District Department of Transportation

Smart DC

Making the District a Smart City

Submitted in response to the U.S. Department of Transportation's
Notice of Funding Opportunity Number DTFH6116RA00002
"Beyond Traffic: The Smart City Challenge"

Part 1 – Vision Narrative

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District Department of Transportation

Smart DC

Making the District a Smart City

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1. The Smart City Vision

The District of Columbia (the District) is working hard to better connect its communities, build economic strength, protect the natural environment, and maintain the safety and security of its infrastructure. But more progress is achievable, and a smarter, connected urban system shows the way forward for all of the District's residents and visitors. A new "**Smart DC**" is needed to address a multitude of challenges, including recent and future growth pressures, income disparities, and persistent congestion across modes of transportation.

The District has made substantial investments to lay the groundwork for transforming into a "smart city."[1] Smart DC focuses on collaboration across agencies and sectors in a strategic and inclusive way to address challenges and capitalize on the opportunities presented by 21st-century technology and best practices for city governance and management.

Looking Ahead to Smart DC

In 2045, the District's population has grown to almost 1 million residents, the largest in its history, and 63 percent more than 2010. Despite this growth, people get around to jobs, schools, museums, and the center of the federal government with minimal delays and without the loss of life. Time spent en route is productive for residents, workers, and visitors through a connected information system. Vehicles are routed around incidents and major events automatically, without the operator even realizing. Infrastructure is maintained in top condition because of automated feedback from roads, traffic signals, and transit vehicles, which automatically dispatches work crews and updates performance dashboards to support long-term decision-making.

1.1. Challenges

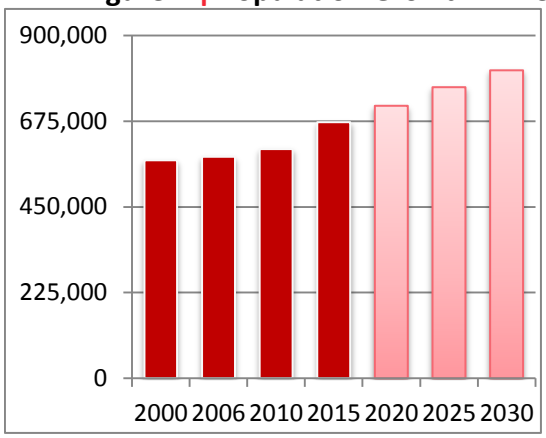
The District has **grown over 17% in the past 15 years** to an estimated 672,228 residents in 2015.[2] The Texas Transportation Institute's annual Urban Mobility Scorecard places the Washington region as **one of the most congested regions in the nation**, with 45 percent of peak vehicle miles traveled occurring in congested conditions.[3] Congestion affects and transit passengers in addition to drivers, with Metrobus speeds **averaging less than 11 miles per hour system-wide**.[4] Some bus corridors carry more than 20,000 riders daily, and these routes often experience crowding throughout the day, especially at peak periods.

Recent growth has brought prosperity, but it has also brought the District has **some of the greatest income disparity** of any city in the country. The top 5 percent of District households earn 54 times as much as the bottom 20 percent.[5] While the District has **high smartphone penetration rates**, with over 75 percent market penetration for smartphones, and 46 percent

[1] A smart city is "one in which information and communication technology facilitates improved insight into and control over the various systems that affect the lives of residents." Cuddy et al "The Smart/Connected City and Its Implications for Connected Transportation," (USDOT ITS Joint Program Office, 2014)
[2] U.S. Census Bureau, 2000 Decennial Census; U.S. Census Bureau, 2015 Population Estimates.
[3] David Schrank et al, *2015 Urban Mobility Scorecard*, (Texas Transportation Institute, 2015)
[4] Washington Metropolitan Transportation Authority (WMATA), "Evaluation of Bus Travel Speeds," (2010).
[5] Wes Rivers, "High and Wide: Income Inequality Gap in the District One of the Biggest in the U.S." (DC Fiscal Policy Institute, 2014).

for tablets as of 2013,[6] smartphones likely increase the "digital divide," with the smartphone dependent more likely to reach data limits or have phone service cut off because of financial constraints. Ten percent of Americans have a smartphone but no other way to access broadband internet services.[7] However, the high adoption rate is reflected in the transportation system, with over half of parking meter transactions now happening with the ParkMobile pay-by-cell system.

Figure 1 | Population Growth in DC



Sources: US Census, DC Office of Planning

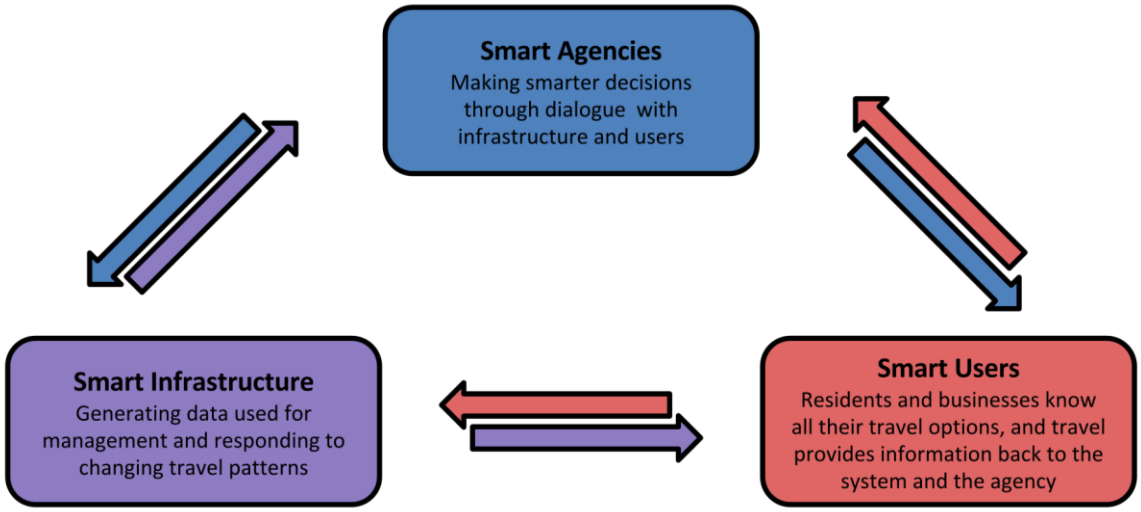
The District, as the seat of the federal government, also hosts **many large scale special events**. For example, over 1.8 million people attended President Obama's first inauguration in 2009, and on a daily basis, the District's streets carry motorcades, host rallies and other political events, and welcome over 100,000 visitors.

1.2. Meeting the Challenges

Smart DC emphasizes opportunities to connect transportation with the city's other systems, including communications, the built and natural environments, and the economy. The vision for Smart DC connects to the goals and objectives defined in section 11 and builds upon three key elements in alignment with initiatives across District government:

- Smart infrastructure
- Smart users
- Smart agencies

Figure 2 | Smart DC Elements



[6] "Top 10 Local US Markets by Smartphone and Tablet Penetration," *Marketing Charts*, 6 February 2014. http://www.marketingcharts.com/online/top-10-local-us-markets-by-smartphone-and-tablet-penetration-39623/.
[7] Aaron Smith "U.S. Smartphone Use in 2015" (Pew Research Center, 2015).

Smart infrastructure: Smart DC takes an expansive view of the District's transportation infrastructure, including travel corridors like roads or rails; vehicles like private cars, buses, and bikes; street furnishings like benches, trash bins, and streetlights; to the underlying public space. Unlike traditional infrastructure, smarter infrastructure communicates its status, maintenance needs, and interaction with the environment. Smart infrastructure also enables private users to use public infrastructure as data portals.

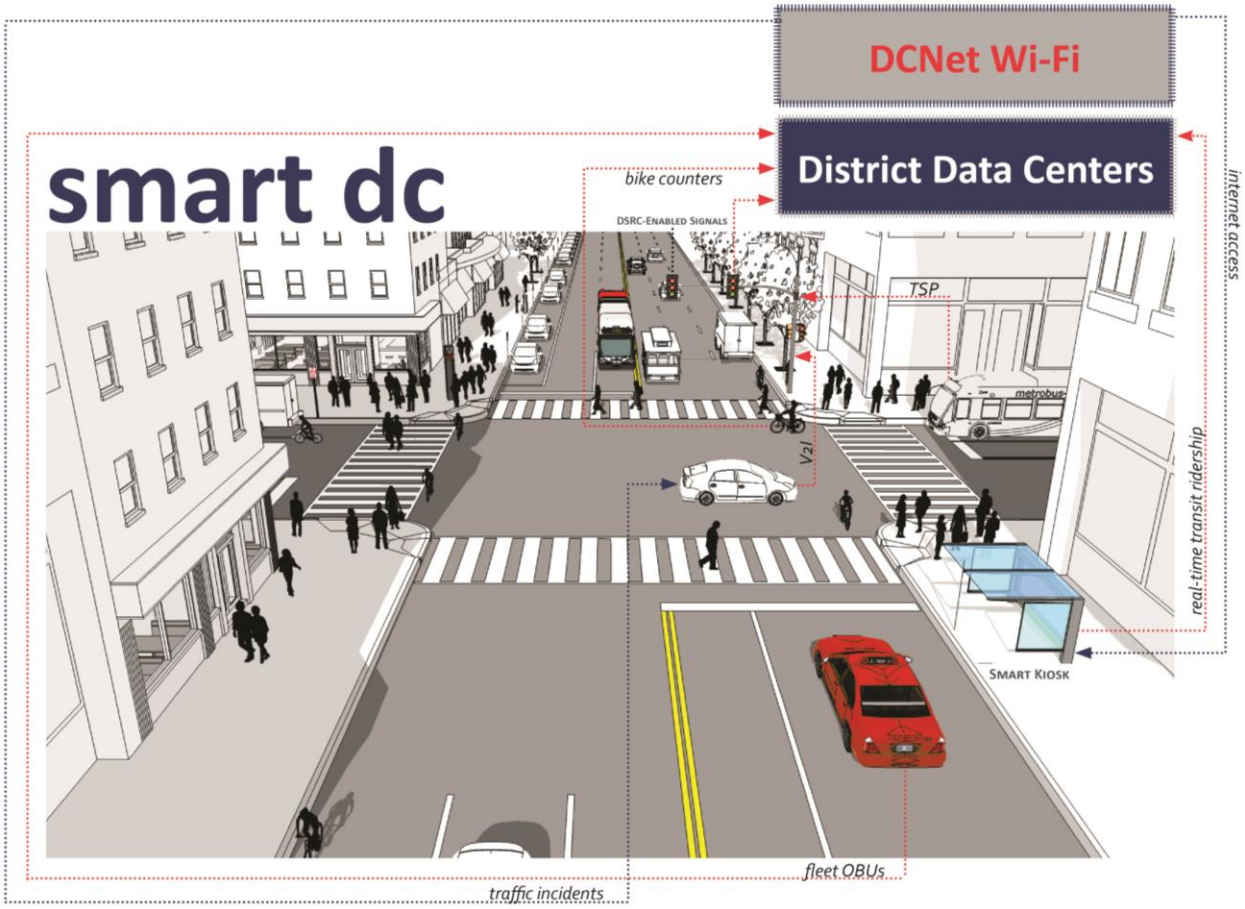
Like many cities, the District's transportation systems struggle to keep pace with technological changes and the growth of its population. In order to support one of the most highly-educated populations and workforces in the country, the District must implement 21st-century technological and infrastructure solutions today to continue to facilitate the city's progress and prepare for the future. Smart DC will deploy new and developing technologies, particularly in the connected and automated vehicle arena, which will make the District a trailblazer in embracing and integrating these technologies.

Smart DC will take an "asset lite" approach to acquiring real-time awareness regarding the operational status of the system. System users, such as pedestrians, bicyclists, and vehicles will communicate real-time information about asset conditions using state-of-the-art technologies. District fleet vehicles will act as probes to assess travel speeds and roadway conditions, crowdsourcing applications will be used for incident detection, and advanced data analytics will identify available on-street parking spaces. The asset lite approach also utilizes a single asset for multiple functions, such as in automated traffic enforcement cameras for traffic counts, parking availability, and incident verification. Information about asset condition and system operations will combine from several sources to limit the need to deploy single-purpose assets and to increase system redundancy.

Smart users: Smart citizens are empowered citizens. The District envisions a city in which its residents, businesses, workers, and visitors are engaged in making their city a better place, by using connected devices and communication tools. Today, many District travelers already use technology-based solutions to improve their transportation experience, with applications like pay-by-cell for city parking, SeeClickFix to report infrastructure in need of repair, and RideDC for multimodal trip planning. Smart DC will link with the District's Connect DC initiative aimed at bridging the digital divide to ensure that residents and visitors will not need a smartphone to participate in the smarter city, while also enabling smartphone users to maximize data access through the transportation systems.

Citywide wireless internet service will facilitate mobile device usage, but new smart infrastructure will also enable resident and visitor feedback, trip planning, and diffusion of information. Connected private and transit vehicles, bikeshare, and communication and transportation infrastructure will be available for all travelers. Users will also be involved in new ways to gain situational awareness and find solutions to city issues through crowdsourcing and other means. In Smart DC, residents and visitors will improve the places where they live, work, and play, and will not be constrained by the capabilities of government agencies.

Figure 3 | Smart DC on the Street



Smart agencies: Fundamental to the implementation of Smart DC is smart leadership. Leading this effort is the District Department of Transportation (DDOT). As a smart agency, DDOT embraces innovation culture to make better plans and better decisions, and Smart DC investments will allow it to nimbly engage citizens and more quickly implement optimal infrastructure. The smart, connected city will supply the District government with a regular flow of rich, meaningful data, allowing DDOT and partner agencies to analyze the transportation systems, and identify and proactively respond to the needs of its users. A smarter DDOT, along with partner agencies, including the District's Office of the Chief Technology Officer (OCTO) and the Washington Metropolitan Area Transit Authority (WMATA), will leverage the assets of both smart infrastructure and smart users to implement smart technology.

How the Elements Interact

The strength of Smart DC lies in the connective tissue between each component. Smart DC envisions a city that is not only "smart" but also "connected" through several components:

Data: The principal currency of Smart DC is data: each element of the smart city is both a generator and consumer of data. Each data system will be closely integrated with networks throughout the city, while also being aware of data privacy needs. The District is already establishing standards in its draft Open Data Policy, which will ensure both the transparency and security of the data the District collects (further detail in Section 9).

Feedback and adaptation: Better information will lead to faster and more effective change by each component in Smart DC. Information from smart infrastructure will feed back to transportation system management centers. This will in turn lead to smarter and more responsive information for users of all modes, with benefits like better transit information at stations and bus stops. With communication between all the region's data systems, users and institutions will be better prepared for and assisted during emergency events.

Looking Ahead to Smart DC

The region is 12 hours into a 28-inch snowstorm. The blizzard snarls traffic on main routes, and many roads are treacherous. A 911 call comes in—there's a four-car crash with severe injuries. The smart dispatch system fuses data on existing congestion and roadway conditions from snow plows, and dynamically routes first responders through the best available routes. Police and Emergency Medical Services get signal priority en route to the incident site and the hospital. Response time is cut in half. Two lives are saved.

Equity: Ultimately, interconnections among smart agencies, smart infrastructure, and smart users will maintain and improve mobility throughout the region, and provide added accessibility. In Smart DC, transportation system will better connect citizens with the broader economy thanks to faster, more reliable transit and a safer transportation network overall. The District's government will expand its current robust outreach and education offerings to help residents, visitors, and businesses better understand how Smart DC can benefit them and evolve to meet their needs. With an existing established transportation demand management program, goDCgo, the District is well-positioned to demonstrate the Smart DC elements and how they work together. The proposed One Call-One Click system will ensure access for travelers of all ages and abilities.

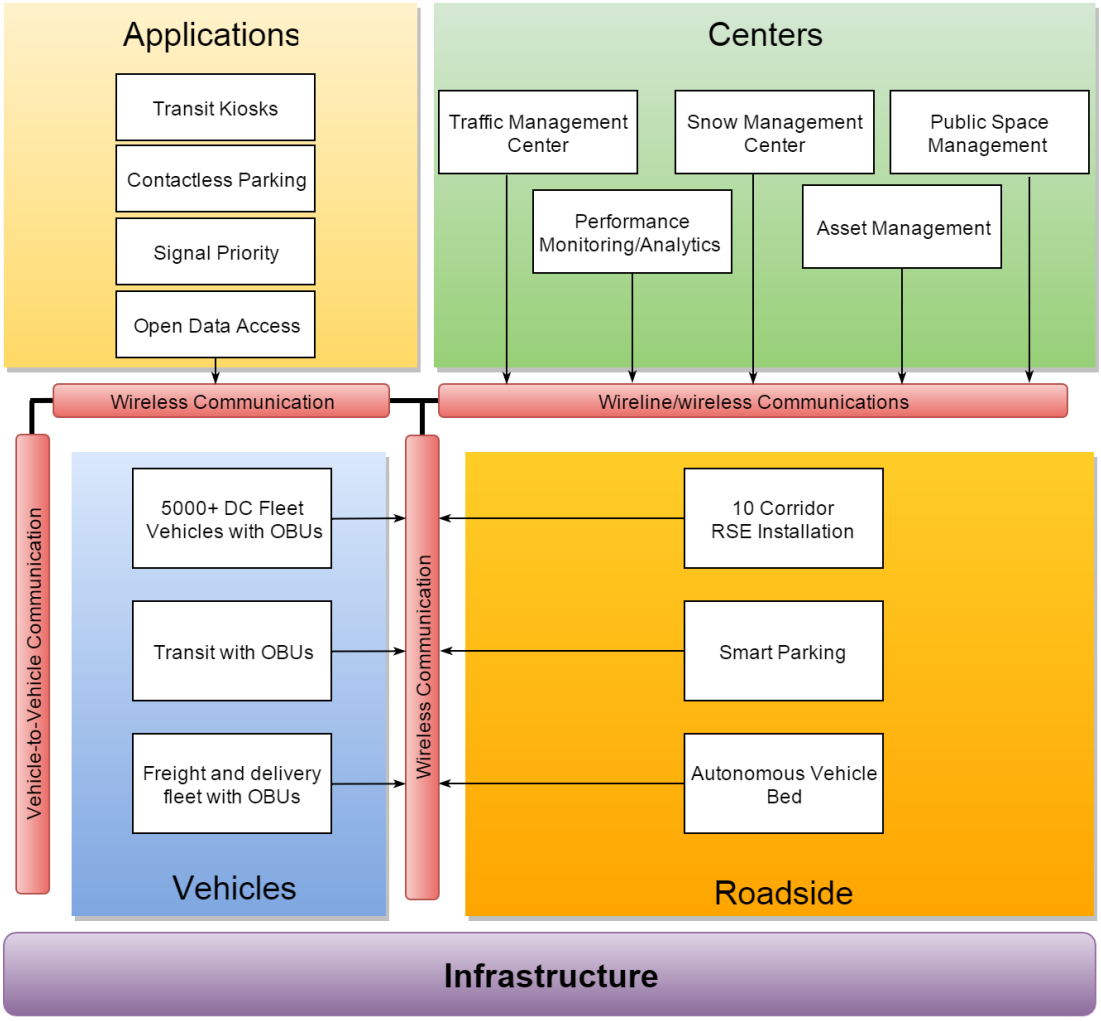
Access to Opportunity: The Smart DC vision transcends transportation. With smarter ways to get around, the District will make progress in many of the economic goals identified in the US Department of Transportation's (USDOT) Ladders of Opportunity initiative. This will lead to more sustainable land use choices, an engaged and productive workforce, and revitalized communities.

1.3. Smart DC Investments

Smart DC is a comprehensive approach to smart city deployment that leverages assets and data to improve agency operations and the quality of service delivered to residents, workers, businesses, and visitors. Smart DC is rooted in four basic categories of implementation:

- **Roadside and roadway infrastructure** that communicates with individual vehicles and transportation systems, as well as providing users with communications access.
- **Vehicle-based infrastructure** on both public and private fleets that communicates with roadside systems and transportation management centers.
- **Transportation management centers and organizational investment** that take in data and prioritize agency and asset management while communicating real-time information to end users.
- **Data and User-based infrastructure** that provides access portals and real time information to individuals and businesses.

Figure 4 | Pilot Infrastructure Diagram



As a first step toward achieving the Smart DC vision, this proposal outlines pilot projects to demonstrate the benefits that a better-connected city can bring. This vision will be realized through investments that serve as building blocks for citywide expansion through three iterative cycles: deployment, integration, and evaluation.

Deployment: Smart DC will deploy new technologies through roadside equipment (RSE) in the downtown area and along selected major corridors (identified in Section 4) and through on-board units (OBU). The RSE, such as dedicated short range communication (DSRC) units, will be installed and integrated per USDOT Intelligent Transportation Systems (ITS) architecture and using the latest standards. Transit signal priority (TSP) is already in place on nearly 100 signals and will expand to 195 signals by summer 2016, accounting for approximately 12 percent of all traffic signals in the District.

The infrastructure will be available for the public, vendors, and auto manufacturers to evaluate their equipment during the Smart DC pilot. RSE will broadcast alerts so that early adopters have a safety and travel incentive to adopt the technology. Features available to early adopters will include traffic signal warnings, curve speed warnings, pedestrian crossing warnings, and red

light violations. The District recently piloted a project during the 2016 Washington Auto Show to provide Signal Phase and Timing (SPaT) through a central server to auto manufacturers to improve safety at signals and improve emissions by turning off engines.

Leveraging the current Federal Highway Administration (FHWA)-funded parkDC "smart parking" pilot, additional RSE will be installed to monitor parking space occupancy, allowing travelers or vehicles to identify blocks with available spaces and DDOT to adjust parking prices so demand is better reflected. Expanded RSE for loading zones will enable enforcement and monitoring of freight parking to reduce double parking and communicate to users. This will enhance the parking experience in the central business district and provide seamless integration with the rest of the RSE.

Smart kiosks will be installed at existing bus shelters, Capital Bikeshare stations, and Metrorail entrances along the most important corridors for real-time travel information, emergency alerts, ticket vending for off-board fare collection, and access to city services. To ensure equity of service, the kiosks will be available to residents and visitors alike, and will provide free public wifi. Smart kiosks will also act as feedback centers for pedestrians, allowing DDOT to understand pedestrian patterns at important locations and better plan for services during peak hours and special events.

DDOT is partnering with several DC agencies on a pilot project which will include the installation of small cell antennas in places that enhance the in-building-wireless service levels for use in and around the building. The proposed pilot would begin with certain District government buildings in the near future. Broader deployment will follow, if successful, and further expand the reach of free public wifi.

An autonomous vehicle testbed with enhanced capabilities will be built to enable collaboration with the private sector for testing the latest technologies. DDOT has already installed limited autonomous vehicle test facilities in an urban environment for specific users, but Smart DC will broaden this infrastructure to a wider area.

The District already has OBUs installed on District taxis, and through Smart DC will expand installations, in partnership with both public and private vehicle operators, on fleets such as transit vehicles, Capital Bikeshare bikes, and freight delivery vehicles.

Integration: The pilot project implementation will be aided by past work acquiring technical know-how, engaging stakeholders, and public outreach. Data from RSEs and OBUs will be integrated into DDOT's existing management centers, including the Traffic and Snow Management Centers, and integrated into public space management systems, asset management systems, and system performance monitoring. The integration of higher-end data analytics capability as well as usage is fundamental to DDOT's smart city endeavors.

The data generated from Smart DC will feed back to a smarter traffic management center and be used to develop detailed analyses of travel time, delays, and other performance metrics. Better data fusion will lead to a comprehensive picture of the transportation system. New tools will allow analysts to overlay permits, traffic, truck routing, and asset management systems to provide real-time updates to employees and external users. Smart DC will provide an impetus to integrate all the generated data into a single unified platform. DDOT currently is leading a

study to identify opportunities to address multimodal congestion and measure overall transportation system performance. The study will result in a public-facing web-based visualization tool that can be built to incorporate additional data coming from Smart DC installations.

Evaluation: The District is committed to data-driven decision making. The Smart DC program will have a substantial evaluation component, grounded in DDOT's research partnership with a regional college and university consortium led by Howard University. This consortium conducts research projects for DDOT and connects students to career opportunities in transportation.

DDOT believes that open data leads to better evaluation. In addition to the generated data, all the design files, installation methodologies, and quality control issues will be available online for public use. These will be made available via real-time data feeds, which can be utilized by public and private partners. Additionally, all the software and algorithms developed during the Smart DC pilot will be open source and available for public participation through the District's GitHub page and USDOT's Open Source Application Development Portal. All the real time data from existing and proposed sources will be made available to data scientists to aid in app and service development by private partners.

The District has already taken a step in this direction by publishing real time traffic signal data for interested parties to develop applications. The District sponsors regular hackathons and other contests with data scientists and enthusiasts to develop a hacker culture using government data, facilitating a vibrant dialogue between agencies and users. The Smart DC pilot will further enhance this process by providing more real-time data, Internet of Things software development kits (SDKs), access to connected vehicle infrastructure, and other interesting scenarios. These projects will be coordinated and convened through the Smart DC partnerships liaison.

The strength of the Smart DC pilot is found in the project's commitment to data collection, management, and analysis, which involves deployment of multiple interconnected data centers. The Smart DC pilot will be a cross-cutting effort, improving the transportation experience for all modes in the District, including people walking, biking, taking transit, or driving personal vehicles, delivery trucks, or vehicles for hire.

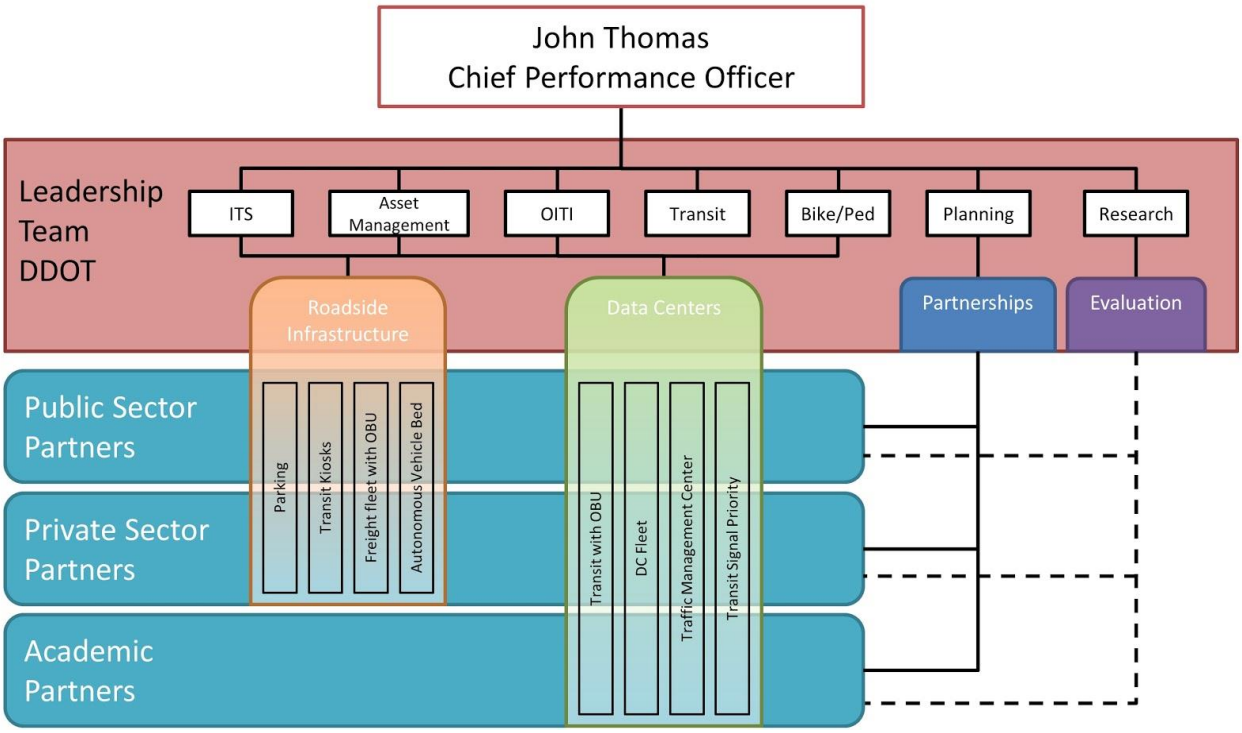
1.4. Program Management Approach

DDOT will build on existing structures and procedures to manage the Smart DC pilot project. The agency anticipates using a standard systems engineering approach, supplemented with strong integrated relationships within DDOT and with partners.

Implementation will be led by DDOT's Chief Performance Officer (CPO), John Thomas. As CPO, John oversees agency performance and the agency's Office of Information Technology and Innovation (OITI). Prior to becoming the CPO, John led DDOT's Urban Forestry Administration, where he oversaw the geocoding of all of the District's 150,000 street trees to automate daily work and integrate resident feedback, the use of LiDAR scans to document and track tree health, and the creation of the innovative "Canopy Keepers" program to enlist citizen volunteers to maintain the District's tree canopy. John will coordinate a cross-agency leadership team in the implementation of Smart DC, including DDOT's ITS, Parking, Research, Planning,

Policy, and Asset Management divisions. John will also coordinate a broader set of agency and private stakeholders from across the District to implement Smart DC.

Figure 5 | Pilot Program Management Structure



Implementation of the Smart DC pilot project will advance over a four-year timeline, as detailed in Table 1.

Table 1 | Smart DC Timeline

	2016				2017				2018				2019				2020			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Partnerships																				
Initial industry notification																				
Formalization of core partnerships																				
Infrastructure																				
Define and schedule deployment					*															
Install RSE in pilot areas							*													
Install OBU in fleets								*	*											
Install smart kiosks								*			*	*								
Integration and Data/Analysis																				
Integration of data into smart centers									*											
Performance metrics				*																
Benchmarking data								*				*				*				
Evaluation																				
Establish evaluation consortium																				
Project-level evaluation reports																				
Program-level evaluation reports																				

Planning and coordination
Major deliverables *

The District can point to past successes in speedily managing and coordinating high-visibility projects among a multitude of stakeholders, such as its administration of USDOT grants made through the American Recovery and Reinvestment Act. District leadership as a whole is providing solid backing to DDOT for this initiative, and, as outlined within Section 3, this leadership positions DDOT for success in implementing new smart city technologies. The District is also on sound footing to leverage the resources of private firms to execute critical components of Smart DC. In December 2014, the District Council enacted the "Public-Private Partnership Act of 2014," which authorizes the District to review opportunities in which a private entity would perform one or more functions normally undertaken by the government.

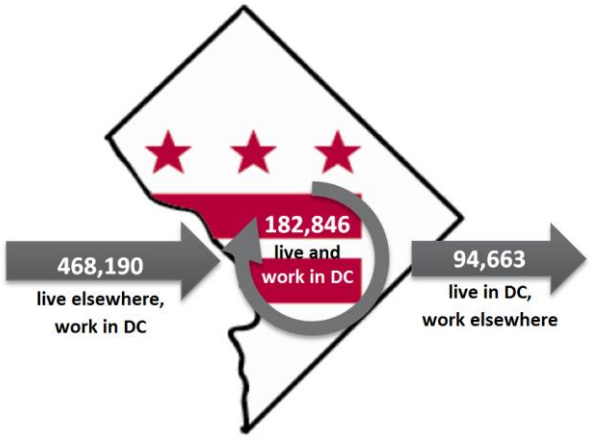
2. Population Characteristics

The District's continually growing population, along with its other characteristics, distinctly qualifies the District as the ideal city for the Smart City Challenge. As of the 2010 Census, the District had 601,723 residents, a 5.2 percent increase from the 2000 Census count. By 2015, the US Census Bureau estimates the District's population had grown to 672,228, representing almost 12 percent growth in the past five years.

The District's population density is moderately high, with 9,857 people per square mile of land area as of the 2010 Census, with over 11,000 people per square mile estimated for 2015. This density level ranks in the top ten for large US cities.

According to 2015 population estimates, the District is currently home to 13.7 percent of the urbanized area's population, but during the workday the population of the District surges with a net daytime inflow of 339,836 commuters, increasing the share of the urbanized area population to 20 percent.[8]

Figure 6 | District Employment Flows



Source: US Census, OnTheMap Application

The District can serve as a model for a range of other cities because of the land use patterns, position within the region, as well as national presence. The urban core of the city and inner neighborhoods with mid-rise housing form a big city environment, but the historic and outlying neighborhoods resemble those of mid-size and smaller cities, with row houses and detached single family. The District's street grid is fine-grained and a mix of uses predominates throughout the city, typically creating small commercial strips near housing. The ideals of smart growth are largely realized in the District. This landscape provides a pragmatic setting to apply new smart city ideals in an urban setting.

Land use and development patterns of the District support high levels of transit ridership, walking, and biking. As of 2014 estimates, almost 60 percent of District residents commuted via modes other than the personal car. The compact nature of the city and the diversity of

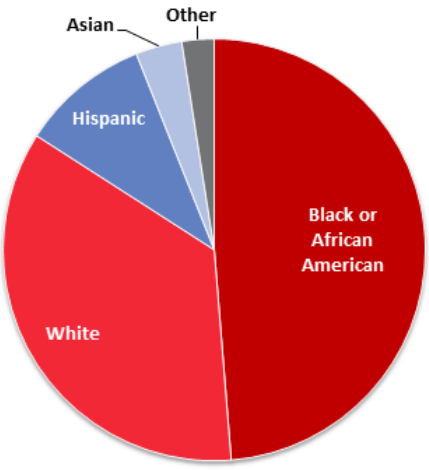
[8] US Census Bureau, OnTheMap Application (2015).

transportation choices already in use make the District an ideal location to test the implementation of smart and connected city concepts.

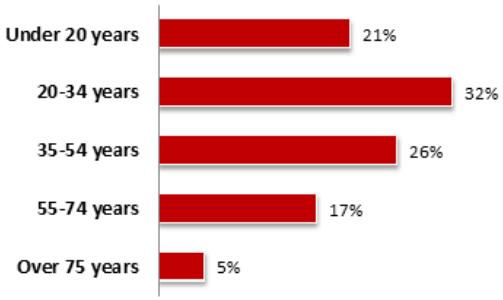
Smart DC will help the District use transportation investments to create pathways to the middle class and support the existing low- and moderate-income population. Recent population growth has impacted housing affordability and accessibility for low- and moderate-income households. In the District, 64 percent of the lowest income residents and one-third of families with incomes up to $54,000 devote at least half of their income to housing.[9] While the District's extensive transit system enables these residents to save on transportation costs, the District must continue to address ways to bridge the economic and digital divide.

Figure 7 | District Demographics

Race/Ethnicity of District Residents



Age of District Residents



Source: US Census, ACS 5-Year Estimates

3. Smart City Characteristics

3.1. Existing Public Transportation Systems

The District has robust public transportation systems. The primary transportation agency is WMATA, which provides Metrorail, Metrobus, and MetroAccess services. Additionally, the District funds the operation of the seven-route DC Circulator bus system, and will soon open the first DC Streetcar line. More than one third of District residents commute to work via transit, and the District now provides free transit rides to all District public and charter school students through high school. Additionally, the District is served by commuter rail services provided by the Virginia Railway Express (VRE) and Maryland Area Regional Commuter (MARC), as well as intercity travel by rail (Amtrak), bus (various private operators), and air (Reagan National and Dulles airports).

Along with neighboring jurisdictions, DDOT operates the Capital Bikeshare system, which functions as another regional transit system that serves over 10,000 rides daily, and has almost 30,000 annual members. Capital Bikeshare was an early pioneer in providing open data and has leveraged private interest in the system into improved approaches to rebalancing bicycles and better customer experience.

DDOT collaborates closely with WMATA and other regional partners to further the effectiveness of these transportation systems, and anticipates implementing smart solutions across agencies. This will allow smart investment within the District to spread functionally and intellectually. DDOT, WMATA, and other regional stakeholders are currently working to implement off-board fare payment or fare collection systems along high-ridership bus corridors, potentially through a public-private partnership (P3). Further, unified fare payment

[9] Wes Rivers, "Going, Going, Gone: DC's Vanishing Affordable Housing," (DC Fiscal Policy Institute, 2015).

technologies have been proposed. This initiative would be leveraged by the Smart DC program to implement transit kiosks with broader functionality, including wifi access.

3.2. Past Demonstration Projects

DDOT is an innovative agency that strives to advance the state of the practice in urban transportation and is no stranger to demonstrating progressive transportation approaches. DDOT has recently deployed several new technology initiatives that have proven successful throughout the city, including the Advanced Transportation Management System (ATMS), the RideDC Portal Dashboard, and the Transportation Online Permitting System (TOPS). The ATMS is a comprehensive system that leverages technology to improve traffic safety and enhance mobility by using real-time traffic data from cameras, speed sensors, probe vehicle systems, and external data sources to appropriately manage traffic. The ATMS is also capable of generating incident response plans and serves as a platform for implementing the plans to improve traffic flows within the District. RideDC is a customized, web-based tool that allows users to easily create their own dashboard that displays a dynamic map of transit options and arrival times near their desired location, such as a local business. TOPS is a one-stop online system that enables users to apply for any type of permit required for use of the public space within the District.

In addition, DDOT has a federally- and locally-funded research program that has supported the development of a number of tools that are now fully deployed, including snow plow tracking (available at snowmap.dc.gov), countdown pedestrian signals, stormwater management tools, and parking pricing. Current research projects include microsimulation to support TSP deployment in the urban core, a variable pricing pilot for parking in Penn Quarter and Chinatown, and several Strategic Highway Research Program 2 (SHRP2) Implementation Assistance Program grants. One such SHRP2 Implementation Assistance Program grant will support migrating to three-dimensional utility mapping in coordination with a major power line undergrounding project underway.

The District has also demonstrated the use of both autonomous and connected vehicles on its city streets and is one of a handful of jurisdictions with authorizing legislation already in place to permit autonomous vehicles to operate on its streets. DDOT is currently partnering with car manufacturers to share signal timing information for developing eco-friendly vehicles.

DDOT is in the final stages of implementing TSP at its portion of over 300 locations regionally through TIGER funds awarded to the Metropolitan Washington Council of Governments (MWCOG). The deployment of this technology has required the same type of regional collaboration on hardware and implementation decisions that will be needed to successfully implement Smart DC. Technologies like these, along with the willingness to approach progressive and innovative concepts, show that the District is a viable environment to demonstrate smart strategies. The desire to innovate is present throughout the agency and has strong support from leadership.

3.3. Leadership

The District is prepared to make a major investment to become the leading smart city in the United States. Under the leadership of Mayor Muriel Bowser, the District is committed to advancing the proposed pilot projects and utilizing best practices to implement them

throughout the District. The existing institutional framework will allow the District to capitalize on the Smart City Challenge opportunity. The District's commitment to innovation is exhibited by the creation of the Director of Technology Innovation position for OCTO. Mayor Bowser took office in January 2015 for a four year term, so there will be consistent political leadership throughout nearly the entire anticipated life of the grant.

> *"…the District of Columbia is answering the call to create innovative solutions to address the challenges we face as a city. [We] will use technology to improve the way we work and serve residents—delivering better access and transparency across District government. [Our] work will be critical in our efforts to expand opportunity and create more pathways to the middle class."*
>
> -Mayor Bowser, May 2015

The Deputy Mayor for Planning and Economic Development has made the digital city a core strategy of economic and real estate development, with the planned development of an Innovation Hub on the St. Elizabeths East Campus. The first investment of the R.I.S.E. Demonstration Center has already helped to link the surrounding community, including some of the lowest income areas of the District, with technology sector opportunities.

The District has also shown leadership in investing in technology sector business incubation. The District invested $200,000 in 1776, a tech startup incubator based in the city. The incubator now works with hundreds of startups, many of them in the transportation sector. Smart DC will build additional partnerships around infrastructure and data on the basis of existing ones.

Within DDOT, the Smart DC leadership team will provide ongoing institutional support, and organizational investments will be made as the initiative progresses. As noted in the program management structure (Figure 3), the agency will draw support from a number of key agency groups, all of whom have a history of developing and supporting successful pilots and full deployments of new technologies.

3.4. Sharing Economy

The District has been an early adopter and supporter of the sharing economy in transportation in particular. This innovation has been driven by the District's residents' needs: over half of District residents commute by means other than their personal automobile (only 40 percent of workers drive alone or carpool) and over one-third of its households do not own a vehicle.[10] In this context, there is a need for alternative approaches to getting around.

DDOT piloted its first bikeshare program in 2008 and launched the successful Capital Bikeshare program in 2010. Carsharing services have been present in the District for over 15 years and the District was one of the early markets for these services. Zipcar, an early carshare operator, opened its second location in the District in 2001, and the District was the third US city to bring in car2go point-to-point carshare in 2012. In four years, car2go has grown from 200 vehicles to 700 and now counts one in twelve District residents as a member. Today there are both traditional and point-to-point private providers operating within the District, several of whom use on-street spaces provided through agreement with DDOT. DDOT has strong relationships

[10] U.S. Census Bureau, 2010-2014 American Community Survey 5-Year Estimates.

with its carshare providers and has innovated performance metrics for the use of on-street spaces as part of those agreements.

The District is also a strong market for transportation network companies (TNCs). In addition to the major national platforms, Uber and Lyft, the District has a local startup, Split, and is the second market for Bridj. Notably, both of these latter services are focused on shared rides, which the District's demographic and geographic characteristics help support. The District has already begun conversations with the TNCs and the DC Taxicab Commission to pursue data sharing, and other projects could follow.

3.5. Open Data

The District is fully committed to making its data accessible to the public, in particular through its open data web site at opendata.dc.gov. The District has taken steps to ensure that its data is open and discoverable in the hopes of fostering greater public participation and collaboration. By instituting an active open data policy, the practices of the city are grounded in dynamic principles including transparency, collaboration, openness, and discoverability.

The District is also utilizing open source technology to increase public access to the stream of information it creates and receives from agencies and partners throughout the city. Smart DC will build on these foundations of 21st-century technology to allow residents, commuters and visitors to make more informed decisions about their government and community.

4. Pilot Project Site Map

To initiate Smart DC, pilot projects will be executed concentrating on the USDOT's three top technology priorities for the Smart City Challenge—urban automation, connected vehicles, and intelligent, sensor-based infrastructure—across targeted geographic areas. The pilot projects will be focused in the core area, as well as other key corridors around the District, chosen according to following criteria:

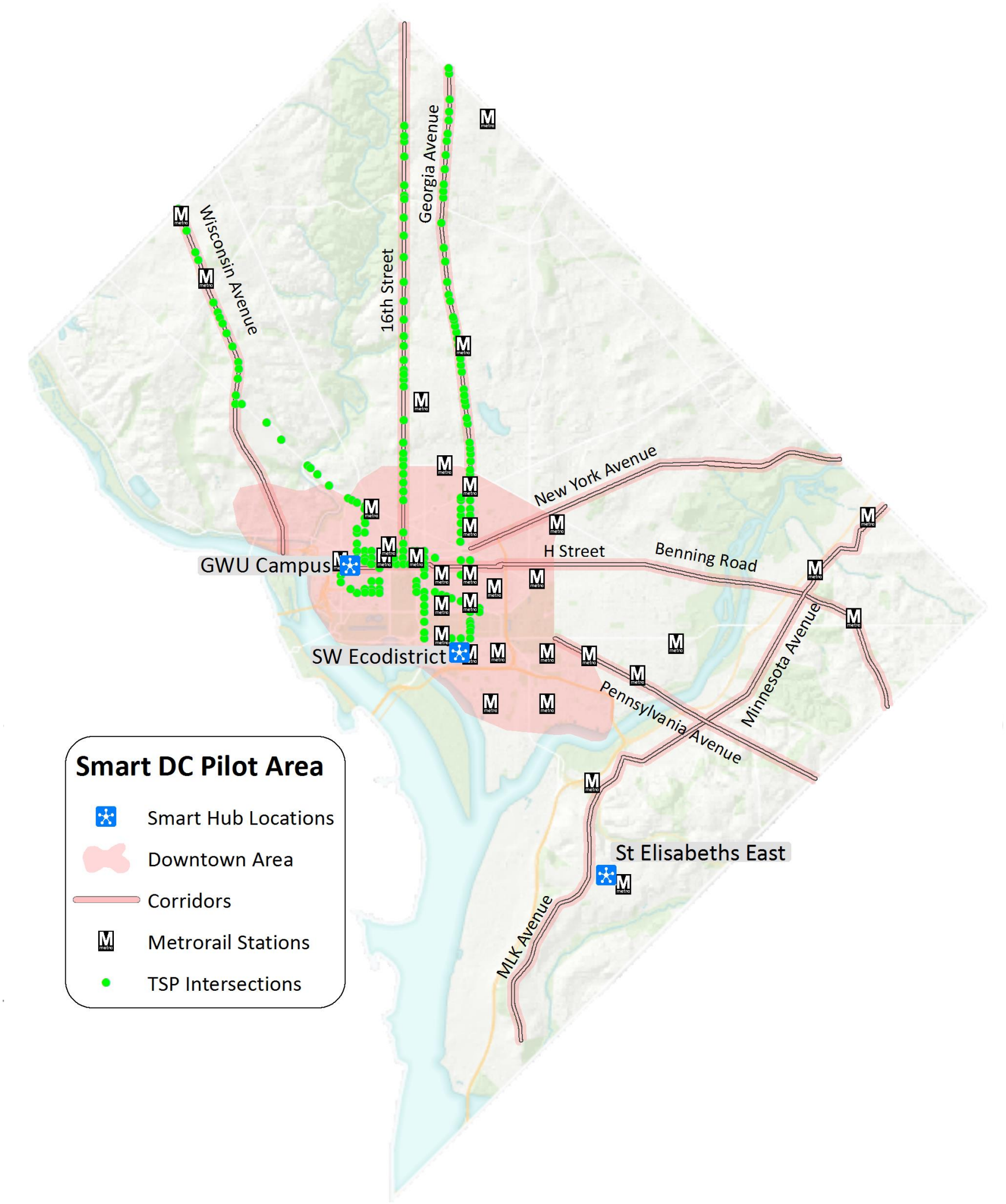
- Building on existing capital projects or planning initiatives.
- Identified in the District's Long-Range Multimodal Transportation Plan, moveDC, as supportive of high-capacity transit.
- Identified in the District's Vision Zero Action Plan as "high fatality" corridors.
- Representative of geographic, demographic, and economic diversity through inclusion of all eight Wards of the District.

Based on these criteria, Smart DC will focus on the downtown area and the following corridors:

- 16th Street
- Georgia Avenue
- H Street/Benning Road
- New York Avenue
- Martin Luther King Avenue/Minnesota Avenue
- Pennsylvania Avenue
- Wisconsin Avenue

The Smart DC pilot area includes 36 of 40 Metrorail stations in the District as well as diverse residential and business areas. In addition, the George Washington University (GWU) campus, the Southwest Ecodistrict, and the St. Elizabeths East campus will serve as "Smart Hubs," hosting Smart DC applications, as well as other smart city elements beyond transportation, addressing sustainability, health, and other fields. Smart city deployments in these locations have already begun and they possess institutional support for further research and testing.

Figure 8 | Smart DC Pilot Areas



5. Alignment with Smart City Vision

Table 2 | Vision Element Alignment

Vision Element	Smart DC Approach	Existing Investment	Proposed Investments	Impact and Linkages
#1 Urban Automation	Public sector policy changes and infrastructure investment to enable private sector innovation	Pilot automated vehicle test routes	•Automated vehicle test-bed •Self-driving vehicles to provide a transit alternative for seniors and disabled	Enhance safety, mobility and accessibility opportunities
#2 Connected Vehicles	Public sector infrastructure investment to enable private sector innovation	TSP installation on major corridors and central business district	Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications	More responsive intersections and street network, reduced congestion, efficient transportation options
#3 Intelligent, Sensor-Based Infrastructure	Public sector-led implementation of DDOT's 2013 ITS Master Plan with open data for private users	•In-ground roadway sensors •Pedestrian and bicycle sensors and count stations •ParkDC pilot parking occupancy sensors	OBUs on District and private fleet vehicles to enhance operations understanding	•Open data on transit system performance •Input for data centers •Real time and long term monitoring for maintenance and improved operations
#4 Urban Analytics	Open data policy for real time responses and long term data analysis and planning. Setting up new transportation management centers or new Smart Center.	•Open data for Capital Bikeshare, safety, etc. •Multimodal congestion study building on RITIS platform •DDOT Traffic Management Centers •WMATA Operations Control Centers • Metropolitan Area Transportation Operations Coordination (MATOC)	•DDOT Single-Window System (TIES) for data feeds •Integrated Transportation Management Center •Existing Traffic and Transit Management Centers •Asset Management Systems •Public Space Management •Snow Management System	Measure performance of transportation network with new policies, performance measures and sensor-based demand responsive infrastructure

Vision Element	Smart DC Approach	Existing Investment	Proposed Investments	Impact and Linkages
#5 User-Focused Mobility	•Market for private providers, such as TNCs with low barriers to entry •More options for senior and disabled transit users	•Waze partnership •RideDC portal	•Wifi enabled transit kiosks •ParkDC real time data •Multimodal Congestion Management Study	•Sensor feedback provides improved reliability •Mobility solutions more efficiently respond to demand
#6 Urban Delivery and Logistics	Public sector coordination with private sector	•Enterprise Routing System •Off-Hours Delivery Pilot	Sensor-based commercial vehicle parking occupancy	•Sensor feedback provides improved reliability •Reduced congestion due to improved coordination
#7 Strategic Business Models and Partnering Opportunities	•P3 opportunities for infrastructure investment and evaluation •Ongoing partnerships with universities	Partnerships with urban innovation sector in, and program management for parking meters	Expanded partnerships with urban innovation sector, including infrastructure delivery	•Allows the District to tap into latest research and adopt cutting-edge technologies •P3 partnerships complement District resources
#8 Smart Grid, Roadway Electrification, and Electric Vehicles	Public sector facilitation of private sector investment	•Vehicle charging stations in public and private space •Pavegen kinetic pavers green energy demonstration project	•Connected EV charging stations with kiosk info-hubs •Develop apps to check status and easily locate available charging stations •Differential pricing of peak/ off-peak power demand for charging stations	•Convenience of kiosk info-hubs and apps will remove barriers for car owners •"Cheaper/dynamic charging rates will balance demand while continuing to be asset lite
#9 Connected, Involved Citizens	Crowdsourcing and deep public engagement in transportation management processes	•Open Data Policy •DC-Net free public wifi •Ride DC portal •Vision Zero crowdsourced safety map •Capital Bikeshare crowdsourced expansion •SeeClickFix	•Expand DC-Net public wifi •Transit kiosks •Open data for app development •One Call-One Click for paratransit and senior mobility	•DC-Net free public wifi will generate more data •User-generated data will result in mobility solutions that are more efficient, responding to demand

Vision Element	Smart DC Approach	Existing Investment	Proposed Investments	Impact and Linkages
#10 Architecture and Standards	Public-private coordination on protocols and policy	•TSP deployment •Engagement in National Association of City Transportation Officials (NACTO) autonomous vehicle working group, coordination with USDOT	•Standardization of asset lite approach •Follow WAVE protocol to send TIM, SPaT, and MAP messages from DSRC to OBUs	•Asset-lite approach will reduce cost of full-scale implementation. •Standardization allows inter-jurisdictional mobility and data sharing for analysis.
#11 Low Cost, Efficient, Secure, and Resilient Information and Commun-ications Technology	Public-private collaboration to provide more efficient and seamless mobility options	•ATMS •TOPS •Capital Data	•One Call-One Click for paratransit and senior mobility •Partner with private software firms and universities to develop best practices in collecting secure and non-invasive data	Improved mobility options because of coordinated service by TNCs and District agencies that provide paratransit service
#12 Smart Land Use	Public leadership in vision setting and community engagement	•Existing transit-oriented development pattern •8-year effort to update zoning code completed in 2016 to facilitate low-parking, transit accessible housing •District's Multimodal trip generation rates and parking utilization tool, "Park Right DC," informs urban development process	Focus infrastructure investments along key corridors	•Maximizes access to mobility while generating larger data samples for more accurate long term analysis •Manage congestion by better real time management of traffic and making transit more convenient •Improve the District's compact, walkable, bikeable neighborhoods along these corridors

6. Risks and Mitigation

The District and DDOT have a proven track record of effectively deploying state-of-the-art technology projects and programs by successfully identifying and managing the inherent risks of such deployments through a robust risk mitigation and management strategy. DDOT also has the framework in place to manage grants that involve multi-agency stakeholders. In the recent past DDOT has successfully managed grants from USDOT (including High Speed Intercity Passenger Rail and TIGER funds through the Federal Railroad Administration, and Value Pricing Pilot funds through the FHWA), the Department of Homeland Security, and other federal agencies. DDOT has identified technical, institutional, and policy risks associated with Smart DC, along with mitigations. Table 3 identifies risks and potential mitigation strategies.

Table 3 | Summary of Risks and Mitigation Measures

Risks	Mitigation
Technological	
DDOT will deploy and test state-of-the-art technology as part of this program. There are technical risks in such deployments. These risks include, but are not limited to: • Lack of consistent standards. • Market-readiness of technologies in a vibrant, multi-modal, urban environment. • Interoperability across agencies, jurisdictions, and transportation modes. • Public acceptance and market penetration of new technologies. • Demonstrating quantifiable benefits that can be traced back to new deployments. • Sustainability of connected vehicle infrastructure beyond grant life cycle.	The District has an innovation culture and experience in deploying new transportation technologies. System-users are early adopters of innovative technological solutions, and past experience has identified mitigations, e.g.: • Develop technical specifications during Phase I and Phase II application, rather than after grant award. • Adopt an incremental and iterative approach to deploying assets. • Follow the District's ITS and Open Data standards and philosophy to avoid getting locked into proprietary solutions. • Leverage lessons learned from other jurisdictions that had similar deployments.
Institutional	
Managing and operating transportation systems requires coordination across a set of traditional stakeholders. Given the District's geographical setting and travel patterns, other stakeholders come into play, including state DOTs, police forces of Virginia and Maryland, county DOTs, MWCOG, the federal government, FBI, Secret Service, and others. This leads to some challenges and opportunities: • Different agencies have different risk appetites, tolerances, and thresholds. • Interoperability and consensus across agency and jurisdictional boundaries. • Incorporating Smart DC concepts and implementation into standard business process.	DDOT has worked closely with federal and regional agencies to establish protocols and maintains working groups that can serve as a model for smart city programs: • Scale of DDOT responsibilities as a state/city DOT mean DDOT is more integrated and nimble in addressing system-level issues. • Autonomous vehicles feature prominently in existing policy documents. • Experience managing interagency processes, recognizing the risk profile of an agency, and developing a customized communication strategy. • Existing forums in the District and the region for these discussions to occur. • Including maintenance and operating costs of

Risks	Mitigation
	assets as part of funding plan. • Marketing and education about Smart DC through goDCgo.
Policy	
Aspects of Smart DC could require policy changes. Some of the policy risks include: • Implications of connected vehicles on system security, particularly in conjunction with open data. • Limited experience thus far in implementing 2014 Public-Private Partnerships Act. • Potential liability for information provided through open data channels.	The District has already worked to set the foundation for policy needs: • DDOT has the legislative and policy framework in place to launch the program. (the District was one of the first jurisdictions to pass legislation on autonomous vehicles) • Engagement with the District's P3 office will identify opportunities to utilize P3s to implement and maintain Smart DC.

7. Partnerships and Stakeholders

Smart DC envisions partnerships in three broad areas: technology deployment, data management, and evaluation. DDOT has existing partnerships in each of these three areas, and each of these may involve overlap of subject matter. The District has had initial conversations with potential partners for Smart DC projects, but in order to preserve flexibility, no formal letters of commitment have been solicited during this phase. All current partnerships discussed in this application will be incorporated into the Smart DC initiative overall.

7.1. University partnerships

DDOT and the District more broadly have strong partnerships with the universities in the region. Currently, Howard University leads a consortium with GWU, George Mason University, Virginia Tech, Morgan State University, and the University of the District of Columbia to support DDOT's Research, Development, & Technology Transfer Program and the agency as a whole. Through this university consortium, DDOT develops and conducts research projects, connects with current students for internships, and has access to experts for project panels and program reviews. Howard University also houses the DDOT Transportation Safety Data and Research Center, which serves as a repository and resource to help DDOT analyze traffic data and design strategies to make the District's streets safer for motorists, cyclists and pedestrians.

Beyond contractual relationships, DDOT staff regularly partner more informally with professors and students at local universities to provide hands-on learning experiences and provide insight and data to university-led research. Many students have completed capstone or studio projects focused on DDOT issues, with direct input from DDOT staff. DDOT has also provided in-kind support for researchers' projects, such as attaching data loggers to Capital Bikeshare bikes for a public health evaluation.

Beyond DDOT, District government is connected to several other university collaborations. DC is one of the founding members of the MetroLab Network with Georgetown University, GWU, and Howard University. The Network was launched as part of the White House's Smart Cities

Initiative. The MetroLab schools currently cooperate throughout the District on several large- and small-scale public health, transportation and sustainability programs and initiatives.

Closely related, the OCTO DC-Net program has partnered with the GWU-led Capital Area Advanced Research and Education Network (CAAREN). This is an advanced regional high-speed fiber optic network providing dedicated research, education and community focused access to computational, storage and network services in the greater metropolitan region, and far beyond. Additionally, multiple GWU scientists and researchers are conducting extensive research into smart city applications in a variety of realms.

These partnerships provide access to critical assets that are not widely available within government. Smart DC will require the integration of transportation and utilities infrastructure with Internet technology and the involvement of academic institutions to research and create new smart city environments and experiences for the next generation. CAAREN can provide the critical pipeline between the District and its MetroLab university partners in areas of sensing technology design and use, utilities and transportation modeling, new vehicle technologies, and human-city systems

7.2. Regional Partners

While the District is the core city of its metropolitan area, it cannot operate alone. The District regularly partners with neighboring jurisdictions on transportation and other issues. Formal structures exist to support this:

- MWCOG is a forum for regional discussion and coordination, and houses the region's metropolitan planning organization, the Transportation Planning Board (TPB).
- The MATOC Program is a coordinated partnership between transportation agencies in the District, Maryland, and Virginia that aims to improve safety and mobility through information sharing, planning, and coordination. One of the projects of this group is the Regional Integrated Transportation Information System (RITIS), an automated data fusion and dissemination system that provides an enhanced overall view of the transportation network.
- WMATA is the regional transit provider and exists through a tri-state compact between the District, Maryland, and Virginia.

The District also regularly engages with its federal partners to coordinate operations, policy, and planning between District and federal lands, including the National Park Service, the National Capital Planning Commission, the Architect of the Capitol, and the US Capitol Police. For example, DDOT recently launched a new Circulator bus route on the National Mall in partnership with the National Park Service. Capital Bikeshare are also docks located on federal lands throughout the city.

An example of a broad partnership is the SW Ecodistrict Initiative, led by the National Capital Planning Commission with local and federal partners. The initiative is focused on sustainability and livability at a neighborhood-level planning scale. The initiative plans to implement Internet-of-things (IoT) and urban sensing applications, which aim to develop solutions to challenges related to environmental quality, livability, health, and economic activity.

7.3. Private and Non-Profit Partners

The District has a strong network of local non-profit partners that strengthen the city and work with the District's agencies to improve outcomes in a range of areas. These partnerships include business improvement districts collaborating on streetscape projects and the Ecodistricts program, and the Washington Area Bicyclist Association helping to maintain trails and teaching key parts of DDOT's Safe Routes to School program.

Another existing partnership includes close coordination with Pepco, the local electricity provider, through the DC Powerline Undergrounding (PLUG) project, which aims to improve the resiliency of the District's energy network by moving key power lines underground. Additionally, DDOT is exploring other energy-related partnership opportunities through the District of Columbia Sustainable Energy Utility (DCSEU), which administers programs to reduce energy consumption and improve energy efficiency.

Supporting ongoing private sector partnering, Mayor Bowser recently established the Office of Public Private Partnerships (OP3) with the authority to enter into partnerships in a variety of sectors, including transportation, utilities, and recreation facilities. Using this and other opportunities, DDOT will strive for greater engagement with the private sector through Smart DC. DDOT will build partnerships with the business community to make infrastructure smarter, expanding on existing strong relationships exemplified by freight and auto show initiatives and in local business partnering seen in the city's business improvement districts.

8. Existing Transportation Infrastructure

The District has an array of rail, bus, cycling, and pedestrian facilities that compose a true multimodal and intermodal transportation network. With over 1,500 miles of roadway (only 31 of which are Interstates, freeways, or parkways), DDOT's system is primarily urban arterial or local in nature with a few major freeway corridors of regional and local importance.

Table 4 | Transportation Assets in the District

Asset	Description
Roadway System	
Total mileage	1,501 linear miles of roadway
-Arterial miles	107 linear miles
-Interstate/freeway	28 linear miles
Bridges/Tunnels	228 bridges (209 vehicle, 19 pedestrian), 16 tunnels
Sidewalks	1,495 linear miles
On-road bicycle lanes	64 linear miles
Cycle tracks	6 linear miles
Off-road trails	56 linear miles
Traffic Signals	1,652 traffic signals
Streetlights	71,000 streetlights
Parking assets	13,525 parking meters on 18,000 metered parking spaces
Transit Services	
Circulator Bus	Service on 43 linear miles; ridership of 5.1 million (2014)
Streetcar	7 linear miles of track, 15 streetcar stops (2016 planned opening)

Asset	Description
Rail Mass Transit (Metrorail)*	38 linear miles (118 system linear miles), 40 stations (91 systemwide) 273.8 million unlinked passenger trips, 2013 (119.2 million in District)[11]
Commuter Rail	VRE for Virginia, MARC for Maryland
Bus Mass Transit (Metrobus)*	Service on 261 linear miles of road 132.1 million unlinked passenger trips, 2013 (73.5 million in District)[10]
Commuter Bus	Various operators (7.6 million unlinked passenger trips in 2013)[10]
Capital Bikeshare	211 stations, with additional 40 awaiting installation 2.8 million trips in 2014 system-wide
Shared Mobility Providers*	Uber, Lyft, Split, Bridj Carshare providers (Zipcar, Enterprise, car2go, getaround)

*Assets not owned by the District

8.1. Intelligent Transportation Systems

ITS are critical to meet the challenges of managing transportation systems in the nation's capital. The District is often described as diverse, as are the DDOT's ITS assets. With over 1,700 traffic signals, 18,000 metered parking spaces, 271 miles of communications cable, six operations centers, and many other assets, the density of ITS assets is high and provides opportunities to advance the state of the practice.

9. Data and Integration

Capital Data: continuously open, shareable and mappable since 2007. The District has maintained a publicly-accessible data catalog, with most District government agencies contributing to over 700 (and growing) datasets. A majority of these data have been published as Geographic Information Systems (GIS) map services, which allow for easy querying and filtering with the added benefit of being mappable by default. From permits to potholes, all data are accessible in a multitude of formats via the common, publicly accessible geospatial Open Data. It is the District government's long-standing view that District data should be open and accessible for public use, and the District is among the first cities to formalize this with an Open Data Policy,[12] which encourages the transparency, collaboration, openness, and discoverability. However, certain data releases are subject to privacy sensitivities. Using guidance from the Department of Motor Vehicles, data is managed and shared based on guidelines in the Driver's Privacy Protection Act (18 U.S.C. §§ 2721–2725).

Recently, DDOT has worked to build up real-time data availability of its current bus system data. The DDOT Transportation Data API currently provides real-time Circulator bus locations (at 5 second intervals), fine-grained estimates of arrival times and delays, and historic usage data.[13] This information and allows developers to build apps with some of the highest-quality data available.

In 2014, DDOT began collected bicycle and pedestrian data from permanent count stations. Building on four existing count stations, DDOT will install an additional seven counters during

[11] National Transit Database, *Transit Profiles: 2013 Full Report* (Federal Transit Administration, 2014).
[12] Draft Open Data Policy: https://drafts.dc.gov/docs/draft-open-data-policy
[13] DDOT Hackathon Portal: https://ddot.portal.azure-api.net/

2015, and will make data publicly accessible. DDOT also has an existing network of permanent vehicle sensors to assist in managing overall traffic flows.

Infused and Enriched. All the data above should not simply be made open, but should be enhanced, interrelated and enriched by integrating data across transportation business systems to the greatest degree possible. Like other transportation agencies, DDOT collects a variety of information on the specification, operation, and condition data of assets, the transportation network, and services. Considered independently, these data are useful but somewhat limited when attempting to answer nuanced questions about the state of District transportation systems or how they should be used. For example, the enterprise routing system for oversize/overweight loads is useful for providing directions to truckers coming to the District but if the routing system is unaware of permitted road closures, the system's operational effectiveness is limited. The District needs truckers and others to have a 'persistently connected workflow' such that any information that is relevant to the operation must be instantaneously available and updated seamlessly.

DDOT's approach to this problem is to place GIS front and center, connecting related data items (both spatial and aspatial) to the base GIS centerline network. Any public space permit which DDOT approves is automatically referenced along the GIS centerline network. Any roadway construction project DDOT begins planning for is registered along the GIS centerline network. All conditions and characteristics about the roadway (number of lanes, pavement condition, etc.) are referenced along the GIS centerline network. DDOT's Transportation Integrated Enterprise Solution (TIES) is purpose-built to conflate and infuse data and make it more useful across systems. As an additional step, these same data are spatially joined to relevant geographies (demographic, political, administrative) to further enhance the usefulness to all users.

Next Steps: Infuse Live Data Streams. All TIES data are published as GIS web services to ensure all stakeholders may rapidly leverage and incorporate them into their workflows. One downside of the current TIES process is that it is a nightly extract, transform and load process which presents only a 'snapshot' in time. This project could serve as a vital springboard to bring live/transactional data systems into persistently connected workflows. A good example of the beginnings of this is with DDOT's public data sharing partnership with Waze. The current data flow is omnidirectional, with DDOT as the recipient of the Waze data feed. DDOT maps and analyzes the Waze traffic feed data within the internal emergency operations centers for snow and traffic incident response. Waze would like to receive live permitted closure information but is unable to because DDOT's published map web services do not have permitted *activity* live. DDOT plans to enable "check-in/check-out" for specific permit types like road or lane closures and broadcast these changes to the public TIES data streams. With this new functionality, Waze, the freight community or a connected vehicle with a route scheduled along the route will receive instant notification.

For DDOT and the District as a whole, data sits squarely in the center of the picture. For this project, DDOT will bring its experience gained thus far and make its data live by default to the greatest extent possible.

10. ITS Standards and Architecture

10.1. ITS Architectures and the Master Plan

The District developed a Regional ITS Architecture in 2009 which has been used as guidance in implementing ITS projects. The Architecture identifies data flows and connections between various ITS components, including the traffic management center and the field intelligent transportation devices. The architecture also covers the structure of data sharing with neighboring agencies such as the Virginia Department of Transportation and the Maryland Department of Transportation. The DDOT ITS team is planning to update the existing Architecture by incorporating the new data flows associated with the emerging connected vehicle technologies by following national ITS communication standards, such as the National Transportation Communications for Intelligent Transportation Systems Protocol (NTCIP).

In 2013 DDOT also prepared an ITS Master Plan in which new infrastructure was proposed for a further fifteen years, based on the needs of traffic operations and incident management. The ITS Master Plan documents the existing communication infrastructure and provides a roadmap for future communications network upgrade and expansion.

In designing ITS systems such as Dynamic Message Signs and CCTV systems, DDOT strictly follows NTCIP. In addition, DDOT follows the Manual on Uniform Traffic Control Devices and DDOT's own specifications (Version 9.0) in designing ITS structures. In the future, the agency plans to:

- Follow the WAVE protocol to send the Traffic Incident Management (TIM), SPaT, and MAP messages from roadside DSRC units to on-board DSRC units.
- Convert the current proprietary traffic signal control data to NTCIP-compliant data.
- Continuously use the NTCIP in the ITS design and implementation.
- Involve AASHTO's efforts in ITS standard development.

10.2. Documentation Sharing

As a smart city, the District will develop a portal accessible to all researchers, companies, and vendors. The portal would provide near real-time information about equipment diagnostics, BSM, and other information from RSE for public access. This will help vendors and standard developers improve products.

11. Goals and Objectives

Smart DC will be implemented within the context of existing plans, such as Sustainable DC, moveDC, and the Vision Zero Action Plan, which outline the high-level vision and objectives for the transportation systems.

Goal: The goal of Smart DC is for the District **to become a connected city that benefits all components of the transportation systems–agencies, users, and infrastructure**–and that the transportation systems support the District's systems and broader goals.

- **Agencies** will have more informed decision-making capabilities, save time deploying resources, and improve system performance.
- **Users** will have equitable access to information to make real-time travel decisions and will be an active part of the solution by feeding data back to the system.

- **Infrastructure** will communicate its status to help users know when to alter their travel choices and to provide data for agencies to better hone their services.

Objective: The objective of Smart DC is to **build the foundation to integrate 21st-century technology into the District's transportation systems.** The District will deploy a platform that will provide all users the ability to provide feedback, test new technologies, and improve movement of people, goods, and services within the city. The District will build subsidiary goals and objectives to feed into the overall goal. This will be an iterative process forming a foundation for broad participation. With this foundation, the District will leverage the newest technologies and provide feedback on existing and emerging technology.

DDOT's Multimodal Congestion Management Study, currently underway, will provide an understanding of District transportation systems' baseline conditions. The performance measures component of the Congestion Study will be complete prior to the submission of the Phase 2 Smart DC proposal, and DDOT will integrate these two processes in the final Smart DC proposal. DDOT envisions managing performance of Smart DC based on the pilot's program framework, with specific measures for Smart Agencies, Smart Infrastructure, and Smart Citizens, such as:

Smart Agencies

a. Reduction in accident identification time.
b. Reduction in average trip length on selected bus routes and freight deliveries.
c. Increased efficiency of addressing service requests through reduction in man-hours deployed for various asset categories.
d. Increased data analytics capability and development of central smart transportation management center

Smart Infrastructure

a. Increase in actionable data collected from connected infrastructure and reduction in infrastructure downtime for signals, streetlights, parking meters, and other assets.
b. Reduction in traffic and transit delay through adaptation by intelligent signals.
c. Reduction in median response time for fire and emergency vehicles.

Smart Citizens

a. Increase in participation from hackers, consultants, researchers, and other groups to access data from District systems.
b. Increase in new services offered by vendors using the District's smart infrastructure.
c. Increase in usage of smart parking by city residents and visitors.
d. Increase in participation from business owners to schedule deliveries using District systems.

12. Capacity and Commitment

DDOT has prepared for Smart DC through system-level planning and individual pilot projects. Over the past 14 months, in particular, since the start of Mayor Bowser's Administration, DDOT has elevated the role of performance and data management within the agency. Many of these initiatives will continue and be elevated further through Smart DC.

12.1. Technical Capacity and Infrastructure Readiness

Advanced Transportation Management System: DDOT recently implemented ATMS for traffic operations and event management. The ATMS system is capable of generating incident response plans and serves as a platform for implementing the plans to improve the traffic flows within the District. Real-time traffic data from cameras, speed sensors, probe vehicle systems, and external data sources flows into DDOT's Traffic Management Center via ATMS where it is processed, analyzed, and responded to appropriately for traffic management purposes.

Fiber Backbone: In March 2016, DDOT will begin constructing a fiber backbone, in partnership with DC-Net and OCTO, and associated cameras and vehicle detection stations along the District's freeways. The fiber network on the freeways will become the backbone of a future city-wide communication network which will connect to the Traffic Management Center (TMC) and DDOT headquarters building. The new cameras will be an integrated part of DDOT's monitoring system for traffic operations and incident management. The new vehicle detection stations will be used to collect data on count, classification, occupancy, and vehicle speed.

Transit Signal Priority: DDOT's TSP project, carried out with the help of an FTA TIGER grant in partnership with TPB, will demonstrate data obtained from the new technology will inform traffic-flow modeling and real-world impacts of prioritization on bus on-time performance, and scalability and infrastructure readiness.

Connected Vehicles: DDOT has embarked on implementing two connected vehicle test beds in partnership with the commercial vehicle industry:

a. Traffic signal data sharing pilot: The pilot aims to integrate signal data with other applications so that connected cars will estimate red time remaining and reduce carbon dioxide emissions. The information will be available to interested partners, and DDOT will receive valuable information about car emissions, delays, and signal timings.
b. DSRC: The 2016 Washington Auto Show also showcased the benefits of V2V and V2I technology through a connected vehicle convoy. The convoy demonstrated the congestion-reducing and life-saving capabilities of V2X applications. In order to most effectively showcase V2X, DSRC radios are installed along the route to generate SPaT messages as well as TIM messages to the vehicles in the convoy.

ParkDC Pilot in Penn Quarter/Chinatown: DDOT is deploying technology to network 7,500 parking meters and implement approaches for parking management. These technologies and approaches will result in different pricing strategies to encourage turnover or offer parking allowances for residents. This program demonstrates that existing infrastructure is ready for further integration with different pricing strategies and individual parking space tracking.

Remote Monitoring and Control of Street Lights: DDOT recently started implementing remote monitoring of all its light poles. The system allows real-time monitoring of each luminaire's health and increase or decrease of lumen output. The data is accessible through an open source data protocol and can be integrated into DDOT's system asset management.

12.2. Data/Analytic Capacity

Big Data Analytics: Since 2014, DDOT has invested significant time and resources in establishing a Data Analytics team. This multi-disciplinary team gathers and works with "big data" to make it malleable for agency performance management and policy making. Recent examples include:

- Gathering curbside use and off-street neighborhood parking data to compare against residential permits, vehicle registration, parking citations, and meter usage data.
- Investigating demographics of pay-by-cell users and identifying patterns and trends that may promote or hinder the growth of pay-by-cell adoption.
- Identifying parking meter overstay patterns.
- Querying usage patterns of point-to-point carsharing to analyze operational policies.
- Fusing bicycle infrastructure and Census mode share data to measure mobility, accessibility, and demographic patterns in cycling.
- Analyzing programs and service data to gauge the equity of DDOT's service delivery.
- Collecting and using data from the locations where TSP is implemented, including identifying the locations or corridors where the greatest on-time performance increases are observed to inform future implementation strategies.

Cyber Security: DDOT initiated a first-of-its-kind project to evaluate the cyber security preparedness of its physical systems, also called CPS. This comprehensive assessment includes evaluating current connected physical infrastructure vulnerabilities and threats. The evaluation also assesses the District's preparedness to implement connected vehicle infrastructure and recommend procedures and practices to improve such infrastructure.

Open Data Portal: On January 12, 2016, Mayor Bowser announced the District's Open Data initiative demonstrating a commitment to utilize technology to innovate, increase transparency and improve accountability across government. The policy is centered on the notion of making District data "open by default." Agencies must justify why data should not be released publicly in its most complete form rather than the public being obligated to justify why data should be released. Consistent with this initiative, DDOT releases datasets whenever feasible on its Open Data portal. Some of the transportation datasets already available include bicycle lanes, public space permit data, bus routes data, and more. The open by default approach furthers government transparency and openness and allows the District to leverage its workforce by hosting "hackathons" with open-data and crowdsourcing applications and software.

Transportation Integrated Enterprise Solution: DDOT uses TIES to address disparate "stove-piped" business applications from various DDOT administrations into a common framework for visualization and reporting. TIES is a GIS-centric solution built on HTML5, which is centered around linear referencing. Its current scope is to connect several DDOT systems, including Cityworks, TOPS, and utility coordination mapping software (Envista Online Map).

Automated Truck Routing for Single Haul: Thousands of oversized or overweight vehicles are provided permits for travel within the District each year. Currently, DDOT staff review each electronic submission on TOPS through a manual process. DDOT is working to improve the way the agency processes these permits by automating the safe routing of large loads, and automating the permitting of certain loads that fall within certain thresholds.

Streetcar e-Fare: DDOT is developing a Mobile Fare Payment System (MFPS) to provide an electronic fare option for streetcar passengers. The system will provide a secure form of visual confirmation, which users can present upon inspection through their mobile device. The system is still in the design phase and it will be based on the latest available technology platform to be flexible and easily scalable, and based on open standards to the extent feasible. E-fare data will also facilitate DDOT's ability to review data and performance based on, for example, ridership alongside on-time performance and automated passenger counters (APCs).

12.3. Organizational Capacity

Anacostia Waterfront Initiative: DDOT is leading the 30-year, $10 billion Anacostia Waterfront Initiative (AWI) to transform the shores of the Anacostia River into a world-class waterfront. In coordination with 19 regional and federal agency partners, the Anacostia Waterfront Initiative area straddles the Anacostia River stretching from the Tidal Basin to the District's northeast border with Maryland. DDOT is coordinating the multi-billion dollar infrastructure investments associated with the initiative, demonstrating the institutional capacity for large, complex projects. In addition to the AWI program, DDOT is leading several other complex public-private infrastructure projects, and this organizational experience will be brought to bear in Smart DC.

Multimodal Congestion Management Study: DDOT is in the midst of a study to assess multimodal congestion, and recommend strategies for remedying existing congestion problems, including one-, three-, and five-year implementation plans. This study will provide an organizational foundation for Smart DC, including refining infrastructure and management strategies to achieve the Smart DC outcomes.

TranStat: Since early 2015, DDOT has held bi-weekly "TranStat" meetings to identify and address agency performance management. The meetings have targeted everything from fleet management to the removal of abandoned bicycles, and bring together leadership teams across the agency, including contracting, finance, administrative services, engineering, and operations, to engage in constructive and collaborative problem solving environment. Smart DC implementation would be a standing topic at TranStat meetings to inform implementation and address issues early.

13. Leveraging Resources

DDOT anticipates leveraging Smart DC funding through several additional sources of funds, including: additional federal grants and formula funds, additional local funds, and partnerships and in-kind donations.

Federal grants and formula funds: DDOT serves as the state department of transportation for the District and in that capacity receives FHWA funding to carry out the core highway program. The projects proposed in Smart DC will build on the efforts already underway to maintain and improve infrastructure and programs supported by these FHWA funds, and can be coordinated with already planned investments on some of the identified corridors. For example, DDOT has programmed FHWA funds for reconstruction projects on Benning Road NE, Pennsylvania Avenue SE, and Minnesota Avenue NE—three of the Smart DC pilot area corridors.

In addition, DDOT has received several grants from FHWA already supporting Smart DC-type projects. These include an FHWA Value Pricing Pilot Program grant for the parkDC pilot to

investigate multimodal, dynamic parking pricing in the downtown. DDOT is also beginning to implement an Off-Hours Delivery Program through federal matching funds.

The District also partners with the Environmental Protection Agency's SmartWay program, which helps the freight transportation sector improve supply chain efficiency. DDOT anticipates combining the SmartWay program with a consolidation center project to show carriers potential cost savings and emissions reduction through use of the consolidation center.

Local funds: DDOT anticipates using local funds to leverage and enhance Smart DC grant funds. For example, DDOT has an existing $6 million local fund for transit efficiency enhancements. A large portion of this funding is expected to be used to fund off-board fare payment kiosks along the critical 16th Street NW bus corridor that carries over 20,000 riders each day. Additional local funds are available for parking meters, streetlights, and other RSE investments.

Beyond DDOT, the Smart DC pilot envisions leveraging the investment in DC-Net wifi led by the Office of the Chief Technology Officer. Other local investments led by the Deputy Mayor for Planning and Economic Development and others will be aligned with the Smart DC program.

Partnerships and in-kind donations: DDOT and the District are committed to partnering to pilot and implement new technologies and programs. In the parkDC pilot, several technology providers are demonstrating their technologies at little or no cost during the initial phase of the project to demonstrate the viability of their solution for eventual broader deployment. Similarly, the small cell antennas project engages the private sector in a pilot with several DC agencies. Public-private partnerships will be key to a successful Smart DC. DDOT has leveraged program support staff from around the agency to help put these pilots into place.

Similarly, DDOT is partnering with USPS to share route data and identify delivery spaces where and when needed. This information presents an opportunity to site electric vehicle charging equipment to charge new USPS electric fleet vehicles. This partnership will not only provide invaluable package delivery route, time, and frequency data, but will lower emissions and improve safety, due to electric vehicles and reduced incidences of double-parking. DDOT will install equipment on USPS trucks to provide DDOT with tracking information, integrate with TSP, and accumulate data on traffic and route impacts.

Finally, the university partnerships and relationships that DDOT has built through its research program and other innovative efforts provide a strong framework to collaborate with the academic sector, and leveraging their research and students to take the Smart DC investment further. Academic partners will also be allies in helping to spread the word about the initiative.