Proposal for

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

Ubiquitous Mobility for Portland

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Introduction

The City of Portland has embarked on a Smart City transformation - a paradigm shift in our transportation system.

The City of Portland is in a moment of significant opportunity with in-migration rates among the highest in the country and robust job growth. However, increasing rents, road safety, and property values threaten our ability to remain a city for all. In the face of such growth pressure, the City is committed to overcoming our legacy of transportation and economic development projects that have dismantled minority and low-income communities. Concurrently, the City is committed to achieving an 80 percent reduction of local carbon emissions by 2050.

Together with our partners, Portland Bureau of Transportation (PBOT) will use the Smart City Challenge grant to address these core issues, advance our goals, and leverage existing investments. We will deploy Ubiquitous Mobility for Portland (UB Mobile PDX) to realize this transformation.

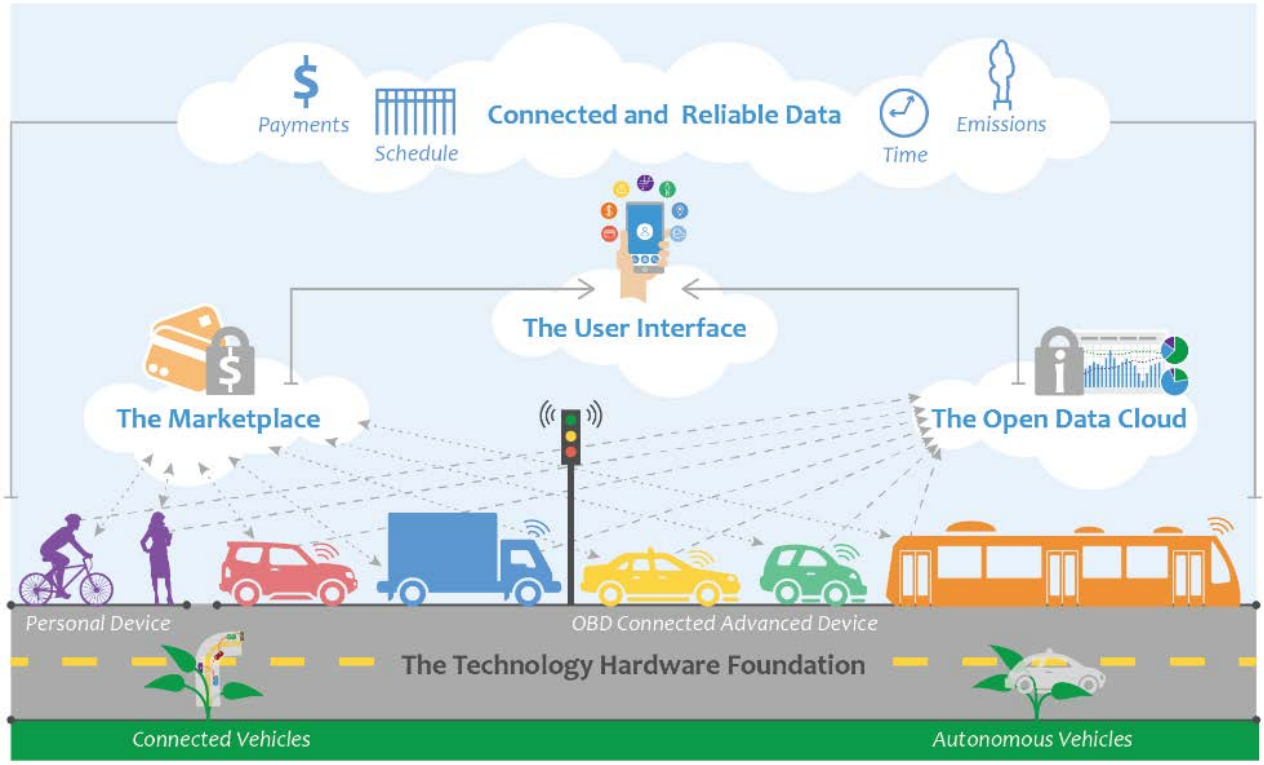
UB Mobile PDX is an operational paradigm that leverages current technologies to provide common access for a spectrum of users - from the well-resourced early adopters to those that are technically left behind, many of whom are low-income and from communities of color. UB Mobile PDX provides a connection to the uniquely diverse transportation ecosystem of Portland and allows for frictionless movement throughout our city and region. UB Mobile PDX engages all current and future connected modes, including transit, connected and autonomous vehicles, rideshare and bikeshare, electric vehicles, and taxis. This data driven ecosystem will not only provide access and information about low-cost transportation choices, but will also support Portland's equity, economic development, and climate action goals. UB Mobile PDX provides key data points that will be used to make our city smarter for current and future Portlanders.

UB Mobile PDX is presented in *Figure 1: UB Mobile PDX Framework*, and includes the following:

- A marketplace, user interface, and open data cloud: that provide pioneering secure open data systems to promote a completely new way for citizens to access mobility.
- A technology hardware foundation: of an intelligent and connected system of Actors that promotes transformative uses of and access to information.
- A variety of real-world implementation projects in priority demonstration zones: to monitor outcomes, promote equity in investment, and automate transportation system improvements through direct, active use of information collected in real time.

Detail on the UB Mobile PDX projects, vision, and approach to each U.S. Department of Transportation (USDOT) Vision Element are provided in **Section 2**.

Figure 1: UB Mobile PDX Framework

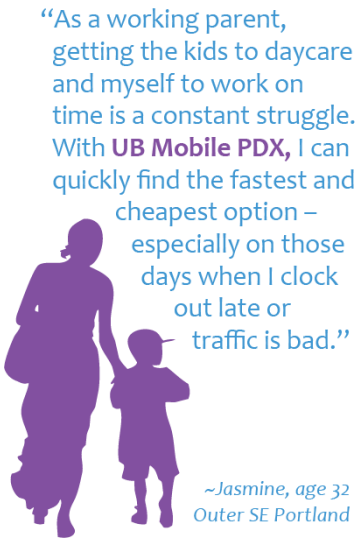


We stand ready to not only become the Smartest City in the nation, but also to collaborate with USDOT to export success and spur action by other cities — improving safety, enhancing mobility, and addressing climate change locally and beyond. UB Mobile PDX is inspired by future-thinkers and climate-focused community members. It is grounded in field-tested approaches and locally established, industry-leading data integration systems. Portland is distinctly prepared to deliver our shared vision for a first-of-a-kind modern transportation system:

- Portland's ***planning system*** is structured to promote complete neighborhoods, decrease reliance on automobiles, encourage implementation of low-carbon transportation options, and focus growth in and around the Central City. While these priorities have helped establish Portland as one of the "most livable" cities in the U.S., minority and lower-income communities still face disproportionate transportation challenges. Partnerships with service providers, community, and educational institutions will be leveraged to place UB Mobile PDX devices in the hands of those who need them most.
- Portland's leadership in ***open-source data standards and architectures*** as well as ***public-private partnerships*** has transformed mobility options. TriMet, which provides bus, light rail, and commuter rail transit services in the Portland metro area, successfully collaborated with Google to develop the General Transit Feed Spec (GTFS) in 2005. GTFS has proved to be a catalyst for the entire industry globally. Today, TriMet is actively engaging in the development of GTFS SUM, which connects transit to shared mobility providers. This complex problem-solving ethos will be carried forward to UB Mobile PDX to further

streamline transportation data that improves safety, efficiency, and sustainable movement of people and goods.

- The Oregon Department of Transportation's (ODOT) Road Usage Charge (RUC) was the first of its kind in the U.S. and is being used as a design model by states around the country. RUC provides an ***open architecture market and a secure and private environment*** to users. The system has already begun to solve issues such as privacy, security, and data ownership that are critical to the success of the marketplace.
- Since becoming the first city in the U.S. to authorize a plan to reduce carbon emissions in 1993, Portland has reduced carbon emissions by 14 percent from 1990 levels. ***Portland's Climate Action Plan*** is a national model that will be leveraged to implement low-carbon transportation solutions, such as electric and autonomous vehicles.
- Portland's history of policy innovation and sustainable solutions for the built environment has enhanced performance of our existing infrastructure, gained global recognition such as the C40 Climate Leadership Awards, and created a distinct culture of creativity and collaboration. ***Alignment between leadership, universities, institutions, private sector partners, and involved citizens*** means that Portland embodies a shared vision of a more sustainable and equitable future.



Our proposal lays out a vision of place-based and people-focused multimodal transportation innovation that incorporates integrated technologies and policy ideas.

Section 1: Portland's Smart City Enabling Environment

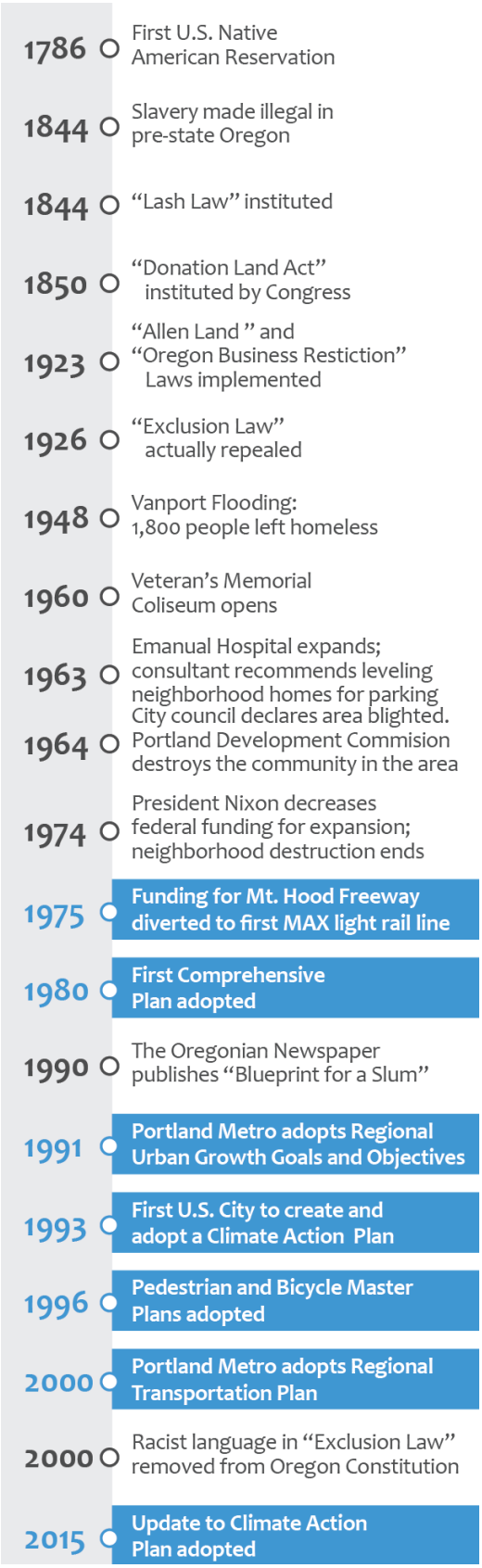
City Characteristics

In 1973, the Oregon Legislature established a first in the nation requirement that each city in the state adopt an urban growth boundary. Spurred on by Hector McPherson, a Lynn County Dairy farmer, the adoption of Senate Bill 100 established Oregon as a leader in conserving essential farm and natural resources and making urban services more efficient. Nobody at the time called it Smart Growth or a paradigm shift. But that is what it was.

Fast forward to 2016. These principles of growth management have helped Portland preserve its livability in the face of dramatic growth. Portland continues to be a national leader for progressive land use and transportation policies, and an innovator in providing a multimodal transportation system for its citizens.

Portland, Oregon is located in the Willamette Valley region in the Pacific Northwest, at the convergence of the Willamette and Columbia rivers. Portland has a population of 583,776 in a region of 1,849,898 (US Census, 2010). This represents 31.6 percent of the regional population and 145 square miles. Portland has a population density of 4,375 per square mile.

Figure 2: Portland, Oregon's Development Timeline



Portland has emerged as a leader on equity and inclusion in an ongoing effort to correct the historical inequities evident in the City. From the birth of the neighborhood system in the 1970s, Portland has sought to include people from all walks of life in governance, planning, and decision making. The City, however, has faced significant challenges to living up to these ideals. As *Figure 2: Portland, Oregon's Development Timeline* illustrates, long before the City embarked on smart planning, transit oriented growth, and addressing climate change, Portland had grown up fostering historic inequalities. Highway construction, stadium construction, and urban renewal eliminated or significantly impacted vibrant African-American communities, homes, and commercial areas in the name of building a better Portland. Even as the City adopted and implemented its first Comprehensive Plan, "redlining" was being practiced in Portland neighborhoods and was only brought to light by the Oregonian newspaper series "Blueprint for a Slum" in 1990, which detailed the lack of mortgage lending in North and inner Northeast Portland.

Through planning for climate action, bicycle and pedestrian connectivity, and urban renewal, uneven progress was made at addressing racial inequality and gentrification. With increasing growth pressure and in-migration rates, City demographics are changing. Nearly 50 percent of current school-aged Portland Public School (PPS) students are children of color. Portland's vision is to administer and deliver City services that provide all Portlanders access to the opportunities necessary to satisfy their essential needs, advance their well-being, and achieve their full potential.

The Smart City Challenge is an opportunity to help correct these historical inequities. The priority demonstration zones of Columbia Corridor and Powell/Division Corridor were selected in part due to direct impacts of the development projects mentioned above. UB Mobile PDX will address ladders of economic opportunity in low-income areas where people ride transit, bike, and walk at higher

rates than anywhere else in the city. Safety will be addressed in these areas, where currently traffic related fatalities are twice as likely to occur as in other areas.

Transportation in a Smart City is not the means to an end, but rather about improving people's quality of life when they are travelling in a city. Portland leadership understands this and that makes us uniquely qualified for this award.

As part of this commitment to equity, PBOT will partner with community colleges and universities, local K-12 schools, and local service and community organizations to get the required tools into the hands of these communities. UB Mobile PDX and the priority demonstration zones create a framework for integrating displaced or underserved communities into the new economy. Portland and its partners can help disadvantaged communities' better use transportation to save time and money, get to jobs, and achieve better health outcomes.

Existing Transportation System

The City of Portland has an extensive transit system that provides the required options to make UB Mobile PDX successful from day one. The City contains 223 miles of freeways and 226 miles of arterial streets. Portland also has 39.5 miles of light rail (MAX) with 5 lines and 70 stops, 12.78 miles of Streetcar Urban Circulator service with 76 stops, and close to 1,400 miles of bus transit service with over 4,500 stops. The Aerial Tram connects the City's South Waterfront district and the main campus of Oregon Health & Science University. And Portland has 350.4 miles of bikeway and 77.4 miles of neighborhood greenways.

The Portland Streetcar, owned by the City of Portland, operates two lines within the Central City. The North-South Line connects the heart of downtown on the west side of the Willamette River and has been central to dense urban residential development and job growth. The A and B Loop Line provides a circulator loop around the Central City with an additional focus on innovative economic development and job creation. The full loop service fulfills the vision from Portland's 1972 Downtown Plan and knits together the east and west banks of the Willamette River. The Streetcar, with about 15,000 boardings a day, provides direct mobility and also attracts development (7,400 housing units directly related to Streetcar and many more within a short distance of Streetcar) that foster mobility without adding more cars to the roadways.

"For years, I drove to work downtown because I thought it was faster. A colleague showed me **UB Mobile PDX** and I started to think differently about my commute. Turns out, Portland has many great options and riding MAX is actually faster than driving at rush hour. I love seeing the dollars saved add up on my app!"

~David, age 50
NE Portland

The City of Portland, in partnership with the Port of Portland, Metro, ODOT, and private sector freight and logistic industry stakeholders, is embarking on a Smart Freight Regional Strategy to facilitate the more efficient movement of goods, employees, and container services. The Strategy is focused on creating a coordinated and comprehensive data hub within various transportation services providing for the following:

- Intensive intelligent transportation system (ITS) management of key freight routes
- Congestion pricing or tolling on key freight corridors

- Facilitated cargo, container, and freight services into and out of the Port of Portland's aviation, marine, and industrial properties and along regional truck routes
- Coordination of port cargo schedules and rail schedule data

This effort will enhance business growth opportunities by providing cost effective and reliable market access. Additionally, it will reduce emissions, provide ladders of opportunity in key economic growth areas, and facilitate Transportation Demand Management to move employees to and from employment centers.

UB Mobile PDX Key Projects and Site Map

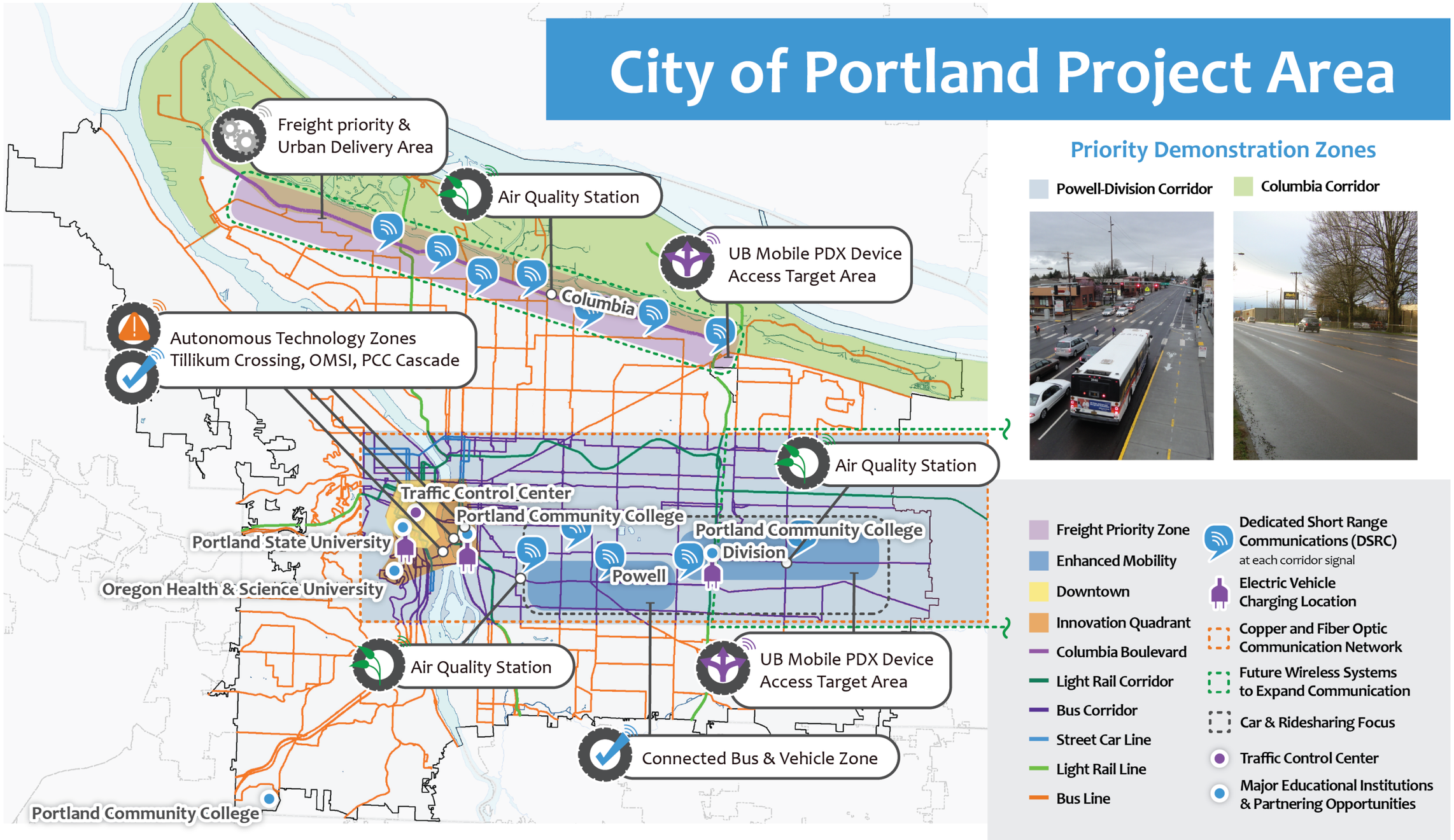
The City of Portland will demonstrate to the world what is possible through implementation of UB Mobile PDX. As shown in *Table 1: UB Mobile PDX Vision Projects* this includes implementing the following outcome-based projects that help realize our vision.

Table 1: UB Mobile PDX Vision Projects

 ***People Focused***	Launch the UB Mobile PDX ***Marketplace*** and ***Open Data Cloud*** with private sector and academic partners to ensure security and equity in ***device access***. Pilot integrated Wi-Fi at transit stations and on transit vehicles, starting with the Portland Streetcar.
 ***Autonomous***	Leverage ***private sector partnerships*** for a driver-assistance and collision-avoidance bus and train pilot on Portland's new car-free, multimodal Tilikum Crossing to provide a dynamic link to the Innovation Quadrant and enhance safety on the bridge while allowing operations at higher speeds. Autonomous vehicle pilots will also be explored at nearby academic and institutional campuses.
 ***Connected and Multimodal***	Deploy two connected vehicle pilots with a TriMet bus fleet and car-share vehicle fleet. ***Communication infrastructure*** throughout the priority demonstration zones will be enhanced with Wi-Fi and Dedicated Short Range Communication (DSRC) radio capabilities. ***Connected vehicle technology***, such as smart on-board diagnostic (OBD) ports will be integrated into the vehicle fleet. MobileEye technology will also be explored for integration with TriMet's bus technology Automatic Vehicle Location (AVL) system Init. At the central traffic control center, Portland's ***central signal system*** will be upgraded for DSRC in partnership with our current vendor Transcore.
 ***Low Carbon***	Collaborate to become a Zero Emission Vehicle City by 2035 through implementation of ***smart grid*** technologies. Electrify priority demonstration zone transit corridors and integrate electric vehicle (EV) charging stations into street lighting systems. Demonstrate dynamic wireless charging of EVs in key locations to enable daytime charging, thus permitting a direct path from renewable energy generation to the user.

Key existing transportation system components and the above technology-based solutions to help realize our vision are highlighted on *Figure 3: UB Mobile PDX Base Map*.

Figure 3: UB Mobile PDX Base Map



Environment Conducive to Demonstrating Proposed Strategies

A number of initiatives make Portland an ideal enabling environment for UB Mobile PDX and the Smart City Challenge grant. Portland has a long history of being early adopters of new technology and transportation. We were the first U.S. city to build a modern streetcar system and the first U.S. city to launch a carshare program. TriMet was the first transit agency to provide real-time trip data to the public, and was on the forefront of opening up its application programming interface (API) to third-party software developers. And Portland has the highest per capita ownership of hybrid vehicles.

Current initiatives that demonstrate Portland's continued commitment to innovative transportation solutions include the revolutionary Hop Fastpass, new bike counting and sharing system, and ongoing leadership in multimodal transportation electrification as discussed below.

The City of Portland and TriMet, along with regional transit partner C-Tran in Vancouver, WA, are currently embarking on a state-of-the-art, electronic transit fare system called Hop Fastpass. This contactless payment system was designed with a geographically redundant and robust backend using open architecture APIs to easily expand and support future services and to capture data as part of UB Mobile PDX. Hop Fastpass will integrate payments for buses, light rail, and the Portland Streetcar and can be used by other modes. The Hop Fastpass infrastructure is being designed in an open and flexible (yet secure) way that will accommodate many other types of use. It will offer a website for employers, schools, and social service agencies, and another website for consumers, as well as mobile Apps for Android and iOS. At full public roll-out in 2017, it will also be compatible with Apple Pay, Samsung Pay, Android Pay, and contactless bank cards, whereby customers can tap their phone or bank card to board. As part of the Smart City Challenge, we will work with TriMet and our partners to integrate cash payment options to promote accessibility to unbanked community members. Other concepts that could be explored after the Hop Fastpass system comes online include expanding the system to the small transit systems that connect satellite communities into the region and elsewhere in the state, as well as bike and ride storages areas in the region.

"I am a PCC student with work, family, and school responsibilities. Before **UB Mobile PDX**, I would check the bus schedule before I left campus. Now, I can check the schedule in real time and even grab a rideshare or BIKETOWN bike rather than waiting for the bus when I'm short on time."

~Javier, age 24
North Portland

Additionally, PBOT is implementing a bicycle ride counting system. As this rolls out and as part of UB Mobile PDX, PBOT will integrate Bluetooth-enabled data streams for the existing bikeway system and the new Portland bikeshare program BIKETOWN. By pulling together these active mobility open-source data streams, Portland can enable better outcomes for the end user with time benefits, money savings, and better health.

Oregon was an early, and continues to be, a global leader in transportation electrification. In 2010, it was the first (and still only) U.S. state to receive the prestigious international "E-Visionary" award. It is one of the top 10 U.S. markets in EVs and chargers per capita, and has one of the most robust DC Fast Charging networks in the U.S. Oregon is a zero emission vehicle (ZEV) mandate state and part of the International ZEV alliance, with a stated goal that all new vehicles sold will be zero-emission no later than 2050. Portland General Electric, the major utility serving Portland, has also been an EV leader – and recently proposed legislative changes in Oregon will also direct and require major utilities to prepare strategies for transportation electrification. Finally, Oregon's low-cost and low-carbon power make EVs even more attractive; the Union of Concerned Scientists recently calculated that an electric car in Oregon gets the equivalent of 94 miles per gallon.

Continuity of Committed Leadership and Capacity to Carry out the Demonstration

Portland's Smart City Challenge goals are broadly supported by City leadership. The Mayor, Commissioner-in-Charge of Transportation, Director of Transportation, and the Director of the Bureau of Planning and Sustainability are committed to seeing UB Mobile PDX implemented. The City, through its existing collaborative relationships with Portland State University (PSU), ODOT, the Metro regional

government, the Port of Portland, and TriMet will continue to work collectively in this multi-agency effort.

The Portland metro area serves as an economic driver for a state with an economy founded on wood products and natural resources and transformed by durable manufacturing. The City of Portland's Economic Development Strategy lays the foundation to build the most sustainable economy in the world. This requires a balanced focus on job growth, innovation in sustainability, and equality of opportunity. Portland holds a unique competitive position as a national leader in the industries and talent supporting sustainability, which will translate into revenue and profit growth for the city's existing business base. These industries include clean technology and sustainable industries, advanced manufacturing, apparel, and software. The City intends to expand exports, support the innovation efforts of higher education institutions, and align workforce development to match the skills needed in sustainable industries.

"For years now, states, cities, and communities across the country have watched Portland, Oregon emerge as a leader in urban transportation. From streetcars to light rail to bike lanes, Portland has been touted by more than one Secretary of Transportation for its forward thinking." - U.S. DOT Secretary of Transportation Anthony Foxx, October 2014 visit to Portland. "

Secretary Anthony Foxx (right) and City of Portland Mayor Charlie Hales (center), U.S. Conference of Mayors 2016.

The City has shown leadership, through the Portland Development Commission (PDC), in helping investment and opportunity for small, new technology startups in the metro area. The City of Portland, through PDC, is an investor and key public partner in the Portland Seed Fund, a privately managed fund and non-resident accelerator focused on providing emerging companies with the capital, mentoring, and connections to propel them to the next level. GlobeSherpa, the company that created TriMet's mobile payment App, is a graduate from this program and has continued to grow jobs and innovation. Further demonstrating the City's commitment to inclusion, the Inclusive Startup Fund provides early-stage investment capital and mentoring to local high-growth companies founded by underrepresented groups across a variety of industries. PDC and Multnomah County each contributed $500,000 and Oregon Governor Kate Brown and Business Oregon committed $250,000 to launch the fund last year[1].

Portland is a national leader in safe, effective, and sustainable transportation solutions. The transportation system is a nearly $10 billion investment in assets that facilitate the movement of people, goods, and services within Portland. PBOT employs more than 750 people at 2 locations in downtown, a maintenance facility in inner North Portland, the Portland Streetcar office in Northwest Portland, and the Sunderland Recycling Facility in Northeast Portland.

PBOT developed Portland Progress, the 2-year work plan that represents a blueprint for how the bureau can build a better Portland. Portland Progress action items are informed first by the multiple long-range plans that guide all City agencies: the Portland Plan, the Comprehensive Plan, Climate Action Plan, and specific to PBOT, the Transportation System Plan. The plan contains 176 steps grouped into 6 themes serving the public. The following four themes directly relate to the Smart City Challenge.

- ***Build A Future Where All Can Grow And Thrive.*** Portland continues to expand and grow in population, employment, and visitors. The city will continue to grow, so PBOT will need to plan and anticipate the challenges of growth by improving connectivity, moving freight more efficiently, and addressing inequities of the past that hinder the future.

[1] See more at http://www.pdc.us/inclusive-startup-fund.aspx

- ***Embrace Vision Zero.*** This theme addresses the need to use street design and public education, and to work with partners in law enforcement and the State Legislature to create streets where everyone, from the youngest to the oldest and people of all physical abilities, can move safely.
- ***Effectively Manage City Assets.*** Approximately one-fifth of the land area of Portland is held in public rights-of-way. This theme addresses the need to make the most of the City's street space by prioritizing among competing uses, supporting the role of streets as community places, and better managing parking.
- ***Contribute To The Health And Vitality Of Our People And Our Planet.*** Healthy and connected neighborhoods are a fundamental goal of the Portland Plan. This theme aims to improve community health and livability by creating safe, active transportation options.

Commitment to Integrating with the Sharing Economy

In 1998, the City of Portland launched the nation's first carsharing program and is now home to four carshare companies. Early on, the City recognized the value and growth of the sharing economy and sought to accommodate the expanse of this new market through lodging with Airbnb and other companies, while still preserving the character of the City and protecting neighborhood livability. PBOT took the lead in crafting regulations to allow Transportation Network Companies (TNCs) in the Portland market, thus providing for equitable treatment of existing taxis and town cars, and introducing more competition to the market. Car2Go now operates a fleet of 530 cars, the largest fleet in the U.S.

Portland's new bikeshare program BIKETOWN will launch in July 2016. In partnership with SoBi, Motivate, and Nike, PBOT is working to create an App that will not only give users real-time data on the location of the bike, but also include real-time route finding. It will be the most technologically advanced App on the bikeshare market. Portland will be the first city to introduce variable pricing and gamification to its bikeshare with the technology on the bike. Instead of rebalancing the bike system with trucks, Portland will use pricing and incentives, thereby reducing the overall carbon footprint of the bikeshare system.

Commitment to Making Open, Machine-readable Data Accessible, Discoverable, and Usable by the Public to Fuel Entrepreneurship and Innovation

The Portland region has a long history of making open, machine-readable data accessible, discoverable, and usable. PBOT partners, including ODOT, TriMet, Metro, and more have made data open and publically accessible through systems such as the TripCheck Traveler Information Portal (TTIP) – hosted by ODOT, the regional archive of transportation data for the Portland metropolitan agencies PORTAL – hosted at PSU, and Civic Apps – hosted at City of Portland. Examples of currently-available data on these systems include the following:

- Travel time data collected from Bluetooth sensors on City and State roadways
- Data from the regional arterial traffic signal system, including traffic volume and signal timing, particularly data from an adaptive traffic signal system along the Powell/Division Corridor
- Transit schedule data available through TriMet's public data feed in GTFS format
- On-time performance and ridership data from the TriMet AVL and Automatic Passenger Counter (APC) systems
- Data on traffic incidents from ODOT's Advanced Traffic Management System
- Freeway speeds, volumes, and travel times from all regional freeways, including road closure data
- A wide variety of geographic information system (GIS) data including streetlights, building footprints, zoning, and hydrography

The existence of archives and websites such as TTIP, PORTAL, and Civic Apps shows the region's commitment to open, accessible data. ODOT is currently enhancing TTIP in anticipation of connected vehicles (CVs), looking at how CV data is captured into TTIP, and how CVs will consume roadside data following through TTIP.

PORTAL is the official transportation data archive for the Portland metropolitan region as specified in the Regional ITS Architecture. PORTAL facilitates the collection, archiving, and sharing of data and information for public agencies within the region. USDOT is familiar with the capabilities of PORTAL through PORTAL's contribution to the ITS JPO's Research Data Exchange, created through the ITS JPO's Connected Data Systems Program. PORTAL has ongoing support through funding from the regional ITS coordinating committee, TransPort.

"At my age, driving isn't easy, and the walk from the bus stop home can be daunting. With **UB Mobile PDX**, I don't have to stay home. I can easily call a rideshare to pick me up from the bus stop and take me to my front door. The information – and volunteer who taught me to use it – has given me my freedom back!"

~Marylin, age 68
East Portland

The City of Portland has made sharing transportation data to fuel entrepreneurship and innovation a standard operating practice. The data collected, as described above, is made available to agencies, project partners, and stakeholders through a variety of existing websites and is shared among agencies on a dedicated fiber network. The PORTAL makes data available as well as supports simple visualization and tables on that data. Data not available for download on the website is available through PSU. TriMet makes an additional set of data available on its data website, and City of Portland makes a wide variety of GIS data available on its CivicApps website. Finally, Portland has created a custom fiber network, called the ITS Network, to facilitate data exchange among agencies and partners, including City of Portland, ODOT, TriMet, and PSU.

The open data sharing applications seek to support smart land use and community reinvestment in underserved sections of our community, while reducing congestion and increasing the safety of travelers. PBOT wants to create an environment where alternative, multimodal trip options are not only encouraged, but also commonplace. However, current data sources (for example, American Community Survey and regional travel surveys) do not provide data often enough or at a fine enough scale to accurately track our progress in increasing multimodal travel.

Because of these problems, PBOT has limited ways to study mode share and mode share changes. As UB Mobile PDX becomes popular, it will provide an opportunity to see real mode split in the city. It also provides a chance to see the real-time evolution of mode share which greatly improves our predictive modeling capabilities. Because the data can be collected in real time, we can produce a predictive model on mode share that accurately accounts for seasonality.

The vision for UB Mobile PDX is to continue the evolution of the National 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, the project partners will coordinate and develop data sharing protocols based on existing protocols and the National ITS Architecture.

With this data, PBOT can more intelligently devise a strategy for increasing alternative and active mode use, improving safety, and reducing greenhouse gas (GHG) emissions.

Section 2: Portland's Vision for a Holistic Smart City Program

Our visionary approach successfully integrates societal trends - including Mobility on Demand (MOD), shared-use transportation, crowdsourcing, and preference for lower-carbon options — and technological advances including automation, vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), smart probes, and electrification — to unlock innovation and realize measurable outcomes for a Smart City.

Societal Trends + Technological Advancements =
Ubiquitous Mobility for Portland

This will be done through implementing key projects as discussed above, including the following:

- Launching UB Mobile PDX Marketplace, User Interface, and Open Data Cloud
- Implementing a driver-assistance and collision-avoidance bus and train pilot on Portland's Tilikum Crossing and leveraging private sector partners for an autonomous vehicle pilot areas
- Deploying two connected vehicle pilots with TriMet's bus fleet and carshare vehicle fleet and improve or install upgraded communication infrastructure throughout the priority demonstration zones
- Implementing smart grid technologies including electrification of priority demonstration zone systems

The measurable outcomes targeted through these projects are based on addressing Portland's most pressing challenges and highest priorities:

- ***Unprecedented growth.*** In a growing city, our residents must find new ways to access jobs, services, education, retail, and recreation. We also must find new ways to manage our transportation system to allow for robust economic growth – which depends on both mobility and access – while continuing to focus on investments in biking, walking, safety, and connectivity rather than widening roadways or building new freeways. UB Mobile PDX addresses both the demand side – providing new access to information about how to get around and supporting a growing suite of public and private sector options – and the supply side by improving system efficiency. Our priority demonstration zones for technology-based solutions will help Portland – and cities around the country – understand how these emerging technologies can make our streets safer and more efficient and demonstrate how we can bridge the digital divide.
- ***Social equity.*** As we make infrastructure investments, the City is conscious of ensuring these investments promote equity rather than deepening divides. This means focusing on traditionally underserved communities, engaging residents in meaningful ways so that all citizens have the opportunity to influence decision making, and improving safety. UB Mobile PDX is a platform for ensuring that the technology revolution changing the way our transportation system works – from connected and autonomous vehicles, to ride sharing and new ways to pay for our system – reaches low-income and minority residents. Using UB Mobile PDX, we can bring transportation costs down, increase choice, and ensure that these benefits are experienced equitably throughout the city.
- ***Climate change.*** Portland has a goal of reducing daily vehicle miles traveled by 30 percent from 2008 levels by 2030 as well as improving the efficiency of freight movement. UB Mobile PDX is an important part of meeting this goal by providing residents with better information about how to get around and how their choices impact GHG emissions in the region, and supporting the growth of transit, ridesharing, and bikesharing options that can only become more robust through increased use. Integration of gamification in active transportation options will also help to promote better health outcomes. And finally, using data collection and smart signal technology, UB Mobile PDX will also improve freight efficiency in and through the city.

Key Features of Portland's Smart City

In Portland's Smart City: Payment for mobility services and cost of supplying service will be transparent and correlated.

The current transportation funding system, largely through the gas tax, parking, and other tax revenue, has become disjointed and regressive. Within the UB Mobile, Portland will develop a secure Marketplace that will collect payments for using mobility infrastructure and services. A transparent marketplace will enable users to select the most cost-effective systems and the City will optimize use and cost by providing updated information to help enhance mobility choices. In addition, the City will be able to provide equity with targeted subsidies for individuals with special requirements that result from physical or financial challenges or because they live in locations currently underserved by low-cost mobility options.

In Portland's Smart City: The Internet of Things will be used to collect information and intelligent systems will analyze the information to optimize operations.

UB Mobile PDX will launch an Open Data Cloud that receives non-personally identifiable information (PII) from all participants. The data integration approach will protect privacy by augmenting data from strategic sensors to collect, analyze, and report data anonymously. At very low cost, vehicles will be fitted with smart probe devices connected to the vehicle OBD port. Cars and trucks will become smart mobile probes, gathering data through CANbus information about speed, breaking, slipping, bumps, and crashes, and analyzing the data and reporting anomalies. The data will be collected and analyzed by a network of researchers granted access to the database, similar to the current PORTAL system managed by our partner PSU. To support data warehousing, PBOT will leverage key private partnerships as well as explore large-scale green data center solutions. They will develop a suite of algorithms which the system operations manager will use to inform city, county, and state agencies. The net result will be improved service, improved operating efficiency, and lower cost.

In Portland's Smart City: Users will be well-informed.

Portland has a leading set of transit system communication tools for riders. Currently, industry is providing drivers and transit user's information tools such as traffic maps from Google, Inrix, HD Radio, Garmin, and a host of others. UB Mobile PDX will integrate and enhance this information with reliability, schedule, GHG emissions, and cost data. User-driven Apps and dashboards will be created for download and the team will leverage partnerships with private sector information providers delivering knowledge to the public. At the same time, through the Open Data Cloud, the system's operation managers will access available data to optimize the safety, equity, environmental impacts, and efficiency of their operations.

In Portland's Smart City: Traffic flow will be managed for safety and low-carbon efficiency.

Portland traffic signals are currently fitted with a robust communication system that connects 70 percent of the City's system. The system is shared by all agencies in the region and are jointly managed with ODOT from the PBOT control center to the Regional ITS Network. Portland uses the Transcore Transuite system, which is the same partner used by the New York City USDOT Connected Vehicle Pilot Deployment. The ITS Network is used to communicate to the PSU data center PORTAL. Portland has a long history of working with TriMet on innovation like transit signal priority and enhanced preemption for light rail. PBOT has also pioneered truck priority which will be deployed in the Columbia Corridor to enhance freight delivery. These applications will be further enhanced by the additional data integrated into UB Mobile PDX and the emerging DSRC technology as it is increasingly integrated into new connected vehicles. Traffic signals will become increasingly smart. The capability to receive information by drivers will be limited by the vehicle technology, not the system. By collecting vehicle data regarding fuel consumption and emissions using the OBD port and correlating the data with signal phase timing (SPaT) information and signal priority strategies, Portland will be able to link GHG emissions and traffic management at the vehicle level with air quality measurement devices in the field, thus offering the first ever opportunity to measure and manage transportation flow for optimal GHG emissions.

In Portland's Smart City: Autonomous transportation will be realized.

Autonomous vehicle technology can improve the safety of our transportation network, energy efficiency, convenience, operating efficiency, and equity. UB Mobile PDX will provide the means by which autonomous vehicles can become mainstream. We have no doubt manufacturers will successfully solve technical issues, but there remains the issues of acceptance and adoption. To aid in this transition, Portland proposes to establish autonomous transportation pilot zones, beginning academic and institutional campuses, as well as a driver-assistance and collision-avoidance bus and train line on the new car-free and multimodal Tilikum Crossing. While these areas fall outside the priority demonstration zones, they provide a critical link to Downtown Portland and complement the nearby Innovation Quadrant.

"I am a father of three and glad that **UB Mobile PDX** provides our city's decision-makers the real time information they need to improve pedestrian and bicycle safety in my neighborhood."

~Mark, age 42
SW Portland

In Portland's Smart City: Fossil fuel consumption will be reduced and renewable energy will be the primary sustainable energy source.

Vehicle electrification is here. In conjunction with our partners, we will explore implementation of dynamic wireless charging for EVs as well as stationary wireless charging at dedicated carshare, bus, and vehicle or truck fleet parking locations within the priority demonstration zones. Development and demonstration of wireless charging is critical to our effort to increase charging of EV batteries that permits a direct path from renewable solar photovoltaic energy generation or renewable wind generation to the ultimate user. Portland is already home to the first solar-powered, battery-driven fast charger for EVs, developed by local company EV4Oregon, with support from key partner Drive Oregon. We will build on this success to continue to maximize renewable integration through vehicle charging. UB Mobile PDX will promote innovative new programs within the priority demonstration zones, such as a network of electric bike and scooter sharing pods powered by solar-powered charging stations.

Ubiquitous Mobility for Portland - Key Components

UB Mobile PDX will enable Portland citizens and visitors to reach their destinations in the most affordable, quickest, safest, or most eco-friendly way possible. It will empower people to move more effectively and freely through the city and provide the reliability necessary to maintain demanding work, family, or academic schedules. Most importantly, through strategic partnerships, PBOT will provide low cost mobile devices and applied education for how to use the tool to control groups in each priority demonstration zone to promote access to the system. Based on the overarching framework of UB Mobile PDX (as shown in *Figure 1: UB Mobile PDX Framework*), the key components to be implemented as part of the Smart City grant include the Technology Hardware Foundation and Actors, the Marketplace, the User Interface, the Open Data Cloud, and finally the Priority Demonstration Zones for technology and infrastructure implementation:

THE TECHNOLOGY HARDWARE FOUNDATION AND ACTORS

The foundation of UB Mobile PDX is the availability of data from the environment, vehicles, and people. The Portland approach divides the people, vehicles, sensors, and devices on the city stage into groups of "actors." Stationary actors generally include infrastructure systems such as intersection signals, lighting, weather, cameras, and other imbedded sensors. The mobile actor group is very large, potentially including hundreds of thousands, and includes vehicles, trains, busses, trucks, bicycles, and pedestrians. Data from many stationary actors is already being collected and archived and procedures for that collection are in place. For the mobile actors, during development and the demonstration, we will offer and install low-cost OBD-connected smart devices to citizen participant vehicles. Commercial vehicles will be encouraged and eventually required to equip their fleet. Pedestrians, bicycle riders, and passengers on public vehicles such as busses and trains or in commercial vehicles such as taxis, will be connected by their personal smart phones (public and commercial vehicles will be connected independently of passenger connectivity). Eventually, as the advantage of UB Mobile PDX becomes evident, we expect a second wave of users to voluntarily "opt-in" to the system and pay for their own device.

Wherever possible, data will be collected and processed at the edge – on or near the sensor. This is enabled by affordable and intelligent sensor technology. For example, the OBD smart device will provide two-way communication with the Open Data Cloud, providing pre-analyzed secure information and receiving transaction information. These same devices will act as smart probes to collect, analyze, and communicate anonymously all types of system information (free of PII) to the Open Data Cloud. OBD interface can provide related Information such as weather, generated from windshield wiper operation to wheel slippage collected from a vehicle, or congestion information which might be inferred from a combination of global positioning system (GPS) location, speed, and breaking/acceleration patterns.

Edge processing will be facilitated by intelligent gateways that aggregate and process multiple instruments such as on train cars. Communication to the Open Data Cloud will leverage cellular 3G, 4GLTE, Bluetooth, Wi-Fi, or systems in development such as DSRC or 5G. Interoperable regional architectures for these systems will be used, including IEEE 802, IEEE 1609 (for cryptology/security), and SAE J2735 Messages. It is important to note that the Portland strategy will be radio agnostic. Clearly some particular applications such as V2V communication collision avoidance will require new technology. The Portland strategy is to pilot and demonstrate what is possible now while building the road to the future.

THE MARKETPLACE

The Marketplace will use intelligent devices to collect and communicate information and enhance mobility, reliability, transportation efficiency, and reduce transportation-related GHG emissions. The Marketplace will be developed as an exchange market that allows drivers, passengers, transit riders, bicyclist, and pedestrians to buy and sell mobility in a secure and private environment with transparent pricing across mobility modes. The Marketplace will provide user options to aggregate mobility payments, including public transportation fares, tolls, taxis, public and private parking, road usage charges, and peer-to-peer sharing payments that enable integrated pricing policies to drive customer behavior. This will allow mobility users to make informed choices and allow a Smart City to send pricing signals to users to optimize actual costs to both the user and city.

The basis for development of the Marketplace is significantly underway. ODOT's third generation road mobility pricing RUC provides a successful model for secure payment management and exchange. As previously mentioned, TriMet's Hop Fastpass will be the nation's most advanced open architecture transit payment system designed by multiple vendors and managed to be non-proprietary. The intent is to link the knowledge of the two systems with other payment systems such as taxi, ridesharing, carsharing, biking, and walking to create a cross transportation mode marketplace. Additional features of the Marketplace include the following:

- Users will be presented with a full view of mobility alternatives.
- Transit and peer-to-peer sharing economy providers will have intelligent tools to enable introduction of selective pricing and behavioral pricing signals.
- Public and private sector partners will join to create "affinity networks" (that is, groups of system users and businesses with common interests) that pull individuals into groups with common goals, motives, and behaviors.
- Individual privacy and security will be assured by using intelligent secure devices at the point of transaction. The devices will provide only the minimum information necessary to accomplish the transaction and all transaction information will be encrypted.
- The systems will continue to accept payments from various sources, which can also be expanded upon as technology and applications evolve. Solutions for cash payments and access for unbanked populations will also be integrated.
- The system will follow the ODOT RUC pilot (legislated) requirements by removing PII information from records 30 days after payment.
- The convenience, incentives, time, and cost savings of the Marketplace will draw participants into the system.

THE OPEN DATA CLOUD

The Open Data Cloud provides the analytics to enable UB Mobile PDX. It is critical that the Open Data Cloud is scalable, secure, performant, and affordable.

Scalable to support rapid growth in data, traditional and non-traditional data types (for example, images and tweets). ***Secure*** to protect access

to protected or private information. ***Performant*** to provide near real-time response to support decisions by mobile actors engaged in the system. ***Affordable*** in terms of dollar per terabyte and dollar per extract, transform load.

Delivering this combination of results will be achieved with open source distributed data tools at a fraction of the cost of commercial relational systems. Access to the Open Data Cloud will be based on a secure API. City systems, the Marketplace, and commercial applications will be able to securely access the Open Data Cloud data to improve controls, and deliver customer value.

Potentially the greatest value from the Open Data Cloud will be the availability of historical data for analytics, modeling, and predictive controls. Access to this rich data set will enable transportation planners with unprecedented visualization of patterns and opportunities. Development of predictive and dynamic traffic management, routing, and charges can dramatically improve system efficiency and provide improved service and transit times to individuals and commercial users of the Portland infrastructure. Additional features of the Open Data Cloud include the following:

- Data fusion, integration, and standards: transportation agencies have long been siloed in use and terminology. Integration with existing systems such as PORTAL, TTIP, Civic Apps, the RUC system, and others will be required. The API will need to transcend individual agency needs and provide a shared view of current and historic transportation information.
- Experience developing TriMet's open data standard: GTFS along with data management expertise at PSU will help the team address data fusion and integration issues. By making our architecture and internal standards open and documented, Portland's architecture and standards can be used as the basis for standards and will be available for other cities to use and leverage.
- Privacy and Security: security needs will inform every data item and interface. The ODOT RUC system has addressed privacy issues in the collection of data from OBD smart devices. Combining data sources together may create additional privacy issues. The team will conduct a thorough security (risk and vulnerability) assessment on applications and transmissions and develop the most appropriate security approaches to secure information and transactions. This assessment will include data provided to the Marketplace, API, mobile applications, and any other sources and consumers of Open Data Cloud data.
- Scale and responsiveness: with the rapid rise of "things" (cameras, sensors, and gateways), the importance of a scalable data environment is critical. In addition, to create a compelling and usable solution, the Marketplace response must support the real-time needs of travelers through nearly instantaneous results. This can be achieved through implementing a No-SQL distributed data store to provide scale and performance at a cost-effective price point. Furthermore, the platform will be flexible enough to cope with both structured and unstructured data.

The User Interface

THE USER INTERFACE

Marketplace and Open Data Cloud information will integrate at the users' smart phone, tablet, or personal computer. APIs and applications will be developed for download to provide specific and user-driven information to support MOD and provide features that could improve mobility, increase cost efficiency, improve sustainability, and lower an individual's GHG footprint. Apps developed with data from the User Interface may suggest alternatives that save time or money on a user's daily commute. The User Interface will provide a dashboard for UB Mobile PDX participants to see their own information presented against a backdrop of all users, thus creating an enhanced user experience. Additional features of the User Interface include the following:

- Affinity groups are likely to be created based on mobility preferences. Users, at their option, may choose to share and receive select data as part of an affinity group in exchange for valuable points, gifts, or social encouragement.
- User-driver Apps will provide accurate data on trip cost, schedule reliability, and GHG emissions to increase us of active modes of transport, including transit.

PRIORITY DEMONSTRATION ZONES

Many UB Mobile PDX solutions are enabled by open-source data and user-driver MOD preferences (as described above), while other technology-based solutions will be pilot tested in priority locations throughout Portland. Selected priority demonstration zones are at the right scale to demonstrate the impact of UB Mobile PDX and are places where we can leverage other community and infrastructure investments. More importantly, our demonstration zones offer an opportunity to provide access to the benefits of UB Mobile PDX to people who are often relegated to a second tier in both infrastructure investments and technology access. Through partnerships with established community organizations that serve and advocate for low-income and minority residents, public schools and community colleges, we will bridge the digital divide and get devices into the hands of the people who stand to gain the most from enhanced access and mobility.

An important part of Portland's model of success in innovation has been to focus on civic centers and transportation corridors, to test innovative approaches, and measure the effectiveness.

The Columbia Corridor and the Powell/Division Corridor will be design labs for specific infrastructure implementation as well as for baselining, monitoring, and reporting against UB Mobile PDX outcomes. Each corridor will have specific outcomes targeted based on leveraging complementary investments as well as their unique development challenges, including equity, safety, congestion, access, mobility, and climate change.

- **Powell/Division Corridor:** The Powell/Division Corridor is in east Portland and is home to the region's most diverse population. As many as 70 languages are spoken at some elementary schools in the area. The Powell/Division Corridor, particularly east of 82nd Avenue has changed dramatically in recent years due to gentrification of Portland's closer in neighborhoods and arrival of new refugees and immigrants. The recent Outer Powell Safety Project (ODOT) and Powell/Division Transit and Investment Study (Metro/TriMet) have used new models of engagement to develop projects that benefit residents including developing land use policies and strategies to prevent displacement as new investments are made in the corridor. The City is in the project development stage with the Federal Transit Administration to obtain bus rapid transit (BRT) funding in this corridor. Currently, there are existing air quality sensors and adaptive system technology with Bluetooth sensors and transit priority in the corridor. Additionally, the Powell/Division Corridor has a unique placement as an education corridor. It connects Mount Hood Community College, Portland Community College, the Oregon Museum of Science and Industry, PSU, and Oregon Health Sciences University. People in between these institutions need fast, reliable, efficient, and flexible transportation options, often within the constraints of busy lives. UB Mobile PDX has the potential to make managing work, family, and education possible for some of our region's most vulnerable community members. This corridor is also one riddled with safety challenges. Division Street and Powell Boulevard are both identified as high crash corridors. Many parts of Powell Boulevard lack sidewalks and bike facilities. These neighborhoods need improved crossings for pedestrians and bicyclists particularly as they access schools and transit stops. Places most critical for pedestrian and bicycle access are adjacent to busy, high-speed roadways. UB Mobile PDX offers the promise to explore autonomous technology-based systems for driver assistance and collision avoidance on the bus fleet features that sense pedestrians and cyclists to improve safety for vulnerable users. In the Powell/Division Corridor, UB Mobile PDX will leverage transit and safety investments with increased access to shared ride services, bikeshare, and peer-to-peer car sharing to provide enhanced choices for getting around. The existing infrastructure

provides data about the (SPaT) status that can lower emissions and reduce congestion in a critical area for access to jobs. Communication infrastructure throughout the corridor will be enhanced with WiFi and DSRC radio capabilities. CV technology including OBD ports will be integrated into the vehicle fleet, as well as integrated dynamic wireless charging and EV charging stations in key locations throughout the corridor.

- **Columbia Corridor:** the Columbia Corridor is home to 60,000 jobs, many low wage, and is a designated regionally significant industrial area. Average wages in the Columbia Corridor are $44,800 per year. Because of the low density characteristics of warehousing, business parks, and industrial land, the corridor is difficult to serve with public transit. At the same time, many workers find the necessity of car ownership a barrier to employment. Providing low-wage workers with better ways to access work enhances the ladder of opportunity for families in Portland. Improving both access and mobility in the corridor can also improve freight mobility and reliability as corridor businesses ship goods using port, airport, and highway facilities. UB Mobile PDX will leverage the investments already made in the corridor, such as freight priority already on North Columbia at Macrum. DSRC will be piloted in the Corridor to provide additional freight signal priority and air quality monitors will be installed to identify benefits and impacts of system management strategies. Commercial freight vehicles will be integrated into the EV charging program pilot demonstrations, such as wireless vehicle charging units in designated freight parking locations.

"I deliver freight to restaurants all over the city. **UB Mobile PDX** tells me the best route for the day and where I can find parking. Predicting where traffic isn't has allowed me to add five more stops to my route each day and reduced the mileage fee that my company pays."

~Marcella, age 33
SE Portland

USDOT's Twelve Vision Elements

Implementation of the proposed technology and MOD solutions will synergistically combine to create measurable impacts while reducing costs. The focus will be on high-value benefit and rapid deployment outcomes including safety, mobility (reliability), efficiency, sustainability (equity and inclusion), and climate change.

The priority demonstration zone projects as presented above, as well as additional potential solutions to advance USDOT and the City of Portland's vision for a Smart City are linked to each USDOT Vision Element in *Table 2: USDOT Vision Elements and UB Mobile PDX*.

Table 2: USDOT Vision Elements and UB Mobile PDX

Vision Elements – Application of Ubiquitous Mobility for Portland	
Vision Elements & Outcomes	**Technology-Based Solutions in Priority Demonstration Zones**
#1: Urban Automation  ✓ GHG reduction ✓ Safety	Portland will provide the means by which autonomous vehicles can become a viable business through establishing autonomous vehicle pilot zones. This will begin with a driver-assistance and collision-avoidance on Portland's new car-free multimodal Tilikum Crossing. Safety outcomes of this pilot will enhance bridge operations by allowing operations at higher speeds (currently limited to 25 miles per hour). Additional autonomous vehicle pilots will be explored in proximity to this area, with PSU, Portland Community College, Oregon Museum of Science and Industry, and/or Mount Hood Community College as partners. These pilot zones will provide critical proof of concept for future public autonomous vehicle implementation projects. Additionally, with this grant, TriMet would introduce the Mobile-Eye collision-avoidance systems in buses within the target corridors to increase safety for all users of the transportation system.

Vision Elements – Application of Ubiquitous Mobility for Portland	
Vision Elements & Outcomes	**Technology-Based Solutions in Priority Demonstration Zones**
#2: Connected Vehicles  ✓ GHG reduction ✓ Equity & inclusion ✓ Efficiency	Connected vehicle technology will be deployed universally through the UB Mobile Technology Hardware Foundation approach (mobile and stationary actors), as well as piloted specifically in the Powell/Division Corridor and Columbia Corridor. TriMet light rail vehicles and buses would be fully equipped with onboard data hubs to integrate all sensor information including GPS and allow better rider information, and traffic, operations and maintenance diagnostics leading to greater effectiveness of transit service and cost-effectiveness of all efforts. Leveraging the $150 million dollar investment in the new 15-mile Powell/Division corridor BRT, a CV pilot in this zone will take advantage of the existing infrastructure in the corridor to complete an advanced transit signal priority implementation.
#3: Intelligent, Sensor-Based Infrastructure  ✓ GHG reduction ✓ Safety ✓ Mobility	Implementation of UB Mobile PDX and, specifically, the smart devices equipped on participating actors, will provide hundreds and eventually thousands of new intelligent sensors. These traveling sensors will provide mobility information to the Open Data Cloud for analysis and system management improvements. There is also opportunity to extend the investments made in Portland's priority demonstration zones to increase coverage of existing sensors. An arrangement between PSU and the City resulted in a collaboration to implement a permanent research station in an existing traffic signal cabinet. Testing for a low-cost air quality sensor that can be integrated with traffic signal data collection is ongoing. The research program includes implementing effective traffic signal settings based on conditions on the street to improve safety for all modes. This effort will extend existing research being conducted by the University Transportation Center at PSU.
#4: Urban Analytics  ✓ GHG reduction ✓ Safety ✓ Mobility	Extend existing data management partnerships between PSU, government agencies, and new data sources such as RideApp (also known as Knock), Strava, and Sobi (bikeshare provider) to collect open-source, real-time transportation, bike and active mode data. Integration of EV charging and on-street parking data will be explored for use as well. Similar to PORTAL, the Open Data Cloud will collect data from many sources and integrate it into UB Mobile PDX. Our stakeholder team, including PSU, ODOT, and TriMet, have already worked together to facilitate complex data transfer and data sharing. The team is prepared to take this one step further and make data analytics more active, whereby we will automate system improvements through direct active use of data collected in real-time. Combining all this open source data together and making it useful in combination, especially in real-time, is difficult to do. But our team is uniquely positioned to be successful.
#5: User-Focused Mobility Services and Choices  ✓ GHG reduction ✓ Safety ✓ Equity & inclusion	For the user, a series of customizable Apps or dashboards 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 information that provides a seamless overview of all options possible to make a trip from A to B, including transit, walking, and BIKETOWN, to services like Car2Go, Lyft, getaround, spinlister, LIFT paratransit, RideConnection, Amtrak, personal vehicles and others. The User Interface will provide visibility of options with respect to cost, schedule reliability, and GHG emissions and be customizable based on user preferences and priorities.
#6: Urban Delivery and Logistics  ✓ Safety ✓ Mobility ✓ Efficiency	The opportunity to improve freight logistics within the city is woven into the fabric of the Portland proposal. Commercial vehicles participating in the system may be given signal phase timing priority based on multiple variables including class of vehicle, in system use of designated truck corridors, time of day, or location in the city. The advanced traffic maps will provide drivers with better information about alternative routes. Data analysis will give the opportunity to produce customized routing recommendations based on vehicle class. By using the city-wide freight logistics data, it should be possible to design a master coordination system to manage in-city deliveries so as to avoid double parking of trucks (and resulting congestion). It will also be possible to support management of freight parking behavior with pricing signals.

Vision Elements – Application of Ubiquitous Mobility for Portland	
Vision Elements & Outcomes	**Technology-Based Solutions in Priority Demonstration Zones**
#7: Strategic Business Models and Partnering Opportunities  ✓ GHG reduction ✓ Safety ✓ Mobility	Unlocking mobility as a service will aggregate all mobility related payment systems including public transportation fare collection, tolls, public and private parking, RUCs, and peer-to-peer sharing payments. The Marketplace will provide a means to gamify by allowing users to direct a portion of transportation revenue funds (points) to a location and mode of their choice. This gamification will be tied to the user interface and incentives for users, such as saving carbon, or improving health outcomes, can be quantified and shared or even awarded per user-driven preferences.
#8: Smart Grid, Roadway Electrification, and EVs  ✓ GHG reduction ✓ Mobility ✓ Equity & inclusion	Achieving a smart grid will include cooperation with our public utility partners and the private sector, namely the development community. PBOT and the Bureau of Development Services will collaborate to determine policies and updates to City Code necessary to meet the City's recently declared goal to be a Zero Emission Vehicle City by 2035. This will include cooperating to establish building code requirements for charging stations both on- and off-street. We will leverage Portland's globally recognized expertise in urban planning and land use to integrate ubiquitous charging into existing urban infrastructure in the right-of-way, such as street lights and parking meters, to build out visible "pods" of DC Fast Chargers, and to develop codes and procedures to integrate charging into new streets and new developments. Our key partner, Drive Oregon, has identified a number of additional potential electrification projects that will be explored.
#9: Connected, Involved Citizens  ✓ Equity & inclusion ✓ Mobility	The Smart City Challenge effort will be integrated with the award-winning public outreach campaigns that have been successful at increasing the diversity of stakeholders in Portland plan making. This project is important to achieve our objective of addressing the equity needs of the community and as such we will work with our partners to ensure UB Mobile PDX devices get into the hands of community members who need them most within the demonstration zones (such as a school partnerships or workforce training program). A key challenge to address is insuring that in providing these tools, government is not increasing the digital divide. PBOT has committed to installing WiFi in Portland Streetcar stations and cars, as well as collaborating with TriMet to expand Wi-Fi access across all transit modes. Additionally, gamification can be used to increase the use of these tools and further engage the community.
#10: Architecture and Standards  ✓ Mobility ✓ Efficiency	CVRIA and National ITS Architecture will be used to provide a definitive and consistent framework to guide the planning and deployment of ITS. Portland's history with the standards led to cooperation that are now national models for regional collaboration. UB Mobile PDX will continue the evolution of the architecture to incorporate technological developments and evolving user needs with a particular focus on CV requirements and that promote a common framework for the ITS community.
#11: Low-Cost, Efficient, Secure, and Resilient Information and Communications Technology (ICT)  ✓ Mobility	Smart City systems are subject to security threats like any other information technology system. This is true not only for systems that process personal or financial information (such as Hop Fastpass collection systems), but also for many other types of ITS systems. We will work closely with private sector partners to mitigate security risk associated with our equity and inclusion priority of providing UB Mobile PDX devices and transit-oriented Wi-Fi hotspots. Comprehensive security needs for these systems will be addressed through a broad range of threat assessments common in the industry.

Vision Elements – Application of Ubiquitous Mobility for Portland	
Vision Elements & Outcomes	**Technology-Based Solutions in Priority Demonstration Zones**
#12: Smart Land Use  ✓ Equity & inclusion ✓ Efficiency	The legacy of land use that is integrated and supportive of multimodal travel is another strength of our application. Oregon Senate Bill 100 that mandated the establishment of an urban growth boundary around each of the state's cities led to the creation of Metro, the only elected regional government in the U.S. This legislation also provided motivation for a comprehensive system of transit, a relatively dense downtown, and the preservation of farms and forests close to the urban core. While this system promoted a number of city-wide benefits such as investment in MAX, it also accommodated investment projects that increased the cost of living in these neighborhoods, disproportionately impacting poor communities. Today, Portland is experiencing unprecedented rates of growth. Through implementation of UB Mobile PDX, the City will measure and document impacts in the identified priority demonstration zones. This will be done in concert with place-making initiatives and updates to the Comprehensive Plan and Transportation System Plan, which are currently under review.

Section 3: Address Issues Identified in Beyond Traffic 2045

It is important to think beyond traditional definitions of mobility when evaluating how to measure the effectiveness of UB Mobile PDX. UB Mobile PDX is about creating new ways to improve our ability to access the services, goods, and places that make up our lives – personal mobility – in more efficient ways. These new ways of getting around can improve mobility, safety, efficiency, and sustainability, and help address climate change.

Beyond Traffic 2045 provides a framework for new thinking about a transportation system. It looks at transportation challenges in five key areas: How will we move? How will we move things? How will we move better? How we will adapt? How will we align decisions and dollars?

How we move

As demographics change in Portland, our residents will need new ways of getting around. Millennials are choosing to drive less, which makes better connected systems for biking, walking, transit, and ridesharing critical to meeting their needs. Boomers are increasingly choosing to reduce driving as they age but desire continued mobility. About one-third of people over age 65 have a disability that limits mobility[2], but many of these people still have the desire to move around their communities independently.

Portland's population is growing quickly and growth in the City is outpacing growth in the suburbs. This population growth creates opportunities for 20-minute neighborhoods where people can meet their daily needs on foot or bike. It also creates challenges with increasing traffic congestion that not only impacts commuters but also hampers the ability to move goods to support a vibrant economy.

"I am a transportation engineer at the City. With **UB Mobile PDX**, I use real-time data from our own fleet vehicles to better time traffic signals to improve system efficiency. Little changes make a big difference – these changes made 3 planned intersection widening projects unnecessary!"

~City Trafic Engineer

UB Mobile PDX provides a new model for moving people in Portland. The Marketplace allows drivers, passengers, transit riders, bicyclists, and pedestrians to buy and sell mobility in a secure and private environment with transparency. This Marketplace and related User Interface can change the way we travel, making decisions about mode transparent and driven by cost-benefit rather than by habit. Through this new Marketplace, we can provide new mobility choices to those who need or want them, and make our transportation system more efficient by helping residents optimize mode choice for each trip. Data collection in the system will allow us to modify the price signals in the system to ensure equitable access to transportation choices, and ensure that transportation choices connect jobs and workforce housing.

[2] U.S. Department of Transportation. Beyond Traffic 2045 Blue Paper. Accessed at https://www.transportation.gov/sites/dot.gov/files/docs/TheBluePaper.pdf.

How we move things

Freight – by truck, air, ship, and train – is the backbone of Portland's economy. As congestion on the highway and roadway system increases, the cost of moving goods increases and compromises economic growth. The ability to move things efficiently both within and through Portland is critical to our economic growth and vitality. Neighborhood businesses are impacted by increased delivery costs caused by unpredictable travel times in the region. Export-focused businesses in the region such as the technology, manufacturing, and agricultural sectors are impacted by their ability to collect freight and move it to intermodal shipping hubs like the airport or port facilities.

UB Mobile PDX will optimize the system using new data collection to inform ITS applications. These ITS applications will improve freight reliability. Freight users will also be able to access better real-time data to predict travel times and choose the best time of day or route to travel. Finally, as we provide information that helps to optimize system use by individuals, people may choose non-single occupant vehicle trips leaving more space on our roadways for trucks.

How we move better

Transportation technology is changing. Autonomous and connected vehicles are moving out of the realm of science fiction and into our daily lives. Smartphones enable new transportation technologies like ridesharing and bikesharing, and big data will influence how transit agencies and roadway agencies manage their systems. Smartphones provide easy, immediate access to congestion information, transit schedules, rideshare vehicle availability, and proximity to bikeshare, as well as easy comparisons of cost and travel times across modes.

UB Mobile PDX is built on connected private vehicles, pedestrians, trucks, busses, and trains providing information to the system and to the users. The user interface will take this to the next level to enable Portlanders access to accurate and user-driven data on cost, schedule reliability, and GHG emissions across the mobility market of the public, private, and sharing economy. Operationalizing transportation data and information will allow Portlanders greater mobility regardless of how they get around.

How we adapt

Climate change is impacting our transportation system and our transportation system impacts climate change. The transportation sector is the second largest contributor to GHG emissions. In 2015, the Portland metropolitan area adopted Climate Smart Communities[3], a strategy for reducing GHG emissions by 20 percent by 2035 as a way to address climate change. Through this work, the region learned that the same strategies that reduce GHG emissions also improve regional mobility, safety, system efficiency, health and equity, and agreed-to performance monitoring. UB Mobile PDX offers the City of Portland an opportunity to move beyond the strategies outlined in the Climate Smart Strategy while achieving the same benefits.

"I walk everywhere in my neighborhood, but sometimes wish the streets were safer. I know **UB Mobile PDX** is the first step in getting cars and trucks that warn drivers of potential crashes with pedestrians onto our streets. I can't wait for a future when more people use this technology and pedestrian fatalities are a thing of the past!"

~Monica, age 46
NW Portland

How we align decisions with dollars

One of the biggest benefits in the deployment of UB Mobile PDX is access to data that will provide for better informed investment decisions in our transportation system and mobility options. Being able to look more holistically at the travel patterns of our citizens, of the multimodal connections that they make, and of the impacts and outcomes associated with specific investments will allow us to target resources in projects and programs that get the best return on investment from a triple bottom line standpoint. Our region is committed to the concept that social, environmental, and financial factors all must be considered when making investment decisions. With historical data silos, it's challenging to truly be able to evaluate investments in this way, but with city-wide implementation

[3] Metro. 2015. Climate Smart Strategy. Accessed online at http://www.oregonmetro.gov/sites/default/files/ClimateSmartStrategy-FinalVersion-2014.PDF. May.

of UB Mobile PDX, the data will allow us to effectively align our decisions and our dollars in the most impactful ways.

Goals and Performance Measures

Closely aligned with the Beyond Traffic 2045 issues, PBOT identified the following goals and key performance indicators (KPIs) for UB Mobile PDX:

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. ***KPI: make Portland's transportation system the safest possible and move toward zero traffic-related fatalities and serious injuries in the next 10 years.***

Mobility: enhance reliability by reducing congestion and increasing access to destinations throughout our community. ***KPI: predict trip time with at least 80 percent accuracy across all modes.***

Efficiency: support a robust local and regional economy and improve access to employment and education for residents. ***KPI: reduce transit and freight trip travel times by at least 5 percent during peak periods and 15 percent during off-peak periods. Reduce congestion and non-recurring congestion by 10 percent.***

Sustainability: improve equity, the economy, and the natural environment. ***KPI: achieve at least 80 percent access to reliable transportation data. Achieve a 25 percent mode split for transit and double existing mode split for biking and walking.***

Climate change: reduce GHG emissions and improve resiliency. ***KPI: reduce GHG emissions from light vehicles by 20 percent by 2035.***

These KPIs will be monitored and measured in the priority demonstration zones (Powell/Division Corridor and Columbia Corridor) using the objective, measure, and monitoring approach described in *Table 3: Key Performance Indicator Measurement and Monitoring Approach*.

Table 3: 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	Use vehicle Basic Safety Message (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.
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	Use mobile BSM data utilization rates to track participation by vulnerable users.
Reduce over-limit speed and red light running infractions	85 percent 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 TNCs and city parking services	TNC rides provided by target area Number of impairment citations Pre-paid "morning after" parking utilization	Use Portland Police DUII citations, Oregon Liquor Control Commission DUII data by retail location, transit, APC, TNC reports, and parking meter data to track impact on DUII citations in relationship to ride home program.

Objective	Measure	Monitoring Approach
Mobility		
 Make transit more effective	Transit travel times	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.
Make transit convenient and reliable	Transit reliability by route Transit route transfer adherence	Use Computer Aided Dispatch (CAD) and AVL, system data to identify travel time variability by route and route connectivity performance.
Make active transportation and shared transportation choices convenient	Mode share to key destinations	Use transit APC, continuous bike and pedestrian counters, crowd-sourced Apps, bikeshare activity, and TNC report data to calculate mode share by location.
Improve reliability for drivers	Travel time reliability System delay	Use combination of in-vehicle and infrastructure sensor data to calculate reliability and delay by corridor.
Improve reliability for freight deliveries within the city and goods movement through the city	Freight system travel time reliability	Use combination of in-vehicle and infrastructure sensor data to calculate reliability and delay by freight corridor.
Efficiency		
 Make transit and freight 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. Signal performance measurement.
Reduce non-recurring congestion	Crashes Freeway Speeds	Use ODOT safety database and emerging information from OBD and DSRC as well as data from TNCs and car sharing.
Improve travel time reliability	Transit On-Time Performance Freight Delivery Metrics	Use AVL Transit Data and private sector data from fleets.
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.
Sustainability		
 Support growth of a vibrant economy	Mix of land use types Reliable and timely access to key destinations Gross Regional Product (GRP)	Use GIS data to calculate jobs to housing ratio by neighborhood. 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 percent or more
Support improved equity in the City of Portland	Transportation and housing cost across income levels Access to biking, walking, and transit facilities by minority and low-income households	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
Climate Change		
 Reduce region-wide per capita roadway GHG emissions from light vehicles	GHG emission rates	Use combination of in-vehicle and infrastructure sensor data to calibrate emissions model.

Section 4: Commitment from Public and Private Sectors

The Portland Metropolitan area has a long history of collaborating on transportation initiatives and groundbreaking sustainable development projects, and UB Mobile PDX is no different. The City of Portland is an inaugural member of the White House Smart Cities initiative and we have demonstrated successful private sector partnerships, experience that can help guide other cities on this path. To realize our vision for the Smart City Challenge grant, various academic, private sector, and institutional partnerships will be brought to bear.

The City of Portland is uniquely positioned to attract private and public partners to implement UB Mobile PDX. As an example of our ability to build partnerships, the City recently announced that Nike will sponsor our new next-generation bikeshare. Portland is home to a growing number of technology firms that are committed to advancing Smart City technologies. Firms like Intel, Jaguar/Land Rover (which has a Research and Development office in Portland), Daimler, and others have a stake in Portland's success and have already demonstrated their commitment to this proposal through in-kind contributions of staff time, resources, and creative thinking. PSU is home to Transportation Research and Education Center (TREC), one of the strongest transportation research programs in the country.

Portland brings a collaborative approach to innovation that began with our decision to compete in the Smart Cities Challenge and will extend to our implementation of UB Mobile PDX. Our proposal grew out of a meeting of more than 20 representatives of academia, consulting, public sector, and technology firms – all who committed their time to develop a proposal. Our ability to leverage partners – both private and public – will continue throughout grant implementation.

Key partners as well as additional potential partners are identified in *Table 4: Key Partnerships*.

Table 4: Key Partnerships

Key Partnerships		Potential Additional Partnerships	
TriMet	Drive Oregon	Pacific Northwest National Laboratory (PNNL)	Booz Allen Hamilton
Metro	CH2M	Kittelson & Associates	Jaguar Land Rover
Port of Portland	Intel	Cisco	Information Technology Industry Council
PSU	ODOT	Qualcomm	Clemson University
TREC at PSU	General Motors	Daimler	Mentor Graphics
Oregon State University	Lyft	Google Fiber	Sanif
University of Oregon	Car2Go	Pangia Motors	GENIVI Alliance
Oregon University System	DKS Associates	Toyota	Verizon
Advanced Computing Center at Oregon Health & Science University	MobileEye	Freedom Pop	Advanced Traffic Products
Portland Public Schools	Savari	Getaround	
Portland Business Alliance (PBA)	Inrix		
Oregon Technology Association	RideScout		
Transcore	T4 America		
	NAMAC Oregon		
	Portland General Electric		

Leveraging Federal Resources

The City of Portland is in a unique position to leverage federal resources to implement UB Mobile PDX. The City is in the project development phase for a transformative BRT system that represents significant high capacity transit in the Power/Division Corridor. As we develop the Marketplace, we will leverage existing systems developed for RUC and TriMet's Hop Fastpass payment system to allow us to build onto existing consumer-facing financial systems rather than building a new system. We will also leverage BIKETOWN and up to $10 million investment from Nike and $2 million in startup equipment

and installation funds from the City of Portland. We have developed partnerships with service providers who can manage consumer financial transactions. And finally, we have several key partners including GM, Lyft, Intel, among others, that will include private investment in the applicable areas.

The TransPort committee, the ITS Network, the PORTAL data archive, TTIP, CivicApps website, and TriMet data website are all multi-stakeholder systems that will all be used to maintain systems, interfaces, and data integrity. TriMet, Metro, and PSU have some of the best open source data collection and sharing programs in the nation. UB Mobile PDX will leverage these programs to advance implementation of a Smart City in Portland and also to share data about the Smart City with other interested cities.

While being city-wide in scope, UB Mobile PDX will focus on priority demonstration zones including the Powell/Division Corridor. This corridor is already receiving significant attention including a transit corridor investment as well as walking, biking, and safety improvements as part of the Powell/Division BRT Project and other ongoing City, ODOT, and TriMet projects such as the Outer Powell Safety Study and the recently completed Tilikum Crossing. UB Mobile PDX will leverage the change occurring in the neighborhoods along Powell Boulevard and Division Street to create a new paradigm for personal mobility.

The City of Portland is committed to leveraging existing projects and resources for UB Mobile PDX. Grant funds will be supplemental to existing projects – not a backfill for these projects. Existing staff working in the policy, planning, and projects group; signals and streetlighting; and transit partnerships on current or funded projects will be leveraged to implement UB Mobile PDX.

Section 5: Technical Capability

Program Management Approach

PBOT understands how vital project management is for a culturally transformative and multi-stakeholder project of this magnitude. Working with a key partner such as CH2M, we will apply a performance management framework and rapid implementation of delivery tools to define project roles, expected outcomes, and KPIs to measure and report impacts of UB Mobile PDX and demonstration projects. The CH2M project management approach tracks performance against developed metrics and detects deviations from the defined path early to make timely corrections and maintain the schedule and budget. Identified delivery tools will provide the team with consistent processes, standards, and protocols for UB Mobile PDX implementation and successful infrastructure demonstration projects in select testbed zones. Furthermore, we will ensure project participants clearly understand their roles from day one and achieve the defined outcomes of their roles.

A programmatic approach can save between 15 and 25 percent of capital costs and between 10 and 20 percent from the schedule.
CH2M's Performance Management Framework and delivery tools focus on establishing metrics and promoting a culture of accountability by developing a common set of criteria to measure and compare actions and outcomes.

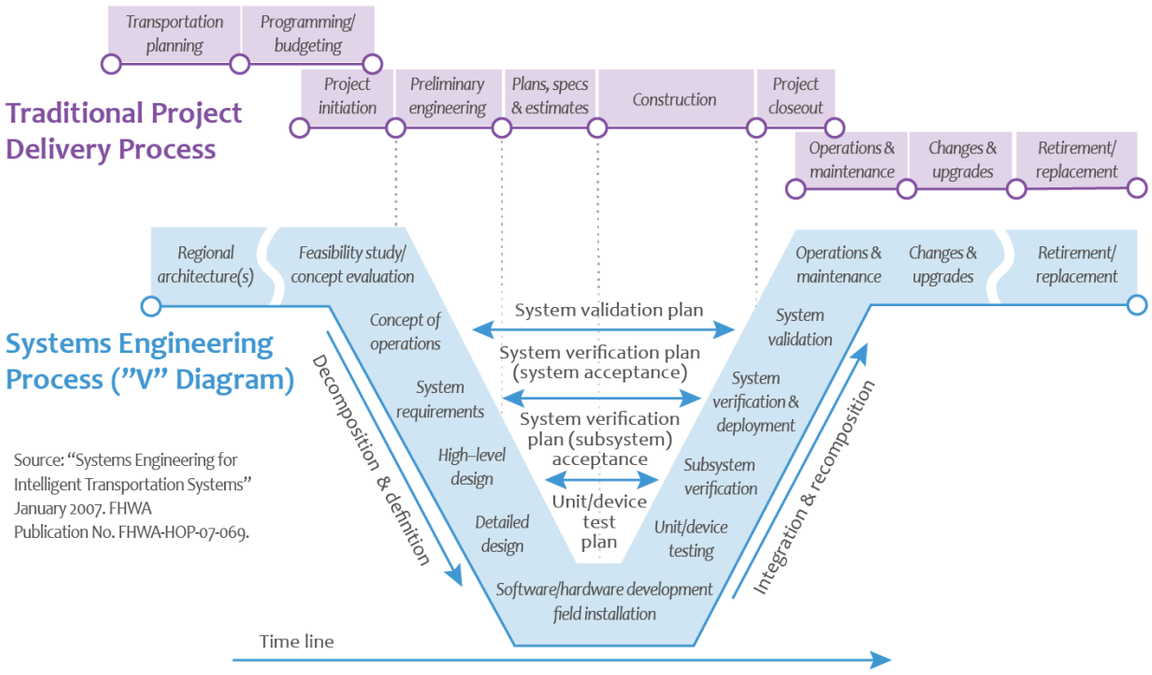
Integral to this approach, the team will conduct kickoff chartering sessions to integrate project management, infrastructure, data management, operations, legal, university partner, and public and private stakeholder groups to define shared scope, goals, behaviors, expectations, and roles and responsibilities. This process is critical to drive integrated performance among project stakeholders working toward a common set of outcomes (see **Section 3**, Goals and Performance Measures).

Risks and Mitigations

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 are best managed through disciplined use of the systems engineering process. Often depicted as a "V" diagram

Figure 4: Systems Engineering Process "V" Diagram as a way of relating the different stages in the system life cycles to one another, systems engineering is a formal process by which quality is continuously promoted. Systems engineering may be described as a "requirements-driven development process;" that is, the user (stakeholder) needs and requirements are the overriding determinant of the system concept, design, and component selection and implementation. Moreover, applying the systems engineering process is required for most ITS projects that involve federal aid.

Figure 4: Systems Engineering Process "V" Diagram



A high-level risk assessment and discussion of the 12 vision elements are identified in *Table 5: Vision Elements Risk Profile.* Although risks are always associated with the demonstration and deployment of new technology, these risks can be adequately mitigated to achieve project goals.

Table 5: Vision Elements Risk Profile

Vision Elements Risk Profile			
Vision Element	**Risk Profile**	**Mitigation**	**Risk Rating**
#1: Urban Automation	Technical risks for the demonstration of semi-autonomous and fully autonomous vehicles on the transportation sites and campuses of project partners include equipment failures and accidents, as well as necessary state legislature approval. These include both program risks and operational risks. The program risks will be addressed by system engineering techniques to ensure delivery of workable solutions are on time and within budget. The operational risks will be covered by traditional insurance instruments associated with operations and maintenance of public transportation. There may be a need or opportunity for public participants to sign a limitation of liability for certain types of autonomous vehicle operation. Policy risks include the adoption of business rules for the operation of vehicles and public participation. Institutional risks include delays associated with implementing new technology.	Systems engineering Custom insurance coverage Limitation of liability	High

Vision Elements Risk Profile			
Vision Element	**Risk Profile**	**Mitigation**	**Risk Rating**
#2: Connected Vehicles	Data security and privacy comprise moderate institutional and policy risks for connected vehicle operations. This will be mitigated by engaging a data security provider and using evolving USDOT CV standards. In addition, connected vehicle technology deployment carries program and operational risks. Unlike autonomous vehicles, a connected vehicle is not reliant upon the connectivity for safe operation, and, therefore, liability is limited. Damage to a vehicle is possible, but unlikely. Program risks will be managed using systems engineering techniques to govern design and implementation. Risk of development prior to the completion of CV standards could be realized in the case of premature obsolescence.	Data security provider Systems engineering Custom insurance coverage	Moderate
#3: Intelligent, Sensor-Based Infrastructure	Implementation of additional types and quantities of sensors is not outside of the normal course of City operations. Modern sensors are typically low cost, low-power, off-the-shelf devices. In the urban environment, there is the possibility of accidental damage, theft, or vandalism as with any City property exposed to the public; however, the risk of injury associated with public exposure to the devices is minimal.	Systems engineering Standard insurance coverage	Low
#4: Urban Analytics	Data analytics are a combination of data engineering and data processing to derive useful information from data and share it. The risks in analytics are technical and institutional. Inconsistent data formats and frequencies are common data engineering problems that introduce risk. The most common technical problem in analytics is the lack of qualified subject matter expertise in interpreting the meaning of data. The most common institutional problem is an unwillingness to share raw data with a frequency that serves real-time applications. Both of these problems are mitigated by the selection of the right program partners.	Qualified partner selection	Moderate
#5: User-Focused Mobility Services and Choices	For the user, the risks associated with development of user Apps and dashboards are well known and readily mitigated. User acceptance of Apps can be tested by standard industry means. Development time and cost are also standardized and quantifiable.	Systems engineering Focus group use	Low
#6: Urban Delivery and Logistics	The risks and mitigations for freight logistics are similar to those discussed for Vision Elements #2, Connected Vehicles, and #5, User-focused Mobility Services and Choices. An additional risk is one of policy and public acceptance, in that advantages provided to commercial enterprise by government can sometimes experience opposition from the public and competing businesses.	Systems engineering Public outreach	Moderate
#7: Strategic Business Models and Partnering Opportunities	Not unique to Portland, successful implementation of Smart City technologies will rely on strategic partnerships between public, private, and academic sectors. Portland has a long history of inter-agency collaboration and developed academic partnerships specific to transportation solutions.	Partnerships	Low
#8: Smart Grid, Roadway Electrification, and Electric Vehicles	The risk profile is similar to Vision Element #1, Urban Automation, in that demonstration involves developing systems that will become operational and used by program participants.	Systems engineering Custom insurance coverage Limitation of liability	Moderate
#9: Connected, Involved Citizens	There is moderate risk associated with not successfully engaging citizens in priority demonstration zones and equipping them with the necessary devices and knowledge to participate to achieve equity goals of UB Mobile PDX. In addition, without early user integration additional users will not buy into the system.	Public outreach Partnerships	Moderate

Vision Elements Risk Profile			
Vision Element	**Risk Profile**	**Mitigation**	**Risk Rating**
#10: Architecture and Standards	Although there are no appreciable risks associated with conformity to standards and architectures, there is a risk of developmental obsolescence associated with demonstrating technologies for which standards are not yet fully developed.	Systems engineering Conformity to standards	Low
#11: Low-Cost, Efficient, Secure, and Resilient ICT	Data security in the development and deployment of ICT systems is moderate for these applications and can be readily addressed through engaging a security provider, as discussed in Vision Element #2, Connected Vehicles.	Systems engineering Security provider	Moderate
#12: Smart Land Use	Typically, there is policy risk in any changes contemplated to urban land use, in that laws and regulations are threaded through the existing fabric governing land use. Due to Portland's track record of smart land use and associated decision making, this risk is negligible.	Policy development	Negligible