Proposal for U.S. Department of Transportation
Beyond Traffic: The Smart City Challenge

Volume 1: *Technical Application*

Ubiquitous Mobility for Portland

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Executive Summary

People in power actually came to see us, kids, fifth graders.

—Student at Jason Lee Elementary School during Secretary Foxx Smart Cities visit

Introduction

Portland is a city known for its multimodal transportation system – and we are at a a pivot point. Our economy is growing and providing job opportunities for more people. Neighborhoods are revitalizing throughout the city – often because they are walkable, bikeable, and well-served by transit.

But that prosperity is not shared by all Portlanders. Rising rents have pushed our most vulnerable residents to neighborhoods farther from the city core, where a disconnected street grid results in traffic congestion and makes it difficult to provide good transit service. Low-income residents and people with disabilities struggle with longer travel times, dangerous conditions for walking or using mobility devices, and less frequent transit service. In east Portland especially, transportation inequities threaten our ability to remain a city for all.

In the face of these pressures, Portland is at a crossroads. A multimodal future is not just desirable – it's necessary. Limited resources for new roads, a lack of space in which to put them, and an imperative to reduce emissions and address climate change all point to shifting daily trips away from single occupancy vehicles. But this multimodal future must be accessible to every Portlander.

The core issues facing Portland are not unique: we need to improve safety, enhance mobility, address climate change, and create opportunity for all residents. The challenge is to address these issues in a way that ensures equity is at the center of this paradigm shift. Here, that means all Portlanders have access to the city's best choices – not just the ones that require personal car ownership.

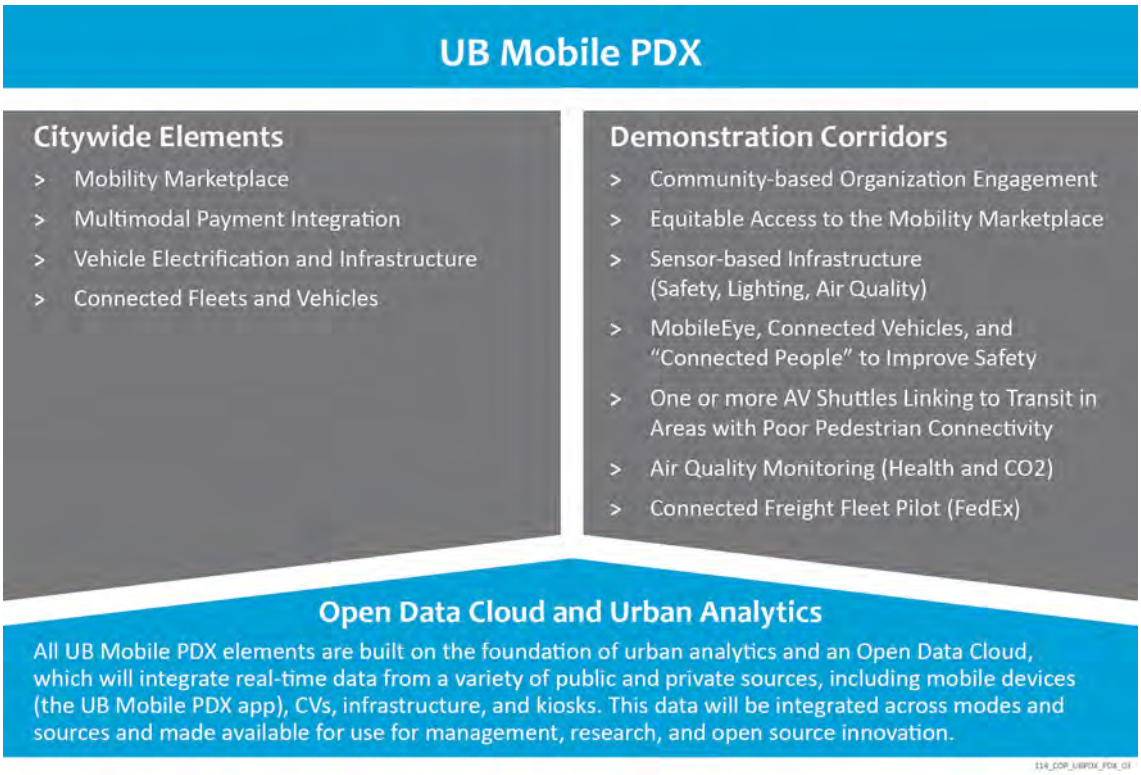
UB Mobile PDX

The Portland Bureau of Transportation (PBOT) will use the U.S. Department of Transportation (USDOT) Smart City Challenge grant to deploy Ubiquitous Mobility for Portland (UB Mobile PDX), a technology and outreach initiative designed to serve the needs of all Portlanders. UB Mobile PDX will help all residents move around the city more easily and safely. Simultaneously, UB Mobile PDX will capture data and develop urban analytics to help direct city actions and investments to improve mobility for everyone whether in a car, on a bike, on foot, on a bus, or using a mobility device.

A Smart City is one where data and technology improve people's lives. We will ground the development of UB Mobile PDX in an understanding of people: how they use the transportation system and technology today. Based on this understanding, UB Mobile PDX aims to create a city where multimodal travel is not just necessary but preferred. The data that enables this will provide access to low-cost transportation choices. It will also provide Portlanders – both inside and outside of government – with information to solve pressing city problems.

Elements of UB Mobile PDX

UB Mobile PDX deployment includes both citywide components and focused research and testing in three specific Portland corridors: Powell/Division, 122nd Avenue in east Portland, and Columbia Boulevard in North Portland. The initiative is built on the foundation of an Open Data Cloud and urban analytics.



Our Partners

Private Sector Partners

UB Mobile PDX will leverage private sector support, including the suite of USDOT-recommended partners. The *Partnerships and Outreach* section lists our expected private sector partners; we have worked with many of them to develop this proposal, although we have not yet formalized binding agreements with those partners. Instead we are taking an "open approach" that may include some competitive elements. We aim to match services with providers who offer state-of-the-practice services and provide the greatest value to the project. This approach is consistent with Portland's history of open data; we expect it to spark innovation and set the stage for participation by both well-established businesses and emerging startups.

Community Partners

We have worked with a number of community partners to develop the UB Mobile PDX program and approach. They have helped us identify needs and potential impacts – and they will be integrally involved in the creation and implementation of the program.

Collaboration and Replicability

No other city does the teaching and idea exchange that we do; our size and scale lends itself to strong relationships and collaboration. In recent years, First Stop Portland has hosted over 400 delegations from 37 countries. We have long been a mentor and prototype creator for other cities working toward a human-centered transportation system. With UB Mobile PDX, we will build on this foundation.

More formally, as part of the Smart Cities demonstration project, we will engage in structured knowledge sharing with five other U.S. cities: Seattle, Washington; Richmond, Virginia; New Orleans, Louisiana; and Los Angeles, California. The partnerships will demonstrate how Smart City technologies can work in cities of different sizes, demographics, and economies.

A Testing Ground for Smart City Technologies

Portland is ideally suited to serve as a proving ground for Smart City technologies. We lead the nation in many arenas, though we have much to learn in others. A Smart Cities investment will build on our existing successes and produce results without a lot of ramp-up time.

A History of Innovation

Portland has built a city to serve its people. With its history of innovation, bold planning, and a strong commitment to sustainability, ***Portland is well positioned to deliver on building the smartest city in America.*** Our proposal lays out a vision of people-focused transportation innovation that incorporates integrated technologies and 21st century data analytics. We will leverage our leadership in many areas:

Leadership in open-source data standards and architectures. Public-private partnerships around open source data have already transformed mobility options in the city. These include the Tri-County Metropolitan Transportation District of Oregon (TriMet) General Transit Feed Specification, PBOT's open data standard for bikeshare, and the multi-jurisdictional PORTAL transportation data repository.

Data open to private and public sector alike. Portland is home to a thriving software development community, and the city actively encourages developers to use public data on several platforms, including CivicApps and OpenStreetMap.

Commitment to safety and Vision Zero. The city and its partners have made a public "Vision Zero" commitment to eliminate fatalities and serious injuries on Portland's streets by 2026.

TriMet riders can connect with other transportation options as part of a new feature in the TriMet Tickets mobile app, called RideTap, developed by Moovel North America. TriMet is the first U.S. transit agency to pilot the RideTap feature, which gives information on nearby transportation options. RideTap currently includes Lyft and Car2Go, and more options, including BIKETOWN bikesharing, will be added soon.

Climate leadership. Since becoming the first city in the U.S. to adopt a Climate Action Plan to reduce carbon emissions in 1993, Portland has reduced carbon emissions by 14% from 1990 levels, even as our population increased 31%.

Challenges Facing Portland

Our successes are real, and our city's prosperity is growing. ***However, Portland's advantages have not been equally shared.*** Too often, local government implemented policies and made decisions that harmed minority communities. Many transportation and redevelopment projects have caused the displacement of families and communities. Urban renewal and freeway expansion in the 1960s was followed by gentrification because of rising home prices in the 1990s and 2000s. One traditionally African-American neighborhood, for example, experienced a 40% increase in average rent over the past 5 years. As a result, the neighborhoods best served by transit are less accessible to low-income Portlanders.

In addition, **Vision Zero** safety data reveals that people living in those neighborhoods – especially in east Portland – suffer the highest number of fatal and serious injury crashes. Pedestrians are especially at risk: someone walking or using a mobility device in east Portland, particularly east of Interstate 205, is 2.3 times more likely to die or be critically injured than a pedestrian in or near the central city.

Moving forward, Portland and other cities need to own, understand, and strive to correct these historic inequities. UB Mobile PDX will help us achieve that.

UB Mobile PDX Demonstration Corridors: Focus, Understand, Innovate, and Measure

UB Mobile PDX will focus on three demonstration corridors: the Powell/Division and 122nd Avenue corridors in east Portland, and the Columbia Boulevard Corridor in north Portland.

Two of the demonstration corridors – Powell/Division and 122nd Avenue – are home to Portland's most diverse communities. Housing is relatively affordable, but these areas lack access to a full range of safe and convenient transportation choices. The third corridor, Columbia Boulevard, is where many of Portland's manufacturing and industrial jobs are located. These family wage jobs are critical to our economy – and to lower-income Portlanders – but can be difficult to reach without a private vehicle.

These corridors are some of the most dangerous in the city for pedestrians. **Figure ES-1** shows Portland's High Crash Networks and communities with a high concentration of minority, low-income, and limited-English-proficiency residents. All three corridors are in areas where the market, without intervention, is unlikely to provide emerging transportation technologies and services.

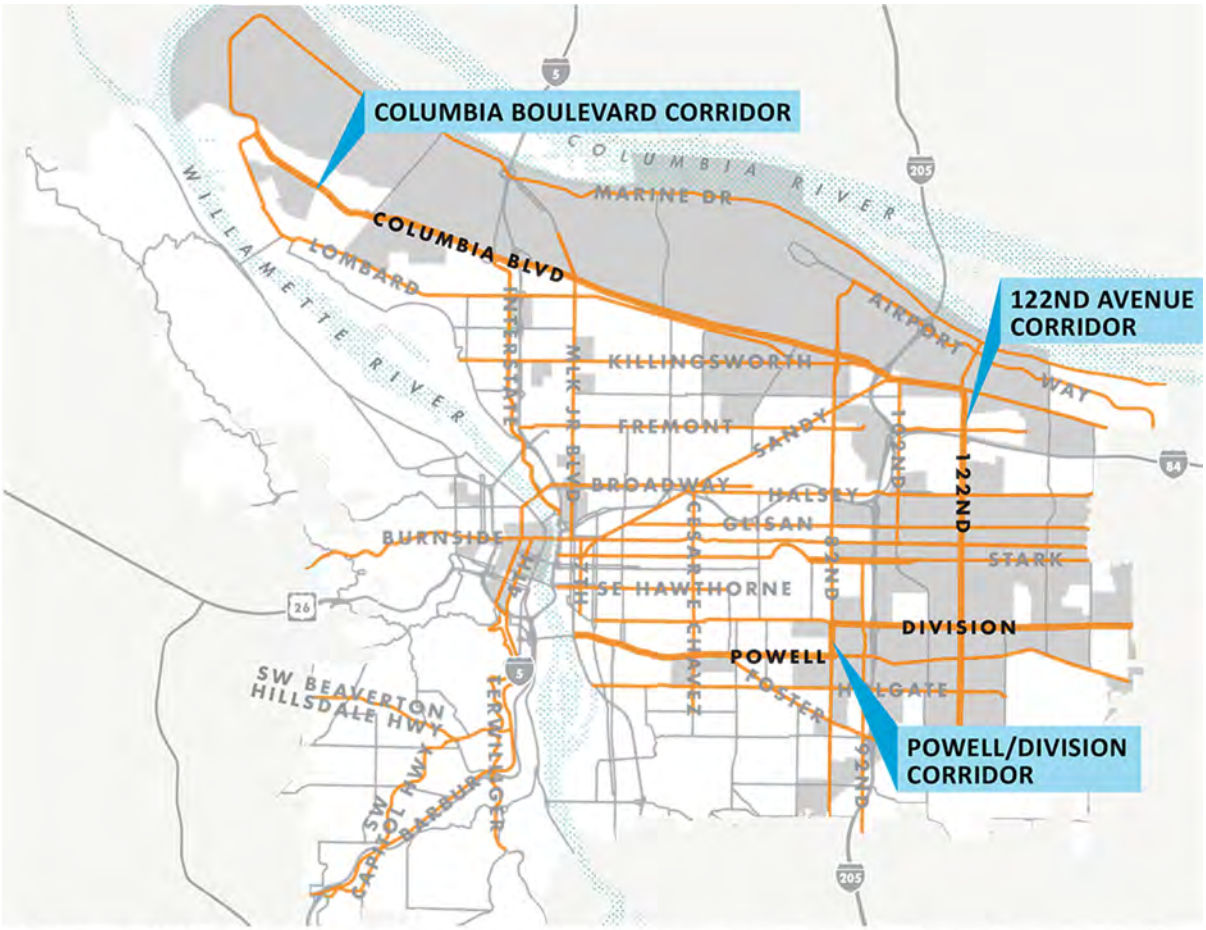


Figure ES-1. Demonstration Corridors: High Crash Network and Communities of Concern

UB Mobile PDX will make safety improvements to address dangerous conditions and encourage multimodal use in the three demonstration corridors.

Each demonstration corridor offers a unique set of conditions in which to pilot emerging technologies. Paired with ongoing community outreach, these technologies – including CVs, infrastructure sensors, kiosks, and targeted mobile app deployment – can improve the quality of life for corridor residents today, and create ladders of opportunity toward a brighter economic future. At the same time, corridor investments will produce and capture data that informs transportation management decisions that provide less direct – but very real – benefits for people living in the corridors. In addition to transportation benefits, UB Mobile PDX will provide access to free and low-cost technology (including smart phones) and technology training for low-income Portlanders.

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Engaging Corridor Residents to Help Design Solutions

UB Mobile PDX will put people – especially those who have all too often been left behind – at the forefront of creating new solutions. Through a human-centered design approach, technology experts and community members will work collaboratively and iteratively to define needs, brainstorm potential solutions, and refine those solutions. This will push our technical experts to see emerging technologies in light of how they can improve people's daily lives.

Recognizing that community capacity building supports meaningful outreach, we will engage community-based organizations (CBOs). We will work with CBOs who serve low-income, minority, immigrant, elderly, and people with disabilities to ensure their participation in the demonstration project, and will provide grants for technology training, Smart City-related job training, and employment programs.

Ladders of Opportunity

UB Mobile PDX offers Portlanders improved access to education and jobs through a new mobility paradigm that emphasizes choice, access to information, opportunity, and efficiency. Ladders of opportunity will provide all Portlanders the means to access the city's growing prosperity by providing:

Work. Workforce training and career coaching, and creating jobs in the three demonstration corridors.

Connections. Technology that creates safe, reliable, and affordable connections to the places people need to go every day: jobs, school, healthcare, and other essential services.

UB Mobile PDX will build capacity in community-based organizations so they can help lead outreach efforts. A cornerstone of this approach is to make the community-based organizations paid team members by providing grants for training and outreach.

Revitalization. With new data from new sources, changing the way the transportation system is managed, improving safety, and identifying infrastructure priorities in underserved areas.

UB Mobile PDX represents a pivot point in Portland's history. The set of actions and investments described in this proposal will create a stronger, more connected city – one that provides opportunity for all.

The Smart Cities grant will be a start – but it can only go so far. The lasting impact will come from the amplification of the project and its benefits through community engagement and partnerships, using a relatively small amount of money to marry technology and culture and move toward ubiquitous, egalitarian mobility by means other than expensive private autos on overcrowded streets.

Mobility Marketplace

- Data from many sources provides real-time information to make streets safer
- Integrated app puts multimodal information at users' fingertips, including trip planning and payment capability
- Expanded access to technology helps bridge the digital divide for underserved community members

4. User-Focused Mobility Services and Choices

5. Urban Analytics

9. Connected, Involved Citizens

11. Low-Cost, Efficient, Secure, and Resilient ICT

12. Smart Land Use

Mobility Marketplace

A Comprehensive Approach to Becoming a Smart City

To address our challenges, Portland will implement a citywide data collection and data sharing platform that enables residents to make daily transportation decisions while helping to guide long-term City investments.

UB Mobile PDX includes both citywide and corridor-specific elements:

- A **citywide Mobility Marketplace** will give all travelers access to more (cheaper, faster, more efficient, and more sustainable) travel choices, and encourage people to use those new choices. We will install electric vehicle (EV) charging infrastructure and support vehicle electrification, and we will implement and test connected vehicle (CV) and Connected Fleet technologies.
- In our **three demonstration corridors**, we will implement a comprehensive set of new technologies and capture the data they generate. The corridors will serve as a focal point for UB Mobile PDX implementation. There, we will provide needed services for people and work to ensure equitable access to the Mobility Marketplace. At the same time, a range of Smart Cities technologies will capture data to create analytics and inform transportation management decisions.

Data will both *drive implementation of* the Mobility Marketplace and simultaneously *be created by* it. All this data will be integrated in an Open Data Cloud that is the core of UB Mobile PDX.

The Mobility Marketplace

As part of UB Mobile PDX, the Mobility Marketplace will transform how users plan and purchase services to meet their mobility needs. Today, transportation users must navigate a fractured array of payment and routing systems when making trip decisions. There is no way to easily assess how different travel options stack up against one another in terms of cost, schedule reliability, and climate impacts. Without this information, people default to the familiar or the known, leading to an overreliance on single-occupancy vehicles (SOVs), even when other means of travel could better serve everyday transportation needs.

Existing Mobility Services and Applications in Portland

Portland was the birthplace of carsharing in the U.S. in 1998, with the founding of a small company that eventually became part of Zipcar. Today, carsharers in Portland have access to many mobility services.

Transit: RideTap, Light Rail, Streetcar, Passenger Rail, Aerial Tram

Ridesourcing services: Lyft, Uber

Carsharing services: Zipcar, Car2Go, Reach Now, Getaround

Peer-to-peer services: Turo, Getaround

Taxi-hailing services: Flywheel, Curb

Bikesharing services: BIKETOWN/Motivate (summer 2016)

Biking and walking route information: RideApp, Strava, Safe Routes to School App (walking routes)

Intercity transit: Ride Connection, Bolt Bus, Amtrak

Paratransit: TriMet, Lyft, Ride Connect

The Mobility Marketplace will fill this information void, making comprehensive, streamlined travel information universally available through a website, smartphone app, text messages, and corridor-specific kiosks to reach all residents, including those who do not have email addresses.

Using integrated data from a variety of open sources, the Mobility Marketplace will help Portlanders meet their daily travel needs with a seamless set of multimodal services that includes the following elements:

- **A consolidated user interface:** For the user, one app or website will provide access to three sectors of the mobility market: private mobility, peer-to-peer-based sharing economy, and public providers. The user will have access to open-source data that provides a seamless overview of trip options and comparative information about the cost, schedule reliability, and carbon dioxide (CO_2) emissions of these options.
- **Bundled transportation services (both public and private):** Private mobility providers, peer-to-peer sharing economy, and public agencies will be able to offer consolidated mobility packages, such as a transit pass plus four rides on Lyft for late-night trips and one Amtrak ticket a month for out-of-town travel. Packages will be designed to meet the full range of mobility needs, allowing a full shift toward mobility as a service, and reducing reliance on car ownership.
- **A pricing structure that makes travel more affordable and promotes alternatives to driving alone:** The Mobility Marketplace system will aggregate multiple payment systems, including public transportation fare collection, tolls, public and private parking, road usage charging, Transportation Network Company (TNC), and peer-to-peer sharing payments.
- **Features targeted toward differently abled residents:** The Mobility Marketplace system will provide route planning focused on accessible routes with curb ramps and unimpeded sidewalks, options to limit the distance a person has to roll or walk to reach a transit or shared ride, notifications about where audible signals are located, and an app-within-an-app for people who use paratransit services –making it easier to access shared ride services. The app and website will be fully accessible to all users, including those with screen readers.

Portland: A History of Mobility Innovation

Portland is the right scale to create and demonstrate change. Shared mobility works best when different travel modes are connected and integrated with one another, and when strong land use regulations are in place. All of these conditions exist here.

With a history of multimodal investment, Portland has broad coverage from the different transportation options within its boundaries. Located in the center of a region with 60 miles of light rail, the city also features a 7-mile streetcar network and an aerial tram connecting the Oregon Health Sciences University (OHSU) campus and hospitals. Our bicycle commute rate is 7.2%, and over 40% of trips into and out of downtown are taken on transit. Portland has committed to improving accessibility on its sidewalks and now has an inventory of curb ramps, making it easier for people with disabilities to get around and access fixed-route transit service.

Carsharing, bikesharing, and ridesharing services serve as first- and last-mile transit connections, expanding the reach and interconnectivity of our transit system. This isn't new: Portland was the birthplace of the first carsharing company effort in North America, and continues to push the sharing economy envelope with companies such as Spinlister (bike sharing) and Getaround (peer-to-peer car sharing).

These systems set the stage for broad acceptance of innovative transportation options and allow for rapid adoption throughout multiple sectors of the city. More transit, bike, walking, and shared-vehicle trips to employment areas and neighborhood commercial centers, including making more of the system accessible to residents with disabilities, will mean less traffic congestion and less competition for limited parking, helping to keep these areas vital and accessible.

UB Mobile PDX App

The safest bike route might be important to a parent biking with his or her child to school. The route with the best air quality might be important to a person with asthma. A route with curb ramps might matter to a person using a mobility device.

The success of the Mobility Marketplace depends on getting marketplace information into the hands of users swiftly, continuously, and universally. The app interface is the primary mechanism by which UB Mobile PDX will provide Portlanders with real-time information about the array of public, private, and mixed public/private transportation choices available to them. Recognizing that not everyone uses apps, all information in the app will also be available through a variety of channels, including mobile and traditional web-based applications.

The UB Mobile PDX app will help users pick the right mode and route for their trip whether they value time, distance, carbon footprint, safety, mobility device access, air quality, or health benefits. It will be multimodal, integrating walking, biking, transit, bikesharing, carsharing, TNCs, and other modal choices in one seamless user interface. It will offer integrated cost information payment.

The UB Mobile PDX app is different from those currently available because it will focus on City goals like **safety, greenhouse gas reduction, and public health**, which translate into real-world benefits for people.

What Sets UB Mobile PDX Apart

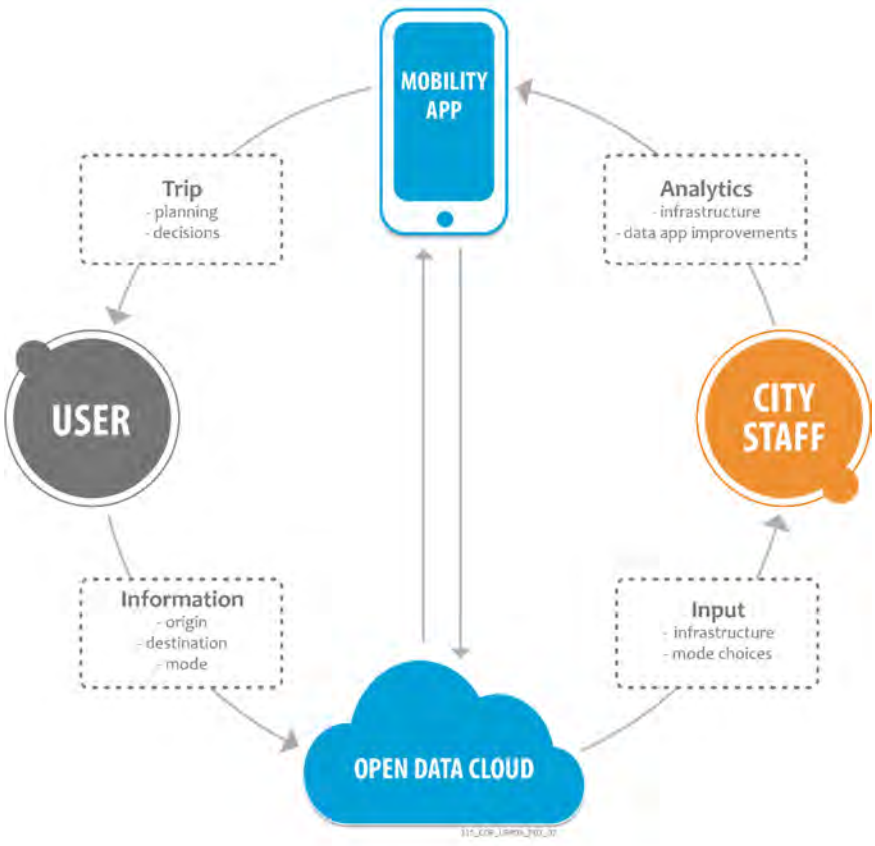

FIGURE 1. Mobility Marketplace Supports Open Data Cloud Urban Analytics While Keeping Data Anonymous

Building on Portland's multimodal past and groundbreaking open data platforms, UB Mobile PDX is an opportunity to push beyond our current successes to create a new mobility app that provides features and benefits far beyond the transportation apps currently in use.

At the same time, as shown in **Figure 1**, app users will be providing real-time data to the Open Data Cloud, supporting analytics that help improve transportation services in the city. The *Open Data Cloud* section describes this in greater detail.

Adding Impact to Portland's Vision Zero Commitment

Portland is a Vision Zero city, with a City Council-stated goal of eliminating traffic fatalities and serious injuries on city streets by 2026. The UB Mobile PDX app offers a powerful set of tools to help the City meet this commitment, including the following:

- **Keeping impaired drivers off the road.** Our Vision Zero team will work with app developers to create a range of elements that discourage impaired driving and encourage alternatives, such as offering lower-price alternatives at certain times and places (i.e., bar closing times).
- **Slowing speeds.** We will work with companies like Waze to develop features that discourage speeding, such as an interface that reminds users to travel at lower speeds on high crash corridors.
- **Prioritizing investments.** UB Mobile PDX will also send speed data back the cloud, helping City engineers prioritize infrastructure investments that reduce speeds in dangerous areas. The app will also educate the public on the location of fixed photo radar equipment installed to encourage compliance with posted speed limits.
- **Focusing on school zones.** Portland has the highest rates of biking and walking to school in the nation. Nearly 43% of kids in K-8 walk, bike, or roll to school, with some schools as high as 92%. While these trips take vehicle demand off the Portland transportation system, the high walk and bike percentage also comes with the responsibility to ensure safer routes. UB Mobile PDX will direct drivers around school zones when students are present, and analyze driver behavior to protect Portland's most vulnerable users.

> Portland's Safe Routes to School app allows children and parents in Portland public schools to crowdsource routes and provide feedback to the City about infrastructure – which will in turn help prioritize how a $5.5 million school bond for Safe Routes is spent.

- **Priority walking routes to schools.** We will build on a one-of-kind project currently underway. This web-app is designed for use across multiple operating systems, in multiple languages, and is scalable across location-service-enabled mobile devices. The app uses a global positioning system (GPS) and geo-fencing to crowdsource concerns and ideas to improve student walk areas. UB Mobile PDX will integrate the crowdsourced data with the app and website to create priority walk routes.
- **Priority biking routes.** Portland has over 375 lane miles of bike lanes, some with higher transportation function than others (Major Bikeway Classification). Based on data from Ride App, Strava, and other companies like Sidewalk Labs, UB Mobile PDX will develop prioritized routes that tell the rider which route is most comfortable.

SmartTrips: Leveraging Innovative Transportation Demand Management Strategies

To meet the climate change goals set out in Portland's Climate Action Plan, we must shift SOV trips to active modes: walking, bicycling, and transit. Portland's SmartTrips is one of the most innovative Transportation Demand Management (TDM) programs in the nation, reaching 91,000 people each year. SmartTrips offers information and incentives to encourage people to try alternative transportation options, with a focus on reaching new residents.

The Mobility Marketplace will take SmartTrips to the next level by integrating it with innovative technology-based services to help people replace driving trips with transit, ridesharing, walking, biking, and teleworking.

Managing Parking and Improving User Information

Portland manages the on- and off-street public parking system by analyzing data gathered through occupancy review, pay station transactions, and customer feedback. Established occupancy thresholds of 85% or one open

space per block ensure the predictability of finding an available parking space and improve freight delivery, transit service, pedestrian safety, and the street environment for bicyclists. The Mobility Marketplace will leverage technology improvements such as mobile payment, virtual permits, pay-by-plate, and license plate recognition to ensure seamless customer experience. UB Mobile PDX trip-planning services could provide travelers information on parking occupancy before they start their trip, offering alternative transport methods such as transit, bicycle routes, or rideshare when parking occupancy is high at their destination.

Integrating Digital Payment and Rewards

The Mobility Marketplace will leverage the cutting-edge electronic payment systems that already exist in Portland, and link more modes to provide one payment mechanism for a comprehensive set of travel options. Building on Tri-County Metropolitan Transportation District of Oregon's (TriMet's) new Hop Fastpass, UB Mobile PDX will integrate transit fare payment with the new BIKETOWN bikesharing payment and other modes – eventually including payment for parking in city garages.

Integrating payment into UB Mobile PDX will allow for targeted incentives and promotions. For example, when a big event happens at one of Portland's large sports venues (both of which are well served by transit), the app can provide discounts for transit and bikeshare users traveling to the event, while alerting drivers that the price of parking will increase based on current occupancy rates. The app can also include special mobility promotions, such as free Chinook Book coupons for users if they visit Portland's EV Showcase, proposed in coordination with the Vulcan foundation grant, for an EV test drive. UB Mobile PDX will also build on the SmartTrips tactic of giving positive feedback or "points" when users choose non-SOV options. Similarly, bonus points and discounts can be given to people who consistently choose options that promote health or have less climate impact.

Through integration of NoAppFee and transportation cost information, users will be able to understand the transportation options, cost, and time for a rental unit. In the first phase, users will be able to research this information. In the second phase, full integration will automatically link each housing option search to transportation costs and nearby options.

Integrating Affordable Housing Options

Last year, in partnership with start-up company NoAppFee, Portland launched a first-in-the-nation app that matches home and apartment seekers to potential residences via an app. NoAppFee is a next-generation online platform that streamlines the rental search process and saves time and money for both renters and property managers. It efficiently matches qualified renters to landlord properties and specifically addresses the challenges faced by homeless families and the organizations that assist them in finding rental housing.

Through integration of NoAppFee and transportation cost information, users will be able to understand the transportation options, cost, and time for a rental unit. In the first phase, users will be able to research this information. In the second phase, full integration will automatically link each housing option search to transportation data.

Technology and Equity: Bridging the "Digital Divide"

The City of Portland recently adopted a Digital Equity Policy, which formally recognized the digital divide between high- and low-income users. UB Mobile PDX will help implement many of the policy recommendations and use the following to help remove barriers:

- **Providing a universal digital interface:** We know from launching the City's Portland Maps and TriMet's Trip Planner that offering a web interface compatible with a variety of screen sizes reaches a greater variety of people. Many people do not have large data plans and prefer to receive information from a web interface either on their phones or on publicly available computers.

- **Providing information in multiple languages:** All UB Mobile PDX interfaces will be initially available in the five most common languages spoken in Portland (English, Spanish, Vietnamese, Mandarin Chinese, and Russian). In addition, the app design will incorporate simple visuals and graphics wherever possible to maximize accessibility to non-English speakers.
- **Providing information in an ADA-compliant format.** All UB Mobile PDX interfaces will be Americans with Disabilities Act (ADA)-compliant, and the web version will be fully compatible with screen readers.
- **Providing technology training**. UB Mobile PDX will offer technology training through partnerships with schools, community colleges, and community-based organizations (CBOs).
- **Broadening access to free Wi-Fi**. Building on its partnership with Google Fiber, UB Mobile PDX will make free Wi-Fi available in more locations through kiosks and open access to all public offices, community centers, and government buildings.
- **Providing free or low-cost phones**. Through partnerships with wireless companies, UB Mobile PDX will provide low-cost or free smartphones with data plans to residents of our demonstration corridors who meet eligibility requirements, such as participation in one of our free technology training programs.
- **Providing access to payment choices.** The UB Mobile PDX app will use an account-based system to integrate payment choices. Similar to TriMet's Hop Fastpass, the City will provide a pre-paid alternative for those without credit cards. Setting up and reloading accounts will be possible at a variety of small and large retailers using a service that sells gift cards. These pre-paid accounts will allow for anonymity if desired, though those who choose to register their cards will have access to discounts and a wider range of app services. We will leverage current TriMet work to identify areas where it is difficult to access a cash payment location, and identify alternatives for those places.

Improving Access for Portlanders with Disabilities

While UB Mobile PDX is designed to be universally accessible, it also offers the following new opportunities to improve access for people with disabilities:

- **Route planning.** The app will help mobility device users navigate our system of ADA ramps by offering trip planning based on accessibility. It will support the visually impaired by highlighting locations with audible traffic signals. The app will also provide data to the City about where people with disabilities are traveling, which will inform the development and future updates of the City's ADA transition plan.
- **App within an app for people with disabilities.** By partnering with TriMet and other service providers, the app could include specific features for paratransit service, such as including information about how to use fixed route service or about subsidized ridesharing services.
- **Hackathon for features to serve people with disabilities.** Recognizing that we have only scratched the surface of how UB Mobile PDX can benefit people with disabilities, we will work with our app provider and advocates for and people with disabilities to host a hackathon to develop new services or new ways of using open source data to improve existing services.

Creating and Deploying the UB Mobile PDX App

Portland has a rich and growing start-up community, thanks to programs from partners Portland Incubator Experiment (PIE) and the Portland Development Commission (PDC), in addition to a thriving open source software community. PIE and PDC, along with our selected app developer, will host a challenge to support development of the most advanced multimodal app on the market.

The UB Mobile PDX app will be deployed in three phases.

Phase I: Open the Data and Create the App

Opening the Data

During the first year, UB Mobile PDX will make City data available in the Open Data Cloud in standardized, open formats accessible to app developers, City staff, and researchers. Data derived from public or semi-public transportation sources will also be hosted in the Open Data Cloud. This will support real-time trip planning and mode choice analytics via open and standardized application programming interfaces (APIs) in a fully accessible format. The City will contract with private transportation providers to access their systems through open APIs, and to the extent possible, share anonymized trip data via the Open Data Cloud. We will work with partners at Portland State University (PSU) to collect, store, and share data. More detailed information on the Open Data Cloud is contained in the *Open Data Cloud* section.

Portland's Open Data Cloud APIs will provide routes, time of arrival, costs, and other information about multimodal travel options. The City of Portland will design the interface to make safety, equity, accessible routes, and housing data available.

UB Mobile PDX will also integrate data from **OpenStreetMap and OpenTripPlanner (OTP)**. OpenStreetMap is a result of a collaboration with the open source community that has created a rich set of street network, walking, biking, and sidewalk data. **OTP**, which began as a collaborative effort at TriMet in 2009, is now deployed in many cities worldwide. TriMet is currently collaborating with agencies in other cities to enhance OTP to support integrated shared-use mobility options. As an open source project, OTP and OpenStreetMap can serve as a foundation to extend both data collection and app features.

Best Practices around Anonymizing Private Data

Portland will bring together private transportation providers and private sector experts in data, to develop a national standard and best practices in anonymizing private data before it is shared in the Open Data Cloud. Data anonymization enables the transfer of information across a boundary while reducing the risk of unintended disclosure, but must still allow evaluation and analytics post-anonymization. We understand the risk of sharing private businesses practices. By working with the coding and open source community (see **Table 1** for examples), we will create a new standard for private companies that allows them to share useful and relevant data in the Open Data Cloud without compromising business-sensitive information.

Table 1. Example Open Data Sources by Mode and Provider

Mode	Provider(s)
MAX light rail	TriMet
Buses and bus rapid transit	TriMet
Aerial tram	City of Portland
Streetcar	City of Portland, Portland Streetcar, Inc.
Bus ramp deployment	TriMet
Small transit providers	Ride Connect
Bikeshare	City of Portland, BIKETOWN (Motivate, Social Bicycles [SoBi])
Carshare	Car2Go, Zipcar, Getaround, Reach Now
TNCs	Lyft, Uber, and other TNCs
Parking management	Central City Parking (Quick Park), Passport Parking (Washington Park TMA and [coming soon] PSU and meters downtown)

Table 1. Example Open Data Sources by Mode and Provider

Mode	Provider(s)
Airport parking	Port of Portland
Intercity travel	Bolt Bus and Greyhound
Individual driving options	UB Mobile PDX app users
Individual walking options	UB Mobile PDX app users, Safe Routes to School app
Individual biking options	RideApp, UB Mobile PDX app users, Strava
Individual route choices for people with disabilities	UB Mobile PDX app users
Taxi-hailing services	Flywheel, Curb
EVs	PlugShare and other EV Supply Equipment (EVSE) providers

Creating the App: the Portland App Challenge

The UB Mobile PDX app and web interface will be developed by a combination of an established vendor and start-ups. We will engage existing vendors that already provide transportation option information, like Moovel, Google, and Xerox, while creating a platform and space for the start-up community to expand the app by adding new features to address issues like safety, greenhouse gas reduction, and affordable housing. Throughout the app development process, we will work closely with CBOs and residents in our demonstration areas to ensure that the app meets the needs of Portlanders from all zip codes and demographic groups.

- **Select the app/web interface provider**

  UB Mobile PDX will use a **creative Request for Information (RFI) and Request for Proposal (RFP)** process to select an app and web interface vendor with a proven track record of delivering secure, accessible, and user-friendly transportation apps. The RFI will specify requirements that go beyond what is currently on the market by requesting additional safety messaging, more choices for route and mode selection, ADA integration, gamification, and integration with digital payment. The RFP will provide space for providers to offer innovative ways to meet City goals.

- **Hold an app challenge to engage start-ups**

  With the primary contractor in place, UB Mobile PDX will then launch an **app challenge** jointly hosted by Technology Association or Oregon (TAO), PDC, PIE, Portland Seed Fund, Intel, and the selected app provider. The challenge will be designed to engage a diverse and inclusive group of entrepreneurs to expand the app and data analytics. The goal: to improve the lives of Portlanders with a special emphasis on meeting the needs of low-income, minority, immigrant, youth, elderly, and disabled residents. From the challenge, a set of teams will be selection to build innovative solutions and, potentially, to build great companies. TAO will support the selected teams by leveraging corporate volunteers with experience in information technology (IT), big data, consumer demographics, user experience, and marketing to improve selected apps. Our app vendor will maintain responsibility for app privacy and security.

Phase 2: UB Mobile PDX App Launch

The UB Mobile PDX app will launch with most features in place, including partial digital payment integration, trip planning, and two-way data sharing features.

Phase 3: App Revision and Improvement

Once the UB Mobile PDX app is launched, we will continue to work with our selected vendor to improve it and add features like fully integrated multimodal payment options. We will also host challenges and additional hackathons to add new features to the app to improve the experience for specific users, integrate with other community programs, and respond to challenges that arise. This will uncover new ways of using collected data to improve quality of life for Portlanders.

UB Mobile PDX Website

For those who do not have access to a smartphone at all or to one that can handle complex apps, the UB Mobile PDX website will host real-time transportation information. Information will be accessible via a web browser, which will be responsively designed and compatible with a range of screen sizes and technologies. The website will allow users to follow a pre-selected route without using a mobile data plan.

The website will also include elements not in the app, including a dashboard that highlights key performance measures gathered through UB Mobile PDX such as air quality readings in demonstration corridors, safety improvements, and citywide changes in vehicle miles traveled. Like the app (and the kiosks), the UB Mobile PDX website will also serve as an important source of public information about current conditions such as air quality conditions in a corridor, traffic congestion, or citywide emergency response.

UB Mobile PDX Kiosks

Through the U.S. Department of Transportation (USDOT) partnership with Sidewalk Labs, UB Mobile PDX will place 100 Sidewalk Labs kiosks within and near the three demonstration corridors. The kiosk locations will be crowd-sourced using a web interface to ensure they are where people can use them, whether that be a bus stop, transit center, or community gathering place. Kiosks will create a community focal point with amenities and information for residents and businesses, and could be enhanced with transit infrastructure. Kiosks will include the following:

- Free broadband internet access
- High-speed phone and device charging
- A tablet with information on transportation, housing, and other social services
- Real-time alerts and information on bus or train arrivals, traffic disruptions, air quality alerts, and emergency response information
- Access to neighborhood-specific information including events, meetings, and elections
- Where possible, integrated electric mobility hubs with charging equipment for BIKETOWN e-bikes and EV charging

At the kiosks, community members can learn about safety, public health, and mobility. For instance, a kiosk could display information about air quality in the Powell/Division Corridor and link to the weather and number of transit rides taken that day in the corridor. Kiosks could also provide information about emergency preparedness or other critical City communications.

The kiosks will also serve an important data collection function. They will be equipped with sensors to monitor air quality, traffic conditions, and vibrations (to detect natural events such as storms and earthquakes). Other data collection functions include the following:

- Trip planning/collecting information on UB Mobile PDX app usage from location to location
- CV sensors and data collection

- Air quality data collection
- Information on foot traffic patterns
- Check-ins using #UBMobilePDX to collect user-based information about trip choices

This data can be used to inform both customer and City agency choices. For example, if air quality is poor in a certain corridor, the kiosk can be used to push out notifications about potential health impacts, and can offer half-price transit tickets for purchase in the corridor. Similarly, if buses are delayed in the corridor, the kiosk can provide information on immediate alternatives, including BIKETOWN bikes, Uber and Lyft, and neighborhood shuttles.

Kiosks can also become part of the community fabric. With help from Sidewalk Labs, we will enable communities to brand kiosks – much like communities can brand transit stops today. Neighborhood associations or CBOs (such as the Jade District/Asian Pacific American Network of Oregon in our Powell/Division Corridor) might be allowed to brand the kiosk location with related public art and use the kiosk to share information about their programs, in exchange for keeping the area around the kiosk clean.

Iraida

Iraida, a visually impaired senior citizen, lives on a fixed income. She can get to basic services like the grocery stores and the laundromat by walking or using transit, but needs her son to drive her to medical appointments and to major shopping areas. She has a cell phone, but not a data plan, and is not necessarily comfortable using app technology.

How does UB Mobile PDX help Iraida?

Better Walking Options:

> Safe pedestrian routing and "geo-fencing" directs her to safe crossings and areas with sidewalks and ADA-equipped signals (SMS and audio)

> Better information helps her move around safely, both in her own neighborhood and other less familiar neighborhoods. Neighborhood outreach programs walked her through training and how to use the program.

Better Transit Information:

> Transit information integrated with safe walking routes helps her move around more quickly and safely

> A kiosk with ADA features such as audio cues and instructions, located in the lobby of her building provides information about what buses serve her doctor's office, when they come, and where the stop is located

Quality Time with Her Son:

> Instead of having her son chauffeur her, she is now able to spend the time she and her son have together on other more mutually enjoyable things

> Through a partnership with AARP, the City, Portland Community College (PCC)/Portland Public Schools (PPS), and NAMC-Oregon, she and other seniors are learning about basic smart technology tools. She prepares for her week each Sunday evening by ordering the select items that pop up in her Grocery delivery apps. And when she wants and needs access to a computer, she visits the church/community center/senior assisted living facility.

Technical Integration:

Analytics have helped develop the information on walking to the locations of basic services. It requires understanding the characteristics of safe walking streets (which includes the physical characteristics of streets as well as traffic information) and combining that information with the locations of basic services and common housing locations. Analytics also provide information to the city about common crossing locations in order to improve the safety of those crossings.

Open Data Cloud

- Open data sets the foundation for ongoing innovation
- Real-time data from many sources helps manage the system to protect people and promote travel options
- Replicable data solutions leverage Portland's existing open source data leadership

1. Urban Automation

2. Connected Vehicles

3. Intelligent, Sensor-Based Infrastructure

4. User-Focused Mobility Services and Choices

5. Urban Analytics

9. Connected, Involved Citizens

10. Architecture and Standards

11. Low-Cost, Efficient, Secure, and Resilient ICT

Open Data Cloud

Data can be both a catalyzing and democratizing agent, which helps inform residents and holds government accountable. Data collected by and distributed through UB Mobile PDX can lead to better informed decisions about how to spend scarce resources on transportation and how to communicate with community members about investment priorities.

The Open Data Cloud forms the foundation for data management in the UB Mobile PDX app, website, and demonstration corridor activities. This cloud will enable agencies and innovators—including Portland's active tech start-up community—to develop applications that apply data gathered by UB Mobile PDX to real-world problems.

Portland's History of Data Sharing

Portland's long-standing commitment to open data, history of cutting-edge innovation, and strongly collaborative ethos sets the stage for Smart City success in the data sharing arena. Our institutional partnerships and initiatives will ensure two-way knowledge transfer with cities across the nation and the world.

The Portland area has a long history of making open, machine-readable data accessible, discoverable, and usable by the public. Portland has led the nation in using OpenStreetMap to distribute spatial data for applications that inform residents' everyday choices about traffic, transit routes and stations, bike routes, sidewalks, buildings, and more.

- The City of Portland provides a wide variety of geographic information system (GIS) data on **PortlandMaps** and hosts CivicApps, a website designed to accelerate innovative ideas using web and mobile technologies to advance civic participation.
- The Oregon Department of Transportation (ODOT) **TripCheck Traveler Information Portal** provides customizable real-time road, weather, and traffic information and integrates data from other agencies and user input from Waze.
- Metro offers a bicycle trip-planning service built on **OpenStreetMap**.
- TriMet maintains a **developer resources website** that provides schedule data in General Transit Feed Specification (GTFS) format. TriMet also provides web services as part of TransitTracker, including trip planner and GIS data. These resources promote the use of transit-related information that, in turn, simplify and enhance the transit user experience.

In 2015, Portland collected data from the Uber and Lyft apps and from taxi dispatch systems as part of a 4-month experiment in taxi deregulation called the Private For Hire Transportation Innovation Pilot Program. After the initial pilot, Portland released its data to the public, including findings such as the need for more wheelchair-accessible service. We continue to use Uber and Lyft data to inform PBOT policies.

TriMet riders can connect with other transportation options as part of a new feature in the **TriMet's app RideTap**, developed by Moovel North America. TriMet is the first U.S. transit agency to pilot the RideTap feature, which gives information on nearby transportation options. RideTap currently includes Lyft and Car2Go. More options, including BIKETOWN bikesharing, will be added soon.

- **PORTAL**, the regional transportation data archive hosted by Portland State University (PSU), integrates data across regional agencies. This includes live feeds from traffic signal systems, freeway and travel time systems, and weather and incident data. PORTAL also supports simple visualizations and analytics.

Finally, Portland created a custom fiber network, the **ITS Network**, to facilitate data exchange among agencies and partners, including the City of Portland, ODOT, TriMet, and PSU.

The Open Data Cloud will transform these and other data sources into actionable data services consumable by apps and real time services.

Principles of an Open Data Cloud

The Open Data Cloud is a foundational piece of UB Mobile PDX. It is a platform for "understanding and analyzing data to address complex urban challenges" and for "measure(ing) the performance of a transportation network" (USDOT Vision Element #4). Through documented, standardized APIs and a well-defined geographic segmentation, the data cloud UB Mobile PDX analytics and the UB Mobile PDX app. Just as TriMet developer resources and GTFS enabled a proliferation of transit apps, the Open Data Cloud and the community it creates will enable a proliferation of urban mobility apps and analytics, greatly increasing the productivity and value of the data.

- **Open source software.** We will use and produce open source software to reduce costs and facilitate usage of the software by other cities. Open source software will be used where possible; however, some commercial products may be used.
- **Open platform.** We will select software and solutions to ensure the Open Data Cloud can be deployed on alternative platforms. The software developed will be deployable on a standard cloud/cluster system of networked servers, and be designed to be adoptable by other cities.
- **Open, accessible data.** A primary goal of the Open Data Cloud is to make data available for innovative entrepreneurs who will continue to build and refine technology and applications that can contribute to a smarter city. We will develop standardized data formats and API calls to develop a solid, consistent platform that be replicated by other cities.

GTFS: Leading the world in transit data sharing

In 2005, TriMet initiated a partnership with Google to build a data sharing standard for transit, which resulted in the now worldwide GTFS. Transit data is now as pervasive as drive-alone data, and an entire industry has been built on the GTFS foundation. In 2011, TriMet became the first transit agency to release GTFS real-time (GTFS-RT) and created the OpenTripPlanner, now deployed worldwide. TriMet is currently partnering with others to build GTFS-like standards for all shared use mobility options. GTFS has proven to be a catalyst for the entire industry across the globe.

UB Mobile PDX and the Open Data Cloud

The Open Data Cloud will integrate real-time data from a variety of public and private sources, including mobile devices (the UB Mobile PDX app), connected vehicles, infrastructure, and kiosks. This data will be integrated across modes and sources and made available for use by researchers, City staff, "the Internet of things" (IoT) - enabled infrastructure, and app developers. However, the vision for UB Mobile PDX doesn't stop there. The goal is to create a continuous two-way flow of data:

- Data **to** users that help them move around safely and efficiently
- Data **from** users in the form of feedback, app usage and travel information, CVs, and connected infrastructure

This two-way data street will improve Portlanders' lives by giving them immediate, timely information. But perhaps the greater impact will be indirect. By enabling integration of high-quality data from multiple sources for transportation management and performance measurement, UB Mobile PDX will help the City and its partners make better decisions and refine services for the people who live here.

UB Mobile PDX's integrated, real-time data feed will reduce the cost of data management for local governments and eliminate technical and institutional barriers to the capture, management, and sharing of that data. At the same time, the open nature of the data will make City operations more transparent and accessible. The very act of collecting data—and having people see what is being collected—can influence actions and priorities.

Benefits of the Open Data Cloud

As depicted in **Figure 2**, UB Mobile PDX will both draw from—and generate data for integration into—the Open Data Cloud. This continuous cycle of **data collection → analytics → improved service →customer information** will support a Mobility Marketplace where more trips are multimodal.

Using – and advancing – established system architecture and data sharing protocols

UB Mobile PDX will advance the evolution of the national Intelligent Transportation System (ITS) architecture and Connected Vehicle Reference Implementation Architecture (CVRIA) to incorporate technological developments and evolving user needs with a particular focus on connected vehicle requirements. For newly collected data, project partners will coordinate and develop data-sharing protocols based on existing protocols and the national ITS architecture.

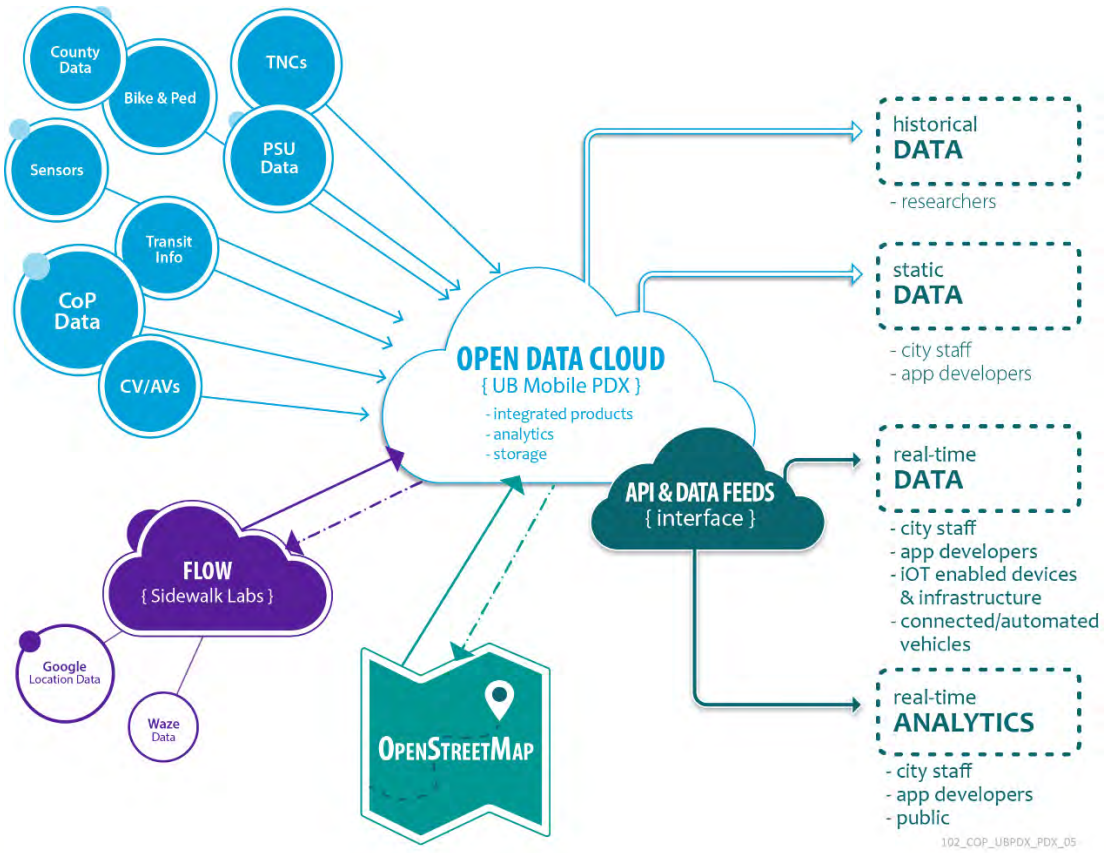

Figure 2. UB Mobile PDX Open Data Cloud Concept

The ubiquitous nature of the data sources will provide decision makers a clearer understanding of the factors influencing people's trip choices.

- More comprehensive and finer grain trip data will be collected than available in American Community Survey or regional travel surveys to enable new applications with new functionality. For example, integrating City GIS data with Sidewalk Labs and sensor data could lead to better understanding of dangerous intersections, which, in turn, could alert mobile app users to dangerous crossings and help City staff prioritize investments to mitigate the hazard.
- UB Mobile PDX data will show actual modal split in the city and allow planning for future changes.
- Data will show the real-time evolution of mode share and travel choices – factors that greatly improve predictive modeling capabilities.

Together, these will help PBOT devise an informed, targeted strategy to increase transit and active mode use for less traffic congestion, safer streets, and lower greenhouse gas emissions.

As described in more detail in the *Data Specifications, Management, and Security* section, UB Mobile PDX will develop specifications, APIs, and documentation to facilitate using collected data and develop analytic products. The Open Data Cloud will also function as a data service, and provide data feeds through standard API, documentation, and analytic products. These products will be used by app and website developers, transportation providers and operators, planners, and researchers. Consistent documentation and standardization will leverage the data source into a valuable service and policy-making tool, while assuring user anonymity. As we work to integrate data from private companies, we will develop appropriate protocols to protect intellectual property while allowing as much access as possible.

The Data Specifications, Management, and Security section provides detail on data management and storage, APIs, and governance and data ownership, and also sets out the UB Mobile PDX approach to data privacy and security.

Making Portland a more predictive city: safety and active transportation

Today, PBOT relies on several sources to see where (and when) Portlanders are walking and bicycling, which include a regional travel survey capturing 1 day of travel, only updated every 5 to 10 years; cordon counts into/out of the central city; and manual hand counts done by volunteers. UB Mobile PDX will provide exponentially more—and better—information to guide City actions and investment. Combined data from the UB Mobile PDX app, kiosks, CVs, and sensors will provide a much clearer picture of where people walk, use mobility devices, bike, where they would like to go but can't, and what barriers must be addressed to make active trips safer and more feasible.

At the same time, Mobileye and CV sensors can help PBOT understand where pedestrian "near misses" are occurring, giving much-needed information to help prioritize technology or infrastructure fixes.

Data Integration and Urban Analytics

Data is most valuable when placed within the context of other data. Following that principle, the value of Portland's urban analytics will be enhanced by the standardized APIs and segmentations in the UB Mobile PDX platform. In addition to enabling the integration of data across data sources, the Open Data Cloud will enable analytics at a fraction of the cost of commercial relational systems.

Using urban analytics, we have the opportunity to better understand how people move through and use the city. Information about behavior leads to better decisions about how to build and operate the system. The UB

Mobile PDX urban analytics platform will offer dynamic content to general public users and provide offline analytics to transportation planners and system operators.

One of the Open Data Cloud's greatest benefits will be the availability of historical data to support analytics for modeling and system management. Access to this rich data set will give transportation planners new insight into patterns and opportunities. Predictive and dynamic traffic management will improve system efficiency. This, in turn, will improve mobility for individuals and commercial users of Portland's transportation infrastructure.

Key elements of the Open Data Cloud include the following:

- **Data fusion, integration, and standards.** The Open Data Cloud will integrate open data sources such as PORTAL, TripCheck, CivicApps, and ODOT's Road User Charging (RUC) system. The platform will be flexible enough to cope with both structured and unstructured data.
- **Open and documented architectural and internal standards.** These standards will enable the integration and sharing of data, and will be made available for other cities to use and leverage.
- **Privacy and security.** Security needs will inform every data item and interface. Combining data sources can create privacy issues. The UB Mobile PDX team will conduct a thorough security risk and vulnerability assessment on all applications and transmissions, and develop appropriate security approaches to secure information and transactions. This assessment will include data provided to the Mobility Marketplace, API, mobile applications, and any other sources and consumers *of Open* Data Cloud data (see the Data Specifications, Management, and Security section for additional data management and privacy detail.)
- **Scale and responsiveness.** With the rapid rise of IoT such as cameras and sensors, the importance of a scalable data environment is critical. This can be achieved by implementing a distributed data store that provides scale and performance at a cost-effective price point.

Working with Sidewalk Labs to develop an analytics platform

UB Mobile PDX teamed with Sidewalk Labs to design a transportation analytics platform to help cities understand how roads are used and how people's actions respond to policy, infrastructure, and technology changes. Integrating this platform with the Open Data Cloud will enable data to be combined across different types of data sources and allow new applications to be developed. Opening up access to data will set the stage for innovation—by both UB Mobile PDX team members and members of Portland's active start-up community. The Open Data Cloud analytics platform will function in tandem with the data and analytics provided by Sidewalk Labs to offer an open source alternative for replicability in other cities and with a range of potential partners.

Tables listing current and anticipated new data sources are included in the Data Specifications, Management, and Security section.

Resiliency

Data captured from the Mobility Marketplace will improve Portland's resiliency, particularly improving emergency response. In an emergency, real-time CV data linked directly to the City's traffic operations and emergency response centers would allow for immediate changes to emergency vehicle routing, evacuation routes, or signal timing. UB Mobile PDX will allow also the City to efficiently provide information to users along with the city's other alert systems. Kiosks will be a critical part of resiliency strategy – both providing predictive information from sensors detecting localized seismic activity and supplementing Portland's Basic Earthquake

Emergency Communication Node (BEECN) sites where residents can find low-tech radio equipment to report severe damage and injuries. Intelligent sensors, including those installed as part of kiosks, will detect seismic activity feeding analytics that predict earthquakes.

Data Capture and Management

The Open Data Cloud is the "platform for understanding and analyzing data to address complex urban challenges and for measuring the performance of a transportation network" (USDOT Vision Element #4). Through documented, standardized APIs and well-defined geographic segmentation, the Open Data Cloud will enable the development of UB Mobile PDX analytics, the UB Mobile PDX app, and the UB Mobile PDX website.

Just as TriMet's developer resources and GTFS enabled a proliferation of transit apps, the Open Data Cloud (and the community of users and programmers who engage with it) will spark a proliferation of urban mobility apps and analytics, thus greatly increasing the productivity and value of the captured data.

UB Mobile PDX will follow industry standards for data capture and management, as further described in the *Data Specifications, Management, and Security* section.

Google and Beacon Data

TriMet is partnering with Google to install Bluetooth Low Energy (BLE) beacons at light rail transit platforms and bus stops. When detected by smartphone, these beacons can offer real-time travel and site information for customers. Simultaneously, the beacons provide enhanced trip data for a large number of customers. This new data set will be incorporated into the Open Data Cloud, providing analytics and setting the stage for the development of new open source apps.

Analytics and the Open Data Cloud

API Development Approach

APIs are specifications that allow for the programmatic exchange of data and information. Standard APIs and data formats do not currently exist for many of the data types to be collected for this project. Building on the Portland area's experience with GTFS, Open Data initiatives, and data archiving initiatives, UB Mobile PDX will develop standards and APIs for existing and new data sources.

TriMet's GTFS data specification was successful because it started with an established, real-world implementation as a foundation, then expanded it to accommodate additional needs as they arose. This discovery process was accomplished through ongoing stakeholder outreach, introducing changes only for demonstrated use in existing applications. More recently, the General Bikeshare Feed Specification (GBFS) was developed using a similar process.

Often, the greatest challenge with APIs is not developing standards, but adoption. Community outreach, therefore, is critical. With GTFS, adoption was greatly aided by Google's presence and the promise of transit data in Google Maps. UB Mobile PDX will leverage Smart City support—in addition to our past successes—to increase adoption.

The *Partnerships and Outreach* section describes the API development process in greater detail.

Segmentation

Segmentation refers to the process by which roadways and pathways are separated for data reporting and analysis. Today, there are a multitude of different and inconsistent approaches to segmentation. Some were created by private sector vendors, while others resulted from federal or City specifications.

UB Mobile PDX will work with different users (planners, app developers, operations managers, and researchers) to develop a single segmentation standard using OpenStreetMap. While the specific segmentation specification developed in Portland may not apply to other cities, the process by which that standard is developed—and agreed upon—will be transferable to cities throughout the United States.

The *Partnerships and Outreach* section describes the UB Mobile PDX approach to creating a single segmentation standard in greater detail.

Jasmine

Jasmine, a single mom, walks her 4th and 5th graders to school by way of 82nd Avenue in East Portland when air quality permits. (Her son, Xayne, has asthma). Nearly every city has a street like 82nd: a busy freight arterial, built for cars rather than people, that is also a socio-economic border between a low-income neighborhood and an industrial/commercial zone. Even though it is far from "pedestrian friendly," residents use it to get around. Jasmine sometimes borrows her neighbor's car or often takes transit to get to her job, also located along 82nd.

How does UB Mobile PDX help Jasmine?

Reduced Stress:

> She can rely on arrival times because congestion information is integrated with transit real-time arrival information

> She has access to full trip planning services by text or app and can receive notifications even when not connected to 3G or WiFi

Better Safety & Health:

> Air quality sensors near her kids' school provide up-to-the-minute information on air quality, which allow her to decide, with certainty, whether it's safe for Xayne to walk to school

Cost Savings:

> Bundled mobility services, purchased through the app, online, or at a kiosk, get her cheap or discounted tickets

> With greater access to alternative modal options, she saves money on fuel costs, maintenance, and parking, and receives green energy credits for using transit and zero emissions autonomous vehicles/Lyft rides and bike share rides

How CV/AV in corridors helps:

> By "talking" to kids' mobile apps, connected transit and fleet vehicles improve safety in school zones by sharing information about where and when kids are present

> CV and EV data help transportation managers make investments to better protect kids near schools by identifying where "near misses"—not just actual crashes—occur

> EV/AV and connected shuttle technology reduce congestion by moving more people in fewer vehicles

> Seniors and people with disabilities have better connections and more transit choices

> School-aged children have safer access to transit and routes to school, because vehicles can be "told" to reduce speeds or avoid school routes when kids are in transit

Technical Integration:

The analytics platform of the Open Data Cloud provides detailed safety data, including air quality, to the City of Portland's Active Transportation and Safety team, which can then identify the safest routes for kids to walk to school.

The technology behind UB Mobile PDX includes: dynamic content delivery to the UB Mobile PDX App; kiosks, online, and text notifications that leverage integrated transit real-time arrival information; traffic congestion; and air quality levels. It also provides for integrated payment and discounted tickets. All data information is available from the Open Data Cloud in standard formats via documented APIs and with consistent time stamps and geo-segmentation such that an app developer can easily combine all of these data sources.

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Ladders of Opportunity

> Job training and workforce programs connect Portlanders to opportunities provided by new technology

> Better connections link people to jobs, education, and services

4. User-Focused Mobility Services and Choices

5. Urban Analytics

7. Strategic Business Models and Partnering

9. Connected, Involved Citizens

12. Smart Land Use

Ladders of Opportunity

In Portland, as in cities around the United States, our least fortunate residents often live in neighborhoods with inadequate transportation infrastructure. In recent years, PBOT and our partners have set out to change that, but change is expensive and slow. Institutional barriers still exist, and prioritizing investments is challenging in a funding environment where there is vast unmet need and too little money.

The actions and investments described in other sections of this proposal target **connections** and **revitalization**, two key elements of the USDOT-described ladders of opportunity. This section describes these in greater detail, with special emphasis on a set of actions targeted to the **work** element.

Providing Opportunities and Jobs

Partnership with Worksystems to Provide New Opportunities

A Smart City with a full range of data analytics, EV and AV technology, ITS, and other systems will require new well-paying jobs to support that infrastructure. To ensure low-income and minority residents can access these jobs, our plan includes partnering with the regional Workforce Development Board, known as Worksystems. The City of Portland will dedicate $400,000 to develop a UB Mobile PDX Workforce Development Plan. Worksystems will engage key industry players to help develop a collaborative Workforce Development Plan.

The UB Mobile PDX Workforce Development Plan will include the following elements:

- New training program procurement and development
- Existing training program enhancement
- Cohort training for groups of new or incumbent workers
- On-the-job training and paid internships/work experiences

Worksystems partners with over 25 community-based organizations who serve underrepresented communities and deliver culturally competent career coaching.

In 2014, Worksystems launched Code Oregon. In 2 years, 16,500 Oregonians developed skills and coded language tracks. Code Oregon participants are matched with internship and on-the-job training opportunities to complement their learning. UB Mobile PDX will develop workforce training programs based on this model.

TriMet partnered with Worksystems on a still-outstanding Bus and Bus Facilities grant application to fund a Workforce Development Needs Report, in which Worksystems works with local employers to identify perceived workforce skill gaps, worker shortages, and training needs. UB Mobile PDX's Workforce Plan will build on these early efforts.

Other UB Mobile PDX Actions to Create Jobs

In addition to the Worksystems partnership described above, UB Mobile PDX will support job training and job creation in many other ways, as listed in Table 2 .

Table 2. Creating Jobs and Opportunity through UB Mobile PDX

Outcome	Action
Workforce development program to help low-income and minority residents access stable, well-paying jobs	Partner with Worksystems to develop a Workforce Development Plan and implementation actions to improve the UB Mobile PDX ladders of opportunity approach.
Application development and data analysis job training	Provide job training to students at Portland Community College (PCC) and to at-risk high school students in application development and data analysis through a partnership with Code for America and PSU. The science, technology, engineering and mathematics (STEM) education provided through these programs can open doors to higher paying jobs in Portland's growing technology sector.
Access to shared mobility jobs	Make EVs available at a low cost to community organizations and churches to offer a pathway to shared mobility jobs to community group members. This might mean that a shared EV owned by a church is used as a Lyft vehicle by a member on weekend evenings.
New job creation and training in the Smart City technology sector	Partner with Worksystems to prepare a program of workforce development to provide low-income and minority residents ladders of opportunity to stable, well-paying jobs in this growing field.
Connected vehicle equipment installation	Create new opportunities for jobs and training through CBOs like Southeast Works. The City of Portland will create a sheltered market contract or other mechanism to ensure that this work goes to people who might otherwise be left out of the technology economy.
Disadvantaged business enterprises	Continue the City of Portland's robust disadvantaged business enterprise (DBE) program, which requires that a percentage of City business goes to certified DBEs. When implementing UB Mobile PDX, the City will continue this practice for professional services as well as trades, to create a robust new call for services.
Traded sector employment	Create opportunities for small businesses to become Smart City experts -- and to support those businesses as they take their products to people around the country. As Portland implements UB Mobile PDX, the city and its entrepreneurs will become experts in Smart City technology. As other cities bring these technologies to their streets, our entrepreneurs will be ready to support them. We will begin this process with our partner cities. We have already made a link between our partner NoAppFee, a Portland startup, and a new market in Seattle, one of our partner cities.
Application development competition and start up support	Hold a challenge for the design and development app components to provide a high profile platform for burgeoning start-ups to compete with established industry leaders. The challenge could provide further support through leveraging the Jaguar Land Rover Innovation Incubator aimed at seeding new technology companies in Portland.

Providing New Connections

UB Mobile PDX will provide new transportation choices to Portlanders with safe, reliable, and affordable connections to the places people need to go every day: jobs, school, healthcare, and other essential services. **Table 3** shows our approach to providing new ladders of opportunity connections.

Table 3: UB Mobile PDX's Approach to Providing New Ladders of Opportunity Connections

Connection	Approach
Semi- or fully -autonomous shuttles	Shuttles focused on radial service from key transit stops will provide connections to jobs in the low-density Columbia Corridor. An autonomous service would broaden access, and reduce travel times and walking distances. Shuttle planning will consider the location of affordable housing and ensure services connect affordable housing to this important job corridor. Shuttles will also offer opportunities to serve Portlanders with disabilities, providing connections to fixed-route transit.
Powell/Division education corridor	The Powell/Division Corridor connects Mt. Hood Community College in Gresham, PCC on 82nd Avenue/Division, OHSU, and the PCC College Continuous Learning for Individuals Management & Business (CLIMB) job training center. By improving transportation in this corridor with better bus service, improved access to shared mobility services, better access to information, and improved multimodal safety, we can make it easier for people to reach these important educational destinations.
ADA mobility services	Today, people who require assisted paratransit service have to plan at least 24 hours ahead for basic transportation services. By partnering with TriMet and other service providers, the UB Mobile PDX app will help users find other ways to meet their needs rather than waiting for a dial-a-ride. This might mean providing a subsidized trip in a shared ride like Lyft, or helping people with trip planning that would allow using fixed route transit.
Access to information	A transportation app is only useful if the people who need it can access it and understand how to use it. UB Mobile PDX will provide low-cost smart phones to residents of targeted neighborhoods, access to free Wi-Fi to access information, and technology training. Together, these programs will not only make UB Mobile PDX more accessible, but will also help to bridge the digital divide.

Revitalizing Neighborhoods

Our demonstration corridors – Powell/Division, 122nd Avenue, and Columbia Boulevard – all serve areas and populations left behind by past transportation projects and improvements. In many cases, these areas lack basic infrastructure like sidewalks and safe pedestrian crossings. UB Mobile PDX cannot in itself fill the need for major capital investments. However, it *can* direct resources to these corridors – and collect data from them – that set the stage for transformative infrastructure and management improvements.

UB Mobile PDX Implementation: City-wide and Demonstration Corridors

- Human-centered design puts Smart City investments where people need them most
- Citywide implementation of CV and electric vehicle technology improves safety and mobility and addresses Portland's bold climate goals
- Real-time information from kiosks, sensors, and the UB Mobile app leads to safer streets and better transit connections


1. Urban Automation


2. Connected Vehicles


3. Intelligent, Sensor-Based Infrastructure


4. User-Focused Mobility Services and Choices


5. Urban Analytics


6. Urban Delivery and Logistics


7. Strategic Business Models and Partnering

8. Smart Grid, Roadway Electrification, and EVs


9. Connected, Involved Citizens


12. Smart Land Use

UB Mobile PDX Implementation: City-wide and Demonstration Corridors

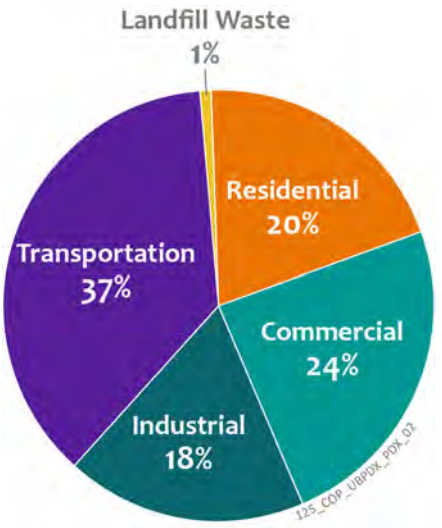
City-wide Implementation: Capitalize on Opportunities to Improve Transportation for all Portlanders

Using real-time data, the City and its partners will improve mobility, access, and safety for all Portland-area residents by enhancing EV infrastructure and connected vehicle technology, deploying Mobileye, and deploying freight applications in all areas of the city.

Electric Vehicles and Infrastructure

UB Mobile PDX will broaden access to EVs and bikes, expand electrification of City and transit fleets, improve the smart grid, and expand access to EV charging infrastructure. This investment will further Portland's progress toward its climate change goals to reduce local carbon emissions by 80% from 1990 levels by 2050, with an interim goal of 40% by 2030. (See **Figure 3** for current carbon emissions by sector.)

With a large share of hydro power today and a mandate to shift to renewables, the carbon intensity of Portland's electricity is poised to fall to nearly zero in the decades ahead. Oregon's only coal-fired power plant will close in 2020, and a 2007 law requires large electric utilities to get 25% of their power from new renewables by 2025. In March 2016, Governor Brown signed a new law ensuring 50% new renewables by 2040 and eliminating out-of-state coal supplying Oregon by 2035.



(Source: sector-based inventory, 2013)
Figure 3. Total Multnomah County Carbon Emissions by Sector

As a result, shifting from gasoline and diesel vehicles to EVs is a key strategy for reaching Portland's Climate Action Plan goals. As we move toward the state goal of having 15% of all new vehicle sales be electric by 2025 and 100% by 2050, we must make our grid smarter to meet charging needs and explore new ways to provide charging infrastructure throughout the city. UB Mobile PDX will enable the City to expand EV adoption to all neighborhoods and prepare the grid for EVs to become a mainstream technology through the following:

- **Increasing Fleet Electrification.** The City is already on its way, but is committed to more than doubling the current number of EVs with UB Mobile PDX. We will also add 60 charging stations for City fleet vehicles.
- **Installing Charging.** We will develop e-mobility hubs that will collocate bikeshare stations with the necessary conduit and electrical supply to charge both electric bicycles and cars. The hubs will be at key locations that are attractive bikeshare destinations as well as visible to EV drivers. These may be located in our demonstration corridors or elsewhere. Visible fast charging stations will drive consumer adoption of EVs.

- **Expanding Workplace Charging Program.** The U.S. Department of Energy (DOE) Workplace Charging Challenge program demonstrated that employers that provide electric charging stations see a six-fold increase in EV adoption among their employees. We will work with transportation management associations (TMAs) and business associations to expand workplace charging programs by adding 40 new employers by the end of 2018 by offering discounted or free charging equipment.
- **Electrifying Transportation Network Companies and Taxi Fleets.** Portland's Electric Avenue already supports a number of Uber and Lyft drivers with EVs, as well as the only all-electric taxi company in the U.S., EcoCab. We will expand the availability of highly visible DC fast chagrining stations to encourage more TNCs and taxi drivers to choose electric. The City may also explore policy options such as reduced fees for EVs or increased fees for higher emission vehicles.
- **Electrifying TriMet Bus Fleet.** TriMet is already moving to electrify its fleet and has applied for grant funding to purchase 5 electric buses. With UB Mobile PDX as a springboard, TriMet will expand its fleet electrification program by purchasing additional buses and adding charging infrastructure to support electric buses.
- **Installing Wireless Charging.** We will install stationary wireless charging devices and dynamic wireless charging devices to be demonstrated as part of a commercial pilot. Because the technology is wireless, drivers will be able to recharge electric autonomous vehicles by hovering over a charging coil or selecting routes with dynamic charging. This technology will be used for Pangea Shuttles in the demonstration corridors, discussed below, and may allow for expansion of EVs as carsharing vehicles.
- **Enhancing the Smart Grid.** Portland General Electric (PGE) uses Sensus's FlexNet radio frequency smart grid network to meet our smart electric metering needs. We will use this investment in a dedicated, secure, long-range network infrastructure and spectrum bandwidth to provision Smart Grid, Smart Lighting, and Smart City applications, and take advantage of existing communications infrastructure. We will use this to demonstrate a model of how cities can partner with utilities and private companies to address smart city needs. In addition, UB Mobile PDX will help drivers maximize their use of lower-cost and renewable power, and will help gather data about charging station utilization and reliability that will improve the charging experience.

Connected Vehicle Fleet Deployment

The City, agency partners, FedEx, and other businesses with fleets will pilot connected vehicle and connected people technologies throughout the city. Fleet vehicles will be outfitted with dedicated short-range communications (DSRC) using the vehicle's on-board unit (OBU) port. To further increase the number of vehicles feeding data to the open data cloud, UB Mobile PDX may gather data from TNCs, carshare providers, and freight participants. Connected people technologies turn active transportation uses – equipped with a simple smartphone app – into another linkage in the connected vehicle system.

We will explore opportunities to tie ODOT's ambitious RUC pilot, OReGO, into UB Mobile PDX 's demonstration project. OReGO allows users to pay by the mile instead of a per-gallon fuel tax and, if fully implemented, will provide a sustainable source of funds for road maintenance, preservation, and improvements even as the statewide fleet becomes more efficient. It also provides the first DOT-driven ubiquitous connected vehicle and payment platform. OReGO participants can become part of the connected vehicle fleet through their existing OReGO certified account managers software using mobile data transfer.

OReGO is the nation's first DOT-driven, private connected vehicle fleet. UB Mobile PDX provides the platform to turn private and fleet vehicles participating in OReGO into true connected vehicles.

Mobileye

As part of the UB Mobile PDX demonstration project, all TriMet buses will be outfitted with Mobileye to help bus operators avoid potential collisions with pedestrians and bicyclists. Mobileye supports TriMet's proactive approach to safety: predict and prevent hazards rather than simply respond to incidents. TriMet will use the data collected to identify key locations and situations that contribute to potential hazards for pedestrians and bicyclists.

UB Mobile PDX Demonstration Corridors: Focused Implementation to Understand Results

Transportation solutions do not exist in isolation—every mode, intersection, traffic control device, and use is connected to a vast network of systems. System users make millions of choices each day to string together various parts of this vast network to make comprehensive trips. UB Mobile PDX has identified three corridors that host some of Portland's biggest challenges and offer an opportunity to deliver tangible, people-oriented results. These are the **Powell/Division Corridor**, **122nd Avenue Corridor**, and **Columbia Boulevard Corridor**.

All three of these corridors represent an investment in places where low-income and people of color live and work in higher numbers than elsewhere in the city, and where past transportation projects have impacted communities. The corridors are described individually in more detail below.

UB Mobile PDX demonstration corridor investments will be focused on one or more demonstration corridors, with some being made in all three corridors. The Annotated Site Map (**Figure 4**, *following page*) depicts UB Mobile PDX corridor infrastructure and investments.

Multi-Corridor Demonstrations

While each corridor has specific demonstration goals and actions, several programs will be deployed in all three corridors. This approach provides a targeted demonstration to show results while demonstrating—across a wide variety of environments—lessons that can be generalized to the city, region, and nation. The following programs will be deployed across all corridors:

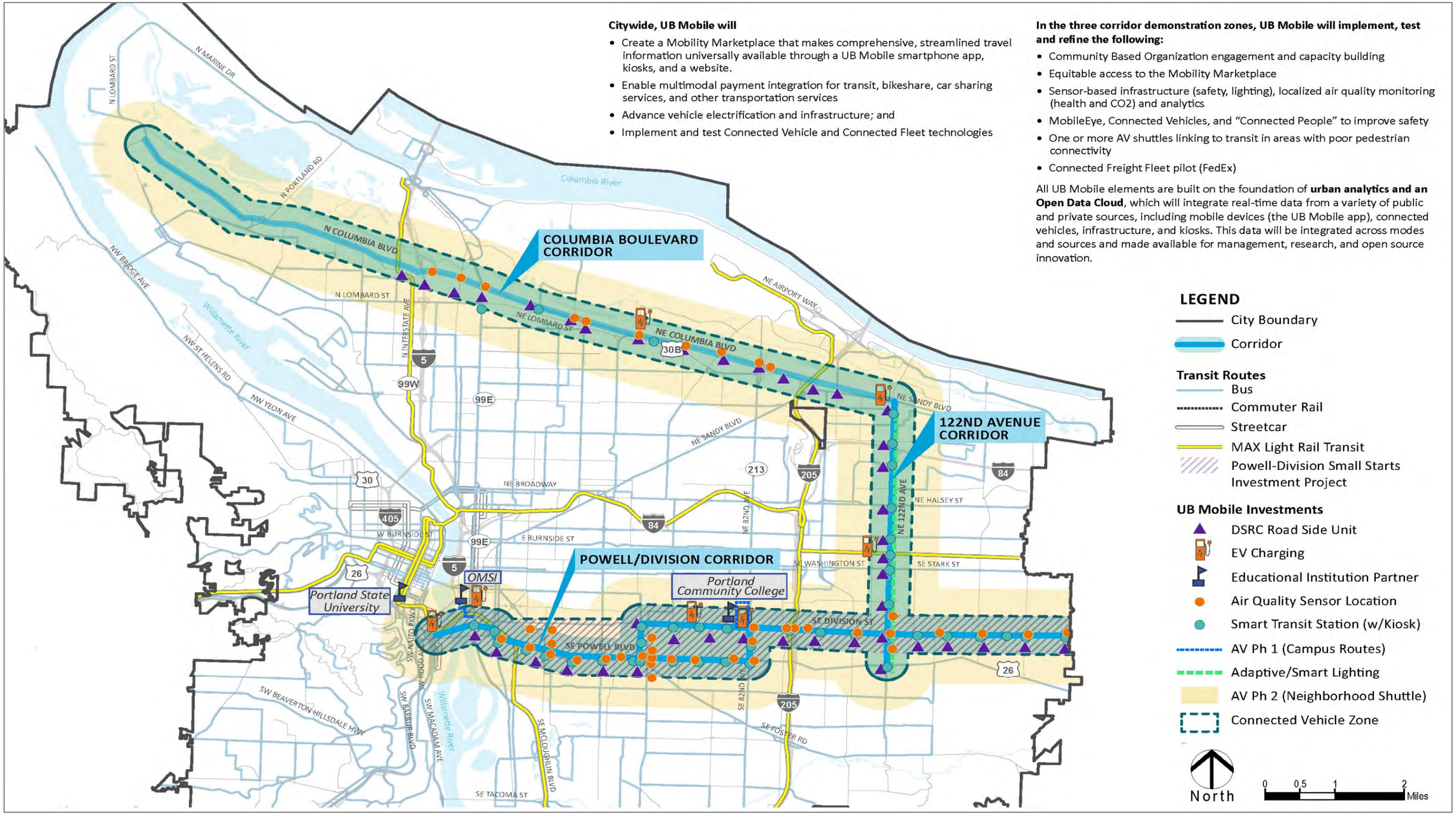
- CVs
- Urban Automation
- Intelligent Sensor-based Infrastructure

Connected Vehicles

CV applications hold promise for significant safety, corridor throughput, and mobility improvements. UB Mobile PDX will use sensors and DSRC radios to provide data to our traffic signals to improve throughput and reduce congestion in these corridors. Incorporating data from TriMet's equipped fleet, private sector freight partners that opt-in, and the UB Mobile PDX app will provide corridor metrics to help determine which applications are most effective in achieving our safety and performance goals and driving future prioritization decisions.

UB Mobile PDX will gather data on intersection operations across the three demonstration corridors using DSRC roadside transmitter units (RSUs) and OBUs installed in fleet and private vehicles. We will outfit hundreds of traffic signals throughout the corridors with CV equipment, including DSRC radios from NXP. The Transcore traffic management system will collect basic safety messages (BSMs). Some CV applications will be expanded to include ECO driving improvements associated with progression speed recommendations and queue management.

Figure 4. Annotated Site Map



Connected Vehicle Applications and Performance Metrics

UB Mobile PDX will test and demonstrate the ability of CV applications to meet City needs as shown in **Table 4.**

Table 4. Performance Measures for Proposed CV Applications

City Needs	CV Application	Performance Measures
Reduce crashes at high crash intersection locations	Red Light Violation Warning	• Reduction of signal violations • Reduction of crashes at intersections
Improve pedestrian safety on heavily traveled bus routes	Pedestrian in Signalized Crosswalk Warning	• Reduction of pedestrian collisions with transit buses • Number of warnings generated
	Vehicle Turning Right in Front of Bus Warning	• Number of warnings generated
Improve safety of visually and audibly-impaired pedestrians	Mobile Accessible Pedestrian Signal System (PED-SIG)	• Waiting time at intersections for crossing • Reduction of pedestrian crossing violation
Balance mobility in heavily congested areas	Intelligent Traffic Signal System (I-SIG)	• Average speed • Average wait time at stops • Average travel time • Average throughput at intersections • Number of hard acceleration/deceleration events
Evacuation and unusual situation alerts	In-vehicle information	• Acceptance and driver interviews
Transit reliability	Transit Signal Priority	• Improved reliability of travel times
Freight reliability	Truck signal priority	• Improved reliability of first-mile travel times
Emergency response	1st responder signal pre-emption	• Improved emergency response times

CV Architecture

UB Mobile PDX will leverage existing investments to communicate with signalized intersections. The existing infrastructure provides data about the signal phase and timing (SPaT) and is currently available through smart phone applications via a partnership with Connected Signals.

We will use advanced traffic controller (ATC) next-generation Linux signal controllers for roadside edge computing, to allow analysis at the source of the data, and will develop multi-processor applications with ATC software providers. This will facilitate collection and dissemination of data for simplified transit/truck priority, CV detection augmentation, and edge path SPaT optimization. This approach will save the City operations and maintenance costs and will allow for easier replication by other cities by reducing points of failure and automating the optimization processes with real-time feedback. We will also use standard technologies such as radar to detect downstream and upstream vehicles and benefit from CV functionality even with vehicles not equipped with DSRC radios.

UB Mobile PDX will also install DSRC roadside equipment (RSEs) and RSUs on PBOT traffic signal poles, allowing the data to be captured at traffic controllers and analyzed by City traffic engineers. **Figure 8** illustrates the concept of the CV demonstration architecture.

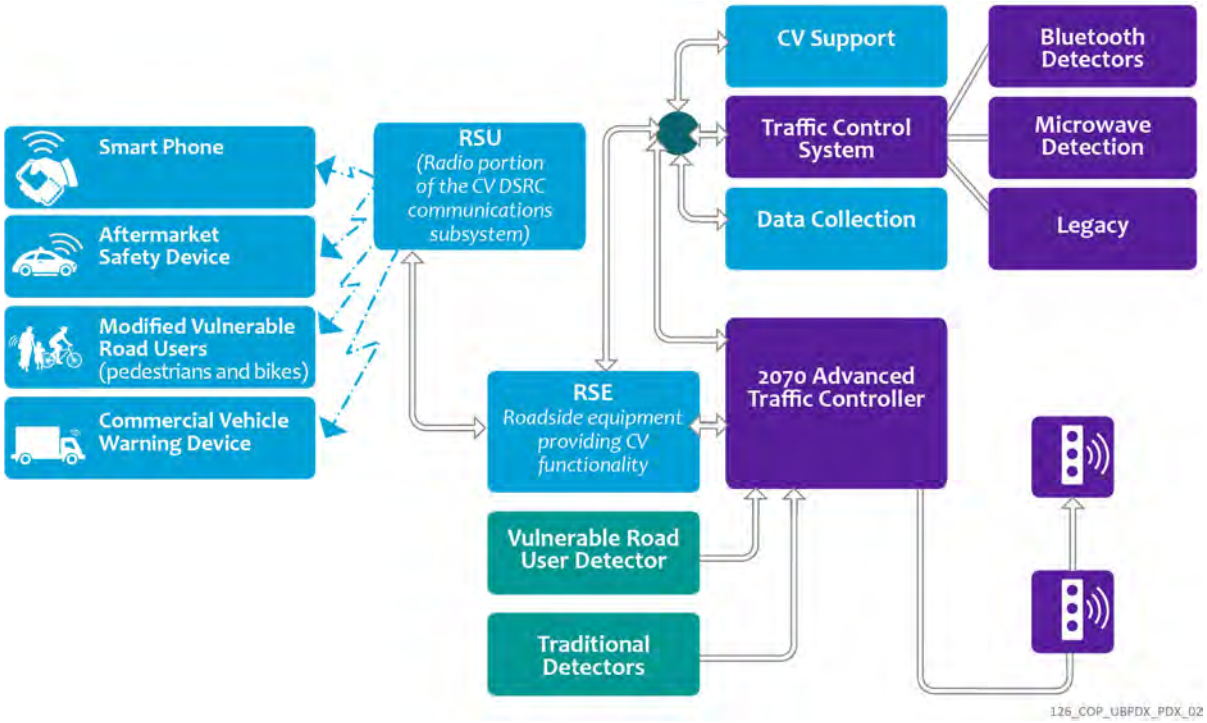


Figure 8. UB Mobile PDX CV Architecture

Urban Automation: Moving AV Technology Forward

UB Mobile PDX will begin with AV deployment over repeatable routes and later expand into neighborhoods. The original routes will include campus deployment at Oregon Museum of Science and Industry (OMSI) and PCC.

Through deployment in controlled environments, we will learn more about local and state policy issues, understand user acceptance of AV, and deploy the necessary education and outreach to support further acceptance. UB Mobile PDX will work with an autonomous shuttle providers, such as the international leader EasyMile to immediately deploy autonomous campus shuttles. This will allow us to begin deployment early in the program. EasyMile has experience in transporting passengers in semi-controlled environments in numerous cities in Europe and Asia and is currently testing at the GoMentum Station in Concord, California.

After successful EasyMile deployment of larger shuttles on highly repeatable routes, UB Mobile PDX will use locally manufactured vehicles from Pangea to deploy smaller, electrified and semi-autonomous circulator routes that link lower density neighborhoods or employment areas to high frequency transit lines. **Error! Reference source not found.**illustrates how shuttle service could be used to feed into TriMet's existing service on Division and Powell streets, using fixed route and deviated route services to target connectivity gaps where sidewalks are missing or in poor quality. UB Mobile PDX would phase in semi-autonomous and fully-autonomous technology for these targeted neighborhoods.

Our partners General Motors (GM) and Lyft have recently announced that, within a year, they will begin testing a fleet of self-driving Chevrolet Bolt electric taxis on public roads. The City of Portland has already begun to understand and address AV regulatory and policy issues, and will use the Smart Cities Challenge to accelerate this process. Customers will have the opportunity to opt in or out of the AV pilot when hailing a Lyft car from the company's mobile app.

Intelligent Sensor-based Infrastructure and Data Analytics

Air Quality Monitoring

Portland's vision for a smart city is one where people can travel by foot or bicycle without fear of ill effect from air toxins. Air pollution disproportionately impacts low-income communities, making monitoring—and more important, action—an important equity action. UB Mobile PDX will have one of the first distributed network of air quality stations to understand the impacts from traffic emissions on public health and climate change. Strategic stations equipped with high-end instruments will be augmented with a larger number of widespread, low-cost sensors to provide real-time air quality information across the city. CV technology will also provide real-time information on emissions from vehicles traveling throughout the city.

Data from the sensor-based network will be used to inform public health and equity policies and investments, advance Climate Action Plan goals, and evaluate Portland's continued mitigation strategies for transportation-related emissions. A key outcome of the urban air quality monitoring infrastructure will be documenting the lessons learned to create a replicable model for other cities to develop their own networks.

To accomplish these goals, UB Mobile PDX will do the following:

- Design procedures to develop, deploy, and maintain a network of low cost sensors to measure urban air quality.
- Create a framework that accounts for the primary technology challenge of creating affordable sensors that overcome sensitivity limitations and interference issues.
- Use statistical analysis to provide baseline data and evaluate Portland's Climate Action Plan strategies.
- Use data to inform project and program priorities particularly as it relates to improving air quality in low income communities.
- Create replicable, field-tested study protocols that are replicable to other cities.

The City of Portland has invested in two **Curbside Labs for Emissions and Atmospheric Research (CLEAR)** stations strategically located at intersections within the Powell/Division corridor. To our knowledge, Portland is the only city in the U.S. to have long-term curbside air quality stations on an arterial roadway.

The stations demonstrate Portland's dedication to the health and welfare of residents and interest in understanding local impacts of emissions.

Portland's CLEAR stations are equipped with federal reference method and research grade instruments capable of measuring nitric oxide (NO), nitrogen dioxide (NO_2), particulate matter with aerodynamic diameter < 2.5µm ($PM_{2.5}$), black carbon (BC), and CO_2, as well as meteorological data. CLEAR stations are housed in repurposed signal cabinets and will be used in conjunction with low-cost sensor devices, placed primarily in low-income neighborhoods, as part of UB Mobile PDX.

The sensors will be used for ongoing field evaluations of how changes in traffic fleet composition, traffic signal operations, and implementation of freight priority signaling affect traffic-related pollutants. The evaluations will provide new data-based models for other cities pursuing climate change adaptation and mitigation strategies.

Partnering with Sidewalk Labs and Intersection will allow us to locate many more kiosk-based sensors. Kiosks could include sensors that track environmental conditions (e.g., temperature, atmospheric pressure), air pollutants (e.g., carbon monoxide, ozone), natural and human events (e.g., acceleration/vibration, sound pressure), and city activity (e.g., average roadway speed, pedestrian traffic, clogged stormwater basins).

Electrification and Electric Vehicles

Low-income and minority residents suffer the most from vehicle air pollution, often drive environmentally inefficient vehicles, have longer commutes, and spend more of their income on fuel and transportation. UB Mobile PDX is an opportunity to help more Portlanders move to electric mobility and a carbon-free grid. While many electrification improvements will occur city-wide, UB Mobile PDX will expand the use of EVs in our demonstration corridors:

- **Provide EVs at a Lower Cost.** UB Mobile will launch the **nation's first bulk-buy program** for used EVs to put affordable EVs in the hands of low-income drivers in our demonstration corridors. This program will identify existing incentives for home charging, including programs for residents of multifamily housing.
- **Demonstrate Electric Carsharing in Low-income Communities.** UB Mobile PDX will implement a demonstration project placing used electric vehicles at CBOs in our demonstration corridors. These vehicles will be managed by CBOs and placed into peer-to-peer carsharing platforms like Turo and Getaround, to create a low-cost carsharing option.

  UB Mobile PDX will partner with community development corporations (CDCs) to provide used EVs for affordable housing developments. In addition to the vehicles, UB Mobile PDX will install charging stations onsite or in adjacent public right-of-way. This program would provide the residents a structured opportunity to use EVs on a check-out basis.
- **Demonstrate Electric Bikesharing in Low-income Communities.** The City will work with Motivate and the bicycle equipment provider, SoBi, to conduct one or more demonstration projects with SoBi prototype smart e-bikes. We will learn bicycle and system design, gauge customer interest and concerns, and raise public visibility of e-bikes and the plans for electrifying BIKETOWN. Through UB Mobile PDX, we will test whether e-bikes can be used to expand the BIKETOWN service territory farther from the central city by deploying electric bikes in our demonstration corridors.

  Bikeshare in these less dense areas could address first- and last-mile issues and provide convenient access to local destinations. In some locations, e-bike charging will be integrated into electric vehicle charging stations in the public right-of-way. Beyond BIKETOWN, we will provide e-bike loans to leaders in low-income, minority, and immigrant communities to demonstrate how e-bikes can support mobility and access for households.
- **Focus EV Marketing in Underserved Communities.** In partnership with CBOs, UB Mobile PDX will target marketing efforts to ensure culturally specific messaging and messengers for both EVs and e-bikes. We will expand our bikeshare marketing partnership with the Community Cycling Center to include e-bikes by promoting the use of e-bikes to women and communities of color. For EVs, we will work with CBOs to share information about access to low-cost electric vehicles.

Individual Demonstration Corridors

UB Mobile PDX will make specific investment in the corridors as discussed below. Each corridor was selected because it provides an opportunity to demonstrate a specific outcome, as follows:

- **Enhance Transit Investment:** The Powell/Division Corridor will demonstrate how Smart City applications create a multiplying factor for traditional infrastructure investments, with a specific focus on improving the lives of those living and working in the corridor through increased connectivity to employment, education, and other services.
- **Efficiently Move Freight and Improve Job Access:** The Columbia Boulevard Corridor will demonstrate approaches that improve freight priority for industry in the interest of boosting reginal competitiveness. It

also provides an opportunity to demonstrate how Smart City technologies can improve job access for low and middle-wage workers.

- **Equitably Enhance Safety:** The 122nd Avenue Corridor will use Smart City investments to provide higher levels of safety and access for users and all modes of travel with the goal of providing enhanced connectivity to employment and education.

Powell/Division Corridor

How can we combine transit investments and Smart City technologies to improve quality of life in a diverse and changing corridor?

The Powell/Division Corridor (**Figure 6**) offers a microcosm of Portland and many other U.S. cities. The inner segment of Division Street is home to recent dense urban infill development, with little parking provided for the new units. This segment is surrounded by an older and more affluent section of Portland. Further east, some of the most ethnically diverse neighborhoods in Portland are located along both Powell and Division, with more than 50 languages spoken at some elementary schools in the area. These neighborhoods are also home to some of our most vulnerable and transit dependent populations, along with some of our most neglected transportation infrastructure. A snapshot of the corridor's diversity is shown in Figure 10. The corridor connects several educational institutions including Mount Hood Community College (east of the demonstration corridor), PCC, OMSI, PSU, and OHSU.

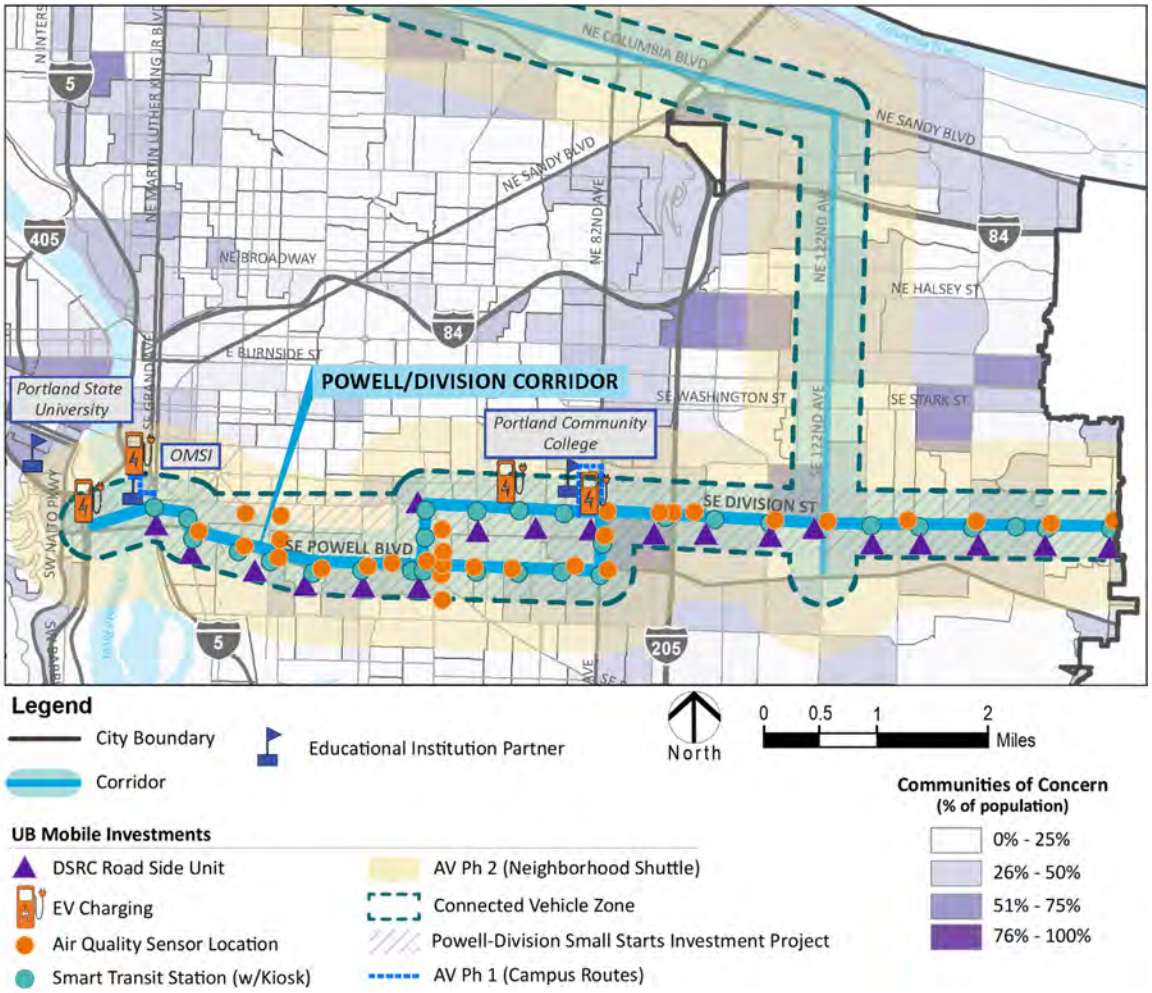


Figure 6. Powell-Division Corridor Demonstration Project Map

Operations on the corridor are constrained. During rush hour, buses are often standing room only or too full to pick up more passengers. Buses are often stuck in traffic, making travel time unreliable. This can have a devastating effect for those who are most transit-dependent, with the least flexible jobs.

Many parts of Powell Boulevard lack sidewalks and bike facilities. Access to transit is problematic in significant portions of the corridor, with bicycle and pedestrian gaps along bus routes, major arterials, and many local streets. These neighborhoods need improved crossings for pedestrians and bicyclists, particularly as they access schools and transit stops. Residents need internet access to access real-time transit arrival information or the locations of bike-sharing and ridesharing vehicles.

Enhancing Transit

Through UB Mobile PDX, TriMet and buses will be fully equipped with DSRC radios interfaced with onboard data hubs to integrate all sensor information, including GPS. This will allow better rider information and traffic and operations and maintenance diagnostics, leading to improved corridor travel times through next generation next generation data collection, coordination and analytics.

Leveraging the $150-million investment in the new 15-mile Powell/Division Corridor BRT project (currently in the Federal Transit Administration's Project Development phase), a CV demonstration in this zone will take advantage of the existing communications infrastructure in the corridor to complete an advanced transit signal priority implementation.

Improving Safety and Access

We will use the Powell/Division corridor as a demonstration site for incorporating, testing, and measuring urban automation concepts into a BRT corridor. UB Mobile PDX offers the promise to explore autonomous technology-based systems for driver assistance and collision avoidance on the bus fleet, including features that sense pedestrians and cyclists to improve safety for vulnerable users.

The Powell/Division Corridor will host neighborhood shuttles, focused at locations with the lowest levels of pedestrian connectivity. We will partner with local- based Pangea and GM/Lyft to provide the vehicles and will use Worksystems to identify operations and maintenance jobs.

Commute times matter to low-income families

For many families living in more affordable areas in east Portland, commute times can be long. Commute times – particularly those under 15 minutes – are a key indicator for social mobility. A Harvard University researcher found that 60% of upward mobility observed in a sample of children could be explained by their parents' commute times. Parents with shorter commutes spend less money on transportation and less time in transit, leaving more for things like childcare and food.

UB Mobile will integrate with NoAppFee to provide a one-stop-shop for information on housing affordability, availability and commute costs and options. This will help individuals and families understand the full cost of housing and transportation when they are applying for housing.

NoAppFee.com
FREE & SIMPLE RENTAL FINDER

Measurement and Evaluation

One reason the Powell/Division Corridor has been selected as a demonstration corridor is to leverage the significant investment that has already been made there. This corridor has the following sensors and supporting communication:

- Existing fiber-optic backbone on Powell Boulevard
- Transit signal priority system

- Extensive traffic detection supporting an adaptive signal control system
- Bluetooth traffic travel time collection
- Limited but growing investment in air quality sensors complimenting the U.S. Environmental Protection Agency (EPA) regional air quality station (also located in the corridor)

Charles

A truck driver for many years, Charles has smoked for most of his adult life, and between the fumes from vehicles, his smoking, and other allergens he has developed respiratory problems, including asthma. Charles lives near a major arterial street in North Portland and keeps his windows closed—even on warm days—because his asthma acts up when they're open.

Charles has been looking at job retraining through the partnership between his union, PCC, the City, and the VA. As a veteran there are additional programs that he can take advantage of through this process. Before UB Mobile PDX, Charles drove to appointments, to shop, and to meet friends because he was not comfortable walking long distances to transit.

How does UB Mobile PDX help Charles?

Better Walking and Transit Options:

> Provides him with optimal wayfinding/routing to medical and training services

> Makes it more feasible for him to increase his physical activity by walking short distances because he knows when/where there is a transit connection

> Makes it more feasible for him to increase his physical activity by walking short distances with the confidence that he won't trigger his asthma due to poor air quality

Workforce Development Opportunities

> UB Mobile PDX supports opportunities for Charles to make a living wage, for example installing or servicing the kiosks or a similar technology-based career track at a regional tech firms.

How CV/AV in corridors helps:

> Sensors located in a kiosk on his street (and others throughout the corridor where he travels) identify when air quality is poor. This allows the Mobility Marketplace to make pricing adjustments—transit fares are half price in that area that day, or Waze routes people around that zone—to reduce the number of driving trips and lower emissions in the area

> EV/AV shuttle provides access to industrial jobs near the airport, shortening or eliminating the need to walk to the bus stop without exacerbating air quality problems in the corridor

> CVs regulate their speeds at times/in areas where air quality is poor

> Electrification of freight could allow Charles to resume his job driving freight delivery in an electric truck

Technical Integration:

Analytics support wayfinding and routing, which requires integration of multiple data sources. Integrating information about transit connections with seniors in need of transit connections has helped outreach groups identify and connect with Charles, and enabled them to inform him about transit connections to basic services.

Columbia Boulevard Corridor

How will the Smart Cities demonstration enhance Portland's economic engine by linking workers to jobs and freight to market?

As Oregon's single largest industrial area and Portland's busiest multimodal freight transportation corridor, the Columbia Boulevard Corridor (shown in **Figure 7**) is critical to the economic health and vitality of the Portland metropolitan region. It supports over 28 square miles of industrial use and traded-sector businesses and is a designated industrial sanctuary. Columbia Boulevard is a freight lifeline between those businesses and the many customers they serve, providing connections major roadways and interstates, as well marine terminals, rail lines, and airport facilities.

Today, the corridor is home to over 65,000 jobs with average wages of $44,800 per year (see Figure 11). Because much of the land use is low density (warehousing, business parks, and industrial land), the corridor is difficult to reach on foot or by transit.

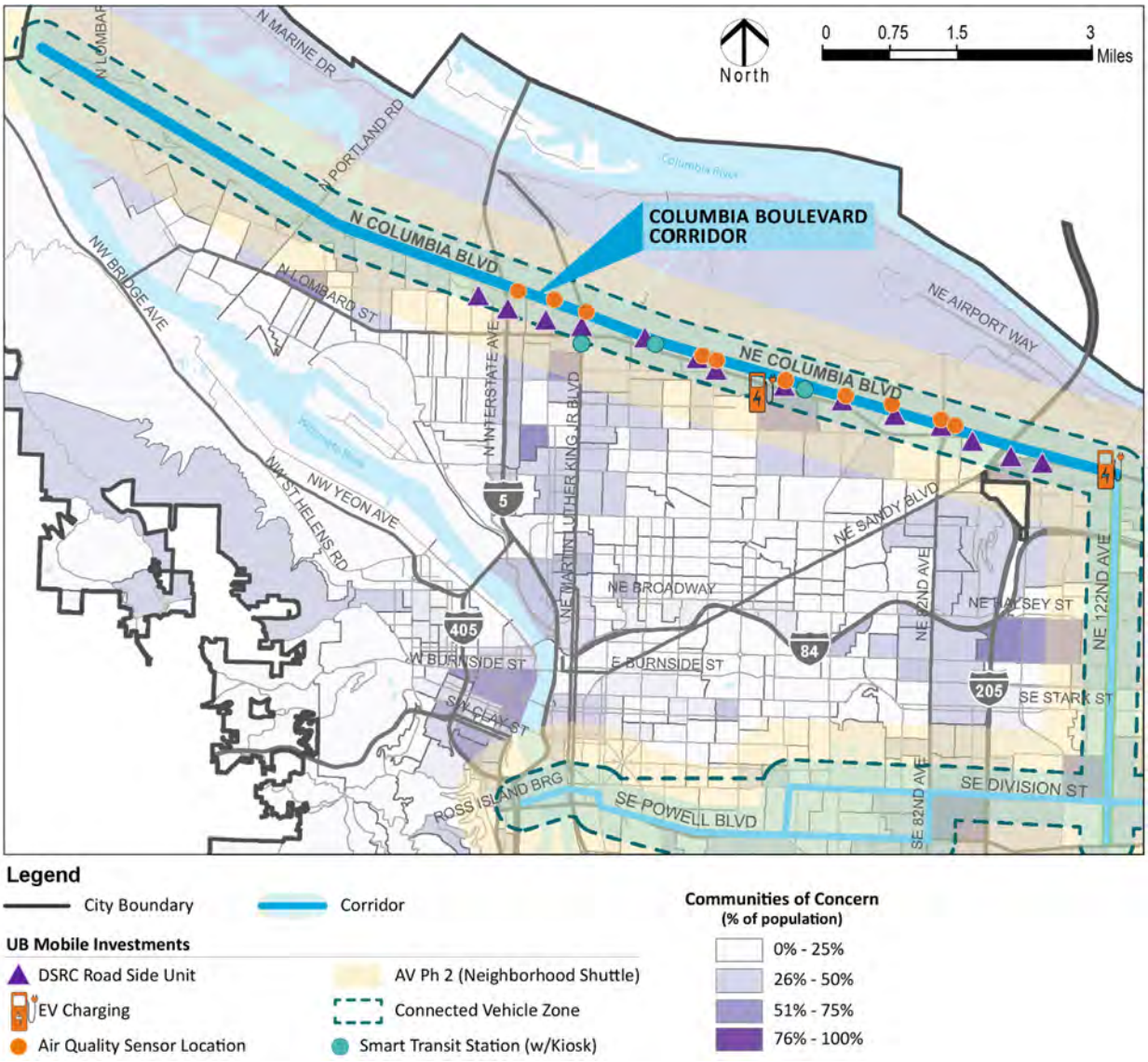


Figure 7. Columbia Boulevard Corridor Demonstration Project Map

Over the last 20 years, a series of transportation investments has improved access and mobility. However, greater-than-expected growth in jobs and housing have led to frequent congestion, causing delays in the movement of goods and threating the ability of businesses to maintain reliable travel times and cost competitiveness. For businesses exporting traded sector goods, the first mile is the most inefficient, which impacts existing businesses and corridor growth.

Connecting Industry to our Smart City

UB Mobile PDX will partner with Portland's biggest freight vehicle manufacturer (Daimler, together with their Freightliner division) and the area's largest freight companies to understand and improve freight traffic conditions in the Columbia Boulevard Corridor. FedEx Air and FedEx Ground distribution and consolidation centers will enhance sharing of operations data with trucks acting as probes to track traffic activity, and provide real-time data that will connect to the City's traffic control center. This data will provide better information for management of signals and ITS applications in the corridor and will allow businesses to make better decisions on how efficiently get their products to market.

The demonstration will employ CV technology to leverage and expand the investments already made in the corridor, such as freight signal priority. Using a combination of DSRC and data from our private sector partners, we will be able to provide a more robust set of choices for strategic routing of freight to improve time to market for all corridor users.

Automation and Access

Heavy freight traffic on Columbia Boulevard leads to significant safety and air quality concerns, including conflicts between heavy freight vehicles and auto, bike, and pedestrian traffic. UB Mobile PDX will leverage technology developed by our partner Daimler/Freightliner to demonstrate the safety features and air quality benefits of heavy trucks with autonomous functionality. Daimler/Freightliner has developed the Freightliner Inspiration Truck, the first licensed autonomous commercial truck to operate on an open public highway in the United States. While this truck has been used in limited access settings, we will demonstrate the use of this vehicle in mixed-use corridor traffic.

UB Mobile PDX will also capitalize on the unique opportunity to offer semi-autonomous or even autonomous transit service to and from parking lots at Portland International Airport, located at the east end of the Columbia Boulevard Corridor. This will not only provide valuable lessons in a controlled environment, but will help familiarize the traveling public with AV concepts.

Better Information to Inform Corridor Management

Signals throughout the corridor are neither intertied nor timed for the heavy concentration of truck activity. As a result, travel through the corridor can be unpredictable, affecting the many companies that depend upon transportation delivery certainty. UB Mobile PDX will leverage planned ITS infrastructure investment, adding functional components. The project will install equipment and integrate devices with City, ODOT, and TriMet transportation operations centers.

UB Mobile PDX will install detection devices on rail crossings in the corridor that will communicate with DSRC to disseminate information more broadly (e.g., to dispatchers and drivers). This will allow truck queueing at the container terminal or other properties to be monitored to assist with planning for the most efficient travel.

Building from the success and lessons learned on the Powell/Division Corridor, we will install air quality monitors to identify benefits and impacts of system management strategies.

Solving First-mile/Last-mile Challenges

The industrial employment area along the Columbia Boulevard Corridor spans the length of the city, more than 15 miles east to west. This area has many jobs dispersed in low-density buildings and warehouses creating a classic first mile/last mile problem for transit. TriMet's Service Enhancement Plan calls for an innovative

community connector. We will provide a contracted automated vehicle connector service that will connect to TriMet service at Parkrose Transit Center to the employment area near the airport. We will supplement TriMet's service with an electrified autonomous neighborhood circulator shuttle that will expand the station area influence, dramatically shorten trips, and potentially eliminate a transfer.

Hong

Hong, a Vietnamese immigrant, works in the Columbia Corridor in North Portland and lives with his sister in East Portland, even though he would like to move into a place of his own. To get to his job, which has a strict 8:00 a.m. start time, he must travel along 122nd, a major arterial in East Portland that is often congested. Congestion increases the amount of "buffer" time he must add to his commute to get to work on time.

How does UB Mobile PDX help Hong?

More Reliable and Active Commute:

> Connected vehicle technology improves the reliability of his commute by reducing the amount of "buffer" time needed to make it to work on time

> Analytics support increased bus service on 122nd to that now, when he works the early or late shifts, he has the option to use transit

Help Finding a Place to Live:

> The NoAppFee app, enhanced to support the Vietnamese language, integrates travel information and costs from transit, which helps him find an affordable place to live with a short, reliable commute. He can also identify safe walking and biking routes in his new neighborhood.

The Support of Community:

> The free calling on the kiosks allows him to talk with family in Seattle who help him better integrate into a new culture.

> He recently heard about a course offered, in Vietnamese, through a partnership between the City, APANO, PCC, and a wireless provider, that can help him learn about basic "smart" technologies. At the end of the course, he will receive a free pre-paid smartphone that will allow him to use UB Mobile PDX and connect with family in Seattle and Vietnam.

> His new smartphone helps him quickly connect, via NoAppFee, with landlords who have rentals in his price range and increases his access to transit options

How CV/AV in corridors helps:

> AV shuttle provides "last mile" service to industrial jobs south of Portland International Airport from Parkrose Transit Center, which is served by the bus line that serves 122nd.

> Autonomous shuttle offers EV and AV trip data. Origin and destination and time of day data provide more information about where (and when) there are transit service gaps.

Technical Integration:

Data analytics have determined that Hong is one of many who are trying to get from East Portland to the Columbia Corridor. This information allows TriMet to make transit service for Hong and others a priority. Finally, analytics have improved the use of transit signal priority, making the travel on 122nd more reliable.

The kiosk and apps have multiple language options, so Hong can interact in his native language. The kiosks and NoAppFee app are all gathering data from the Open Data Cloud and using the Mobility Marketplace for integrated purchasing options. The common formats and APIs make it easy to get data from the Open Data Cloud.

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122nd Avenue Corridor

How will the Smart Cities demonstration address safety for Portland's most vulnerable active transportation users?

Pedestrian safety is a critical problem on 122nd Avenue (shown in Figure 8). The pedestrian and vehicle crash rate in the corridor is the highest in Portland. A major north/south connector route, 122nd Avenue extends from Sandy Boulevard to Foster Road. 122nd Avenue is designated as a City Bikeway and City Walkway, and classified as a Transit Access Street. It hosts one of Portland's busiest transit lines. Despite these classifications, much of the area lacks transportation infrastructure, including sidewalks and fully improved streets.

Car ownership rates are low, and a high percentage of people in the corridor primarily walk and bike. A sizeable number of the corridor's residents primarily speak a language other than English.

The city's top three high crash intersections are along 122nd Avenue at Glisan, Stark, and Division streets. UB Mobile PDX will focus on addressing safety, which is this corridor's most significant challenge.

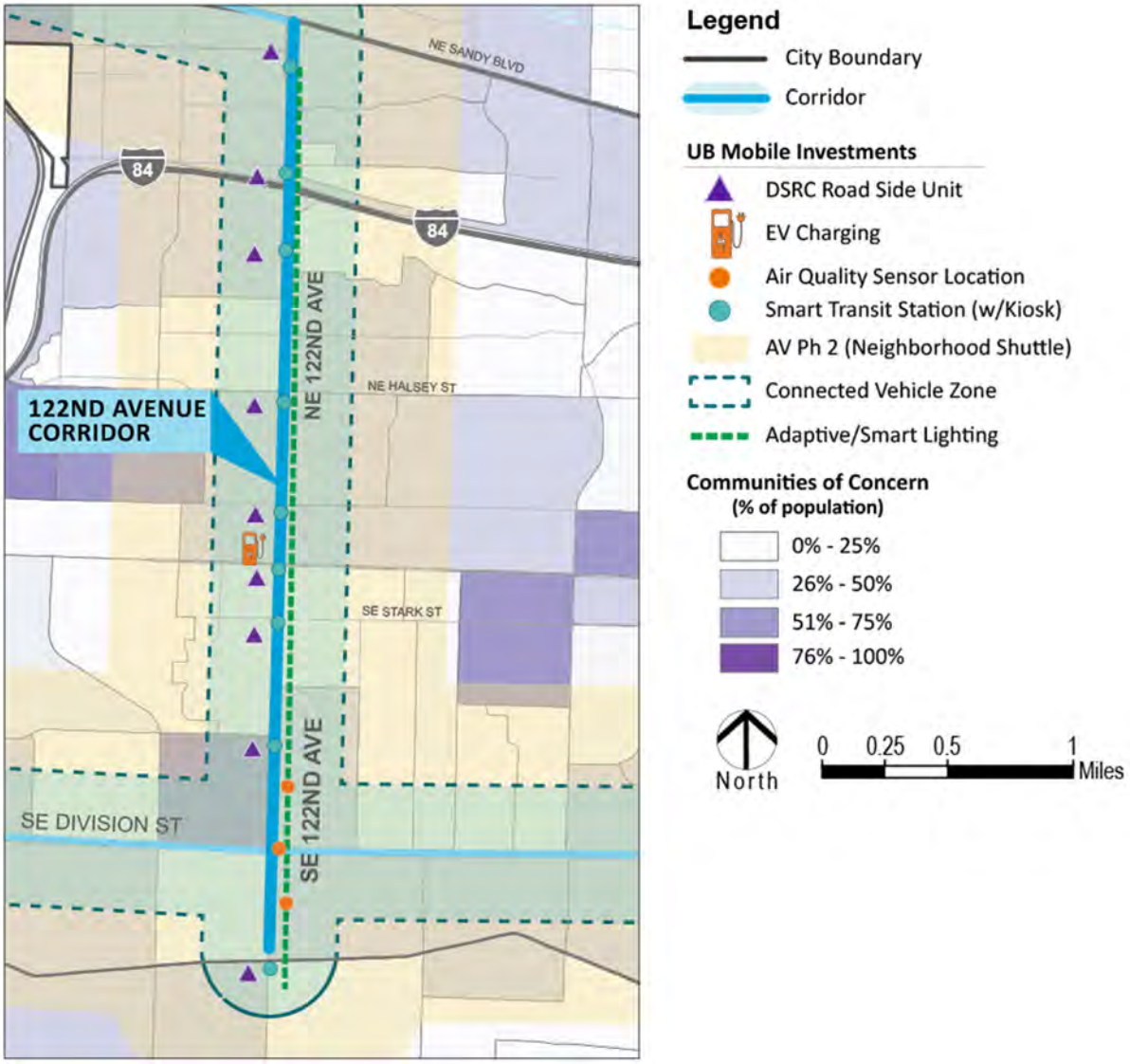


Figure 8. 122nd Avenue Corridor Demonstration Project Map

Toward Vision Zero

The pedestrian crash rate on 122nd Avenue is nearly 50% higher than the citywide average, with 64 crashes involving pedestrians resulting in 2 fatalities and 8 serious injuries over the last 10 years. UB Mobile PDX will work with the Multi-Modal Intelligent Transportation Signal System (MMITSS) research group from the University of Arizona to build on field tests they have implemented in Anthem, Arizona and on work completed under the New York City CV Pilot to implement connected pedestrian (V2P) strategies to protect vulnerable users.

The 122nd Avenue corridor is also hazardous for drivers, with crash rates 50% higher than the citywide average. Many are severe turning and angle crashes from driveways along the corridor that lack access control. We will use DSRC RSUs and OBUs, applied to fleet and private vehicles, to gather data on intersection operations and near misses to support periodization of future improvements.

Innovative Pedestrian and Bicycle Technology

UB Mobile PDX will use 122nd Avenue's high active transportation demand to demonstrate Vehicle to Pedestrian (V2P) and Vehicle to Bicycle (V2B) technologies. These technologies will provide real-time data to alert drivers of approaching pedestrians and cyclists and will provide information to the City for planning and operations.

As described above, Mobileye and AV technologies will be used to improve safety in all of our demonstration corridors. Use of the technologies on 122nd Avenue will improve safety for all users.

Adaptive Lighting

UB Mobile PDX will leverage infrastructure improvements planned along the 122nd Avenue Corridor to enable advanced sensing. We will use a combination of adaptive street lighting for both roadway and pedestrian zones. To date, adaptive lighting technologies have been used primarily to cut energy consumption and reduce maintenance needs, but research has shown that street lighting is also an important contributor to multimodal safety. To this end, the City will implement adaptive street lighting (with partner Current) to enhance the lighting levels in nighttime conditions and detect pedestrians and vehicles at all hours, to provide passive connected traveler data.

In addition to lighting, light-emitting diode (LED) smart lighting modules will have sensing capabilities to provide unprecedented data analytics. This will combine the controls system for street lighting with CV technologies. Combined with LED street lighting, PBOT will monitor the lighting systems and automatically identify maintenance issues allowing maintenance crews to be dispatched directly to the problem light. This enables the City to lower and increase light levels as needed for nighttime activities. Finally, UB Mobile PDX will place permanent traffic surveillance cameras with connections to the PBOT communications system throughout the corridor.

Improved Transit Infrastructure

Many bus stops on 122nd Avenue lack amenities and do not comply with ADA standards. UB Mobile PDX will promote transit use by combining planned upgrades to bus stops with kiosks to provide real-time transit info and free Wi-Fi. TriMet and the City of Portland have partnered to make investments in this bus line: the City will improve sidewalks, crossings, accessibility, and transit operations along 122nd Avenue; TriMet will improve service to make 122nd a new frequent-service bus line, meaning buses will arrive at least every 15 minutes much of the day. These planned improvements, combined with Smart City investments, will improve the quality of transit for people using the bus along 122nd Avenue.

Performance Measures

> Focused investment accelerates progress on bold city goals

> Measuring success drives innovation in safety, mobility, and equity

1. Urban Automation

2. Connected Vehicles

3. Intelligent, Sensor-Based Infrastructure

4. User-Focused Mobility Services and Choices

5. Urban Analytics

6. Urban Delivery and Logistics

7. Strategic Business Models and Partnering

8. Smart Grid, Roadway Electrification, and EVs

9. Connected, Involved Citizens

10. Architecture and Standards

11. Low-Cost, Efficient, Secure, and Resilient ICT

12. Smart Land Use

Performance Measures

Key Performance Indicators and Measures

Table 5 shows the PBOT identified goals and key performance indicators (KPIs), which are closely aligned with the Beyond Traffic 2045 findings and the desired outcomes for the Portland region for UB Mobile PDX.

Table 5. UB Mobile PDX Goals and Key Performance Measures

Goal	KPI
Safety: Advance Portland's stated Vision Zero goal and deploy lessons learned from the New York City CV Pilot Deployment project to improve safety for all travelers, regardless of how they choose to get around.	Make Portland's transportation system the safest possible and move toward zero traffic-related fatalities and serious injuries in the demonstration corridors in the next 10 years
Mobility: Support a robust local and regional economy and improve access to employment and education for residents. By 2025, increase the mode share of daily non-drive alone trips to 70% citywide (City of Portland Transportation System Plan)	Achieve a 25% mode share for transit and double existing mode share for biking and walking in the demonstration zones in the next 5 years
Efficiency: Maximize the existing transportation system to achieve reliable and accessible travel for people and freight.	Reduce travel delay for people and freight in demonstration zones by 10% in the next 5 years
Sustainability: Improve equity, the economy, and the natural environment; Create vibrant neighborhoods where 80% of residents can easily walk or bicycle to meet all basic daily needs and have safe pedestrian or bicycle access to transit. (Climate Action Plan, Portland Plan)	Grow the gross regional product (GRP) by 2% annually. Positive trend in reducing income disparity
Climate Change: Reduce carbon emissions by 80% from 1990 levels by 2050 - and by 40% by 2030 Climate Action Plan)	Reduce greenhouse gas emissions from light vehicles by 20% by 2035

These KPIs will be monitored and measured in the demonstration zones— the Powell/Division Corridor, Columbia Boulevard Corridor, and 122nd Avenue Corridor—using the objectives, measures, and monitoring approaches described in **Table 6**. A baseline for each performance indicator and measure will be established ahead of implementation. A performance management plan will be prepared to establish policies and procedures to support ongoing data management and reporting.

Performance Measures

Table 6. Key Performance Indicator Measurement and Monitoring Approach

Objective	Measure	Monitoring Approach
Safety: Reduce serious and fatal crashes at high crash locations	Number of serious and fatal crashes at high crash locations	Augment existing Department of Motor Vehicles (DMV) crash reporting with vehicle BSM data to identify locations where driving events (such as speed, hard breaking, vehicle type, and windshield wiper use) indicate risk. Integrate BSM data from mobile devices as available. Use Mobileye near-miss data to assess locations and situations to better understand potential hazards in demonstration zones.

Objective	Measure	Monitoring Approach
Reduce serious and fatal crashes involving vulnerable users (including motorcycles, bicyclists, and pedestrians)	Number of serious and fatal crashes involving vulnerable users Participation in BSM broadcast for mobile devices	Augment existing DMV crash reporting with mobile BSM data usage rates to track participation by vulnerable users.
Reduce over-limit speed and red light running infractions	85% speed compliance Red light violations	Use data generated by signal controllers to measure intersection entry on red light. Use combination of in-vehicle and infrastructure sensor data to measure vehicle speed by corridor.
Reduce driving under the influence by establishing a "ride home" partnership with TriMet, TNCs, and city parking services	Transit ridership by stop in demonstration zones TNC rides provided by target area Number of impairment citations Pre-paid "next-day" parking	Use Portland Police Driving Under the Influence of Intoxicants (DUII) citations, Oregon Liquor Control Commission DUII data by retail location, transit automated passenger counters (APC), TNC reports, and parking meter data to track impact on DUII citations in relationship to ride home program.
Mobility: Make active transportation and shared transportation choices convenient	Mode share to key destinations Origin-destination patterns for demonstration zones	Use transit APC, continuous bike and pedestrian counters, crowd-sourced apps, bike share activity, and TNC report data to calculate mode share and origin-destination patterns by demonstration corridor.
Make transit convenient and reliable	Transit schedule adherence by route Transit route transfer adherence	Use computer aided dispatch (CAD) and automatic vehicle location (AVL) system data to identify travel time variability by route and route connectivity performance.
Increase accessibility to goods, services, activities, and destinations for people and businesses	Homes within a 20-minute walk of commercial services and neighborhood amenities Travel time isochrones for employment and industrial areas	Use GIS data to document features including street connectivity, sidewalks, protected crossings, services and amenities, and topography. Use travel-time data to create isochrones to assess market reach for different travel periods.
Reduce average daily light duty vehicle trips traveled in demonstration zones	Average daily light duty vehicle counts at key intersections	Use data generated by signal controllers to measure the number of light duty vehicles passing through key locations.
Efficiency: Make transit trips more competitive	Transit-auto travel time ratio Transit signal priority performance assessment	Use AVL transit data and Inrix, Bluetooth, and DSRC data for vehicle analysis. Measure signal performance.
Improve travel time reliability for transit	Transit on-time performance	Provide greater capture and analysis of operational, automatic passenger counting, and GPS data captured by all 600+ TriMet buses as well as 100+ light rail vehicles.

Objective	Measure	Monitoring Approach
Improve reliability for freight deliveries within the city and goods movement through the city	Travel time reliability System delay	Use combination of in-vehicle and infrastructure sensor data to calculate reliability and delay in demonstration zones.
Reduce non-recurring congestion	Crashes and incidents Freeway speeds	Use ODOT operations center database and emerging information from on-board diagnostics and DSRC, as well as data from TNCs and car sharing.
Sustainability: Support growth of a vibrant economy	Mix of land use types Reliable and timely access to key destinations GRP	Use GIS data to calculate jobs to housing ratio in demonstration zones. Use CAD/AVL/APC data to measure availability and quality of transit services within a 10-minute walking area; also see transit reliability metric. Track GRP to targeted annual growth rate of 2% or more
Support improved equity and access to ladders of opportunity	Transportation and housing cost across income levels Access to biking, walking, and transit facilities by minority and low-income households Workforce training	Evaluate availability and costs of transport compared to household income. Use GIS and probe data to track travel time by mode between transportation analysis zones and identified environmental justice communities. Track Code Oregon training and internship placement.
Expand access to information	Wi-Fi coverage UB Mobile PDX app usage Kiosk usage	Track Wi-Fi geographic coverage. Use data from UB Mobile PDX app and kiosks to ascertain use of services.
Support access to sustainable transportation options	Community-based EV car share usage BIKETOWN usage	Use data from car share and bike share programs in demonstration zones to track use of services.
Climate Change: Reduce regionwide per capita roadway greenhouse gas emissions from light vehicles	Greenhouse gas emission rates	Use combination of in-vehicle and infrastructure sensor data to calibrate regional emissions model.
Accelerate the turnover from gasoline-fueled to electric-fueled vehicles	EVs registered in Portland Publicly available charging stations Employers offering workplace EV charging EVs used in city and other fleets including taxis and TNCs	Use DMV data to track growth in EVs registered in the city of Portland and surrounding communities. Partner with Drive Oregon to track public charging stations, survey major employers (50+) to track number of workplace charging stations, and survey fleet managers to track the number of EVs in fleets.

Partnerships and Outreach: Building a Smart City Together

- > Established partnerships enable quick ramp-up and ongoing cooperation
- > Flexible approach means both established and emerging technology companies can participate
- > Proven partnerships with community-based organizations supports meaningful public engagement

7. Strategic Business Models and Partnering

9. Connected, Involved Citizens

Partnerships and Outreach: Building a Smart City Together

Partners

As the hub of the Smart City wheel, UB Mobile PDX brings together a host of business, nonprofit, and community partners with a single vision: make Portland's transportation paradigm safer, more connected, and greener. These organizations are local, regional, national—even international—leaders in advanced technology, transportation, and education. As a group, they bring the capacity, imagination, and collective will to create a new model for connecting and moving people around the city of the future. These organizations made significant contributions to the development of the proposal, and they are committed to moving UB Mobile PDX forward.

Portland is a city of collaboration. Our scale as a small big city, in combination with the region's economic interdependence and Oregon's strict land use planning framework, means we must collaborate fiercely to compete with larger cities in a global economy. And we have a history of doing it well.

In the transportation arena, we have created innovative collaboration structures to bring partners together for critical investments. The Portland Streetcar (TriMet, the City of Portland, and private sector partners) and the Aerial Tram (City of Portland and OHSU) are successful examples. Today, the Port of Portland and FedEx are sharing freight data to improve delivery efficiency.

Industry and Transportation Partners

UB Mobile PDX brings a variety of industry and transportation partners. These are shown in **Table 7**, along with a description of their role. Some are USDOT partners; others are specific to UB Mobile PDX. We have worked with these partners to develop this proposal, although we have not yet formalized binding contracts or agreements. Instead, we are taking an "open approach" with some competitive elements (including a UB Mobile PDX app challenge). We aim to match services with providers who offer state-of-the practice services and provide the greatest value to the project. This approach is consistent with Portland's history of open data; we expect it to spark innovation and set the stage for participation by both well-established businesses and emerging startups.

Some of our local partners are minority-owned businesses, such as NoAppFee. Through the UB Mobile app development challenge and City contracting standards, we will focus on engage more emerging, woman-, and minority-owned businesses and startups to deliver UB Mobile PDX elements. This enhances our program, and it also launches these businesses to provide similar services around the country.

Government, Agency and Institutional Partners

Our government and agency partners (Metro, Multnomah County, ODOT, the Port of Portland, and TriMet) are integral to delivering UB Mobile PDX. We will build on a history of collaboration to deliver innovation. ODOT's Road Usage Charge program (OReGO) is a potential partner for our CV fleet. TriMet will leverage the Hop Fastpass to enhance the UB Mobile PDX app and integrated payment interface. Portland Public Schools (PPS) is keenly interested in pedestrian and bicycle safety and will support the development of safety applications for connected vehicles as we leverage the new PPS safety and crowdsourcing app as a part of UB Mobile PDX.

PSU is a top-tier research university with a focus on transportation engineering, planning, and data analysis. PSU hosts the National Institute for Transportation and Communities, one of five USDOT National University

Transportation Centers, which links studies of transit, biking, urban planning, housing, and computer science. PSU's Portland State Business Accelerator has spawned Smart City startups like Globe Sherpa and RideScout. PSU will manage the UB Mobile PDX Open Data Cloud, building on a history of providing open source data to researchers, government agencies, private industry, and the public.

Table 7. Industry and Transportation Partners for UB Mobile PDX

Partner	Role in Smart Cities	In-Kind Contribution
BIKETOWN	Support expansion of bikeshare network to encompass areas where transportation choices are currently limited by providing 100 e-bikes systemwide	Yes
Car2Go	AV and CV applications	
Daimler/Freightliner	Demonstration of a fully autonomous truck in the Columbia Corridor; first-/last-mile freight delivery	Yes
Drive Oregon	Support implementation of EV and smart grid; lead on implementation of Vulcan grant	Yes
GE (Current)	Smart sensors and networks to enable smart sensors	Yes
General Motors	Support for AV and CV applications	
HERE	Provide next generation mapping for CV and AV applications	Yes
Intel	Advisor on implementing UB Mobile PDX with subject matter expertise on security and edge computing solutions	Yes
Intersection	Deliver interactive smart kiosks that include sensors and Wi-Fi	Yes
Lyft	Test CV, AV, and EV technology during the demonstration; provide access to EV rental for rideshare drivers	Yes
Mobileye	Provide crash avoidance technology for TriMet buses	Yes
Moovel	Existing provider for TriMet's Ride Tap for integrated electronic transit fare and travel planning	
NoAppFee	Integration of affordable housing information with UB Mobile PDX	
NXP Semiconductors	Manufacturer of roadside and onboard DSRC equipment	Yes
Oregon Technology Assoc.	Advisor on implementing UB Mobile PDX; assistance with app challenge and hackathon	Yes
Pacific Northwest National Laboratory	Advisor on air quality and analysis	
Portland General Electric (PGE)	Advisor and partner on smart grid and Portland's efforts to address climate change	Yes
Sidewalk Labs	Support for data analytics, kiosks, and sensors	Yes
Transcore	Support for traffic-signal upgrades to accommodate DSRC	

PCC provides a ladder of opportunity for families and individuals throughout the region. With a major campus and a workforce training center located in one of our demonstration corridors, PCC will host an autonomous campus shuttle and will be a partner in outreach, training, and education around technology and data analysis.

Community-based Organizations and Institutions

We have worked with a number of community partners to develop the UB Mobile PDX program and approach. They have helped us identify needs, impacts, and sensitivities, and they will be essential to help us bring UB Mobile PDX to Portland's most vulnerable community members. Our equity-focused partnerships, including the community organizations and institutions shown in **Table 8**, represent a commitment to building capacity in those organizations. Partnering with community organizations—and in some cases providing stipends or in-kind services—will engage community members in design and implementation. Table 8 lists our community partners and their roles.

Table 8. Community-based Partners for UB Mobile PDX

Partner	Role in Smart Cities
Asian Pacific American Network of Oregon (APANO)	Support community engagement for Asian community members in the demonstration corridors
Community Cycling Center	Support community engagement to low-income Portlanders particularly focused on safe cycling
Girls Inc.	Support a community engagement process for at-risk girls
National Association of Minority Contractors of Oregon	Partner that will help Portland ensure that the Smart City Challenge will provide opportunities to emerging, woman-, and minority-owned businesses
Ride Connection	Support engagement for elderly and disabled community members
Self Enhancement, Inc.	Support a community engagement process for at-risk youth
Verde	Support community engagement for Latino and Spanish-speaking community members in the demonstration corridors
Worksystems, Inc.	Develop a workforce development plan to support ladders of opportunity

Stakeholder and Communications Plan

A Smart City is one that brings everyone forward together. UB Mobile PDX is built on a platform of equity, intended to benefit those traditionally left behind. Our outreach strategies are designed to reach a broad spectrum of people, including low-income residents, members of minority groups, people living with disabilities, older people, and youth.

A Smart City is home to active and engaged stakeholders. That means that community members need to be part of the development and implementation of Smart City technologies from beginning to end, as follows:

- **Design of demonstration.** Stakeholders must help us answer questions about where autonomous shuttles make sense, how the user interface works, and how we can overcome technology barriers.
- **Adoption of new technology and overcoming the digital divide.** A Smart City only works if all people in ***all*** neighborhoods use the technologies, including the Mobility Marketplace, electric charging infrastructure, and CVs.
- **Communicating lessons learned.** A Smart City is a national and international laboratory that will be successful if we can share successes and lessons learned to the benefit of others.

Phase 1: Outreach and Involvement to Design the Program

During the design phase, our technical teams will develop a concept of operations. Simultaneously, our outreach team will conduct engagement activities to gather input that informs the demonstration. Working with our community partners, we engage people to ask questions like the following:

- What transportation challenges do you face in your daily life? How can technology help you meet your daily transportation needs?
- What barriers might keep you from using the Mobility Marketplace? How can we help overcome those barriers?
- Where should specific parts of our demonstration be deployed (e.g., kiosks and autonomous shuttles)?

Public Education Campaign

This will be accompanied by a robust public education campaign about UB Mobile PDX, with clear, targeted, culturally specific messages about what a Smart City is and how it benefits Portlanders. This will include both traditional and social media campaigns, as well as video used to explain complex technologies in understandable ways.

Specific communication messages and tools will target different audiences, using culturally and language-specific messages. For example, we might explain how CV technology improves pedestrian safety when talking to elementary school parents, or how to plan a quicker trip with the UB Mobile PDX app when talking to Columbia Corridor employees. We will conduct a series of market-based focus groups with a diverse set of community members to test communication messages and our outreach campaign before launch to be sure that we are telling a compelling and understandable story.

Innovative Citywide Outreach

As we take the message about UB Mobile PDX to the entire city, we will launch a **Smart City video contest** where amateur videographers can create video shorts about the Smart City. Using the City's summer Movie in the Park event, we can show the best of the Smart City video shorts and ask members of the community to vote on their favorite. The best videos will be posted to our website. Using creative communications tools – such as in-street 3D art and messaging visible only in the rain – can help engage people.

We will also develop a web-based input tool that can be adapted to a variety of questions such as "Where should kiosks be located?" or "Where are the most critical pedestrian crossings to improve? " Using an online game to gather input is another way to engage community members in helping us solve real problems.

Partnering with CBOs to hear from new voices

However, traditional outreach methods are not enough. The success of UB Mobile PDX will depend on hearing from people throughout the city, including traditionally underserved communities. To accomplish this, we will partner with CBOs that serve low-income, disabled, older, minority, immigrant, and limited-English proficient residents. Outreach through Title 1 and Schools Uniting Communities (SUN) schools will allow us to reach both students and parents in traditionally underserved communities. The Multnomah County Youth Commission will help us plan youth and underserved community-focused outreach. We will leverage existing groups like the Oregon Commission for the Blind and the City of Portland's Accessibility Community to ensure that people with disabilities are engaged in program design and that the program serves people with limited mobility and vision impairment.

By providing CBOs with stipends to conduct outreach on the UB Mobile PDX's behalf, we can reach people where they are. CBOs benefit by receiving funding that supports their capacity building and organizing activities. Outreach strategies might include the following:

- Walking or van tours to suggest specific locations for technology deployment
- Tabling at cultural events like the Jade Night Market and other community gathering places
- Idea walls
- Focus groups
- Supper chats where the community-based organization invites people to attend a social dinner that invites input
- "Pop ups" with large input maps
- Intercept surveys on buses or at bus stops
- Youth-led canvas events to businesses in the corridor
- Youth outreach through existing groups or schools

Phase 2: Implementation and Digital Equity

As we move from demonstration design to implementation, our outreach will focus on engaging participants and addressing digital equity. As in Phase 1, this will require a general outreach program to let Portlanders know about the Mobility Marketplace, user interface, and payment options. Once again, a robust traditional and online media campaign with traditional transportation partners will help us launch the tools.

Specific engagement strategies will include (but not be limited to) the following:

- **Smart Cities exhibit at OMSI**. The exhibit will clearly explain UB Mobile PDX in words that everyone—from kids to seniors—can understand. School partnerships will fund OMSI field trips to see the Smart Cities exhibit and engage kids and their parents engaged. This exhibit could also go on the road to science and technology museums in other cities.
- **Coding initiative at PCC**. Students will use data collected through UB Mobile PDX to develop applications to enhance mobility or improve their community.
- **Partnership with Girls Inc. to engage girls in Smart City technology**. Portland's Women's Transportation Seminar (WTS) Chapter has a strong partnership with Girls Inc., a nonprofit that serves at-risk girls, to promote STEM education. We will engage girls in developing a curriculum and marketing strategy to get other middle- and high-school-aged girls to use the Mobility Marketplace and user interface. We may partner with other nonprofits such as Chick Tech or Urban Teen to engage teens in app development for their peers.

Bringing technology to people who might not otherwise use it will require support for behavior change, in addition to awareness. This might include:

- **A mobile technology lab** where the city outfits a bus with smartphones and computers to travel to community events and teach people about UB Mobile PDX.
- **Outreach to libraries and librarians about UB Mobile PDX**; libraries are at the front lines of the push to overcome the digital divide.
- **Leveraging SUN schools**, which are already teaching technology to low-income people and people who are learning English. SUN schools have additional community-supporting activities, and services are provided after school hours. By partnering with SUN schools or the Oregon Commission for the Blind, we can enhance technology training already underway with training on UB Mobile PDX.
- **Community-supported ride and drive events** with EVs or **ride and bike events** with e-bikes to demonstrate these technologies in our demonstration corridors.

We will work with CBOs in this phase, engaging them in training people to use the new Mobility Marketplace and push the Mobility Marketplace to Portlanders from a variety of backgrounds.

We will also make UB Mobile PDX visible to people throughout the community. This will be particularly important as more subtle pedestrian and bike safety enhancements that are not as visible as, for example, a new crosswalk, are implemented. One way to do this would be to install artwork—either artwork that only comes out when it rains or permanent artwork—in areas with heavy pedestrian traffic and safety issues to

explain the new technologies. The artwork can be both beautiful and informational, both enhancing and educating communities.

Replicability

Portland is not alone in the challenges: cities across the nation are struggling with poor access to transportation choices, rising housing costs, safety, and climate change issues. Strategies and technologies tested here can have impact in cities throughout the country.

Formal Smart Cities Partnerships

Portland is formally partnering with five cities across the country: Seattle, WA; Richmond, VA; New Orleans, LA; and Los Angeles, CA. These cities have communities and corridors similar to Portland's demonstration corridors. UB Mobile PDX will continue to engage in technology transfer with these cities. As we learn more about what works—and what doesn't—we will share those lessons with our partner cities so they can begin to design and implement their own systems. Smart City solutions will be tailored to the specific needs and challenges of our partner cities, extending USDOT's investment beyond the Portland region.

Portland's Partner Cities

- Seattle, Washington
- Richmond, Virginia
- New Orleans, Louisiana
- Los Angeles, California

Portland will use grant funding to send technical experts to support the start-up phases and share lessons learned.

Becoming a National Hub for Smart City Innovation

Portland is already a national and international destination for cities studying sustainability and smart transportation and land use. UB Mobile PDX will benefit from—and build on—that reputation. In addition to our formal Smart Cities partnerships, we will work will well established knowledge-sharing institutions such as First Stop Portland (which has hosted hundreds of delegations from all over the world) to lead customized "study tours" for out-of-town delegations. These include field studies, site visits, presentations, workshops, lectures, networking opportunities, social events, and other opportunities to explore and promote UB Mobile PDX projects.

UB Mobile PDX: Sustainability over Time

The City of Portland is committed to UB Mobile PDX beyond the 4-year grant period. By creating a nonprofit organization to support UB Mobile PDX, we will have the capacity to seek future grant funding to complement local agency partnerships and traditional transportation funding to continue successful UB Mobile PDX efforts into the future. In many cases, we will leverage existing City and partner programs in new ways. For example, an AV shuttle route operated as a Community/Jobs Connector could continue as an ongoing service with funds from TriMet. If the demonstration shows that the BIKETOWN system and private carsharing services can be successful in traditionally underserved neighborhoods, these services will continue to operate in the future.

Our outreach, training, and marketing programs are grounded in partnerships with long-standing CBOs. By building capacity to conduct technology training and develop workforce expertise in Smart City technologies within these organizations, they can sustain these activities in their communities as part of a future partnership with the UB Mobile PDX nonprofit or on their own. Institutional partners such as PSU have been leaders in open source data for many years. UB Mobile PDX provides an opportunity to broaden data collection and—as more CVs and infrastructure come online—to continue to grow that data collection and analysis. Ultimately, the Smart Cities grant will be a catalyst for permanent change in how our city delivers transportation services that improve the lives of all Portlanders.

Program Delivery Model

- A proven yet nimble structure provides oversight and transparency and encourages innovation
- Local experts are engaged from both within and outside of government

7. Strategic Business Models and Partnering

9. Connected, Involved Citizens

Program Delivery Model

UB Mobile PDX Project Management Plan

Overall Implementation Approach

The USDOT-launched Smart City Challenge has tapped into a remarkable entrepreneurial spirit, creating excitement and spurring innovation in the cities across the country. The City of Portland's approach to implementation starts with and builds upon this entrepreneurism. It also takes advantage of the wide range of public and private partnerships that have been catalyzed by the proposal process.

Our implementation strategy—and the resulting organizational structure—has been developed with the following three primary principles:

- The organizational structure must be **nimble**, responding quickly and efficiently to change while continuing to deliver high performance, and be open to innovation.
- The City, as the grant recipient, must be **accountable for and transparent** about the expenditure of public funds.
- The community, particularly the community along the Powell/Division, 122nd Avenue, and Columbia Boulevard corridors, must feel a sense of **ownership** for the project.

The organizational structure has the advantage of having already worked effectively to implement the City's most important infrastructure projects. It is a tried and true model of project delivery where the project is complicated and community support is essential.

The proposed UB Mobile PDX implementation structure uses the same model that has been used for major projects in Portland for many years: Portland Streetcar, the OHSU Aerial Tram, and Transit Mall Management. The private non-profit implementation entity provides nimble responsiveness, the board of directors ensures consistent policy leadership and inclusiveness as well as focus, and the City Council still retains the bottom-line assets and fiscal authority.

Project Management Plan for UB Mobile PDX

Purpose

The purpose of the UB Mobile PDX Project Management Plan (PMP) is to establish the implementation structure and processes for UB Mobile PDX. When Portland is notified of its selection, Mayor Hales will initiate formal approval of the PMP by the Portland City Council.

Guiding Principles

- The PMP has been developed around three fundamental principles (nimble, accountable, and shared ownership) that will guide the implementation of the program.
- The leadership structure and processes for implementation must be nimble and facilitate innovative approaches to project delivery.
- The organization that is created must have the capacity to implement the program.
- The City must retain accountability; processes and the expenditure of funds must be transparent.
- The equitable distribution of the technology is a priority.

UB Mobile PDX: the Organization

This section describes the non-profit organization that will serve as the implementation arm of the UB Mobile PDX program (Figure 9).

Modeled after the successful partnership that manages Portland's Streetcar system, UB Mobile PDX will act on behalf of PBOT and its partners to implement the Smart Cities initiative. Overseen by a Board of Directors that includes all participating agencies, UB Mobile PDX will have the following responsibilities:

- Design the UB Mobile PDX initiative and develop the concept of operations.
- Manage the implementation and operation of UB Mobile PDX, including vendor contracts.
- Coordinate public outreach and involvement, including grants to CBOs.

Figure 9. UB Mobile PDX Organization Chart

- Assure security for the Open Data Cloud and the Mobility Marketplace, in collaboration with other partners.

A contract with the City will define these roles and responsibilities with much greater specificity. As shown in the organizational chart in **Figure 9**, UB Mobile PDX will operate through a Program Manager, who will staff the Board of Directors and oversee implementation.

Roles and Responsibilities of Key Players

UB Mobile PDX Board of Directors

UB Mobile PDX will be legally formed by an incorporating board with the following members:

- Resident of the Powell/Division Corridor
- Representative of a Community-based Advocacy Organization
- Business Representative in the Columbia Corridor
- Innovation and Entrepreneurship Partners (service providers)
- Entrepreneur in Residence
- Rotating Technology Partner (representative of a current corporate partner)
- Rotating Technology CEO
- City of Portland PBOT Director
- TriMet General Manager
- Technology Association of Oregon Director
- Drive Oregon Director
- Portland Development Commission
- Port of Portland
- PSU
- PCC
- Oregon University System Representative

UB Mobile PDX Program Manager

The Program Manager will provide the day-to-day staffing for implementation and continuing oversight of the Project. UB Mobile PDX will select the Program Manager on behalf of—and in collaboration with—PBOT, with the contract formally procured and approved by PBOT. The Program Manager will have general expertise in the management of large complicated public programs and specific expertise in transportation and the UB Mobile PDX technologies.

City Project Manager

PBOT will appoint a City employee as the Project Manager to serve as the day-to-day connection between the UB Mobile PDX Program Manager and the City. The Project Manager will be responsible for processing all contracts required by the program, monitoring budgets and expenditures and assuring schedule compliance. The Project Manager will report to and be accountable to the PBOT Director.

Community Advisory Committee

A Community Advisory Committee (CAC) for the project will be appointed by the Portland City Council. The CAC will be broadly representative of the residents and businesses within the Powell-Division, 122nd Avenue, and Columbia Boulevard corridors. The CAC will advise on program design and implementation with specific attention to the dissemination of the technology throughout the community. It will act in its advisory capacity directly with the City and with UB Mobile PDX.

Authority and Contracting

The Portland City Council is the governing body for the City. City government bureaus report to the Council through the City Commissioner in Charge of that Bureau. Most City policies and all contracts in excess of $100,000 must be approved by the Council.

For the UB Mobile PDX program, the City Council will adopt a PMP and authorize PBOT to work within this structure to implement the program and approve a contract with UB Mobile PDX that establishes its responsibilities and accountability to the City.

UB Mobile PDX will advise PBOT on procurement of services and materials, from hiring the Program Manager through vendor contracts.

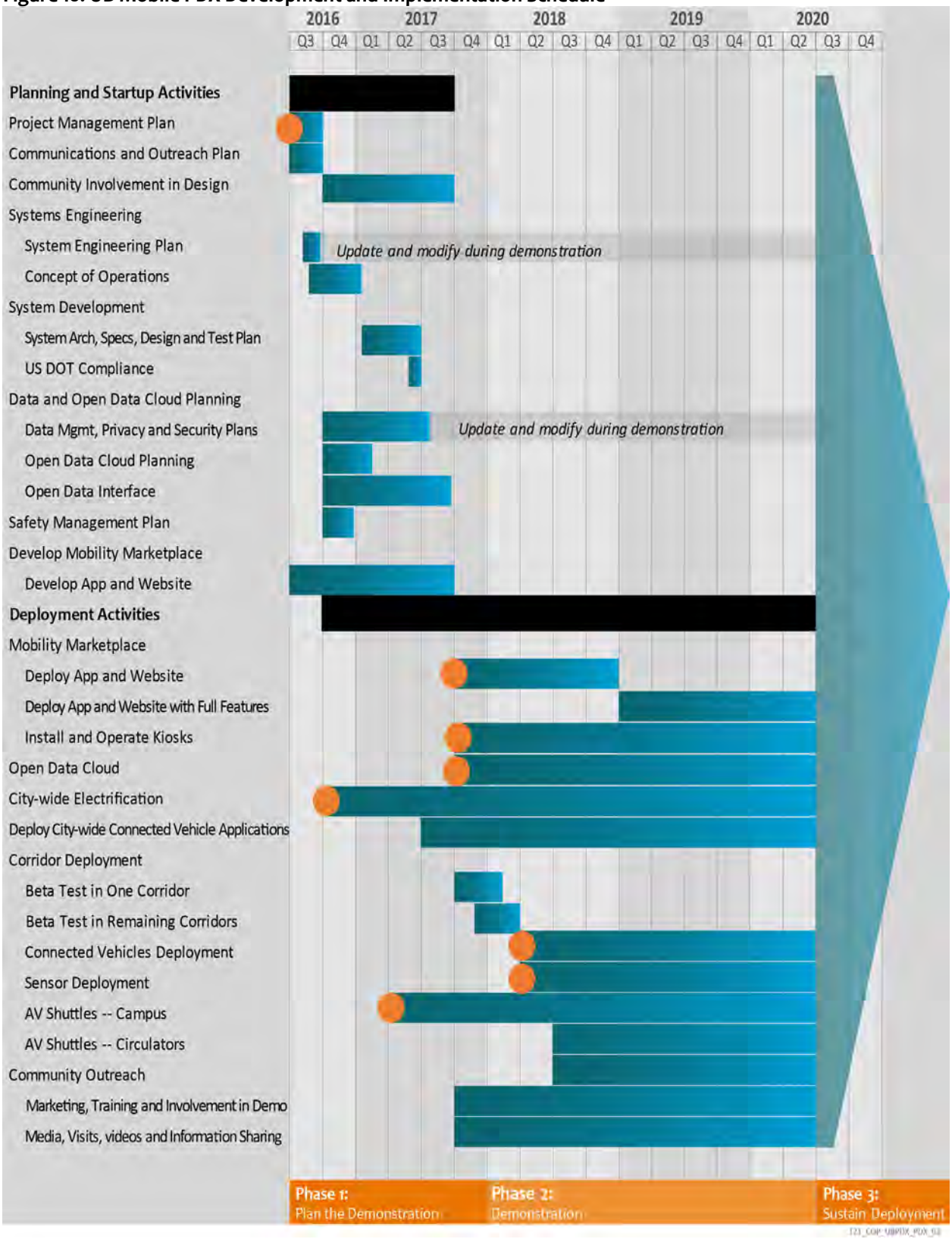
UB Mobile PDX Program Manager Responsibilities

- Administer budgets, contracts and schedule
- Respond quickly to opportunities and project challenges
- Coordinate with the City Project Manager
- Conduct vendor selections
- Monitor data to ensure electric vehicles are meeting program goals
- Set up the data cloud, including vendor selection and data management protocols
- Assure data security in collaboration with other security organizations
- Work with private vendors to refine connected vehicle technologies
- Facilitate communications among public agencies and between private partners
- Staff the UB Mobile PDX Board
- Coordinate public outreach and community involvement
- Meet all city requirements and be responsive to City Council and bureau leadership

Implementation Schedule

Figure 10 outlines the UB Mobile PDX project development and implementation schedule.

Figure 10. UB Mobile PDX Development and Implementation Schedule



Sustaining UB Mobile PDX beyond the Grant Period

One of the key outcomes of UB Mobile PDX is ensuring that the demonstration elements, if successful, can be sustained over a longer term beyond the period of the grant. Successful elements that hit performance targets can be integrated into the City's ongoing operations over the longer term. In general, these are expected to include the following:

- Maintaining advocacy and oversight of Smart City projects through the UB Mobile PDX Board of Directors
- Installing CV technology in all new capital construction for traffic signals and signal reconstruction
- Ensuring new City fleet vehicles are equipped with DSRC or similar CV technology
- Continuing transition of Portland's Fleet to EVs and expanding electrification to medium- and heavier-duty vehicles
- Continuing the expansion of Portland's BIKETOWN to include an e-bike system
- Maintaining the UB Mobile PDX app through ongoing partner sponsorships
- Maintaining Portland's Open Data Cloud with the multi-jurisdictional partnership to ensure data are available for research and integration with public and private uses

Financial Sustainability

Over the period of the demonstration project, UB Mobile PDX will develop sustainable funding mechanisms using existing funding models for the City of Portland. Existing adaptable City models include the following:

- Working with private sector partners to build sustainable funding models for a wide range of UB Mobile PDX services
- Using regional transportation funding to support TMAs (such as the Columbia Corridor Association and the Division-Midway Business Alliance) work to advance UB Mobile PDX elements such as AV pilot project supplemental transit services
- Maintaining mobility hubs or kiosks through business improvement districts, sponsorships, and grants to CBOs
- Continuing to expand mobility access to underserved communities through grant funding, direct City financial contribution, sponsorships, and support from Portland's business community

Capacity and Capability to Implement the Program

The City is a general service government that provides the full range of urban services to its residents, with PBOT as the City bureau delivering all transportation services within the City. It has 800 staff with a wide range of skills. PBOT has a well-deserved national reputation for advancing multimodal projects including bike facilities, bikeshare, and the Portland Streetcar.

Portland is the only large city in the nation with a Commission-based government: there are four City Commissioners and a Mayor whose offices are all non-partisan; all are elected at large. Collectively, the Commissioners and the Mayor act as the legislative body for the City. Individually, they are the managers of bureaus (departments) of the City.

This structure is meaningful because it facilitates stable government. City Commissioners normally maintain their Bureau assignments through multiple terms. Bureau directors serve at the pleasure of the Commissioner

in Charge, but all other staff are permanent civil service employees. Their role in City government is to ensure that the work of the City continues even as political leadership shifts. While political leadership does change (a new Mayor will be elected in November), there is a high level of political alignment that virtually eliminates the mercurial shifts in policy and direction that are evident in many cities.

Stability in our City government is also helped by a tradition of collaboration among City bureaus as well as among the region's governmental partners. Disagreements, both minor and vigorous, will occur, but those disagreements happen in a framework that supports getting to consensus.

The bottom line is that the political context in which UB Mobile PDX is implemented will be very stable. Over the multi-year implementation schedule, a change in political leadership will not impact the City's commitment to the program.

For a project like UB Mobile PDX, that stability is reinforced by using special purpose nonprofit organizations to plan and implement unique investments and services. These organizations provide stability and also enhance the capacity of the City to deliver complicated projects. The Portland Streetcar, the Transit Mall Management program, and OHSU tram are examples of City–owned facilities that were conceived of, implemented, and are now managed by a non-profit organization under contract with the City.

Staffing Approach

Table 9 lists our key and supporting resource staff for the project organization shown in **Figure 9**. A Program Management consultant would be chosen through a competitive selection process following award of the grant.

Table 9. Project Staffing Approach for UB Mobile PDX

	Role/Responsibility	Name	Title/Organization	% Allocation of Time
Project Management	PBOT Director	Leah Treat	Director, PBOT	25%
	Project Lead	Maurice Henderson	Deputy Director, PBOT	45%
	Project Management	Art Pearce	Policy, Planning, Projects, and Active Transportation & Safety Group Manager, PBOT	50%
	Equity and Inclusion	Zan Gibbs	Equity and Inclusion Manager, PBOT	50%
	Community Outreach	Irene Schwoeffermann	Public Involvement Coordinator, PBOT	70%
Implementation	Carshare/Car for Hire Lead	David Benson	Parking Services Group Manager, PBOT	30%
	BIKETOWN Lead / Safety Lead	Margi Bradway	Active Transportation & Safety Division Manager, PBOT	30%
	EV Lead	Ingrid Fish	Conservation Program Coordinator, Climate Policy & Planning, PBOT	30%
	Utility/Right-of-Way Lead (EV infrastructure)	Alex Bejarano	Utilities, Construction, Inspection Division Manager, PBOT	30%
	Streetlight / Signal Lead (CV Infrastructure, EV Charging)	Peter Koonce	Principal Engineer – Signals and Streetlighting Division Manager, PBOT	50%

Data Specifications, Management, and Security; Systems Engineering and Risk Management

- Open source data expertise ensures efficiency, security, and privacy – and supports ongoing innovation
- Systems engineering enables holistic solutions that respond to changing conditions and achieve climate change, safety, ladders of opportunity
- Portland's approach creates solutions that are scalable and transferable to other cities
- Human-centered design engages people in creating the solutions that will ultimately serve them

1. Urban Automation

2. Connected Vehicles

3. Intelligent, Sensor-Based Infrastructure

5. Urban Analytics

7. Strateg Business Models and Partnering

11. Low-Cost, Efficient, Secure, and Resilient ICT

Data Specifications, Management, and Security

Data specifications, management, and security are critical when developing and implementing new technologies. The *Open Data Cloud* section introduced the Open Data Cloud and described more generally how UB Mobile PDX will implement open data and urban analytics. This section provides detailed technical information about a variety of data specifications, management, and security protocols.

Data Capture and Management Technologies

Deployment

The UB Mobile PDX Open Data Cloud will be deployed on Amazon Web Services (AWS) using the resources provided by AWS to the winning Smart City. The Open Data Cloud will leverage AWS virtual hardware (EC2 and S3) for processing and storage, which provides a deployment option that can be replicated by other cities.

This flexible structure will allow a range of implementation options, depending on the adopting city's IT infrastructure and support system. The Open Data Cloud will be designed to ensure transferability to public or private cloud servers, ensuring that future Smart Cities are not locked into a single cloud provider.

Application Programming Interface Specifications

APIs developed in this project will follow the JSON RESTful architecture, with a specific set of constraints applied to elements within the architecture. The Open Data Cloud will read and produce data using these APIs.

Existing data sources for the Open Data Cloud (including PORTAL, TripCheck, CivicApps, Portland Maps, TriMet developer resources, and others) will be documented and existing APIs will be revised to be consistent with the newly created Open Data Cloud APIs. Existing sources will either be published directly through the Open Data Cloud for transparency, or will be published via a pass-through; that is, data with an existing storage location will not be moved, but will be redirected as needed. This will enable public data to be integrated with data from private sources (such as TNCs, sensors, and Sidewalk Labs) to provide a deep and rich source of data.

The Open Data Cloud will include both external and internal APIs. External APIs will be designed for the general public and third-party developers. Internal APIs will share data between agencies where data is not appropriate for the public domain, or is not usable without specific expertise.

Stakeholder Engagement in API Development

Stakeholder engagement in the development of APIs is a key element of the UB Mobile PDX approach. Potential developers—and users—of UB Mobile PDX data and services will be consulted to ensure that formats, specifications, and APIs are accessible and practical. Stakeholder engagement will be similar to the process by which TriMet vetted the GTFS program, but will reach more broadly out into the community.

In large part, the acceptance of GTFS was driven by Google's inclusion of transit data in Google Maps based on the GTFS format. For UB Mobile PDX, public availability and documentation can help drive acceptance of the Open Data Cloud specifications. Stakeholder outreach will include consultation with app developers (both private and open source), university researchers, agency staff, and potential users.

Data Ownership, Storage, and Governance

Using GitHub to Facilitate Collaboration on Open Source Software

Software developed for Portland's Smart Cities program will be open source, and the team will work to develop a community around that software. GitHub, a popular web-based collaborative software repository, will be used to store software, facilitate a developer community, and propagate updates from the UB Mobile PDX team. This open source, community-oriented approach will allow outside partners to contribute. Contributions will need to be screened by team members, but have the potential to greatly increase the value and facilitate adoption of the Open Data Cloud system.

Data Ownership and Storage

UB Mobile PDX data encompasses a range of data sources, including existing data and new data collected as part of the Smart Cities initiative. Some of the UB Mobile PDX data (including data in PORTAL, TripCheck, CivicApps, PortlandMaps, and TriMet Developer resources) have existing storage locations. As discussed previously, this data will not be duplicated, but will remain in its existing storage location. UB Mobile PDX will ensure these sources have open, documented APIs for accessing the data.

Smart City data sources and analytics products will be handled in a variety of ways. By their nature, many data sources are collected by or belong to a specific agency. In cases where analytic products combine multiple data sources, the data will be owned and controlled by the Open Data Cloud Governance Committee. The agency that collects or controls the data will have control over where that data is stored.

In many cases, agencies have existing data storage systems – and those systems will be heavily leveraged. Examples include the ODOT Data Acquisition System (DAC), TriMet's operational database, the City's PortlandMaps map services, and the PORTAL data archive that houses regional data. As with existing data, any new data will have open, documented APIs for accessing that data.

Storing the Results from Analytics Products

Results from analytics products, particularly analytics products that combine multiple data sources, will be stored in the Open Data Cloud itself, leveraging the AWS credits provided to the winning Smart City. The AWS platform may also serve as the platform for agencies needing additional storage resources, although in that case, the AWS storage will be controlled by the agency in question.

For data sources in the Open Data Cloud, a set of storage options will support analytics and accommodate both structured and unstructured data. PostgreSQL is our open source database of choice. An unstructured system such as Cassandra will be used for unstructured data.

Data Management Governance

Because of its cross-agency nature, the Open Data Cloud and Mobility Marketplace will require a clearly defined and agree-upon governance structure. With respect to data management, this governance will be similar to existing data management governance structures in the Portland metropolitan region, such as TransPort, the regional ITS organizing committee. Similar to TransPort, the governance committee will include representation from all collaborating UB Mobile agencies. Private partners will be included as non-voting members. The governance committee will be established early in project implementation, and will facilitate collaboration by actions such as the following:

- Executing data sharing agreements
- Creating necessary networks

- Documenting and resolving policy questions surrounding open data

Data Security and Privacy

With the collection and integration of data comes a host of privacy concerns – both perceived and real. For UB Mobile PDX to succeed, data must be secured and people's privacy must be protected. Data from connected vehicles, sensors, kiosks, and the UB Mobile PDX app must not reveal sensitive information about individuals. Personally Identifiable Information (PII) must be removed from all data. We will secure UB Mobile data storage to prevent access by hackers, and we will ensure that only authorized people have access to certain data sets.

CV Data Privacy: Protecting Personally Identifiable Information

State and federal governments have developed a formal set of requirements for PII management. Our team is familiar with these, and our project will comply with local, state, and federal PII regulations. We understand that technical management of PII is not static, but requires a dynamic response over time.

This is not a low-level static operations function, but an ongoing senior strategic responsibility. Fundamentally, we understand that the success of UB Mobile PDX deployment will depend on a high level of public trust as we deliver new products and services. Portlanders will need to be convinced they can use the UB Mobile PDX app, website, and kiosks with confidence that their privacy will be protected.

UB Mobile PDX Approach to Ensuring Privacy

Human systems play a critical role in ensuring people's privacy. Policies, procedures, and organization are essential, but the ability to respond proactively to changing conditions is equally important. Technological advances can threaten even the strongest systems, so our team understands the need for monitoring to ensure ongoing protection. UB Mobile PDX will develop management policies, contractual requirements, and human systems to manage privacy (**Table 10**).

Human system development is crucial. Our approach will include the following elements:

- Assign clear responsibility for privacy and security.
- Develop strong, but realistic policies with accountability and training and awareness.
- Engage experienced partners who understand the importance and business rationale for good PII protection.

UB Mobile PDX: Experienced in Data Privacy Protection

As a result of groundbreaking data integration efforts in the Portland metro area, the UB Mobile PDX team brings on-the-ground experience to ensure the privacy of Smart Cities data.

- As part of their work developing the Hop Fastpass mobile ticketing app, TriMet has implemented privacy controls including tokenization at the source to maintain PCI/data security standard (DSS) compliance, and separating customer personal information from usage/travel information to ensure anonymized and secure PII.
- PBOT is collaborating with ODOT to use Bluetooth readings from cell phones and other equipment to collect travel times for project planning. The data is anonymized, and all personal data (particularly device MAC addresses) is scrubbed.
- ODOT is working to ensure that RUC providers have demonstrated proper data security and privacy procedures for individual vehicle data collected in the test pilot phase. Only anonymized and aggregated data is ever received; no personal data such as origin and destination of particular trips can be linked to particular individuals.

- To the greatest degree possible, use third-party partners to anonymize and aggregate data and remove PII before that data is integrated into the Open Data Cloud.
- Engage the UB Mobile PDX governing board in policies and activities to ensure privacy.

Table 10. Ensuring UB Mobile PDX Data Privacy

Process	• Establish privacy policy that defines access, usage and roles and responsibilities, as was done by project partner CH2M for FasTrak and Clipper • Develop internal process and procedures for access and use of data • ISO 27001 "specifies the requirements for establishing, implementing, maintaining and continually improving an information security management system within the context of the organization"
Data Access	• Subpoena or court order required • Data never sold or provided to any third parties • Access on a need-to-know basis
Transparency	• Share privacy policy with customers and the public

Anonymizing Data to Address Potential Privacy Issues

UB Mobile PDX data will be anonymized whenever possible. We understand that data set combinations may raise potential re-identification issues, where enough travel pattern data over time can lead to the identification of individuals. UB Mobile PDX will use strong, state-of-the-practice anonymization algorithms. Sidewalk Labs, a key UB Mobile PDX partner, is highly experienced with travel pattern data. We will work closely with them to ensure those techniques are applied to all potentially sensitive data.

UB Mobile PDX Data Management Plan

All data collection, storage, and management elements of UB Mobile PDX will adhere to existing best practices, including those set out in the USDOT Data Capture and Management (DCM) Program to address data captured from connected vehicles, mobile devices, and infrastructure.

Our data management plan will track closely with the structure of the DCM Program Plan. It will describe which data will be controlled, and how. It will determine documentation requirements, and where responsibility for those processes resides.

We will follow a structured process to develop the UB Mobile PDX Data Management Plan, which will include the following elements:

- **Early Engagement with Experts and Partners (Including Community Partners)**. Early on, we will solicit feedback to identify the needs of practitioners and the community. How will we ensure the plan matches up with the practices of our partners and the public's need for transparency, privacy, and security?
- **Ongoing Stakeholder Engagement**. Will be used to test data sets, data collection, and analysis methods; we will share information with the broader community to ensure transparency and public buy-in.
- **Plans and Procedures for the Following Data Management Activities:**
  - **Conducting coordinated research and development** to address technical, institutional, and standards issues surrounding data collection and the creation of data analytics.
  - **Testing standards, procedures, tools, and protocols** to ensure successful real world application.

- **Conducting pilot deployments and demonstrations** of the data capture and management techniques in an operational setting.
- **Developing evaluation and performance measures** to assess benefits of the data environments. Plan for regular audits (both security and data).
- **Sharing procedures and findings with stakeholders and other Smart Cities** through coordinated outreach activities and technology transfer. Portland will build on our experience in this arena: in 2012, PSU provided the Portland Region Multimodal Test Data Set (consisting of a variety of arterial, transit and freeway data) to the Research Data Exchange (RDE). This data set was one of the original data sets on the RDE.

ITS Architecture

The Portland metropolitan area is acknowledged as a national leader in the development and consistent management of regional ITS architecture.

The team updating the regional ITS architecture has significant experience with traditional architecture development. They also have expertise in the newly developed Connected Vehicle Reference Implementation Architecture (CVRIA), having just recently completed a statewide CV Implementation Plan for ODOT that used CVRIA and associated tools such as the SET-IT software. This same team is currently developing ODOT's Statewide CV Architecture, building off of the Implementation Plan and further using these same tools.

For over 15 years, a multi-agency collaboration group known as **TransPort** has met on a monthly basis. This group oversaw the original regional ITS architecture adopted in 2000, and has continued to use this architecture to drive regional interoperability. The architecture has been maintained as a living tool and underwent an update in 2010 as part of the regional Transportation System Management & Operations (TSM&O) Plan. As of this writing, TransPort has just kicked off an effort to update the regional ITS architecture once again, and has committed to incorporate all of the elements included in the UB Mobile PDX proposal. This updated architecture will be completed by the end of 2016.

Through this work, our team has identified gaps in the existing architecture and how these must be addressed to achieve our goal of moving people, not just cars, throughout the region. For example, the emergence of TNCs and third-party data providers/disseminators presents opportunities to refine and expand the architectures. Increasingly, pedestrian and bicycle solutions have information and data components that are underrepresented in the architectures. And the merging of the CVRIA with the National ITS Architecture later in 2016 or early 2017 provides a major opportunity to address these gaps. UB Mobile PDX is committed to working with USDOT to identify and incorporate these and other needed elements into future ITS Architecture updates.

Existing and New Data Sources for the Open Data Cloud

Existing Data Sources

Table 11 describes the data that the City of Portland and our partners are already collecting and analyzing. The Portland region continues to lead the nation in data collection and analytics, using innovative sources. This table summarizes the data sets collected by City of Portland and its partners. An exhaustive list has been collected, but is too long to include in the proposal. The data sources listed in this table will be standardized and incorporated into the Open Data Cloud and used to support analytics and app development as described in the *Open Data Cloud* section.

Table 11. Existing Data Sources

Data Type	Description	Coordinating Agency	Current Status
Regional Data	Oregon DOT freeway speed, volume, and travel times; City of Portland traffic signal data and travel times; TriMet aggregated performance data. Data set includes traffic signal and travel time data on the Powell Boulevard corridor.	Hosted at PSU	Stored in PSU PORTAL Database. Available on PORTAL website and undocumented JSON API
Transit	Schedule in GTFS format, GTFS-RT, web services from TransitTracker and OpenTripPlanner, GIS data.	TriMet	TriMet Developer Apps website and GitHub
Civic Data	Aggregates datasets from an array of local government jurisdictions including City Portland, PPS, TriMet and more. Much of the data is GIS.	City of Portland	Available from City of Portland CivicApps website
Safety / Crash	Crash data compiled from ODOT and Portland emergency responders.	City of Portland	Storage at City of Portland, ODOT Incident data at PSU PORTAL
Traveler Information	Includes traffic incident data, road weather reports, automated roadside weather station data, dynamic message sign data and links to roadside camera images.	Oregon DOT (TripCheck)	Stored by ODOT; available through the TripCheck API
Bicycle/ Pedestrian	Bicycle and pedestrian data collected from automated sensors and manual counts.	Regional Data	Stored at PSU. Available on BikePed Portal website. API planned
Probe Data	ODOT is purchasing probe data from a private vendor.	ODOT	Available to other public agencies
GIS Data	Transportation infrastructure, streets, signals, signage, buildings, crime incidents, development activities. Portland was the first city in the nation to combine regional jurisdictional data into seamless GIS datasets via our Regional Land Information System (RLIS).	Regional Data	RLIS available on web from Metro (regional planning agency)
Equity	Demographic data compiled from U.S. Census products, PPS. Analysis from PSU and others on economically vulnerable populations.	City of Portland	Internal to City of Portland
Bridge Lifts	Real-time information on bridge lifts for bridges across the Willamette River, which runs down the middle of City of Portland.	Multnomah County	Available via API
Portland Streetcar	Real-time ridership and on-time performance.	City of Portland	Internal to City of Portland

Data Type	Description	Coordinating Agency	Current Status
Air Quality	Strategically located high-end air quality sensors.	City of Portland / PSU	Internal to City of Portland / PSU

New Potential Data Sources

Table 12 describes the anticipated new data sources that will shape and in turn be derived from UB Mobile PDX program elements. This list is preliminary and partial, recognizing the rapidly changing nature of open source platforms and the mechanisms that generate data for the analytics developed on those platforms.

Table 12. New Data Targeted for the Open Data Cloud

Data Type	Description	Coordinating Agencies
Air Quality	Existing high-end sensors will be augmented with a larger number of low-cost sensors. CV technology to provide real-time information on emissions. Link kiosks contain air quality sensors.	City of Portland/PSU
Bicycle and Pedestrian	New bicycle and pedestrian data from the UB Mobile PDX app, kiosks, CV, BIKETOWN bikeshare system. Potential for Strava data.	City of Portland/ PSU/ TriMet
BLE Beacons	TriMet partnered with Google to install BLE beacons at light rail platforms, with plans to extend to all bus stops. When detected by smartphone, these beacons can offer real-time travel and site information for customers.	TriMet
Connected / Automated Vehicle	Data on intersection operations across the three demonstration corridors using DSRC RSUs and OBUs installed in fleet and private vehicles. The Transcore traffic management system will collect BSMs.	City of Portland / PSU
Mobileye	Incident information from Mobileye systems. TriMet will use the data collected to identify key locations and situations that contribute to potential hazards for pedestrians and bicyclists.	TriMet
OpenStreet Map	Additional mapping information to be added to OpenStreetMap, including crowdsourced information about changes to and condition of city infrastructure such as sidewalk and crossing data, turn restrictions, speed limits, and buildings.	City of Portland / TriMet
Sidewalk Labs Flow	Anonymized trip origin/destination data and analytics for various modes (transit, bike, walking); parking data and analytics	City of Portland / PSU
TNC Data	Trip information from TNCs such as Uber, Lyft, and Car2Go.	City of Portland / PSU
WAZE	Community-based, crowd-sourced traffic and navigation information.	City of Portland / PSU

APIs – Development Approach

API development within UB Mobile PDX will begin with an established, real world implementation as a foundation, then be expanded it to accommodate additional needs as they arise (see the *Open Data Cloud* section). This process will be accompanied by ongoing stakeholder outreach, introducing changes only for demonstrated use in existing applications. The Open Data Cloud will build on this approach to develop API call standards for all aspects of shared-use mobility and related travel data. A series of outreach activities will draw

in participants from a wide industry cross section. Once a beta standard is established, it will be tested by including it in real world apps.

APIs – Phasing and Implementation

For each existing and new data source, we will create the following:

- Format specification (similar to that of GTFS)
- API based on the format specification
- Documentation for the API and format specification

Note that for existing data sets, the basis for these format specifications already exists in the PORTAL, TripCheck, and TriMet databases and CivicApps storage system. What we will be doing is looking at the formats already in the PORTAL, TripCheck, CivicApps, and TriMet Developer data systems, adjusting to make them consistent with each other, and then publishing. For new data sets, we will need to develop format specifications. Our experience in developing GTFS and the PORTAL database will be key factors to our success.

Segmentation – Approach

The foundational underpinning of GIS is creating a data model that represents the physical world—organizing points, lines, and polygons in a way that references the spatial orientation of real world objects. While this practice is now well established, differences in methods for implementing these spatial data models present obstacles in bringing disparate data sets together for analysis or application development.

Issues such as when and where to split street segments, how to define sidewalk data, and how to reference segments are examples of the many individual choices that can make or break a GIS project.

Portland has been a leader in tackling these important issues in a very collaborative way: for more than two decades, multiple City jurisdictions, Metro, and TriMet have worked together to build a robust set of GIS data layers. This has been accomplished over the years by building on data integration, conflation, and other techniques to combine and compliment data sets.

Most recently, Portland has taken the next step in collaboration by applying our GIS data resources toward building out the OpenStreetMap with the crowdsource community in the area. Portland data and features that are actively maintained in OpenStreetMap include transit information, sidewalk and crossing data, turn restrictions, speed limits, and buildings. As a result, we enjoy one of the most rich base map datasets in the world, making OpenStreetMap the logical platform for standardizing spatial data going to and coming from the Open Data Cloud. OpenStreetMap is a seamless spatial data platform that is completely open to the public, one on which the software development community can build applications that work consistently across jurisdictional boundaries. It is a platform in which Portland and its regional partners have already invested and one that we have taken a leadership role in developing.

Smart Cities and IoT data bring a similar set of challenges, but on a much grander scale. Sensors, traveler movements, and vehicle and infrastructure communications all bring a tremendous amount of data points in potentially disparate ways. It will not be enough to simply rely on the existence of an xy coordinate to combine and make use of this data. Consistency is key in dealing with such issues as aggregation to anonymize data or to cope with the sheer volume of data in a usable way. Efficient and effective analysis and application development will depend on forethought as to how the data is prepared and presented.

We plan to apply the techniques and lessons learned through our GIS experiences to the evolving set of Smart City data. We will bring together our industry and civic partners, along with the strong open source development community of Portland, to develop standards, best practices, and a data referencing model.

Systems Engineering and Risk Management

Systems engineering is a requirements-driven development process where user (i.e., stakeholder) requirements are the overriding determinant of system concept and design, component selection, and implementation. This is particularly relevant for UB Mobile PDX, where many different stakeholders are involved, new technology is being deployed, and there is a significant level of integration.

UB Mobile PDX will implement systems engineering protocols that meet both federal-aid compliance requirements and the standard practices of the City of Portland. The City will create a Systems Engineering Management Plan (SEMP) to guide the technical planning and deployment of the UB Mobile PDX app, the Mobility Marketplace, the Open Data Cloud (including management), and each technology deployed in the demonstration corridors. The SEMP will be the key guiding document to ensure the objectives of UB Mobile PDX are met by the specific systems during the demonstration period.

Systems engineering helps accomplish four key activities that can impact a project's success:

- **Identify and Evaluate Alternatives' Feasibility:** The feasibility of each alternative will be measured from three different points of view: technical feasibility, cost feasibility, and schedule feasibility.
- **Design Quality Into Systems:** The SEMP will address factors that can negatively affect quality such as complexity, inflexibility, lack of standardized components, reliability, and availability and will provide quality assurance and control processes.
- **Address Program Management Issues:** Throughout the project, the SEMP will remain one of the guiding documents and a means of checking that the various plans are adhered to.
- **Manage Uncertainty and Risk:** Risks will be identified, prioritized, and mitigated throughout the demonstration.

At the end of the demonstration period, UB Mobile PDX will submit a Systems Engineering Compliance Report (SECR) that documents the demonstration's compliance with federal standards and provides a template for replication.

Concept of Operations

Before deploying UB Mobile PDX, a concept of operations (ConOps) based on guidelines contained in Institute of Electrical and Electronics Engineers (IEEE) Standard 1362-1998[1] and American National Standards Institute and American Institute of Aeronautics and Astronautics (ANSI/AIAA) G-043 guidance will be developed.[2] The document will set the stage for subsequent development of (and stakeholder agreement to) the system requirements, user interfaces, and designs in an easy-to-read and understandable manner. The ConOps will be a human-centered design approach where people, rather than technology, lead, ensuring that the UB Mobile PDX is built by and for the community. The concept development and the subsequent designs will start with people and fit technology to their needs, rather than asking people to fit their needs and expectations to technology. It will describe the what, where, when, who, why, and how of the system operations and stakeholder interaction.

[1] *IEEE Guide for Information Technology—System Definition—Concept of Operations (CONOPS)*
[2] *Guide for the Preparation of Operational Concept Documents, ANSI/AIAA G-043-1992*

Stakeholder involvement throughout the ConOps development process is critical. Our technical team will engage with our outreach team and CBOs to facilitate this iterative process starting with understanding the needs of our target audiences, particularly those who have been left behind by past transportation investments and who live, work, or otherwise are part of the community in our demonstration corridors. To develop the ConOps consistent with this human-centered approach, we will do the following:

- Ask CBOs to conduct outreach to drive our understanding of the needs of our target population, including minority, low-income, elderly, disabled, and immigrant communities.
- Develop a wide range of potential solutions and ideas.
- Work iteratively with a self-selected group of people from these target audiences to test and refine solutions, including asking the stakeholders to describe a day in the life of the solution, to address both nominal and off-nominal situations from their perspectives and expectations.
- Partner with youth-focused organizations to not only understand the needs of young Portlanders, but also to engage them in the design process to open up new career and educational possibilities.

The ConOps will inform our approach to implementation citywide and in our demonstration areas, and will form the foundation for how we implement each technology element.

Risks and Mitigation

Risks associated with implementing Smart City technologies range widely from acute risk related to passenger vehicle safety and user privacy to broad public acceptance or rejection of the program. A comprehensive risk management strategy is warranted.

Technology deployment risks will be managed through disciplined use of the systems engineering process. Through systems engineering, user needs and requirements are the overriding determinant of the system concept, component selection, and implementation. Identifying mitigation strategies and managing potential risks allows the project team to best manage the deployment of UB Mobile PDX (**Table 13**). This will be developed into a Risk Management Plan that is part of the broader PMP.

Table 13. Risks and Potential Risk Avoidance and Management for UB Mobile PDX Program Components

Description of Risk	Potential Risk Avoidance and Management
Urban Automation: Operational risk from semi- and fully-autonomous vehicles operating in demonstration zones and partnering campuses, including equipment failure Institutional risks including delays associated with implementing new technology Program risks including a slow rate of public acceptance, potentially materializing through policy and regulation of operations	Operational risks can be mitigated through transitional insurance instruments associated with operations and maintenance of public transportation. Participants may be offered the option to sign a limitation of liability for some operation of autonomous vehicles. Program risks will be addressed by system engineering techniques to ensure delivery of workable solutions on time and within budget.
Connected Vehicles: Institutional and policy risks regarding data security and privacy associated with connected vehicle operations and implementation.	Data security risks will be mitigated by engaging a security provider and using evolving USDOT CV standards and lessons learned from ODOT's RUC program, which provides data security on all vehicles enrolled in the program.
Sensor-based Infrastructure: Accidental damage, theft, or vandalism	Risk is low, and mitigation will reflect typical operations and maintenance procedures for other City sensor-based technology. Employing a systems engineering based approach and standard insurance coverage will mitigate the risks.

Description of Risk	Potential Risk Avoidance and Management
Urban Analytics: Technical and institutional risks in analytics, in the collection and processing of data Inconsistent data formats Institutional risk of lack of qualified expertise to interpret data and unwillingness to share raw data	Data formats common across platforms will be designed for collection and processing. Data collected will be scrubbed for privacy, and made public for open source coding. Strong partnerships with leading research institutions such as TREC will ensure qualified expertise to lead analytical approaches.
Collecting or storing PII and PII-related information not necessary to meet the goals of the system	Data will only be accessible and used for legitimate purposes, which may include sharing with qualified researchers through the prototype security credential management system (SCMS) provided by DOT for DSRC systems. Established OReGO privacy policies for non-DSRC systems will be used.
Mobility Marketplace App, Kiosks, Website: Risk that the mobility marketplace will not serve users Risk that the app or website will not function properly	Systems engineering approaches and public outreach through user groups will be used to mitigate risks of the mobility marketplace. Development time and cost will follow standard industry practice.
Partnering Approach: Institutional risk from diminishing participation or enthusiasm from UB Mobile PDX partners.	A partnership, outreach, and communications plan that engages partners early and often in the process will be developed and implemented. The City of Portland has a long history of inter-agency collaboration and partnerships between the public, private, and academic sectors to serve as successful models.
Public Engagement: Not successfully engaging community members in demonstration zones in meaningful ways Technological risk that community members may not be able to engage because of lack of necessary personal devices or knowledge	A robust engagement strategy that partners with CBOs to act as trusted messengers will be implemented. CBOs will help to engage and enroll community members in programs such as workforce training, learning travel options, or applying for free cell phones and reduced data plans.
Open Data Cloud: Data security and developmental obsolescence associated with demonstrating technologies for which standards are not yet fully developed	A data security provider will be engaged and established best practice standards will be followed. Systems engineering practices that conform to standards when developing technology architecture will be engaged.
Attacks on security mechanisms, embedded systems, data cloud, and PII information	Secure solutions will be integrated into architecture designs and security risks will be managed iteratively through our systems engineering approach. Our partner, Intel, will provide robust cybersecurity best practices for implementation.
Program Management: Common program management risks including cost overruns, schedule delays, and staff changes	The program management structure will mitigate risks by serving as an oversight board with regular meetings and milestones. Annual progress reports will ensure the project stays on track to meet deliverables for the USDOT demonstration project.
Electric Vehicles: Slow growth in market demand	Portland already leads the nation in sales per capita, showing strong baseline interest, and the project will undertake a robust marketing and outreach campaign to engage consumer interest.

Conclusion

Ubiquitous, Egalitarian Mobility for Portland and the Nation

UB Mobile PDX represents a pivot point in Portland's history. The set of actions and investments described in this proposal will result in a stronger, more connected city that provides opportunity for all. The Smart Cities grant will be a start, but it can only go so far. The real, lasting impact will come from the amplification of the project and its benefits through community engagement and partnerships.

We don't have unlimited money to spend on safety infrastructure. But we will marry the commitment of Vision Zero with the innovation and leverage of the Mobility Marketplace and the Open Data Cloud to create a city where it is just as safe and efficient to move around without a car as with one. In the process, we will narrow the gap between those who come here looking for an urban lifestyle that doesn't depend on driving and those who *must* have good non-auto choices just to make it here.

Nearly all midsize American cities are growing and becoming more diverse, so what we accomplish with ubiquitous, egalitarian urban mobility in Portland will have resounding impacts throughout the country. The dramatic demographic changes now happening here make Portland like the urban America of our near future: multicultural, multilingual, and connected in new ways. With UB Mobile PDX, we will demonstrate how *people* can be enlisted in mobility partnerships to change the face of the city, and how people move around in it.

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