



City of Pittsburgh Proposal

Beyond Traffic: The Smart City Challenge

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City of Pittsburgh – USDOT “Smart City Challenge” VISION NARRATIVE

1. Define your vision for your Smart City.

The City of Pittsburgh sees the confluence of transportation and energy as the key to U.S. Department of Transportation’s (USDOT) Smart City Challenge. To meet the challenge, we will develop an open platform and corresponding governance structure to improve the safety, equity, and efficiency of our transportation network and its interaction with the energy and communications networks. By building on existing technology deployments and increasing fixed and mobile sensors over a number of major “*Smart Spine*” corridors that connect with primary commercial centers and amenities, Pittsburgh will collect, analyze, visualize, and act on information to improve mobility for residents. The non-proprietary nature of our platform allows the City of Pittsburgh and its partners to set an open, national standard for a municipal service delivery platform, which enhances industry and supports innovation.

Problems and Challenges

Like many cities in the postwar period, Pittsburgh faced significant transportation and economic challenges. Together, local, state, and federal governments set about on a frenzy of downtown renewal through brazen demolition and bold, yet sometimes ill-advised, construction of buildings and roads. This coordinated effort built our modern highway system and provided quick access to and from our Downtown Business District, but, unfortunately, also left a legacy of isolation in its wake for many low-income neighborhoods.

The 20th Century transportation network created significant challenges for Pittsburgh and its residents. Neighborhoods such as Homewood have some of the worst asthma rates in the state as a result of their proximity to transportation infrastructure. Neighborhoods such as Uptown were bisected by highways and are still recovering. Research on “black carbon rivers” conducted by Professor Alberto Presto of Carnegie Mellon University (CMU) highlights a fundamental correlation between the City of Pittsburgh’s transportation network, location of neighborhoods and amenities, and transportation generated emissions. To address these challenges, Mayor Peduto called for the reduction of transportation born pollutants by 50% before 2030 as part of the U.S. Conference of Mayor’s Climate Delegation to the UN Paris Climate Conference in November 2015.

Having internalized the lessons of the past, Pittsburgh must establish a new paradigm to solve its problems: Air quality, though vastly improved from the time of Pittsburgh’s industrial prominence, still lags much of the rest of the country. Shifting patterns in the way the city residents live, work, and play are making once blighted communities and abandoned brownfields into boomtowns, and shifting the transportation demand to previously marginalized sections of our city. Streets designed for horse carts must now safely carry cars, buses, freight, and, increasingly, cyclists and pedestrians. In areas where growth has yet to arrive, the existing transportation infrastructure fails to provide a corridor to new opportunities.

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Our existing infrastructure is simply insufficient to deal with current usage, and we see far too many accidents and fatalities of pedestrians, cyclists, and drivers alike. Currently, the system is static and oriented toward the travel and land use patterns of the 1940s, not the 2040s. To solve our challenges, the City of Pittsburgh has neither the resources nor the willingness to employ the tactics of demolition and displacement that were used during Pittsburgh’s first renaissance in the immediate post-war period.

Instead, we must design a bold new framework using the resources that we do have at our disposal: Forward-thinking leadership in the public sectors, information and communication technologies, and internationally-lauded research and development from our world-class universities.

The City of Pittsburgh is now developing a new lens to view these and other problems. Called *P4*, this framework is built around four simple but necessary themes to guide decision making - people, place, planet, and performance. First, the system puts the needs of people first. Second, the system considers and cares for the quality of place, the urban form and natural assets that comprise the city. Third, those decisions are guided to improve our planet and our collective health and well-being, and finally the system measures performance and allows for adaptive management approaches.

Pittsburgh’s Solution: SmartPGH

Pittsburgh’s challenges can only be solved by a major collective action on par with the city’s renaissance of 60 years ago. Fortunately, USDOT’s Smart City Challenge presents us with an opportunity to begin to create the next generation of public infrastructure: an adaptive, living communication and data platform that allows the City of Pittsburgh to respond to the transportation and energy needs of residents efficiently and equitably. As our street grids, electric, water, and gas networks provided a platform for the 20th Century Pittsburgh to be built upon, we firmly believe that open data will be the platform the 21st Century Pittsburgh is built upon.

Pittsburgh seeks to embark on the creation of an accessible platform for a new economy that is rooted both in the foundation and growing interrelation of information communications technology, intelligent transportation systems and energy and utility information networks. The platform recognizes that the primary role of local government is to provide for the health, safety and welfare of citizens and visitors. The City of Pittsburgh’s integrated approach provides a vendor-agnostic foundation that will serve as an enabler for new technology, egalitarian economic opportunity, reduced travel-related accidents, and emissions reductions.

Thus, ***SmartPGH*** will integrate pre-existing and new networks and create *systems-of-systems* that create multiple benefits. First, the City of Pittsburgh will organize a system of governance to ensure the uniform collection of this data: we will establish the ***SmartPGH Consortium***, a governance structure combining executive, strategic, and operational leadership led by the City of Pittsburgh and bringing together major transportation, energy, and communications players

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to work collaboratively on our next generation of infrastructure. By beginning with this shared-governance model, *SmartPGH* can quickly deploy an open platform; identify opportunities to leverage existing technology investments to advance broad community goals, coordinate future investments, and work jointly to develop a regulatory framework that encourages innovation.

The *SmartPGH Consortium* will quickly establish an operating and financial structure, and begin deploying the assets that will build the *SmartPGH* platform in Year 1. Using fixed assets such as streetlights and traffic signals, storm-water pipes, electric lines, and even city staircases, Pittsburgh will create a number of “*Smart Spines*”, our major corridors which flow with as-yet-untapped, but valuable data. For instance, on streetlights we will deploy CMU’s Center for Atmospheric Particle Studies (CAPS) Real-Time Affordable Multi-Pollutant (RAMP) sensors, a low-cost package to measure concentrations of air pollutants. The City of Pittsburgh’s existing network for Dedicated Short Range Communications (DSRC) equipped traffic signals will be significantly expanded. Along our corridors, mobile assets - public buses, city fleet vehicles, bike share bicycles, and more – will be equipped with DSRC and become “connected vehicles” to provide a more robust picture of Pittsburgh’s transportation ecosystem. This increased level of sensing and connectivity lays the critical groundwork for Pittsburgh as it expands its growing automated vehicle testing and deployment.

SmartPGH will also be informed by smart phone users, themselves human assets, as we pull social media content into our platform in real-time. Finally, the platform will simplify the adoption of new technology by the coordination of business models that can be supported through both permitting and procurement.

This integrated, adaptive *SmartPGH* platform will serve as the ideal framework for application developments that provide increased safety, mobility options, equity, and efficiency while also allowing innovators to build freely on an open platform. This system of interconnected sensors, monitors, and controls will provide information carried over an already existing city-wide fiber network to the Western Pennsylvania Regional Data Center (WPRDC), a university hosted collaborative led by the City of Pittsburgh and Allegheny County, and the University of Pittsburgh. This data will drive decision making as well as serve as a foundational platform for applications like Mobility Analytics Center (MAC) at Carnegie Mellon, and our proposed robust Multi-Modal Travel & Accident Reporting app, *MovePGH*. We will have never-before-seen integrated information on traffic flows, pedestrian counts, air quality, energy usage and a host of other variables. All of these applications will engage a wide range of stakeholders, and will be measured not only for their impact on mobility and efficiency, but on the way that they positively contribute to the social well-being of neighborhoods. These applications will maintain a strong focus on leveraging the significant presence of ride-share services and integrating them with all modes to enable all residents to thrive.

Pittsburgh, through its partnership with DOE, is developing an integrated energy platform that will be compatible and complimentary with *SmartPGH's* transportation network. This synergy builds a bridge between conventional transportation and energy systems, and allows for the

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development of applications benefiting both. For these reasons, we believe that Pittsburgh is best positioned to make significant “smart” gains at the confluence of transportation and energy, and *SmartPGH* lays the groundwork for a truly 21st Century vision: Autonomous, connected vehicles moving safely through Pittsburgh’s “*Smart Spines*” and all our streets powered by a clean, reliable, and local energy, connecting residents of every neighborhood and all ages efficiently and affordably to their place-of-work, their homes, and one another.

To move toward this vision, our proposed suite of application deployment and demonstrations under the *SmartPGH* umbrella are as follows:

Surtrac: Real-Time Adaptive Signal Control with Smart Transit Priority

This application proposes a “*Smart Spines*”-wide deployment of the Surtrac adaptive signal control system with enhanced DSRC radios to provide multi-modal support and transit priority and urban freight priority. Surtrac is an innovative smart signal technology developed by researchers at CMU specifically for urban environments, and its current deployment in the East Liberty neighborhood has demonstrated significant performance improvements in both traffic flow efficiency and air quality control. *(The application addresses the following Vision Elements: #2: Connected Vehicles, #3: Intelligent, Sensor-Based Infrastructure, #4: Urban Analytics, and #11: Low-Cost, Efficient, Secure, and Resilient Information and Communications Technology.)*

Intelligent Freight Management

This application will introduce two technical innovations that exploit deployed sensing infrastructure (both fixed and mobile) to expedite and streamline freight pickup, movement and delivery citywide. First, to expedite freight movement through the city, we will equip freight-carrying vehicles with DSRC radios capable of communicating location and mode information to intersections, and exploit the Surtrac adaptive signal control system to give priority to truck traffic. Second, we will deploy and pilot delivery zones designated for more efficient and cost-effective freight delivery services. *(The application addresses the following Vision Elements: #2: Connected Vehicles, #3: Intelligent, Sensor-Based Infrastructure, #4: Urban Analytics, #6: Urban Delivery and Logistics, #7: Strategic Business Models and Partnering Opportunities.)*

Autonomous Shuttle Network

The application will demonstrate the convenience and safe operation of autonomous EV shuttles, beginning with travel along *Electric Avenue*, and over time scaling to a wider network. While the regulatory environment is currently not structured to permit the deployment of fully autonomous vehicles, Pittsburgh has long been the epicenter of connected automation technology, using sensors and communication systems to enhance and support autonomous safety and performance. Partnering with USDOT’s National University Transportation Center for Safety at CMU and partners such as Uber’s Pittsburgh-based Advanced Technology Center, *SmartPGH* will demonstrate successful autonomous-assisted usage in a bustling urban environment. Pittsburgh’s Urban Redevelopment Authority (URA), a Federal Transit Administration designated agency; and the Port Authority of Allegheny County are key resource

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partners in this proposed activity, and the intention is to connect the corridor to other potential autonomous deployments, including the Junction Hollow Connector being evaluated by the City of Pittsburgh that would connect the net-zero energy Almono site in Hazelwood with the Oakland neighborhood. A PennDOT and CMU study completed in 2014, *Autonomous and Connected Vehicle 2040 Vision*, assesses the impacts of automated and connected vehicles in the Pittsburgh region. PennDOT continues to pursue both automated and connected vehicle policy and deployment and will coordinate these efforts with **SmartPGH**. (The application addresses the following Vision Elements: #1: Urban Automation, #2: Connected Vehicles, #3: Intelligent, Sensor-Based Infrastructure, #4: Urban Analytics, #10: Architecture and Standards, #11: Low-Cost, Efficient, Secure, and Resilient Information and Communications Technology.)

Electric Avenue: Nexus of EV, Renewable Energy, and a Smarter Grid on 2nd Avenue

This application will deploy new sensed city fleet EVs, which will be charged in a public parking lot near the Downtown Business District. The smart charging station infrastructure will be covered by a solar photovoltaic (PV) canopy, and be connected to energy storage and microgrid infrastructure. By using smart charging and on-vehicle high-resolution data logging, the project can both actively contribute toward shifting electricity demand to improve grid resiliency, as well as understanding the mobility needs of the municipal fleet. City of Pittsburgh Capital Budget funds have already been set aside for purchase of the EV fleet.

Pittsburgh will create a clean energy-transportation corridor along 2nd Avenue extending from the Downtown Business District, past the Pittsburgh Technology Center, to the Almono brownfield in the underserved Hazelwood neighborhood – a major 170-acre development site in Pittsburgh. Once the home of Carnegie Steel and Westinghouse Electric, the Monongahela River Valley will be reinvented as a hub of 21st Century Smart City technology. *(The application addresses the following Vision Elements: #4: Urban Analytics, #7: Strategic Business Models and Partnering Opportunities, #8: Smart Grid, Roadway Electrification, and Electric Vehicles, #10: Architecture and Standards, #12: Smart Land Use.)*

MovePGH: A Robust Multi-Modal Travel & Accident Reporting App

This application is a data archiving and sharing platform aimed at integrating high-resolution multi-modal data, including data pertaining to public transit, ride-share, parking, incidents, weather, freight, cyclists and pedestrians. The platform can provide multi-modal traffic information for travelers that take into account predicted travel time, travel time reliability, parking, travel cost, energy consumptions and emission exposure. Furthermore, we are working to create unique datasets that reach beyond typical reporting methods to capture pedestrian/bicycle behavior to create safer routes for these vulnerable users. The application will pay keen attention to persons with disabilities and supportive services for the elderly. *(The application addresses the following Vision Elements: #3: Intelligent, Sensor-Based Infrastructure, #4: Urban Analytics, #5: User-Focused Mobility Services and Choices, #9: Connected, Involved Citizens.)*

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Dynamic Parking Management along “Smart Spine” Corridors

This application will extend the already-piloted dynamic pricing for parking in the City of Pittsburgh throughout the Smart Spine corridors. Integrating *SmartPGH* data will also allow the *SmartPGH Consortium* to better understand the effects of parking and parking pricing on traffic congestion and flow, local pollution effects due to reduced cruising for parking, and how dynamic pricing affects the use of alternative means of transportation (transit, bike share, ride sharing, etc.), parking asset optimization, and land use. In addition, benefits to neighborhoods (reduced traffic, pollution) and businesses (higher availability of parking for customers) will be tracked. *(The application addresses the following Vision Elements: #3: Intelligent, Sensor-Based Infrastructure, #4: Urban Analytics, #5: User-Focused Mobility Services and Choices, #7: Strategic Business Models and Partnering Opportunities, #9: Connected, Involved Citizens, #12: Smart Land Use.)*

While these applications are certainly exciting in isolation from one another, we believe the possibilities emerging from *SmartPGH* are truly endless, especially given the platform’s open and non-proprietary nature; the applications detailed above only begin to scratch the surface of what others may build. The underlying governance of the *SmartPGH Consortium* and the data collection network of fixed and mobile sensors will create a solid structure with which application can be built, specific outcomes reached, and larger goals attained.

Goal Attainment:	Vision Zero, 50 % Emissions Reductions by 2030, Corridors of Opportunity- mobility services for all residents
Outcomes:	Traffic Management, Safety, Mode Shift, Corridor Investment, Best practice as a national standard
Demonstrable Applications:	Connected Autonomous vehicles, Integrated payment systems, Integration of district energy system
Deployable Applications:	Surtrac expansion, Expansion of existing connected vehicle network, Electric Avenue, MovePGH, Intelligent Freight Management
Data Collection Network:	Fixed, Mobile, Human (Social Media) Assets, RAMP Air Quality Monitors, Mobility Analytics Center, and Western Pennsylvania Regional Data Center
Governance Structure:	<i>SmartPGH Consortium, Existing research</i>

Fig. 1: The *SmartPGH* enabling hierarchy.

Why Pittsburgh?

Given our optimal location on the waterways and railways that powered the Industrial Revolution, Pittsburgh has led the nation in the development of transportation technology from its founding, beginning with the boatbuilding industry that equipped Lewis and Clark through the mass production of the Westinghouse Air Brake. Our varied topography and seasonality has long offered an ideal testing location for major transportation research.

The City of Pittsburgh is particularly well-positioned because of our partnerships with our city’s two world-class research institutions, Carnegie Mellon University (CMU) and the University of Pittsburgh (Pitt). Additionally, Pittsburgh is in a moment of shared vision. The leaders of the

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City, County, Commonwealth, corporate interests, anchor non-profit institutions, and philanthropies have not worked so closely together since the age of Carnegie and Mellon. The national narrative around Pittsburgh has turned positive, and we are now recognized the world over for our story of resilience and resurgence in the face of ecological disaster and economic collapse.

Coordinated investments geared towards innovation and emissions reduction is a primary function undertaken by the City of Pittsburgh. Building and transportation emissions are the first and second biggest sources of greenhouse gas emissions in Pittsburgh. Addressing emissions reduction in a coordinated way provides the opportunities for a variety of co-benefits. District Energy Pittsburgh, a partnership among the U.S. Department of Energy (DOE), The National Energy Technology Lab (NETL), The City of Pittsburgh and the University of Pittsburgh was created in June 2015 to help modernize existing district energy and create new cogeneration and micro-grid facilities. By aligning the energy and transportation activities, coupled with a dense fiber-optic system supplied by Pittsburgh-based telecommunications company DQE, the City of Pittsburgh is able to bring together these compatible networks and enable deep emissions reduction through coordinated resource deployment and optimized infrastructure.

The development of *SmartPGH* will be the culmination and integration of many efforts currently underway in Pittsburgh. Locally, it offers a technology framework and asset that can further advance the complete streets and storm-water management work. We believe that USDOT’s Smart City Challenge is also an opportunity to build on a string of strong partnerships with the White House, culminating in the new Memorandum of Understanding with the DOE on microgrid development. Additionally, *SmartPGH* will build upon physical and economic corridors of opportunity already laid with projects such as *Choice Neighborhoods*, *My Brother’s Keeper* and *TechHire*, leaving a reinvented Pittsburgh as a noteworthy example of urban transformation in the early 21st Century.

2. Describe the population characteristics of your city and show how it aligns with the USDOT’s characteristics for a Smart City.

According to the 2010 Census, the population of the City of Pittsburgh is 305,704 within our 55.367 square miles. Our population density is therefore 5,521.4 per square mile. Pittsburgh is the 19th densest among American cities with between 200,000 and 850,000 residents. Pittsburgh’s CDP constitutes 17.63% of our UZA.

Though spanning a relatively small geography, Pittsburgh boasts a range of densities over its ninety neighborhoods. The City of Pittsburgh is home to a dense Downtown Business District, urban neighborhoods, streetcar suburbs, and post-war bedroom communities. Steep topography, rivers, and other natural and man-made boundaries have created a patchwork of neighborhoods with a range of densities, which make Pittsburgh the ideal city for simulating a variety of locales, climates, and levels of density.

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3. Describe other characteristics of your city and show how it aligns with the USDOT’s characteristics for a Smart City.

The City of Pittsburgh and Allegheny County are served by the Port Authority of Allegheny County, Pennsylvania’s second-largest public transit agency and the 26th largest in the United States. The Port Authority offers traditional bus transit service, Bus Rapid Transit (BRT) on our separated busways, light-rail service, and even funicular service on two lines affectionately known to locals as "the inclines". As of 2014, Port Authority served an average of 213,000 people per day, with the vast majority (176,900) riding their buses¹. Their fleet consists of 706 buses of various sizes, 83 light rail cars, and the 2 previously mentioned funiculars. In addition, the City of Pittsburgh, and in particularly the Downtown Business District, is also served by transit agencies headquartered in the surrounding counties of Beaver, Butler, Fayette, Lawrence, Washington, and Westmoreland. In 2014, transit agencies provided more than ½ million round-trips to Pittsburgh’s Downtown Business District.

Since 2000, the Zipcar service has been operating in Pittsburgh, including system expansions as recent as November 2015. In late 2014, both Lyft and Uber ride-share services came to Pittsburgh, and were broadly welcomed by Mayor Peduto, despite some early regulatory issues with PA's Public Utility Commission. These issues have since been resolved, in part, due to the City of Pittsburgh's willingness to advocate for the value of the sharing economy. As noted elsewhere in this proposal, in 2015, Uber also chose to locate their Advanced Technology Center headquarters to our city as well, which works to develop automated vehicles technology. Even Pittsburgh's more traditional taxi services, mostly notably Yellow Cab, have adopted a more forward-thinking model business model, utilizing apps for scheduling services, making for easier data tracking.

As a partnership between the City of Pittsburgh, local advocacy organization Bike Pittsburgh, and Allegheny Health Network, Pittsburgh Bike Share launched the *Healthy Ride* bike share system in June 2015 with 500 bicycles and 50 stations city-wide. The system is one of very few "smart bike" systems now in operation worldwide, in which the customer's point of interaction is physically located on the bicycles themselves instead of a nearby kiosk. This on-board computer makes these bikes ideal for integration into the larger *SmartPGH* system.

Given this wealth of transportation options, it should come as no surprise that Pittsburgh is already a truly multi-modal city. In January 2016, Mayor Peduto announced initial results of the *Make My Trip Count* survey, offering a glance at the complexity of the Pittsburgh commuter, and which modes they regularly use. A startling 20,710 local residents responded, and the results reveal an interesting picture of 21st Century urban commuter habits:

¹ [American Public Transportation Association, *Transportation Ridership Q4 & End of Year 2015*, March 3, 2015.](#)

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Mode	Rate
Public Transit	39.6%
Drive Alone	33%
Bicycle	8.6%
Walk	9.3%
Other	9.5%

Fig. 2: Make My Trip Count commuter mode results².

The City of Pittsburgh has already begun conversations with local organizations including the Port Authority of Allegheny County, the Pittsburgh Parking Authority, and local utilities like Duquesne Light and People's Gas have signaled their support and full engagement in our *SmartPGH* plan. Perhaps even more heartening, regional and state-level officials including Pennsylvania Department of Transportation (PennDOT) Secretary Leslie Richards, Southwestern Pennsylvania Commission (SPC) President James Hassinger, state legislators on both sides of the aisle, and Governor Wolf have shown enthusiasm and support for the ideas contained within this proposal. It is clear that for many across the state, this is truly Pennsylvania's application for the USDOT Smart City Challenge and will be met with all the resources as well as institutional and regulatory support necessary for resounding success.

Here in Pittsburgh, a wide swath of leaders in our community realize that this Smart City Challenge has the ability to vastly advance Pittsburgh's transportation, energy, and data infrastructure in ways more profound and economically impactful than simply pouring more capital dollars into 20th Century-style infrastructure projects. As such, Mayor Peduto, Allegheny County Executive Fitzgerald, CMU's President Suresh, and Pitt's Chancellor Gallagher are deeply committed to the success of *SmartPGH*. Our substantial philanthropic community, including such luminaries as the Heinz and Mellon families, shares this vision, and has been closely engaged throughout this process as well.

As covered in greater depth later in this proposal, the City of Pittsburgh has already spearheaded a pioneering effort to develop the Western PA Regional Data Center, a one-stop shop for all the City and County's current collected data, which is accessible by the public in an open, machine-readable format. These previous accomplishments position us well to move forward with a substantial deployment of sensor-based infrastructure projects, connected and ultimately autonomous vehicles, and exciting new apps that connected residents all across our city. However, the success of the WPRDC also shows the City of Pittsburgh's clear commitment to an open, non-proprietary, and replicable approach to *SmartPGH* technologies. We believe that our efforts to fuel entrepreneurship and innovation locally can be shared across the country and, ultimately, around the world.

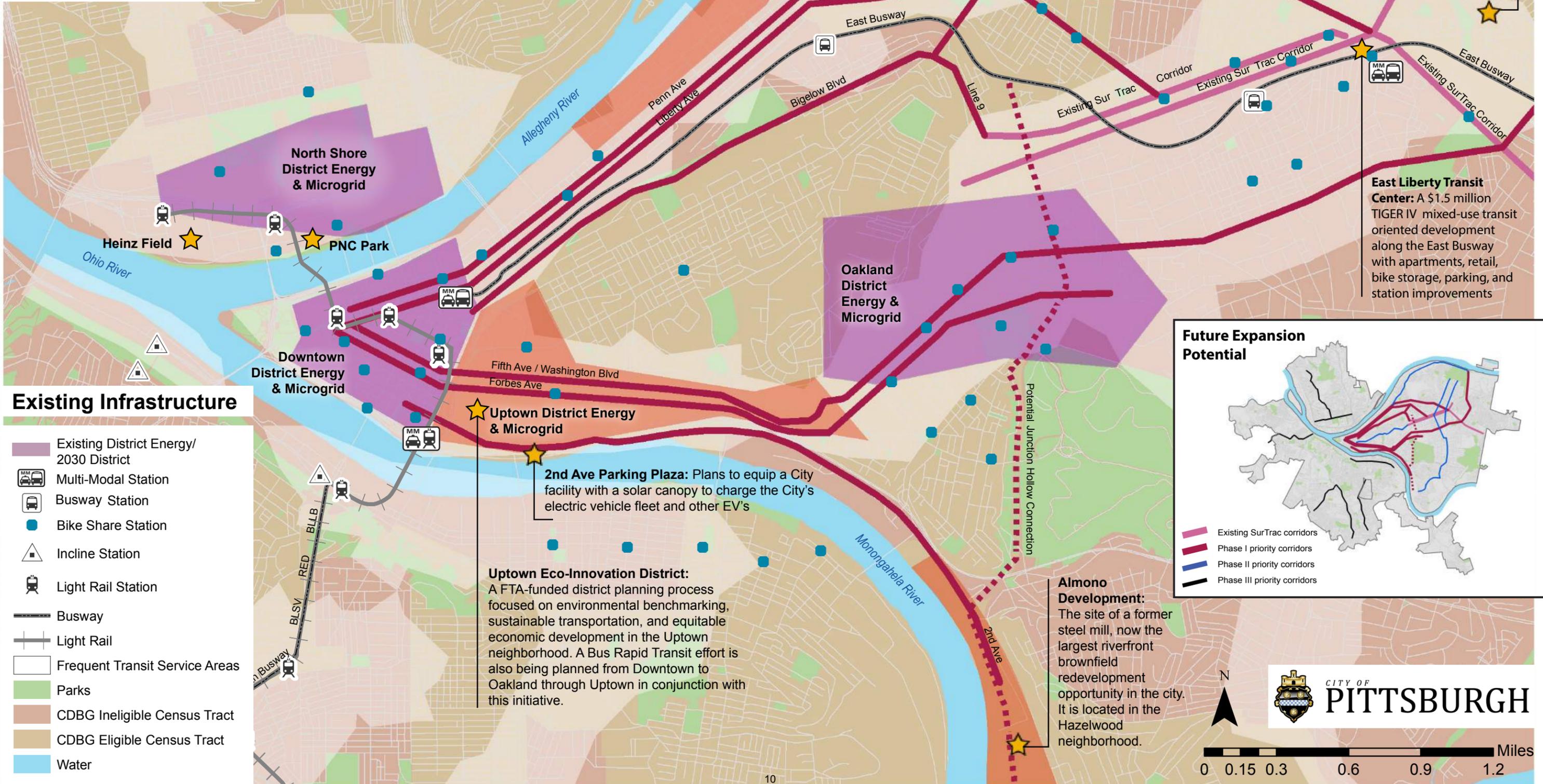
4. Provide an Annotated Preliminary Site Map (see following page).

² [Bike PGH, Survey Says: 8.6% of City Residents' Work Trips are by Bike!, January 15, 2016.](#)

Smart Spine System

Proposed Infrastructure

- Existing SurTrac Corridors
- Phase I Priority Corridors



N

Miles

0 0.15 0.3 0.6 0.9 1.2

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5. Describe how your holistic, integrated approach aligns to the twelve USDOT vision elements described in this solicitation.

We envision Pittsburgh becoming a model smart city where quality-of-life is measurably improved with engaged and informed citizenry, improved safety, better mobility options, and cleaner air. Well-defined “*Smart Spines*” crisscross the heart of the city and serve to highlight the ITS deployments that make the City of Pittsburgh “smart”. Connected and automated vehicles reduce accidents, injuries and fatalities within the city. A distributed sensed infrastructure provides real-time data from around the city to (a) dynamically optimize, smooth and reroute traffic through its dense urban corridors, (b) and measure the quality of air throughout the day. A Mobility Analytics Center identifies trends, recommends near-term and long-term optimizations, and offers predictive information for both planning and operations. End-to-end and easy-to-use transportation options are readily accessible to all citizens and available with convenient payment options. Electric vehicles are connected to a smart grid optimized for flattening electricity loads. Freight vehicles, appropriately incentivized during off-peak hours, use urban corridors efficiently and affordably. Public fleets of snow plows, garbage trucks, maintenance vehicles, and police cars monitor and report any problems with infrastructure. A growing and evolving suite of *SmartPGH* applications provides customized and ready information to citizens, who in turn feed crowd-sourced information back to the platform, enriching its value for all including the less privileged. Parking, maintenance, construction and transit bus information are available anytime on-demand through smartphones, tablets and more. Bike-share and ride-share choices abound. More transportation options are available to disadvantaged neighborhoods, which benefit from increased opportunities.

Our *SmartPGH* technologies are built on an open platform that is highly resilient and based on national standards that safeguard security and privacy. Anonymized datasets, best practices and core principles of operation are available through a data portal for other cities and regions to learn from Pittsburgh’s highly positive experiences. Technology-friendly policies are both introduced and encouraged to facilitate the testing, demonstration and deployment of smart city technologies. Long-lived and focused deployments are augmented by demonstrations to showcase the potential of ITS, and the foundations for enabling future transformations are also laid. Cutting-edge business models allow the City and its citizens to benefit from the investments made by the private sector, who also gain in the longer term. Risks are assessed and mitigated on an ongoing basis. Well-defined metrics objectively gauge progress. Different City agencies, motivated by committed and impassioned City leadership, coordinate easily and regularly lead to substantial savings in planning and operational costs. The City of Pittsburgh undergoes yet another renaissance to become a model for other cities around the nation and the world. Below, we will outline in detail our proposed *SmartPGH* plans for each of the USDOT Vision Elements:

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Vision Element #1: Urban Automation

The City of Pittsburgh’s close partner Carnegie Mellon is widely considered the birthplace of autonomous vehicle technologies, dating all the way back to the early 1980s. More recently, the CMU team won the 2007 DARPA Urban Challenge, a competition that triggered the chain of rapid developments of automated vehicles in recent years and is currently revolutionizing the industry. In addition, CMU has also worked closely with General Motors (GM) since 2000, with GM research funds to CMU exceeding \$25 million. USDOT’s National University Transportation Center on Safety, located at CMU, and has provided additional support of over \$24 million, as has the National Science Foundation’s Cyber-Physical Systems Program, which focused on the development of autonomous vehicles. In the past, CMU has hosted multiple public demonstrations of its leading automation technology and has accordingly received widespread international acclaim for such work.

To address Vision Element #1, *SmartPGH*, working closely with experts like Professor Raj Rajkumar from CMU and engaging in a robust public process, will demonstrate electric autonomous shuttle deployment from a parking area near the Downtown Business District into the heart of the city itself, moving commuters from their personal vehicles to their offices. This electric autonomous shuttle will move through a dense, urban environment on city streets, encountering cars, city buses, cyclists, and pedestrians along the way. In doing so, this demonstration will show that automation integrated into city streets can be done safely, provide convenient mass transport, and have a direct impact on traffic congestion and air-quality by removing a significant number of vehicles from the city center and relying on microgrid electric power. Finally, driver-assist technologies developed by CMU will also be used to enhance traffic safety.

Furthermore, using the connected, sensor-based infrastructure deployments discussed below in Vision Element #3, a truly connected autonomous vehicles network will become a reality. To ensure this comes to pass sooner rather than later, on-going conversations between Mayor Peduto and state-level officials such as PennDOT Secretary Leslie Richards are promising with regards to regulatory changes to address the real possibility of full autonomous shuttle and vehicles deployment in the coming years. The City of Pittsburgh has also had productive conversations with Pennsylvania state legislators regarding policies to allow for the graduated deployment of self-driving vehicles.

Vision Element #2: Connected Vehicles

The widespread adoption of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure technologies (V2I), together known as V2X, bring with them the potential to prevent or seriously mitigate up to 80% of traffic accidents, reduce travel times upwards of 20%, and contribute to significant reduction of congestion and vehicles emissions by minimizing idling. Excitingly, CMU is a world-leader at integrating Connected Vehicles technology with Urban Automation (Vision Element #1). CMU has already demonstrated the benefits of connected automated vehicle technologies in and around Pittsburgh as well as in Washington D.C., even giving automated test-rides to USDOT officials and Members of Congress. As such, much of the City of Pittsburgh’s connected

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vehicle-specific applications are also informed by autonomous vehicles technologies and principles. The City of Pittsburgh and CMU are also currently participating in a USDOT ITS Joint Program Office Affiliated Test Bed program with their 24 DSRC equipped signalized intersections

To address Vision Element #2, we will further deploy the Surtrac adaptive signal control system with enhanced multi-modal support and transit priority throughout our identified “Smart Spines” traffic signals. We will also further outfit Port Authority buses, and possibly City fleet vehicles, with DSRC radios to create V2X interactions that allow for smooth transit and emergency vehicles to be prioritized. This concept, already deployed and fully functional in a few select corridors in Pittsburgh, reduces bus idling and travel times and, therefore, increases the attractiveness of public transit for riders while also minimizing emissions. *SmartPGH* is also proposing to apply this concept to freight carriers such the United States Postal Service, local Pitt-Ohio, or even FedEx Ground. In these freight-specific cases, V2X will expedite freight movement through the city, by employing the same DSRC radio on large, polluting freight trucks.

In addition, we would like to work with Pittsburgh Bike Share, Uber, Lyft, and others to move towards more robust V2V communications that allow Port Authority buses, City fleet, bike share bicycles, ride-sharing services, etc. to become safer by sensing one another on Pittsburgh’s streets and generating safety alerts for drivers or cyclists. In the future, the commuter shuttle proposed in Vision Element #1 will be equipped to react to DSRC alerts through its automated capabilities, and avoid collisions without human assistance.

Vision Element #3: Intelligent, Sensor-Based Infrastructure

Even prior to the Smart City Challenge, the City of Pittsburgh was engaged in actively reimagining our public infrastructure to serve as the platform for sensed data collection, and other functions well beyond their traditional use. Now, we are preparing for the replacement of up to 40,000 streetlights city-wide with advanced sensors featuring cameras, Wi-Fi and cellular technology, and more.

As mentioned previously, the City of Pittsburgh has already deployed real-time decentralized adaptive signal technologies called Surtrac on 49 traffic signals within its Bloomfield and East Liberty neighborhoods. While Surtrac has the ability communicate with cars, freight, and buses, it also monitors real-time queue buildups along each direction at intersections, and, in cooperation with neighboring traffic signals, decides every 2 seconds to appropriately modify signal phase and timings. Traffic wait time has improved by 40% and emissions have been reduced by an estimated 20% through these neighborhoods.

To address Vision Element #3, SmartPGH aims to extend Surtrac technologies to all of the City's traffic signals along the proposed “Smart Spines” and will work with the *SmartPGH Consortium* members to have multiple fixed assets (streetlights, gas meters, city steps, etc.) and mobile assets (fleet, public buses, bike share, freight, etc.) outfitted with sensors as well. These Traffic

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signals will also be equipped with pedestrian cameras to increase sensing of and optimization for vulnerable users. The Port of Pittsburgh Commission in partnership with the Department of Homeland Security have already deployed sensed infrastructure along Pittsburgh’s waterways as well.

This web of intelligent sensors across the City of Pittsburgh, and supported by a city-wide fiber-optic network, will create the platform that many other *SmartPGH* applications can be built upon. For instance, this information pulled in by our sensor network creates an initial infrastructure for automated vehicles deployment (as documented in Vision Element #1), the V2I inputs required for bus and emergency vehicle prioritization (as documented in Vision Element #2), and many of the datasets which fuel our *MovePGH* app and *Mobile Analytics Center*.

Vision Element #4: Urban Analytics

Voluminous streams of data will be generated by sensors on fixed and mobile assets and citizens themselves using apps and social media. Fortunately, the City of Pittsburgh and its partners, such the Western PA Regional Data Center and CMU’s School of Computer Science, have scored a number of resounding successes in the last few years creating open data portals and developing new, exciting ways to analyze and visualize very large, yet relevant data sets.

To address Vision Element #4, *SmartPGH* will work with the City of Pittsburgh and WPRDC to pull in all data being created by our network of fixed and mobile sensors, along with support from the Pittsburgh Supercomputing Center. These massive datasets will then be offered online in an open, machine readable format to any and all members of the public to build their own exciting apps and concepts upon. However, we will also work actively with CMU’s School of Computer Science to analyze and visualize the most relevant and informative data and trends for residents through the further development of their *Mobile Analytics Center*. Beyond this, we will also work with CMU faculty to develop a *MovePGH*, a real-time traveler information app which will be covered in more detail in Vision Element #5.

Despite the obvious value of the specific applications developed by *SmartPGH*, the true value of these open, machine readable datasets to the City of Pittsburgh and its residents will likely come in the form of as-yet-unthought-of applications developed by academics and entrepreneurs. We believe that the potential for significant economic gains will be unleashed by this work, both in Pittsburgh and beyond.

Vision Element #5: User-Focused Mobility Services and Choices

Building off of the work done by the WPRDC and CMU’s Mobility Analytics Center, we trust that such a wealth of available data and analytic findings will create an atmosphere locally in which our residents have far more information regarding their travel decisions than anywhere else in the United States. However, we believe that we have the ability to deliver a rather substantial applications that will begin to revolutionize travel decision made by many of our residents,

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especially those who would like to factor specific mode, health, or environmental considerations into their decision making process more fully.

To address Vision Element #5, *SmartPGH* will work closely with CMU faculty in their School of Computer Science and Civil & Environmental Engineering to develop the *MovePGH* app. This app will enable mobility-on-demand services for a variety of Pittsburgh-based users to make real-time travel decisions covering a wider variety of modes (personal vehicles, public transit, bicycling, ride share, and even EV) based on a wealth of factors like travel time, congestion, trip cost, and even the air quality of a given route. It thus, aims to maximize travel network efficiency throughout Pittsburgh. In addition, users will be able to customize the platform for their own habits and preferences (i.e. default to most environmentally or disability friendly, most affordable, safest, or fastest route). This app becomes even more unique by allowing users to report “near misses” and other traffic accident data, creating an extremely helpful tool for cyclist and pedestrians who want to choose the safest routes possible.

In addition, the expansion of the City of Pittsburgh and the Pittsburgh Parking Authority’s dynamic pricing for parking spaces throughout our “Smart Spine” corridors will also be integrated into *MovePGH*. The Mobility Analytics Center will then be able to review users’ decisions to better understand the effect of parking and parking pricing on traffic congestion and flow, local pollution effects due to reduced cruising for parking, and how dynamic pricing affects the use of alternative means of transportation and use of private parking resources.

Vision Element #6: Urban Delivery and Logistics

Pittsburgh is home to \$3 billion privately-owned freight operator Pitt-Ohio and also a substantial hub for FedEx Ground, and major freight movement on our rail and waterways that can be optimized through participation with *SmartPGH*. Furthermore, the City of Pittsburgh and CMU’s Metro21 have begun promising conversations with the US Postal Service around the “smart” freight projects proposed below.

To address Vision Element #6 and as covered in Vision Element #2, *SmartPGH* is proposing to partner with these and other freight agencies to create signal prioritization for freight vehicles along our “Smart Spines” by utilizing Surtrac sensors and DSRC within vehicles. The impact of this strategy will be to vastly reduce the emissions of large freight vehicles idling in our city’s urban core, as well increasing the reliability and efficiency with which freight carriers meet their delivery expectations.

In addition, the City of Pittsburgh is currently evaluating the merits of incentive policies for urban delivery at prescribed off-peak hours. In addition, we are open to further exploring the possibility of drones as a medium for urban delivery or employing car-sharing options for delivery.

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Vision Element #7: Strategic Business Models and Partnering Opportunities

Pittsburgh, like many cities across the US, has a wealth of resources at its disposal in the form of public agencies at various levels of government, both public and private utilities, significant private business interests, our philanthropic community and universities. The USDOT Smart City Challenge has already pushed the City of Pittsburgh and our partners to explore where our interests overlap, culminating in the *SmartPGH Consortium* concept, detailed more fully in other sections for this proposal.

At its core, the *SmartPGH Consortium* is a strategic business model based on partnerships of mutual benefit. Core partners like CMU, Pitt, Port Authority of Allegheny County, and PennDOT see the obvious benefits to participating in such an effort, as the Consortium will help them directly advance their research and non-profit business models. New public-private partnerships with major private-sector stakeholders such as Uber, and Duquesne will provide additional benefits to residents, creating a truly “smart” Pittsburgh. Bringing this diverse group of organizations together for conversations around technical standards, capital resources leveraging, and greater overall coordination will create cost and energy savings that will be truly game-changing for our region.

Beyond the direct benefits to consortium members, the *SmartPGH* platform creates an attractive amenity for established businesses and start-ups considering locating in the City of Pittsburgh, and offers a R&D resource for private-sector and academic experimentation.

Vision Element #8: Smart Grid, Roadway Electrification, and Electric Vehicles.

SmartPGH is designed to bridge the gap between transportation and energy. The City of Pittsburgh, USDOE, and the regionally-located National Energy Technology Lab signed a historic agreement to research, develop and deploy of district energy and microgrid systems throughout our city. In addition, the project directly engages close partners at Pitt’s Center for Energy to help evaluate microgrid system development and advance next generation energy infrastructure in Pittsburgh. At the same time, fortuitously, the City of Pittsburgh’s Department of Innovation & Performance (I&P) has worked diligently with Mayor Peduto to develop a long-term capital plan for the acquisition of a new EV fleet.

2nd Avenue abuts the Downtown Business District, railways, the Monongahela River, as well as the I-376 Energy Corridor, DOE’s corridor of EV charging stations. A recent CMU study demonstrates that Pittsburgh's notorious poor air quality is most acutely situated within our river valleys, home to our major transportation arteries and our much beloved network of riverfront trails and bikeways. We believe that the convergence of these assets and challenges makes 2nd Avenue the ideal location to demonstrate how the City’s entire fleet could be taken off the grid over time by replicating this strategic integration of microgrid, solar, and EVs in one setting.

To address Vision Element #8, *SmartPGH* will implement our ambitious “*Electric Avenue*” project that includes the purchase of a new EV fleet to be parked and charged at the City-

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owned 2nd Avenue parking lot coupled with charging stations that receive power through a solar canopy tied into the local district energy microgrid. The fleet will utilize grid-to-vehicle (G2V) charging, which can also support other assets on the grid. The electric autonomous shuttles previously mentioned in Vision Element #1 will also charge at this location, and 2nd Avenue will serve as a major corridor for autonomous demonstration. The “*Electric Avenue*” application will later be extended further west into the city center to incorporate the Allegheny County Jail, the larger 1st Avenue garage, and even connect to the 1st Avenue Light Rail Station seen below and east to the Hazelwood brownfield development site, as seen below:

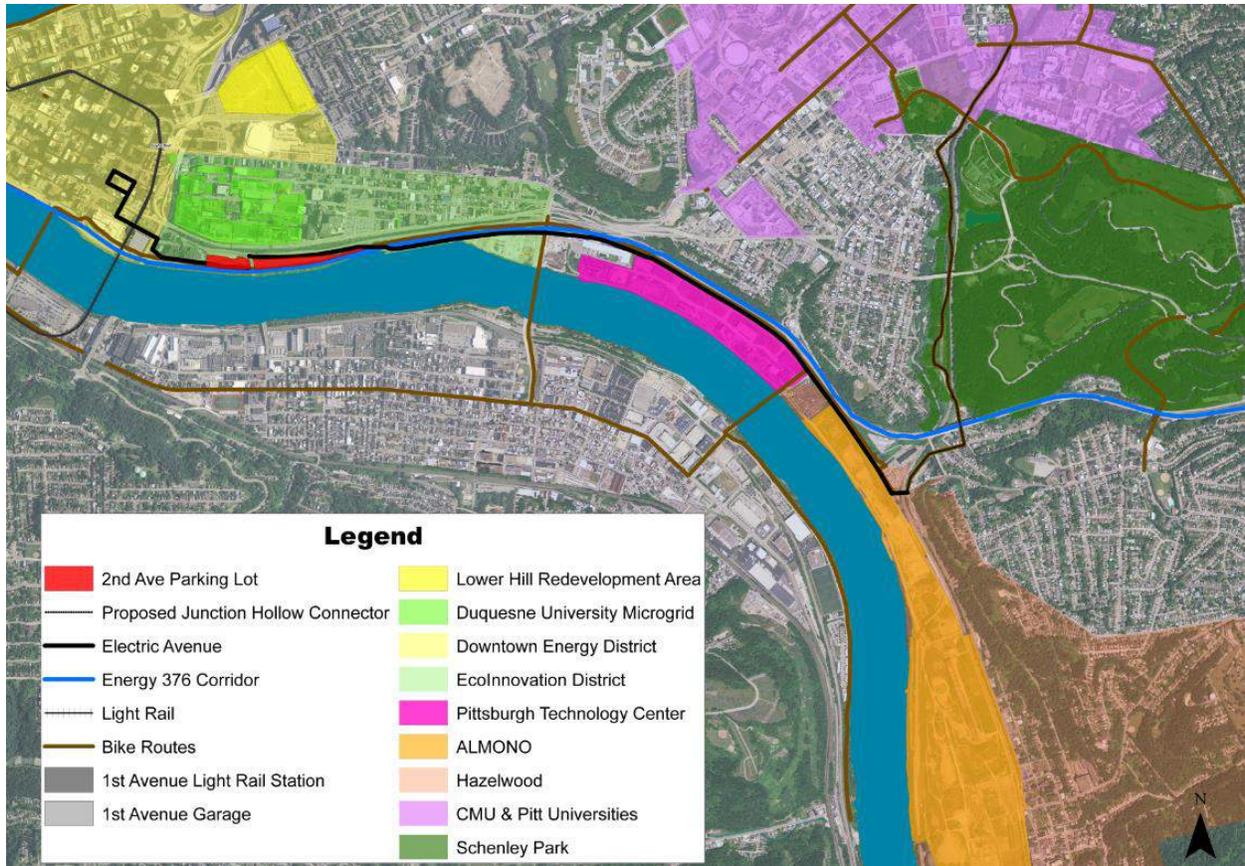


Fig 3. “*Electric Avenue*” and Autonomous Shuttle Route.

Mayor Peduto aims to reduce transportation-related greenhouse gas emissions by 50% by 2030. This aggressive goal will require substantial changes in traffic management, mode shift, a transition away from fossil-based fuels as well as improvements to land use and development practices. We believe that the “*Electric Avenue*” deployment will be the beginning of a much larger transition, including operating a completely fossil-free fleet by 2030.

Vision Element #9: Connected, Involved Citizens

The citizens of Pittsburgh will be encouraged to become actively engaged and involved with *SmartPGH* through their extraction of information via the *MovePGH* app and the Mobility Analytics Center and the Western PA Regional Data Center, which already work directly with residents. However, the truly transformative aspect of these applications as it relates to citizen

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“involvement” is that partners at CMU’s Human-Computer Interaction Institute have now developed methods of using those interactions, as well as interactions with social media in general, to create a significant amount of data to feedback and refine our analytics.

To address Vision Element #9, *SmartPGH* will deploy our “*Citizens as Sensors*” effort aimed at extracting relevant data from social media. Scrubbing these sites and app will provide information on what people are doing in different places across Pittsburgh, data that can be used to infer behavior and data that can detect changes in behavior due to physical modifications made by *SmartPGH* and the City of Pittsburgh. Using this data a machine-learning classifier can detect changes in social media behaviors that signal a specific change in how citizens engage with or use a specific part of a city. Using this classifier, a “smart” Pittsburgh can more easily detect if the modifications it is making are producing the desired changes or if they are leading to unanticipated outcomes or unhappy residents. For example, changes to the number of check-ins citizens make to restaurants and retail establishments following the parking rate change can provide evidence of how much this change has impacted dining and shopping behaviors, providing valuable feedback not just on residents emotional reactions but also the wider economic impact of such decisions.

The Peduto Administration is committed to a people-first approach, beginning with the creation of the Bureau of Neighborhood Empowerment to focus specifically on issues within marginalized communities. Furthermore, we have had great success in creating public processes for extracting resident input on consequential decisions, like our nationally-lauded police chief search and Deliberative Democracy forums. Hosting on-the-ground public meetings such as these will allow *SmartPGH* to connect with all residents, including populations that may be less likely to engage online, such as elderly or low-income residents.

Vision Element #10: Architecture and Standards

SmartPGH will work with our close partners the Southwestern Pennsylvania Commission, PennDOT, Society of Automotive Engineers (SAE), academic experts at both CMU and Pitt, along with USDOT, to determine the most appropriate ITS standards for the *SmartPGH Consortium* moving forward. Fortunately, both SPC and PennDOT have already been consulted regarding our proposal and are willing and indeed eager to play a role in deciding upon ITS standards that will allow our breakthroughs to be most easily exported to surrounding cities and counties.

SPC serves as our region's standard-setting institution, and they will work with us closely to ensure that all decision integrate seamlessly into their current ITS standards and architecture. However, innovative deployments that have already occurred in the City of Pittsburgh, such as the Surtrac adaptive traffic signal control systems and DSRC which have already been successfully integrated into regional, state, and federal ITS standards an architecture.

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Vision Element #11: Low-Cost, Efficient, Secure, and Resilient Information and Communications Technology (ICT)

Data collected by *SmartPGH* via our fixed and mobile assets sensors across our “Smart Spines” will be consolidated using local area networks into a much smaller number of portals. The latter in turn will use low-cost wired or wireless communications to stream their data to the Western PA Regional Data Center and the Mobility Analytics Center. High-volume data like video streams may be gathered either in raw form using fiber links, or in condensed form by using analytics to extract and communicate only the relevant information such as vehicle count instead of raw video streams. The latter will have dramatically lower bandwidth requirements, but raw video will also have value for later analyses - hence, a mix will be supported, along with the current ITS deployments such as Surtrac which employ on-site data processing as well. The platform will be designed to be resilient by being decentralized and redundant. If the WPRDC or MAC fails, the other can be readily instantiated at the same or different location. Sensitive data will be encrypted, private data will be anonymized before archival and high-security hardware, software and personnel practices will be utilized to ensure the integrity and authenticity of operations.

SmartPGH will work closely with the CERT Division of Carnegie Mellon University’s Software Engineering Institute on issues of privacy and cyber security. Part of CMU, CERT is a Federally Funded Research and Development Center that has partnered with government, industry and others agencies to counter sophisticated, large-scale cyber threats.

Vision Element #12: Smart Land Use

Furthermore, *SmartPGH* and our “Smart Spines” will build on the density of our city as it already exists, encouraging further growth in our most-populous areas. In the longer-term, we realize the implications that fully autonomous vehicles may have on sprawl and economic development far from our Pittsburgh’s city center, and we are committed to addressing zoning and regulatory issues to incentivize infill, rehabilitation, and smart growth.

To address Vision Element #12, *SmartPGH* will fold land use considerations into many proposed applications, such as our larger deployment of dynamic pricing for parking space, garages, and creation of EV-charging specific parking spaces at our “Electric Avenue” parking area. In addition, the City of Pittsburgh has begun working with our Department of City Planning to explore changes to our parking code, including the viability of removing mandatory parking minimums for new developments. Since 2014, the City of Pittsburgh, PennDOT, and CMU have been collaborating on a *Connected and Autonomous Vehicle 2040 Vision* for the Pittsburgh region, and have recently begun to explore more deeply the potential land use impacts.

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6. Identify and rate key technical, policy, and institutional risks associated with the deployment vision and discuss plans for mitigating those risks.

A number of technical, policy, and institutional risks exist with the implementation of any project as large and complicated as the Smart City Challenge. The City of Pittsburgh is confident that we can design strategies to successfully mitigate these risks.

High risks include those that directly endanger the safety of residents travelling through the city. For example, signal interference, incorrect configuration, software bugs, and device failures impact the base platform, connected vehicles, and connected automated vehicles that build upon it. *SmartPGH* will take steps to do extensive testing and refining of the platform, and will test any new demonstrations at low speeds with human drivers for emergency situations. These technical risks also lead to policy risks in liability and regulation, and Pittsburgh will work closely with state partners to allow for innovation while protecting residents.

The City of Pittsburgh also takes the high risks associated with data management and privacy seriously from both a technical and policy standpoint. The platform will use local analyses at collection points to minimize data volumes, and prioritize resource for faster delivery of the information and alerts that are most time-sensitive. The *SmartPGH Consortium* will develop standards to anonymize or mask sensitive personal data, and not archive privacy-insensitive information. Pittsburgh is fortunate to have world class cyber-security experts participating in the process, including CMU’s Software Engineering Institute. In order to stem risks of a sub-optimal system, Pittsburgh and its partners will work closely on designing strong and unified data architecture.

There are moderate risks associated with energy and electrification applications of the platform. Changes in market forces and technology could make capital investments undesirable or suboptimal. However, the City of Pittsburgh is confident that we can work with our expert partners to design applications that take advantage of our existing infrastructure.

The City of Pittsburgh will also take precautions to address the risks of scalability. By working through the consortium model, Pittsburgh will make sure that the project is delivered in a reasonable, incremental timeframe and will work to leverage additional resources. Working closely with the Pittsburgh’s Department of City Planning, the *SmartPGH Consortium* would not lose sight of the need to build the platform and applications not just for the demonstration and deployment area, but over time for the City as a whole.

One institutional challenge is that while regional priorities are all in alignment at the moment, changes in leadership or operational capacity among consortium members could destabilize platform integration and application development. Pittsburgh is confronting this risk by making a strong and adroit governance structure to form the foundation of all following work. A clear governance model that provides executive vision, strategic coordination, and operational delivery can weather institutional changes.

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7. Outline team partners, key stakeholders, and demonstration governance processes.

The City of Pittsburgh is supported in its application by over 50 partners, from private industry, government, philanthropic, and community sectors. Our robust portfolio of letters of support and commitment demonstrate the interest of our partners to work in harmony and the interest of technology providers to participate in this process.

The design of a robust governance structure is absolutely critical to the development of *SmartPGH*. A strong organizational design able to take cooperative action will reap an economy of scale on improvements and build a shared platform that benefits all organizations, and ultimately, residents. Regardless of the outcome of the Smart City Challenge, Pittsburgh views the setup of a *SmartPGH Consortium* as integral to our success as a 21st Century city.

The Peduto Administration has a strong track record of successful partnerships and cooperation, both with other government agencies and with public-private partnerships. Pittsburgh would model the *SmartPGH Consortium* after our successful Envision Downtown and the Resilience Steering Committee working groups, both successful projects with dozens of stakeholders representing diverse interests.

The *SmartPGH Consortium* will involve both an executive team of leaders to make strategic decisions about investment decisions and integration, and a project management team to directly manage the development, deployment, and execution of the platform. Leadership of the consortium is expected to include:

- Allegheny County
- PennDOT and the Commonwealth of Pennsylvania
- Southwestern Pennsylvania Commission
- Port Authority of Allegheny County
- Pittsburgh Parking Authority
- Port of Pittsburgh Commission
- Pittsburgh Bike Share
- Utilities including energy distribution, water, and natural gas
- University Partners, particularly University of Pittsburgh and Carnegie Mellon University
- Major freight operators in Pittsburgh
- Representatives of the Business and Philanthropic Communities
- Citizens and Community Stakeholders
- Industry partners

This group will be in the unique position of setting standards on sensors, data collection, storage, legal and privacy issues, etc. for creating an open platform “data utility” in Pittsburgh that will be freely available through the WPRDC. By working in concert, Pittsburgh can guarantee that its 21st Century transportation and energy infrastructure is built-out regionally in a thoughtful, integrated manner.

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This structure ensures that fixed assets and mobile assets installed or purchased by private companies and public agencies in our region all collect and feed standardized data into the same open platform and publically accessible system. Applications can then be built on-top of this data.

8. Describe existing transportation infrastructure and system features in your city.

Arterial and Freeway Miles

While the City of Pittsburgh owns two-thirds of Pittsburgh’s roadways, the remainder are owned and operated by PennDOT. These include 44 miles of major highways such as the I-376 Penn-Lincoln Parkway and the I-579 Crosstown Boulevard, which carry commuters and freight into and out of downtown. Pittsburgh's 1,298 miles of streets account for half of its public space. Key local arterials include the Liberty-Penn corridor to Lawrenceville, the Fifth-Forbes corridor to Oakland, and the Baum-Centre corridor through East Liberty.

Transit Services

Pittsburgh is home to the oldest busway in North America. The Port Authority of Allegheny County operates a comprehensive transit network in the city, which includes 18.4 miles of busway, 26.2 miles of light rail, 72 local bus routes and two funiculars. Combined, this network transports more than 200,000 passengers every day. Port Authority also sponsors ACCESS, a door-to-door, shared-ride paratransit program that primarily serves seniors and persons with disabilities. Riders may use *TrueTime*, Port Authority's web application, or a number of third-party mobile apps to track real-time bus arrival information.

Shared-use Mobility Services

Pittsburgh recently introduced shared-mobility services, including Uber and Lyft, in 2014, which has reduced the need to own a vehicle and complements existing services such as taxis and other forms of transit. Moreover, residents utilize the city's unique system of 712 public staircases, 40 miles of on-street bike infrastructure, 31 miles of trails, and numerous sidewalks and on a daily basis, including three protected bike lanes completed within the last two years. 2015 also marked the launch of Pittsburgh's bike-share program, *Healthy Ride*, which operates 500 rental bikes at 50 stations in various neighborhoods throughout the city. Healthy Ride is one of the few shared mobility systems in the country which feature smart bikes, with an on-board computer that make each rented bicycle a “connected” vehicle equipped with GPS tracking.

Information and communication technology (ICT)

The City of Pittsburgh is in conversation with Duquesne Light and partner-company DQE Communications regarding the use of their extensive network of dark fiber. Currently, they control an ever-expanding network of 2700 Route Miles of fiber, 1140 On-net Buildings, 33 Business Parks, 12 Data Centers and multiple Hub Sites. The private, secure, customizable DQE

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Communications network is 65,000 times faster than a T1 line, allowing for the transmission of 12.5 GB file every second. Fortunately, the DQE Communications network is technology-neutral and compatible with voice and data communications, Internet access, video, backhaul, or data storage. Most of the network capacity is currently “dark” and available for use by partners including the City of Pittsburgh. To make the most of their network, Duquesne Light recently built a wireless communication infrastructure to support the increased data-flow between their electric meters and the company’s centralized operating center. This effort has evolved into a high-capacity, resilient, wireless network covering the entirety of the City of Pittsburgh and the surrounding 817-square-mile service territory.

Currently, the City of Pittsburgh believes that by partnering with DQE to make use of the combined wireless and dark fiber networks we can deliver maximum coverage all city neighborhoods while also delivering maximum speed and reliability. However, while Duquesne Light and DQE have the largest and most appealing ICT network in the City of Pittsburgh, also Google, Verizon, Comcast, and AT&T also have their own networks that should be evaluated on their own merits moving forward.

Intelligent Transportation Systems (ITS)

PennDOT’s Western Regional Traffic Management Center (WRTMC) has 24/7 manned coverage with 13 full-time employees covering one third of Western PA. The center includes a fully integrated Centralized Software System, a Media Partner room that broadcasts live on-air reports of traffic conditions, and, a state of the art video wall capable of displaying 160 video images. The center monitors and/or controls ITS devices on 12 freeway corridors, including many within Pittsburgh's limits. These devices include: 293 CCTV cameras, 37 Highway Advisory Radio transmitter locations, 86 Highway Advisory Radio signs with beacons, 200 Microwave Traffic Detectors, 24 Dedicated Short Range Communication (DSRC) radios, 93 Digital Wave Radar Vehicular Detector units and many more specific ITS-related items.

Smart Grid

The City of Pittsburgh, in partnership with the Pitt and DOE are in the process of developing the grid-of-microgrids concept, based on the idea of the socially responsible microgrid. The grid-of-microgrids is designed to connect critical infrastructure like hospitals, universities, and data and telecommunications centers. Other partners in the effort include the UPMC health system, NRG energy, Duquesne Light and People’s natural gas. Currently, there are existing district energy and microgrid systems and we’re looking at the opportunity to create inter-relations between these system, reinforcing grid security, providing redundancies, and creating business continuity. Existing systems include Downtown, Uptown, Oakland, the North Side neighborhoods, and planned future systems will be located in Hazelwood and the Lower Hill District neighborhoods.

EV Charging

Pittsburgh had historically lagged behind other regions in EV charging station deployment. However, we have recently moved to increase the number of charging stations in partnership with the Pittsburgh Clean Cities Coalition. There are now approximately 50 charging stations

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within the City, and additional installations are planned. However, downtown Pittsburgh is the second largest central business district in the Commonwealth of Pennsylvania and yet only about a dozen EV charging stations exist out of more than 23,000 traditional parking spaces. These existing downtown stations are primarily located in a mix of Pittsburgh Parking Authority garages and office building parking garages. Because of the density downtown and multi-modal transportation options in and adjacent to the central business district, there is a prime opportunity to expand this network of electric vehicle charging stations, which can dramatically increase the share of electrified mobility in Pittsburgh, and drastically reduce air pollution.

9. Define the data your city currently collects.

As previously noted, the City of Pittsburgh has spearheaded a pioneering effort to develop a data-sharing infrastructure for our region. Together, with partners at Allegheny County, the University of Pittsburgh, the Richard King Mellon Foundation, and the Heinz Endowments, we successfully built the Western Pennsylvania Regional Data Center. Pittsburgh’s City Council unanimously passed Open Data legislation in February 2014 with input from local and national experts including professionals at the Sunlight Foundation. This legislation requires records to be “open by default” and established a process for identifying and approving datasets for publication through the WPRDC.

Housed at Pitt and funded by our local foundations, the WPRDC serves as the official Open Data portal for the City of Pittsburgh and Allegheny County. The model for the WPRDC is unique because it is designed to be extensible and inclusive, able to host datasets from any municipality, non-profit, or researcher with data to share. By bringing together various levels of government, civil society, and academia around information resources, we have begun to improve our region’s capacity for innovation and evidence-driven policy-making.

The WPRDC’s web resources provide machine-readable data downloads and APIs of key administrative data on topics such as property assessment, building inspection, public health, crime, and asset management. The open data portal can support *SmartPGH* by providing a publicly accessible front door to raw data, including metadata catalog to facilitate data discovery, data dictionaries, data licenses, and other documentation for data users. The WPRDC portal operates on a federated model, meaning users can directly access data hosted in the WPRDC open data repository through download, visualization, or API, or through a link to an external repository.

In addition to the technical resources offered by the WPRDC, the City of Pittsburgh approached the design of the governance and legal infrastructure of WPRDC to be scalable and easy-to-use, including thoughtful user agreements and flexible, but standardized, licensing options for data providers. In addition, the WPRDC will also support the *SmartPGH* by providing a framework for community engagement by convening conversations on how data can benefit all residents. The WPRDC can also support community efforts to build tools using *SmartPGH* data by connecting

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community transportation and mobility needs with data analysts, data scientists, and developers.

The information and technical resources of the WPRDC create a powerful platform for development, communications, and eliminating barriers for inefficiency. As we move into the future and increase the density of sensing equipment, the potential of the WPRDC platform expands to create a basis for collaboration and inclusivity in developing a truly *SmartPGH*.

10. Describe your approach for using existing standards, architectures, and certification processes for ITS and connected vehicle based technologies and plans for documenting experiences and cooperating with architecture and standards developers to improve the quality of these products based on lessons learned in deployment.

The development of *SmartPGH* relies heavily on our strong relationship with the Southwestern Pennsylvania Commission, which is the Metropolitan Planning Organization for the 10-county region. SPC’s Transportation Operations & Safety Committee brings together traffic engineers and transportation planners from around the region to collaborate on projects that work toward improved efficiency and operation of the transportation system. As an identified priority in the Regional Operations Plan, SPC has established a regional Traffic Incident Management program that brings together police, fire, EMS, towing, hazmat, transportation and other agencies to identify opportunities for increasing responder safety, reducing the time needed to clear incidents, and promoting awareness and information sharing.

Some examples of existing ITS technology in the region include: Traffic Operations Centers, Variable Message Signs, Traffic Signal Systems, Electronic Toll Collection (E-Z Pass), Transit Control Centers, Smart Card Fare Collection Systems, and CCTV Cameras. Within the City of Pittsburgh, these updates include adaptive traffic signal control systems, Dedicated Short-Range Communications, and the planned use of fixed assets (traffic signal and street lighting poles) for future networks, such as the *SmartPGH* platform.

Consistent with the goals of USDOT’s ITS Strategic Plan and PennDOT’s Transportation Systems Operations Plan, SPC has recently completed an update to the Regional Operations Plan and the Regional ITS Architecture. In 2015, SPC staff met with 25 regional ITS stakeholders to discuss the current ITS architecture and their ITS capabilities and to gain input on future plans and needs. Based on the discussions at these meetings, an update to the Regional ITS Architecture has been completed and is currently undergoing a quality assurance/quality control review. This update process provides the opportunity to review the ROP objectives, identify the most effective Congestion Management Process-based strategies to achieve these objectives, and translate the strategies into longer-term projects that can be identified in the Regional ITS Architecture, ROP, and Long-Range Plan. This encourages consistency between proposed ITS projects and the architecture and helps to ensure that additional integration

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opportunities are considered. The 2016 Regional ITS Architecture is expected to be fully compatible with, and supportive of, our *SmartPGH* technologies, services, and projects.

State-wide ITS standards have recently been consolidated by PennDOT and the Pennsylvania Turnpike Commission. These standards have been incorporated into the updated Regional ITS Architecture and can be utilized for projects performed by others. This collaborative consolidation effort can also be utilized for the standards expected to be developed through USDOT’s Smart City Challenge, and SPC can facilitate the implementation of standards on a regional, statewide, and potentially national basis.

The region's stakeholders already have significant experience collaborating on, and learning from, project deployments, for example the previously discussed Surtrac adaptive traffic signal deployment along the Baum Boulevard and Centre Avenue corridors. In addition, the region's stakeholders and potential consortium members have already executed a number of agreements for data sharing, communications, coordination, and cooperation necessary to advance technological and analytical solutions through projects in the Pittsburgh region. The City and the region are exceptionally well-prepared to address the ITS needs of the Smart City Challenge.

The Pittsburgh region is fortunate to be the headquarters of the Society of Automotive Engineers who have agreed to partner with the city in the *SmartPGH Consortium* and guide the standards development process from an industry perspective. SAE will be a valuable partner in evaluating transportation and energy technologies that emerge from this effort.

11. Provide measurable goals and objectives for your vision and describe your approach for monitoring the impact of the demonstration on mobility, safety, efficiency, sustainability, and climate change.

The City of Pittsburgh is prepared to track our progress towards the goals of the challenge; we associate measurable metrics with each goal and objective. In order to assess the impact of the platform and the various applications under consideration or yet to be identified, the City of Pittsburgh and consortium partners will use the following framework:

- The metric should objectively reflect the impact of a technology deployment or demonstration on mobility, safety, efficiency and/or sustainability.
- The metric must be able to collect information in a regular and systematic fashion.
- The metric should be able to be integrated into a decision-making process.
- The metric should be easily understood by the public.

Some performance metrics may be directly unobtainable, and would require sophisticated data analytics to model and predict metrics prior to platform or application deployment or demonstration. The City and potential consortium partners have identified the following metrics:

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Goal	Metrics
Mobility	<ul style="list-style-type: none"> • Coverage of urban area that is traversable by automated vehicles • Number of features and functions supported by semi-automation • Number of connected vehicles and connected-automated vehicles • Reduction in multi-modal travel time • User satisfaction of applications as seen by user ratings • Amount of crowd-sourcing information • Citizen participation rate
Safety	<ul style="list-style-type: none"> • Numbers of accidents, injuries, and fatalities
Efficiency	<ul style="list-style-type: none"> • Reduced congestion • Reduction of travel delay (relative to traveling at free-flow speed with no stops) • Reduction of travel time • Reduction in idling time • Time to find a parking space • Parking occupancy rates and turnover
Sustainability & Climate Change	<ul style="list-style-type: none"> • Reduction in emissions and progress toward 2030 District goal • Flattening of electric load curve • Distribution of greenhouse gases • Number of EVs, car-sharing rides, and bike-sharing rides • Efficiency of District Energy

Ultimately, these metrics will be important for improving the transportation network. However, Pittsburgh will also assess the impact of the platform and applications on Pittsburgh residents. *SmartPGH* is meant to provide corridors of opportunity to Pittsburgh residents, and mobility and efficiency improvements must also be viewed through the lens of equity.

Working with local non-profit Jackson/Clark Partners and University of Salford (UK) Professor Erik Bichard, *SmartPGH* would like to measure Sustainable Return on Investment (SuROI). Their proposed process will involve community outreach to identify equity indicators directly from residents in the communities proximate to our “*Smart Spine*” corridors, and will target attaining an estimated participation level of 30 to 40% of all targeted community households.

With this process, we hope to make the social value of *SmartPGH* evidentially explicit, and to allow that evidence to drive future decision-making. The transportation interventions of the 20th Century fundamentally missed this measuring process, and as a result created disparity and isolation in many Pittsburgh communities. By constantly evaluating our progress on this front, Pittsburgh can assure that *SmartPGH* does not create winners and losers. We believe that SuROI can quantify the generation, retention and growth of social capital as a result of our work, and can serve as a national model for people-first interventions.

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12. Provide evidence that establishes your capacity to take on a project of this magnitude, including executive commitment, workforce capacity, degree of infrastructure readiness, data and performance management capabilities.

In 2013, then-Councilman Peduto issued 100 Policy Papers during his campaign. Of these 100, nearly ¼ show a substantial focus on transportation, including entries with such titles as “Smart Traffic Signals”, “Complete Streets: Creating Safer, More Accessible Neighborhoods”, and “Traffic Calming: Keeping Our Streets Safe for All Modes of Transportation”. More specifically, he also outlined clear, actionable policy and administrative changes that would move Pittsburgh in a “smarter” direction, such as “Pittsburgh Open Data” and “Where’s My Plow?: GPS Tracking for Snowplows”, both concepts that were prioritized and tackled fully in the first year of the administration.

In fact, upon assuming office in early 2014, Mayor Peduto took steps in his first few weeks to significantly scale-up the City of Pittsburgh’s capacity to both design and implement complex technological and energy-focused projects by establishing the Department of Innovation & Performance (I&P). Within weeks, the Mayor’s Office and the new I&P were working with Pittsburgh’s City Council to pass bold Open Data legislation, which at the time drew much national and even international attention. The legislation was the first step in creating, in partnership with Allegheny County Executive Fitzgerald and the University of Pittsburgh’s University Center for Social and Urban Research (UCSUR), what would come to be known as our Western PA Regional Data Center, the City and County’s free and publicly accessible clearinghouse for open, machine-readable data.

Beyond the highly-skilled, tech-savvy employees who have been leading the charge in departments like I&P, Public Works, City Planning, our academic community brings an unrivaled level of expertise in the fields of transportation technology and clean energy. Carnegie Mellon has led the charge internationally in applying forward-thinking technologies to real-world urban environments, including the much-praised Traffic21, Remaking Cities Institute, and Metro21, which served as the inspiration for the White House’s new, national MetroLab Network.

Working with CMU, the City of Pittsburgh has made great strides on transportation projects like the deployment of sensors and Surtrac in selected corridors to create “smart signalization”. The City has also worked with our local branch of the DOE’s National Energy Technology Laboratory to develop a long-term plan for district energy.

In addition, the City’s Department of Public Works has joined with faculty from CMU’s Robotics Institute to deploy an innovative, low-cost solution to measure pavement distress conditions across our 1,200 miles of city-owned streets, allowing the City to more efficiently and equitably reach decisions about road maintenance and paving.

In recent years, the forward-thinking nature of civic leadership and the pools of young talent emerging from our universities have made Pittsburgh an attractive home-base for many leading

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technology companies. Google chose to locate here nearly 10 years ago, and has since scaled up their presence in Pittsburgh dramatically. In addition, Uber recently chose to locate their Advanced Technologies Center in Pittsburgh, and has been in on-going to conversations with the City of Pittsburgh to further develop a substantial test-site for automated vehicles. In early-2016, Facebook announced their decision to locate offices in Pittsburgh, as have Bosch, Apple, Ta Ta, Intel, Disney and many more before them. Beyond these household names, there is quite a substantial amount of home-grown talent as well, such as Aquion Energy, a company that has invented a new class of battery, made of non-toxic materials, which can provide long-term storage of energy from solar, wind, and other intermittent sources at a very low cost.

While it is clear that the technical expertise exists locally to implement our *SmartPGH* proposal, we do understand that there may be a significant workforce development component also required to ensure that local firms and their employees have the training necessary to physically implement and maintain the forward-looking infrastructure that we are proposing. Fortunately, we have already begun discussions with our region's strongest workforce development group, the Three Rivers Workforce Investment Board (3RWIB), regarding the need for a more substantial workforce training effort regarding many of the technologies proposed in this proposal. In fact, these conversations began in August 2015, when the City of Pittsburgh was announced as a participant in the White House's *TechHire Initiative*.

13. Describe any opportunities to leverage Federal resources through cost share, in-kind donations, and partnering.

USDOT's Smart City Challenge is an opportunity to connect a number of existing federal resources together. Federal initiatives Pittsburgh is participating in such as *TechHire*, *Choice Neighborhoods*, and the Investing in Manufacturing Community Partnership can be prioritized and integrated into the deployment of the *SmartPGH* platform and application development. The location of the National University Transportation Center on Safety at Carnegie Mellon University provides a critical bridge between transportation innovation and the City of Pittsburgh. In addition, our first-of-its-kind partnership with the Department of Energy further links transportation and energy.

Pittsburgh's infrastructure challenges also afford us an opportunity to make investment in a coordinated manner. The City of Pittsburgh and our partners will make billions of dollars of investment decisions in the areas that we identify in this proposal over the next decade. Investments by Duquesne Light, Peoples Natural Gas and water providers like the Pittsburgh Water and Sewer Authority are poised to bring upwards of \$3 billion dollars in the near future to upgrade lines, pipes, and wires and install new smart meter technologies and sensors. Likewise, PennDOT and the Southwestern Pennsylvania Commission will invest hundreds of millions of dollars in local roads and bridges, transit, river and rail networks in the coming years. The consortium model developed for *SmartPGH* will better coordinate these outlays and provide value to ratepayers and taxpayers. PennDOT has become a national leader in the

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deployment of intelligent transportation systems, including connected vehicle infrastructure. PennDOT and local foundations have already invested millions of dollars into Pittsburgh’s innovative Surtrac adaptive traffic signals and DSRC. Now, through Act 89, PA finally has resources to re-invest with progressive programs like “Green Light Go.”

Similarly, the City of Pittsburgh and surrounding municipalities are poised to rebuild sewer infrastructure and invest an estimated \$4 billion over the next 20 years to provide clean water and address the Federal Clean Water Act consent decree under the advisement of the Environmental Protection Agency (EPA) and the Department of Justice (DOJ). This opportunity allows for Pittsburgh to integrate water management into the *SmartPGH* platform built for transportation and energy.

The philanthropic community has been an integral part of Pittsburgh’s success in recent years. The City of Pittsburgh and local and national foundations have partnered on issues ranging from land use and economic development to education and neighborhood empowerment. The consortium would work to leverage the resources provided by USDOT with additional foundation support that supports our corridors of opportunity. Carnegie Mellon’s Traffic21 and Metro21 Initiatives were both Hillman Foundation efforts aimed at positioning Pittsburgh as a “smart city” test-bed. Hillman, along with numerous other local foundations, has already invested nearly \$10 million into these efforts.

Pittsburgh is also able to draw on strong relationships with national organizations and associations to help disseminate the successes of *SmartPGH*. Our active participation in the Rockefeller Foundation 100 Resilient Cities, National Association of City Transportation Officials, the Urban Land Institute, and many other organizations provides a dissemination network for the best practices learned through *SmartPGH*. Pittsburgh is a founding member of the MetroLab Network, and Mayor Peduto sits on the Board of the National League of Cities.

The ability to leverage previous federal investments, coordinated capital improvements, philanthropy, and national partnerships establishes Pittsburgh as the ideal site to demonstrate a truly successful Smart City - a model for the nation and the world.