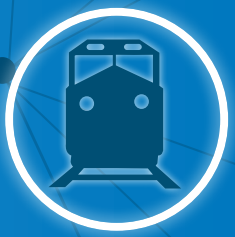
SMART CITY

THE CITY OF
COLUMBUS
ANDREW J. GINTHER, MAYOR



COLUMBUS, OHIO

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COLUMBUS' VISION: BEAUTIFUL, HEALTHY, AND PROSPEROUS FOR ALL OF US

Columbus has a bold vision to be a community that provides beauty, prosperity and health for all of its citizens.

A **beautiful city** provides clean transportation options that serve the mobility demands of the city and reduce the impacts on the environment. A **healthy city** provides safe and inviting opportunities for non-motorized travel and smart technology with a complete digital network that links people to services, such as healthy food and health care. A **prosperous city** connects workers to jobs and employers to workers, gets goods to market, supports world-class institutions, and provides reliable travel options affordable to a range of household budgets.

Figure 1 Columbus' Vision

This vision for a healthy, prosperous, beautiful city for everyone builds on our planning activities over the past three years. As Figure 2 highlights, these foundational plans address investments, data, and innovative solutions that meet the needs of our citizens. Along with our partners who share this vision, we identified several common **goals and actions** for achieving it:

- ✓ Ensure the vitality of Columbus neighborhoods by connecting them to one another, Downtown, and the region as a whole;
- ✓ Improve personal health and safety through complete streets, connected networks, and safe street design with particular attention to the most vulnerable populations;
- ✓ Mitigate inequities by ensuring all residents have access to quality, affordable transportation choices that connect them to jobs, housing, education, services, and the needs of daily life;
- ✓ Strengthen the economic competitiveness of Columbus by building infrastructure and networks to attract and retain jobs and meeting the needs of industry;
- ✓ Address climate change by reducing consumption and emissions, pursuing alternative energy sources, and preparing for and responding to anticipated effects;
- ✓ Fully engage community members in problem-solving and decision-making through transparent communications and information and engaged government; and
- ✓ Practice fiscal sustainability by leveraging the opportunity of rich data, collaborating with partners, prioritizing investments to meet goals, and consistently measuring progress.

Figure 2 Foundational Plans of the Columbus Vision

Connect Columbus is the City's Multimodal Thoroughfare Plan which provides a long range vision and priority investments for transportation plan in the City. The plan is designed to improve safety, reduce congestion, assist children, the elderly, and people with ADA needs and promote economic development, fitness and environmental responsibility.

insight 2050 is led by the Mid-Ohio Regional Planning Commission (MORPC), the metropolitan planning organization for Columbus. It is a collaborative initiative among public and private partners designed to help Central Ohio proactively plan for growth and development. Over the next 30+ years the region will grow substantially in numbers and must grow differently in form with more walkable neighborhoods, more mixed use environments, more mixed age and mixed income communities and more transportation choices. insight 2050 provides scenario testing tools and data to enable decision makers to understand the impact of future land use policies and the transportation investments.

As our region continues to grow and funding availability becomes more limited, the region is prepared with innovative transportation solutions to address increasing infrastructure needs. The **Metropolitan Transportation Plan** is the federally required long range planning document led by MORPC that brings together local governments from around Central Ohio and other local, state, and federal agencies to identify and coordinate transportation goals, policies, strategies and projects over the next two decades.

The **NextGen Plan** is the Central Ohio Transit Authority's (COTA) long-range planning effort to identify transit needs and opportunities for 2025, 2040 and 2050. The initiative will recommend system enhancements, including a prioritized list of bus and rail projects along with what technology to employ. COTA is comprehensively realigning its network to better meet the needs of our growing community. With extensive involvement from the public and stakeholders, a comprehensive review of our system was completed in 2014. The resulting plan - the **Transit System Redesign (TSR)** - will make COTA service simpler, more convenient and easier to use with a planned completion date of May, 2017.

These foundational plans also allowed the City to identify the challenges to achieving these goals. Columbus faces four primary issues: an aging population; a growing younger population that is moving to the dense urban areas; mobility challenges in select neighborhoods; and a growing economy and population with related housing and commercial, and passenger and freight, and environmental issues.

Our approach to addressing these challenges and achieving our vision embraces our existing infrastructure, network, and data while leveraging the strategic implementation of smart technologies with our partners and stakeholders. Columbus' challenges are not unlike other mid-sized US cities. However, unlike some of these cities, Columbus has the technology-based resources, the collaborative environment, and the existing physical and network infrastructure to successfully complete this demonstration project. Moreover, we are committed to sharing our strategies and lessons learned with other mid-sized cities.

To complete the demonstration project and achieve our vision, we will establish a new **Smart City Program Office** to manage the design, development, demonstration, and integration of our project. The Office provides a central organization that will enable numerous city, county,

regional, business, and technology partners and vendors to work together to implement, evaluate, execute, and share our project results.

> *"Improving access to jobs, the efficient movement of goods and increased access to services is critical to the sustained growth and prosperity of the Columbus region," said Mayor Andrew J. Ginther. "Columbus neighborhoods, new Americans, disadvantaged residents and visitors to the region will all benefit from a smarter, safer and more accessible community."*

COLUMBUS: A CITY OF OPPORTUNITY

Columbus is the fastest growing metro area in the Midwest, the top metro for job growth in the Midwest, and the top metro for wage growth in the U.S. A growing tech area, research and technology institutions in the Columbus region are attracting the brightest minds from around the world. Columbus is nationally recognized for innovation, and with a growing population and economy, we are fueled by a workforce that is younger and more educated than the national average. Our youthful, progressive nature is matched by a diverse economy that offers a variety of career paths.

Columbus has an existing infrastructure system to build on with our proposed demonstration project: a dynamic highway network, including smart corridors with 600 miles of fiber; rail, air, warehousing and intermodal freight facilities, including the Rickenbacker Inland Port; and public and personal transit services. Columbus also has a demonstrated commitment to the sharing economy, shown most recently in the City's investment along with policy and regulatory changes, to encourage bike sharing (CoGo) and car sharing (Car2Go, Uber) services.

Columbus has another significant feature that underscores our commitment to smart technologies: our experience with open, accessible data. The City has a fully operational *MyColumbus* app that enables citizens to access city services; publicly accessible transit routes, schedules, and stop data; MORPC Regional Data Lab portal that provides access to transportation, housing, and other public information available around the region; and statewide accessible travel-time data. Columbus and its partners have used these data in sponsored research programs, such as the US Department of Transportation (USDOT) Integrated Dynamic Transit Operations Prototype Deployment project, led by Battelle, which integrated transit data from both Central Ohio Transit Authority (COTA) and Ohio State University (OSU) to demonstrate advanced transit concepts, and the Effectiveness of Travel Time Reliability project, also led by Battelle, which connected local and regional travel-time data to assist drivers in travel-planning decisions.

ACCOLADES FOR COLUMBUS

#1 Intelligent Community, Intelligent Communities Forum (2015)
#2 Large American City "City of the Future" fDI Magazine (2015)
#3 Best city for Millennials, Money Magazine (2015)
#3 Best city for African-American owned small businesses Thumbtack, Inc. (2015)
#1 Opportunity City, Forbes (2014)
#6 American Dream Cities, The Burghard Group (2013)
#1 City for working mothers, Forbes (2012)
#8 Among the top 10 most creative cities in the nation according to the "Vitality Index" (2011)

Columbus Smart City Alignment

With a population approaching 800,000, Columbus is the 15th largest city in the U.S. – comparable to San Francisco, CA and Austin, TX and larger than Boston, MA, Seattle, WA or Washington, DC. It is relatively dense for a mid-sized American city with 3,383.6 inhabitants per square mile and serves as a strong regional anchor with 39% of the Metropolitan Area

population living in the City. Figure 3 demonstrates that Columbus aligns with the Smart City Challenge city characteristics.

Columbus has grown consistently over its history, steadily becoming more diverse with growing African-American, Latino and Asian populations. Over the next 25 years, the Columbus region is expected to add another 500,000 to its existing 2 million residents –130,000 of whom are expected to live in Columbus – making it the fastest growing area in the Midwest and among the most rapidly growing areas outside of the sunbelt states.

Figure 3 Alignment with Smart City Characteristics

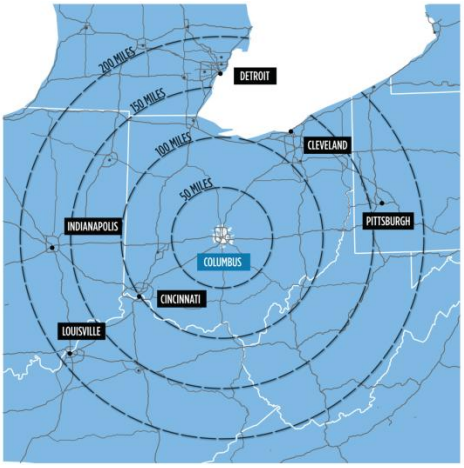
Characteristics of Smart City	Columbus Alignment
Population between approximately 200,000 and 850,000 people within city limits as of the 2010 Census	Columbus - 787,033 (2010 census)
A dense urban population typical for a mid-sized American city	3,383.6 inhabitants per square mile.
Represents a significant portion (more than 15%) of the overall population of its urbanized area using 2010 Census data	39% of Metropolitan Area population (1.99 million)

Economy

Columbus is an international economic powerhouse with a gross metropolitan product (GMP) of $118 billion – an economy larger than 142 countries and 17 states. The Columbus Region is home to 15 Fortune 1000 companies and four Fortune 500 companies including Cardinal Health, American Electric Power, L. Brands, Inc. and Nationwide Mutual Insurance Company. Other companies with a major presence in the region are JP Morgan Chase & Co., Honda of America Mfg., Inc., Alliance Data Systems, Emerson Network Power, and IBM. The Columbus economy is stable and diverse, where no single major industry sector represents more than 18% of employment.

Columbus is a hub for freight and manufacturing. Located at a strategic crossroads, the City is within a 10-hour truck drive of nearly 50% of the U.S. population and national manufacturing capacity. The Columbus Region offers the greatest access to the U.S. market of any major domestic metro as shown in Figure 4. Over the past decade, while other Midwestern and national manufacturing centers have declined, employment growth in skilled manufacturing in the Columbus metro area has exceeded 35%.

Figure 4 Columbus in Context



The City is thriving – retaining and attracting top quality talent and a young workforce thanks in part to a low cost of living (8% lower than the U.S. average) and higher average wages. Millennials make up over one-quarter of the population, many attracted to the area's job growth rate (9.3%). Quality of life in Columbus means great restaurants, entertainment and culture as well as outstanding sports teams. The City's world-renowned sports events, arts attractions, and cultural centers attract over 37 million visitors a year generating over $8 billion annually for the economy.

Environment

Columbus has deeply held environmental values and is committed to sustainability. Columbus is proud for STAR (Sustainable Tools for Assessing and Rating) Communities to certify Columbus as a 4-STAR Community in December of 2015. STAR includes 44 objectives and over 500 sustainability outcome and action measures. Of nearly 20,000 incorporated communities in the U.S. only 18 hold this level of certification in the STAR Community Rating System.

Through the Columbus Green Spot initiative, more than 12,000 individuals, organizations, and businesses have committed to taking specific steps toward a sustainable way of life. Through Branch Out Columbus, Columbus and more than 20 non-profit organizations have created an urban tree nursery and have committed to plant 300,000 trees throughout the City by 2020.

Columbus recently completed the Scioto Greenways, a $35 million restoration that has transformed the Scioto Riverfront through the heart of downtown Columbus by removing a low head dam, restoring the natural flow of the river, improving the ecological systems and river habitat, and adding 33 acres of new greenway and 1.5 miles of bike trails.

The commitment to preservation of beauty and environmental performance extends to the transportation sector as well. Columbus was honored by 100 Best Fleets for having the greenest fleet in North America in 2011 and was named the best fleet in North America in 2014. We currently have two CNG stations in operations, with two more in development, and have converted 167 vehicles to CNG fuel. The CNG conversion displaced 400,000 of diesel fuel with cleaner CNG, and Columbus is on pace to convert another 273 vehicles to displace diesel usage at 1.3 million gallons annually by 2020. Columbus, working with Clean Fuels Ohio, has installed nearly 300 public electric vehicle-charging stations throughout the region, including at Columbus City Hall, and this commitment to clean energy led the City to an early adoption of bike sharing, car sharing, and ride sharing that complement the region's exceptional public transit system. Additionally, AEP, a regional electric company, recently completed a major Smart Grid project in Columbus with favorable results. And, COTA is dedicated to improving the environment through the construction of LEED certified buildings:

- Completed an $18.5 million renovation of the 275,000 sq. ft. Fields Avenue fixed-route bus storage and maintenance facility, obtaining LEED Gold certification.
- Completed a $21.2 million renovation of the 104,000 sq. ft. Paratransit facility, obtaining LEED Silver certification.
- Purchased and completed a $12.8 million renovation of a 10 story, 86,000 sq. ft. office building in Downtown Columbus for COTA's administrative offices, obtaining LEED Silver certification.

COLUMBUS: ADDRESSING OUR CHALLENGES

With all the spectacular strengths and assets, Columbus is not without our challenges. We recognize that, like other Midwest cities, we must address issues of socio-economic and geographic isolation, a built environment and mobility systems dominated by the private automobile, and limited financial resources. Specifically, our foundational plans provide us with well vetted challenges with outreach to stakeholders and analysis. In general, our pressing challenges include: 1) aging population, 2) growing younger population moving to dense areas of the City, 3) mobility access for several of our neighborhoods, and 4) a growing economy and population with its related housing and commercial, passenger and freight, and environmental issues.

Columbus is a richly diverse city where people of every type have succeeded in achieving the American Dream, though we recognize that our city, like many others, has pockets of isolation that handicap the success of some of our residents – particularly racial or ethnic minorities and those with lower incomes. The Linden Neighborhood in Columbus faces many of these challenges, which is the primary reason for proposing this neighborhood for a mobility-access related project. Parts of Linden have an unemployment rate of over 15%, more than three times the rest of Columbus, and a high portion of carless households. This statistic, along with a poverty level almost three times that of Columbus, and a median household income of less than half of the rest of the City, compels Columbus to focus on access to jobs and connecting citizens to community services.[1]

This socio-economic isolation is exacerbated by the predominantly auto-centric urban form that Columbus has grown by for more than 50 years. Urban sprawl with its disaggregated job and population growth threatens our community, economic and environmental health. Currently, 4 out of every 5 people in Columbus drive alone to work and many people have few other options for getting around. Climate change is a growing concern, making it imperative to implement smart technologies to counter this issue.

Parking is becoming an impediment to the development of Columbus's most significant job centers. In the downtown Columbus market, corporate office users budget 3.75 parking spaces per 1,000 square feet of office space. With above ground, structured parking construction costs ranging from $20,000 to $25,000 per space, automobile storage will add nearly over $50 million in cost to a 12-story downtown office building. With monthly parking rates in downtown Columbus ranging from $150 to over $250 per month, workers and developers are ready to look to alternatives.

Columbus, our partners and people are committed to facing these challenges and achieving our vision. We are committed to providing services and opportunities that can help to overcome this isolation and provide greater access to opportunity and success for all our citizens. We are committed to reorienting our city to its citizens, travelers and the user experience through more diversified, flexible and nimble transportation options using data and a connected and complete network that supports activity and a more healthy and sustainable urban form.

We will address our challenges with five interrelated strategies:

- **Access to Jobs:** Columbus has several major employment centers but has challenges of workers having reasonable access to these jobs. Our primarily solution is to develop smart corridors and concentrate transit services on these corridors and address last mile connections that will connect these employment centers with their work force.
- **Smart Logistics:** Columbus is a major freight hub with a multimodal inland port. However, the reliability of our highway system needs to keep pace with our growth. Our primary solution is to enhance the timeliness and quality of the traffic condition data as well as develop a routing app for trucks to improve the reliability of our highway system and operational efficiencies.
- **Connected Visitors:** Columbus is a regional destination for its sporting events, Zoo, airport, medical services and shopping offerings. However, these events lack real-time information related to traffic and parking conditions, and transit options. Our primary solution is to seed fund a private sector developed app for a specific event with the expectation of private funding for other city events as well as expansion of such service to other mid-sized cities.

[1] American Community Survey 2009-2013

- **Connected Citizens:** Columbus has select neighborhoods with mobility challenges that limit its citizen's access to jobs, health care, and education services. Our solution is to examine the Linden neighborhood mobility challenges and work with local private and public social services providers to rationalize current transportation services and offer more efficient mobility services.
- **Sustainable Transportation:** Columbus has a Green Community Plan and recently completed a major Smart Grid project. Our plan challenges us to create a future urban type vehicle ownership/sharing and driving/mobility patterns environment that encourage the use of sustainable modes and energy consumption, such as electric vehicles (EV) and smarter grid. We plan to explore the usage of additional EVs with several policy and practice changes at the City focused on incentives to developers and others to greatly expand the number of recharging stations, and expand our Smart Grid project to other parts of the City.

Columbus will implement a new Smart City Program Office responsible for our demonstration project. This program office will focus solely on implementing our five strategies and integrating our ITS research and technology partners (such as OSU, Battelle and IBM Data Center) with our technology vendors and service providers (such as GM, Uber, Car2Go, GE and Siemens). Additionally, this program office will deploy, evaluate and share the project results with other mid-sized cities with the goal to transfer these technology-based solutions.

COLUMBUS: PROJECT UNDERSTANDING

Columbus has a clear vision of where it wants to go and the necessary goals and actions to get there. We have identified the needs and gaps that stand in our way and have already developed and initiated a series of programs and investments to address them. We have the capital and organizational and information resources to successfully advance toward our goals.

But we know we can do more.

We can build on the assets we have and the robust foundation of work already underway by the City and public and private partners. With assistance from USDOT, we can further our smart deployments, better evaluate and learn from them, further engrain them in the fundamental workings of the City, and share this knowledge with sister cities and enterprises around the globe. Columbus is proud of the work we have done to date and believe it provides an unrivaled foundation on which to meet the Smart City Challenge.

Modern Mobility

Columbus has been leading a quiet revolution in sustainable transportation systems. Early on (1971) the Columbus region established a regional transit authority to provide seamless transit services throughout the greater Columbus area. The City was among the first to establish a formal Bikeway Advisory Committee (1993) and was an early leader in Safe Routes to School with our Walk Smart School Program (1998).

Since that time, the City has continued to advance mobility, adopting a robust complete street policy and fully embracing the sharing economy. CoGo, Columbus' bikesharing system, launched July 30, 2013 with 30 stations and has grown to its present 410 bicycles and 41 stations across the City serving over 120,000 trips and counting. In the same year, Car2Go launched in Columbus with 300 point-to-point shared cars – one of only nine U.S. cities to enjoy the service – which complements the rent-and-return car share service Zipcar. Newly passed statewide legislation governing ride sharing operations has been praised by Uber and other Transportation

Networking Companies (TNCs) for providing a fair, consistent, predictable and welcoming foundation for their operations. And the *MyColumbus* app brings a number of these mobility options together with robust information about everything from bus arrivals to nearby parks, plus the app provides unique two-way information and idea exchange with Columbus officials so the City and services can respond quickly and grow even better. Taken together, the people and businesses of Columbus enjoy an enviable diversity of mobility choices, as shown in Figure 5.

Figure 5 Quick Facts about Transportation in Columbus

Existing Infrastructure	Fact
Arterial miles	1,005 centerline miles
Freeway miles	171 centerline freeway miles
Transit services	360 buses on 67 fixed routes carrying more than 62,000 passengers each weekday
Walking	over 1,300 miles of sidewalks
Bicycling	225 miles of bicycle facilities
Shared-use mobility services	CoGo bikesharing system; Car2Go; Uber
Information and communication technology (ICT)	City and ODOT TMCs, *MyColumbus App*, Food Vending Site Reservation App
Intelligent Transportation Systems (ITS)	Columbus and Ohio TMCs; *MyColumbus App*
Smart Grid Infrastructure	300 public electric vehicle charging stations, including at the Columbus City Hall; AEP Smart Grid Project in northeast portion of Columbus

City Leadership and Partners Committed to Innovation

Sound and stable leadership is a hallmark of Columbus. Mayor Andrew J. Ginther assumed office on the first of January this year after serving nine years on the City Council and five years as its president. Mayor Ginther will provide continuous leadership over the entire Smart City Challenge grant. He continues the steady leadership the City has enjoyed over the past 16 years under former Mayor Michael Coleman, the longest serving mayor in city history. The Mid-Ohio Regional Planning Commission (MORPC) is a voluntary association of Central Ohio governments and regional organizations and serves as the metropolitan planning organization for the region. Since 1943, when it was first formed as the Franklin County Planning Commission, the agency has grown to include innovative planning for transportation, energy, housing, land use, the environment and economic development. Finally, COTA has a region's public transit provider service area of 1.2 million residents and provides more than 19 million passenger trips annually.

Additionally, Columbus has a long history of productive public/private cooperation manifested by the Columbus Partnership, a membership-based organization comprised of over 50 CEOs from the City's leading businesses and institutions. For over a decade, this group has helped position the City to embrace innovation and strategically prepare it for the future. Through extensive public engagement and dialogue, the Partnership created Columbus 2020, a comprehensive economic development organization and strategy for the region.

There are a number of other additional partners in the Columbus Region that are committed to innovation. The Ohio Supercomputer Center provides a reliable, high-performance computing and communications infrastructure for a diverse statewide community, including education, academic research, industry and state government. SciTech is a state-of-the-art research park located on

the OSU campus that links world-class academic technical expertise with cutting-edge, commercial, technology-based innovation. Ohio TechAngels is the largest angel investor network in the country and engages qualified entrepreneurs who are developing high-growth businesses in Ohio, predominantly focused on innovation in the life sciences, information technology and physical sciences market sectors. The Ohio Third Frontier is a technology-based economic development initiative that is successfully changing the trajectory of Ohio's economy by supporting existing technology industries that are transforming themselves with new globally competitive products. The Columbus Region contains three of Ohio's six Edison Technology Centers, which provide product and process innovation and commercialization services to both established and early-stage technology-based businesses.

Demonstrated Success Fostering Innovation

Columbus has a longstanding commitment to technology and innovation that makes it an environment conducive to demonstrating proposed strategies. Columbus is an early leader in automated vehicle technology, partnering with OSU to test Smart Mobile Operation: OSU Transportation Hub or SMOOTH, a network of on-demand automated vehicles. The vehicles have GPS, a map database to help in routing, and Vehicle to Vehicle (V2V) communication capability. They will also be equipped with pedestrian detection technology, enabling them to function in zones on campus where pedestrians are abundant. This research and demonstration project is already underway with partial National Science Foundation (NSF) support through an EAGER grant. A key issue is creating a system that can link to the software and hardware applications that already exist in Columbus, allowing this system to work in many different communities. We are specifically looking at embedding SMOOTH into Service Packages of the National ITS Architecture. The next phase is planned to be compatible with portions of the architecture like "APTS01-Transit Vehicle Tracking", both "APTS02-Transit Fixed-Route Operations" and "APTS3-Demand Response Transit Operations", "APTS06-Transit Fleet Management", "ATIS03-Autonomous Route Guidance", and possibly others.

To foster the next generation of entrepreneurs and innovators, the OSU Center for Innovation and Entrepreneurship facilitates entrepreneurial and innovation-based learning and experiences that will impact the global economy by assisting in new company formation and the development of new products and services within existing businesses. The City's business catalyst Rev1 Ventures has been recognized for offering startup acceleration, business mentoring, seed funding and capital attraction. In 2014, Rev1 Ventures provided 169 companies with funding or business services and invested in 18 companies, making it one of the most active feed funds in the Midwest. In November, Rev1 Ventures launched VentureNEXT, an annual event that gathers the region's top entrepreneurs, investors, economic developers, and community leaders. And Rev1 Labs, a small business incubator, was ranked #3 incubator in the world by UBI Global in 2014.

COTA is planning to expand citizen's access to WiFi by offering free connections in the CMAX Cleveland Avenue Bus Rapid Transit (BRT) (September 2017) one of the City's smart corridors. WiFi will also be provided on fixed-route bus service offering a direct connection between Port Columbus International Airport and Downtown seven days a week service. In the second quarter of 2016, COTA will make real-time data available to the public for free, providing application developers with real-time bus locations, stop locations and other related data.

State-of-the-Art Facilities and Networks

Columbus has completed construction of a new state-of-the art Traffic Management Center (TMC), and construction is presently underway with the City's multi-year, $76 million investment in the

Columbus Traffic Signal System (CTSS) project. When completed in 2018, CTSS will link the Columbus TMC to all 1,250 signalized Columbus intersections and utilize new weather-tracking software and sensors to relay pavement conditions while a GPS system provides real-time information about where snowplows are operating. Most importantly, the CTSS project and the new Columbus TMC will provide traffic management coordination between Columbus, 12 regional communities, Franklin County, OSU and ODOT. The TMC consolidates traffic signal, special event traffic, and snow removal operation command into a centralized location for Columbus. Columbus is also home to ODOT's TMC, which monitors traffic conditions in each of the major metropolitan areas of the state and is linked to city infrastructure through a robust network of sensors, cameras and communication technologies.

Smart Grid technology is a dramatic modernization of the electric utility grid (power lines, transformers and meters) serving residential and commercial customers. Working with AEP, the Columbus recently completed deployment of the system in the northeast part of the City. A foundation of the Smart Grid technology is the installation of 'smart' meters that allows for two way communication between the utility and the consumer. At its core, this two-way communication dramatically improves how the utility identified and managed power usage/demand and outages. This alone allows for improved planning and recovery by the utility, but as it impacts a truly Smart City, another facet of this technology is even more critical to managing future demand and controlling cost. As a general rule, the cost of producing and delivering electricity is a function of demand. The higher the demand, the greater the cost. As part of Smart Grid, consumers are able to configure specific devices in their home, such as the heating or air conditioning system, washers and dryers, and other high energy demand appliances, to operate at different times, or different levels (think temperature), depending on the cost of the electricity at that time.

Accessible and Usable Data

Columbus is a city committed to transparency and partnership, comfortable and confident in sharing and using data, information and visualizations to engage with the public and inspire further innovation and private enterprise.

Columbus has an active and engaged citizenry with whom the City routinely communicates through established institutional structures such as our Mobile City Hall, Neighborhood Pride, and Area Commissioners. Since 2013, Columbus' Mobile City Hall, "The CBUS," has been a regular fixture at festivals across the City. The CBUS provides residents with WiFi access and technology to access a variety of online services. Neighborhood Pride is a team effort by city departments, neighborhood groups and individual residents, businesses, schools and other partners to make neighborhoods safer by providing a menu of services such as street cleaning, pothole repair, bulk trash pick-up, litter, and graffiti removal and other services to targeted areas of the City.

Columbus maintains information and communication technology (ICT) data from across the City made available to the public in the *MyColumbus* app. Winner of the 2014 Consumerization of IT in the Enterprise (CITE) Award for Best Customer App, the app puts the City at residents' fingertips, providing enhanced access to city and community resources including COTA bus schedules, Columbus capital project information, 311 service requests, and more. The app promotes personal and environmental health by providing information about parks, local sporting events, and pointers for environmentally sustainable behavior. The *MyColumbus* app, in addition to "pushing" information to users, "pulls" information as well through an interactive feedback loop.

Figure 6 *MyColumbus* App

To make data accessible and user friendly to the public, Columbus maintains a robust data visualization program called MyNeighborhood, which aggregates the data from a variety of city agencies and databases into a user friendly format, synched with the *MyColumbus* app. In addition, MORPC maintains a publically available online data center, with access to zoning, aerials, traffic counts, GIS layers, and population estimates. DataSource 2.0 is a regional data visualization tool developed by MORPC, which allows users to create maps, charts and other visualizations free of charge using a variety of data and geographic areas from the Columbus region. COTA maintains a public website at COTA.com/data with GTFS and GIS files available to the public for download. The agency is currently testing a real-time bus API and hopes to launch the data publically in spring 2016. Finally, for over 20 years Columbus, ODOT, MORPC and the Federal Highway Administration (FHWA) have partnered on Paving the Way, the Columbus region's one-stop source for road construction and roadway safety information.

COLUMBUS SMART CITY DEMONSTRATION PROJECT

The demonstration project that the City and its partners propose is the culmination of a coordinated, multi-step consensus process that builds on the existing vision of the community and extends this vision to incorporate the approaches and technologies encompassed by the Smart City Challenge. Using the region's foundational plans, the City and its partners understand the challenges facing our community and have developed solid strategies to address them. We worked collaboratively to develop the strategies included in our Smart City demonstration project, in order to ensure we address challenges that are found city-wide and affect all demographics and modes of transportation. In our proposed approach, we include autonomous and connected vehicles, electric vehicles, sensors, and both vehicle- and infrastructure-based solutions. We generate, capture, and benefit from a tremendous increase in available data. We intend to integrate this data with existing data sources to make more informed decisions about the operation of the systems, and to meet our target performance measures. We also expect to promote an environment that is data rich and supports entrepreneurial investment by third parties. As a whole, this approach serves to meet the vision and challenges identified previously.

PARTNERSHIPS, STAKEHOLDERS, AND GOVERNANCE

Columbus is the primary applicant to the Smart City Challenge. One of the fastest growing major metropolitan areas in the country, Columbus is an up-and-coming tech city anchored by nationally renowned research and technology institutions. Columbus has a diverse suite of implementation partners, collaborators, and supporters as demonstrated by the numerous letters of support included in this application.

Partnerships

Through Columbus' new Smart City Program Office, implementation partners will assist the City with achieving our Smart City vision by leading and collaborating on the proposed five strategies' projects. Our business and public entities in the region, including Columbus2020, Rev1 Ventures, MORPC, and Experience Columbus will be the key implementation partners to Columbus with policy/regulatory and economic development responsibilities. ODOT and COTA are our public service providers and are key to several of the projects.

Our data and ITS technology partners include Clean Fuels Ohio, OSU (which has several research centers leading deployment projects, including a University Transportation Center, the Center for Automotive Research, the Transportation Research Center, and the ITS Center for Excellence), the IBM Analytics Data Center, and Battelle with research, test bed, and demonstration expertise. Columbus will also collaborate with key regional cities and universities with ITS technology research/testbed expertise, including Ann Arbor and the University of Michigan (car and ITS traffic research and testbed) and Pittsburgh and Carnegie Mellon University (smart vehicle research and testbed).

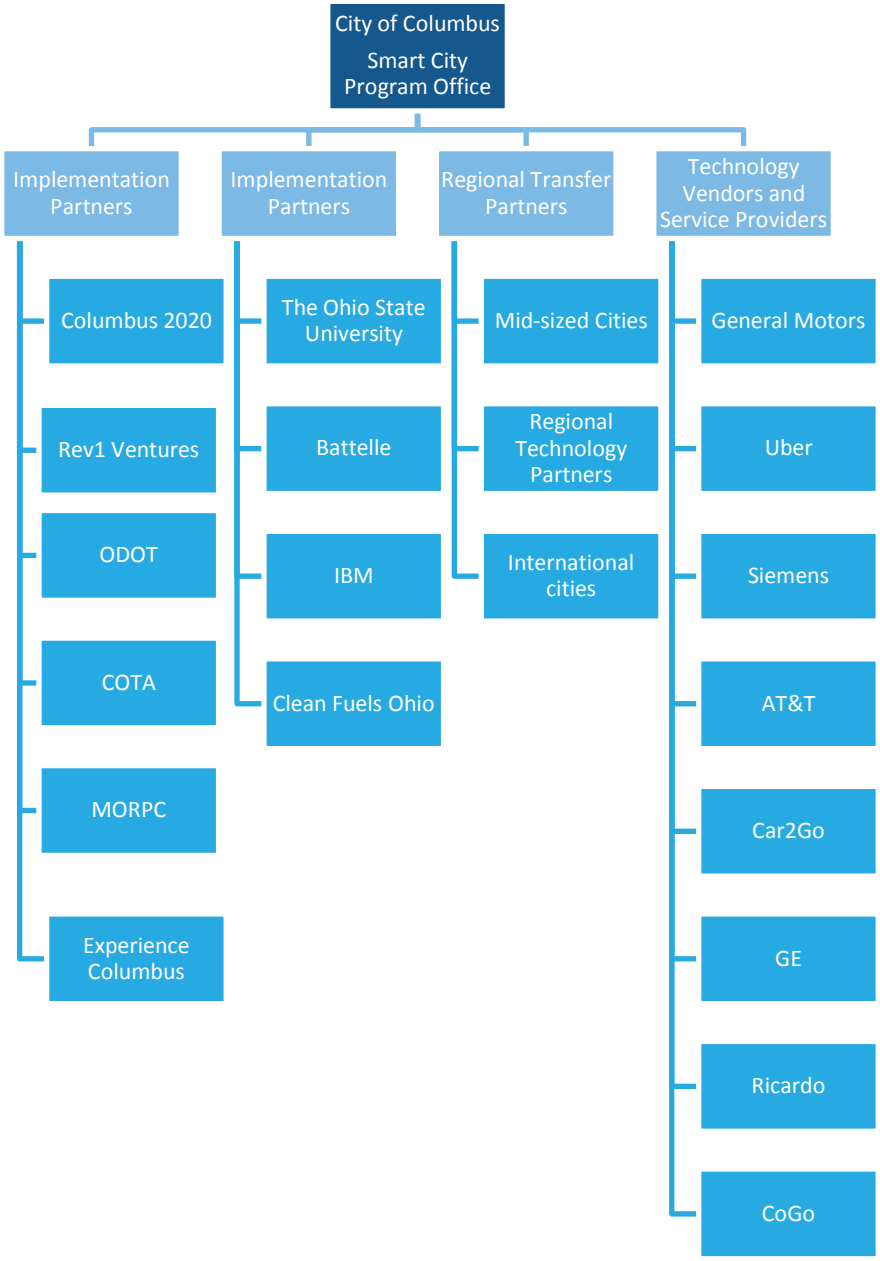
Our approach includes partnering with international entities with Smart City technology and projects, including City of Barcelona and the IDIADA Lab. Also, we plan to formally organize many mid-sized cities to share our project results. The advantage of this strategy means:

- Columbus will leverage research and testbed expertise in Columbus and the Midwest's regional universities and industry's centers of excellence

- These key centers of excellence vehicle and traffic technologies will unite their experience to better assess potential projects with the Program Office
- Transferability of program to other mid-sized cities will be demonstrated

With strong support in the region for our Smart City application, Columbus has secured support from private sector collaborators and public entities that are available to assist with projects and support implementation and transfer efforts. Some of these collaborators include General Motors, Honda, Uber, Car2Go, CoGo, the banking and insurance sectors, Clean Fuels Ohio, Siemens, AT&T, GE, Ricardo, Franklin County and other communities in the Columbus region. Figure 7 highlights our organization, and our partners and their roles.

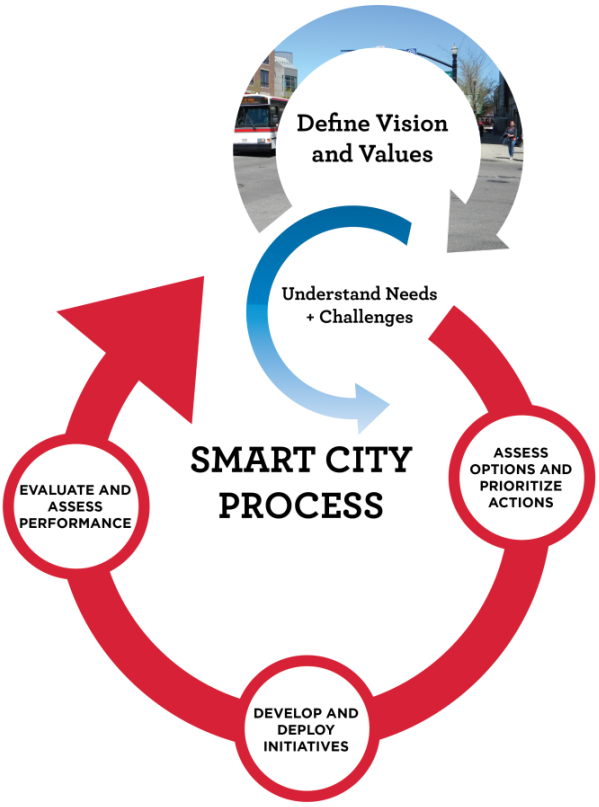
Figure 7 Columbus Partnership Organization Structure



Governance

Our demonstration project will be guided by a new Smart City Program Office. It will oversee a holistic and multifaceted demonstration project targeted to address the fundamental challenges our city, like countless other mid-sized cities, faces. Each component of the demonstration project is associated with a core strategy serving our overall vision. By closely monitoring and evaluating each component's effectiveness, the Smart City Program Office will be able to refine and redeploy these technologies in a cycle of continuous learning and improvement. The Program Office will collect and evaluate performance data both for component initiatives as well as synthesizing findings across all to determine opportunities for synergy, greater efficiency, multiple benefits, and lower costs.

Figure 8 Demonstration Project Model



Columbus' new Smart City Program Office will manage and govern the Smart City Challenge and will be staffed by select representatives from the Implementation Partners. The Program Office responsibilities will include:

- Deploying practical, service-oriented mature technology
- Partnering with regional research and testbed players to leverage technology understanding
- Partnering with international partners to leverage project experience
- Economic development strategies to sustain the program after USDOT funding ends
- Sharing project results with service providers to deploy in other mid-sized cities
- Utilizing integrated economic development to address institutional and regulatory barriers
- Assessing and reporting deployment project performance and determining a sustaining owner

The Smart City Program Office will be supported by the following Key Implementation Partners:

The Central Ohio Transit Authority (COTA) is the regional public transit provider for greater Columbus and central Ohio. With a service area of 1.2 million residents, COTA provides more than 19 million passenger trips annually.

The Mid-Ohio Regional Planning Commission (MORPC) is a voluntary association of Central Ohio governments and regional organizations that envisions and embraces innovative directions in transportation, energy, housing, land use, the environment and economic prosperity. MORPC is representative of the rural, urban and suburban communities that comprise the burgeoning Central

Ohio region. In addition, MORPC's transformative programming and innovative public policy are evident throughout the 15 counties it serves.

The Ohio Department of Transportation (ODOT) is responsible for maintaining one of the largest transportation networks in the nation. Guided by ethical principles and accountability, ODOT works to improve safety, enhance travel and advance economic development. As a $2.8 billion enterprise, the department wisely invests in its core services of snow and ice removal, annual construction program and highway maintenance operations.

Columbus 2020 is comprised of 20 dedicated economic development professionals, and an impressive list of allied organizations help to move the Columbus 2020 Regional Growth Strategy forward. The 11-county Columbus Region has one of the largest and fastest growing economies in the United States. It takes a well-resourced team and a group of equally committed allies to accomplish all that needs to be done. Columbus 2020 was launched in 2010 to strengthen and diversify the economic base by building existing assets, attracting new investment, and creating new business opportunities.

Experience Columbus is governed by a Board of Directors and supported by more than 1,000 members who invest in the efforts of Experience Columbus and help make Greater Columbus an appealing destination by offering their services, attractions and facilities to visitors, meeting planners, convention delegates and residents.

Stakeholders of the Columbus Smart City project are the citizens and businesses of Columbus and other mid-sized cities. The Columbus themes are all about connections: connected citizens and visitors, connections to jobs, logistical connections for freight, and a community connected to the how it impacts the environment. We plan to continue the involvement of these stakeholders during the conduct of this demonstration project to sharing of the project results.

DEMONSTRATION PROJECT STRATEGIES

The USDOT identifies 12 vision elements that comprise a Smart City. As shown in Figure 9, the demonstration comprises five strategies that align with and foster integration among all the Smart City elements. Figure 10 shows the Site Map for our demonstration project, and shown below are highlights of the projects in our strategies.

Develop smart corridors to demonstrate the capability of intelligent infrastructure to improve transit service and efficiently

Enhance the timeliness and quality of the traffic condition data, complemented by a routing app for trucks to improve the reliability of our highway system for the movement and delivery of freight

Push real time information to users on traffic and parking conditions and transit options to minimize the impacts of concentrated travel demands associated with major events or incidents

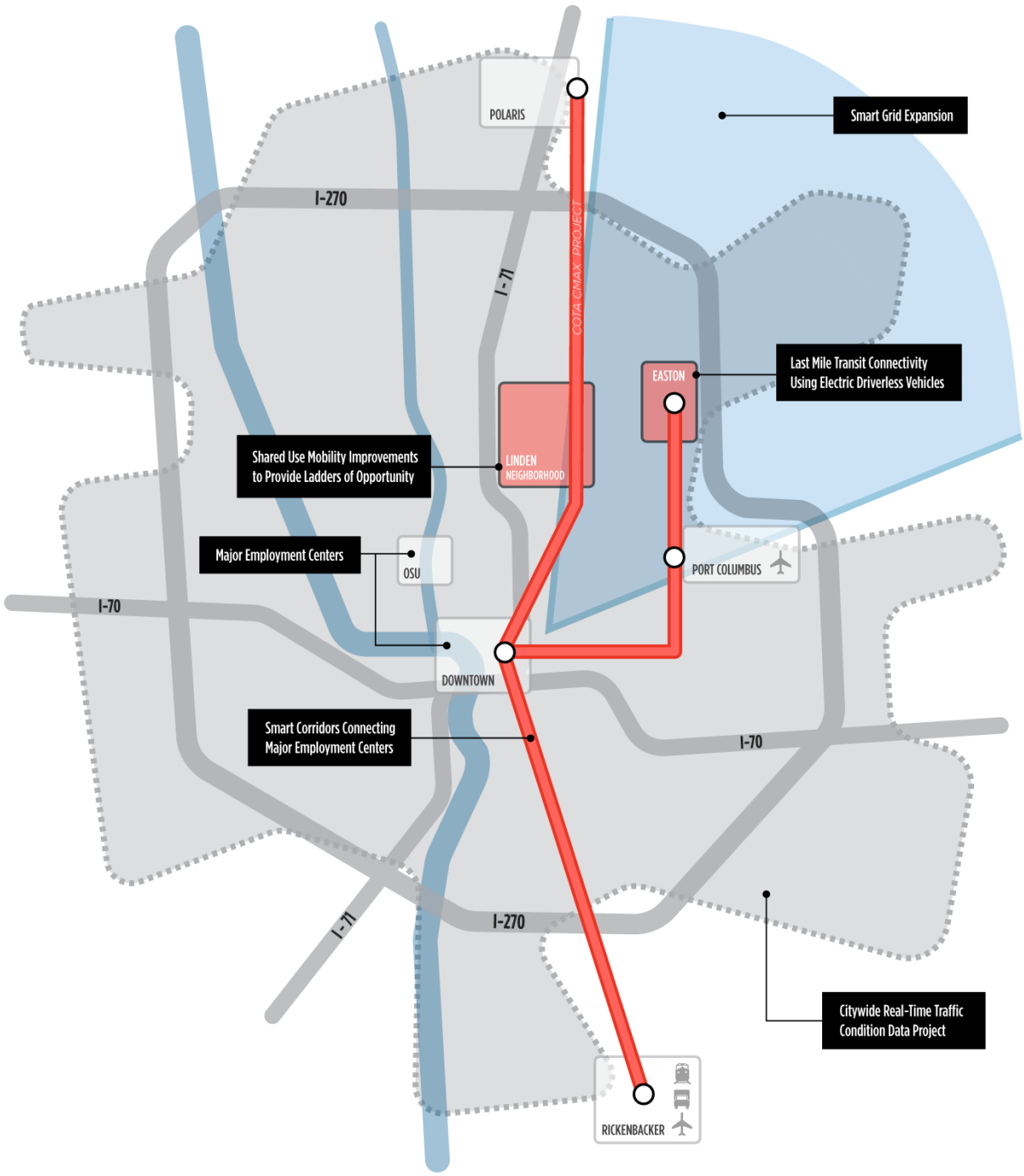
Develop and deploy communication technology solutions to address the obstacles that low-income "unbanked"/cash-economy based residents and those who lack smartphone data services face in accessing and using shared and real-time transportation options and app-based services

Expand the usage of electric and smart vehicles through changes to policy and practice and the expansion of our Smart Grid in order to serve our energy and climate change objectives

Figure 9 Columbus Project Alignment with Smart City Challenge Vision Elements

Element	Access to Jobs	Smart Logistics	Connected Visitors	Connected Citizens	Sustainable Transportation	Example of Solution Implementation
Urban automation	X				X	Expanded Autonomous Vehicle (SMOOTH) project will include self-driving, electric vehicles coupled with smart infrastructure to address last mile issues.
Connected vehicles	X				X	The Smart Corridor couples V2V with V2I communications to improve transit and vehicle operations as part of COTA's CMAX BRT rollout.
Intelligent, sensor-based infrastructure	X	X	X	X	X	Expanded TMC will integrate sensor data with existing transportation data and operations, improving transportation system operations.
Urban analytics	X	X	X	X	X	Data will be used for travel demand management for citizens, visitors, and freight transportation.
User-focused mobility services and choices			X	X	X	A focus of the effort includes communication and payment solutions to address obstacles faced by low-income "unbanked"/cash-economy based residents and those who lack smartphones.
Urban delivery and logistics		X			X	Real time traffic condition and routing data for trucks will improve the reliability of our highway system for the movement and delivery of freight.
Strategic business models and partnering opportunities		X	X	X	X	Builds on and strengthens the region's strategic partnering between public agencies, universities, and the private sector, as evidence by our supporting technology and transportation partners.
Smart Grid, roadway electrification, and electric vehicles	X				X	Expand our existing Smart Grid to support deployment of EVs, and to increase utilization and integrate with other city systems.
Connected, involved citizens	X		X	X	X	*MyColumbus* provides a platform on which the City will provide a platform for citizens to serve as co-creators and co-producers of new and innovative transportation data and services.
Architecture and standards	X	X	X	X	X	The City will use the CVRIA, the National ITS Architecture, and other emerging ITS standards to ensure interoperable ITS capabilities.
Low cost, efficient, secure, and resilient ICT	X	X	X	X	X	The City will ensure that security mechanisms are embedded in systems and infrastructure to protect, including use of the USDOT backed Security Credential Management System (SCMS)
Smart land use	X				X	The City vision and foundational documents reinforce the connection between land use and transportation; downtown parking is currently at maximum capacity.

Figure 10 Site Map



The following sections describe each of the five strategies, including the work we have accomplished to date, the potential to leverage federal funds, and the specific projects we propose to deploy.

Smart Corridor to Provide Access to Jobs

Columbus is one of the fastest growing regional employment centers in the country. It is a hub for a range of industries from medical research and health care to insurance to finance to manufacturing and technology. However, much of this growth is occurring near the outskirts of the City, limiting transportation choices, increasing congestion, and worsening health outcomes. With the region projected to grow by about 500,000 people and 300,000 jobs between 2010 and 2050, Columbus will address these challenges and increase access to jobs by developing a Smart Corridor along Cleveland Avenue in conjunction with COTA's CMAX BRT project.

Access to Jobs	
Work Done to Date	City's Smart Corridors Development, CTSS Fiber Project on Smart Corridors, COTA's CMAX Cleveland Avenue BRT (One of the City's Smart Corridors), OSU ITS Smooth Project
Leverage Federal Funds	CMAX Cleveland Avenue BRT Project, City's CTSS Fiber Project
Deployment Projects	Enhance COTA's CMAX BRT Project (One of City's Smart Corridors) I. Additional system wide service information (mobile ticketing, smart cards, smart fare boxes) via smart phone apps II. Add Mobileye technology to COTA buses (system wide) III. Install Smart intersection technology on corridor to enhance Mobileye Self-Driving vehicles (electric vehicle fleet) servicing (fixed route) Easton Office/Shopping Park addressing first and last mile connection issue from transit center

The Cleveland Avenue Smart Corridor is the next generation of Intelligent Transportation Systems (ITS), integrating a variety of technologies and data across multiple modes in order to better manage the corridor and provide information to the traveling public in real time. With a network of integrated electronic signs, sensors, and other state-of-the-art elements this project will enhance safety for all road users, improve travel time reliability and reduce accidents and associated congestion. Cleveland Avenue is the first Smart Corridor identified by the City; future corridors are currently being developed to extend from downtown to the Port Columbus airport and Rickenbacker Intermodal facility connecting the employment centers with concentrated transit services, corridor traffic flow technology and digital transit service information for its riders. The Cleveland Avenue corridor was selected to be the first Smart Corridor in the City because it builds on the Columbus Traffic Signal System project (CTSS) deployment that is already occurring along the route.

This project will leverage the CMAX Cleveland Avenue BRT project, currently in the Federal Transit Administration (FTA) Major Capital Investment grants program pipeline. COTA will expand its onboard Automated Vehicle Location (AVL) technology to the BRT vehicles to provide accurate and timely bus location data. The COTA operations office will monitor, and if necessary, adjust system performance and Transit Signal Priority requests, to keep the buses on schedule. Arrival time information will be displayed at bus stops and on COTA's website. In addition, the AVL data will be made freely available to allow application developers to build mobile applications for local transit users. COTA and Battelle have demonstrated experience building and testing these

systems and providing open data for integration with third-party tools, having led the USDOT Integrated Dynamic Transit Operations prototype deployment project. The project used schedule and route information to provide real-time travel planning and transfer request tools to the traveler. Beyond publishing AVL data, the project will also make additional information available for COTA operations and third-party developer use, such as occupancy, available bike rack space, or accessible seating space.

Columbus and COTA are committed to installing the Mobileye Shield + technology as a retrofit kit for the transit bus fleet and working with Columbus City School buses as a demonstration to provide invaluable vehicle-autonomous collision avoidance system. This system will reduce and potentially eliminate bus incidents involving pedestrians, cyclists and motorcyclists, in line with the City's goal of reducing vulnerable road user deaths. The Mobileye Shield + technology can also provide Columbus and its partners with data on the transportation system condition and operations surrounding the transit vehicle. Essentially, this technology puts another 'set of eyes' on the road. It lets COTA and Columbus extend the reach of current fixed-location cameras, and utilize this mobile technology to detect and report traffic incidents, congestion, road conditions, and potentially serve as video evidence for any crime or related incident.

Working with COTA, Columbus is committed to installing Transit Signal Prioritization (TSP) along the Cleveland Avenue corridor to support the CMAX BRT project. The TSP project will be implemented using Connected Vehicle (CV) DSRC technology, as opposed to current, optical line-of-sight technologies. It would integrate this advanced signal timing and coordination capability into the City's current TMC system. Installation of this technology will leverage the planned upgrades along this corridor, including the fiber backbone and upgrade of the traffic signal systems. As Cleveland Avenue crosses several major east-west corridors, many of which are also being converted to crosstown routes, the City will use these advanced signal coordination techniques to maximize the operations of these routes based on peak period volume, and other considerations. The City's fleet of Public Safety vehicles will also be CV-equipped, allowing emergency vehicles to have signal preemption.

Finally, to address the last mile connection challenge, the City will deploy and test on-demand, self-driving electric vehicles. Building on the SMOOTH pilot project at OSU, these automated vehicles will circulate a fixed-route from the existing Easton Transit station and include residential, commercial, and retail facilities in the Easton office/shopping park and Port Columbus areas. The Easton area is presently underserved due to the limited and fluctuating demand for service, but offers tremendous potential to improve access to jobs in this region. The envisioned system would utilize existing public roadways that have been upgraded with technology infrastructure to ensure vehicles stay in their lanes and adhere to signal timing. Vision technology, such as Mobileye, combined with CV technology will serve as the key enabling technology to support this vision.

Real-time and Integrated Data for Smart Logistics

The Rickenbacker Inland Port, located in the southeast part of Columbus, is a high-speed international, multimodal logistics hub, includes one of the world's only cargo-dedicated airports, and boasts the 7th most active foreign trade zones in the United States. A continuing challenge for the freight and logistics industry is the limited availability of robust and accurate navigation and traffic condition information specific to heavy vehicles. Available GPS 'navigation' systems cater to light-duty vehicles, and as such, typically lack information critical to efficient and safe heavy vehicle operation, such as size and weight restrictions (particularly height), road geometry, and lane restrictions. Further, increasing congestion and urban development are challenging the delivery systems in urban areas, increasing costs and sprawl.

Smart Logistics	
Work Done to Date	Regional TMC traffic data (ODOT and City), City's Mobile Food Vending Site Reservation app, Battelle/Limited Supply Chain Study
Leverage Federal Funds	Regional TMCs (City and ODOT), CTSS Fiber Project, COTA's CMAX Cleveland Avenue BRT project, ODOT ITS Program (OHGO), Short North Parking Study
Deployment Projects	Provide real time regional traffic condition data via smart phone apps/current routing services Provide a regional truck routing data using the real time traffic data with smart phone apps/current routing service. Improve routing service for trucks in the region Provide delivery site location/availability data for reserving sites in select dense locations in the City via smart phone app. Leverage the City's Mobile Food Vending Site App.

Both Columbus and ODOT collect travel time information along all of the major corridors into and out of the City, in all directions, including I-70, I-71, and I-270; US 23 and 33, and SR 315. Further, both of these entities also maintain restricted route information, in the form of spatial databases, which are used as part of the size and weight permitting process. The geography and existing roadway infrastructure of the Columbus region make multiple routes available to approaching vehicles, whether local or through, as these vehicles approach the City.

Building on both the availability of data, as well as the unique geography and options available, the City, ODOT and other data aggregators could make this travel time and heavy-vehicle restriction data available in an open data environment to allow for third-party application development. The goal is to provide the freight community reliable routing and traffic condition information in sufficient time to make necessary, appropriate, and legal route choices. This same data will also be used to provide truck-specific guidance, as appropriate, on existing variable message board gantries located on routes into the City. Given our location as an intermodal gateway, the team will work closely with the local logistics, freight, rail and air communities to corroborate and promote the development and use of this information and the corresponding applications. The traffic condition elements of the broader regionally, federated database, will function as shown in Figure 11.

Figure 11 Proposed Traffic Condition Database Project

Data Input	Database	Proposed Project Apps
ODOT TMC	Real Time Traffic Condition Database (Publicly Available)	Truck Routing
City TMC		Truck Delivery
COTA AVL		COTA Services
COTA Traffic		Event Routing
Data Flow →		

And finally, in support of the final delivery of the freight or goods, a strategy is planned to address the location and availability of delivery sites. Presently, the availability of both on-street parking and temporary delivery zones in dense, mixed-used urban areas in the downtown area continue to present challenges both in Columbus and in other dense, mid-sized American cities. Demand for on-street parking is at its highest point in decades, and current development plans are considering the reduction of available delivery zones to accommodate this additional parking demand.

Similar to parking availability sensor project applications underway in urban environments, including the Columbus Region, we will develop open data. We will also create an app that both indicates delivery zone availability and expands this concept to include an advanced reservation capability for these limited spaces. Preliminary concepts include the use of vision technology, installed in the infrastructure, to determine space availability. Third-party developers can then use information from these systems to implement applications specific to this need, as well as support enhanced parking availability applications in these same urban areas.

Connected Visitors

Columbus is a regional destination for sporting events, shopping, medical services, and arts and cultural events. In the Columbus Region, visitors spend $5.7 billion each year, which has an overall economic impact of $8.7 billion and supports over 71,000 jobs. Visitors to these events might stay for just a few hours or for a few days, and need to know real time information related to traffic and parking conditions, transit options, and other nearby destinations. Columbus will build on recent efforts by Experience Columbus, the City's tourism agency, to expand its certified tourism ambassador (CTA) program to include open data and an app for specific events and regional attractions.

Connected Visitors	
Work Done to Date	Experience Columbus has been focusing on its certified tourism ambassador program and a related event data app TMCs (City and ODOT) have traffic condition data Experience Columbus CTA Program and website host of event information
Leverage Federal Funds	City's CTSS Fiber Project and COTA CMAX BRT Project
Deployment Projects	Develop event apps (via smart phone) that provide: I. Real time traffic conditions and routing information II. Real time transit options III. Real time parking conditions and availability IV. Event information (i.e., hours of service)

Building on the similar data sources supporting the Smart Logistics strategy, there are several key elements to enabling satisfied Connected Visitors, particularly as they relate to local events. They include travel time information, route guidance, and parking availability. Unique to this challenge is the local and temporary nature of these situations, which adds an additional complexity that needs to be considered. For instance, in the case of parking, several of the large local events, weather permitting allow for parking in public fields located near the events. Maintaining availability counts is difficult in these situations. However, there are opportunities to improve traffic patterns and share them with the public, such as using portable, temporary vehicle count and classification equipment, both at entrances and exits to these temporary parking facilities, and integrating information from these type of devices with existing route guidance.

Leveraging the expertise of OSU can allow the implementation of expected wait times to support this strategy. This involves using other sensors and related results, such noise and pollution sensors, heat maps of traffic, pedestrian, bikes; counts of people in spaces and queues of popular venues and event sites, and of animal (deer) crossings. OSU is a pioneer in large scale wireless and wired sensing infrastructure. It has long lived testbeds for federated, low power sensing (Kansei, KanseiGenie), building scale monitoring (PeopleNet, ThermoNet), campus scale camera monitoring (Davis Lab), and vehicular sensing (CAR). Common to all of our proposed strategies, the City and

our partners would then create 'open' access to this data to encourage third-party applications developers to generate these types of applications.

Columbus will encourage the event sponsors to share event schedule and similar information to these same third-party developers to allow for even more robust and useful information delivered to the consumer. COTA's website will soon have the capacity to push emails and text notifications to users who sign up for a rider alert program. There is potential to expand this service to event-based notifications to alert visitors to realignments, delays, and changes to transit services.

Connected Citizens

Columbus has a number of isolated neighborhoods that face longstanding economic and mobility challenges limiting residents' ability to access jobs, health care, and education. Major challenges include reliable alternatives to personally owned cars as well as last-mile options, both for able-bodied and physically challenged residents. Personal transit services, whether in the form of vehicle-for-hire transportation (taxis, TNCs), car sharing, and ride-sharing have typically avoided this market, leaving traditional fixed-route bus service, and in the case of disabled citizens, paratransit services, as the only options. Access to transportation is also a challenge in select areas of Columbus. For example, the Linden neighborhood has a high proportion of carless households, unreliable access to employment and health services, a lack of access to digital information, and a high portion of cash-based households.

Connected Citizens	
Work Done to Date	Celebrate One Initiative, Private service providers (churches, food pantries), Public sector social service providers (all levels), OSU ITS SMOOTH Project, City Kiosks with WiFi (Mobile City Hall)
Leverage Federal Funds	City's CTSS Fiber Program and COTA's CMAX BRT Project
Deployment Projects	Work with debit card type service offering (via bank partner) to address cash based Citizens access to mobility services Increase and/or introduce personal transit (Uber, Car2Go) service offerings Understand other barriers (such as smart phone ownership and WiFi availability)

To begin to address these needs and provide a Ladder of Opportunity, Columbus will work with private and public sector service providers in the Linden Neighborhood to understand mobility barriers and develop solutions. Columbus will work with private sector partners to eliminate barriers that cash-based and credit-challenged citizens face in accessing shared-use mobility services, and increase the availability of TNCs and other mobility options in the community. For example, the City's strategy is to encourage new partners and growth in this market to work through existing barriers to overcome the obstacles and allow for growth in this underserved market. Inclusion of private sector services in public transportation planning applications, backing by the City for insurance and liability, subsidies to service providers, eliminating barriers to deploying the services, guaranteed quantity of trips, and others, are all possibilities. Independent of this application, the City continues to work with the private-sector entities to identify a solution to these current needs, and an influx of supporting technologies supported by a Smart City award would only help accelerate these offerings.

Other barriers to smart mobility, such as smart phone ownership and WiFi service availability, will be addressed through innovative deployment of WiFi hotspots or access points, building on the digital infrastructure that the City is deploying. The Smart City Program Office will collect and

analyze project information from this demonstration project for possible expansion into other areas of concern in the City.

Addressing the needs of cash-based citizens requires both technical and institutional elements to be put in place. From a technology standpoint, one of the simplest, but proven technologies is the adoption of a common smart card system throughout the region. Similar to how today's OSU student can use their Student ID to pay the fare to ride COTA buses, our approach would expand this concept to include all forms of local transportation, both public and potential vehicle-for-hire, ride sharing and car sharing companies. Kiosks would be installed in key transfer locations, allowing cash-based riders to purchase or add funds to their smart cards. Another option is a mobile application that tracks an account rather than a card itself. This would be an app based service, which is safer than a card, requires much less permanent infrastructure (e.g. kiosks) and is easy to update and maintain through software updates.

Institutional elements might include added protections and insurance, held by the City or private providers that allow for this segment of the population to utilize their services even in the absence of established credit. And while not immediately planned, the area is also a possible opportunity to deploy automated and electronic vehicles to address last-mile challenges. Inclusion of this element is dependent on the level of funding provided. It is envisioned that through these efforts Linden will become a transit-advantaged neighborhood and help provide improved ladders of opportunity to our residents.

Sustainable Transportation Options

The vision for Columbus is a healthy, prosperous, and beautiful city that requires the City to take a proactive approach to addressing climate change. Building on the recently completed AEP Smart Grid project in northeast Columbus, we will work to increase utilization of electric vehicles and expand Smart Grid technology to new areas of the City. AEP is currently working with the Public Utilities Commission of Ohio (PUCO) to expand their initiative. We plan to pursue expanding the use of electric vehicles (EV) with several policy and practice changes at the City and incentives to developers, and expand our Smart Grid project to other parts of Columbus.

Sustainable Transportation	
Work Done to Date	Clean Fuels Ohio EV installations & preparedness study and installation of EV recharging facilities, USDOE Clean City Program Pending State of Ohio's JobsOhio low-interest loan recharging facility program Green Community Plan policy changes (i.e., air emissions and fuel reduction goals, public/private fuel policies and recommendations) Alternative Fuel and EV recharging facilities location app/online, US DOE Clean Cities Program AEP Smart Grid Project City's smart metering program
Leverage Federal Funds	Alternative Fuel and EV recharging Facilities App- US DOE Clean City Program, AEP's smart metering program
Deployment Projects	Expand AEP's Smart Grid to other parts of the City. This Smart Grid project will incorporate EV storage capability. Encourage EV usage. This is a combination of specific City policy/regulation. Work with the current car sharing service providers to convert to EV fleet by installing

	EV recharging stations Pursue continued conversion to CNG and investigate converting portion of City fleet to EVs and share EV fleet (during off hours) to citizens Enhance the alternative fuel and EV recharging facilities location app Adopt parking codes that require EV recharging facility parking facilities and street parking

Encouraging electric vehicle usage will require the City to both push and pull. Columbus will work directly with our electric company partner (AEP) to expand the Smart Grid project to other parts of the City. The City will also explore policies and changes to codes that encourage the use/ownership of electric vehicles by focusing on availability of recharging stations and EV car sharing. Together, these efforts will take advantage of the EV storage capability.

To encourage the purchase and use of electric vehicles in the region, the City will focus on installing recharging stations in a variety of locations for public use, and leverage the work conducted by Clean Fuels Ohio. EV recharging stations at on-street parking spaces will have first priority, followed by stations at public and private parking facilities. The future vision includes: 1) working with current car sharing services to convert to EVs with the City installing recharging stations at select sites, 2) reviewing the City parking codes regarding requirement for recharging stations, 3) explore converting an additional portion of the City's fleet to EV and the potential for public use during off hours with EV recharging stations, and 4) developing of an alternative fuel fueling and EV recharging stations' services and location app.

At the same time, the City will increase the ease and cost of using EV charging stations using a cost-sensitive approach similar to that of the Smart Grid that will help reduce spikes in demand and to keep operating costs as low as possible for the installed system. Multiple charging stations will be configured to stagger charging cycles so that the demand remains as flat as possible. Depending on the impact of the selected technology, this same system will look to identify times during operational periods when it is optimal to perform even a quick, partial recharge. These combine to produce optimal performance balanced with minimal cost.

The addition of EVs and charging stations to the electric grid offer unique opportunities to test new ways of energy capture, storage and use. Solar panels, which are a major component of the Tesla recharging model, will be installed in large arrays adjacent with recharging stations. Columbus will also explore the possibility of 'selling' excess capacity back to the grid, offsetting costs. This practice is already in use for consumers and business that have solar or wind generating capabilities, so expanding the Smart Grid to facilitate this could be a major benefit to other mid-size cities. Columbus is also interested in using the EV itself as a storage device on the grid. For example, the electric utility, instead of having to increase output, may be able to obtain some stored electricity from EVs connected to a charging station. Eventually, after the period of peak demand, the grid would reverse and restore charge in the EV. As part of this project, the City, OSU researchers, AEP, and our EV partners will explore ways in which a system acting in this manner might be possible to implement, possibly building a model for future energy storage.

DATA COLLECTION, MANAGEMENT, AND INTEGRATION

A Smart City is measured by its ability to implement sustainable, environmentally friendly solutions that improve the quality of life for its residents, both present and in the future. Fundamental to achieving this goal is the need to capture, manage, understand, and most importantly, react to this data as part of a continually evolving and improving process. Critical also to this success is the ability to establish regional practices where all entities, both consumers and data-providers,

private and public, are able to interact and participate in a fully integrated and 'open' data environment.

Columbus and its partners have a longstanding commitment to ensuring data is accessible to its citizens, private partners, and other cities in order to fuel entrepreneurship and innovation across the Midwest. As an example, the Regional Data Lab for the Columbus Region integrates and aggregates data from a 15-county region that is home to over 2 million people. The lab has two prongs: a robust website serves as a portal to search data from multiple sources to support research, government and business; and a collaborative approach for governing the website to assure credibility and sustained support. The task force that helped design this capability recommended that the website include a data catalog, opportunities for public interaction, ready-made maps and tables, and a platform for sharing analyses. This website has already proven to be a catalyst for entrepreneurialism, building awareness around social issues, and supporting other value-added applications. MORPC administers the website with help from Columbus, OSU, business, and other multi-disciplinary partners familiar with health, infrastructure, and environmental data in the region.

We will expand this current asset into a truly regionally integrated, federated, open environment for data sharing that provides contributors and consumers a single interface point to access these resources. The database will go beyond current data sources to include the emerging data sources envisioned as a result of this project, and begin to identify the capacity needed for future data. As an example, both Columbus and ODOT collect and disseminate travel-time data acquired from equipment deployed by the City and the state, as well as data obtained from third-party providers. These data coupled with future data sources such AVL data from COTA, and vehicle probe data from the Smart Corridor connected vehicles, will also be integrated, and will serve as a model for how the remainder of these legacy and emerging data sources are federated. The number of other sources is too numerous to list, but as evidenced by the letters of support for this Smart City application, Columbus is well-positioned to achieve this vision and fully expects to expand this to include others not listed.

Accompanying this richer data set is the need to understand and react to this data in a continuously evolving and improving process. As is discussed in a future section, this data rich environment will implement and support a robust set of performance measures, aligned with our vision. This allows Columbus to evaluate and react to changing conditions in support of our vision.

We will look beyond traditional transportation data and include information about social and community programs, charities, and private resources to support our vision of the Connected Citizen strategy. Similarly, we will encourage and support private transportation providers, financial institutions, logistics firms, researchers, and third-party applications developers to interoperate in this same environment. Columbus cannot realize the Smart City vision alone, but is dependent on the support and investment of third-parties to help achieve these goals, and as such, will continuously strive to provide the data-rich environment to support this objective.

TARGETS, METRICS AND OUTCOMES

The Columbus Region is performance-driven and outcome-oriented with established targets to fully realize the long-term vision of the City identified in the 2015 - 2040 Regional Transportation Plan. In preparing this Smart City application, the City looked to these targets to ensure they would be directly supported by the proposed deployment project. We did not create new themes or initiatives simply to align with this application, but rather, we looked to the needs of the region and focused on helping solve those needs using Smart City approaches. These established targets include the following:

- ✓ Reduce the crash rate by 15% by 2035
- ✓ No disproportionate adverse affect on minority or poverty populations
- ✓ Reduce commuter drive-alone rate from 83% to 78% by 2035
- ✓ Increase the percent of population in urban areas within 3/4 mile from bus stop from 69% to 80% by 2035
- ✓ Increase the percent of population within 3/4 mile from bikeways from 62% to 80% by 2035
- ✓ Increase density of population and jobs within 3/4 miles of arterials from 4.1 to 6.0 people and jobs per acre
- ✓ Stay in air quality compliance through 2035
- ✓ Congestion levels no worse than today throughout the planning period
- ✓ 95% of pavement in acceptable condition by 2035
- ✓ Reduce structurally deficient, functionally obsolete bridges by 25% by 2035

In addition, as part of the Columbus 2020 goal setting process, the project team formed an initial list of potential evaluation metrics for each of the planned goal areas. These evaluation criteria will be monitored with data emerging from a variety of tools (GIS, MORPC travel demand models, health impacts, best practice research, etc.) as well as new tools emerging from the smart cities effort. Transportation projects will ultimately be tested against these set of criteria and citywide metrics to determine which best serve community needs. MORPC presently produces an annual regional Report Card, measuring the outcomes of these target performance measures, and with Smart City, will expand to include the additional targets.

Those additional targets to be specifically addressed by this initiative include:

- Number of additional jobs accessible by transit
- Number of low income residents able to take advantage of "new mobility" opportunities
- Efficiency and adoption of freight movement tools
- Reliability, use and utility for transit riders on the smart corridor
- Lower transportation costs as a percent of household expenses
- Less time commuting/less "down time" commuting

The specific target values will be developed as part of the planning and design process that accompany the deployment of the Smart City project, and will be developed in coordination with the broad partner team. We understand the importance of these metrics and evaluation efforts to USDOT, and will work to ensure that the data to support these metrics, along with those of the USDOT are met.

CAPACITY TO LEAD DEMONSTRATION PROJECT

Mayor Ginther has committed the City and its resources to lead this demonstration project. The Smart City Program Office will lead implementation efforts and coordinate the work of our region's best data and ITS technology vendors and manufacturers as well as private service providers. The Smart City Challenge is an exciting and massive undertaking and Columbus and its partners have demonstrated capacity to take on a project of this size and complexity, as shown in the following examples:

- ✓ Columbus is the only city of its size with an AAA bond rating from Moody's Investors Service, Standard & Poor's, and Fitch Ratings.
- ✓ Columbus and its partners have delivered recent major city capital projects on time and on budget. The Columbus Traffic Signal System (CTSS) project ($76.2 million) replaces all 1,250 signalized intersections within Columbus and Central Ohio Region, along with installation of 565 miles of fiber optic cable, and over 100 new or updated traffic flow cameras at CTSS sites. This system provides the ability for inter-jurisdictional communication enabling the sharing of video and traffic data and coordination of traffic signals between agencies. The city completed Phase A in 2012, construction of the City TMC in 2013, Phase B in 2015, and is on target to complete Phase C in 2016. The $11.6 million Phase C is being completed with $8.8 million of Congestion, Mitigation & Air Quality funds.
- ✓ Columbus and Columbus Metropolitan Housing Authority are demonstrating our continued interest in transforming neighborhoods, creating job opportunities, and providing enhanced mobility for residents through a $30 million 2013 HUD Choice Neighborhood Grant. Implementation of the grant will improve conditions for the Poindexter Village residents as well as other underserved populations on the City's Near East Side.
- ✓ MORPC successfully completed a nearly $1 million Sustainable Community Challenge grant from the US Department of Housing and Urban Development to integrate a local food system into Weinland Park, a low-income neighborhood.
- ✓ Over the last 10 years COTA has been awarded and managed over $25 million dollars per year of Federal and State Grant dollars. COTA's staff has demonstrated the capability to successfully implement major renovation projects, from design and categorical exclusion documentation, to procurement and construction, to contract close out and operations. There are no outstanding legal, technical, or financial issues that would make COTA's project high risk. The Authority has been awarded ARRA funds, Clean Fuels Discretionary funds, and State of Good Repair Discretionary funds allowing our projects to be completed successfully and on time.
- ✓ COTA has a longstanding history of working collaboratively with the Federal Transit Administration to develop and fund new transit services in the region. For example, COTA successfully completed a $1 million 2012 Clean Fuels grant from FTA to purchase a compressed natural gas (CNG) monitoring system, allowing the agency to monitor CNG fueling at its McKinley Avenue Operations Facility. The CMAX BRT project is currently in Small Starts project development phase of the Section 5309 Capital Investment program. The preliminary project cost is $46.8 million. $37.4 million from FTA's New Starts program, 80% of the project cost, has been recommended in President Obama's Fiscal Year 2016 budget.

RISK IDENTIFICATION AND MITIGATION

Columbus has committed resources to immediately launch the Smart City Program Office to manage this project and ensure timely and on-target implementation of the demonstration project. The Program Office will be responsible for the selection, conduct and evaluation of our proposed projects as well as business models used for each project when interacting with the private vendors and service providers. The Program Office will identify and rate key technical, policy, and institutional risks and determine appropriate mitigation by:

- ✓ Coordinating with our public, private, and university partners;
- ✓ Ensuring continuing, collaborative, and authentic community engagement and dialogue with our stakeholders;

- ✓ Assessing the risks associated with each project and determining an owner for each project;
- ✓ Monitoring each project for risks via a risk registry;
- ✓ Identifying institutional/regulatory challenges early and documenting lessons learned; and
- ✓ Interoperability and creating synergies between projects and other areas of the City.

The Smart City Program Office will use a standardized process to methodically assess risks and rate them (low, medium, high probability and low, medium, high impact) and regularly report on appropriate mitigation efforts. The program office will follow standard PMI, Project Management Plan (PMP) requirements with its risk register. The PMP as well as monthly reports will be publically available and provided to USDOT and to our Midwest sister cities.

STANDARDS, ARCHITECTURES, AND CERTIFICATION PROCESSES

Deploying ITS technology and related-systems is critical to achieving our vision of a smarter city. However, connected and autonomous vehicles have a need to interact with these increasingly advanced and robust ITS systems. That's why it's imperative that these systems are interoperable at a national level, allowing equipped vehicles, particularly those implementing the 5.9GHz Dedicated Short Range Communications (DSRC) technology, be able to travel from location to location and retain the same performance level expected from CV technology. The ability to achieve this end is predicated on the use and adherence to the standards and underlying architecture that has been painstakingly but thoroughly captured by USDOT under the Connected Vehicle Reference Implementation Architecture (CVRIA), and its supporting standards.

As a present advocate of these same deployment approaches, Columbus expects to continue to follow USDOT guidance for the use of Standards, Architectures, and the Certification Processes as an integral part of the overall deployment activities. As early as MORPC's 1999 Integration Strategy, The Central Ohio Regional ITS Architecture followed guidance prescribed in the National ITS Architecture (precursor to the CVRIA) and the recommendations provided by FHWA. This regional ITS architecture provides a framework for the integration and interoperability of ITS systems in the region. With the integration of Connected and Autonomous Vehicle technologies in the region, the CVRIA shall also be implemented as a foundation for this transformative technology. Presently, Columbus, along with MORPC and COTA, convene quarterly ITS committee meetings to closely coordinate current and future ITS capital projects so they can be integrated into MORPC's Regional ITS Architecture plan. With this Smart city work, this committee would be expanded to encompass a broader set of stakeholders to ensure interoperability in the region. Further, the City would also commit to participating in an even broader USDOT-led committee on this subject, sharing the documentation, successes, and lessons learned from our experiences.

COTA's ITS Product Manager and IT Director have received a certificate of course completion for Quick-Starting Your Regional Architecture Update Workshop that was presented by USDOT. COTA's project management methodology stresses thorough documentation during all stages of ITS project implementations.

Coupled with the adherence to the CVRIA, Columbus fully expects to deploy technologies and hardware that are certified to the USDOT sponsored standards and specifications. This includes in-vehicle and roadside CV equipment, as well as broader elements, such as the Security Credential Management System (SCMS).

COST SHARE, IN-KIND DONATIONS, AND PARTNERING

Columbus will leverage longstanding public and private cooperation efforts, such as the Columbus Partnership, to successfully accomplish our vision. Recent examples of cooperation, cost-sharing, and blended funding include Columbus 2020's Columbus Regional Logistics Council, which provided private donations to Rickenbacker Parkway Intersection. This was an Ohio Stimulus project, which included cost sharing between public and private sectors. To support the Heartland Corridor Double-Stack Clearance Project, Columbus, Licking County, and Franklin County with the Columbus Regional Airport Authority received a 2012 TIGER grant which included local public and private sector matches, including cash cost share and land donated by Norfolk Southern Railroad.

For this project Columbus will leverage federal funding, including the COTA CMAX BRT Cleveland Avenue project, currently in the FTA Major Capital Investment grants program pipeline and OSU's SMOOTH ITS Project, which was funded in part through a National Science Foundation (NSF) grant. The city and OSU plan to leverage the project experience and project staffing to implement a more robust demonstration of autonomous vehicles.

Columbus - Columbus will dedicate staff to the Smart City Program Office, procure vendors and contracts, manage contracts, project management, bid and manage the construction of installation projects. In addition, Columbus intends to allocate up to $8 million in new capital improvement funding (20% program match) over the life of the Smart City Challenge and continue funding the Smart City Program Office beyond the USDOT Smart City Challenge period of performance.

COTA - COTA will dedicate resources to coordinate the Smart City enhancements to its CMAX Cleveland Avenue BRT project, such as additional sensor infrastructure along the 15-mile route and WiFi and information kiosks at the 32 stations.

Experience Columbus – The region's visitor and convention bureau is allocating over $100,000 to develop our proposed connected visitor project, in support of enhancing the visitor experience.

AT&T and IBM Data Center – Both companies are committed to supporting Access to Jobs and Smart Logistics traffic condition projects and application development.

Large technology firms/Automotive industry – Columbus has reached out to potential vendors and technology firms for in-kind donations and participation in the project to demonstrate self-driving vehicles on a fixed route in the Easton area.

MORPC funding from its 5310 program could support our proposed Linden Neighborhood project where we are focused on using data with public and personal transit service providers to improve mobility and overall efficiency of such services in the Linden Neighborhood.

City of Barcelona/IDIADA – The City of Barcelona and IDIADA will provide lessons learned to Columbus and our technology partners on their private SMART City Experience in the EU.