcement, equity considerations, privacy and verification protocols, as well as the transparency and ease of user fee collections.
* Create an opportunity for the Phase II Demonstration and the ultimate deployment of the Minnesota MaaS user based fee system.

## System Maturity and Scalability

The rate of change and adoption of new business models and their impact on the automotive industry is already causing significant change and reaction, and is likely to become extremely disruptive in the future. Coming changes could even make personal vehicle ownership obsolete for large sectors of the population. Today, businesses such as car-sharing, ride-sharing, taxi-sharing and even bike-sharing are setting the stage for different transportation expectations and cost structures. While not yet available broadly, automated vehicles, or driverless cars and trucks, could be the most disruptive of all, and what may appear to be a niche market could have broad appeal to the consumers in general when introduced.

Even though these models are not immediately expandable to the general population, the rate of change and adoption could be rapid given the associated benefits of reduced ownership costs, efficiency, and improved safety with little compromise on personal mobility. As we know from many examples in today’s world, new technology can ripple through society rapidly. Clearly, these models change the public calculus on service pricing, mobility, and ownership expectations.

A focus of this demonstration design will be to keep operations costs competitive or below those of the motor fuel tax and to have the ability to adjust rates by select parameters. This is an imperative because without those features we are merely trading a highly efficient fee collection system. i.e., the motor fuel tax, for a complex and costly fee collection mechanism. Market research shows that that notion is extremely puzzling, irrational, and volatile with the public.



The Minnesota user based fee demonstration will not only build upon lessons learned in previous demonstrations conducted in Minnesota and other locations, but will take the next step in transportation finance planning by focusing on how personal transportation is likely to develop in the not so distant future. The maturity and scalability path is described in the above graphic. Ultimate deployment of a road user charge will require policy makers to create an appropriate regulatory framework. Though that will take political will, any of the potential proposals coming through this demonstration process face that same reality. We believe that the scalability of this approach provides an easier path for policy makers than convincing the public to apply road user charge to their existing individually owned vehicles. With the rapid pace of adoption of technology and innovations in transportation as the backdrop, this approach positions states and the federal government to prepare for significant changes over time.

# Proposed Approach and Study Tasks for Pre-Deployment

This section provides detail on the elements included in the eight major tasks which will be conducted in the pre-deployment phase of this project. The planning timeline, milestones and budget information listed by task are attached in the tables immediately following the task descriptions. These tasks are identified below.

## Task 1. Project Management

Lead: MnDOT

Duration: 18 months

Cost Estimate: $100,000

This task focuses on effective project management and oversight by MnDOT to advance the decision making process and maintain the project schedule. It assumes that the University of Minnesota will be a collaborative partner for the two year project duration focusing on the modeling of pricing strategies, stakeholder outreach, multi-modal analysis, and legislative strategies and authority. We procure technical consulting expertise for conceptual design of back office operations protocol and software and for planning and design for deployment in Phase II demonstration and for execution of other technical tasks. The project management team, including MnDOT, the University of Minnesota, and other partners essential to the project, will meet on a monthly basis for the project duration. It is anticipated there will be three meetings with MnDOT’s top staff and FHWA to keep all partners apprised of progress and problems that may arise as well as outcomes of experiment design and testing. To keep stakeholders and our customers apprised of this work, MnDOT will be responsible for creating and maintaining a study website to be accessed through MnDOT’s home page.

As the project manager, MnDOT will administer the project, establishing ongoing project coordination with partners, and convene Project Management Team (PMT) meetings and other technical and policy project meetings as necessary. Deliverables will include a detailed project plan and schedule, monthly progress reports, copies of project correspondence and public meeting material including presentations and displays and a final report that will be developed in collaboration with research partners.

## Task 2. Recruit MaaS Providers: Customer Needs and Data Privacy, Security and Enforcement Requirements

Lead: Humphrey School with MnDOT

Duration: 14 months

Cost Estimate: $75,000

Minnesota is uniquely positioned to deploy a demonstration of a user based fee system with MaaS providers. MnDOT has already established a relationship with the local nonprofit MaaS provider HourCar, which currently has 2500 members in the St. Paul and Minneapolis metropolitan area. MnDOT has also established a relationship with Car2Go, a for profit car-sharing business in the St.Paul and Minneapolis metropolitan area with 28,000 members. Both car-sharing businesses have expressed interest in partnering in this demonstration project.

MnDOT is also working with the University of Minnesota to engage other MaaS providers in the demonstration. One expectation of the partnerships we form with MaaS providers will be the ability to interface with the embedded telematics already provided on the MaaS vehicles to account for various fee based alternatives. It is assumed that MaaS providers have the GPS and location software capacity to demonstrate a variable user based fee system with existing on board technology. The issues of data privacy and customer expectations are integral to recruitment and discussions with MaaS providers and their customers. Output from this task feeds into Task 3 and Task 4.

Under Phase I of our user based fee trial, MnDOT will establish a collaborative partnership with MaaS providers that will identify the logistical and operational requirements for conducting a demonstration.

Key questions to be answered and information to be gathered in the pre-deployment includes:

* Identifying MaaS provider needs and policy requirements for administering a user based fee demonstration
* Conducting customer outreach and market research with MaaS providers
* Determining the data privacy, security and enforcement expectations and needs and protocols for MaaS providers and MaaS customers
* Developing a range of user based fee options with MaaS providers and testing financial viability and market response to transparent distance based charges
* Identifying a scalable approach to administering user based fees with a MaaS provider’s defined fleet of vehicles
* Documenting how telematics information will be collected with the lowest administrative burden
* Developing an understanding of software requirements, support systems, and compliance tools
* Designing supporting system and incentives concepts

## Task 3. Modeling of Pricing Strategies

Lead: Humphrey School

Duration: 5.5 months

Cost Estimate: $40,000

The project team will work with MaaS providers to explore multiple pricing schemes of user-based fees, which MaaS providers will be charged during the trial period in Phase II. In exchange, they will receive fuel tax rebates in addition to other necessary trial financial incentives. Pricing may be applied at the provider level, with participating MaaS providers making annual payments to MnDOT based on total operating mileage for different vehicle types. The research may also explore the option of providers receiving financial incentives to design their operating systems so as to encourage more customer usage in less congested time of the day or less congested areas. Alternatively, the user-based fees could be collected at

the customer level, for example, as a surcharge calculated per mile (varying by vehicle types) or as a fixed percentage of MaaS charges.

Each pricing scheme will be evaluated based on multiple criteria, including (1) effectiveness in changing travel behavior in a way that leads to more efficient use of roadway infrastructure; (2) ability to recover fuel tax revenues that are forgone through rebates; (3) extent and types of incentives created for participation by MaaS providers; (4) cost of implementing the scheme both from an administrative perspective (for MnDOT) and from a compliance perspective (for MaaS providers and customers; and (5) other possible policy concerns.

Several options that are considered viable will be applied later in the trial deployment period, when empirical data can be collected to analyze the actual outcomes. Output from this task feeds into Task 2.

## Task 4. Design Back Office Operations Protocol and Software

Lead: MnDOT with Professional-Technical Consultant

Duration: 6 months

Cost Estimate: $110,000

Under this task, several alternative models will be evaluated to help design the most cost effective interface with MaaS providers in cooperation with the State of Minnesota Department of Revenue. The back office infrastructure could consist of a private server stored in a secure location or an external cloud-based service. While a private server will enable finer control of the back office infrastructure, this usually also translates to higher costs in data backup and redundancy, and data security. This will be evaluated against various cloud service providers and one system will be chosen to host the back office. The back office software design specifications will be developed to support the actual trial. Those specifications will include:

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

In the Phase II deployment these specifications will be installed and setup on this system. Tests will be conducted to ensure that the system is ready for operation for the period of this phase. The back office will also demonstrate the unique motor fuel tax reconciliation, if necessary, to collect the equivalent mileage-based fee (associated with each vehicle/driver) and will consider, based on the travel data available, what the implications are for inclusion of variables such as time-of-day or facility type or variable rates by jurisdiction.

## Task 5. Stakeholder Analysis and Outreach

Lead: Humphrey School with MnDOT and Professional-Technical Consultant

Duration: 12.5 months

Cost Estimate: $85,000

A key outcome of the pre-implementation phase will be a demonstration plan that has support and commitment from all participants needed to make it happen. This includes MaaS providers, the DOT, state and local government leaders, and others. Under this task, stakeholders will be identified and brought into the conversation to clarify their role, determine their interest and incorporate their needs into the Phase II deployment. The models developed in Task 3 will incorporate these variables and help determine the most viable options and partners for implementing them.

Through this task, we will develop public awareness for the need of user based fee systems and alternative approaches. It is imperative that we address the “value proposition” of user based fee systems for the public and develop persuasive arguments as to why such systems are better than the current system(s). This task will include symposiums on user based fees, other stakeholder meetings, and website support for the project. Concepts and issues to be probed include:

* Equity analysis
* Decision makers input
* Market research
* How to effectively use the finding/recommendations
* Develop measures of support

Further, learning these perspectives will serve as inputs for key factors to be addressed in developing and presenting the Phase II deployment. These factors include discussions of how data will be handled and privacy issues addressed, what measures will be taken to ensure participation by users from diverse backgrounds, and other points to ensure that MaaS providers retain their current membership and business models. Ideally, we will collaboratively develop new strategies to increase their membership.

Specific efforts include individual and stakeholder meetings, presentations and policy briefings to transportation, business and community policy leaders, as described in Task 7, and surveys of MaaS membership as appropriate.

## Task 6. Multi-Modal Pricing Options

Lead: Humphrey School

Duration: 7 months

Cost Estimate: $40,000

User based fees with MaaS could be much more easily scaled than those of traditional approaches. People using MaaS platforms are already embracing the telematics that enables this service. Since user based fees would be applied to a shared vehicle and not necessarily an individual, privacy concerns would be greatly reduced or removed all together.

MaaS, electric vehicles, and autonomous driving are the future of transportation and user based fees applied to these emerging approaches are currently feasible with existing technology. Further, MaaS services can be made even more attractive through coordination with other transportation modes including transit, access to MnPASS high-occupancy toll lanes, and even bike-sharing. (For example, in Minneapolis – St. Paul, one carsharing provider has already upgraded its technology such that members can access a car though their transit pass card). With a coordinated collection system, for example, through a common multi-modal transportation card, customers may get access to MaaS services, use MnPASS lanes (with additional charges determined by the dynamic pricing system), ride the public transit, or even transfer to a shared bike to cover the “last mile” from a parking facility or transit stop.

This study will be to investigate the feasibility of creating the opportunity for customers to make a combined trip that involves multiple transportation modes, for example, ridesharing or car-sharing to a park-and-ride, taking transit, and/or riding a shared bike for one single payment.

## Task 7. Develop and Execute Legislative Strategies

Lead: Humphrey School

Duration: 14 months

Cost Estimate: $20,000

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

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

The Minnesota State Legislature funds a multi-year project on Transportation Policy and Economic Competitiveness (TPEC) for research by the Humphrey School of Public Affairs on transportation finance, economic development and new technologies. The TPEC advisory board, which meets twice a year, includes the transportation committee chairs and ranking members from the Minnesota State Legislature as well as other transportation, business and community policy leaders. We propose to use the TPEC advisory board as a primary approach to engage state legislative leadership on legislative strategies related to this project in the pre-deployment phase.

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

## Task 8. Planning and Design for Deployment in Phase II Demonstration

Lead: MnDOT with Professional/Technical Consultant

Duration: 12 months

Cost Estimate: $130,000

The wide range of knowledge and information gathered from the Phase I pre-deployment will feed into this Task with the objective of designing a cogent approach for an actual deployment under Phase II. Our main goals for this task are to execute an agreement with a MaaS provider or providers and to create the system architecture and back office design to efficiently collect user based fees. In this phase we will develop the concept of operations and system requirements suitable for further design, building, testing, and operation with careful attention to completion of the subtasks identified below. The structured concept will include identifying specific performance measures, targets, and capabilities associated with performance monitoring and performance management.

In this phase, the pilot deployment concept is designed in detail through the development of a Comprehensive Pilot Deployment Plan which will be built and tested prior to operation. Elements of this plan will detail specifications including:

* Project management plan, milestones, budget and timeline
* Execute MaaS agreements
* Develop concept of operations and system requirements
* System architecture and system design and development
* Back office setup and operations
* Verification and reconciliation protocol
* Data collection plan and analysis of results
* Evaluation and monitoring of fee collection and operations costs
* Pilot deployment and system build out
* Providing partner and customer support
* System testing and security operations interface
* Reporting plan / findings and recommendations

## Planning Timeline and Milestones for Pre-deployment

**Listing of major milestones in the process**

* April-May 2016 – Meet with first MaaS provider to gauge interest in pre-deployment partnership
* Summer 2016 – Meet with MaaS providers in Minnesota to identify one to three partners for the pre-deployment analysis
* Fall 2016 – Conduct pre-deployment study with MaaS provider partners
* Spring 2017 – Legislative authority and matching funds.
* Summer 2017 - Federal Demonstration grant award
* Fall 2017 - Prep for launch
* Winter 2018 - Demonstration launch
* 2018 to Summer 2019 - Conduct demo
* Fall 2019 - Final Report to U.S. DOT

#### Proposed Timeline and Deliverables

|  |  |
| --- | --- |
| **Tasks** | **Months** |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |  |
| 1.Project Management |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2.Recruit MaaS Providers: Customer Needs and Data Privacy Requirements  |  |  |  |  |  |  |  |  |  |   |  |  |  |  |  |  |  |  |
| 3.Modeling of Pricing Strategies |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.Design Back Office Operations Protocol and Software  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.Stakeholder Analysis and Outreach |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.Multi-Modal Pricing Options |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.Develop and Execute Legislative Strategy |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8.Planning and Designs for Phase II Deployment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Milestone Deliverable

|  |  |  |
| --- | --- | --- |
| **Deliverable** | **Due Date** | **Sec. 508 Compl.** |
| 1.Project management plan  | 12/15/2016 |  |
| 2. Report on customer needs, data privacy requirements | 2/15/2017 |  |
| 3. Report on modeling and pricing strategies | 8/30/2017 |  |
| 4. Report on back office concept design, software, and ops protocol | 10/30/2017 |  |
| 5. Report on stakeholder analysis, outreach and equity | 1/15/18 |  |
| 6. Report on multi-modal pricing options | 12/30/17 |  |
| 7. Legislative authorization and funding | 5/30/17 |  |
| 8. Report on system design recommendations and Phase II deployment | 3/15/18 |  |

#### Proposed Budget for Pre-Deployment Activities for a User based fee Demonstration in Minnesota\*

|  |  |  |  |
| --- | --- | --- | --- |
| Tasks | Federal(50%) | State(50%) | Total |
| 1.Project Management | $50,000 | $50,000 | $100,000 |
| 2.Recruit MaaS Providers: Customer Needs and Data Privacy Requirements | $37,500 | $37,500 | $75,000 |
| 3.Modeling of Pricing Strategies | $15,000 | $25,000 | $40,000 |
| 4.Concept Design / Requirements for Back Office Operations Protocol and Software  | $55,000 | $55,000 | $110,000 |
| 5. Stakeholder Analysis and Outreach  | $42,500 | $42,500 | $85,000 |
| 6.Multi-modal Pricing Options | $20,000 | $20,000 | $40,000 |
| 7. Develop and Execute Legislative Strategies | $20,000 | - | $20,000 |
| 8.Planning and Design for Deployment in Phase II Evaluation | $60,000 | $70,000 | $130,000 |
| **Total** | **$300,000** | **$300,000** | **$600,000** |

**\***The budget of this pre-deployment could be expanded depending upon how many entities we partner with and upon determination of eligible in-kind contributions from our MaaS partners.

# ATTACHMENT 1: LEVELS OF AUTOMATION

The U.S. DOT’s National Highway Traffic Safety Administration policy on automated vehicles established five distinct levels of automation in vehicles.[[9]](#footnote-9) Defining levels of automation provides clarity when discussing the topic among different states, product developers, and other stakeholders.

**Level 0 – No-Automation**

Level 0 includes all vehicles where the driver is in complete and sole control of all primary vehicle controls at all times. These include the vehicle’s brakes, steering, throttle, and motive power. Many older passenger vehicles fall into this category. Vehicles that have warning systems but do not actively change the vehicle’s speed or path would be considered Level 0.[[10]](#footnote-10)

**Level 1 – Function-specific Automation**

Level 1 includes automation of one or more specific control functions that operate independently in the vehicle. The driver remains in control of the vehicle and is responsible for safe operation, but has assistance from vehicle technology should she choose to utilize it. Common examples of level 1 automation systems include electronic stability control and dynamic brake control that prevents rear-end collisions. An important distinction to keep in mind for level 1 automation is that each automated system does not interact with other automated systems, and must be allowed to act by the driver of the vehicle.

**Level 2 – Combined Function Automation**

Level 2, as suggested by its name, involves automation of at least two primary control functions that work together and are intended to relieve the driver of controlling those functions. Most commonly vehicles with level 2 automation combine adaptive systems like adaptive cruise control and automatic lane centering. While using level 2 automated systems the driver must be ready to re-take control from the vehicle at any time should it encounter a situation that the automated systems are not able to navigate. Vehicles with level 2 automation are available on the market today, and include Tesla’s Autopilot function and General Motors’ yet-to-be-released Super Cruise system.[[11]](#footnote-11)

**Level 3 – Limited Self-Driving Automation**

Level 3 automation enables the driver to give the vehicle all safety-critical functions under certain conditions. While in self-driving mode the vehicle is responsible for identifying situations which require driver assistance and alerting the driver to retake control of the vehicle. The amount of advanced warning provided before driver takeover is a key distinction between levels 2 and 3. A level 2 vehicle does not give the driver advanced notice that she needs to retake control of the vehicle, while a level 3 vehicle would provide advanced warning that allows for a transition back to no-automation mode.

**Level 4 – Full Self-Driving Automation**

Level 4 automated vehicles are designed to perform all safety-critical driving functions while traveling and monitor activities happening around them. Passengers in level 4 autonomous vehicles are only required to enter a destination – the vehicle takes over from there. Google’s autonomous vehicle prototypes fit into the level 4 classification.

 **National Highway Traffic Safety Administration, 2013**



**Identification of Source and date TBD**

# ATTACHMENT 2: MINNESOTA’S DISTANCE BASE FEE TRIALS AND MARKET RESEARCH SUMMARY

1. **Minnesota Road User Fee Test**

The 2013 Minnesota Road User Fee Test (MRUFT) project provided a significant advancement in understanding the technological feasibility of implementing a road user fee through aftermarket devices, particularly a Smartphone. As with most research projects that seek to advance the

boundary of known research, designing, developing, and implementing a robust, first of-its-kind, system was an extraordinary endeavor. More than 1 terabyte of data was successfully collected representing millions of miles traveled and hundreds of thousands of trips from 500 participants over a one year. The project clearly demonstrated that the technology embedded within today’s Smartphone is sufficient to capture accurate and frequent GPS measurements (at one second intervals) as well as providing a viable mechanism for the delivery of other safety related applications such as dynamic signage. The MRUFT project also demonstrated that such technology could be understood by the traveling public and can collect and process data through a cloud-based architecture securely and with complete transparency to the end-user. These lessons have helped inform MnDOT in terms of future research and deployment efforts to enhance the user experience, improve operational efficiency, and avoid technology-based limitations encountered during the project. The complete technology and operations reports, evaluation, and policy reports for the MRUFT project can be found at: <http://www.dot.state.mn.us/mileagebaseduserfee/pdf/OperationsReportBattelle.pdf>; <http://www.dot.state.mn.us/mileagebaseduserfee/pdf/EvaluationFinalReport.pdf>;

<http://www.dot.state.mn.us/mileagebaseduserfee/pdf/mbufpolicytaskforcereport.pdf>

1. **Minnesota Pay-As-You Drive Demonstration**

In 2006 MnDOT completed a Mileage-Based User Fee Demonstration Project through the support of the Value Pricing Pilot Program grant administered by the Federal Highway Administration. The purpose of this project was to demonstrate how consumers would change their driving behavior if some of the fixed costs of owning and operating a car were to be converted to variable costs. One hundred and thirty participants were given OBDII port linked devices that recorded mileage and time of travel. Prices per mile were assigned randomly to each participant, ranging from 5 cents per mile to 25 cents per mile. The findings indicate that per mile pricing does result in measurable, but small reductions in driving. The largest effect is on weekend driving and on peak weekday travel (as some participants were able to substitute mass transit for their vehicle). One key finding in this experiment is that those households that are willing to change their driving behavior will do so with low per mile cost incentives. On the other hand it was also determined that those households unable to change their behavior do not do so even under relatively higher cost incentives. Therefore, the marginal effect of per mile prices seems to drop off dramatically after some point in the lower range of prices. The complete demonstration operations and marketing reports can be found at:

[2006-39A](http://www.dot.state.mn.us/research/TS/2006/200639A.pdf), <http://www.dot.state.mn.us/research/TS/2006/200639A.pdf>

[2009-39B](http://www.dot.state.mn.us/research/TS/2006/200639B.pdf), <http://www.dot.state.mn.us/research/TS/2006/200639B.pdf>

[2009-39C](http://www.dot.state.mn.us/research/TS/2006/200639C.pdf) <http://www.dot.state.mn.us/research/TS/2006/200639C.pdf>

1. **Public Acceptance of MBUF in Minnesota**

In 2009 Minnesota completed an in depth study of public acceptance around mileage-based fees. The overall goal of the research was to understand public attitudes and awareness regarding mileage-based user fees (MBUF) and to learn how to communicate with the public regarding transportation funding and potential solutions. This was a three phase project that used interviews, focus groups, surveys, and concept testing to explore the many facets of public acceptance surrounding mileage based fees in depth. Major conclusions from this research include:

* Drivers are skeptical about the need for a new user based fee system and/or the need for new revenue for highways
* Add on technology to collect user fees is generally viewed negatively although younger drivers are less averse to technologies
* Simpler user fee systems are preferred among drivers and are perceived to be fairer and less costly to operate
* More information and time spent with drivers helps them understand the objective of a user based fee system
* Clear communications on the objectives of a new user based fee system is a key to broader public acceptance

More information can be found at:

<http://www.dot.state.mn.us/mileagebaseduserfee/pdf/09mbufphase3finalrpt.pdf>

1. **Report of the Mileage-Based User Fee Policy Task Force**

The Mileage-Based User Fee (MBUF) Policy Study Supporting Technical Information document offers necessary detail regarding the work performed and reviewed as part of the MBUF Policy Study and serves to complement the separate MBUF Policy Task Force Report. As such, it summarizes activity within, and inputs informing all phases of, the MBUF Policy Study process, including findings from Greater Minnesota listening sessions; the 2011 MBUF Symposium in Breckenridge, Colo.; perspectives from national experts; national expert and transportation finance roundtable events; an internet panel survey of Minnesotans; and additional targeted outreach. The MBUF Policy Study was commissioned by the Minnesota Department of Transportation (MnDOT) to identify and evaluate issues related to potential future implementation of an MBUF system in Minnesota.

Under a potential MBUF system, drivers would be charged based on the number of miles they drive, regardless of the type of energy source used to propel the vehicle, instead of being charged by the gallon for fuel consumed in operating a vehicle. Over a period of approximately one year, the MBUF Project Management Team, made up of individuals from MnDOT, the Humphrey School of Public Affairs, and consultants, secured valuable quantitative and qualitative policy feedback, drove completion of several deliverables including development of potential MBUF business models, and staffed a Policy Task Force.

More information can be found at: [**http://www.hhh.umn.edu/state-and-local-policy-program/transportation-finance**](http://www.hhh.umn.edu/state-and-local-policy-program/transportation-finance)

Mileage-based User Fee:  Supporting Technical Information [**http://www.cts.umn.edu/Research/ProjectDetail.html?id=2011046**](http://www.cts.umn.edu/Research/ProjectDetail.html?id=2011046)

# ATTACHMENT 3: PROPOSING TEAM QUALIFICATIONS AND RESUMES

**Minnesota Department of Transportation**

Kenneth R. Buckeye, Project Manager

Christopher Berrens, Lead Researcher

Serge Phillips, Government Relations Attorney

**University of Minnesota, Humphrey School of Public Affairs**

Frank Douma, State and Local Policy Program Director

Jerry Zhao, Associate Professor

Lee Munnich, Senior Fellow

Adeel Lari, Director of Innovative Finance

**Resumes Attached**

1. Levinson, D. et al. “The Transportation Futures Project: Planning for Technology Change.” Minnesota Department of Transportation Research Services & Library, 2015. [↑](#footnote-ref-1)
2. Levinson, D. et al. “The Transportation Futures Project: Planning for Technology Change.” Minnesota Department of Transportation Research Services & Library, 2015. [↑](#footnote-ref-2)
3. North America Insight, Autos and Shared Mobility, Morgan Stanley Research, March 1, 2016 [↑](#footnote-ref-3)
4. [National Highway Traffic Safety Administration, 2013](http://www.nhtsa.gov/About%2BNHTSA/Press%2BReleases/U.S.%2BDepartment%2Bof%2BTransportation%2BReleases%2BPolicy%2Bon%2BAutomated%2BVehicle%2BDevelopment) – SAE International, an engineering organization, offers an [alternative classification system](http://www.sae.org/misc/pdfs/automated_driving.pdf) with a 5th level on the fully autotomized side of the scale that is achieved when cars are 100 percent self-driving in all scenarios. For the purposes of consistency, this proposal will rely on the NHTSA definitions of autonomous vehicle capabilities. [↑](#footnote-ref-4)
5. McKinsey & Company, Automotive revolution-perspective towards 2030. January 2016 <https://www.mckinsey.de/sites/mck_files/files/automotive_revolution_perspective_towards_2030.pdf> [↑](#footnote-ref-5)
6. Background for the Per-Mile Road Usage Charge in the USA; Presentation for the IBTTA Transportation Finance and Road Usage Charge Conference Portland, Oregon, by James Whitty, Road Usage Charge Program Manager, Oregon DOT. April 26, 2015 [↑](#footnote-ref-6)
7. National Cooperative Highway Research Program, Synthesis 487: Public Perception of Mileage-Based User Fees, Transportation Research Board 2016. [↑](#footnote-ref-7)
8. Mileage-Based User Fee Public Opinion Study: Summary Report Phase I (Qualitative); Dieringer Research Group Inc., for the Minnesota Department of Transportation, August, 2007. <http://www.lrrb.org/media/reports/200750.pdf> [↑](#footnote-ref-8)
9. [National Highway Traffic Safety Administration, 2013](http://www.nhtsa.gov/About%2BNHTSA/Press%2BReleases/U.S.%2BDepartment%2Bof%2BTransportation%2BReleases%2BPolicy%2Bon%2BAutomated%2BVehicle%2BDevelopment) – SAE International, an engineering organization, offers an [alternative classification system](http://www.sae.org/misc/pdfs/automated_driving.pdf) with a 5th level on the fully autonomized side of the scale that is achieved when cars are 100 percent self-driving in all scenarios. For the purposes of consistency, this paper will rely on the NHTSA definitions of autonomous vehicle capabilities. [↑](#footnote-ref-9)
10. Ibid. [↑](#footnote-ref-10)
11. [Davies, 2016](http://www.wired.com/2016/01/cadillacs-delaying-its-first-whack-at-a-self-driving-car/) [↑](#footnote-ref-11)