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SMART
PGH

THE CITY OF PITTSBURGH
USDOT-BEYOND TRAFFIC:
THE SMART CITY CHALLENGE

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Innovation is in Pittsburgh's DNA. We're known for it, particularly our innovations in manufacturing. But our inventive spirit isn't bound by one industry. Before steel, the great minds and makers of Pittsburgh created the modern highway system, aired the first commercial radio broadcast and powered the first nuclear submarine. Steel is a part of our history, but it's not the most important part. The important part is what happened after the mills closed and steel skipped town. We fell far. Unemployment soared and people moved away. Not many places could come back after this kind of disruption, but we did. That is our story. Pittsburgh knows the seismic changes that innovation can bring, probably better than nearly any other city in the United States.

In the course of just a few decades, Pittsburgh went from explosive wealth and growth to rapid decline. It was through sheer force of will and a tradition of institutional coordination that we bent the curve of that trajectory. Today, we are recognized as a national leader in education, healthcare, and advanced industries, and we have begun to reinvest in infrastructure for the next generation.

SmartPGH

We are on the cusp of a new revolution in transportation and information technology that has the potential to again reshape the urban environment and our way of life. Pittsburgh's approach to the U.S. Department of Transportation's (USDOT) Smart City Challenge, *SmartPGH*, will place us on the leading edge of that revolution. It will allow us to adapt in ways that will avoid the mistakes of the past and improve safety, enhance mobility, address climate change, and enhance ladders of opportunity. Our critical transportation infrastructure can no longer be viewed as just a means of travel. It must evolve into a resilient network that connects people to opportunity and accelerates innovation in energy supply and distribution, storm water management, and data-driven decision-making.

SmartPGH is not about the deployment of new technology for technology's sake. At the core of our approach is a people-first strategy. We're prioritizing technology interventions that will improve the lives of those most in need in our communities.

And there are real issues that we must work together to solve. A recent report by the American Council for an Energy Efficient Economy revealed that Pittsburgh has the second-highest energy cost burden for low-income residents in the country. Meanwhile, our air quality remains among the worst in the country. Many residents are without adequate transportation options or lack safe routes to access them, leaving them isolated and disconnected from opportunities. Our region's workforce is aging and studies indicate that we will need to fill approximately 80,000 jobs by 2025. We must grow and improve the training and certification pathways to connect the people who need them. *SmartPGH* will deploy infrastructure and assets to address these challenges, keeping people at the center of our strategy and planning at all times.

This new approach will be led by the SmartPGH Consortium, a governance body made up of leaders from all sectors who will be responsible for infrastructure planning and capital coordination. The SmartPGH Consortium has already met for the first time and they've begun to establish an operating and financial structure. They are poised to begin assisting the City in deploying the assets that will move SmartPGH forward.

Improving Safety and Enhancing Mobility

Self-driving technology and adaptive traffic signals will allow for the kind of connectivity and automation that improves safety and increases mobility. Surtrac, the world's first decentralized real-time adaptive traffic signal system designed specifically for urban areas, was developed at Carnegie Mellon University Robotics Institute and it's already being tested. We plan to expand the Surtrac pilot area to connect it to the major job centers and transit hubs along Smart Spines. It also serves as a USDOT Affiliated Connected Vehicle (CV) Test Bed. Twenty-six of fifty continuous intersections along two parallel streets are equipped with Dedicated Short Range Communications (DSRC) devices. Mobile assets will also be equipped with DSRC, creating an extensive connected vehicle environment. This will allow, for example, the Port Authority of Allegheny County's fleet of 726 public buses to be fully optimized when traveling the Smart Spine corridors. Travel and queue time will decrease, air emissions will be reduced and the transit experience will improve for all riders. Our entire transportation network will be fully optimized as more public and private vehicles are outfitted with these vehicle to vehicle (V2V) and vehicle to infrastructure(V2I) technologies.

In coordination with the expansion of Surtrac, the City will complete an LED smart streetlight conversion of up to 36,365 lights beginning with those along Smart Spine corridors. In addition to providing an energy savings of 60%, these streetlights will be equipped with sensors and collect and transmit data to improve safety for users of all modes, particularly for pedestrians and cyclists.

SmartPGH will develop our network of key Smart Spine corridors—layering environmental, communications, energy, and transportation infrastructure supported by technology—to improve connections between historically isolated neighborhoods and major centers of employment and educational and healthcare services.

Key sections of the Smart Spine corridors will see the first deployment and testing of autonomous vehicles. These deployments will further solidify Pittsburgh as a worldwide leader in connected and autonomous vehicle technologies and attract new investment in research and development. Infrastructure improvements within the corridors will be coordinated with large-scale regenerative green infrastructure installations to control storm water and collect data about water quality and runoff volume. These strategic investments will move the city towards compliance with a regional Environmental Protection Agency consent decree for water quality while adding green space, improving air quality and reducing urban heat, and creating new jobs.

The wealth of new data from fixed and mobile assets and the administrative and legal structure to freely access it will provide the ideal environment for data-driven decision making. Tools like our proposed trip planning and reporting app and MovePGH app will be built on open data by CMU's Mobility

Data Analytics Center (MAC). In order to close the digital divide and provide access to these tools to all of our residents, we will continue to expand our network of free, public WiFi at senior and recreation centers throughout the City and continue to partner on initiatives like PittMesh, a community-owned wireless mesh network. The City will soon be rolling out a municipal ID card, the Bridge Card, that will eventually allow unbanked and underbanked residents, including new immigrants, to access transit, bike share, ridesharing, and other services without the need for a credit card.

Addressing Climate Change Through Local Action

As our transportation and information infrastructure is modernized, we will continue to improve our energy infrastructure making it cleaner, more efficient, and more resilient. The City will deploy a suite of energy applications along Second Avenue — 'Electric Avenue' — creating a showcase of clean energy technology that will provide a replicable and scalable model for the region and the country. We will equip a large municipally-owned surface parking lot with a 100KW solar canopy and EV charging infrastructure to allow for a rapid conversion of the public fleet to electric vehicles powered by 100% renewable energy. We will also expand our district energy partnership with The University of Pittsburgh, Duquesne Light, and the Department of Energy to build a network of microgrids and maximize the efficiency of our local system. By shifting our grid mix towards renewables and accelerating the conversion to electric vehicles, the City will chart a course to meet our goal of a 50% reduction below the 2013 baseline in transportation emissions by 2030.

Enhancing Ladders of Opportunity

Transit optimization along the Smart Spines connecting low and moderate income neighborhoods to the job centers of Downtown and Oakland will help the City's most disadvantaged residents.

The vast majority of public housing, Section 8, and Low Income Housing Tax Credit units are clustered within the Smart Spine corridors and within ¼ mile of a frequent service area transit stop.

In addition to the benefits that will accrue from transit optimization, the Smart Spines will become corridors of opportunity through a comprehensive workforce development program in green jobs, infrastructure improvements, advanced manufacturing and cybersecurity. We're leveraging Pittsburgh's status as a TechHire and Investing in Manufacturing Communities Partnership city. The economic, social, and environmental performance of these investments will be tracked through an iterative Sustainable Return on Investment model combining door-to-door sociological "Community Census" surveys with data analysis. This new Community Census is modeled after the 1907 Pittsburgh

Survey, which launched the Progressive movement. The census will identify transportation barriers and employment needs by household, as well as the range of social determinants that create barriers to opportunity, sharing that data with workforce development partners. In essence, *SmartPGH* will connect residents with transit, jobs, and resources by actually meeting them where they live, peer-to-peer, door-to-door, and listening to what they have to say. Through targeted interventions and technology, the City will pilot new ways of linking transportation with health and human service provision.

Additionally, the City will use targeted technology interventions to address residents with with mobility impairments and other human service needs, piloting new ways to link transportation with health and human service provision.

SmartPGH will integrate pre-existing and new networks and create systems-of-systems that will allow Pittsburgh to accelerate our work to improve safety, enhance mobility, address climate change, and enhance ladders of opportunity. *SmartPGH* lays the groundwork for a truly 21ST Century vision: a connected city that provides efficient, affordable, safe, and clean transportation access to jobs and services to all of our residents while continuously improving that service through an iterative, community-driven system based on real time streaming data.

(From left to right; top to bottom) Patricia Franz; Raheene Dodd; Ron Kludo; Aleia Scott; Kevin Gales; Sister Suzanne Suzany; David Matvey; Randolph Duva; Zimam Gebremedhin; Aja Hardin; Nathan Wittler; Valentina Scholar, Milan Johnson; Emily Munk; Patrick Francart

The Elements of a SmartPGH

SmartPGH is not simply our next big transportation project. It's a chance for us to build an infrastructure that embodies our values. In the past, we focused on highways, bridges, and construction projects. Now we're focused on the people and the neighborhoods affected by them. The citywide p4 Framework guides our decision-making and reminds us to analyze the impact—on people, place, planet, and performance—of every initiative we're proposing. The network transportation plans we're developing will help *SmartPGH* deploy infrastructure and technology to make streets safer and connect people to jobs and other essential services. Our vision pushes us beyond complete streets. We're planning for a complete city. We're taking the long view and considering not only what's best for now, but what can be sustained into the future.

SmartPGH Deployments

THE SMARTPGH CONSORTIUM

Working Better Together

The SmartPGH Consortium is a multi-sectoral governance structure combining executive, strategic, and operational leadership led by the City of Pittsburgh. The Consortium comprises representatives from government, public authorities, utilities, universities, community-based organizations, philanthropy, and corporations and is designed to provide the structure for collaborative planning and decision-making to guide the creation of the City and region's next generation of infrastructure. This multi-sectoral governance will allows *SmartPGH* to quickly identify opportunities to leverage existing infrastructure and technology investments, coordinate future investments, and work together to develop a regulatory framework that encourages innovation and shared prosperity.

History and Context

The SmartPGH Consortium builds upon existing utility coordination efforts led by the City of Pittsburgh Department of Public Work. It extends that successful model to a broader set of stakeholders that touch the public rights of way and make investments in infrastructure—both physical and human.

Implementation and Operation

The SmartPGH Consortium ensures that infrastructure investments are optimized and that project and capital coordination becomes the standard operating procedure and a best practice model that can be adopted by other cities and regions. This governance structure is the foundation upon which *SmartPGH* is built and is designed to outlive changes in political and corporate

Total Budget

$12,685,261

Matching Funds

$4,858,317 (TOTAL)

- $50,000 *The Heinz Endowments*
- $100,000 *The Hillman Foundation*
- $4,708,317 *City of Pittsburgh*

Partners

- *SmartPGH Consortium Members*
- *MAYA Design*

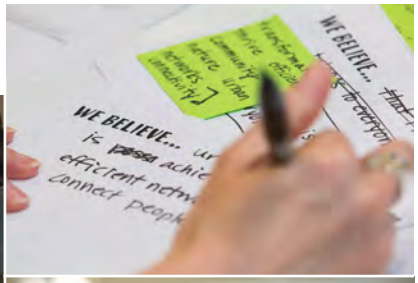
leadership, allowing for long term planning and coordination. The SmartPGH Consortium is supported by two full time staff members at the City of Pittsburgh reporting directly to the Mayor's Chief of Staff.

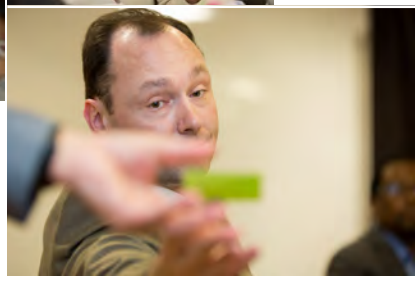
The Founding Members of the SmartPGH Consortium

ORGANIZATION	SMARTPGH CONSORTIUM MEMBER
City of Pittsburgh	*William Peduto, Mayor*
Allegheny County	*Rich Fitzgerald, County Executive*
Urban Redevelopment Authority	*Kevin Acklin, Board Chair*
Pittsburgh Parking Authority	*Dave Onorato, Executive Director*
Pittsburgh Water and Sewer Authority	*David Donahoe, Executive Director*
Allegheny County Sanitary Authority	*Arletta Scott Williams, Executive Director*
Allegheny County Health Department	*Dr. Karen Hacker, Executive Director*
Port Authority of Allegheny County	*Ellen McLean, Executive Director*
Southwestern Pennsylvania Commission	*Jim Hassinger, CEO*
Three Rivers Workforce Investment Board	*Stefani Pashman, CEO*
The Allegheny Conference on Community Development	*Dennis Yablonsky, CEO*
Pennsylvania Department of Transportation	*Leslie Richards, Secretary*
Carnegie Mellon University	*Dr. Subra Suresh, President*
University of Pittsburgh	*Patrick Gallagher, Chancellor*
Community College of Allegheny County	*Quintin Bullock, CEO*
ALMONO Partners	*Rebecca Flora, Owners' Representative*
Duquesne Light	*Rich Riazzi, President and CEO*
Neighborhood Allies	*Presley Gillespie, President*
Uber	*John Bares, ATC Director*
Envision Downtown	*Sean Luther, Executive Director*
UrbanInnovation21	*Bill Generett, President and CEO*
Urban League	*Esther Bush, President*
Hillman Foundation	*David Roger, President*
Pittsburgh Parks Conservancy	*Meg Cheever, President and CEO*

The SmartPGH Consortium meets regularly with the ability to call special meetings should a time-sensitive opportunity or challenge arise. The Consortium is chaired by Mayor William Peduto and held its inaugural meeting on May 13, 2016, during which time members worked together to craft the following mission statement:

"We believe in using our collective resources to ensure that *SmartPGH* results in a system of transportation networks that are more efficient, effective, and equitable for all. We will become the global model for urban transportation planning, replicating our effective approach within this region and out to others across the United States. We will be the keepers of the *SmartPGH* vision, providing leadership, input, oversight, and accountability."





In 1944, The Allegheny Conference on Community Development formed to coordinate development efforts.

In 2016, the SmartPGH Consortium collaboratively plans for the next generation of city infrastructure.

Facilitation and organizational design for the SmartPGH Consortium is provided by MAYA Design, a renowned, Pittsburgh-based, human-centered design consultancy that has worked with some of the largest companies in the world. MAYA Design is providing the Consortium with ongoing services to build a resilient structure that will outlast Mayors and CEOs.

There are several goals and standards that potential SmartPGH Consortium members must agree to meet as a condition of full participation. These include: open data standards and participation in the *SmartPGH* data utility, a commitment to meet or exceed the City of Pittsburgh's Minority, Women, Disadvantages Business Enterprise (MWDBE) contracting requirements, open book capital planning coordination, participation in the *SmartPGH* workforce development pipeline program, and participation in the City of Pittsburgh's Climate Action Plan greenhouse gas reduction program.

Conclusion

The SmartPGH Consortium represents the latest example of Pittsburgh's proud history of civic and corporate cooperation. These kinds of partnerships are what powered our 'Renaissances' after World War II, leading to the first air quality standards in the country and much of the transportation infrastructure we rely on today. Building on our past and looking toward the future, the SmartPGH Consortium leading Pittsburgh into a new Renaissance that puts people first and provides ladders of opportunity to all of our residents.

MOBILITY OPTIMIZATION ALONG SMART SPINES

Building a Backbone for the Future

One of the foundational elements of *SmartPGH*, this deployment of real-time adaptive traffic signals, pedestrian detection, and V2V and V2I technology along key corridors — Smart Spines — will set the stage for connectivity and automation and improve mobility and enhance safety for users of all modes in our rights-of-way. Combining real time adaptive traffic signals with installation of Dedicated Short Range Communications (DSRC) units on all 726 Port Authority Transit buses and MobilEye detection on City of Pittsburgh heavy vehicles will create an ideal system-of-systems model. It will allow for a flexible adaptive network that recognizes the needs of transit riders, drivers, cyclists, and pedestrians through detection, connection, and integration and makes intelligent decisions to optimize their mobility and enhance their safety. Eventual citywide and regional deployment will move Pittsburgh toward our long term Vision Zero goals. The Smart Spine corridors connect Pittsburgh's densest population centers to Downtown and Oakland, the second and third largest employment hubs in the Commonwealth of Pennsylvania, where 50% of our region's residents work.

History and Context

The City of Pittsburgh is a dense and topographically complicated city. The winding hills and valleys preclude the development of large, multi-lane limited access highways. Key transportation corridors throughout the City are built into

Total Budget
$30,806,040

Matching Funds
$18,275,948 TOTAL
- $11,000,000 *PennDOT*
- $7,275,948 *City of Pittsburgh*

Partners
- *City of Pittsburgh*
- *SmartPGH Consortium Members*
- *Carnegie Mellon University*
- *Port Authority of Allegheny County*
- *Sports and Exhibition Authority*
- *NXP*
- *MobilEye*
- *PennDOT*
- *Southwestern Pennsylvania Commission*
- *SAE International*

the sides of steep hillsides, paved over streams, and bored through mountains. Much of the flow of the City happens not on freeways, but on boulevards and avenues laid out before the advent of personal automobiles. These roads wind through our residential neighborhoods and business districts, carrying vehicles, pedestrians, transit riders, and cyclists through the urban environment.

In response to these challenges the Surtrac technology was developed by researchers at Carnegie Mellon University (CMU) specifically for dense urban environments and rights-of-way managing multiple modes and uses. In contrast to most commercial adaptive traffic control systems, Surtrac takes a decentralized approach to control of traffic in a road network: each intersection allocates its green time independently based on actual incoming vehicle and pedestrian flows. Then, projected outflows are communicated to neighboring intersections to increase their visibility of future incoming traffic. For example, a recent study showed that Surtrac maintains pedestrian wait times below 20 seconds per light cycle—40 seconds less than the maximum recommended in national Complete Streets guidelines—while at the same time reducing vehicle idle time. Furthermore, integration with the Port Authority of Allegheny County bus fleets' onboard Clever Device system—which tracks location, passenger counts, and other key data points—will allow Surtrac to leapfrog traditional transit priority approaches to achieve a fully adaptive and optimized transit system, benefiting not just transit riders but users of all modes.

Beginning in 2012 with a handful of intersections in the East Liberty neighborhood, the current Surtrac implementation in Pittsburgh now encompasses 50 intersections located in the City's East End neighborhoods. CMU studies.

Aggregate idle time at Surtrac intersections decreased by 40% while emissions decreased by 21%.

The encouraging results from the initial Surtrac deployment point to the possibility of the proposed expansion to significantly impact two regional challenges—managing the demands of multiple transit modes on Pittsburgh's topographically constrained road network and helping to improve the region's air quality.

Implementation and Operation

The City has identified a number of Smart Spines for implementation of Surtrac technology. As this technology is rolled-out, the Allegheny County Port Authority will simultaneously equip their entire fleet of 726 buses with NXP's mobile DSRC units, which will work in concert with Surtrac and Port Authority's already installed Clever Devices to optimize mobility throughout our Smart Spines and feed real-time travel information into our Western PA Regional Data Center and CMU's Mobility Data Analytics Center.

Yesterday, urban renewal initiatives devastated what was once the jazz and entertainment hub of Pittsburgh.

Today, the Hill District is being reshaped for its residents with an ambitious plan by BIG architects, one of the world's leading design firms.

SMART SPINE 1: DOWNTOWN PITTSBURGH The economic center of the 22nd largest Metropolitan Statistical Area, Downtown Pittsburgh is the hub of all transportation in the region and the nerve center of the Smart Spine system. Also known as the Golden Triangle, the central business district is less than ¾ of a square mile, but contains approximately 40% of all salaried jobs located in the City of Pittsburgh. After 200 years, downtown Pittsburgh is still central to economic and cultural life in Pittsburgh. The implementation of Surtrac technology downtown will have substantial benefits along the rest of Pittsburgh's transportation network.

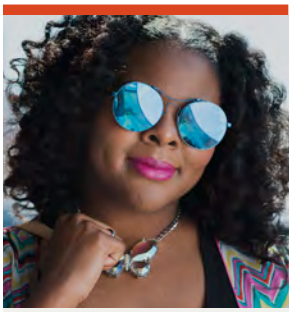
SMART SPINE 2: BIGELOW BOULEVARD Hugging a cut in Bedford Hill, Bigelow Boulevard is one of the primary connection points between Downtown Pittsburgh and Oakland, the education and healthcare center of the City, home to both the University of Pittsburgh and CMU, and the third largest job center in the Commonwealth of Pennsylvania. Bigelow Boulevard is also the primary access point into downtown for neighborhoods such as Polish Hill, Bloomfield, and portions of the historic Hill District. Bigelow Boulevard provides the quickest connection between the existing Surtrac deployment sites in the East End of Pittsburgh and downtown.

SMART SPINE 3: SECOND AVENUE AND IRVINE STREET Second Avenue (at various points in the City also known as Irvine Street) extends from Downtown Pittsburgh along the Monongahela River valley. Once known as the River of Steel, the Monongahela was the center of the Pittsburgh region's industrial engine. Within City limits, Second Avenue connects Downtown to the Hazelwood neighborhood and the ALMONO development site.

SMART SPINE 4: FIFTH AVENUE AND FORBES AVENUE As two of the major thoroughfares through the East End of the City, Forbes and Fifth Avenues parallel one another from Downtown Pittsburgh to Oakland. In doing so, they travel through the Uptown neighborhood, one of the lowest-income neighborhoods of the City. The City, Allegheny County, and the Port Authority are pursuing the full deployment of a Bus Rapid Transit system with a trunk line extending through this corridor from Downtown to Oakland. Surtrac deployment will serve as a down payment on this system and will provide enhanced mobility and increased safety for the tens of thousands of people who travel this corridor every day. Moving further East, Fifth Avenue connects Oakland to the neighborhood of East Liberty, the site of the original Surtrac pilot deployment.

SMART SPINE 5: LIBERTY AVENUE Liberty Avenue is one of the primary thoroughfares connecting Downtown with the East End. Liberty Avenue serves as a major transit and biking corridor and is the site of a large number of the crashes that occur in the East End. Optimizing traffic flows and installing pedestrian detection along Liberty Avenue will be beneficial to tens of thousands of users of all modes every day.

"It's the most bike friendly city I've ever lived in."
—Casey Buta



"[Pittsburgh is] definitely an upcoming city. Probably going to be known for its technology...just a tech savvy city."
—Aleia Scott

SMART SPINE 6: CENTRE AVENUE Centre Avenue connects Downtown Pittsburgh to the Hill District and extends to the existing Surtrac deployment area in East Liberty. As one of Pittsburgh's oldest neighborhoods, the Hill has long been one of the centers of African American culture in the City. The recently developed Centre Avenue Corridor Redevelopment and Design Plan has generated renewed interest in redevelopment throughout the corridor.

SMART SPINE 7: SAW MILL RUN BOULEVARD/ROUTE 51 A major artery into and through Pittsburgh State Route 51 (referred to as Saw Mill Run Boulevard within the City) connects Pittsburgh to suburban neighbors in the South and West, for a distance of nearly 90 miles. A deployment along the Saw Mill Run corridor will set a baseline for future deployment across inter-municipal borders. It can additionally offer an alternative to new construction of limited access highways.

Deployment Structure

In tandem with the creation of Smart Spines outfitted with adaptive signal control and DSRC, the City of Pittsburgh is planning significant physical upgrades to intersections along these key corridors. In many cases, intersections along the Smart Spine corridors do not meet current ADA standards and do not have the basic infrastructure in place to support vehicle, cyclist, and pedestrian detection required for implementation of Surtrac. These fundamental infrastructure investments are required in order to provide a solid foundation for *SmartPGH* and ensure that all modes of transportation are optimized for safety and mobility in these key corridors.

The scope, sequence, and timing of this deployment are designed with the following considerations in mind:

1. Improve upon existing Surtrac deployment by balancing the needs of all modes;
2. Prioritize corridors that leverage other elements of *SmartPGH*;
3. Focus on corridors that provide connections between Downtown, Oakland, and the current Surtrac implementation area;
4. Prioritize corridors that have the most public transit demand and could benefit most from DSRC signal optimization.

Conclusion

The use of optimization technology will revolutionize Pittsburgh's ability to manage traffic in Smart Spine corridors. The ability to balance loads for pedestrians and transit riders will allow for a safer system for all users. Additionally, improvements to the speed of public transit vehicles will further incentivize mass transit, accelerating mode shift away from single occupancy vehicles. As resources become available across Consortium partners, *SmartPGH* will further expand corridors across the City, and connect our Smart Spine

network to outlying suburbs. An optimized, regional system of adaptive signals enable Pittsburgh to stand out as a national and international model of Smart technology integration.

Project Implementation Plan

PHASE	TASK	START	END
I	**Upgrade infrastructure at existing Surtrac intersections**		
	Complete design work for ADA upgrades to existing Surtrac intersections, including pedestrian signals, audibles, and ramps.	10/1/2016	2/28/2017
	Complete ADA upgrades to existing Surtrac intersections	3/1/2017	8/31/2017
	Pilot DSRC-based transit optimization		
	Install DSRC on-board units on Port Authority buses originating from the East Liberty garage	10/1/2016	1/31/2017
	Test DSRC-based transit optimization within the existing Surtrac implementation footprint	2/1/2017	7/31/2017
	Evaluate pilot of transit optimization	8/1/2017	9/30/2017
	Complete Bigelow Boulevard Smart Spine		
	Install Surtrac at three additional intersections	10/1/2016	1/31/2017
	Complete infrastructure upgrades on Second Avenue Smart Spine		
	Complete design work for ADA enhancements and the addition of vehicle and pedestrian detection at intersections	10/1/2016	1/31/2017
	Complete intersection upgrades at intersections	2/1/2017	7/31/2017
	Install Surtrac at intersections	8/1/2017	9/30/2017
	Complete infrastructure upgrades on transit optimization corridors in Downtown Pittsburgh		
	Complete design work for ADA enhancements and the addition of vehicle and pedestrian detection at intersections	10/1/2016	1/31/2017
	Complete intersection upgrades at intersections as needed	2/1/2017	7/31/2017
	Install Surtrac at intersections	8/1/2017	9/30/2017
	Begin design work required for intersection upgrades for Phase II projects		
	Complete design work for ADA enhancements and intersection reconstruction at Phase II intersections	1/1/2017	5/30/2017
II	**Upgrade intersections along Fifth and Forbes Avenue Smart Spines**		

PHASE	TASK	START	END
	Complete full intersection reconstruction at intersections	6/1/2017	2/28/2018
	Complete ADA upgrades and addition of detection at intersections	6/1/2017	2/28/2018
	Install Surtrac at intersections	3/1/2018	9/30/2018
	Expand transit optimization to Phase I Smart Spines		
	Test DSRC-based transit optimization in new corridors	1/1/2018	6/30/2018
	Evaluate expansion of transit optimization	7/1/2018	9/30/2018
	Begin design work required for intersection upgrades for Phase III projects		
	Complete design work for ADA enhancements and intersection reconstruction at Phase III intersections	6/1/2017	12/31/2017
III	**Upgrade intersections along Liberty Avenue Smart Spines**		
	Complete full intersection reconstruction at intersections	1/1/2018	3/30/2018
	Complete ADA upgrades and addition of detection at intersections	1/1/2018	9/30/2018
	Install Surtrac at intersections	3/1/2018	9/30/2018

SMART STREETLIGHTS

Lighting the Way to Cleaner Air

In order to build out a network of connected infrastructure and enhance the data picture this infrastructure can provide, *SmartPGH* will allow for a conversion of up to 36,365 City of Pittsburgh streetlights to LED technology with integrated control systems and installation of supplemental sensor technology, including pedestrian detection and air quality monitoring along Smart Spine corridors.

History and Context

The City of Pittsburgh maintains 40,000 streetlights on the more than 2,400 lane miles of city, state, and county-owned roadways. In 2011, the City of Pittsburgh began converting streetlights in primary corridors and in neighborhood business districts to LED. Currently about 12% of the total streetlight inventory has been converted.

Implementation and Operation

The LED conversion project will provide for significant energy savings, increased safety and mobility, and an array of sensor data that will support other *SmartPGH* elements. Based upon the results of the initial conversion, the City expects to save approximately 60%, or $650,000, on annual energy costs. Additionally, LED streetlights require less maintenance and repair, so the City estimates that an additional $780,000 will be saved through a reduction in our

Total Budget

$13,464,304

Matching Funds

- $12,439,579
  City of Pittsburgh
- $11,000,000
  PennDOT

Partners

- *SmartPGH Consortium Members*
- *Carnegie Mellon University*
- *Duquesne Light*

In 1940—during Pittsburgh's industrial heyday—streetlights ran around the clock due to the City's notoriously bad air quality.

In 2017, smart streetlights equipped with LED and sensor technology will save energy and monitor air quality.

existing maintenance contract. Based on both the energy and O&M savings, the City plans to complete the full LED retrofit using a Guaranteed Energy Savings Contract.

As part of the streetlight conversion project, Pittsburgh will also install 2,840 wireless sensor devices atop all streetlights located in each of our Smart Spines to support other elements of *SmartPGH*. While the wireless sensor devices can serve as WiFi hotspots and offer a wide range of possible applications, including air quality monitoring, real time traffic counts, gunshot detection, noise monitoring, and dynamic advertising capabilities, Pittsburgh will focus on two primary applications—additional traffic and pedestrian detection to support our Surtrac implementation, and monitoring of local air quality. Pittsburgh will conduct a pilot test of these wireless sensor devices paired with LED conversion of 340 streetlights within our existing Surtrac deployment area. The pilot will provide an opportunity for Pittsburgh to test both the advanced lighting controls but also the sensor units prior to a larger rollout to all Smart Spines.

Wireless sensor devices deployed throughout our Smart Spine corridors will provide a wealth of additional data that can be fed to Surtrac to further optimize traffic flows. Additional traffic detection along a corridor can be used to identify significant traffic origins and destinations located between signalized intersections that would otherwise not be detected by the Surtrac deployment. For example, traffic leaving a parking garage at the end of an event can have a significant impact on traffic at surrounding intersections. Sensors mounted on streetlights would be able to efficiently collect this data and communicate it to the controllers at surrounding intersections to optimize traffic flow and improve safety.

The other main focus area for the wireless sensor deployment is monitoring of local air quality. The goal is two-fold: collect real-time local ambient air levels of CO, CO_2, NO_2, SO_2, O_3, and $PM_{2.5}$ to better understand geospatial air quality 'hot spots' and the role that transportation infrastructure plays; and provide a means for us to measure success in reducing overall emissions along Smart Spine corridors as a result of other *SmartPGH* initiatives, including Surtrac and Electric Avenue.

Conclusion

Conversion of all City streetlights to LED technology will provide for substantial operating and maintenance savings and provide a platform to support other *SmartPGH* initiatives. As part of the LED conversion, the City plans to implement new 7-pin photocell receptacles that are required to support the advanced sensor nodes planned for our Smart Spine corridors. While our focus will initially be on the identified Smart Spine corridors, the City intends to expand this physical infrastructure to provide a foundation for future Smart City deployments. In addition to providing the real-time data required to

continually enhance our mobility optimization goals, the sensor infrastructure can potentially be used for a mesh network of public WiFi, as the City is currently exploring, which would help to close the digital divide. In addition to providing substantial annual operating and maintenance savings, a Smart LED system increases pedestrian safety and well-being.

Project Implementation Plan

TASK	START	END
Select a vendor for streetlight conversion project		
Issue an RFP to select a vendor	7/1/2016	8/31/2017
Complete final vendor selection and execute Guaranteed Energy Savings contract	9/1/2017	12/31/2017
Prepare for streetlight conversion		
Complete audit of current streetlight inventory	1/1/2017	2/28/2017
Finalize design and implementation plans	1/1/2017	2/28/2017
Complete streetlight conversion		
Install LED fixtures on all city-owned streetlights	3/1/2017	2/28/2018
Install wireless sensor devices on 2,840 streetlights along Smart Spines	3/1/2017	2/28/2018

AUTONOMOUS SHUTTLE NETWORK

Connecting Community Assets

SmartPGH will demonstrate the convenient and safe operation of autonomous EV shuttles, beginning with travel along one key corridor, and over time scaling to a wider network. While the regulatory environment is not yet 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 Carnegie Mellon University (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, is a key resource partner in this proposed activity, which will connect the net-zero energy ALMONO site in Hazelwood with the Oakland neighborhood and Downtown.

History and Context

CMU is widely considered the birthplace of autonomous vehicle technologies, dating back to the early 1980s. More recently, the CMU team won the 2007 DAR-

Total Budget
$8,826,402

Matching Funds
- $40,000 *Regional Industrial Development Corporation*

Partners
- *SmartPGH Consortium Members*
- *Urban Redevelopment Authority*
- *Carnegie Mellon University*
- *University of Pittsburgh*
- *Regional Industrial Development Corporation*
- *ALMONO Partners*
- *Studio of Spacial Practice*
- *Pittsburgh Parks Conservancy*
- *Pittsburgh Water & Sewer Authority*
- *Allegheny County Sanitary Authority*
- *Jackson/Clark Partners*

PA Urban Grand Challenge, a competition that triggered the chain of rapid developments of automated vehicles in recent years and is currently r evolutionizing 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, has provided additional support of over $14 million, as has the National Science Foundation's Cyber-Physical Systems Program, which focused on the development of autonomous vehicles. CMU has hosted multiple public demonstrations of its leading automation technology and has accordingly received widespread international acclaim for such work.

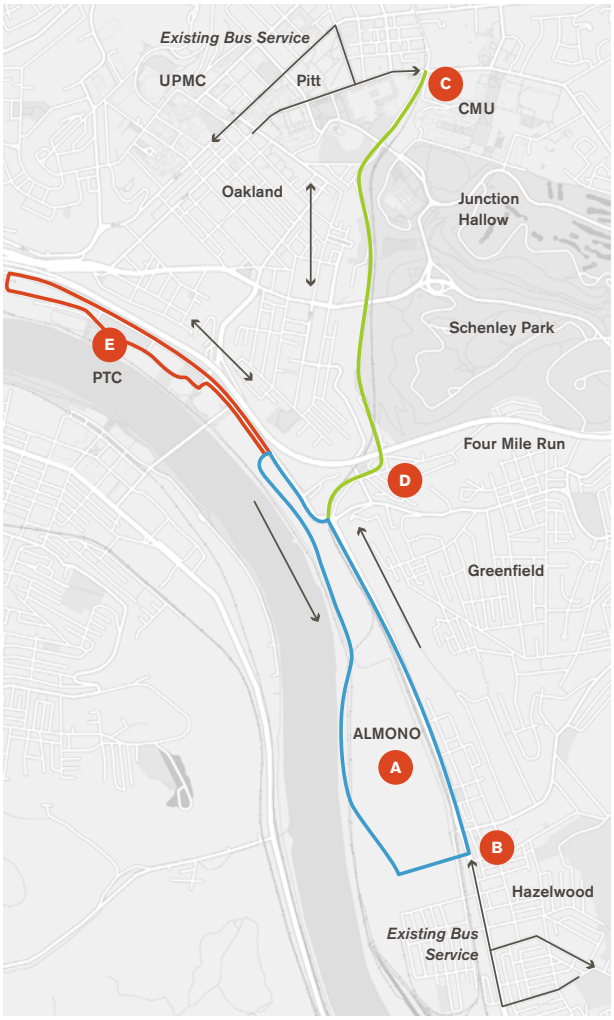
Implementation and Operation
The ALMONO Junction Hollow Connector Study produced by the Studio for Spatial Practice and Trans Associates in May 2016 provides a comprehensive construction, operations, and systems engineering plan for an autonomous EV pilot connecting the ALMONO site and the Hazelwood neighborhood to the heart of Oakland, reconnecting neighborhoods and connecting people with jobs. The publicly-accessible shuttle service will run on a mix of existing streets and a new transit-only cartway through Junction Hollow.

Building a new transit-only cartway through Schenley Park will require the existing Junction Hollow Trail to be replaced and improved, relocating the trail to the eastern side of the valley and extending it to South Neville Street in Oakland where it connects to existing high-frequency public transit routes. A multi-use trail bridge will be constructed to connect the Junction Hollow Trail with existing trail networks in the eastern portion of Schenley Park. The bridge will create a legal crossing for pedestrians and cyclists over the CSX/AVR railroad tracks to the hillside below Phipps Conservatory. All of this will be coordinated and integrated with future efforts to improve Panther Hollow Lake, the Four Mile Run Watershed, and Schenley Park's trail network and other recreational facilities in the Hollow.

The proposed shuttle loop and stop locations are indicated on the map on the next page. This scenario takes into account existing Port Authority Transit bus service in Oakland and Hazelwood in order to maximize the efficiency of the shuttle service and provide the shortest travel time possible.

Across all scenarios, the round trip travel time is greatly reduced with the introduction of the new connector. The connector would save up to 25 minutes on a trip driving from Hazelwood to Oakland, reducing a 45 minute trip to only 20. Most noticeably, the travel time savings for ALMONO to Hazelwood to Oakland are over 75 minutes when compared to using public transit for the same route.

Proposed Shuttle Loop



SHUTTLE ROUTE & STOP LOCATION	AVERAGE TIME (MINUTES)
Shuttle Route Travel Time	
Junction Hollow Loop	8
PTC Loop	7
ALMONO Loop	12
Total Shuttle Route Travel Time: ALMONO – Junction Hollow – PTC	**27**

SHUTTLE STOP BOARDING & ALIGHTING TIME	AVERAGE TIME (MINUTES)
Shuttle Route Travel Time	
A ALMONO	1
B Hazelwood Ave. / 2nd Ave.	1
C CMU / Boudary St.	1
D 4 Mile Run / Boundary St.	1
E Pittsburgh Technology Center	1
Total Boarding & Alighting Time, All Stops	**5**
Total Travel Time: Shuttle Travel & Stops	**32**

This would provide immediate benefits to residents of Hazelwood and Greenfield, dramatically improving their access to the education, healthcare, and retail services of Oakland and significantly reducing their overall travel time.

In 1977, the country's first dedicated busway ran through Pittsburgh's underserved communities.

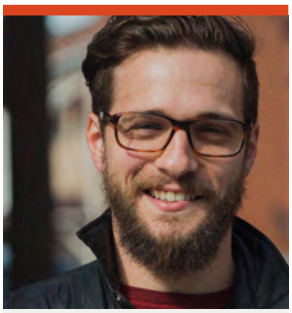
In 2016, Uber developes first-of-its-kind AV technology at its Pittsburgh-based Advanced Tech Center.

Round Trip Travel Time Comparisons:
New Connector vs. without New Connector

ROUTE – ROUND TRIP	TRAVEL TIME	
	AM PEAK	PM PEAK
ALMONO Site to Carnegie Mellon University (CMU)		
With Connector	19:46	20:21
Without Connector	38:08 / 48:08	35:18 / 45:18
Time Savings	**13:22 / 23:22**	**14:57 / 24:57**
ALMONO Site to CMU w/ Hazelwood Loop		
With Connector	27:19	28:00
Without Connector	40:41 / 50:41	42:57 / 52:57
Time Savings	**13:22 / 23:22**	**14:57 / 24:57**
ALMONO Site to Hazelwood to CMU to PTC to ALMONO		
With Connector	35:15	34:05
Without Connector	42:19 / 52:19	44:03 / 54:03
Time Savings	**7:04 / 17:04**	**9:58 / 19:58**
ALMONO Site to Hazelwood to CMU via Public Transit		
With Connector	27:19	28:00
Without Connector	102:00	112:00
Time Savings	**75:19**	**84:00**

Ridership projections for travel between the stops are summarized on the next page. These projections reflect conditions anticipated to exist in 2017 when Phase 1A of the ALMONO site is completed and fully occupied. Ridership between the institutions, Pittsburgh Technology Center (PTC), and the ALMONO site represent trips made during the course of the day between destination points. Including all destinations shown in the limited scenario, the AM peak hour ridership is projected to be 281 persons per hour, with 222 persons per hour projected to ride during the PM peak hour. In total ridership is projected to be 2,220 people a day on weekdays. While providing quality connections for the institutional riders is important, the benefits for the public riders could be even greater.

Providing this new access to residents who have lacked reliable, frequent access for many years is a core component of this deployment.



"I mean we're in my home, my neighborhood right now. And it's just a beautiful part of town. It's my favorite place to be."
—Patrick Francart

Forecasted 2017 Shuttle Ridership

USER TYPE	LOCATION	TOTAL RIDERS
Institutional	ALMONO (CMU)	710
	Pittsburgh Tech Center (CMU)	170
	Pittsburgh Tech Center (PITT)	200
	Pittsburgh Tech Center (UPMC)	470
	Total	**1,550**
Public	Oakland / Hazelwood	170
	Squirrel Hill / Greenfield	80
	4 Mile Run (Residential)	170
	4 Mile Run (Students)	250
	Total	**670**
Total Weekday Daily Shuttle Ridership, 2017		**2,220**

Using the projected Phase 1A ALMONO development conditions, ridership development conditions, ridership and travel times, the numbers of shuttle trip and shuttle vehicles necessary to serve the route, including various headways, were calculated and are summarized below. This projection assumes a 22-person shuttle vehicle. To achieve the recommended four to five minute headway during the AM and PM peak an active fleet of seven shuttles would be required.

Forecasted 2017 Shuttle Ridership

FREQUENCY (MINUTES)	NUMBER OF SHUTTLE TRIPS	NUMBER OF SHUTTLES	OCCUPANCY (NUMBER OF RIDERS)		ESTIMATED PEAK HOUR RIDERSHIP		RECOMMENDED NUMBER OF SHUTTLES
			100%	80%	AM	PM	
4	14	7	308	252			
5	12	6	264	216			
10	6	3	132	108	281	222	**AM – 7**
15	4	2	88	72			**PM – 6**
20	3	2	66	54			

In order to maximize the community benefits of this new autonomous EV transit connection, a large-scale green infrastructure investment will be implemented in Junction Hollow to reduce flooding in the Greenfield and Hazelwood neighborhoods and move toward compliance under the Allegheny County Sanitary Authority's water quality consent decree with the EPA. Residents of this section of Greenfield commonly called 'The Run' have been plagued by chronic flooding due to stormwater runoff for years. This comprehensive infrastructure investment will not only address that issue but also provide new, frequent transit access.

This is a unique opportunity to create a dynamic, high-performance, signature piece of infrastructure that integrates three important systems: transit, trails, and stormwater infrastructure.

Conclusion

Working closely with experts like Professor Raj Rajkumar from CMU and engaging in a robust public process, *SmartPGH* will apply the lessons learned through the Junction Hollow Connector deployment to demonstrate electric autonomous shuttles in additional corridors, including from a parking area on Second Avenue near downtown into the heart of the Golden Triangle, 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. These technology deployments will not only make travel safer and more efficient for all modes, they will be prioritized for communities that lack adequate transportation options, providing critical access to jobs and services.

Furthermore, using connected, sensor-based infrastructure deployments a truly connected autonomous vehicles network will begin to grow. To ensure this comes to pass sooner rather than later, on-going conversations between Mayor Peduto and state-level officials including PennDOT Secretary Leslie Richards are promising with regards to regulatory changes to address the real possibility of dynamic testing and eventually full autonomous vehicle deployment in the coming years. Legislation to develop rules and regulations and create pilot autonomous vehicle corridors has been introduced in the Pennsylvania General Assembly in support of the City's application and enjoys bipartisan support. As the regulatory environment evolves, Pittsburgh will have the legal ability to begin pilot testing autonomous vehicles in several of the key corridors identified.

Project Implementation Plan

PHASE	TASK	START	END
I	**Pre-development**		
	Complete engineering and construction documents	6/1/2016	8/31/2016
	Complete environmental impact study	7/1/2016	9/31/2016

II	**Site preparation and infrastructure**		
	Relocate bike/ped trail to eastern side of corridor	4/1/2017	6/1/2017
	Install green infrastructure BMPs to capture and convey to new stream course	4/1/2017	7/1/2017
	Construct new 12′ cartway with 24′ passing area	5/1/2017	8/1/2017
	Construct bike/ped bridge over railway crossing	8/1/2017	11/1/2017
III	**Operations**		
	Acquire eight EV shuttles with autonomous capability	12/1/2017	2/1/2017
	Identify operator and begin testing	1/15/2018	4/1/2018
	Identify areas of concern and implement additional site improvements (if needed)	2/15/2018	5/1/2018
	Begin full operations	6/1/2018	1/31/2018

THE SMARTPGH DATA UTILITY

Making Data Work for Us

SmartPGH deployments will create a vast new set of information resources that can unlock new insights about how the City of Pittsburgh works. These new data resources will provide benefits not only to the City and other public agencies, but to researchers, businesses, and actively engaged citizens. The City firmly believes in the value of publicly available, machine readable open data and will leverage the Smart City Challenge opportunity to both collect and distribute more data on its own while assisting SmartPGH Consortium partners in creating an open data ecosystem that is greater than the sum of its parts. The Data Utility offers a platform and a process framework to collectively make decisions, recognize economies of scale, and create standards of interoperability regarding the transmission of data: 1) from data collection source to the network, 2) from the network to a location for archiving, anonymizing, and organization, 3) from the storage location to the broader Internet and to the public, and 4) for public-sector focused application development, including both internal decision-making tools and publicly accessible applications. The legal and governance framework already in place in Pittsburgh as a result of the work of the Western Pennsylvania Regional Data Center (WPRDC) offers the City the ability to now focus on scaling this service and moving along both directions of the supply chain.

History and Context

The Pittsburgh region is a leader in open data. WPRDC was founded in 2015 by the City of Pittsburgh and Allegheny County, operated by the University of Pittsburgh, and supported by the Richard King Mellon Foundation and The

Total Budget
$6,471,246

Matching Funds
$1,755,496 (TOTAL)
- $377,748 *The Heinz Endowments*
- $377,748.00 *Richard King Mellon Foundation*
- $1,000,000 *Amazon Web Services*

Partners
- *Allegheny County*
- *SmartPGH Consortium Members*
- *Western PA Regional Data Center*
- *CMU Mobility Data Analytics Center*
- *Amazon Web Services*

Heinz Endowments. The WPRDC currently hosts over 120 datasets, and provides the technical and legal framework to disseminate public and private sector open data on the open-source CKAN platform.

The WPRDC is designed to be flexible and extensible, able to grow to include a variety of public and private sector data providers. Operating on a federated model, the WPRDC can provide technical, legal, and documentation support for publicly sharing datasets regardless of whether they are hosted on the WPRDC servers or elsewhere.

The WPRDC offers support to data users including training in the use of the data portal, visualization tools, support to learning and volunteer communities, data user guides, technical assistance, and special events.

Though currently all datasets available on the WPRDC are generated by the City and County, in June, the WPRDC will begin hosting a number of transportation datasets, several owned by Consortium partners. As the data center matures, it will continue to host theme-based rollouts of data from a variety of partners around a particular topic. These datasets will provide a baseline of information as the Data Utility begins operating in its expanded role.

WPRDC Transportation Datasets

City of Pittsburgh	Pittsburgh Parking Authority	Allegheny County Port Authority	Pittsburgh Downtown Partnership	Southwestern Pennsylvania Commission	Bike Pittsburgh
• Bicycle Lane Usage Counts • Paving Schedules • Scheduled Closings	• Parking Utilization by Zone • Garages & Lot Capacity • Garage Capacity & Real-Time Usage • Permit Parking Areas & Schedules	• Real-Time Bus Locations • Bus Routes • Bus Stops / Schedules • Ridership Statistics	• Commuter Survey • Events	• Traffic Counts • Population & Employment Forecasts • Traffic Models & Outputs	• Recommended Routes • Bike Racks • Recommended Service Areas

Implementation and Operation

The City of Pittsburgh owns existing installed fiber capacity in nearly every identified Smart Spine corridor. In areas where City capacity is insufficient

The Golden Age of Radio was ushered in by Pittsburgh with the first commercially licensed radio broadcast.

In the Era of Big Data, the City is building a platform for sharing data so it can be used to monitor and improve infrastructure.

or incomplete, the City and other SmartPGH Consortium partners will competitively identify and enter into a partnership with one or several existing providers in order to supplement the network for transmitting information. As the City and its partners continue to scale *SmartPGH* deployments, the partners will work cooperatively to ensure a shared capacity for transmission along collective fiber.

STORAGE TO DISSEMINATION The federated nature of the SmartPGH Consortium model allows for partners to select data storage options that best meet their needs. Rather than having a single repository of all data collected, datasets will be collected and stored in the manner that is most cost-effective or efficient. The City already hosts some data on its own servers, some at off-site locations, and others in cloud-based servers. As the volume of information increases, the City and other SmartPGH Consortium partners will secure additional capacity, including at the Pittsburgh Supercomputing Center.

While datasets may be stored in a variety of settings, standards related to the ownership, security, and interoperability of the information will be key. The WPRDC will provide Consortium partners with training and assistance on extracting data from internal systems, data transformation, metadata transformation, and data licensing. The interoperability of these extract transform load (ETL) processes across Consortium partners will ensure the benefit of data collection is magnified.

The WPRDC will also serve the Consortium in the role it already plays for the City and the County: that of the public data portal. Industries and the public will have a single portal for all Consortium data. New data created as a result of the *SmartPGH* initiative will be accessible alongside existing housing, environmental, public safety, and other data types. This support will be scaled as additional datasets are brought online.

APPLICATION DEVELOPMENT While the public-facing component of the Data Utility will be managed through the existing WPRDC, the City and SmartPGH Consortium partners will require assistance developing decision-making tools and public facing applications that are built upon the information infrastructure. Existing capability within most Consortium member organizations is insufficient to develop and manage these applications.

In order to ensure that the City and Consortium members receive the decision-support tools they need, Carnegie Mellon University's Mobility Data Analytics Center (MAC) will be brought on to serve as an 'on-call' application developer for the SmartPGH Consortium. MAC will assist the City and the Consortium in interpreting information to make better decisions in the public interest. MAC can build environments integrating both the public data hosted on WPRDC and non-public datasets in developing these decision tools. While the MAC will be the primary developer of *SmartPGH* content, the City may also

"I think the people are really nice here... when you meet people on the bus... here people ask you how you are and they actually want to know the answer, you know it's like kind of a cool thing."
— Cella Neilly

elect to partner with other organizations, contract, or crowdsource other applications, depending on the need.

The City and Consortium have identified several projects of early importance for long-term success. The MAC will help the City and the Pittsburgh Parking Authority expand its current dynamic pricing pilot program from 400 spaces to thousands of spaces across Smart Spine neighborhoods such as Oakland, East Liberty, and Downtown utilizing datasets on occupancy rates. Working with USDOT Partner Flow Parking, the City and the Pittsburgh Parking Authority can optimize pricing and enforcement structures, generating more revenue for the City and a higher level of availability for business districts.

MOVEPGH One of the first applications of highest priority to the City is the development and deployment of a real-time traveler information and reporting application. Called MovePGH, this application will provide residents and visitors with the ability to view comparable options across multiple modes such as public transportation, taxi, bikeshare, carshare, biking, walking, and driving and parking. Users will be able to compare travel options over categories such as real-time travel time, carbon emissions, construction detours, safety, and condition of travel paths (i.e., sidewalk presence or condition). The application will also let the user select to record trips, providing the City additional mobile sensors for pedestrian, cycling, vehicular, and transit movements and planning. Following a public engagement process to assess the highest priorities of users and residents, the MAC and the SmartPGH Consortium will partner with an application developer to build a Pittsburgh-specific application, including but not limited to Flow, Moovel, WhereIsMyTransport, and Xerox. Leveraging Consortium relationships and through existing multi-municipal organizations and initiatives such as the University of Pittsburgh's Congress of Neighboring Communities (CONNECT), this application will eventually expand to outlying communities and to the broader Southwestern Pennsylvania region.

Conclusion

The Data Utility has significant and demonstrable impacts on quality of life in the Southwestern Pennsylvania Region.

The provision of so much public data in such a coordinated manner will be a useful element of the 'urban laboratory' model supported by Mayor Peduto, where students, developers and researchers partner with the City to address public challenges.

Additionally, the data utility will serve as utilities have in the past—a public service that acts as a foundation for further innovation by the private sector. Already a national leader in Open Data, the City of Pittsburgh will stand out

as a global model not only in what data it provides, but how it encourages and supports the use of that data.

Project Implementation Plan

TASK	START	END
Expand WPRDC Infrastructure to include *SmartPGH*		
Structure participation agreements to include data sharing	9/1/2016	8/31/2017
Project data collection and asset management protocols incorporated	9/1/2016	12/31/2016
Establish ETL protocols for datasharing	9/1/2016	11/1/2016
Maintain responsive updates to data pipelines	11/1/2016	12/1/2016
Conduct User Groups around themes, projects, communities	12/1/2016	6/1/2017
Develop Applications on *SmartPGH* Data		
MAC and others conducts user interviews with stakeholders to determine needs	9/1/2016	2/28/2017
Project/Product Roadmaps developed by MAC and approved by City	9/1/2016	1/1/2017
Developers launch apps and engage in iterative development	1/1/2017	6/1/2017
SmartPGH works with MAC/WPRDC to create ongoing pipeline of application needs to be matched with data resources and developers	2/1/2017	6/1/2017

"ELECTRIC AVENUE"

Charging Into a Fossil-Free Future

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

Pittsburgh will create a clean energy-transportation corridor along Second Avenue extending from the Downtown Business District, past the Pittsburgh Technology Center (PTC), to the ALMONO site in the underserved Hazelwood neighborhood. 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.

Our ambitious 'Electric Avenue' project includes the purchase of a new EV fleet to be parked and charged at the City-owned Second Avenue parking lot

Total Budget

$11,899,200

Matching Funds

$11,899,200 (TOTAL)

- $1,000,000 *City of Pittsburgh*
- $900,000 *Pittsburgh Parking Authority*
- $9,999,200 *Vulcan Foundation*

Partners

- *SmartPGH Consortium Members*
- *Duquesne Light*
- *University of Pittsburgh Center for Energy*
- *Vulcan Foundation*
- *Pittsburgh Parking Authority*
- *Pittsburgh Region Clean Cities*
- *Green Building Alliance*

coupled with DC charging stations that receive power through a solar canopy tied into the local district energy microgrid. The fleet will utilize grid-to-vehicle charging, which can also support other assets on the grid.

History and Context

For decades, Pittsburgh was the fossil-fuel powered engine of the nation's industrial economy. We generated and consumed massive quantities of power and built our infrastructure to facilitate that power. Pittsburgh was even the home of the country's first drive through gas station. But as our economic base has changed so too must the infrastructure that powers our city.

In an effort to build a cleaner and more resilient electric grid and provide a local, renewable option to power EV charging infrastructure, the City of Pittsburgh, United States Department of Energy, and the National Energy Technology Lab signed a historic agreement to research, develop and deploy district energy and microgrid systems throughout our city. The project directly engages close partners at The University of Pittsburgh's Center for Energy to evaluate microgrid system development and advance next generation energy infrastructure in Pittsburgh.

Implementation and Operation

The City of Pittsburgh maintains a five-year vehicle acquisition plan that is updated annually. The plan prioritizes high-mileage and high-emissions vehicles for retirement and aims for a six year turnover of sedans and a 10-year turnover of trucks. Pittsburgh City Council established a Green Vehicles Ordinance in 2008 to prioritize purchasing vehicles with high fuel efficiencies and alternative fuels. The fleet currently includes seven gas-electric hybrid vehicles, five CNG trucks, and 24 diesel refuse trucks outfitted with biodiesel tanks.

The City has completed a three-year Electric Vehicle Acquisition Plan from 2017 to 2019 that proposed a $5 million budget to purchase 10 electric motorcycles, 81 electric sedans, 14 electric medium-duty SUVs and 107 Level 2 charging stations.

The City and the Parking Authority will install 25 Level 2 charging stations on a DC microgrid powered by a 100kW photovoltaic array and backed up by a 900 kWh Cradle-to-Cradle certified battery bank at the Second Avenue lot. In addition to providing clean energy, the system will build resilience and function even if the AC grid goes down. The charging stations will be open to the public during the day and will recharge the City of Pittsburgh's Department of Permits, Licenses, and Inspections (PLI) vehicles at night. Through collaboration with local utility Duquesne Light, the Pittsburgh Parking Authority will be able to charge for parking and electricity use through the existing Go Mobile PGH app.

Lastly, in an effort to reduce redundant, proprietary networks for monitoring and operating some of these decarbonization technologies, *SmartPGH* will also leverage wireless communication technologies, built on an IPv6 protocol, in partnership with Duquesne Light. The wireless communication network at Second Avenue will support the site's charging stations, LED lighting, and smart utility meters. This strategy will corroborate how an IPv6 network could also provide a city-wide Internet of Things (IoT) network platform to support an expanding array of city wide services and monitoring capabilities to drive significant improvements in energy efficiency, water conservation, transportation and traffic management to create a more livable, sustainable and economically vibrant Pittsburgh community.

Conclusion

Building upon the deployment at Second Avenue, the City of Pittsburgh will expand charging and renewable generation opportunities at all City- and City Authority-owned garages and lots. A primary focus will continue along the Second Avenue corridor by expanding vehicle electrification facilities at the (PTC) garages owned by the Urban Redevelopment Authority of Pittsburgh and the Pittsburgh Parking Authority's First Avenue Garage. Furthermore, the City of Pittsburgh plans to relocate the majority of its non-emergency fleet to a new facility which will meet Pittsburgh's equipment and maintenance needs and is committed to designing the facility to incorporate renewable energy generation, microgrid capabilities and non-carbon based 'fueling' systems.

Project Implementation Plan

TASK	START	END
Solar-Charging Infrastructure Build Out		
Capital infrastructure plan development	9/1/2016	11/1/2016
Project data collection and asset management protocols incorporated	9/1/2016	12/31/2017
Project design and engineering	9/1/2016	11/1/2016
Approvals capital budget, engineering, and design	11/1/2016	12/1/2016
Construction preparation	11/1/2016	3/1/2017
Construction	3/1/2017	6/1/2017
Fleet Conversion		
Refine Capital Purchasing and financing strategy	9/1/2016	12/1/2016
Metrics and asset management protocols incorporated	9/1/2016	1/1/2017
Vehicle orders submitted	1/1/2017	2/1/2017
Deployment	2/1/2017	6/1/2017

MOBILITY THROUGH TECHNOLOGY

Meeting Our Neighbors Halfway

President Obama's Ladders of Opportunity agenda is present throughout throughout Pittsburgh's Smart City Challenge application. Deployments that enhance mobility options such as public transportation, pedestrian accessibility, and cyclists disproportionately improve transportation outcomes for low and moderate income travelers, since they are the dominant users of those modes. Time savings, reliability, and safety improvements will enhance the lives of low- and moderate-income residents. However, the City also recognize the need to design applications that directly enhance outcomes for residents with unique needs. As a result, the City is partnering on three micro-pilots to enhance mobility outcomes for the impaired community, the homeless and those seeking preventative healthcare. These three pilots use technology to improve not just transportation outcomes, but also health and human service outcomes.

History and Context

The City and the SmartPGH Consortium members will embark on three pilots related to populations with specific and unique transportation needs. These pilots will demonstrate the intersectionality of Smart City technology with healthcare and human services. Operating off of our central premise, "If it's not for all, it's not for us," Pittsburgh will integrate these applications into the larger *SmartPGH* initiative, and work to partner with other nontraditional partners to expand the systems-of-systems approach.

Implementation and Operation

INCLUSIVE COMMUNITY By deploying Bluetooth low-energy beacons and transceivers in the Oakland neighborhood, and allowing users to register their profiles (e.g., type of limitations) via a smartphone app, we will make the physical environment aware of users' abilities and needs, and thus provide personalized services. The open framework and tools resulting from this pilot deployment could allow such services to be easily replicated in other areas of the City.

HOMELESS TRANSPORTATION Research has demonstrated that over 60% of the homeless population has access to a smartphone. In order to leverage this technology and provide human services, the City has partnered with the Homeless Children's Education Fund to develop BigBurgh, a web-based app for computers and smartphones that provides geographically-specified human service needs for homeless individuals, targeted to age and identity. The City will further integrate this application into data streams provided by the MovePGH app.

HEALTHCARE TRANSPORTATION Transportation remains one of the largest impediments to improving healthcare access. Unpredictability and unreliability of informal transportation networks (such as "jitneys") increase the number of no-shows to preventative or follow-up appointments. Existing policy does not

Total Budget
$1,856,073

Partners
- *University of Pittsburgh School of Health & Rehabilitation Science*
- *Homeless Children's Education Fund*
- *ACCESS Paratransit*

In the past, homes and businesses in East Liberty were razed to make way for highways and parking lots.

Currently, East End economic development plans focus on social equity and affordable housing.

fund the operation of paratransit vehicles (such as the ACCESS program) to pick up riders with less than 24 hours notice, meaning that if transportation was not arranged ahead of time, the unpredictability could lead to a cancellation or a no-show.

The City would partner with the Allegheny County Department of Human Services and ACCESS to provide a two-step transportation pilot at a number of facilities in the East Liberty area of Pittsburgh. The first part of the pilot would integrate transportation scheduling into appointment scheduling. A "Transportation Coordinator" will be housed within ACCESS. When a patient schedules an appointment, the health care provider would simultaneously schedule an ACCESS paratransit vehicle, or provide information regarding fixed route transportation services.

In the event that the patient's primary transportation option failed them, the Transportation Coordinator could serve as a concierge to provide real time bus arrival information or serve as a dispatcher for local transportation provision such as a taxi or TNC. The City and ACCESS are in negotiations with a number of potential providers of this service.

For all three of these projects, generating outcomes will be key to demonstrating their eventual widespread adoption and implementation. The linkage of these outcomes with transportation technology will set the stage for new ways of thinking about how cities connect to residents with needs.

Conclusion
Though these pilots are small, they are significant demonstrations of the potential power of technological integration into the lives of Pittsburgh residents, and the unique role that transportation and mobility play in the quality of life for residents. These demonstration projects will tie into the larger applications by way of the Data Utility, and demonstrate the City's partnership with outside organizations.

Project Implementation Plan

PHASE	TASK	START	END
I	**Inclusive Communities**		
	Design of Inclusive Communities Pilot Site	3/30/2017	5/30/2017
	Installation of Inclusive Communities Pilot Deployment	6/1/2017	7/1/2017
	Evaluation of Inclusive Communities Pilot Deployment	7/1/2017	7/30/2018
II	**Homeless Transportation**		
	Public launch of BigBurgh application	6/30/2016	
	Integration of BighBurgh application with MovePGH	1/1/2017	2/1/2017

III	Health Care Access		
	Onboarding of Transportation Coordinator	9/01/2016	
	Pilot Period of Operation	9/1/2016	5/1/2018

WORKFORCE DEVELOPMENT PIPELINE

Forging New Pathways

The Brookings Institution describes advanced industries as those with "deep involvement with technology research and development (R&D) and STEM (science, technology, engineering, and math) workers… encompass[ing] 50 industries ranging from manufacturing industries such as automotive technology and aerospace to energy industries...to high-tech services such as computer software and computer system design, including for health applications."

Advanced industries employ 12.3 million US workers—9% of the nation's total employment—and produce $2.7 trillion dollars in revenue, nearly 20% of the US's gross domestic product. In Pittsburgh, 95,000 workers are employed in this industry, and according to the Three Rivers Workforce Investment Board, this industry is seen as a major 'Opportunity Sector' in our region.

We see the Smart City Challenge as an opportunity to deploy cutting-edge transportation technologies, but also an opportunity for Pittsburgh to create pathways to new careers in advanced manufacturing and cybersecurity.

By working with local higher education institutions, vendors and employers engaged in the *SmartPGH* initiative, and our local workforce development system, Pittsburgh will align education and job training priorities with this rapidly growing market. In fact, new research from Bruce Katz of Brookings Institution suggests that more than 50% of the emerging jobs in our region in these fields will require less than a Bachelor's Degree. Clearly, the opportunity to connect residents of all backgrounds and education levels with well-paying jobs is within our grasp, especially when harnessing the potential innovation and investment of *SmartPGH*.

History and Context

Pittsburgh is fortunate to have a number of existing resources in advanced industries and cybersecurity. Carnegie Mellon University's Computer Emergency Response Team (CERT) cybersecurity think tank and the cybersecurity programs at the University of Pittsburgh are considered amongst the most advanced in the country. Pittsburgh is also designated as both a "TechHire"

Total Budget
$1,919,000

Matching Funds
- $1,309,000 *Three Rivers Workforce Development*

Partners
- *Three Rivers Workforce Investment Board*
- *Community College of Allegheny County*
- *University of Pittsburgh*
- *Carnegie Mellon University*
- *The Brookings Institution*
- *Remake Learning Network*
- *PA CareerLink*

and "Investing in Manufacturing Communities Partnership" city, bringing national resources and expertise to bear.

Existing workforce programs in this fields will also be further leveraged to help connect employers with employees and connect students with potential employment paths. For example, the National UTC for Safety at CMU has an existing partnership with the Community College of Allegheny County (CCAC) to train automotive technicians. *SmartPGH* provides a vehicle to assess existing programs and opportunities, create new programs to respond to emerging and future needs, and provide for system-wide coordination and cooperation.

Implementation and Operation
In order to take advantage of workforce opportunities presented by growth in the advanced industries and cybersecurity fields, *SmartPGH* will:

1. Develop both an Advanced Manufacturing Certificate and a Cybersecurity Certificate with a local higher education institution;
2. Release an RFP in advanced manufacturing and cybersecurity training to leverage and scale existing programs;
3. Create advanced manufacturing and cybersecurity advisory groups to examine best practices, monitor trends, and engage employers.

CUSTOMIZED ASSESSMENTS Once participants are engaged and deemed eligible, they will undergo a three-part assessment to determine the most appropriate program track and supportive services needed to be successful. These assessment pieces include examining the participant's basic needs, his/her workforce readiness level, and the support services needed to ensure his/her successful completion of the program.

CAREER PATHWAYS Working with the employers and vendors participating in the SmartPGH Consortium, the USDOT Partners, and local employers in these fields, Pittsburgh will map out the education and workforce skills necessary, drawing on lessons learned from the Pittsburgh Technology Council and CMU's Cyburgh initiative.

CREDENTIAL FOCUSED COMPONENTS A workforce certificate will be developed with a local higher education institution to begin preparing participants for the needs of the employers.

An Advanced Manufacturing Certificate at a Community College will support students to demonstrate a knowledge and understanding of the application of various geometric and trigonometric functions, blueprint reading skills, the safe use of manufacturing equipment, and quality control methods and procedures. Students will also learn to operate manufacturing machinery.

A Cybersecurity Certificate at a Community College will teach students to identify, describe and analyze vulnerabilities, threats, and risks for critical

"[Pittsburgh] is a city that is transitioning and there's a lot of change happening, and I think, as someone of my age—I'm in my early 30s—you can be part of that...it's great for startups. I started my own thing last year, bike tours."
—Valentina Scholar

information assets. They will also learn to plan, implement and maintain security measures and controls to protect critical information assets; prevent, detect, analyze and respond to system intrusions and data breaches; and analyze and evaluate emerging cybersecurity risks and solutions with critical-thinking and research skills.

EMPLOYER ENGAGEMENT When designing both credit and noncredit curriculum, CCAC will seek input from regional employers and invite them to serve on the program's advisory committee. CCAC will work closely with the Three Rivers Workforce Investment Board and regional employer partners to design the career lattice pathway for high demand workforce training programs. Members of CCAC's Workforce division will be in constant discussion with employers to ensure workforce training programs closely align with the workforce training need of the region. Employers will be engaged through direct participation in an Advanced Manufacturing or Cybersecurity Advisory Committee to ensure program participants are obtaining the essential skills needed.

WORKFORCE TRAINING To successfully, complete this component, an Advanced Manufacturing and Cybersecurity Request for Proposals will be developed and launched in the region to:

- Leverage and scale existing programs that include industry, education, and workforce systems
- Align our education and workforce partners to meet both regional and statewide goals for manufacturing and cybersecurity workforce needs
- Support capacity at the infrastructure and human resource levels of our education and workforce providers for technical education and employer relationship building
- Expand employer engagement and participation in training programs
- Increase the pipeline of new workers to meet employers' needs and recruit workers from diverse and underserved backgrounds
- Assist employers with succession planning and worker training.

Conclusion

SmartPGH provides an important opportunity to align jobs in new industries, primarily advanced manufacturing and cybersecurity, with a ready and able local workforce. Pittsburgh is perfectly positioned to capitalize on our existing network of workforce training providers, higher education institutions, employers, and intermediaries to activate the workforce of the future and provide pathways to family-sustaining jobs for those who need them. Leveraging existing resources through our designation as a "TechHire" and "Investing in Manufacturing Communities Partnership" city, our ongoing research engagement

with The Brookings Institution, and our SmartPGH Consortium partnership, Pittsburgh will build new pathways to work for thousands of our residents.

Project Implementation Plan

PHASE	TASK	START	END
I	**Engage Employers**		
	Conduct face-to-face meetings with advisory group	8/1/2016	12/1/2016
	Conduct webinars and conference calls to organize and complete the advanced manufacturing initiative's activities	8/1/2016	12/1/2016
	Conduct research to present to advisory group	9/1/2016	1/1/2017
	Deliverables inform creation of career pathways for high demand advanced manufacturing and cybersecurity occupations mapped to educational and training programs	9/1/2016	1/1/2017
II	**Establish Career Pathways**		
	Document and map career pathways for the advisory group and to employer-approved educational and training programs	1/1/2017	5/1/2017
	Use pathways to create awareness campaigns about advanced manufacturing and cybersecurity careers and secondary and postsecondary educational programs for high and middle school students	1/1/2017	5/1/2017
	Create an RFP and select a research firm to do the assessment	1/1/2017	5/1/2017
	Conduct research and present findings and recommendations for a systematic approach to advisory groups	1/1/2017	5/1/2017
III	**Leveraging Career Pathways**		
	Work with CCAC, Remake Learning, and PASSHE to develop an advanced manufacturing microcredential	1/1/2017	6/1/2017
	Evaluate access to information among untapped pools of talent, students, workers, job seekers, and people with employment barriers	1/1/2017	6/1/2017
	Evaluate alignment with high and middle school coding, advanced manufacturing, and maker awareness courses	1/1/2017	6/1/2017
IV	**Bridge Digital Skills Divide**		
	Assess employers' knowledge and experience with 3RWIB and PA CareerLink's services and programs	6/1/2017	8/1/2017
	Determine options to increase employers' use of services and programs to develop the skills and credentials associated with career pathways	6/1/2017	8/1/2017
	Pilot options with employers and training providers	6/1/2017	8/1/2017

PHASE	TASK	START	END
	Create RFP for training grant program with community organizations	6/1/2017	8/1/2017
	Implement and evaluate community based organizations' performance	6/1/2017	8/1/2017

SMARTPGH COMMUNITY CENSUS

Sensing Our Citizens

SmartPGH will work with Jackson/Clark Partners, a leading engagement, civic participation, and research firm, to gather quantitative and qualitative data to measure the performance of *SmartPGH* strategies and their impact on Pittsburgh's residents — and to ensure that these strategies can be replicated by other cities.

Jackson/Clark Partners Community Census process moves beyond engagement to build community through community participation — hiring residents from the community to gather data from their peers, a participatory process highlighted in November 2016 as a Choice Neighborhoods Promising Practice by HUD for its deployment in Pittsburgh's Larimer neighborhood. The Community Census will incorporate an accompanying statistically valid random sample survey, conform with key University Center for Social and Urban Research (UCSUR) Regional Quality of Life Survey indicators, and Census methodology will be evaluated through a controlled analysis as part of the project.

This community-derived information will provide people with a real and deliberate role in informing how smart transportation should best work for them. It is the *SmartPGH* mechanism that provides people with a better deal in urban transportation planning for their community, giving them a participatory voice in the design process for their experiences, aspirations, and visions for the Smart City they want. The SmartPGH Community Census approach puts people first to define, design, and implement a replicable urban transportation system model for the 21ST Century. *SmartPGH* will employ this best-practice community peer participation to complement and enhance our systems engineering approach, and will use the pioneering new approach of Sustainable Return on Investment to monetize, prioritize, and evaluate the social and environmental change ensuring that our smart transportation strategies not only put people first but that they drive smart community design.

History and Context

Our city has a rich history of innovation in urban data gathering, best reflected in the Pittsburgh Survey of 1907, which set the 20TH Century standard for urban sociological studies. This contrasts directly with the 19TH century model where railroad trusts were preeminent, and rail lines disconnected Pittsburgh's people from our three rivers; and the 20TH Century practices where technocrats like Robert Moses and the idea of single occupancy vehicles dominated planning,

Total Budget

$1,909,839

Partners

- *TREK Development*
- *Jackson/Clark Partners*
- *City and County Taskforce On Disabilities*
- *PolicyLink*
- *Made Right Here*
- *Keystone Research Center*
- *Economic Development South*
- *CMU School of Design*
- *Allegheny County Jail Collaborative*
- *Carnegie Libraries of Pittsburgh*
- *Pittsburgh Housing Authority*
- *Allegheny County Health Department*

necessitating the Uniform Relocation Act, passed in 1970 and promulgated by the U.S. Department of Transportation to mitigate the devastating social impact of urban planning where people decidedly did not come first.

Through the Community Census and the Sustainable Return on Investment valuation models, we will apply the lessons of history to reorient infrastructure planning toward a needs-based people-first approach.

Implementation and Operation

The SmartPGH Community Census will gather data from residents in neighborhoods proximate to planned smart transportation infrastructure deployments, and in key City ladder-of-opportunity communities. Target communities include public housing and senior citizen housing residents (leveraging Larimer Choice Neighborhoods Community Census data gathering); public school and community college students; formerly incarcerated residents; people with disabilities; veterans (leveraging data from a 2015 Veterans Administration regional needs assessment); and new American immigrants (leveraging survey data gathered as part of the 2015 Welcoming Pittsburgh Plan).

Jobs and transit access are our highest priorities in building opportunity. We will support ladder of opportunity communities by creating jobs and hiring residents beginning with the very first phase of *SmartPGH*, and by utilizing those employees to connect their neighbors with employment resources, including the Maker Professional Apprenticeship that builds digital tools and robotics operations skills. Workforce development partnerships will connect participants from ladder of opportunity communities who have identified household employment or training needs with requested resources as a part of Census outreach. Volunteer participants will continue to gather household air and water quality data, including lead levels.

The Community Census outreach will be supported by a series of public community innovation sessions, following the Larimer Choice Neighborhoods Promising Practice methodology, to ensure robust community participation as well as input and collaboration from key institutional partners.

In addition to contributing to the understanding of current experience and to the generation of new ideas for the future, the data gathered from the Community Census will also be used as the basis for comprehensive Sustainable Return on Investment (or SUROI) reports. SUROI challenges the notion that the value of development can only be calculated in terms of the return on investment from the sale, rent or revenues gained on completion. Instead, the SUROI approach assumes that most development, including all that is promoted or

The Pittsburgh Survey of 1907 gathered data from the city's working class to measure the social impact of urban planning.

Transportation infrastructure projects of the future will be shaped by data gathered from residents in the neighborhoods affected.

"You know we say yinz, we got our own language. Own style, you know, we [Pittsburgh] can't be replicated. That's how I feel."
—Kevin Gales

sanctioned by the public sector, is instigated with the intention that it not only represents prudent use of land and resources, but crucially that it also promotes positive social and environmental change.

The SUROI puts our triple-bottom-line performance measures for equity and environment into a clear language that everyone can understand—dollars and cents. This approach commits *SmartPGH* to transportation improvements that have positive impacts for the residents and visitors of Pittsburgh in terms of better health outcomes, reduced criminal activity, increased affordable housing access, higher skills and education attainment, more and better job opportunities, increased benefits from high quality environments, and higher levels of well-being.

These positive impacts will be felt across the city, but will be magnified in underserved communities targeted for ladder of opportunity interventions.

Information is more than just data when people come first, so we will also document our *SmartPGH* process working with Pittsburgh multimedia partners, including MAYA Design, to capture the bigger picture of the human stories and technological innovations of *SmartPGH* to better support replication in other cities. We will leverage community media resources to provide residents with a direct public voice to tell their story throughout the *SmartPGH* process.

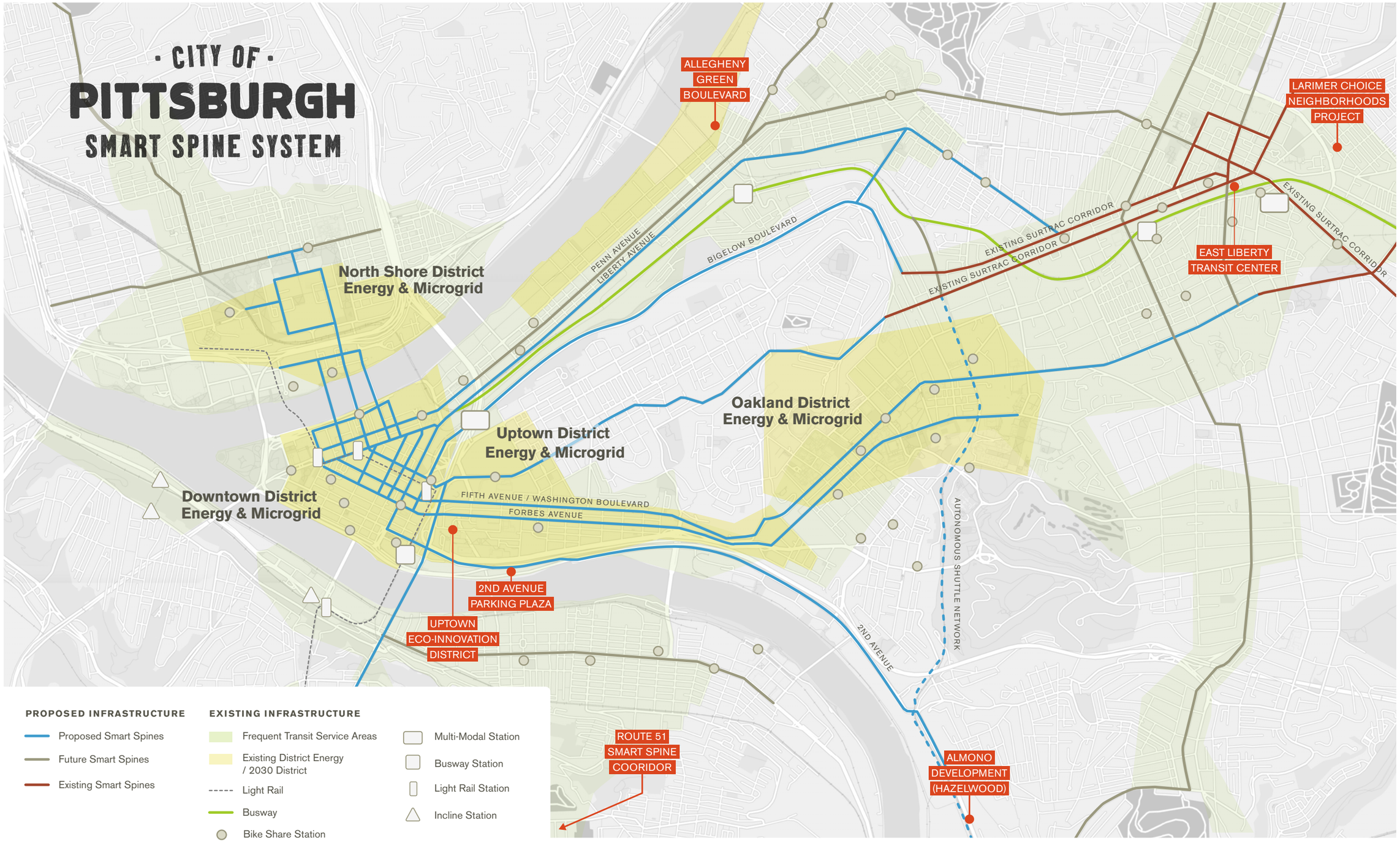
The SUROI team led by Professor Erik Bichard has extensive experience in working with a range of partners wishing to understand the full sustainable value of their interventions. This includes: private developers responding to civic bodies or evidencing their corporate social responsibility; not-for-profit housing bodies identifying benefits for their tenants; community enterprise groups wishing to evaluate granted programs; and research programs interested in demonstrating the efficacy of implemented solutions in the built environment. Consequently, the team has developed a clear and systematic approach to understanding social and environmental change in urban contexts, culminating in the creation of evidenced reports containing the monetized value of these changes.

Conclusion

SmartPGH will ensure that the SUROI methodology can be most effectively replicated through collaborations with local, national, and international partners so that the work can be studied by others and used in a variety of other contexts. Research partnerships will include the Carnegie Mellon University Design School, Allegheny County Health Department, Rockefeller 100 Resilient Cities partners, MetroLab Network, human resource and workforce partners, Policy Link, and the Keystone Research Center.

Project Implementation Plan

PHASE	TASK	START	END
I	**Preparing the Community, Partners & Survey**		
	Establish a collaborative Census Working Group, project team, schedule & project management plan	9/1/2016	11/1/2016
	Capture community input on the Census goals and content; branding; events; communications resources; Census Team candidates; volunteers; and supporting assets	11/1/2016	2/1/2017
	Hire, train & manage the resident Community Census Team	2/1/2017	11/1/2017
	Capture Community Census data & document individual resident stories on visual, video, audio, and social media	11/1/2017	2/1/2018
	Develop draft & final Community Census reports and documentation	11/1/2017	2/1/2018
II	**Designing & Integrating Performance Measures**		
	SuROI Team and CMU Design School begin implementation of the systems engineering integration plan	2/1/2018	6/1/2018
	Participation in design and development meetings to help the understanding of the social and environmental implications of each proposed element of the SmartPGH program	2/1/2018	6/1/2018
	Calculation of the Sustainable Return on Investment of the preferred options contained in the SmartPGH program	2/1/2018	6/1/2018
	Convene Collaborative Partner Table to review SuROI outcomes and systems engineering integration plan and process	2/1/2018	6/1/2018
	Initial convening of Research & Replication Partners to evaluate SuROI outcomes, set schedule, and coordinate activities	2/1/2018	6/1/2018
III	**Performance Evaluation, Research & Collaboration**		
	Quarterly convenings of the Documentation & Communications Team to coordinate documentation	6/1/2018	9/1/2019
	Quarterly convenings of Collaborative Partner Table to evaluate SuROI performance and overall SmartPGH project progress	6/1/2018	9/1/2019
	Annual symposium in Years 1, 2 & 3 with Research & Replication Partners, convened in partnership with MetroLab Network	6/1/2018	9/1/2019
	Participation in outreach events to other organizations and cities that would like to learn from the approach taken by Pittsburgh	6/1/2018	9/1/2019


· CITY OF ·
PITTSBURGH
SMART SPINE SYSTEM
ALLEGHENY GREEN BOULEVARD
LARIMER CHOICE NEIGHBORHOODS PROJECT
EAST LIBERTY TRANSIT CENTER
North Shore District Energy & Microgrid
Downtown District Energy & Microgrid
Uptown District Energy & Microgrid
Oakland District Energy & Microgrid
PENN AVENUE
LIBERTY AVENUE
BIGELOW BOULEVARD
EXISTING SURTRAC CORRIDOR
EXISTING SURTRAC CORRIDOR
EXISTING SURTRAC CORRIDOR
FIFTH AVENUE / WASHINGTON BOULEVARD
FORBES AVENUE
2ND AVENUE PARKING PLAZA
UPTOWN ECO-INNOVATION DISTRICT
2ND AVENUE
AUTONOMOUS SHUTTLE NETWORK
ROUTE 51 SMART SPINE COORIDOR
ALMONO DEVELOPMENT (HAZELWOOD)
PROPOSED INFRASTRUCTURE
Proposed Smart Spines
Future Smart Spines
Existing Smart Spines
EXISTING INFRASTRUCTURE
Frequent Transit Service Areas
Existing District Energy / 2030 District
Light Rail
Busway
Bike Share Station
Multi-Modal Station
Busway Station
Light Rail Station
Incline Station

Applications and Technology Solutions by the Numbers

TECHNOLOGY OR APPLICATION	QUANTITY
Newly deployed automated vehicles	10
Vehicles equipped with DSRC vehicle technologies	726
Intersections equipped with advanced technologies	188
Connected vehicle applications	6
Sensors and ITS devices	8,520
Public EV charging stations (current / proposed)	139 (64 / 75)

SmartPGH Performance Measures

CATEGORY	PERFORMANCE MEASURE
Overall	• Vision Zero by 2030 • 50% reduction in transportation related emissions by 2030
Mobility	• Increase in available matching funds for transportation improvements (SmartPGH Consortium) • Increase in number of transportation-related data sets in Western Pennsylvania Regional Data Center (SmartPGH Consortium) • Travel delay reduction where travel delay refers to the amount of additional time required to travel through the signal network over the minimal time that would be required if one traveled at free flow speed and never stopped (Mobility Optimization Along Smart Spines; Smart Street lights) • Travel time reduction where travel time refers to the amount of time required to move through the signal network (Mobility Optimization Along Smart Spines; Smart Streetlights) • Number of stops reduction—the number of times that a vehicle must stop when traveling through the signal network (Mobility Optimization Along Smart Spines; Smart Streetlights) • Wait time reduction (drivers and pedestrians)—the amount of time spent idling while moving through the signal network (Mobility Optimization Along Smart Spines; Smart Streetlights) • Decrease in unlit or poorly lit roadways and intersections (Smart Streetlights) • Reduction in queuing time at target intersections
Safety	• Increase in available matching funds for transportation improvements (SmartPGH Consortium)

CATEGORY	PERFORMANCE MEASURE
	• Reduction in crashes involving all modes (vehicle, bicycle, and pedestrian) (Mobility Optimization Along Smart Spines; Smart Streetlights) • Reduction in stormwater volume entering combined sewer system within the M29 sewershed (Autonomous Shuttle Network)
Air Quality	• Reduction in CO, CO2, NO2, SO2, O3, and PM2.5 (Mobility Optimization Along Smart Spines; Smart Streetlights; Autonomous Shuttle Network; Electric Avenue) • Reduction of CO2 equivalent (Mobility Optimization Along Smart Spines; Smart Streetlights; Electric Avenue) • Number of installed EV charging stations (Electric Avenue) • Number of public fleet vehicles converted to EV (Electric Avenue) • Number of private fleet vehicles converted to EV (Electric Avenue) • Fuel cost savings as a result of EV conversion (Electric Avenue) • EV miles traveled (Electric Avenue) • Amount of fossil-free power produced and gasoline equivalents replaced (Electric Avenue)
Ladders of Opportunity	• Increase in MWDBE contracts (SmartPGH Consortium) • Travel time reduction to job centers of Downtown and Oakland (Mobility Optimization Along Smart Spines; Autonomous Shuttle Network) • Total participants enrolled in Advanced Industries or Cybersecurity certificate programs (Workforce Development Pipeline) • Total Advanced Industries and Cybersecurity certificates issued (Workforce Development Pipeline)
	• Reduction in regional unemployment rate (Workforce Development Pipeline) • Increase in Area Median Income (Workforce Development Pipeline) • 30% or greater household participation in Community Census in neighborhoods in or adjacent to project area (Community Census) • 10% or greater household participation in Community Census in neighborhoods outside of project area (Community Census) • Increase in Wellbeing Valuation in neighborhoods in or adjacent to project area (Community Census) • Decrease in no-shows to preventative and follow-up healthcare appointments (Mobility Through Technology)

In 2015, The City of Pittsburgh partnered with the Green Building Alliance to conduct a mode share survey with over 20,000 respondents. Called "Make My Trip Count", the survey identified that in Pittsburgh's two largest employment centers, Oakland and Dowtown, 38.3% and 47.3% respectively, reported commuting by driving alone, for a total mode share of 46.7%.

The City believes that a full deployment of *SmartPGH* initiatives could reduce that mode share to below 40% by 2019.

Electric and Autonomous Vehicles

Self-driving and vehicle-to-vehicle communication technologies are progressing steadily all over the country, but Pittsburgh is uniquely positioned to accelerate change. We've been pioneering automotive technology at Carnegie Mellon University for 30 years and Uber chose Pittsburgh as the site for its new Advanced Technologies Center and 35-acre autonomous vehicle test track. We are addressing the regulatory and policy issues related to the rise of this technology as we advance it by bringing energy companies and policymakers into our discussions from day one. We know this automotive innovation offers the promise of cleaner air, less traffic, safer streets, and increased mobility for the people of Pittsburgh and we're ready for it.

Testing, Demonstrating, and Deploying Urban Automation

We will both deploy commercial automated shuttles and test automated vehicles on public roads. These two activities will happen in parallel and the safety of passengers and pedestrians will be paramount during all demonstrations.

1 DEPLOYMENT OF COMMERCIALLY AVAILABLE OPERATOR-LESS AUTOMATED SHUTTLES which operate at speeds of 25mph and below in well-defined and restricted neighborhoods. These shuttles will operate on a schedule and will only stop in predetermined locations to pick up and drop off passengers. They will be taken in daily for routine testing and maintenance as per vendor guidelines. The *SmartPGH* team will work closely with vendors (such as Navya or EasyMile) to ensure that all required and recommended safety guidelines are followed. Each of these autonomous shuttles will be equipped with emergency buttons that, when pressed by passengers, will come to an immediate stop. Explicit action by a qualified operator will be required before the shuttle can start moving again.

2 THE USE OF AUTOMATED VEHICLES THAT DRIVE THEMSELVES ON PUBLIC ROADS. These vehicles will initially be operated only with a licensed operator in the driver's seat. The testing steps for these automated vehicles are described below and must be carried out every time when the vehicle is stationary for the vehicle to become eligible for automated driving.

Testing Steps and Documentation

CATEGORY	GUIDELINES
General	• The vehicle must always have a licensed operator in the driver's seat during operation. • All designated operators must be fully trained and explicitly authorized to serve as an operator in the driver's seat. • The operator must at all times have one hand on the manual/automation button and the other on the steering wheel to regain control immediately if necessary. • The operator must always be paying attention to the roads and the operation of the vehicle. • The operator must have a safety lookout in the front passenger seat serving as an additional pair of eyes on the roads and the vehicle operation.
Safeguards and Restrictions	• The vehicle operates like a stock vehicle while in manual mode. • When the vehicle is in autonomous driving mode, the operator can: directly turn and control the steering wheel and override any computer controls; press the brakes; press a button to regain complete manual control; completely shut down automation subsystems added to the vehicle with an emergency E-Stop button. • Cellphone usage by the operator is completely prohibited. • Eating or drinking beverages during operations is strictly prohibited. • Driving under the influence of any drugs is prohibited at all times. These drugs include prescription drugs, which may cause nausea, dizziness and/or drowsiness.
Vehicle Operation Details	• The vehicle must have been registered and inspected in Pennsylvania. • All vehicle operations must meet the laws of the Commonwealth of Pennsylvania, as they exist at the time of operation. • The vehicle can be operated autonomously only when a designated and licensed operator is in the driver's seat. • The vehicle is always immediately controllable by the designated operator at all times.

CATEGORY	GUIDELINES
Safety Precautions	• All sensor enclosures are kept clean from dust and dirt before operations. • The E-Stop button is tested at least once a month. • Any stock malfunctions reported by the vehicle (on the dashboard) are taken care of before the vehicle is put in autonomous mode. • All regular maintenance on the vehicle is carried out on a timely basis. • The temperature inside the computer enclosure is monitored on a regular basis to ensure that it is within operating range. • Any actuators added to the vehicle are tested for proper functionality in a safe setting before being used on public roads. • A system test is conducted to ensure that all systems are functioning normally before the vehicle can be eligible to put into autonomous mode. • A safety checklist must be used to ensure that all appropriate steps have been conducted and function correctly before the vehicle is eligible to put into AV mode.

REMOTE OPERATION For applications like a "Virtual Valet" and a driverless on-demand taxi, an automated vehicle needs to operate without a licensed operator (or any human in the vehicle for that matter). A remote E-Stop system in the vehicle can be triggered by a remote, licensed and authorized operator, who must be within direct line of sight of the automated vehicle at all times. However, we currently anticipate having the vehicle operate without a driver only within private enclosed tracks with completely controlled traffic.

TRIP DOCUMENTATION Before each trip where the vehicle is switched into automation mode, a detailed checklist must be completed. All subsystems must be in operational status for the trip to be continued. After each trip where the vehicle has been switched into autonomous mode, a detailed form must be completed (this form is paired with the checklist above). This form contains the date and time of operation end, and a listing of any and all issues encountered. Each issue must be categorized as critical, important, major or minor and will be reported to an official before the next test trip

DEMONSTRATION STEPS We anticipate demonstrating seven automated shuttles on a predetermined route along Second Avenue and through Junction Hollow to Oakland and up to three automated vehicles on public roads with uncontrolled traffic conditions.

The automated shuttles will be configured to drive at relatively low speeds and will stop at predetermined stops along a specific route to pick up and drop off passengers. The automated car will drive itself (with a hands-off licensed operator in the driver's seat serving as a safety backup) on urban, suburban, and highway routes obeying the rules of the road, changing lanes, making turns, following traffic light status, merging with traffic, taking appropriate exits, performing parallel, head-in and tail-in parking, following vehicles or bicycles at appropriate speeds, abiding by precedence rules at multi-way stop intersections, waiting for pedestrians in crosswalks, and stopping for road blockages. The self-driving car will be able to operate in slight to moderate rain, fog and snowing conditions.

REGULATORY BARRIERS We believe that the automated car, with a licensed operator in the driver's seat, driving itself on public roads abides by federal regulations. A working group organized by PennDOT is actively looking at these issues and we expect that their recommendations will be released before the Smart City Challenge winner is announced. There is bipartisan support today in the Pennsylvania legislature to permit the testing of driverless vehicles in the state. Local ordinances may or may not be required. However, we strongly emphasize that the safety of the traveling public as well as that of pedestrians, bicyclists and vehicles on the roads is a collective priority. In order to establish trust in the system, for a substantial period of time, the automated shuttles will have trained operators onboard the automated shuttle to stop the vehicle immediately in case it becomes necessary. Only after the automated shuttle has proven its reliability and safety without any manual takeover for several consecutive months will it operate without an operator on public roads

Commitment to EVs and Decarbonizing Our Electric Grid

The City's commitment to buying fuel-efficient and alternative fuel vehicles pre-dates *SmartPGH*. We have had a green vehicle purchasing policy in place since 2008 and The Office of Management and Budget's 2017–2018 plan proposes $5 million dollars to purchase 10 electric motorcycles, 81 electric sedans, 14 electric medium SUVs and 107 Level 2 charging stations. In addition, the Port Authority of Allegheny County (PAAC) operates 726 diesel public transit buses and has begun to develop a plan to transition portions of their fleet to EV over the next three years. Taxis are privately managed in Pittsburgh and regulated by the Pennsylvania Public Utility Commission, but we have identified opportunities to improve drivers' profits by installing electric charging infrastructure.

Pittsburgh Electrification Partnership (PEP)
The City of Pittsburgh and its Consortium partners, along with the local Pittsburgh Region Clean Cities Chapter, are committed to establishing the Pittsburgh Electrification Partnership (PEP). PEP will convene local fleet owners and operators to share resources, plan EV infrastructure, and give 'PEP Talks,' EV demos and presentations.

Pittsburgh is in ongoing conversations with Allegheny County, both for public transit buses and the county fleet, local electricity distribution company Duquesne Light, freight company Pitt Ohio, grocery outlet Giant Eagle, car rental agency Enterprise, healthcare agency UPMC, and the transportation/shuttle managers at CMU and the University of Pittsburgh to develop plans to allow our public EV charging infrastructure to help catalyze other public and private EV fleet conversions.

DUQUESNE LIGHT Duquesne Light has committed to developing a corporate strategy related to transportation electrification. This corporate strategy is intended to include not only a review of Duquesne Light's own vehicle-fleet to assess its potential for conversion to EVs but also a review of the company's corporate policies and business practices to determine how it might makes changes that would promote an increase in EV fleet conversions and personal usage within Pittsburgh. Upon completion of this review, Duquesne Light is expected to adopt the resultant recommendations as its corporate strategy related to EVs. Upon official adoption of its EV strategy, Duquesne Light would work with its customers, its regulators, and other community stakeholders to implement its strategy, with the overall goal of increasing EV utilization in Pittsburgh.

UBER In addition to these fleets, the City of Pittsburgh is working closely with Uber to develop and connect EV infrastructure along Electric Avenue to Uber's planned 35-acre Autonomous Vehicle Test Track at the ALMONO site. The City's ongoing partnership with Uber and other TNCS will allow for coordinated EV infrastructure investments to support the conversion of their fleets.

Pittsburgh Decarbonization & Electrification Strategy
Pittsburgh has a four-pronged strategy that (1) reduces demand for energy, (2) creates efficient district energy systems, (3) installs local renewable energy generation, and (4) converts systems from combustion to electrification. Successes piloted in Pittsburgh will have an exponential impact in the 32-county region and serve as a blueprint for mid-sized cities around the country.

1. REDUCED DEMAND Over 435 commercial buildings in Pittsburgh's 2030 Districts in Oakland and Downtown have committed to reducing energy and water use by 50% below 2003 levels by 2030, and they are on target to reach this goal. The 2030 District also set a goal of reducing transportation emissions by 50% below the 2015 modeled baseline by 2030. The 2015 transportation survey revealed the model underestimated bus and bike trips and did not account for telecommuting, so the actual performance in 2015 was already 24.2% below the baseline.

2. DISTRICT ENERGY The City of Pittsburgh, in partnership with the Department of Energy, the National Energy Technology Lab, Duquesne Light, and the University of Pittsburgh Center for Energy,

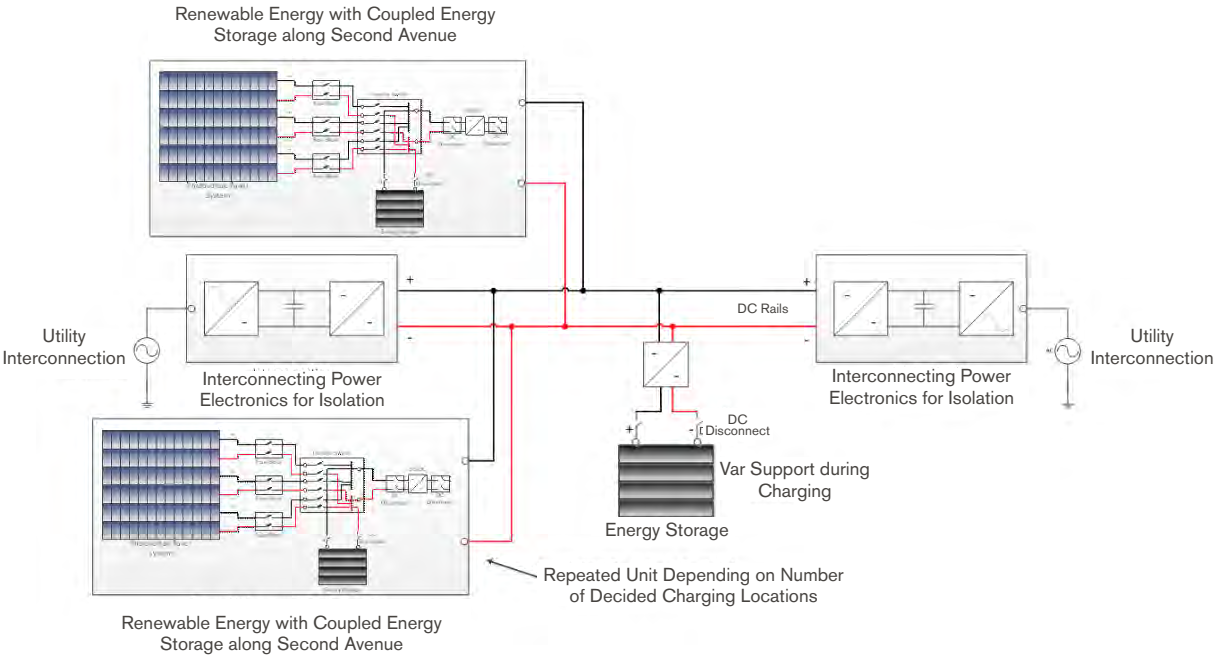
is currently developing a 21st century energy infrastructure plan for the region through the expansion and optimization of district scale energy systems, such as microgrids, thermal loops, and combined heat and power systems.

A microgrid is a group of interconnected loads and distributed energy resources with clearly defined electrical boundaries that act as a single controllable entity. They can connect and disconnect from the grid to enable operation in both grid-connected or island mode. Duquesne Light believes that the deployment of microgrids has the ability to significantly reduce the line-losses for electricity generated by distributed energy resources. Distributed energy resources are smaller than utility-scale generating assets and are located closer to the loads that they serve. Due to this proximity, the application of these resources reduces thermal line-losses associated with transmitting electricity over long distances, which occurs when transporting electricity from centralized power plants to distant end-uses. At peak times, line losses are approximately 50% higher than the overall average value, and can approach 8-10% of the power sent through the lines. If line-losses were reduced by 8–10%, then 8–10% less electricity would need to be generated in order to provide end-users with electricity.

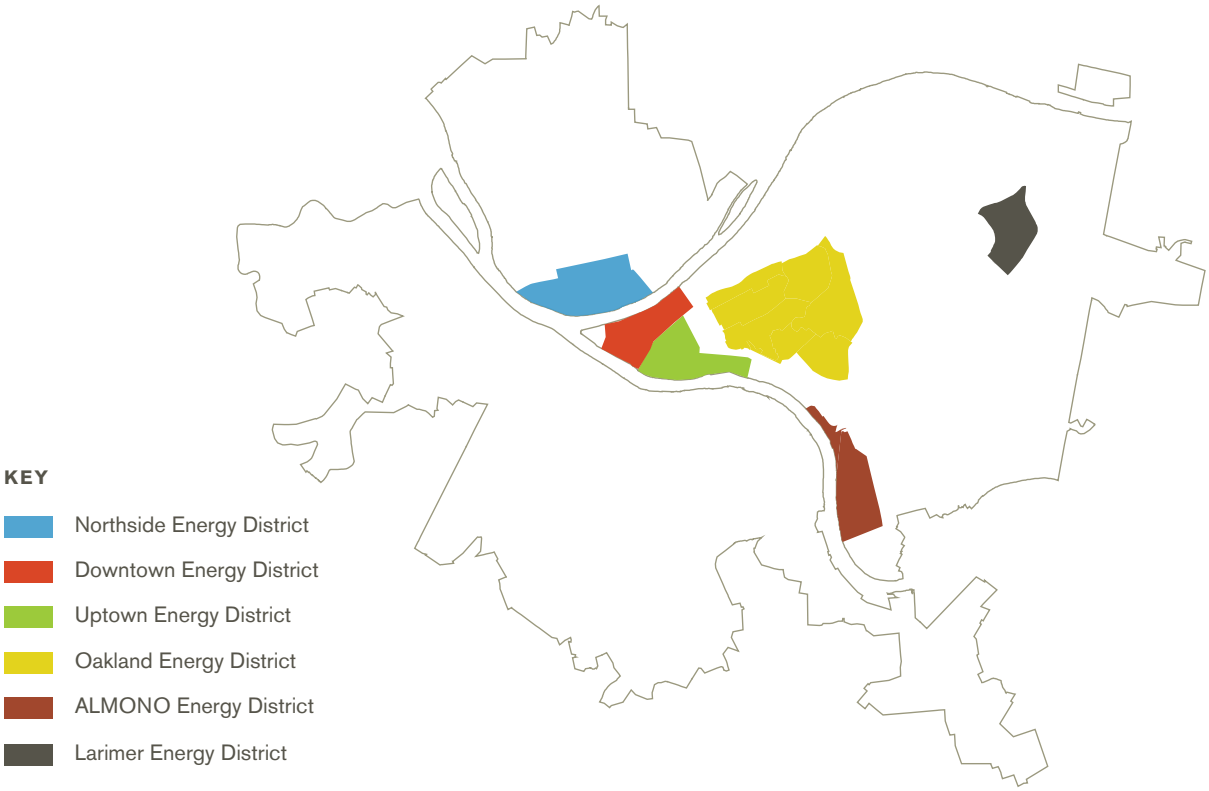
District Energy Pittsburgh has proposed two direct current (DC) microgrids powered by solar photovoltaic electricity; one at the Duquesne Light training facility and one at the Second Avenue parking lot. While DC power is not ideal for long transmission, it works well for local energy networks. It also eliminates the need to convert grid AC power to DC in order to power LED lights, electronics, data and telecommunications. Solar and wind power can now be integrated into the fabric of the city with enough regularity to feed a DC grid.

This solution is carbon free, utilizes renewable energy resources in the form of photovoltaics, and uses energy storage at various points throughout the architecture. Most importantly, the system is supported through a DC backbone. Hence, the system is resilient enough to always maintain service to the vehicle in the case of a disturbance felt in other portions of the AC network that may propagate toward Second Avenue.

DC MicroGrid: Technical Description



Current and Proposed District Energy Systems



The distributed energy resources will improve efficiency in electricity distribution and lower the barriers to renewable energy installation, but there is still a need for complementary efforts to reduce energy demand through weatherization, retrofit programs, and technology upgrades.

3 LOCAL RENEWABLE ENERGY The City of Pittsburgh has committed to using 100% renewable energy to meet its operational loads by 2030 through both city-owned generation and power purchase agreements that install more renewables locally. The City manages the Western Pennsylvania Energy Consortium (WPEC), a group of 30 local government entities and universities who use reverse auctions to purchase electricity at a lower cost. WPEC specified 10% non-certified renewable energy credits (RECS) in the first auction in 2008, and has increased that percentage by 5% each auction WPEC currently purchasesd 30% non-local non-certified renewable energy.

Duquesne Light is proposing to evaluate the benefits of entering into long-term contracts to support utility-scale solar projects in Pennsylvania and more specifically within Duquesne Light's service territory, up to a cumulative total of 10-20 MW. The alternative energy credits associated with this proposal could be used to help satisfy the solar requirements of serving residential default service customers stipulated by Pennsylvania's Alternative Energy Portfolio Standard AEPS. AEPS currently only requires that 5.5% of electricity come from Tier 1 sources. This proposal is not only intended to support utility-scale solar alternative energy generating facilities in Duquesne Light's service territory in an effort to achieve least-cost environmental compliance with the requirements of Act 129 and AEPS, but also to help achieve the policy objectives of the Clean Power Plan.

4 TRANSPORTATION ELECTRIFICATION Pittsburgh aims to reduce reliance on personal vehicle ownership by weaving together a cohesive network of EV public

transit, bike and pedestrian infrastructure, and EV car sharing and ride sharing that can service all personal trips. Planning for transit-oriented development and mixed use, walkable neighborhoods will reduce the miles people need to travel to meet their needs and disincentivize personal vehicle ownership.

The Pittsburgh Parking Authority (PPA) operates 11 parking garages and 34 off-street surface parking lots across the City of Pittsburgh. There are currently 15 Level 2 EV chargers in PPA garages with budget authorization to add 15 more in 2017. There are 64 total charging stations in Allegheny County. *SmartPGH*, working with the SmartPGH Consortium, will allow for exponential growth in EV charging infrastructure beyond current plans and a more rapid adoption of EVs both in the public sector and the private market.

The Pittsburgh Green Garage Initiative (GGI) began when the City changed two lines of building code to allow for LED lighting in parking garages, which has resulted in dramatic energy savings. The GGI has evolved into a collaboration of the Green Building Alliance, the Pittsburgh Parking Authority, and the Urban Redevelopment Authority to reduce energy use in garages and install electric vehicle infrastructure as well. A recent study concluded that 6,000 kW of solar photovoltaics could be installed on Pittsburgh Parking Authority garage roofs and at the Second Avenue parking lot. The Parking Authority is currently developing several pilot projects to begin this pv installation at key garages.

Intelligent Transportation Systems (ITS) and Connected Vehicle Standards

The Southwestern Pennsylvania Commission (SPC) is working closely with *SmartPGH* to determine the most appropriate Intelligent Transportation Systems (ITS) standards for the SmartPGH Consortium. *SmartPGH* will also consult PennDOT, the Society of Automotive Engineers International (SAE) and academic experts at CMU and Pitt. SPC and PennDOT are aware of the Smart City Challenge and our proposal and they are eager to help determine standards that will allow our breakthroughs to be easily exported to surrounding cities and counties.

The City and the region are exceptionally well-prepared to address the ITS needs of the *SmartPGH* initiative. Stakeholders have significant experience collaborating on and learning from project deployments like the Surtrac adaptive traffic signal deployment along the Baum Boulevard and Centre Avenue corridors. The SPC has supported this and successfully integrated it into regional, state, and federal ITS standards and architecture. The region's stakeholders and SmartPGH Consortium members have also 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.

2016 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, while ensuring that additional integration opportunities are considered. The 2016 Regional ITS Architecture is expected to be fully compatible with, and supportive of, the *SmartPGH* technologies, services, and projects

Statewide 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.

As an identified priority in the Regional Operations Plan, the SPC Transportation Operations & Safety Committee 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. Additional examples of existing ITS technology in the region include: Traffic Operations Centers, Variable Message Signs, Traffic Signal Systems, Electronic Toll Collection (EZ Pass), Transit Control Centers, Smart Card Fare Collection Systems, and CCTV Cameras.

SAE AND INDUSTRY STANDARDS The Pittsburgh region is fortunate to be the headquarters of SAE who has 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. SAE has capabilities to provide subject matter experts in mobility engineering consulting to assist in the development and implementation for urban automation strategies. In addition, SAE Ground Vehicle Standards Technical Committees are engaged in the development of industry standards to support ITS and Connected Vehicle based technologies. SAE International has some 20,000 industry technical experts committed as volunteers working within over 850 already established committees and working groups. This massive resource could be engaged in an expedited fashion to enhance existing standards or develop new standards that might be required to fully implement *SmartPGH* initiatives and projects as this program develops.

SmartPGH Operations & Administration

For 200 years, thinkers and doers in business, government, and education have come together in Pittsburgh to build robots, cure diseases, and improve policies. We understand coalition-building is necessary to tackle the big problems and make real progress. Our philosophy has always been if you see something that needs to be changed, gather a group of like-minded people and get it done. We've built this city on working with others—it's the Pittsburgh way. It's opened us to hearing new voices and considering diverse perspectives. *SmartPGH* will continue that tradition by uniting people and sharing what we learn about the way we live and work to make all of our lives better.

SmartPGH Partnerships

We believe that public and private entities working together will produce more positive outcomes for the region, which is why the SmartPGH Consortium is at the core of the Smart City application. After just one meeting, several Consortium partners have already committed financial and operational resources to both the Smart City application and *SmartPGH* initiatives in the future.

While the SmartPGH Consortium will serve as the portal to participation in *SmartPGH*, the City of Pittsburgh will also rely on its existing partnerships to ensure the success of *SmartPGH* projects.

TECHNOLOGIES FOR SAFE AND EFFICIENT TRANSPORTATION Technologies for Safe and Efficient Transportation, The National USDOT University Transportation Center for Safety at Carnegie Mellon University (T-SET) has been partnering with the City of Pittsburgh to use Pittsburgh as a testbed for part of its research model since 2011. T-SET will first and foremost provide open access to the Mobility Data Analytics Center to assess the impacts of the Smart City applications deployed throughout the grant period as well as develop new applications as determined by the SmartPGH Consortium. Expertise in autonomous technologies and adaptive traffic signal technology will be shared via a data sharing agreement the City already has in place with Metro21 and the MetroLab Network. The same data sharing framework will be applied for this partnership. T-SET will also provide expert advisors on best practices in the areas of disruptive and emerging transportation technologies, resiliency and energy, and sustainable, restorative urban design. T-SET's USDOT UTC Federal dollars will be leveraged to align research with Smart City goals.

STATE DEPARTMENTS OF TRANSPORTATION Carnegie Mellon, the University of Michigan and the Ohio State University have joined with the state DOTS from Pennsylvania, Ohio and Michigan, to discuss the development of a Connected and Automated Vehicle Multi-State Corridor that will establish a living lab to test and deploy technologies and policies to enable an interoperable and nationally replicable system. Through this initiative current and proposed *SmartPGH* efforts can be coordinated and linked with other current and proposed smart city deployments in cities such as Columbus, Detroit, Ann Arbor and along the highways that connect them.

DISTRICT SCALE ENERGY SYSTEMS The City of Pittsburgh, in partnership with the Department of Energy, the National Energy Technology Lab, Duquesne Light, and the University of Pittsburgh Center for Energy, is currently developing a 21ST century energy infrastructure plan for the region through the expansion and optimization of district scale energy systems, such as microgrids, thermal loops, and combined heat and power systems. This partnership will allow us to move quickly to implement the "Electric Avenue" deployment and scale up efforts to decarbonize our grid and accelerate adoption of electric vehicles.

EDUCATION AND TRAINING The Community College of Allegheny County in partnership with the Three Rivers Workforce Investment Board will assist the City in developing and implementing a comprehensive workforce training pathway to jobs in advanced manufacturing and cybersecurity. Leveraging existing resources and matching them with catalytic funding from USDOT, this new initiative will ensure that Pittsburghers are equipped with the training and certifications necessary to immediately take advantage of jobs in these growing industries.

PARTNERSHIPS AND PROCUREMENT The City of Pittsburgh firmly believes in the values of an open and transparent procurement process and also recognizes the need to evolve from traditional models of procurement. In 2015, the City embarked on a "Year of Procurement Reform" to identify new ways to procure goods and services. The National Institute of Governmental Purchasing was brought in to provide recommendations that are modernizing the City's purchasing practices. A Code for America team worked in Pittsburgh on several applications related to procurement, including Beacon— an opportunity portal for businesses of all sizes and sectors to participate in the City's procurement processes.

Partnerships with leading experts in new and innovative fields will also need to be forged as the City begins to identify advanced technological deployments. As a Smart City Challenge finalist, the City has already benefited from potential partners identified by the USDOT:

AUTODESK The City participated in a full-day training on the AutoDesk platform. Additionally, as a Rockefeller 100 Resilient City, Pittsburgh has access to Impact Infrastructure, and its integration with Autocase. Moving forward, the City will continue to explore uses of the AutoDesk technology.

VULCAN FOUNDATION The City has been actively collaborating with Vulcan Foundation regarding the development of decarbonization and electrification initiatives. The City's Second Avenue project encapsulates many of the objectives laid out by Vulcan.

MOBILEYE Because the Port Authority already has pedestrian detection technology on all of its buses, the City intends to use the detection devices generously provided by Mobileye to equip heavy fleet vehicles, starting with Environmental Service trucks. These vehicles are some of the most potentially dangerous across public fleets, and the vehicles could be substantially improved by blind spot detection and pedestrian avoidance.

Also, through the Transit Operators Committee of the Southwestern Pennsylvania Commission (a SmartPGH Consortium member), the City intends to make Mobileye devices available to the nine other regional transportation fleets, many of which travel from outlying counties into Pittsburgh. Because the benefit of Mobileye does not require on-street infrastructure, the devices benefit not only City residents, but pedestrians across the length of the routes.

NXP The Port Authority of Allegheny County will equip their entire fleet of 726 buses with NXP DSRC sensors to provide transit optimization in all Smart Spine corridors.

AMAZON WEB SERVICES The City has engaged in several conversations with Amazon Web Services (AWS) regarding the potential use of cloud hosting credits. The flexibility of the Amazon Web Service platform is beneficial for particular datasets that will be generated as part of the Consortium. The City intends to use AWS hosting in service to the Data Utility, either for data generated by streetlight sensors, or in service to one of the related partners.

SIDEWALK LABS The City of Pittsburgh will integrate Flow into the work of the Mobility Data Analytics Center, and will use it to further support application development. While the City is still exploring the regulatory and operational limitations on the Link systems offered by Sidewalk Labs, we are interested in partnering with a community organization to distribute a demonstration kiosk.

DEPARTMENT OF ENERGY The City of Pittsburgh has entered in a Memorandum of Understanding with th DOE's National Energy Technology Laboratory (NETL) to facilitate the deployment and expansion of district energy.

Staffing and Management Approach

In order to immediately begin deployment of *SmartPGH* we will create two new staff positions within the Mayor's Office: the SmartPGH Manager and SmartPGH Coordinator. The SmartPGH Manager and support staff will serve as the central hub of the entire deployment, working with existing City staff in the Mayor's Office, Department of Public Works, Department of City Planning, Department of Innovation and Performance, and Office of Management and Budget to coordinate project implementation and communicate critical information up and down the chain of command.

Furthermore, the SmartPGH Manager and support staff will also serve as the primary public-facing staff responsible for managing the SmartPGH Consortium and other non-City partners. Placing these staff within

the Mayor's Office ensures that they will establish a high level of visibility and authority to effectively interact with the Mayor himself, other City staff, and outside partners.

Contingency plans are in place to replace City and non-City staff in the event that it is necessary. Each project is structured to include a project lead as well as project support staff that can fill critical gaps if staffing changes take place. Each project has the necessary staffing redundancy to ensure that milestones and implementation timelines will not be significantly impacted.

In addition, the Smart City Challenge has encouraged the City of Pittsburgh to examine a possible reorganization that would allow staff to better address transportation issues and provide a structure for enhanced coordination with non-City partners. We have worked with outside consultants, including the National Association of City Transportation Officials (NACTO), for the past year to determine the optimal structure to manage mobility and infrastructure processes and decision-making. The Mayor has committed to the creation of a Department of Mobility and Infrastructure for budget year 2017. We believe that a stand-alone department dedicated to mobility and infrastructure within the City will strengthen our relationships with our partners, increase communication internally and externally, shorten project timelines, and streamline processes.

Systems Engineering Process

The *SmartPGH* deployments outlined within this proposal will be managed through a Systems Engineering Management Plan (SEMP). The SEMP describes how the systems engineering effort will be managed in order to reduce the risk of schedule and cost overruns and increase the likelihood that systems meet the requirements and the needs of the users. This SEMP, which is the technical management of the project, describes how the systems engineering process will be structured and conducted. This document supports the Project Plan and Staffing and Management Plan from the technical aspect of the project.

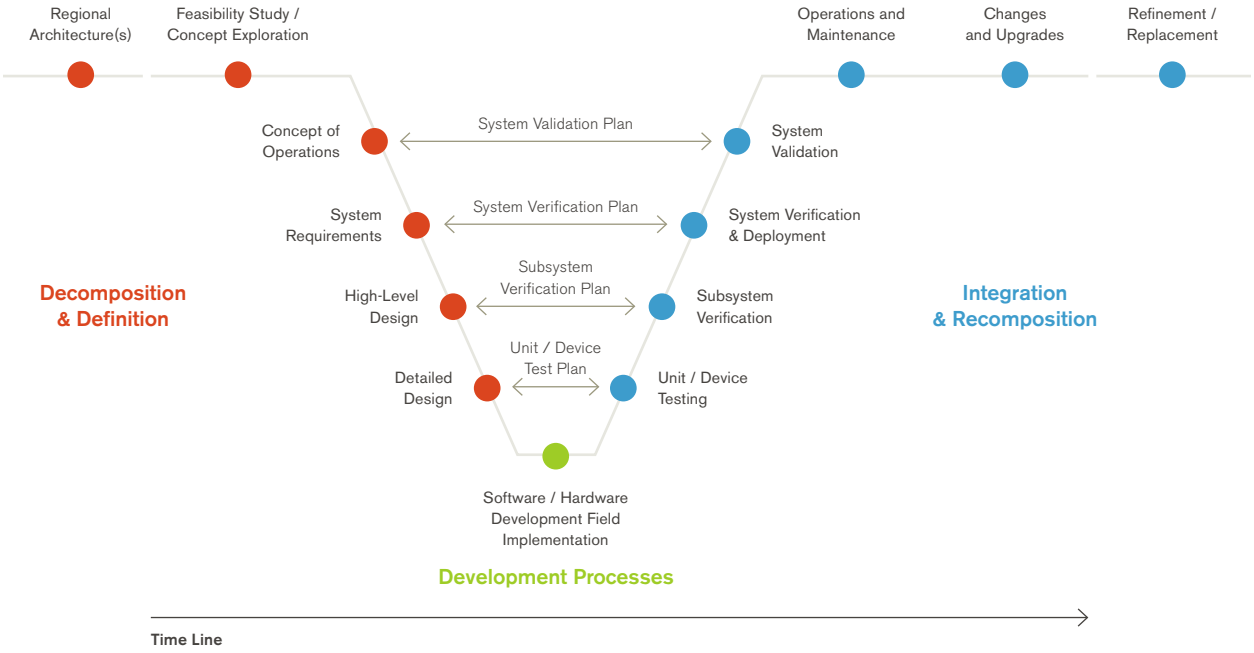
Based on guidance from the Federal Highway Administration, a SEMP is advisable above and beyond a project plan for this project because it:

- provides the appropriate technical guidance of the system engineering process to the SmartPGH Consortium and ensures the successful integration of all the project elements;
- provides a clear outline for the large number of stakeholders, as identified in the communication plan, that will be involved in the system engineering process; and
- reduces the risk for the customized applications that are required for the project.

At the onset of the project, a detailed SEMP will be developed for all systems engineering activities, including a work breakdown structure of critical tasks, significant deliverables, individual task meetings and reviews required, resource and procurement needs, a listing of critical technical elements required (e.g., research or best practice support, technical development support, etc.) and a system engineering schedule for each subsystem and the overall system deployment and integration. The basic elements of our approach to the design, deployment, testing, and acceptance of the various schemes and integration of systems are as follows:

- FOLLOW CONCURRENT SYSTEMS ENGINEERING "V" PROCESSES This proven process is followed in the design and deployment of Intelligent Transportation System (ITS) to ensure stakeholder participation, the development of robust user needs and high-level requirements, and thorough validation and testing of systems before they are put into operation. The process includes inherent "checks and balances" between the concept development and system definition phase (left side of the "v") and the implementation phase (right side of the "v").
- PROCURE SEMT TEAM Procure a single Systems Engineering Management Team (SEMT) to act as an

System Engineering "V" Process



owner's representative throughout the systems engineering process. The SEMT will work directly with the SmartPGH Manager and the various deployment implementation teams. On the front end of the "V," the SEMT will align system planning with the Regional ITS Architecture, fully develop concepts of operation, traceable high-level system requirements, and, when required, requests for proposals to secure vendors for detailed system design and deployment. On the back end of the "V" the SEMT will oversee testing and actively participate in the User Acceptance Testing for independent validation and verification. Throughout the process, the SEMT will provide system vendors with templates of required system documentation—use cases, design documents, system architectures, test plans, and test scripts as examples—and will review these deliverables and check documentation.

- DELAY TECHNOLOGY DECISIONS Delay specific technology decisions until absolutely necessary. Since technology changes so rapidly, delaying selection of specific technologies helps ensure that systems do not become obsolete prior to procurement or integration.
- MANAGE SUBSYSTEMS INDIVIDUALLY Manage each subsystem individually while keeping in mind the overall system approach. The interrelationship of many of the systems proposed in this application can create challenges for developing system requirements, engineering, and implementation. By managing them as individual subsystems, it makes them easier to define and develop. Once they are implemented, they can be recombined later in the process. Each subsystem will have a subsystem integration plan that will be incorporated into the overall systems engineering plan.
- HOLD REGULAR SYSTEMS MEETINGS Hold regular systems meetings to review the following: schedule, costs and cost projections, and risks and risk mitigation status. Most of the time, schedule and cost overruns can be managed through regular communication and touch points. The SEMT would lead these meetings with the various system design and deployment vendors to review the schedule, cost and cost projections, and risk management plan implementation.

Systems Description

While there are number of projects and elements to the *SmartPGH* proposal, the table below summarizes those projects and project elements that will be directly under the purview of the SEMT and the systems engineering processes described herein. Not all projects related to this application are listed because a system engineering approach may not be necessary. For example, non-system projects such as workforce development and straightforward deployments such as LED light fixtures (part of the Smart Streetlight Sensors) are not included. However, the SEMT will be responsible for evaluating the projects and project elements to ensure that any pertinent elements (including training) are included in the systems engineering process.

The system will be designed to be open-source and that will be adaptable and sustainable in the sense that it can be continually built upon with the identified existing systems for potential future *SmartPGH* integration and with to be determined future systems that come online.

Systems Management Structure: Roles & Responsibilities

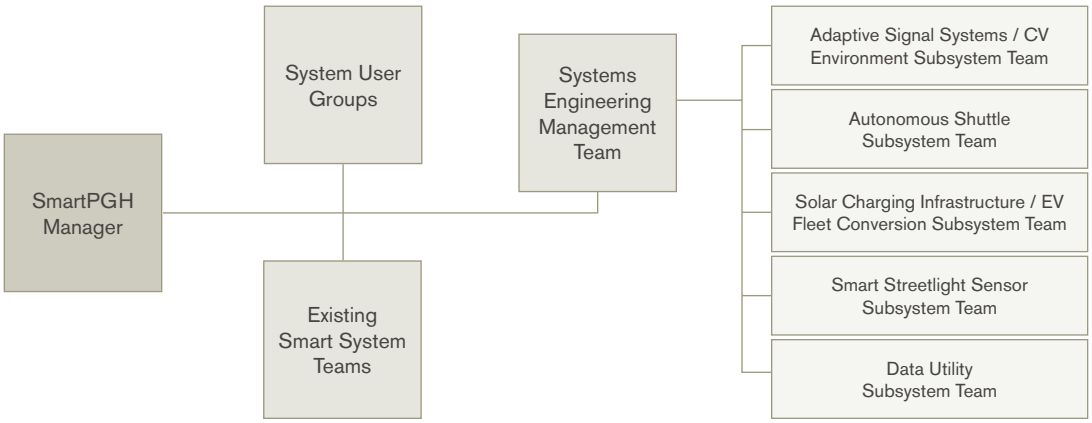
The system management structure defines the roles and responsibilities within the development cycle of the project. The roles and responsibilities of each team member include:

SYSTEMS ENGINEERING MANAGEMENT TEAM (SEMT) would be procured prior to notice to proceed and would act as the COP's agent. Specifically the SEMT would:

SEMT Supervised Projects and Project Elements

PROPOSED SUBSYSTEMS	EXISTING SMART SYSTEMS	EXISTING SYSTEMS (FUTURE)
• Adaptive Signal Control Systems (Surtrac)/ Connected Vehicle (CV) Environment • Autonomous Shuttle Network • Solar Charging Infrastructure/EV Fleet Conversion • Smart Streetlight Sensor Deployment • Data Utility Deployment including Pitt Western Pennsylvania Regional Data Center (WPRDC), CMU Mobility Data Analytics Center (MAC) and Fiber Network	• Pittsburgh traffic responsive Signal System (known as CTRCTS) • Existing Surtrac Adaptive Signal Systems • PennDOT District 11-0 Traffic Management Center (TMC) and ITS network • Pitt Western Pennsylvania Regional Data Center (WPRDC) • CMU Mobility data Analytics Center • Existing communications networks, particularly fiber-optics both City- and privately-owned (e.g., DQE, Comcast)	• COP snow plow tracking • COP asset management systems • Port Authority of Allegheny County bus location tracking systems • COP smart parking meters • ParkPGH real-time parking information • Pittsburgh Bike Share • Transportation Network Companies (Uber, Lyft, Yellow Z, etc.)

SEMT Supervised Projects and Project Elements



- Finalize the SEMT to include further details on roles/responsibilities and risk mitigation.
- Review the ITS Regional Architecture and Regional Operations Plan in coordination with PennDOT and the Southwestern Pennsylvania Commission (the MPO).
- Act as a business analyst to capture user needs and requirements working with the *SmartPGH* Team and user groups/stakeholders.
- Prepare concepts of operations and procurement documents with the *SmartPGH* Team for procurement of subsystem teams where needed (# 3 below and in the org chart).
- Be a conduit for information between the overall *SmartPGH* Team, existing system owners, and the subsystem teams.
- Develop processes and standards that each of the project deployment teams would abide by for design, development, deployment, and testing of their subsystems.
- Oversee the systems engineering process for each subsystem.
- Act as the system integrator for integration of the subsystems and the subsystems with the existing systems.

SUPPORTING PARTNER SUBSYSTEM TEAMS Carnegie Mellon University and University of Pittsburgh are partner organizations to the *SmartPGH* Team and will be supporting the subsystem teams for the adaptive signal subsystem and the Western Pennsylvania Regional Data Center and Mobility data Analytics Center subsystems.

TO BE PROCURED SUBSYSTEM TEAMS The Autonomous Shuttle, Solar Charging Infrastructure/EV Fleet Conversion, and Smart Streetlight Sensor subsystem teams will need to be procured. The SEMT will work directly with the City's Office of Management and Budget procurement team.

User Needs—Stakeholder Participation
Developing comprehensive, but specific, user needs and requirements is critical upfront to ensure successful operational outcomes. We have identified stakeholders to be engaged throughout the process of each subsystem deployment. Participation of stakeholders is essential for the successful development of each subsystem. The stakeholders will be heavily involved during the initial stages (i.e., Concept of Operations) of the deployment with periodic and defined participation at each deployment phase completion milestone. A similar process will be utilized for each subsystem, therefore enabling stakeholders to understand the process and actively participate in the development.

External stakeholders will primarily be engaged using the outreach program strategies identified in the *SmartPGH* Communications and Outreach Plan. Feedback on user needs will be gathered for each subsystem. The system owner and internal stakeholders will be engaged throughout the process through standing deployment meetings between the owner, SEMT, and appropriate internal stakeholders identified for each subsystem above.

At the onset of the system engineering process for each subsystem, a stakeholder engagement process will be implemented to ensure that user needs are met and that all concerns are tracked and addressed accordingly. This process includes the following:

- Review Core Project Team's list of needs, problems, and concerns with each stakeholder to solicit missing items of importance. The core team (owner and SEMT) should develop the list initially and then review the list with each stakeholder and document input.
- Prioritize the collective needs of all the stakeholders. The stakeholders will be permitted to have a say in the prioritization process. At the conclusion of the prioritization, the Core Team will develop means to address the needs and will share the solutions with the stakeholders to get their buy-in.
- Periodically review the needs and concerns with the stakeholders, ensuring that all stakeholders are comfortable with how their concerns are being addressed. This also aids in ensuring that faulty solutions are not implemented, risks are properly mitigated and the system will be meaningful and useful.

Subsystem Development Stakeholders

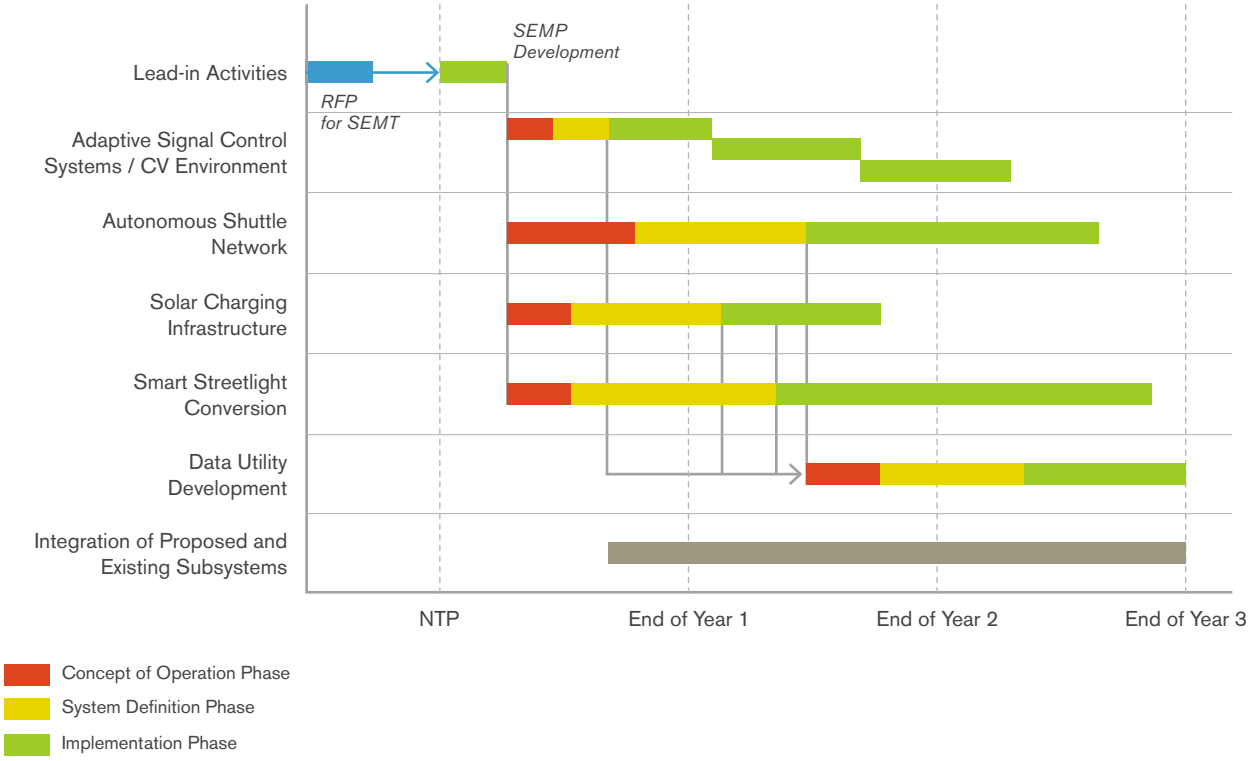
PROPOSED SUBSYSTEMS	USERS/STAKEHOLDERS
Adaptive Signal Control Systems / CV Environment	• COP Department of Public Works (DPW), Engineering and Construction Division • Southwestern Pennsylvania Commission (SPC) • PennDOT D11-0 Regional Traffic Management Center (RTMC) • Carnegie Mellon University • Port Authority of Allegheny County
Autonomous Shuttle Network	• COP DPW, Engineering and Construction Division • Port Authority • Heinz Endowments • Carnegie Mellon University • COP Residents and Community Groups
Solar Charging Infrastructure/EV Fleet Conversion	• COP, Mayor's Office • Department of Permits, Licenses and Inspections • Department of Public Works, Engineering and Construction Division • Department of Innovation & Performance • Duquesne Light • University of Pittsburgh
Smart Streetlight Deployment	• COP, Mayor's Office • Department of Public Safety • Department of Public Works, Engineering and Construction Division • Department of Innovation & Performance • Vendor • Carnegie Mellon University • Entrepreneurs and Investors
Data Utility Deployment	• Carnegie Mellon University • University of Pittsburgh • Allegheny County • COP DPW, Engineering and Construction Division • Third-party application developers • SPC • PennDOT District 11-0 RTMC • Entrepreneurs and Investors

Deliverables — Schedule and Cost Control

Each subsystem deployment will require a series of deliverables to ensure that the overall deployment schedule is met and that cost is controlled. The deployment of each subsystem can be broken down into three elements or phases: (1) The Concept of Operations (ConOps) Phase; (2) the System Definition Phase, which includes defining the system requirements, developing the high level design, and ultimately the detailed design; and (3) the Implementation Phase, which includes the system deployment, integration, testing, verification, and evaluation.

The ConOps and System Definition phases of each subsystem vary based on the maturity and deployment history of the subsystem. For example, the adaptive signal control system has already been piloted in the City of Pittsburgh for four years so there is sufficient documentation on the concept of operations, system requirements,

Development Schedule



and design that the deployment cycle is much shorter than other proposed subsystems such as the AV Shuttle Network that has not yet been deployed. The deployment schedule below accounts for these various concept and system definition phases. The final comprehensive integration of the existing and proposed subsystems is intended to occur after the final subsystem definition is complete and will extend throughout the project completion. The SmartPGH Consortium intends to issue a Request for Proposal for a SEMT following selection as the Smart City awardee so that the SEMT is under contract when Notice to Proceed is received from USDOT.

At each stage noted in the schedule, applicable documents will be developed. The following list summarizes, at a minimum, the deliverables that will be included within each subsystem as part of the system engineering process.

- Systems Engineering Management Plan
- Concept of Operations
- Demonstration Site Map and Installation Schedule
- System Architecture and Standards Plan
- System Requirements Specification (SYRS)
- System Design Document (SDD)
- Configuration Management Plan
- Deployment Plan
- System Integration Plan
- Interface Control Documents
- Individual / Unit Test Plans
- System Acceptance Test Plan
- Verification Plans
- Test Plan Results
- Maintenance Plan
- Operations Plan

To keep control of costs, the SEMT will update cost estimates for each deployment in concert with each monthly status meeting and for every milestone submission. A standardized estimating process will be used that promotes consistent and accurate estimates. A full risk assessment of cost estimates will be used to identify risks associated with the project, assign a probability of occurrence to each risk, and record these risks in a "risk register." With a focus on the items identified in the risk register, the Core Team

will work at eliminating or mitigating these risks through recommendations or design efforts.

Documentation, Testing, and Independent Verification and Validation

The previous list of deliverables will help ensure that comprehensive documentation of the system design and testing requirements, and that verification and validation testing is completed. Project documentation control will include processes to ensure that the project is administered in conformance with the contract requirements. Documents will be developed to detail requirements for the identification, preparation, and maintenance of records for the projects and deployed systems. Proper documentation and documentation management controls will enable efficient sustainability and maintenance of the systems in the future.

Deliverables will include traceability matrices to ensure traceability from user requirements through the testing phase of the project. This includes test use cases and scripts. The testing will include subsystem/unit testing within a virtual lab setting to validate communication protocols, conduct vulnerably assessments, and investigate reliability and test redundancy.

Verification, validation, and evaluation will be conducted to determine whether the deployed system functions as defined, as intended, and that it meets the requirements. Verification and validation would help reduce malfunctions and defects, and ensure that the system is properly documented so that future enhancements and modification to the systems could be simply implemented. These checks, which will be presented to stakeholders as part of the technical reviews, include:

1. The implementation team (vendor/contractor/integrator) will work with the SEMT to perform a check for completeness and correctness of the needs (Concept of Operations).
2. The implementation team will conduct a bench test and operation environment test of the systems prior to implementation into the real world to validate that it meets system requirements.

Stakeholders will review and comment on the check of needs and requirements performed by the contractor to ensure that all user needs are defined and that the requirements stated satisfy a particular user need. Once the SEMT is satisfied with the disposition of the system, a user acceptance test will be conducted after implementation within the environment, but while still in a testing phase. The SEMT will oversee this step.

Risks and Mitigation

Risks are inherent to every project of this complexity. There are risks associated with the subsystem and overall system deployment and integration. Early identification of the risks is key along with the development of mitigation strategies. Some proposed subsystems have the advantage of having already been piloted, therefore the potential for high impact risks is reduced. Included is the initial identification and assessment of risk for the various deployments.

A risk management plan will be used to define requirements for evaluating the potential for occurrence of risks and the monitoring of those risks, and a risk management workshop will be conducted early in the project to further refine the risks. During the workshop, the stakeholders will rank the impact of each risk into categorizes such as low, medium, and high and help determine the probability or likelihood that a cost or schedule impact could occur. This process will be used to rank the risks based on the potential to occur and negative consequences.

The risk management plan and corresponding risk register will detail the process of monitoring the risk and document how to address the risks that have the greatest probability of occurring and the greatest impact to the project. The prioritized list of risks will be reviewed and tracked on a monthly basis and mitigations will be reviewed and updated as needed. Those that have the highest priority will be scrutinized in greater detail and at more frequent intervals. The SEMT will be responsible for updating, analyzing and managing threats to the success of the project.

Ensuring the Safety of All *SmartPGH* Subjects

A detailed risk assessment will be carried out for each of the Smart City demonstrations. The risk assessment will include due consideration of what in the demonstration might cause harm to travelers, subjects and other personnel associated with the demonstrations, how and which people who might be affected. It will take into account any

controls already in place and identify further controls, if any, that are required. The objective of our assessment is to insure all proper checks were made, all people who might be affected were considered, all significant risks have been assessed, the precautions are reasonable, and the remaining risk of any harm is low.

Insignificant risks, such as those from everyday life, will not be included. However, work activities risks will be included. A risk assessment will be carried out before any work or demonstration that presents a risk of injury or ill health is done. The outcomes of the risk assessment will be clearly documented. Specifically, all significant findings —what the risks are, what is being done to control them and what further action is needed—will be captured. The details of any particular groups of travelers, subjects and employees who have been identified as being especially at risk will be listed.

Initial Identification and Assesment of Risk

SUBSYSTEM	RISKS	RISK TYPE	MITIGATION STRATEGIES
Adaptive Signal Control Systems (Surtrac)/ CV Environment	Scale of the project could make implementation difficult	Schedule	• Implement in three phases, with Phase III requiring the most engineering, procurement, and construction, therefore providing sufficient schedule float • Leverage experience with existing Surtrac implementation to help define schedule requirements
	Safety of all users, particularly pedestrians	Technical	• Carefully select vendor with proven implementation • Define pedestrian movement requirements early and implement into engineering design
	Communication network reliability	Technical	• Have a variety of implementable technologies available, including City-owned fiber, leased fiber, and spread spectrum
	Transit optimization algorithms	Technical	• Use experienced team to guide the algorithm development • Model the algorithm in the virtual world before deployment • Monitor performance against the model and real world conditions
Autonomous Shuttle Network	Testing/deployment of AV technology has safety and reliability concerns	Technical and Cost	• Utilize a hands-off operator that can E-stop the automated system and take control of the vehicle • Perform outreach through the SmartPGH Consortium and SuROI to enhance public support
Solar Charging Infrastructure/ EV Fleet Conversion	Technologies are being advanced rapidly	Technical	• Delay specific technology or vendor selection by utilizing performance specifications, therefore placing burden of proof of concept on the vendor
	Scalability of the system engineering for other garages	Technical	• Document challenges and successes throughout the process • Identify features that may be unique to this individual application
Smart Streetlight Sensor Deployment	Current technology may not be reliable and technology is being advanced rapidly	Technical	• Delay specific technology selection by utilizing performance specifications, therefore placing burden of proof-of-concept on the vendor • Keep sensors as an option to build upon – what, where, how many, what is the use case

SUBSYSTEM	RISKS	RISK TYPE	MITIGATION STRATEGIES
	Timeliness of deployment	Schedule	• Initial deployment limited to LED replacement with option to implement sensors at a later date based on use case
	Policy and political implication and hurdles	Institutional and Schedule	• Develop an early action plan to vet out policy implications such as image storage time, privacy issues, and securing and sharing of data intended for the public • Utilize SmartPGH Consortium to address policy issues
Data Utility Deployment	System engineering and integration with other subsystems	Technical, Cost and Schedule	• Evaluate end-user needs and needs of other subsystems early in order to define the required two-way movement of data
	Management of Data/Data Storage	Technical and Cost	• Evaluate multiple technologies available and build redundancy into performance specifications and cost estimates
	Defining the data fusion process	Technical	• Leverage mobility analytics experience of CMU • Partner with technology providers (Google, Amazon, etc.) to develop best practices for data fusion and implement best practices into system engineering process
	Security of data risk	Technical and Schedule	• Leverage existing expertise of the WPRDC and MAC in providing a "scrubbed" public interface that included private data • Create a data management and security plan at the onset of the project
Integration of Proposed and Existing Subsystems	Technology or communication incompatibility between systems	Technical, Cost and Schedule	• Validate that all existing and proposed subsystems implement national standard communication protocols • Conduct virtual testing of systems (virtual lab) after defining system requirement to validate system compatibility
All Subsystems	Adaptability, resiliency, and long-term sustainability	Technical	• Documentation is key to identify equipment life cycles, staffing, operations, and ongoing maintenance • Capture requirements and testing for those requirements to aid in adapting, maintaining, and expanding

Hierarchy of Control

Risks will be reduced to the lowest and reasonably practicable level by taking preventative measures in order of priority. The list below sets out the order that we follow when reducing risks identified in the Smart City demonstrations.

ELIMINATION Redesign the system, subsystem or component, or substitute the item so that the hazard is removed or eliminated.

SUBSTITUTION Replace the material or process with a less hazardous one.

ENGINEERING CONTROLS Use work equipment (for example) or other measures to prevent injuries, install or use additional machinery to control risks, or separate the hazard from operators by methods such as enclosing or guarding dangerous items of machinery/equipment. Give priority to measures which protect collectively over individual measures.

ADMINISTRATIVE CONTROLS These controls identify and implement the procedures needed to operate safely. These may include, for example, reducing the time workers are exposed to hazards (e.g., by job rotation) or limiting shift times, prohibiting the use of mobile phones in hazardous

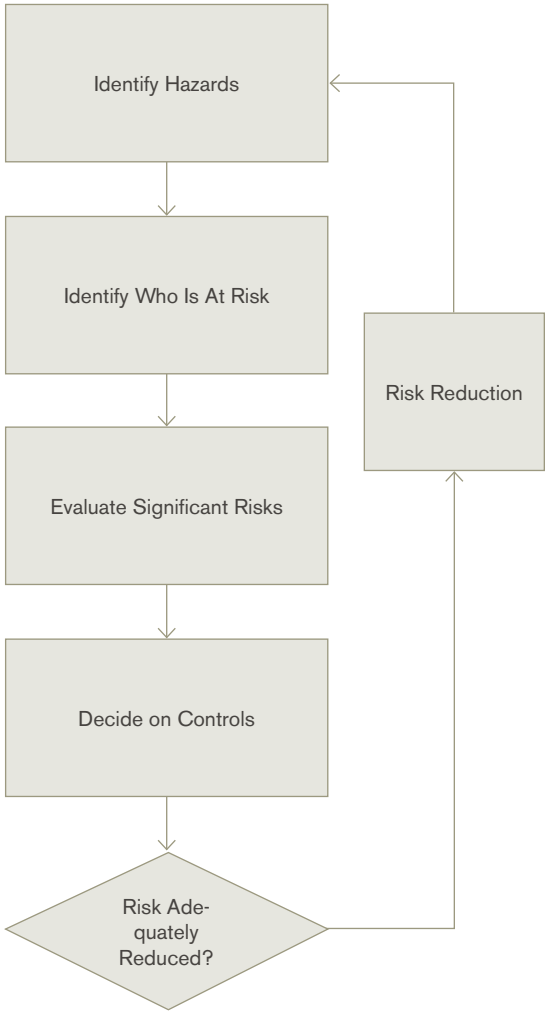
areas, increasing safety signage, and performing regular risk assessments.

PERSONNEL PROTECTIVE CLOTHES AND EQUIPMENT

Only after all the previous measures have been tried and found ineffective in controlling risks to a reasonably practicable level will personnel protective equipment (PPE) be used. If chosen, PPE should be selected and fitted by the person who uses it. Workers must be trained in the function and the limitations of each PPE item.

Based on a preliminary safety risk assessment, the risks are acceptably within the exception of the autonomous shuttle. During the concept of operations through development of system requirements and design, safety standards as well as safe testing and deployment strategies will need to be considered and documented for this subsystem.

Assessment of Risk



Data Management Approach

The creation of a Data Utility that serves as a platform for storing, transforming, and communicating data to meet the needs of all stakeholders is a major component of Pittsburgh's vision of a Smart City. Throughout the course of project implementation, an extraordinary amount of data will be generated about the way Pittsburghers live, work, and move. This new availability of structured information is in itself a very important outcome for this initiative and will serve as a crucial organizing framework for helping all members of *SmartPGH* get the most out of our initiative.

Our approach to setting up and managing information flows will be a scaled version of the way the City has approached its internal information systems management in the last several years. Since the beginning of the Peduto Administration, the Department of Innovation and Performance has encouraged all applications procured by the City and its Authorities to opt for cloud hosted solutions with built-in APIs that allow for the free and reliable exchange of information between systems. In this way, we can easily engineer exchanges of relevant information between departments that increase productivity and situational awareness for everyone.

Types of Data To Be Produced In the Course of the Demonstration

DATA TYPE	ASSET DESCRIPTION	ASSETS
Asset Data	**Fixed Assets:** locations, construction and product information, maintenance operations, operational status and any associated algorithms (i.e., "on and off" triggers for street lights), environmental metadata	• Traffic lights • Bus-Stops/Shelters • Light Rail infrastructure • Street Lights • Traffic Signs • Bike Share Stations • Streets (surface area, directionality, materials, weight limit. condition, usage by transportation type)
	Mobile Assets: locations, routing and associated algorithms, speed, fuel usage, occupancy	• Buses • Bike Share Bikes • Civilian fleet Vehicles • First Responder Fleet Vehicles
Incident Data		• Traffic Crashes • System/Device Failures
People Data		• Community Census Data • Usage on transit routes • Pedestrian/Bicycle counts • Employment rates in targeted areas

For example, because our 311 CRM for non-emergency requests and our asset management systems are connected via API, all maintenance operations are tied to individual assets, while both work groups are free to manage their respective applications to meet their needs. At the same time, the City's Analytics team maintains connections to both systems (and many more) and uses them to develop dashboards, maps, and other decision support tools for internal users. A thoughtful selection of data is simultaneously automatically presented to the public via the Western Pennsylvania Regional Data Center, which itself provides an APIS.

Policies For Access and Sharing Data

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 (WPRDC). 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. Policies and provisions for re-use, re-distribution, and the production of derivatives.

Housed at the University of Pittsburgh and funded by our local philanthropic community, 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 started improving 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 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*.

Policies and Provisions For Re-Use, Re-Distribution, and the Production of Derivatives

The legal infrastructure of the WPRDC provides a framework for enabling the University of Pittsburgh to operate a shared open data repository that will be expanded under *SmartPGH*. As providers enter the consortium, the data resources associated with their role will be evaluated and we will work with each one to determine appropriate terms and licenses based on a menu of established guidance. Legal infrastructure surrounding public data sharing will include three components:

1. DATA DEPOSIT AGREEMENT The first part of this legal infrastructure consists of a data deposit agreement between publishers and the University of Pittsburgh. This agreement enables these organizations to share data on the Data Center's open data repository and helps establish expectations around the role of the University as an intermediary.
2. TERMS OF USE The second piece of the infrastructure governs the standard terms of use for the Data Center's open data repository. Data users are prompted to agree to these terms (via a click-through license) prior to using the open data repository.
3. DATA LICENSE The third piece of the infrastructure involves the data license. Data licenses are important in that they allow data users to clearly understand conditions under which data can be re-used. The Data Center asks each data provider to either assign a license to each database they share, or explicitly assign the database to the public domain. A Creative Commons attribution (CC BY) license will be assigned by the Data Center if no other license is specified by a data provider at the time of publication.

Plans For Archiving Data and Other Research Products

The federated model of the WPRDC allows for archives to be hosted in various environments that can scale as appropriate and still be regulated by the *SmartPGH* framework.

As data is made available, we look forward to cultivating a collaborative ecosystem in which academic and applied research enjoys a close relationship with practitioners, advocates, and citizens. Although companies and researchers near-and-far will have access to our data, Pittsburgh benefits from a network of geographically and professionally close relationships between academics and government. The City of Pittsburgh and Carnegie Mellon were a founding members of the MetroLab network, committed to bringing our model of city-as-laboratory innovation to cities across the county. Through MetroLab Network, we look forward to trading best practices with others and providing national leadership on urban research.

Data Currently Collected by the City of Pittsburgh

DATA TYPE	DATA SETS	
Activity Data	• Computer Automated Dispatch (CAD) for 911 calls • Incidents of crime • Police stops/actions/interviews • Incidents of fire • Non-Emergency Requests (311) • Public Works Operational Activities • Building Inspections/Violations	• Building Permit Issuances • Public Works/Right of Way obstruction permits • Special Event Permit Issuances • Animal Control Actions • Bicycle and Pedestrian Counts • Information Technology Operations
Asset Data	• City Facilities Metadata	
Rules and Regulations	• Zoning Data • Zoning Hearings	

SmartPGH Communications & Outreach

No *SmartPGH* initiative would be successful without the endorsement of the community it will serve. Our human-centered approach to building a new generation infrastructure starts with telling people what we're doing and why. We want to articulate our values, share out the vision and then be a sounding board. People need to understand *SmartPGH's* goals and where they fit into them in order to contribute to shaping our collective future. We won't repeat the mistakes of the past and concentrate decision-making power among the few to the detriment of the many. This time around we've decided if it's not for all, it's not for us.

The City of Pittsburgh Smart City application team and partners at CMU's Traffic21 Institute began working with MAYA Design to create a consistent and compelling identity for the *SmartPGH* initiative and a messaging strategy. The initial strategy is outlined below, but it will continue to evolve as we work with MAYA and the City's Communications Team.

Communications Strategy
The goal of the Communications and Outreach Strategy is to establish SmartPGH as an innovative initiative that positions Pittsburgh as a relevant, progressive, and just city where transportation infrastructure serves people now and into the future.

As part of the human-centered communications strategy and brand identification process, the City of Pittsburgh application team articulated *SmartPGH's* values and identified primary stakeholders. The strategy that developed from these aims to:

- Establish a strong brand identity for *SmartPGH* that communicates the vision of the organization, creates brand recognition, and differentiates the initiative from other similar efforts.
- Provide stakeholders relevant and timely information regarding *SmartPGH* initiative objectives, outcomes, progress, and achievements.
- Build trust with those stakeholders through consistent, honest messaging and multiple points of entry for feedback.

The *SmartPGH* Brand
To hone in on the key elements of the *SmartPGH* brand the application team worked with MAYA Design to development a brand rationale and key words, as well as an intentional look, feel, and copy tone. A logo, color palette, typography, and approach to photography serve as fundamental building blocks from which any *SmartPGH* outreach can be developed.

Our Stakeholders
The following stakeholders have been identified as particular audiences to be aware of in developing our messaging and choosing the appropriate platforms for delivering them. The "primary audience" stakeholders are those without which our *SmartPGH* initiative cannot move forward, while the "secondary audience" stakeholders have been identified as important constituencies. We see "internal" stakeholders as audiences that will participate in message crafting and dissemination. "External" stakeholders will receive communications, although feedback mechanism will be in place for them as well.

Stakeholders

STAKEHOLDER	TIER	INTERNAL	EXTERNAL
City of Pittsburgh Residents	Primary		X
Project Partners (CMU, Port Authority, etc.)	Primary	X	
SmartPGH Consortium Members	Primary	X	
Local Media	Secondary		X
Future Residents, Entrepreneurs, and Investors	Secondary		X
National Media	Secondary		X
National Policymakers and Practitioners	Secondary		X

Objectives and Outreach

The objectives of all outreach about *SmartPGH* will be to:

- Ensure timely, accurate, and consistent communications with partner organizations, SmartPGH Consortium members, residents, media, and broader stakeholders.
- Build credibility with internal and external audiences by establishing expectations, executing, and reporting on activities and progress.
- Engage internal and external stakeholders to on-going feedback through the project implementation period— minimizing risk.
- Ensure that local and national media, as well as USDOT themselves, have an authoritative source of information regarding all aspects of the *SmartPGH* initiative.

Roles and Responsibilities

SMARTPGH MANAGER The SmartPGH Manager will be the primary person responsible for crafting content for communications in all formats (press releases, web updates, social media, public appearance, etc.).

MAYOR'S OFFICE COMMUNICATIONS TEAM As the resident "experts" at the City of Pittsburgh on communications, messaging, and media relations, Tim McNulty and Katie O'Malley will be the primary points-of-entry for the media when inquiring about the *SmartPGH* initiative.

MAYA DESIGN The team at MAYA Design will continue to provide design and content support, which will allow the SmartPGH Manager, Mayor Peduto, and other *SmartPGH* partners to effectively communicate timely, coherent messages related to the initiative to various audiences.

DIRECT COMMUNITY ENGAGEMENT The City of Pittsburgh's Office of Community Affairs (OCA) works directly with residents on neighborhood issues and to manage relationships with neighborhood groups and all residents. As such, OCA staff attends regularly scheduled community meetings City-wide, covering all of Pittsburgh's 90 neighborhoods each month. This makes OCA an invaluable asset to disseminate information related to the SmartPGH initiative and an important avenue to collect residential feedback.

TOOLS FOR DISSEMINATION The SmartPGH Manager will work directly with the Mayor's Office Communications Team and MAYA Design to identify the best way to communicate messages to specific audiences. Currently, we see the following tools as valuable assets to communicate the "brand" and timely messages from *SmartPGH*.

- Press Releases
- *SmartPGH* website
- *SmartPGH* newsletter
- Social Media

Beyond one way, out-going messages, establishing reliable feedback mechanisms is also deeply important to the success of *SmartPGH*. As noted above, residents will be able to provide verbal feedback directly to the Office of Community Affairs and the Community Census team on-the-ground. However, we will work to encourage healthy, robust conversations on social media and the *SmartPGH* website, as well as direct contact with the SmartPGH Manager via phone and in public meetings.

Pittsburgh's Proven Capacity

Pittsburgh has institutional and human resources that have allowed us to weather the economic catastrophes of our past and emerge even stronger than before. We've never stopped innovating. We've led humbly and quietly and we're prepared to lead again. In fact, the foundation for *SmartPGH* initiatives is already being laid to meet and exceed the USDOT goals to improve safety, enhance mobility, and address climate change. We're making inroads and we're doing it the Pittsburgh way: through partnerships and hard work.

A Strong *SmartPGH* Foundation

In order to fully capitalize on this momentum and ensure future success, the City is moving forward with a plan to create a new Department of Mobility and Infrastructure in budget year 2017 to strengthen our relationships with our partners, improve communication and coordination internally and externally, shorten project timelines, and streamline processes.

These key investments have primed the region for a new wave of innovation in transportation that will be realized over the next three years as we implement the following deployments that make up the core of the *SmartPGH* strategy.

THE PORT AUTHORITY OF ALLEGHENY COUNTY is finalizing plans for an expansion of our Bus Rapid Transit system beyond three existing busways to connect and reconnect neighborhoods and create new corridors of transit-oriented development. Eco Innovation Districts have been established in two City neighborhoods along Smart Spine corridors, instituting a comprehensive planning approach that addresses climate change and complements *SmartPGH*. Envision Downtown, a public-private partnership between the City of Pittsburgh and the Pittsburgh Downtown Partnership, in collaboration with Gehl Studios, is employing principles of tactical urbanism to improve the experience of moving around downtown for all people, with a particular focus on improving safety and mobility for transit users and people with disabilities.

THE CITY'S SPORTS AND EXHIBITION AUTHORITY has submitted a TIGER proposal to 'cap' a critical section of highway that was cut through the heart of the historically African American Hill District neighborhood in the 1970s, dramatically limiting pedestrian access to Downtown. This cap would provide much-needed high quality green space and serve as the centerpiece in a new uninterrupted pedestrian and cyclist connection from the Hill District through Downtown to Point State Park and our extensive network of trails.

HEALTHY RIDE, our bike share system that launched in 2015 with 50 stations and 500 bicycles, has ambitious expansion plans to better serve low- and moderate-income neighborhoods. Expanding the existing network into Homewood, the Hill District, and the Central Northside will allow new first mile and last mile access to key transit and business centers as well as access to the City's network of bike lanes and trails.

Enduring Leadership to Sustain *SmartPGH*

These partnerships are essential not only to the City of Pittsburgh, but also to our ability to successfully deploy the integrated projects within this proposal and to leverage many millions of dollars towards those deployments.

GOVERNMENT Prior to becoming Mayor, then-Councilman Peduto issued 100 Policy Papers during his campaign. Of these 100, nearly 25% of them focused on transportation. More specifically, he outlined clear, actionable policy and administrative changes that would move Pittsburgh in a "smarter" direction. Mayor Peduto honored his campaign promises. He took steps in his first few weeks in office to significantly scale-up the City of Pittsburgh's capacity to 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 drew national and 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.

ACADEMIA Beyond the smart, tech-savvy employees who are leading the I&P, Public Works, and City Planning, our academic community brings an unrivaled level of expertise in the fields of transportation technology and clean energy. Carnegie Mellon University gets worldwide recognition for its 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. 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" by collaborating with them. 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.

The University of Pittsburgh is one of the preeminent research universities in the country in fields such as energy, biomedical, and cybersecurity, and has pioneered research in advanced manufacturing, brain imaging, and microgrids. Working closely with The University of Pittsburgh's Center for Energy, the City has entered into an MOU with the Department of Energy's National Energy Technology Laboratory around district energy deployments using highly efficient direct current microgrids.

Business & Technology

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 technology companies.

- Google chose to locate here nearly 10 years ago, and has since scaled up its presence in Pittsburgh.
- Uber recently chose to locate their Advanced Technologies Center in Pittsburgh, and has finalized plans for a 35-acre test site for autonomous vehicles.
- In early-2016, Facebook announced their decision to locate offices in Pittsburgh centered around virtual reality research, as have Bosch, Apple, Ta Ta, Intel, Disney and many more.
- Beyond these household names, there is a substantial amount of homegrown talent like 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 recognize that a significant workforce development component is also required to ensure that local firms and their employees have the training necessary to physically implement and maintain the 21ST century infrastructure that we are proposing. In fact, a recent report released by the Allegheny Conference on Community Development entitled Inflection Point: Supply, Demand and the Future of Work in the Pittsburgh Region predicts that by 2025 the Pittsburgh region will face a workforce shortage of nearly 80,000 people due to retiring baby boomers that currently dominate our workforce. Fortunately, through partnerships with The Brookings Institution, the Three Rivers Workforce Investment Board, the Allegheny Conference on Community Development, and the Community College of Allegheny County, we are well positioned to build a pipeline for employment in industries from advanced manufacturing to cybersecurity.