Washington Road Usage Charge Pilot

Information School Capstone ’17

Assignment #4

8 March 2017

Dylan Babbs
Jackson Brown
Jack Fox
Nick Nordale
Ishan Saksena

Agenda

I. Project Information

II. Project Status & Research Updates

III. Competitive Matrix

IV. Solution Selection

V. Prototypes & State Diagrams

VI. Appendix

I. Project Information

Project Background

- WA state gas tax revenue to decline as vehicles become more fuel efficient
- Conservative forecasts suggest fuel efficiency will increase from 20.5 to 35 MPG by 2035
- This means a **nearly 50% reduction** in state gas tax revenues
- Current gas tax funding system is unfair—drivers are paying different amounts depending on fuel efficiency
- In order to continue funding public roads, WA state must consider taxing citizens on a “per-mile” basis

Team Roles

Dylan Babbs

Role
Product Manager

Assigned
POC w/ sponsor
Research
Prototyping & ideation

Jackson Brown

Role
Project Manager
Software Engineer

Assigned
UX design & research
Front-end development
Data visualization & engineering

Jack Fox

Role
Software Engineer
Analyst

Assigned
Back-end development
PostGIS development

Nick Nordale

Role
Software Engineer

Assigned
Back-end development
Infrastructure mgmt
System admin

Ishan Saksena

Role
Software Engineer

Assigned
App development
Onboard diagnostics integration

Project Goals

WSTC to begin pilot program in Fall 2017 experimenting on “per-mile” tax

Capstone Project Goals (us)

- Develop a proof of concept by June 2017 for WA state citizens to self report their auto mileage

WARUC Project Goals (WA state)

- Does a RUC make sense for Washington long-term?
- How does it work for drivers?
- Will it enable us to better fund our transportation system into the future?

Team Working Agreement

Goal

1. Create a proof of concept for a distance-based road usage charge.
2. Produce all deliverables in a timely manner.
3. Be respectful and helpful in a professional manner.
4. Learn more about transit technology and software development.
5. Gain experience working with a sponsor client

Purpose

Successfully execute a long term project and gain real world experience on how comprehensive projects are carried out and delivered.

Outcome

To develop a prototype/ proof of concept testing the feasibility of a long-term driver mileage tracking solution. The results of our prototype will influence the replacement of the Washington State gas tax to increase revenue.

Conflict Resolution

Each team member will:

1. Hold themselves **responsible** for their work so that they can then **rely** on group members to do the same
2. **Respect** one another we can form deeper **relationships** with each other (thus improving the quality of work)
3. If we **have** conflicts we can then take a step back and **reflect** on where and how the conflict started

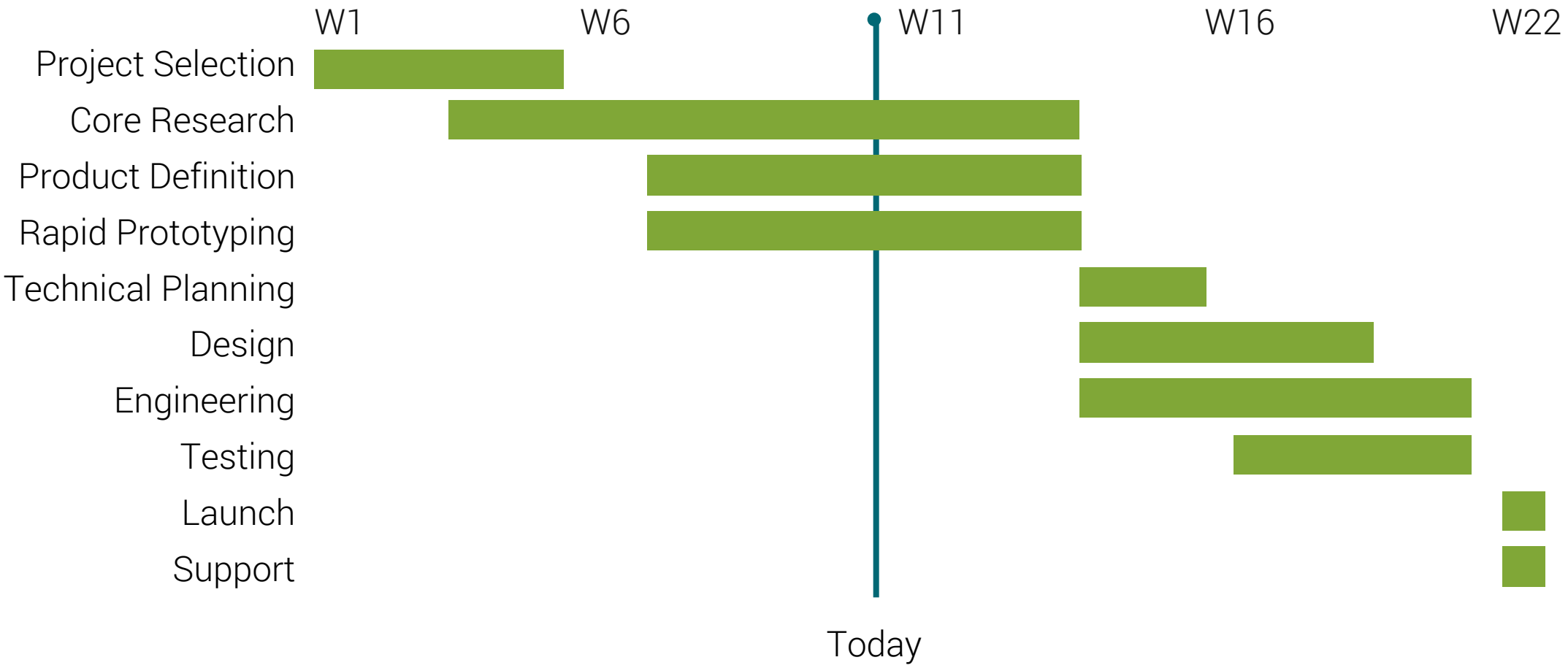
Signed and agreed by all team members 1/27/17

*22 week assumption

Project Plan

Item	Weeks*	Description
Project Selection	1-5	Brainstorm, accept WARUC project
Core Research	5-13	Interviews, research to determine best tracking method
Product Definition	7-13	Define product scope from conducted research
Rapid Prototyping	**7-13**	**Build and test low fidelity prototypes**
Technical Planning	13-15	Technical architecture and implementation research
Design	13-18	UX / UI
Engineering	13-19	Let's build
Testing	16-19	Bug and user testing
Launch	22	Present at Capstone event & to Challenge Seattle sponsor
Support	22	Continuous support following Capstone II

Project Timeline (cont.)



II. Project Status & Research Updates

OBD-II port purchase

- Purchased Foseal iOS WiFi OBD-II scanner
- Setup and connection is a simple process; took less than one minute to begin working
- When connected to WiFi, user unable to use cellular data -> no access to streaming music or mapping

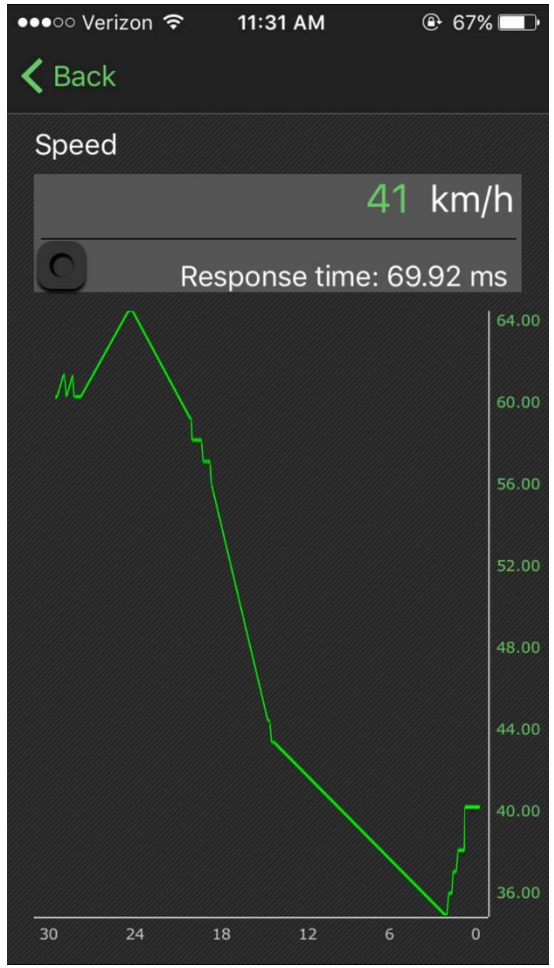
- **Area for further research**: Since WiFi connection limits ability to connect to cellular data, will we still be able to access GPS data to calculate location? Or must we grab distance from OBD-II velocity?

iOS OBD-II Scanner

Data received from OBD-II port

Some of the data fields received from the live streaming OBD-II during exploration:

- Fuel Type
- Fuel Economy
- Command Equivalence Ratio
- Ambient Air Temperature
- Accelerator Position
- Oxygen Sensors
- Fuel Level
- Vapor Pressure
- Barometric Pressure
- Engine RPM
- Speed
- Throttle Position
- Engine Load
- DTC Status
- Fuel System Status
- Timing Advance
- Drive Cycle Status



Screenshot from "OBD Doctor" iOS app, showing velocity of vehicle

Meetings with other departmental teams

- Met with Electrical Engineering and HCDE2 teams working on same WARUC project on 2/22/17
- No contact with team HCDE1 team
- EE team to build Android application that calculates distance using velocity from OBD-II port
- HCDE2 to focus on user research and “public acceptance”; will conduct research into determining the most acceptable approach for the application. Will not build prototype

- **EE contact**: Amanda Tran -- trana19@uw.edu
- **HCDE2 team lead**: Alex Gilbert -- agilbe@uw.edu

Research Update: Unknowns Answered (1 of 5)

How accurate is deriving distance from the [odometer's] velocity?

According to our technical expert, this method is more accurate for measure the vehicle's distance traveled than either the vehicle's mileage odometer, or through GPS mapping.

- Although owners strongly believe the odometer is an accurate measurement of vehicle miles traveled, currently there's no federal standard for odometer accuracy. A few automakers have been sued for inaccurate odometer reporting (up to 5% variation), as the mileage reported by the odometer is used for determining the expiration of a vehicle warranty.
- GPS is not always an accurate representation either. For example, miles could be over or under-reported when the signals change, or the GPS signal is temporarily obstructed. At the very small measures, GPS with map-matching may not capture mileage from lane changes, off-road or off-map deviations, etc.
- For purposes of assessing a RUC, both odometer and GPS are treated as acceptable measures of miles driven.

Research Update: Unknowns Answered (2 of 5)

Which Model Year vehicles have OBD ports?

Although the OBDII standards were not finalized by the regulatory agencies until 2006, all vehicles sold since 1996 have an OBD port that is capable of providing data required to calculate a RUC.

Can ODD-II devices store data?

Yes. It might be worth researching the ability of the smartphone to store mileage data, rather than storing it on the OBDII device. Possible collaboration with a firm from Norway [Q-Free, https://www.q-free.com] reported they were working on an app that would keep road charging information on the phone itself (I believe they were considering tolls, not RUC).

Research Update: Unknowns Answered (3 of 5)

How often is mileage data transmitted to the cloud?

In the recent California pilot, the transmission of data is 1x per day. This is not a requirement, since mileage is billed to RUC participants only once every month (or quarter).

- As the team considers ways to build an app that users will like, having mileage data available at least daily (if not in real-time) might be a desirable feature that can spawn other interesting features. For example, OBDII device providers Azuga, IMS and Automatic all have interesting features to provide drivers so that the data they are collecting for their clients (government RUC and tolling programs, insurance companies wanting to verify mileage) is not the only reason for drivers to use their devices.

Research Update: Unknowns Answered (4 of 5)

How many cars are equipped with Bluetooth technology?

Market forecasts from 2010 indicate that about 90% of new vehicles would be Bluetooth enabled by 2016. The team might want to research this question further. However, in reality, dependability of Bluetooth in automobiles has been poor. If consumers are frustrated by the poor performance, relying on Bluetooth as a means of critical vehicle authentication for RUC purposes could be an issue. More info.

- For the pilot project (and development of this app), we are not concerned about wide availability of Bluetooth or USB, since the smartphone approach is still in proof-of-concept phase. If the team uses Bluetooth or USB as a means of RUC vehicle authentication, we will just need to point out that the system's functionality will depend upon the availability and reliability of the drivers' in-vehicle Bluetooth capabilities.

Research Update: Unknowns Answered (5 of 5)

How many cars are equipped with USB inputs?

The number has increased from 3.3 million in vehicles sold in 2005, to a projected 16.7 million in vehicles sold MY 2022.

Can vehicles be authenticated via the USB port?

Still unknown – will continue to research

Platform Considerations

- Project to be built with **iOS/Swift**

Why?

- Team has experience with iOS development
- EE team is already building Android
- iOS is second most popular mobile OS in the United States

Persona # 1 (of 3)

Michael Cornell

Age	24
Education	Bachelors
Marital	Single
Location	Seattle
Car	2001 Ford Escape

- Michael is a recent graduate of the University of Washington working at Microsoft in Redmond, WA
- Living in Capitol Hill, Michael commutes to the eastside 5 days a week across the 520 to get to work
- Michael drives a white 2001 Ford Escape, which averages 25-30 mile per gallon
- One day at work, Michael sees a senior executive at the company parking lot driving a Tesla and realizes that he doesn't have to pay the gas tax Michael has to when he goes to the pump
- Michael is unhappy about this and wants the WA state government to enact a fair tax across all citizens (regardless of car type) to improve roads

Persona # 1: Storyboard

Michael Cornell

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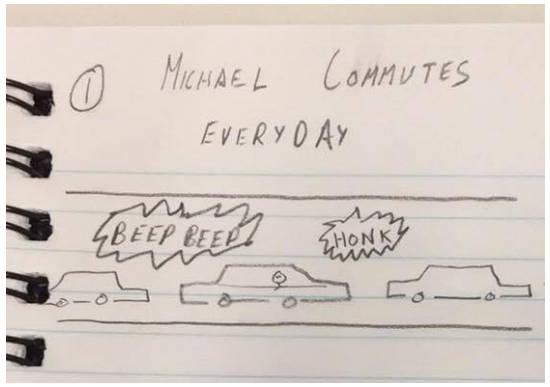

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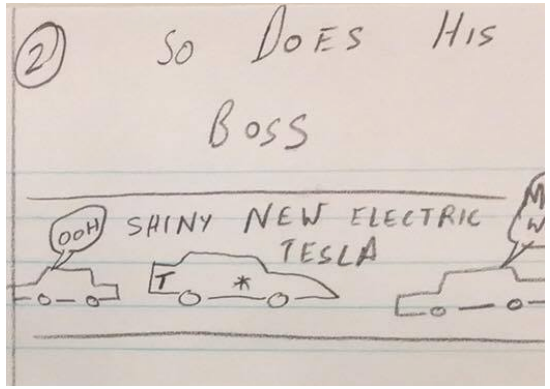

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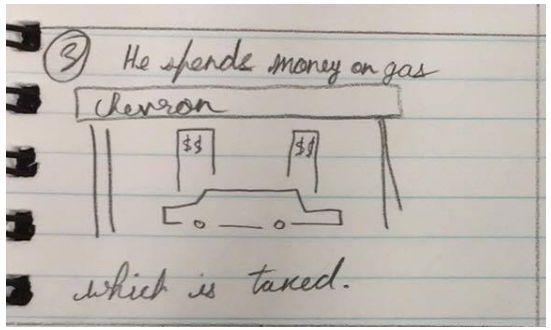

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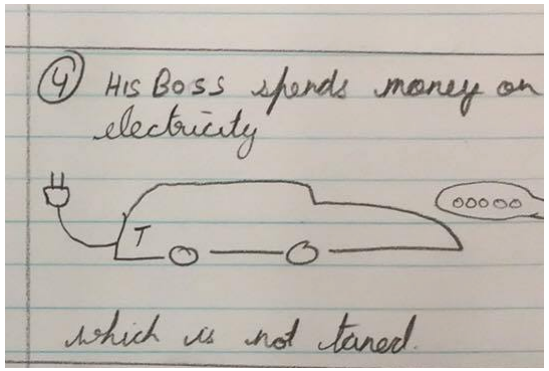

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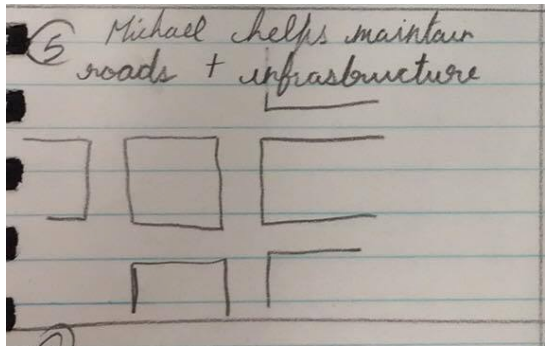

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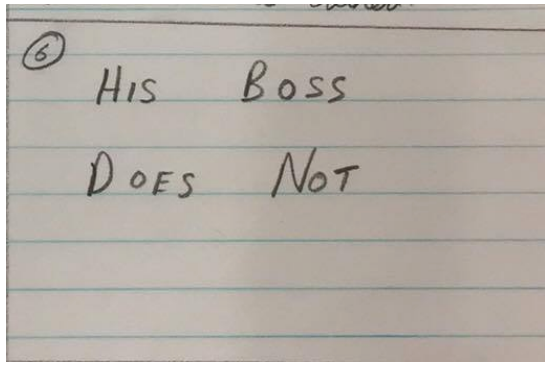

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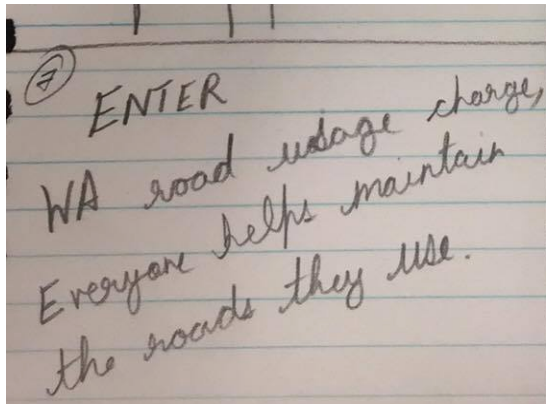

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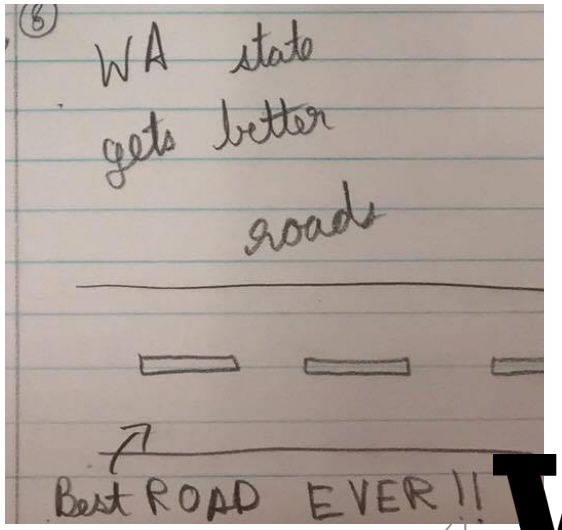

Persona # 2 (of 3)

Jaclyn Smith

Age	24
Education	Associates
Marital	Single
Location	Tacoma
Car	2006 Acura TL

- Jaclyn is an office manager at a Tacoma medical clinic
- As an avid skier, Jaclyn travels to Stevens Pass every weekend during the winter season
- Similar to Michael, Jaclyn is frustrated by the unfair gas tax she has to pay with her 20 mpg Acura TL compared to fuel efficient vehicles
- Jaclyn heard about the WARUC pilot program through the the KING5 daily news and is eager to volunteer for the program because she wants to make a difference
- Jaclyn purchased a brand-new iPhone 7 two months, and would like to sign up for “mobile-only GPS” reporting option available in the program

Persona # 2: Storyboard (1 of 2)

Jaclyn Smith

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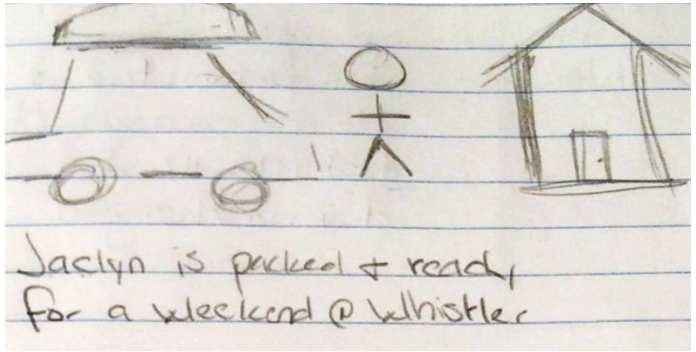

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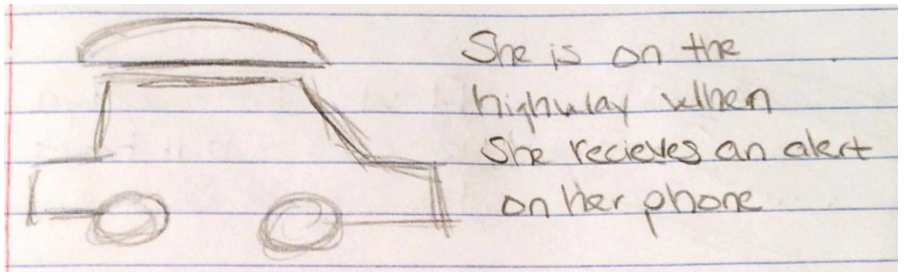

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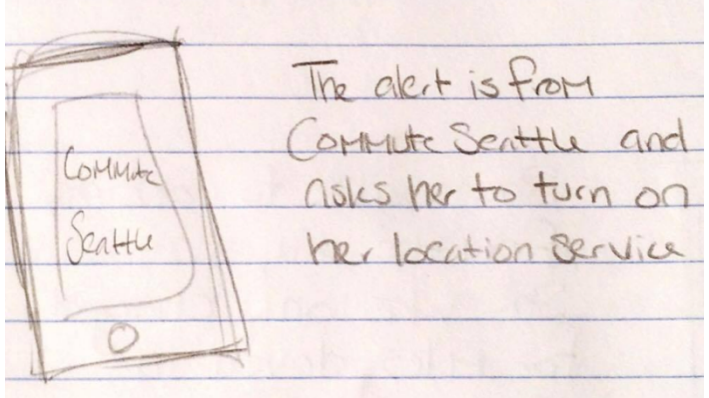

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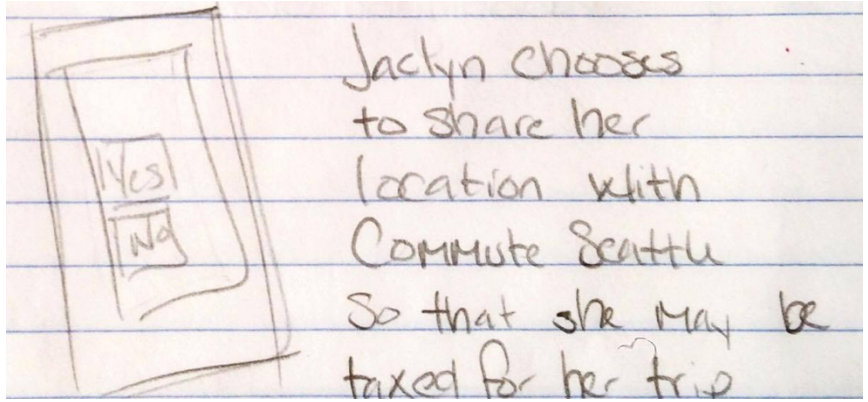

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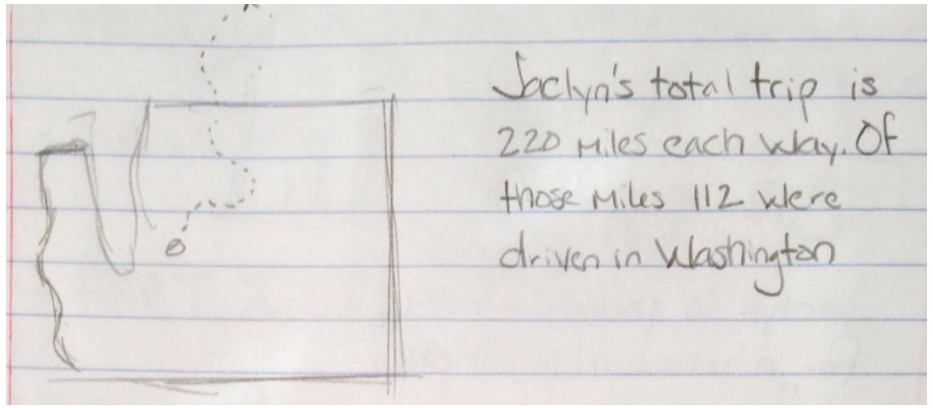

Persona # 2: Storyboard (2 of 2)

Jaclyn Smith

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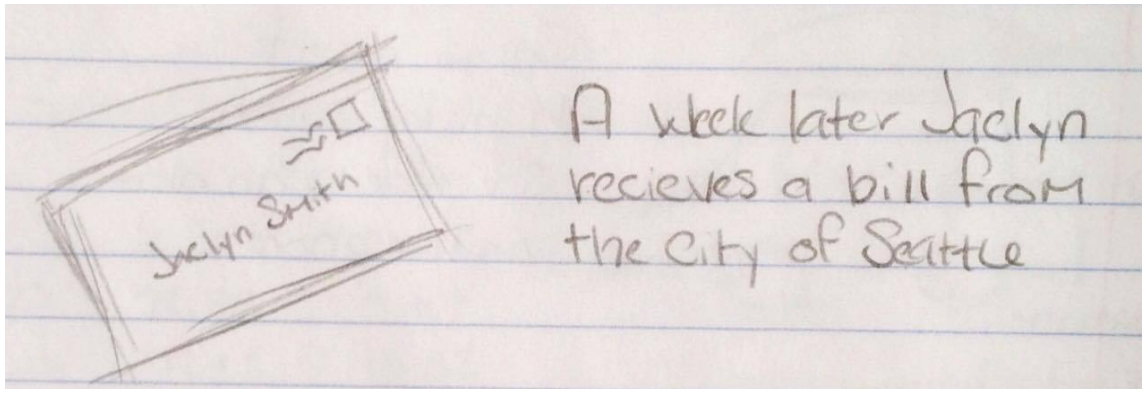

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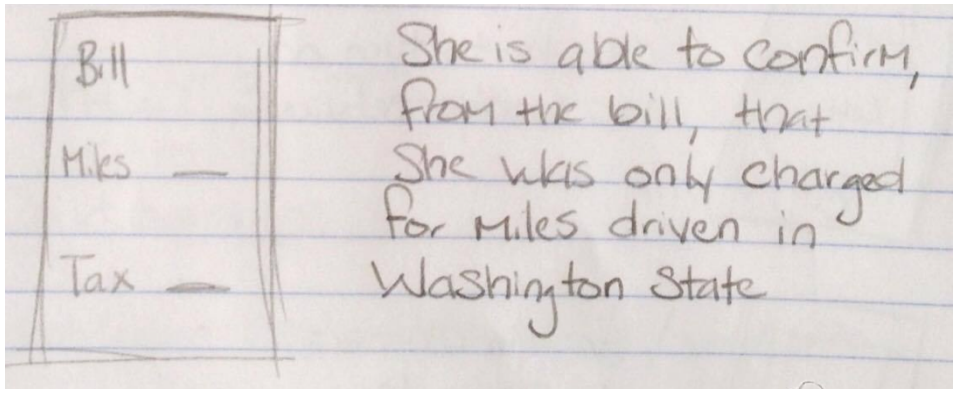

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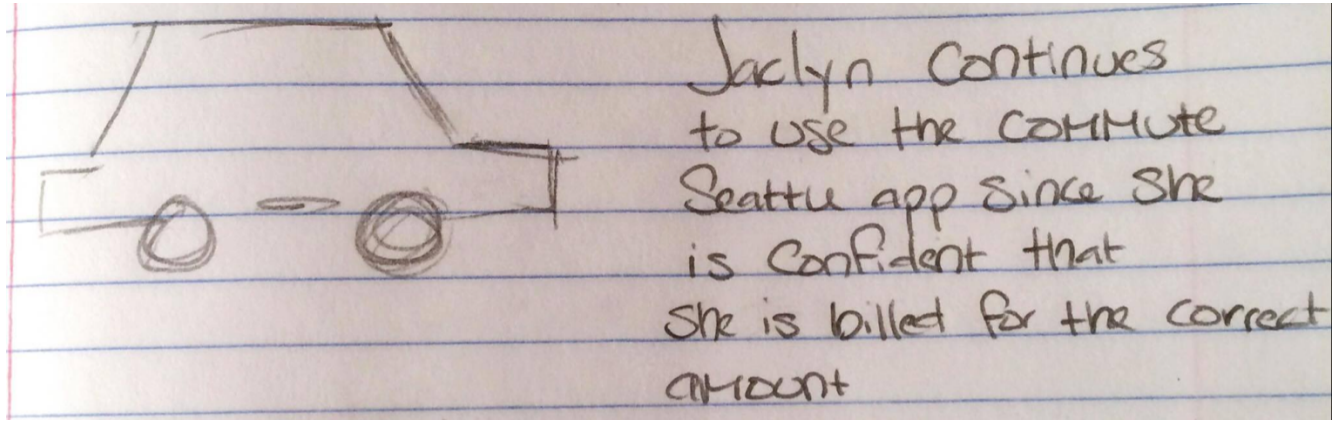

Persona # 3 (of 3)

John Lent

Age	56
Education	MBA
Marital	Married
Location	Kirkland
Car	BMW i8

- John is a senior director at the Bill & Melinda Gates Foundation, commuting to Seattle five days a week from Kirkland
- At work, John focuses on public policy issues around the environment, and is passionate about transportation infrastructure in WA state
- John has noticed the continuing lack of funding for WA roads due to the unbalanced gas tax and wants to take part in the WARUC pilot program
- John's navy blue BMW i8 has an OBD-II port, and is interested in leveraging this port during the pilot program

Persona # 3: Storyboard

John Lent

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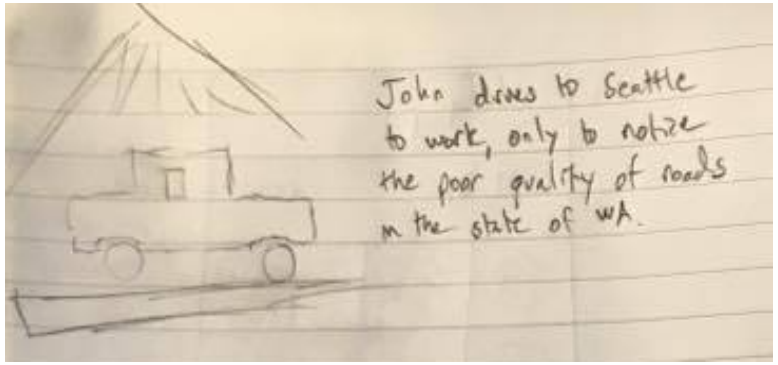

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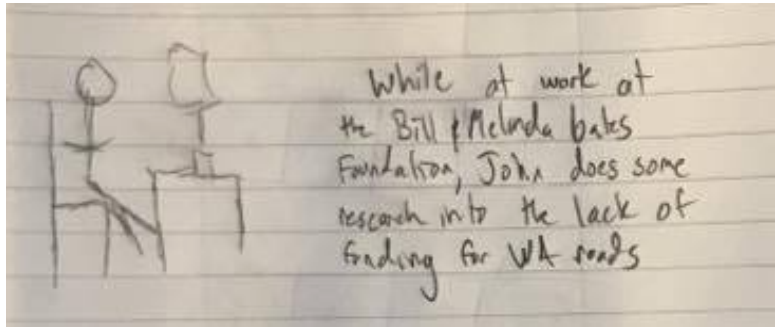

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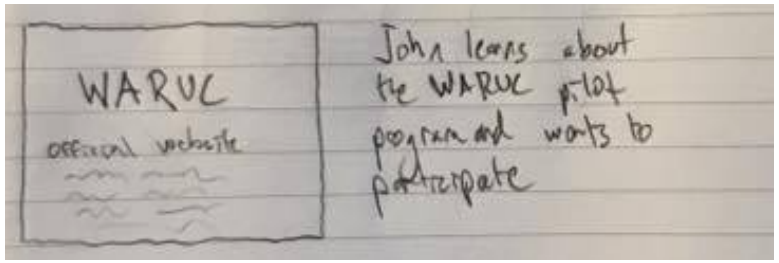

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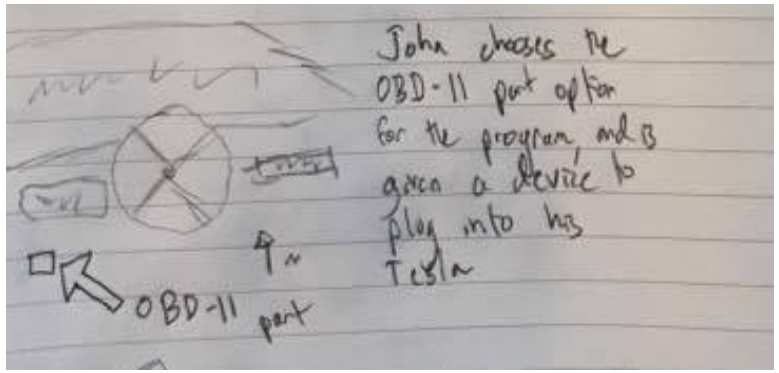

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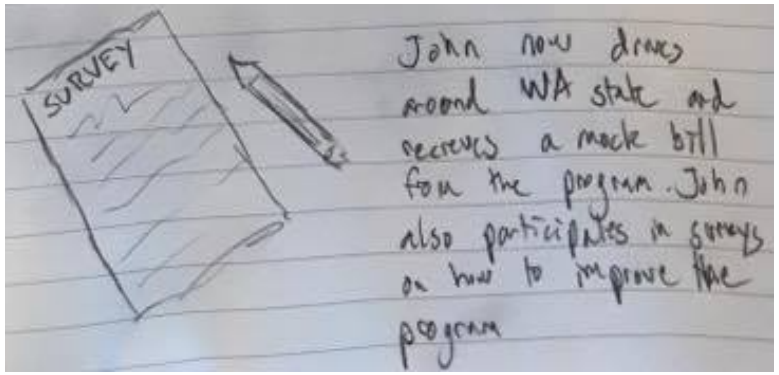


III. Competitive Matrix

Competitive Matrix

Due to the nature of our project and the lack of competitors in the space, we have split up our competitive matrix into three areas:

1. Similar road usage-based tax pilot programs from other states
2. Potential tracking solutions for the WA state program
3. Location-based services/vendors we are considering working with

The entire matrix can be found on Google Sheets as well: https://docs.google.com/a/uw.edu/spreadsheets/d/1VoQABWpvKPAMlVfsjg6A3Y8Ee_ugLepcI9I7sa2-rFY/edit?usp=sharing (requires UW authentication)

1. Oregon Pilot Program

Area 1: States with similar pilot programs

	Positioning	Distance Tracking & Calculations	Privacy to user	Accuracy	Public/Private Road Classification	Fraud Mitigation	Tracking/ Reporting	Manual Toggling	Road Condition Monitoring	Current Status of program/ feature
How	Positioning enabled through "advanced reporting" device installed in car	Distance is calculated through one of four options: basic reporting (no location), factory installed advanced reporting, after market advanced reporting, and switchable reporting (no location/location hybrid)	Basic reporting does not provide location; protects user's privacy	Advanced reporting methods (location + distance) provide more accurate measurements	Road classification is determined by GPS positioning	No information available in report about fraud detection or prevention	Four options: Basic reporting (no location), factory installed advanced reporting, after market advanced reporting, and switchable reporting (no location/location hybrid)	With the smartphone plan, participants could control when the location data was enabled or disabled.	No road condition monitoring available	Fully operational http://www.myorego.org/
Benefits	Location is provided along with distance aggregate	Participant has option to choose between different methods	User can choose between basic and reporting options depending on their privacy concerns. Additionally, the switchable reporting allows participants to turn off their location when choose to.	Accurate measurements are beneficial to the state	Participants aren't charged for private road usage	N/A	Participant has option to choose between different methods	User privacy protected when they didn't want location tracked	N/A	Oregon citizens can now pay by mile instead of gallon
Distinction	Advanced reporting option provides location	Oregon provides for factory install tracking, meaning that some cars would come with tracking device installed by OEM	Switchable reporting option is unique to California and Minnesota	N/A	N/A	N/A	Tracking devices implemented by OEM or aftermarket	N/A	N/A	Only state out of 3 pilot programs with operational system

2. California Pilot Program

Area 1: States with similar pilot programs

	Positioning	Distance Tracking & Calculations	Privacy to user	Accuracy	Public/Private Road Classification	Fraud Mitigation	Tracking/ Reporting	Manual Toggling	Road Condition Monitoring	Current Status of program/ feature
How	Choice between plug-in device, smartphone, telematics for automated positioning	Option to choose automated methods or manual methods (time permit, mileage permit, odometer charge)	User privacy details unknown due to disclosure of project details; assumption is only distance aggregates are collected	Accuracy depends on positioning and distance calculation methods. Methods involving GPS will be less accurate than odometer count	Recommendation from program check-in report: "The pilot should offer methods to exempt miles driven on private roads or out of state."	Methods to prevent odometer fraud in plug-in device	Option to choose automated or manual tracking method	The use of location data may be enabled or disabled directly through the telematics app.	No road condition monitoring available	Program still in pilot program
Benefits	Many different options for the participant to choose from	Choices make the participant more comfortable participating in program	N/A	Odometer count provides more accurate data; accurate data is a benefit to the state	N/A	Prevents participants from hiding mileage and paying less	Participant can choose option that matches their level of comfort	User privacy protected when they didn't want location tracked	N/A	Program is still in pilot; changes likely to come from results of program
Distinction	California gives the participant a choice in vehicle positioning methods	Participant has choice in distance tracking methods	N/A	Each positioning and tracking method is distinct in accuracy	N/A	Less fraud results in higher tax revenue	Participants are more likely to participate in a program they feel comfortable in	N/A	N/A	N/A

3. Minnesota Pilot Program

Area 1: States with similar pilot programs

	Positioning	Distance Tracking & Calculations	Privacy to user	Accuracy	Public/Private Road Classification	Fraud Mitigation	Tracking/Reporting	Manual Toggling	Road Condition Monitoring	Current Status of program/ feature
How	Location is provided by mobile device GPS	Hybrid between mobile GPS and OBD-II distance aggregates	User privacy wasn't a top concern during pilot program design; trip data including speed, lat/long, timestamp and GPS accuracy was collected. However, program report noted that "privacy was not of paramount concern to users"	Accurate measures provided by hybrid GPS/OBD-II odometer reading	No classification	Fraudulent mileage reporting has been noted as a concern, but no measures have been put in place to prevent it	Hybrid between mobile GPS and OBD-II system	Ability to temporarily disable program with push of button	Ability to recognize road type, not road condition	No current update on Minnesota program
Benefits	Nearly all smartphones have GPS	Two different methods can provide (and verify) accurate distance data	N/A	Accurate data is a benefit to the state	N/A	Less fraud results in higher tax revenue	Unique hybrid system providing data from both smartphone and car	User privacy protected when they didn't want location tracked	N/A	N/A
Distinction	N/A	Only state out of 3 pilot programs to provide hybrid method	Privacy was not a top concern during pilot program; privacy will be a factor if solution is implemented in the future	Minnesota is only state to provide hybrid GPS/OBD-II odometer method	N/A	N/A	Only pilot program to implement hybrid method	N/A	N/A	N/A

4. Mobile-based GPS Tracking

Area 2: Methods to report mileage

	Positioning	Distance Tracking & Calculations	Privacy to user	Accuracy	Public/Private Road Classification	Fraud Mitigation	Tracking/Reporting	Manual Toggling	Road Condition Monitoring	Current Status of program/ feature
How	The mobile phone GPS is used to track the position of the car.	Distance calculations are done by aggregating the distance between GPS coordinates received from the mobile device.	Location data is collected and sent to the service provider	Mobile-based GPS tracking provides very accurate location data.	Private versus public road classification would be done by referencing GPS locations with a database of known public roads.	Users could toggle on / off location data at their discretion	Mobile-based tracking could provide a feature to drivers that allows them to track how many miles they have driven in a given month or year.	Users will be able to turn location tracking on and off from the mobile application.	Road conditions can be monitored by leveraging data collected from the accelerometers in users' phones.	These systems have been in place for several years (e.g. Google Maps)
Benefits	Mobile phones provide both accurate location data, and a very high rate of GPS coordinates. Collecting a high frequency of locations would enable speed estimate calculations. This would help in determining whether the observed citizen movement was in a car or, for example, on a bicycle.	Once the location data has been captured, the outputs from the algorithm can be stored and collected at a separate time.	Data is only available to service providers	Having this accurate data is very beneficial in calculating distance traveled and determining which miles driven are taxable (in-state public roads).	This provides very accurate determination on whether the driver is on public or private roads.	The risk for fraud is high, however, users feel that they have more control over their privacy with the ability to turn an app on and off	This could also allow users to potentially track how much total tax they would pay on those miles over time.	This provides more privacy for the user and it would allow the government to implement more specific policies to promote carpooling and ride sharing.	By measuring data from the accelerometers in users' phones to monitor road conditions, the government would be able to more quickly and efficiently repair damaged infrastructure.	There are a variety of location based APIs and SDKs so that new applications do not need to start from the ground up
Distinction	The application will meet the same standards of other location tracking services	The application will meet the same standards of other location tracking services	Test users are informed that their location data will be shared with City officials. However, this data will not be sold to any outside entitles	Our application will make use of best in breed location tracking accuracy	Classifying miles driven on private roads and land is a stretch goal for this project	The application will detect if a user is driving and prompt them to turn the app on so that it can collect location data	The application will may include dashboards that communicate to the user how many miles they have driven and of those miles how many of them were taxed	We will conduct usability testing and discover if users prefer to toggle the app on and off or if they would want it to always be on	Commute Seattle is currently uninterested in users reporting road conditions	Our application will make use of these API and SDKs

5. Self-reporting odometer scanning

Area 2: Methods to report mileage

	Positioning	Distance Tracking & Calculations	Privacy to user	Accuracy	Public/Private Road Classification	Fraud Mitigation	Tracking/Reporting	Manual Toggling	Road Condition Monitoring	Current Status of program/ feature
How	Not able to provide location data.	Distance is determined based on the difference in miles on the cars odometer.	Self-reporting odometer scanning provides a very high level of privacy for users.	Distance is determined based on the difference in miles on the cars odometer. Odometers are cars are very accurate so we consider this calculation to be very accurate in determining total miles driven.	N/A	Users can choose not to report the miles driven	N/A	N/A	N/A	Previous programs have relied on self reported data
Benefits	N/A	Very accurate determination on the total distance the vehicle has traveled in a given amount of time.	The user does not have to submit to location tracking. With this solution the government would not be able to monitor the whereabouts and travel patterns of civilians.	Self-reporting odometer provides a very accurate measure of the total distance a vehicle has traveled.	N/A	N / A	N/A	N/A	N/A	Allows users to feel that they are in control of their privacy
Distinction	We will be able to provide accurate positioning and location data. This will allow us to distinguish between miles traveled on public roads or private roads.	This solution, for the most, part sets the standard for total distance tracking. Other solutions could provide more detailed distance calculations which allow for fine grained filtering of taxable vs nontaxable miles.	Other solutions that do not track detailed location data will be able to provide more privacy to users.	While self-reporting odometer provides a very accurate measure of the total distance a vehicle has traveled, it does not provide very accurate measure of taxable miles the vehicle has traveled.	While self-reporting odometer provides a very accurate measure of the total distance a vehicle has traveled, it does not provide very accurate filtering of "taxable" miles. That is, we will not be able to determine the miles the vehicle traveled out of state or on private roads versus the miles it traveled on public roads.	Our product will not rely on any self-reported data	For tracking/reporting, other solutions that provide that feature would beat self-reporting odometer monitoring.	For manual toggling, other solutions that provide that feature would beat self-reporting odometer monitoring.	For road condition monitoring, other solutions that provide that feature would beat self-reporting odometer monitoring.	City officials are looking to shift away from self-reported data, and our application will reflect this trend

6. OBD-II Port Hardware Integration

Area 2: Methods to report mileage

	Positioning	Distance Tracking & Calculations	Privacy to user	Accuracy	Public/Private Road Classification	Fraud Mitigation	Tracking/ Reporting	Manual Toggling	Road Condition Monitoring	Current Status of program/ feature
How	Not able to provide location data.	Does not perform any calculations. Instead, it captures all miles driven	Devices are not integrated with the Internet	OBD-II port hardware integration provides a very accurate measure of total distance traveled.	N/A	OBD-II devices are easily hacked	N/A	N/A	N/A	Widely available and used in numerous sectors, such as Insurance
Benefits	N/A	Establishes trust with the user since they know their odometer captures the same data as the OBD-II	Secure data	Highly accurate data	N/A	N/ A	N/A	N/A	N/A	Some built in knowledge base on what the product is
Distinction	For tracking/reporting, other solutions that are able to get specific location data and provide that feature would beat OBD-II hardware monitoring.	Application will provide distance tracking calculations	The application will attempt to mirror the same trust factor that users have developed with OBD-II systems	We are currently exploring options to integrate an OBD-II device into our product so we can achieve the same level of accuracy	For tracking/reporting, other solutions that are able to get specific location data and provide that feature would beat OBD-II hardware monitoring.	Because we will integrate an application with the OBD-II we will be able to detect if the device has been tampered with	For tracking/reporting, other solutions that provide that feature would beat OBD-II hardware monitoring.	For manual toggling, other solutions that provide that feature would beat OBD-II hardware monitoring.	For road condition monitoring, other solutions that provide that feature would beat OBD-II hardware monitoring.	Take advantage of individuals who are familiar with OBD-II devices

7. Telematics through Automobile hardware

Area 2: Methods to report mileage

	Positioning	Distance Tracking & Calculations	Privacy to user	Accuracy	Public/Private Road Classification	Fraud Mitigation	Tracking/ Reporting	Manual Toggling	Road Condition Monitoring	Current Status of program/ feature
How	This would involve the vehicle's hardware and software to store and periodically transmit the cars location information.	This would involve aggregating the distance between the collected location points.	The privacy of the user would be in the hands of the car manufacturer and the government.	This would be very accurate data because it would be collected from hardware and software that is physically integrated into the vehicle.	Private versus public road classification would be done by referencing GPS locations with a database of known public roads.	This solution is not vulnerable to fraud. The only possible manipulation would be for a user to upload software to his vehicle that compromises this solution.	N/A	Theoretically, this could offer some manual toggling through the cars built in display and navigation tools.	N/A	Not currently available on any cars.
Benefits	Does not require adding additional hardware to people's cars or software to people's phones.	This is fairly simple and easy to execute. It can be done quickly and does not require massive computational power.	The data is subject to fewer risks as it is not being constantly streamed across a network.	The data collected from the automobile hardware would not have to be filtered. That is, we could be sure that every data point we received from the car would reflect the vehicle location versus, for example, the users location. Collecting data from user devices requires filtering the points and looking only at ones where we determine the user is driving.	This provides very accurate determination on whether the driver is on public or private roads.	This solution would ensure the government is getting all the tax revenue it is owed.	N/A	This would allow the government to implement more specific policies to promote carpooling and ride sharing by letting users toggle whether they being taxed if they currently met certain exceptions (such as carpooling).	N/A	There are not any benefits, this solution is not readily available.
Distinction	Not every car on the road has the hardware capabilities to support this.	This solution, for the most, part sets the standard for distance tracking.	Other solutions that do not track detailed location data will be able to provide more privacy to users.	This solution, for the most, part sets the standard for accuracy.	This solution, for the most, part sets the standard for public/private road classification.	This solution, for the most, part sets the standard for fraud mitigation.	For road tracking/reporting, other solutions that provide that feature would beat Telematics through auto hardware monitoring.	While this solution could theoretically provide manual toggling, there are other solutions that could provide safer functionality. Requiring users to click through their car's dashboard interface to toggle the tax tracking software is not very safe/	For road condition monitoring, other solutions that provide that feature would beat Telematics through auto hardware monitoring.	Other solutions that can be implemented more quickly will beat this solution to market .

8. Dashboard cam to determine location through computer vision

Area 2: Methods to report mileage

	Positioning	Distance Tracking & Calculations	Privacy to user	Accuracy	Public/ Private Road Classification	Fraud Mitigation	Tracking/ Reporting	Manual Toggling	Road Condition Monitoring	Current Status of program/ feature
How	A computer vision program would recognize and record street signs as the vehicle travels to determine its location at various times.	Distance tracking would be done by measuring the distance between recognized locations.	This data would be procured and managed by the government, so it would be their responsibility to protect users.	The location of all possible recognized streets and locations would be stored in a database. This data is static obviously, so we would consider this data to be very accurate.	Dashboard cam monitoring would not be able to recognize private roads because they are not typically marked with street signs.	Since this technology is still in the prototype phase, the extent in which these devices can be compromised is unknown	N/A	This solution could theoretically allow the user to turn the camera on and off.	N/A	These devices are not yet commercially available
Benefits	The GPS location of various streets and intersections are known which makes this positioning data very accurate.	This would provide very accurate distance calculations because the recognized locations would be used in conjunction with a database of streets & street lengths to determine the distance the car traveled between points.	The data is subject to fewer risks as it is not being constantly streamed across a network.	The accuracy of recognized locations would be very accurate.	N/A	N/A	N/A	This would allow the government to implement more specific policies to promote carpooling and ride sharing by letting drivers toggle whether the dash cam was recording and they being taxed.	N/A	Limited
Distinction	This solution is somewhat expensive. It requires installing dashboard cameras on every car and it would also require transmitting and processing a tremendous amount of video.	If it is raining or visibility is compromised, the distance between recognized locations could be very large which would impact the accuracy of the results.	Other solutions that do not track detailed location data will be able to provide more privacy to users.	The issue with this solution is consistency. This solution is subject to be compromised by a number of variables including weather, dirty camera lens, or a dirty windshield.	N/A	N/A	For tracking/reporting, other solutions that provide that feature would beat Dashboard cam monitoring.	This solution actually probably provides the best ability for users to manual toggle whether they're being taxed or not.	For road condition monitoring, other solutions that provide that feature would beat Dashboard cam monitoring.	N / A

9. Google Maps

Area 3: Existing Location-based services

	Positioning	Distance Tracking & Calculations	Privacy to user	Accuracy	Public/Private Road Classification	Fraud Mitigation	Tracking/ Reporting	Manual Toggling	Road Condition Monitoring	Current Status of program/feature
How	Uses smartphone GPS and network triangulation	Reports how long journeys will be. Doesn't record journey length.	Records users' destinations.	Uses GPS, cellular network triangulation and Wi-Fi location services.	Maps everything. Routes only through public roads.	N/A	Tracks users only to improve the service. Reports only to store user data at Google.	Users can select to share their location with app	N/A	In service. Over a billion users.
Benefits	Is very accurate for current location	Helps people take the shortest route.	Caches them for quicker access.	Highly accurate	Accurate directions through public roads.	Free navigation service.	Users enjoy an intelligent product that can make recommendations etc.	Provides a sense of privacy	N/A	A lot of user data generated.
Distinction	Due to how robust the Google Maps technology is, we are currently exploring how we might be able to leverage their technology through APIs	We record the actual distance that the user travels.	We won't store the user's location, only distance travelled.	Limits battery life for the user. We would stick to GPS only because the service should work while travelling across states.	We have to differentiate miles on private roads versus those on public roads.	We'd have to deal with users being able to switch off their phone etc.	Our service would report to tax authorities.	We are exploring if we will allow users to turn the application on and off	N/A	N/A

10. Waze

Area 3: Existing Location-based services

	Positioning	Distance Tracking & Calculations	Privacy to user	Accuracy	Public/Private Road Classification	Fraud Mitigation	Tracking/ Reporting	Manual Toggling	Road Condition Monitoring	Current Status of program/feature
How	Uses smartphone GPS and network triangulation	Reports how long journeys will be. Doesn't record journey length.	Records users' destinations and inputs like potholes.	Uses GPS, cellular network triangulation and Wi-Fi location services.	Maps are augmented by crowdsourced demarcations.	N/A	Shares real time traffic data with other users	Users can choose what details they want to report	Crowdsources data about road conditions	In service. Millions of users. Acquired by Google.
Benefits	Is very accurate for current location	Helps people take the shortest route.	Caches them for quicker access.	Is very accurate.	Can accommodate data for public vs private roads.	Is a free service, no scope for fraud.	Quick updates, effortless sharing of information	Privacy is maintained well.	Can update whenever anybody comes across.	Lots of crowdsourced data at the ready.
Distinction	Due to how robust the Google Maps technology is, we are currently exploring how we might be able to leverage their technology through APIs	We record the actual distance that the user travels.	We won't store the user's location, only distance travelled.	Limits battery life for the user. We would stick to GPS only because the service should work while travelling across states.	N/A	Track distances without abruptions.	Shares only distance data with only tax authorities.	We don't want manual toggling to prevent fraud.	Probably not available in our service.	N/A

IV. Solution Selection

Evaluation of options

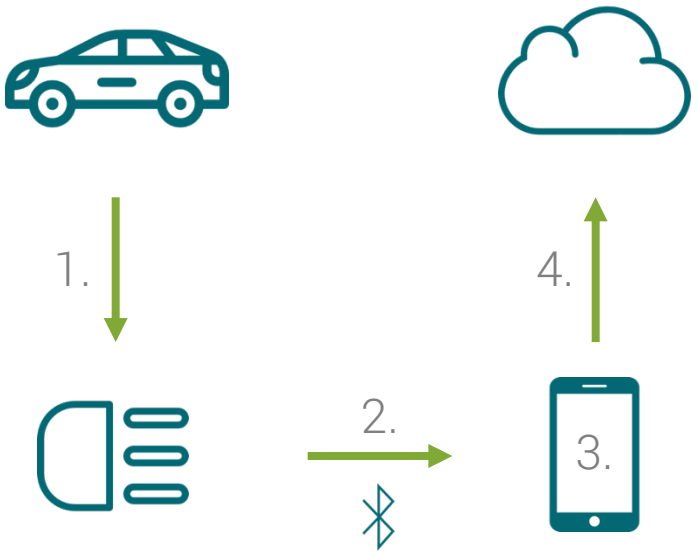
1. OBD-II & mobile app to track miles through **velocity output**
2. OBD-II & mobile app to verify user presence in vehicle (**Bluetooth/WIFI**)
3. Mobile app with car computer **Bluetooth** verification
4. Mobile app with car computer **USB** verification
5. Mobile app & **algorithm** to determine public road trips
6. Odometer **photo** tracking

1. OBD-II & App Using Velocity Output

About

- Requires Bluetooth/WIFI hardware OBD-II dongle to be placed in car
- Dongle collects live streaming **velocity** data from OBD-II port and sends to mobile device
- Mobile application derives distance from time logged and vehicle's velocity
- User's location is only pinged in infrequent increments to ensure user is still within WA state lines

Question: How accurate is deriving distance from the odometer's velocity?



1. Vehicles live streams velocity data to OBD-II
2. OBD-II sends data to mobile via Bluetooth
3. Mobile derives distance via velocity and time
4. Distance is reported to WA state

1. OBD-II & App Using Velocity Output

Cost-Benefit Analysis & Criteria Evaluation

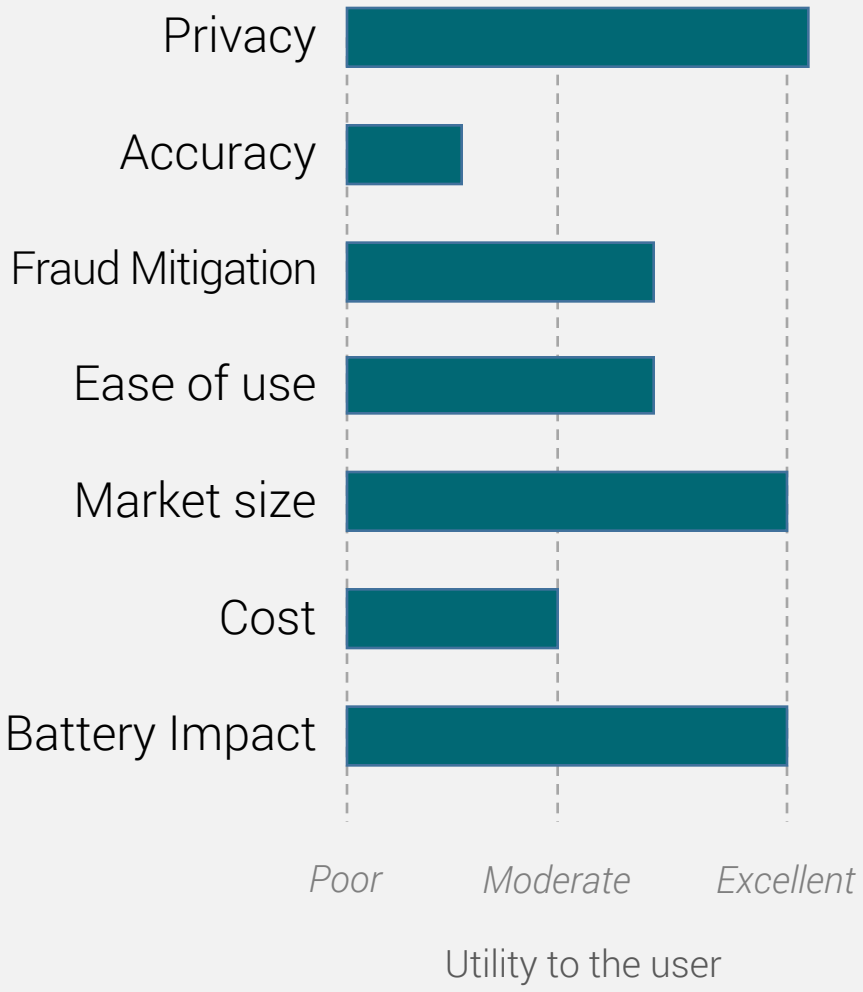
Strengths

- Location is not being tracked at all times
- Minimal battery usage and computation required from mobile device
- All cars after 2006 have OBD-II ports (cars prior to 1996 have OBD-I)

Weaknesses

- Inability to determine private road usage
- Can accurate distance be determined from the vehicle's velocity by time. IE: is data being fed to us at an accurate enough rate?
- Hardware component required
- WIFI only for iOS devices– **See Appendix II**

Criteria Scoring



2. OBD-II & App to Verify User Presence

About

- Place an OBD-II Bluetooth/WIFI device in the user's vehicle to verify the user is driving
- When the user's phone detects a Bluetooth/WIFI signal matching the specified ID within a range (noting the phone is within range to the car), location will begin being tracked
- Helps mitigate the possibility of false tracking when the user is on a bus or traveling in a similar pattern to driving a car

1. Mobile enters range of Bluetooth/WIFI emitting OBD-II
2. Mobile confirms pair with OBD-II
3. Mobile calculates distance through GPS
4. Distance is reported to WA state

2. OBD-II & App to Verify User Presence

Cost-Benefit Analysis & Criteria Evaluation

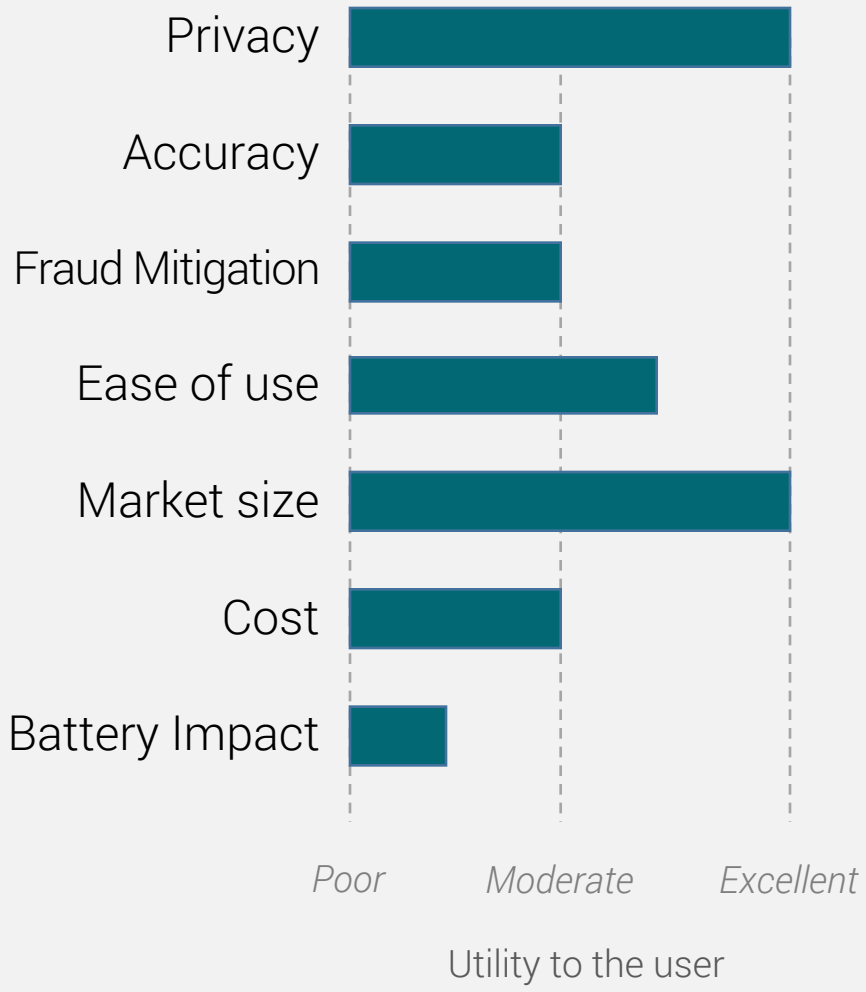
Strengths

- Heavy computational load and battery drainage from mobile device
- Only tracking user's location when they come in range of the OBD-II dongle, results in tracking location only when the user is driving
- Accounts for public/private road usage

Weaknesses

- User can spoof by turning off Bluetooth/WIFI
- Hardware component required

Criteria Scoring

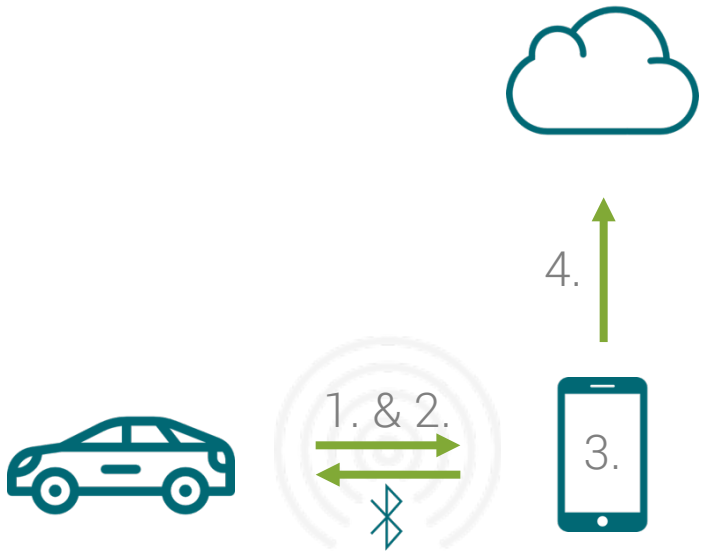


3. App with Car Bluetooth Verification

About

- Perform all distance calculations through mobile device
- Verify user is in their car through mobile to car computer Bluetooth connectivity
- Don't track location until user is connected (or within range) to Bluetooth

- **Question:** Market size of cars with Bluetooth capability?
- **Question:** Is it okay to design for this population size?



1. Mobile enters range of Bluetooth emitting vehicle
2. Mobile confirms pair with vehicle
3. Mobile calculates distance through GPS
4. Distance is reported to WA state

3. App with Car Bluetooth Verification

Cost-Benefit Analysis & Criteria Evaluation

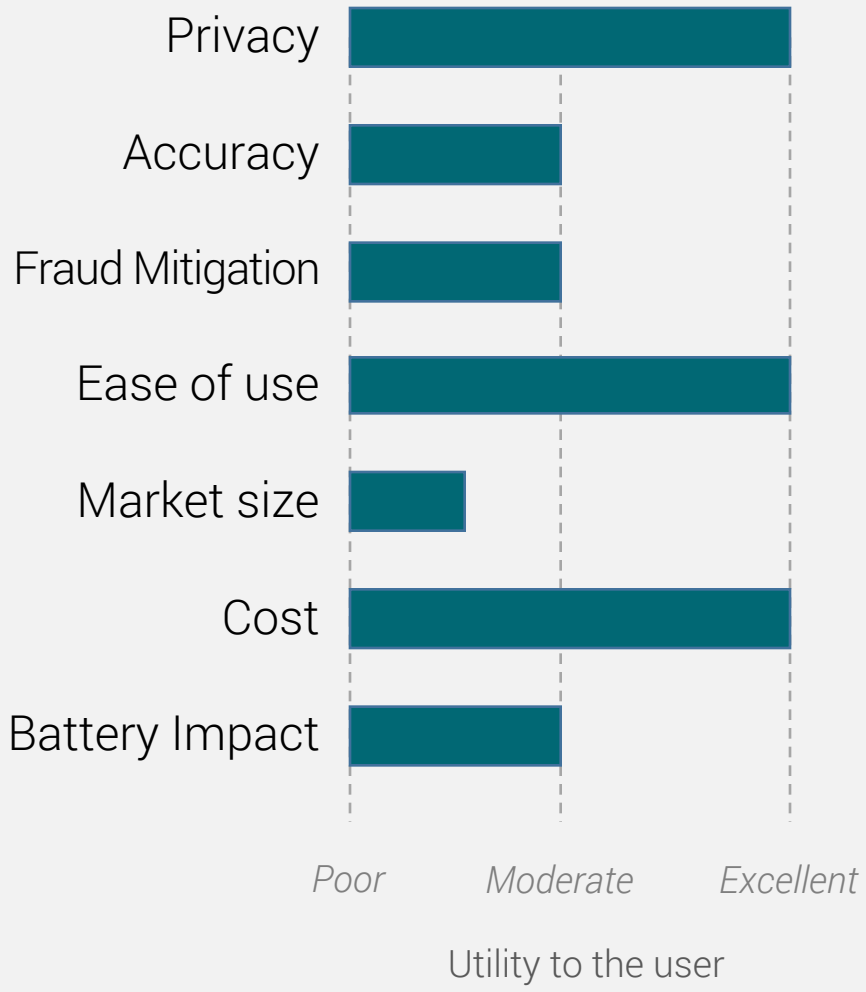
Strengths

- No location tracking until user is connected to Bluetooth

Weaknesses

- Only available to users with Bluetooth cars
- Ability to avoid/spoof tracking by turning off Bluetooth

Criteria Scoring

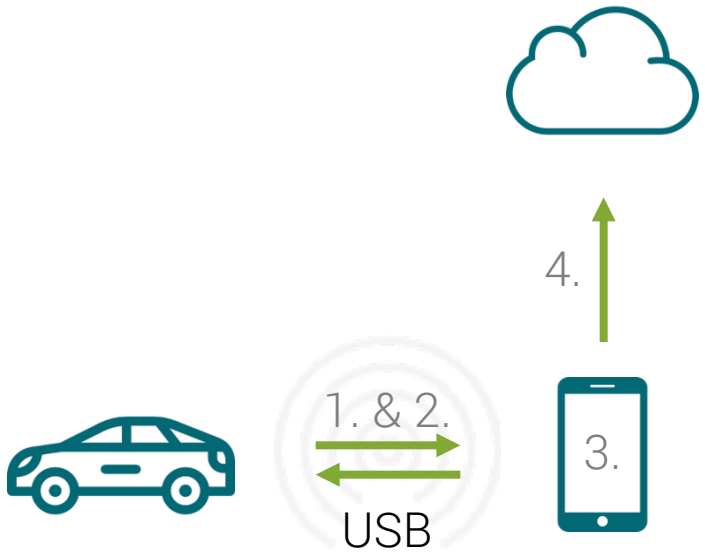


4. App with Car USB Verification

About

- Identical to previous option, but verify through car's USB cord connection
- Phone gets charged through this process, making up for GPS battery strain

- **Question:** Market size of cars with USB capability?
- **Unknown:** Can we uniquely identify vehicles through information available in USB ports?



1. User enters vehicle and plugs in mobile device
2. Mobile confirms pair with vehicle and recognizes vehicle
3. Mobile calculates distance through GPS
4. Distance is reported to WA state

4. App with Car USB Verification

Cost-Benefit Analysis & Criteria Evaluation

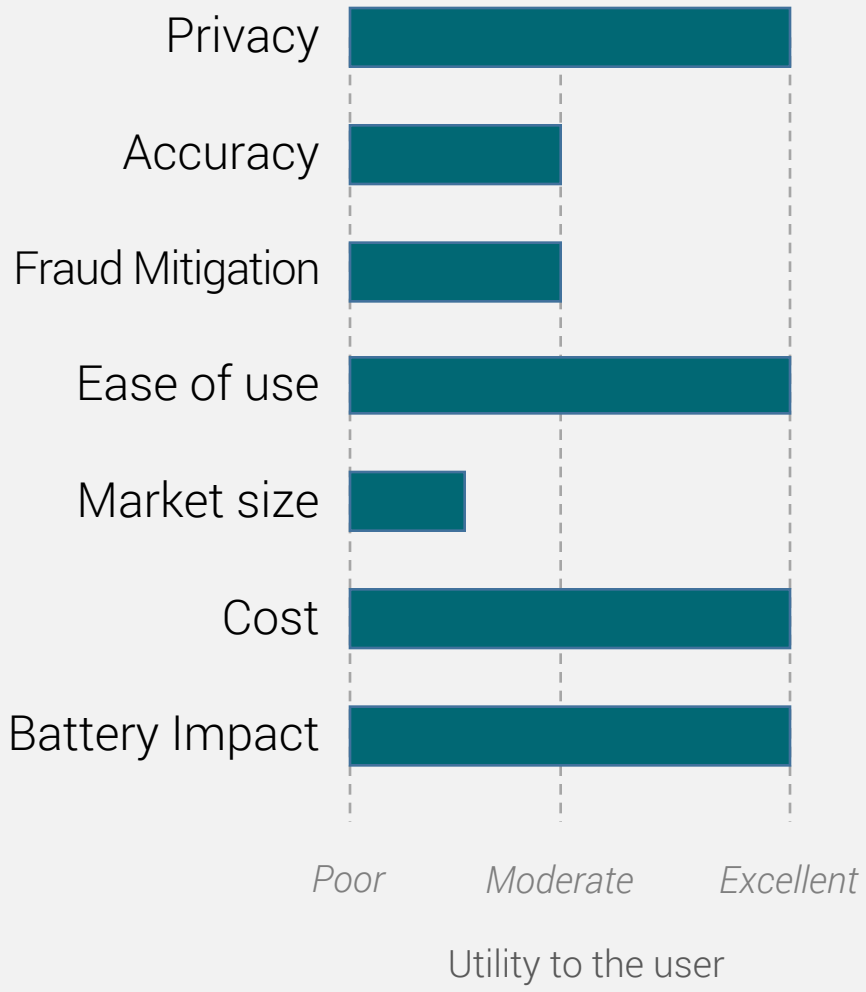
Strengths

- No location tracking until user is connected to Bluetooth
- Charges the phone, reducing battery strain

Weaknesses

- Only available to users with USB port cars
- Ability to avoid/spoof tracking by not turning on USB

Criteria Scoring



5. Post-trip algorithmic analysis

About

- A mobile application that is constantly tracking user's location
- Location is taken in infrequent increments; increments are increased when movement is detected
- Algorithm then determines automobile trips based upon speed, time, other factors
- Based upon MileIQ--used by IRS, so meets some level of government quality

- **Unknown:** Our ability to create such an algorithm

1. User drives as they normally would
2. Mobile devices tracks location and algorithmically determines trips post-drive
3. Distance is reported to WA state

5. Post-trip algorithmic analysis

Cost-Benefit Analysis & Criteria Evaluation

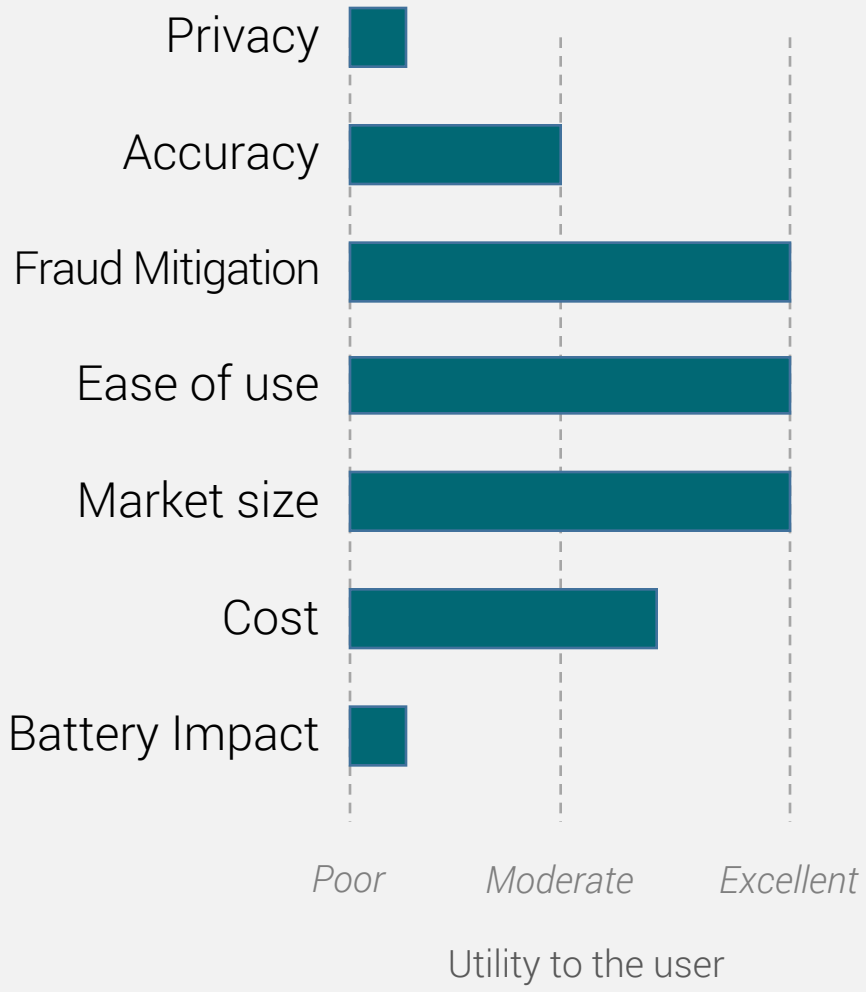
Strengths

- No additional hardware or verification steps required
- Expensive on battery and memory operations

Weaknesses

- User's location is always being tracked
- Unknown accuracy level of algorithm

Criteria Scoring

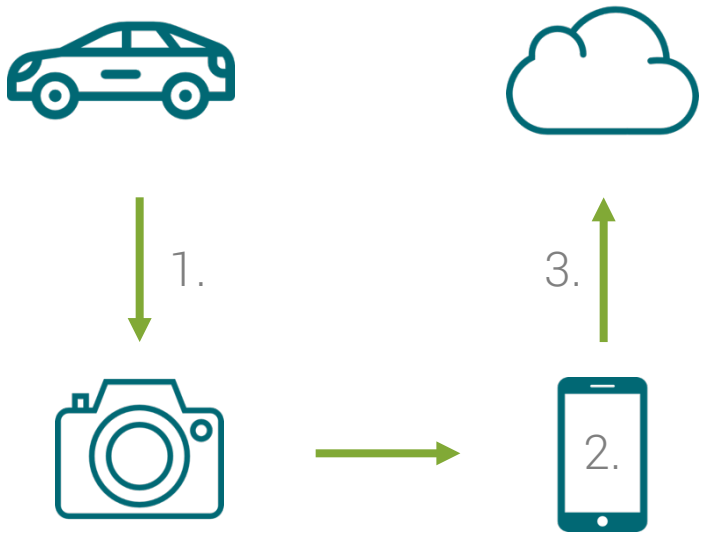


6. Odometer Photo Tracking

About

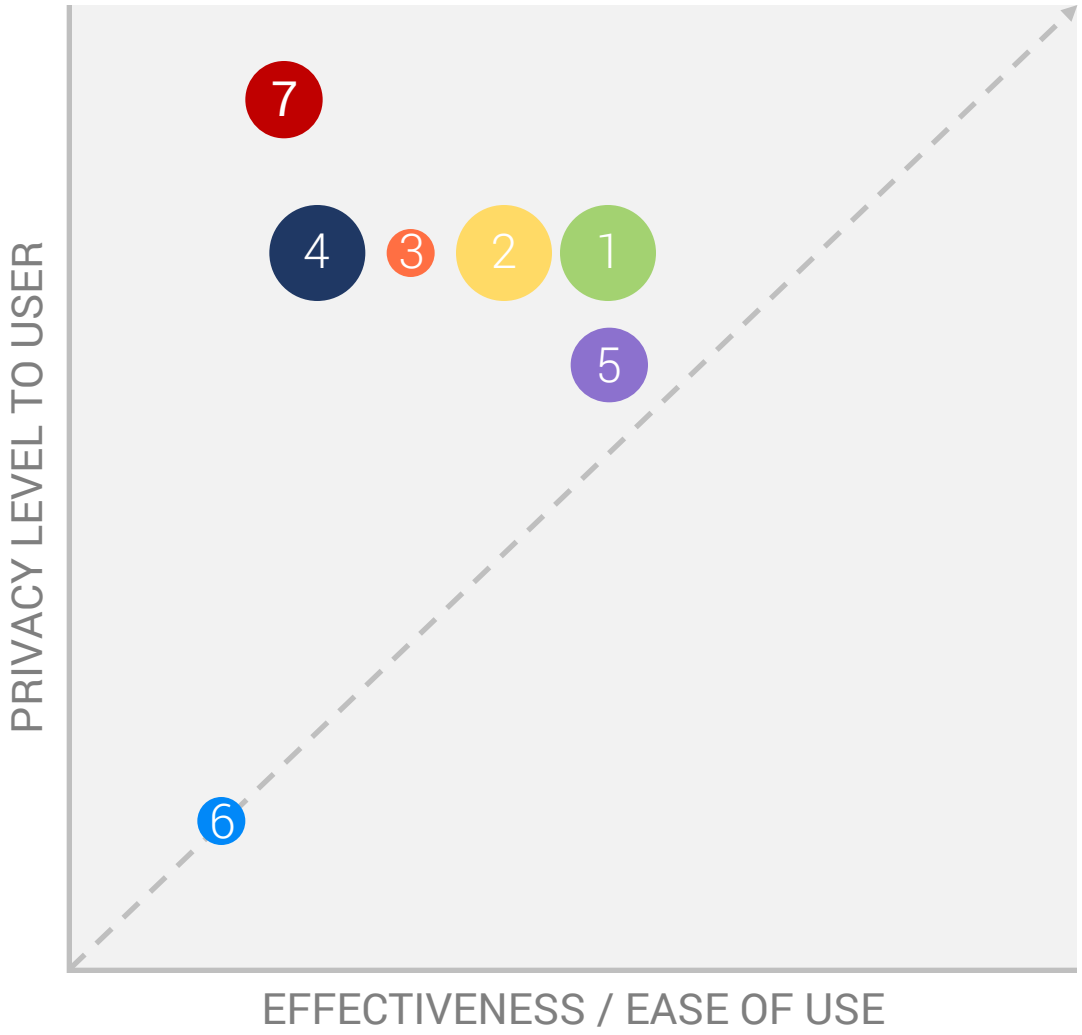
- To be used as a backup/combination to any of the previous methods
- In the event location cannot be collected, user will be notified and prompted to take a photo of the odometer

- **Question:** More info on this startup/can we arrange a call?



1. User takes photo of odometer using mobile camera
2. Mobile adds distance calculation to aggregate sum
3. Distance is reported to WA state

Evaluation of Options



1. OBD-II & App to Verify User Presence
2. App with Car Bluetooth Verification
3. App with Car USB Verification
4. App with On/Off toggle **(New)**
5. OBD-II & App Using Velocity Output
6. Post-trip algorithmic analysis
7. Odometer **photo** tracking

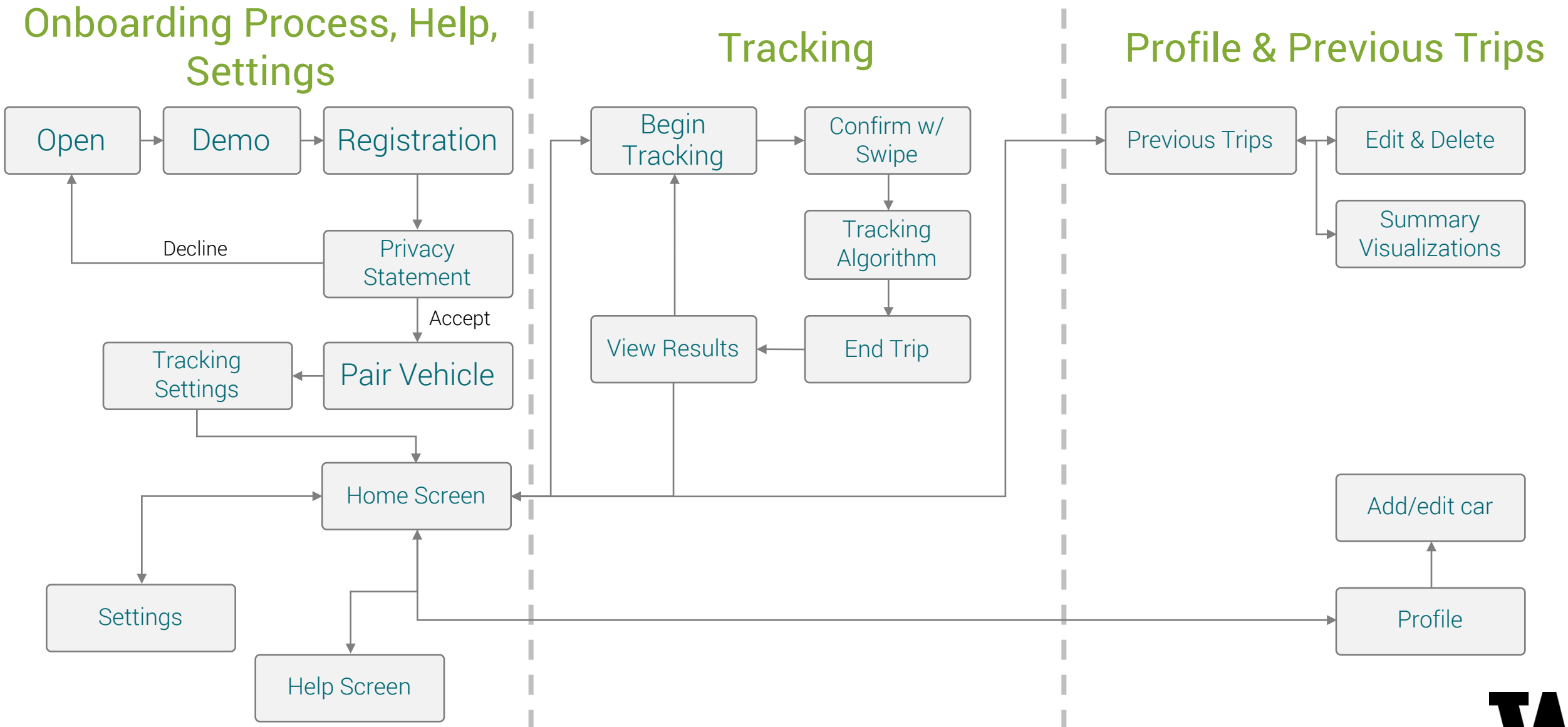
Ability to implement

V. Prototypes & State Diagrams

User Experience Overview

Application View:	Items
• Main Tracking	Tracking Off, Tracking On
• Trip History	Individual Trip Summary
• Settings	Units, Tracking Options, Payment
• Profile	Account Information, Vehicle Management
• Help	Documentation

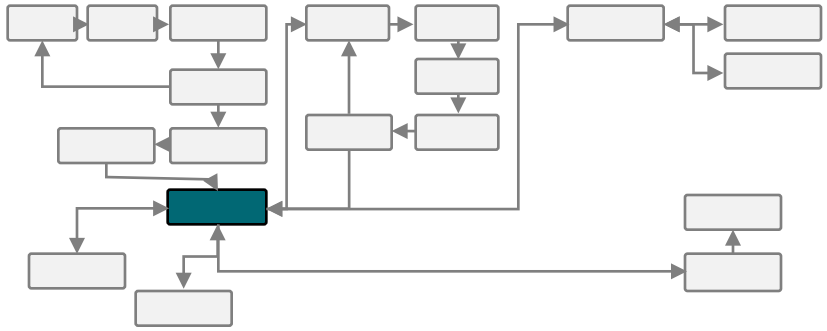
User Experience Flow

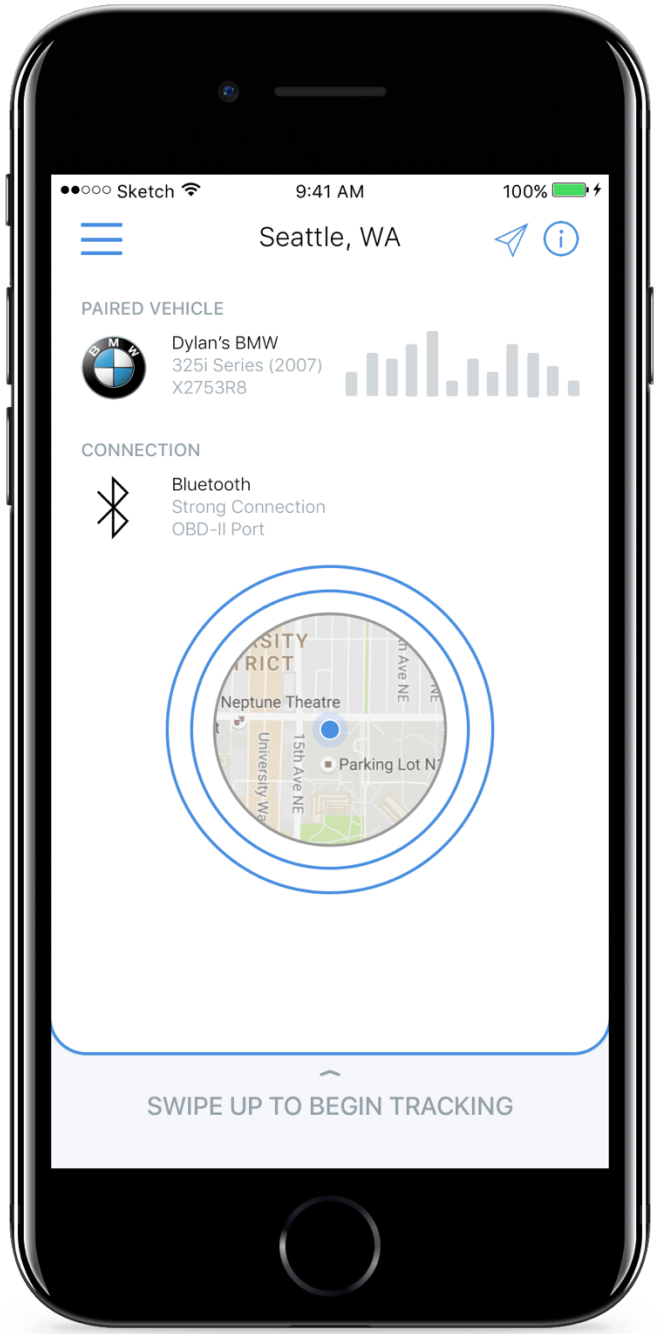


Main Screen

Tracking OFF

- The start screen on app following onboarding process
- Blue = tracking is OFF
- Swipe up to begin tracking
- Paired vehicle and connection status widgets
- Hamburger menu to lead to other options
- "Send" icon leads to connection details; "i" icon leads to help

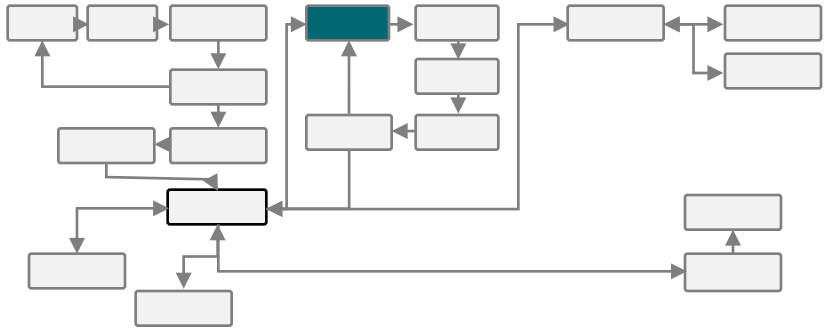


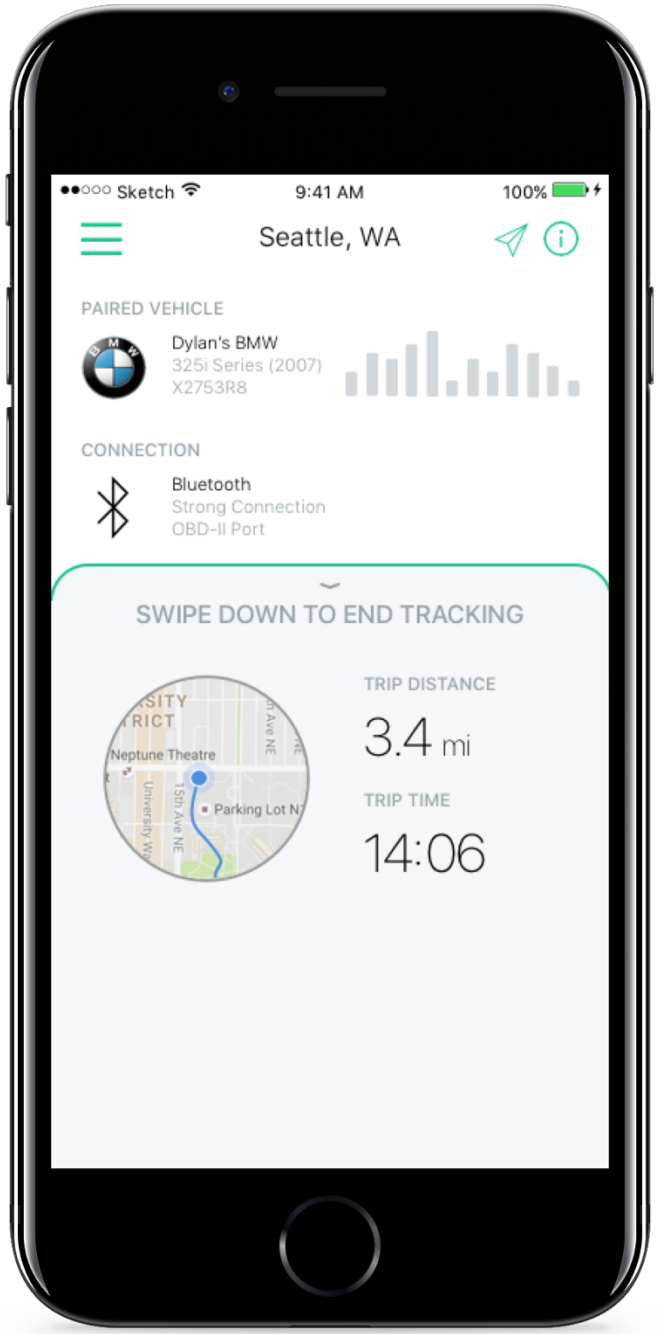


Main Screen

Tracking ON

- Bottom bar is “swiped up”; tracking is active
- Green = tracking is ON
- Distance, time, map indicators available during tracking
- Swipe down to end tracking

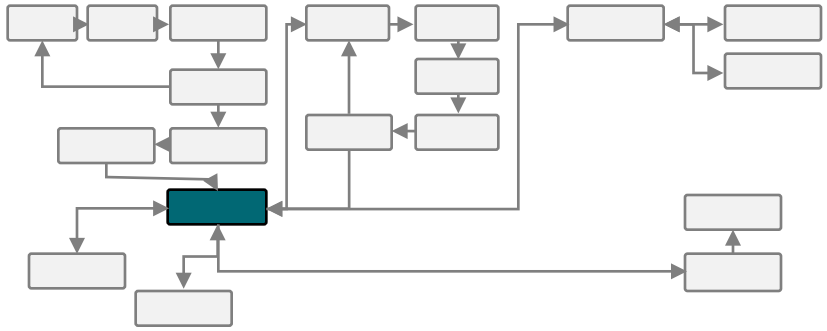


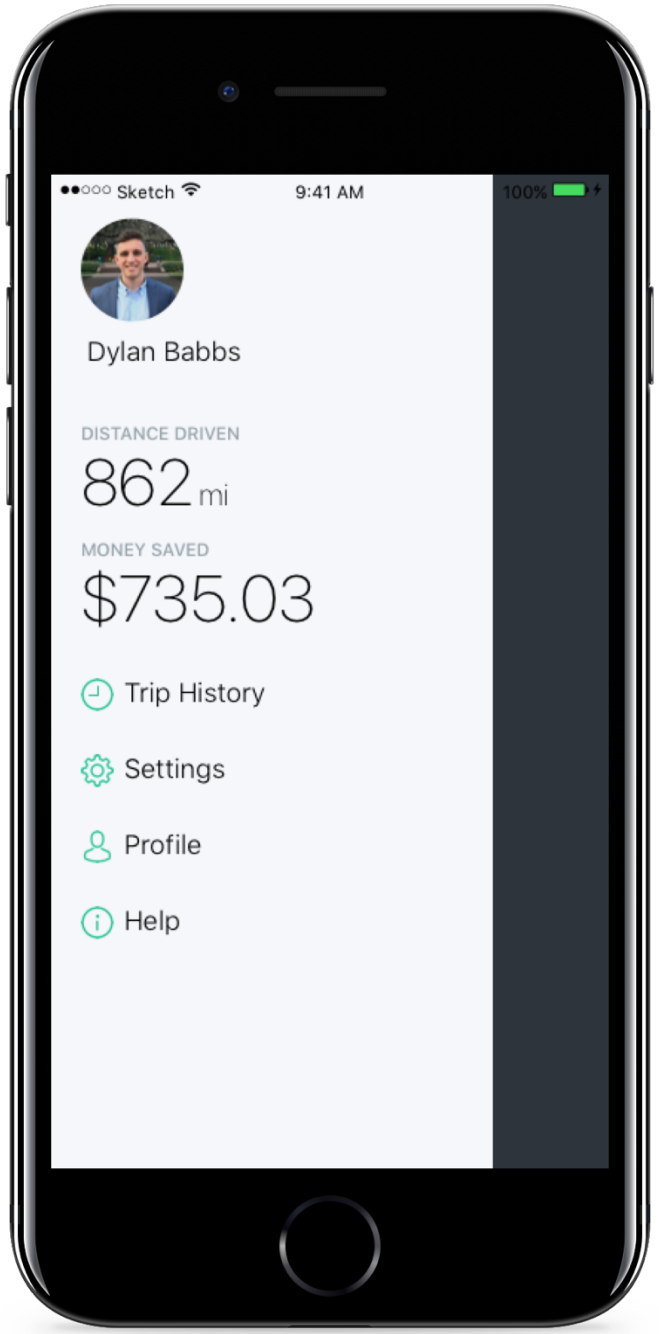


Navigation Menu

Tracking ON or OFF

- Profile picture for personalization
- Monthly distance and money saved aggregates
- Navigation to Trip History, Settings, Profile, and Help

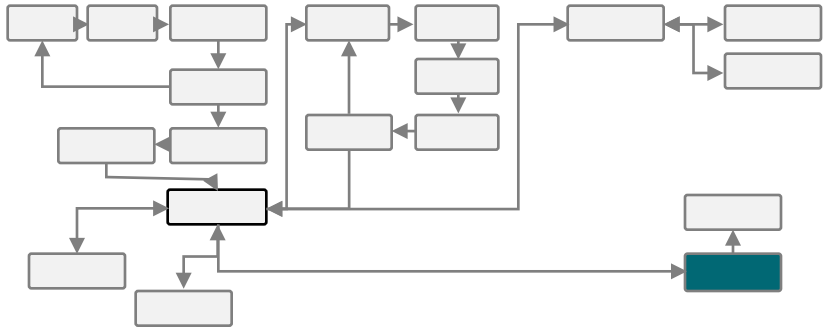


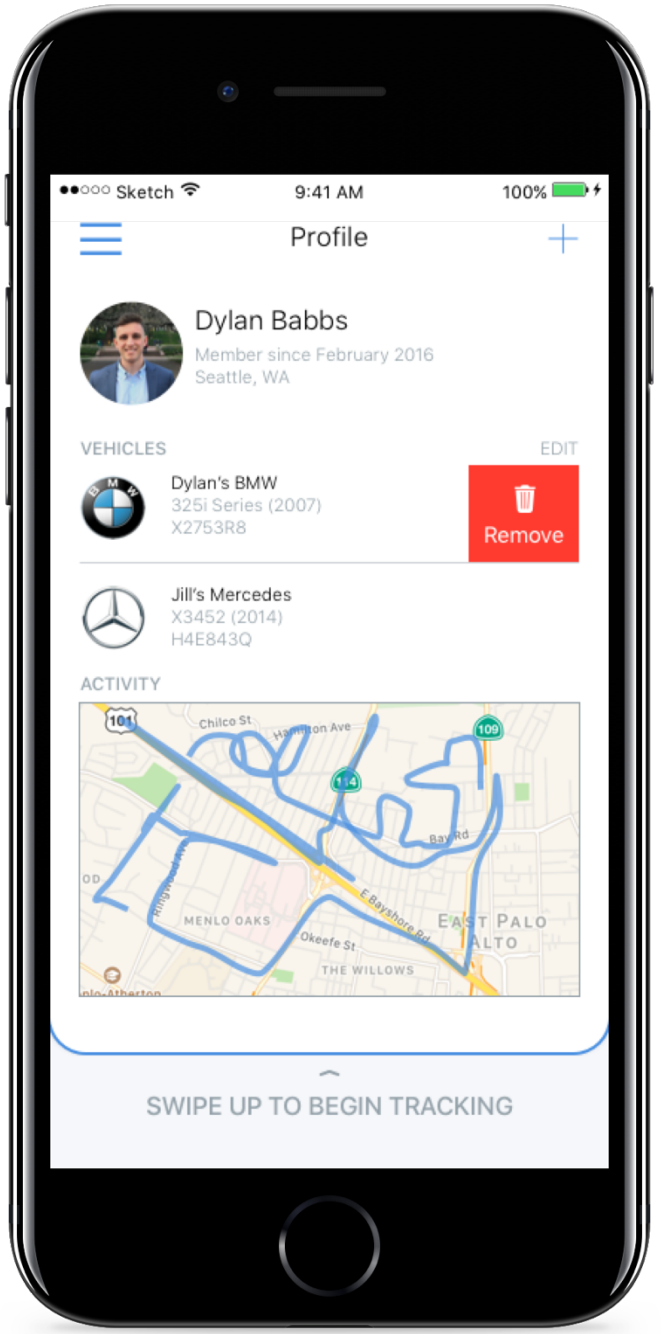


User Profile

Tracking ON or OFF

- Profile picture for personalization
- Vehicle Management
  - Ability to edit and remove
- Activity heat map (ability to remove for privacy reasons)

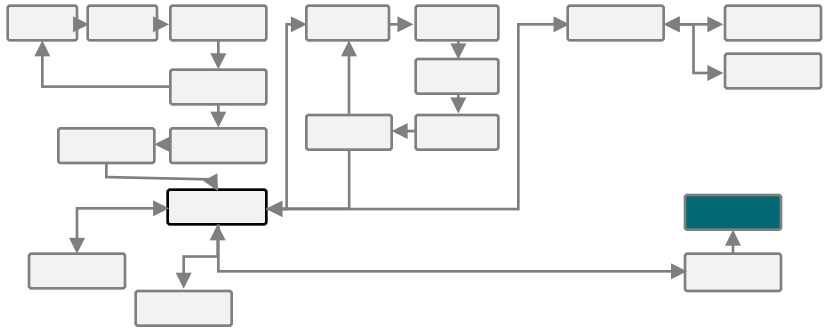


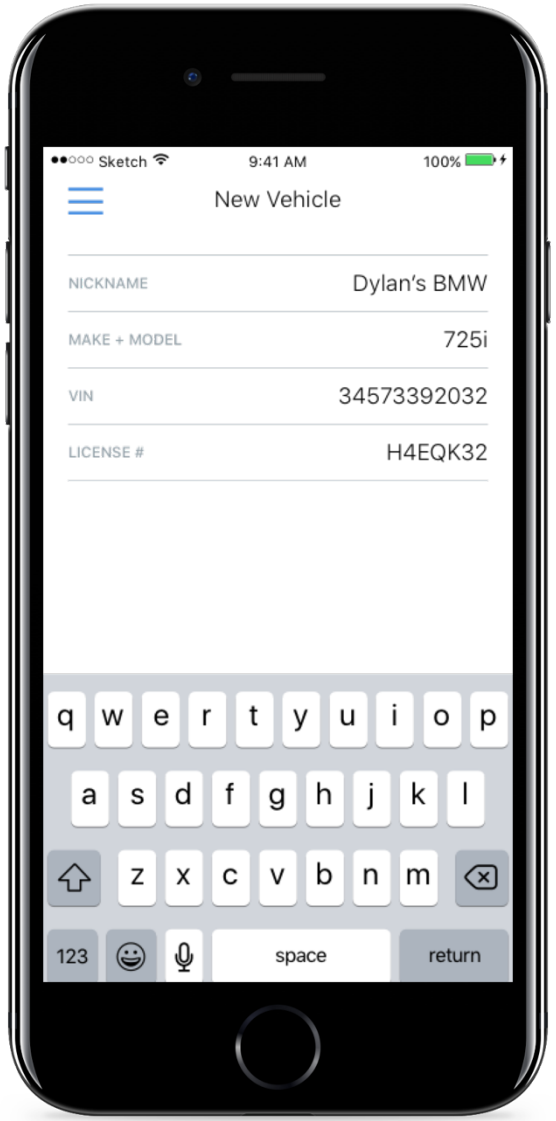


User Profile: Adding a New Vehicle

Tracking OFF

- Left screen:
  - New vehicle text entry
- Right screen:
  - Automated camera license plate grab

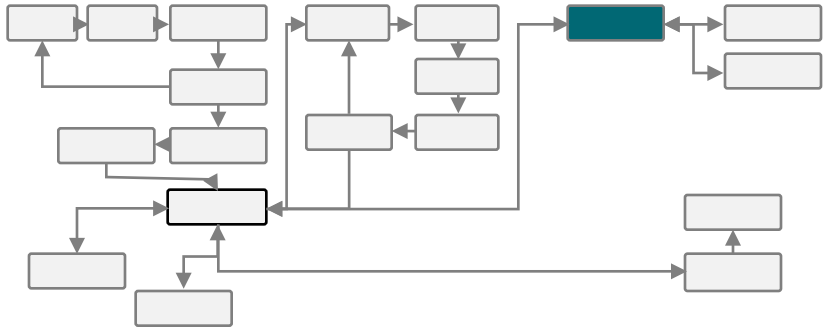


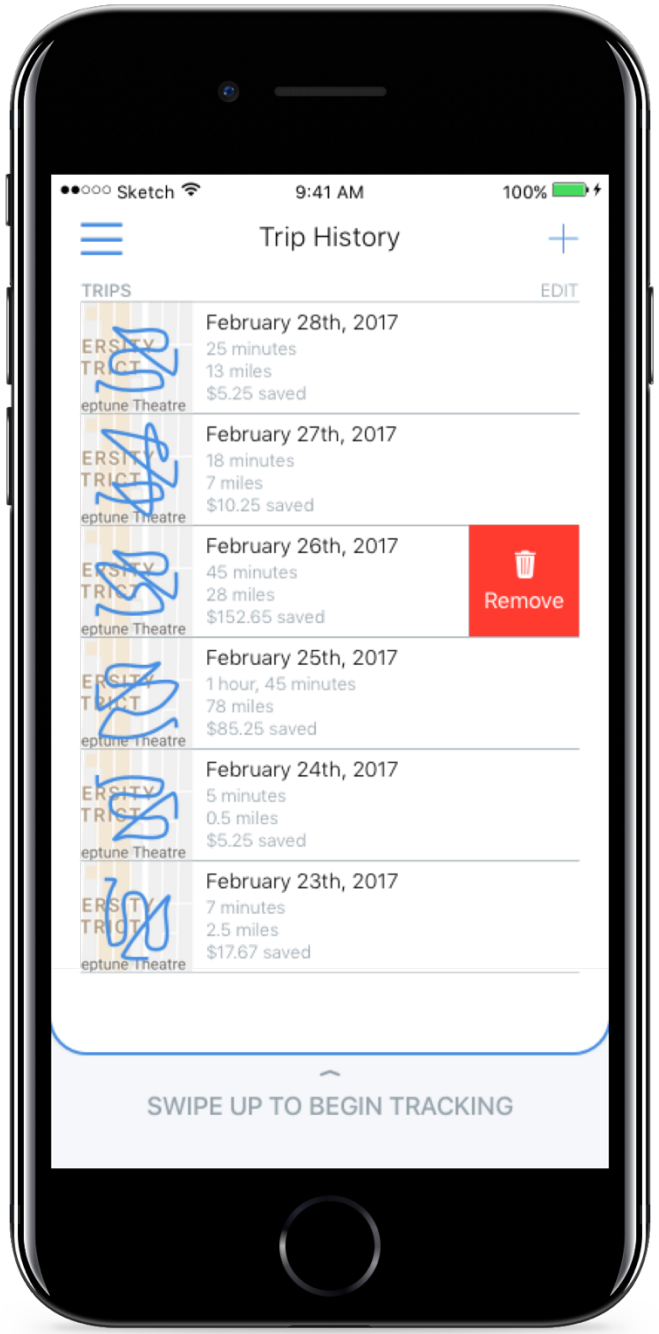


Trip History

Tracking ON or OFF

- Map thumbnail, date, trip time, trip distance, money saved
- Ability to delete individual trips or completely disable this screen

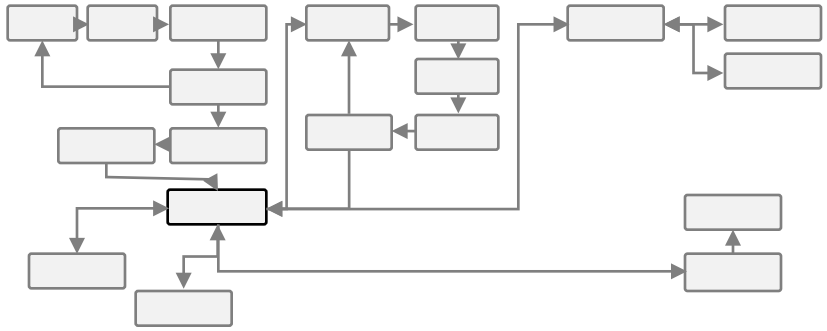




Miscellaneous Features

Tracking OFF

- Left screen:
  - Touch ID for privacy concerns
- Right screen:
  - Reminder to user to begin tracking if device senses movement on roads



VI. Appendix

Appendix I: Mobile Phone Usage

- Android market share: **52.7%**
- Apple: **43.9%**
- Smartphone US Market: **79.3%**
- WA State pop: 7M * .79 = **5.53M drivers w/ smartphone**

Appendix II: WIFI only on iOS OBD-II drawback

- OBD-II Advantages:
  - Available to 100% of drivers in WA state
  - Cheap hardware component
- Disadvantages:
  - Requires hardware component
  - **iOS cannot connect via Bluetooth (WIFI only):** https://www.lifewire.com/elm327-iphone-adapter-doesnt-work-534643

- **Question:** how does WIFI connection with iOS affect normal phone operations? Can I still browse the web while connected to OBD-II WIFI network?
- Alternative to Bluetooth/WIFI: lightning/USB cord?

Appendix III: Open-source OBD-II Hardware

- Lots on Amazon

SKENOY
- Bluetooth for Android **$13.29**
- WIFI for iOS **$18.98**

Purchased

VeePeak
- Bluetooth for Android **$11.99**
- WIFI for iOS **$16.99**

Panlong
- Bluetooth for Android **$12.99**
- WIFI for iOS **$16.99**