2016 Grant Application

Beyond Traffic: The Smart City Challenge

The City of Virginia Beach, VA

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1. PROJECT VISION

The City's Vision and the Smart City Challenge

Virginia Beach is proud to offer itself as a candidate for the *Beyond Traffic: The Smart City Challenge*. This effort will support our vision of livability and sustainability with seamless and ubiquitous transportation services. We envision Virginia Beach in 2045 as a well-planned community offering unique opportunities to live, work, play, and grow in a culturally rich and safe environment. Our neighborhoods and residents will be interconnected through an award-winning, multi-modal transportation system, the ubiquitous presence of broadband communication technologies, and, most importantly, a deep sense of community. In short, our city seeks to be the most livable coastal community in the world.

As described in the City of Virginia Beach's Envision 2040 Report, the future vision for the City places considerable focus on transportation to develop a "Connected Community." The Unites States Department of Transportation (USDOT) Smart City Vision Elements, as stated in the Notice of Funding Opportunity (NOFO), clearly support the City's transportation goals; thus, the Smart City Challenge provides a key step toward realizing our vision for the future.

Figure 1. The Virginia Beach Town Center serves as the City's business, residential, and transportation focal point

What Makes Virginia Beach the Best Smart City Candidate?

Virginia Beach has always been a technology-savvy city. From the military technology of the Oceana Naval Air Station to its investments in advanced broadband technologies to the City's extensive investment in state-of-the-art Geographic Information System (GIS) technologies and processes which permit rapid updating of assets and topography, Virginia Beach offers an ideal basis for a Smart City. Further, our southern Chesapeake Bay location connects us to rich natural resources and exciting, diverse, and interconnected neighborhoods. In November 2015, the City of Virginia Beach was named by the Center for Digital Government as one of America's Top Digital Cities. Among the many initiatives that the City was recognized for were Open VB, a new open data portal that lets citizens access city information such as budget and capital improvement program information; the launch of new mobile apps that, for example, let citizens submit service requests via their mobile devices and receive status updates; a new program that uses technology to automate the calls to neighboring cities' dispatch centers; numerous improvements to the city's data center, which helps ensure business continuity should a regional emergency occur; and a fiber infrastructure being built to provide increased bandwidth to the city's off-campus facilities, such as libraries, parks, recreation centers, and fire and police stations.

To enhance its strategic capabilities, the City has partnered with the following public and private entities: Iteris, the Virginia Tech Transportation Institute (VTTI), Virginia Modeling, Analysis, and Simulation Center (VMASC), Virginia Beach Development Authority (VBDA), Virginia Department of Transportation (VDOT), Hampton Roads Transit (HRT), Albeck Gerken, Inc., Armada Hoffler, Bishop Consulting, Bosch, Central Business Development Authority, (CBDA), Cox Business, Esri, HERE, MTS Systems Corporation, Peloton Technology, RideScout, SAE International, Socrata, Trafficware, and Volkswagen Group of America. These partnerships are further described in Section 7.

In addition, Governor McAuliffe has declared the Commonwealth of Virginia to be open for business for vehicle and technology manufacturers and researchers who are developing, testing, and deploying automated and autonomous vehicles. Working with VTTI, the City is ideally situated to serve as a test bed for the technologies proposed as part of the Smart City Challenge.

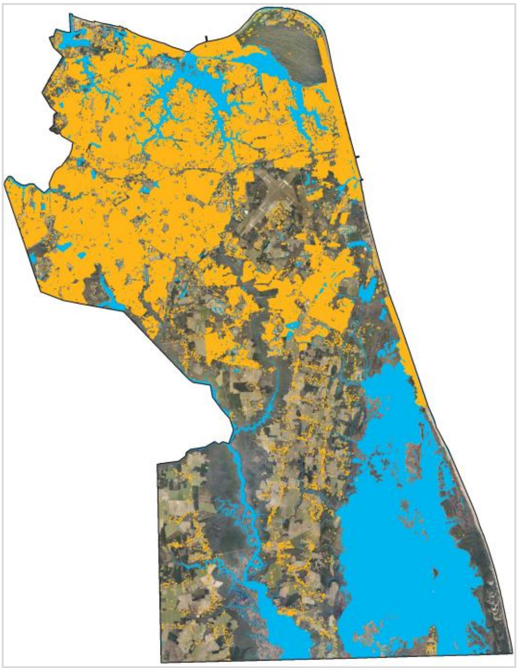

Figure 2. Developed and populated areas in Virginia Beach

Virginia Beach spans 310 square miles, with the vast majority of the 431,273 in population concentrated in the central and northern areas (Figure 2), which include the rapidly-developing Town Center (TC) area. Our City also includes a substantial waterfront/ocean beach resort community and environmentally sensitive areas.

The City's arterial road network is heavily instrumented for real-time traffic operations and is connected to the City's Traffic Management Center (TMC) via fiber-optic communications (Figure 3). The network also includes a traffic-responsive and adaptive central signal system and closed-circuit television (CCTV) camera monitoring at key intersections (see Section 8 for further details). The City's TMC is connected to VDOT's Eastern Region Operations center, which manages and monitors traffic and incidents along I-264 and other Interstates in the Hampton Roads area. CCTV and other traffic information is shared between the two centers to assist in the management of corridor operations.

Section 9 offers more detailed information about the City's extensive technology capabilities.

Envisioning a New Transportation Hub in Virginia Beach

The development of the City's TC in combination with the light rail extension will create a new transportation hub. To facilitate access to the Resort Area and other destinations, alternative transportation modes are under consideration, including maglev guideways that could save money and time when compared to extending the light rail beyond the TC. The City will also consider automated propulsion and guideway operations for short-haul shuttle services. In the Envision 2040 report, the City details an experimental transportation district in the TC to meet the needs of a growing retirement community, including transportation systems for disabled residents. Connectivity to the new light rail extension is of paramount interest, as is providing access for the

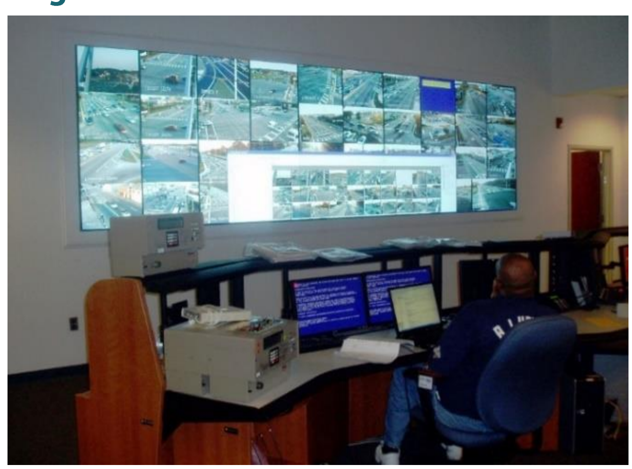

Figure 3. City of Virginia Beach Traffic Management Center (TMC)

disabled and cyclists. Virginia Beach's Smart City efforts include scheduling paratransit and rideshare services and accommodating wheelchairs using smartphone applications. Automated delivery vehicles are projected to help residents receive deliveries from grocers, pharmacists, and florists without having to drive. The City's publicly available datasets will enable transportation experts to identity the traffic concerns of residents and design new systems to meet those requirements.

Our Smart City Project Approach:

We have identified four essential areas of concentration for our emergence as a Smart City by 2045:

1. Enhancement of Personal Mobility

With a focus on allowing local residents and dependent users without their own motor vehicles to travel to activity areas (e.g., TC, Resort Area) and access lodging, businesses, the beach and/or other attractions, the city is considering the following potential applications.

Figure 4. Virginia Beach's Boardwalk provides an example of pedestrian- and bicycle-friendly facilities being developed

Ubiquitous Mobility for All Citizens

The City will employ smartphone-dispatched paratransit services, shuttle services including "last mile" services to final destinations, ridesharing, preferential treatment for pedestrian and bicycle users, parking reservations, and improved transit operations via signal priority and convenient connections between different transit lines. Candidate technologies include:

Dynamic personal mobility and navigation applications will allow travelers to request trips and obtain itineraries using a handheld mobile device or personal computer. The trips and itineraries will include public transportation modes, private transportation services, ride sharing, walking, and biking. The applications will coordinate within and between transit providers to dynamically schedule and dispatch or modify the route of an in-service vehicle by matching compatible trips. After the trip, the application will receive feedback to improve the user's experience for future trips and monitor the use of high-occupancy lanes. Users will also be able to make parking reservations and payments, book taxis, and assist in trip planning by comparing multiple travel modes.

Figure 5. Pedestrian mobility technologies will enable crowd-sourced pedestrian volume data and special service requests

Dynamic routing systems will determine the fastest or least costly (in terms of minimum fuel consumption or emissions) routes of individual travelers. These systems could be integrated with in-vehicle applications or as a tool within dynamic personal mobility and navigation applications.

Pedestrian mobility services will integrate traffic and pedestrian information from roadside or intersection detectors and collect data from wirelessly connected mobile devices carried by pedestrians or cyclists to request pedestrian signal indications or inform pedestrians of when to cross. Such services will enable a "pedestrian call" to be routed to the traffic controller from a nomadic device of a registered person with disabilities after confirming the roadway that the pedestrian intends to cross.

Transit signal priority will use communication between transit vehicles and infrastructure to allow a transit vehicle to request priority at one intersection or a series of intersections. The transit driver will receive feedback indicating whether the signal priority has been granted or not. This application can improve the operating performances of transit vehicles by reducing the time spent stopped at red lights.

Transit transfer connection protection enables transfers between transit routes without excessive waiting time by coordinating the arrival and departure times at transfer locations using GPS, computer-aided dispatching, and user requests for connections at specific transfer points.

Dynamic Mobility in Key Activity Zones

Dynamic mobility technology is envisioned for rapidly developing areas such as the TC and Resort Area. These zones require special mobility strategies to assure connectivity between different areas along with access in and out of key destinations. *For the purposes of the proposed Smart City project, the focus of dynamic mobility deployments is in the TC area.*

Figure 6. Automated shuttle

Automated driverless shuttle services. Autonomous shuttle vehicles holding between 5 and 15 passengers (Figure 6) will provide services between the transit transfer points or parking locations and specific destinations. Following reserved travel lanes or using guideway technology, the shuttles would connect Union Station (the light rail station at the TC) with particular locations in the TC, including the parking garage, restaurants, offices, and Pembroke Mall. They may stop where requested based on dynamic requests from smartphone users using the dynamic personal mobility and navigation application.

Figure 7. Delivery cargo bike

Energy-efficient dispatch and delivery services will include efficient delivery services to reduce the number of trucks blocking parking zones or streets, particularly in areas with high-density, narrow streets, such as the TC. Cargo bikes using electric pedal assist may be deployed via electronic dispatch through the delivery services of grocers, restaurants, etc. (Figure 7). External facilities on the perimeter of the TC will act as collection points for trucks to deliver goods, and the cargo bikes will then pick up the packages and distribute them as well as pick up packages to bring to the collection point.

Smart parking will provide real-time information on parking capacity and support traveler decision-making on to where park and when to use transit alternatives. This information will be delivered to travelers via smartphones and connected vehicles and will also enable the user to make parking reservations. Smart parking will require the implementation of parking space sensor technologies along with monitoring systems to determine the availability and location of parking spaces.

2. Congested Corridor Management

Using integrated corridor management and active traffic management strategies, the City aims to reduce congestion City-wide, with a focus on the I-264 corridor, a congested corridor that offers a variety of route and mode options; these options will facilitate reductions in congestion while reducing emissions and prioritizing transit and other high-occupancy vehicles. The strategies below incorporate advanced transportation management systems and leverage existing technologies within the City's Smart Traffic Center and along the road as well as connected vehicles and sensor technologies.

Integrated Corridor Management / Decision Support (ICM/DSS) uses historical, real-time, and predictive traffic and environmental data on arterials, freeways, and transit systems to determine operational decisions to manage congestion and the environment. The ICM/DSS collects information from various multimodal systems and then uses the data to determine operational strategies for arterials, freeways, and transit. Candidate ICM/DSS technologies include the following.

Assisted approach and departure at signalized intersections uses wireless data communications sent from roadside equipment (RSE) units to connected vehicles to provide smoother and more efficient approaches/departures to/from signalized intersections, reducing emissions and stop-and-go operations. These applications collect information regarding intersection geometry and signal phase movement using vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communications.

Dynamic lane management employs communication technology to gather traffic and environmental information from multiple sources including infrastructure, vehicles, and other systems and configures the dynamic use of specific lanes for high-occupancy vehicle traffic during non-rush hour periods or hard shoulder running during off-peak periods due to congested conditions. This application will involve VDOT operations along I-264 but could also be employed by the City on arterial routes with multiple lanes.

Ramp metering collects traffic and environmental data from connected vehicles to control on-ramp traffic signals that control the rate of vehicles entering the freeway in order to reduce freeway congestion and improve safety.

Intelligent traffic signal systems (ITSS) utilize connected vehicle information and infrastructure information on non-equipped vehicles to adjust signal timing for an intersection or a group of intersections to improve traffic flow, including allowing platoon flow through the intersection.

Vehicle data for traffic operations uses probe data obtained from vehicles in the network to support traffic operations, including incident detection and the implementation of localized operational strategies (e.g., altering signal timing based on traffic flow and using vehicle data collected on the freeway mainline to employ speed harmonization or to optimize ramp metering rates).

Collision avoidance systems on transit vehicles. As specified by the USDOT, the City will work with Mobileye to implement automated collision avoidance systems on its bus fleet. The City of Virginia Beach has already engaged HRT as an integral partner in this effort.

Figure 8. Hurricane waves reaching the shores of Virginia Beach

3. Emergency Evacuation

Virginia Beach is vulnerable to damage from coastal weather events (Figure 8). As such, personal safety and evacuation are of paramount importance, as is the timely provision of information to the public. Several applications are focused on this concern.

Road weather motorist alert and warning will provide the capacity to collect road weather data from connected vehicles and use it to develop short-term warnings for motorists. The information collected can be combined with observations and forecasts from other sources to provide intermediate-term and long-term advisories through a variety of interfaces.

Road weather information and routing for emergency responders will collect road weather data from connected vehicles and other sources and then develop short-term warnings or advisories to provide to emergency response vehicles or emergency response dispatchers. The information may come from private vehicles or public fleet vehicles (e.g., snowplows, maintenance trucks, and other agency pool vehicles). The raw data will be processed in a control center to generate road segment-based data outputs and generate short-term horizon alerts with maximum geographic precision that will be pushed to user systems and made available to emergency response dispatchers. These alerts will include information on high winds, standing water, and roadway flooding, and the information will be acquired from other fixed and remote observation systems. This information will be combined with other observations and forecasts to provide intermediate-term (next 2-12 hours) or long-term (more than 12 hours) advisories through a variety of interfaces including web-based and connected vehicle-based interfaces.

Figure 9. Gates at freeway entrances/exits are a key element in managing evacuations in Virginia.

Evacuation traffic management will utilize current and forecast weather information and pre-determined evacuation response plans to implement "flush outbound" signal timings, traveler information message and dynamic message sign displays, and in-vehicle displays that describe the route ahead and communicate appropriate signal timing and lane closure information.

4. Asset Management

As discussed above, the City has an advanced GIS and asset management system in which all city resources are documented. The expansion of this system to support more efficient transportation services is a logical extension of the City's current capabilities. The following asset management strategies will be considered.

Electric charging station management will allow the exchange of information between vehicles and charging stations. The charging station can use vehicle information such as vehicle capability (e.g., operational status of the electrical system, how many amps the vehicle can handle, and percent charge complete) to ensure proper charging and estimate the time required to complete charging. The charging stations may be networked on a smart electrical grid and monitored by the City (Figure 10).

Figure 10. Virginia Beach electric charging station

Smart roadside lighting uses the presence of vehicles based on V2I communications as an input to control roadside lighting systems.

The lighting will be appropriately adjusted based on the presence of vehicles and the environmental conditions (e.g., fog, rain, snow) provided by the vehicles.

Enhanced maintenance decision support system will collect data (e.g., road weather and maintenance information) from vehicles used during winter maintenance and other maintenance vehicles and equipment used year-round. The collected data will be used by maintenance or fleet dispatchers to monitor the status of maintenance operations.

Project Governance

The City of Virginia Beach will administer the USDOT Smart City Challenge grant in partnership with HRT and VDOT. The City has assembled a core technical team that includes itself, Iteris, and VTTI along with numerous public and private sector partners (see above and Section 7) for planning, developing, and deploying its Smart City Vision. The **City Public Works Department** will serve as the overall program manager and oversee the funding allocations and contracting activities associated with the project. Systems engineering, design, and testing activities will be performed in coordination with partner **Iteris, Inc.**, who are heavily involved in national connected vehicle architecture and security initiatives and also bring expertise in analytics, detection systems, and traveler information services. **VTTI** will serve as the key partner for conducting research related to the project and related technologies and for coordinating with national and international research institutions. For traffic modeling activities, we will utilize the expertise of **VMASC** at **Old Dominion University** and the **Center for Sustainable Mobility (CSM) at VTTI.** Both VMASC and CSM are members of the TranLIVE Tier 1 University Transportation Center Consortium. Other private sector partners and the proposed organizational structure are identified in Section 7 along with their expected roles.

2. PROJECT DEMOGRAPHICS

The Census Bureau's 2014 estimate of Virginia Beach's population is 431,273, qualifying it as a mid-size city based on the USDOT classification. According to the 2010 decennial Census, the urban population of Virginia Beach is 431,273, which represents 98.47% of the City's total population. Its urban population density is 3,193.7 people per square mile, and the urban land area covers 54.27% of the City. Virginia Beach comprises 26.3% of the metropolitan statistical area's population. The city's population grew at an annual rate of 0.73% per year from 2010–2014.

Virginia Beach continues to see a shift in the ethnic diversity of the community. The white population represented 80% of the population in the 1990 Census; however, by 2014, the non-white population represented 32.3% of the community. African Americans are the largest minority group followed by Asian-Pacific Islanders. The African American population is younger, while the Asian-Pacific Islander population is more mature in terms of average age. In 2014, the citywide poverty rate was 8.3%, and lower income areas were concentrated along the US 58 East-West corridor and around the Oceana Naval Air Station and Joint

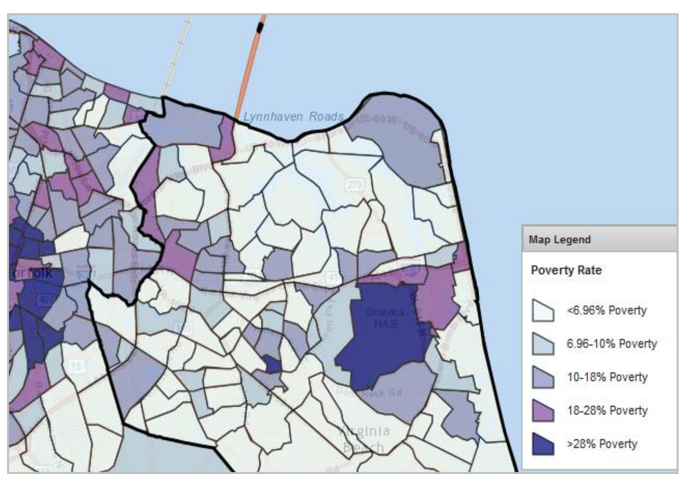

Figure 11. Poverty Rate by Census Tract (U.S. Census, 2014)

Expeditionary Force - Little Creek (Fort Story) area (Figure 11). These areas are populated primarily by military personnel and resort service workers. Such areas would directly benefit from enhanced transportation alternatives as they are proximate to the Route 20 and Route 1 bus lines, which have the highest daily commuter usage in the network. The proposed Smart City enhancements will also benefit homeless persons as the City is nearing completion of the $22.8 million Virginia Beach Housing Resource Center near I-264 in the Town Center Strategic Growth Area (SGA), next to the Witchduck light rail station to be completed by 2019; the Resource Center will provide a 32-bed shelter for single people, a 60-bed shelter for families, and, potentially, 24 efficiency apartments. It will also feature a health clinic, dining area, classrooms and office space. Other demographic trends shaping our City's future include: an aging community; changes in household composition; and trends affecting the built environment and transportation services.

Aging Trends Shaping Virginia Beach

According to the Boomer Project, the percentage of Virginia Beach residents 65 and older will increase 10.6% (2010 census) to 22% in 2040. The Virginia Division for the Aging also projected a dramatic increase in residents exceeding 85 years of age. This age group will create economic opportunities for the City; their health will likely be less than optimal, creating additional demand for nursing home care, medical services, and transportation services.

Changes in Household Composition

Household living relationships are changing; families (individuals living together who are related to the householder) comprised about 70% of households in 2014 compared to nearly 80% in 1980.

Trends Impacting the Built Environment and Transportation Services

The Generation X and Millennial generations are gravitating to urban areas. They desire urban hubs connected by rail systems and the opportunity to live, work, and play centrally. This will likely result in less demand for suburban home ownership. At the moment, City residents largely remain dependent upon their cars for commuting to work (less than 0.9% commute to work using public transit). However, the changes in demographics, the developing activity centers such as the TC and Resort Area, the eventual completion of the east-west light rail service, and the introduction of new transit services will make car dependency less necessary and less convenient due to the increased density of development.

3. PROJECT ALIGNMENT WITH SMART CITY CHALLENGE

As demonstrated below, the characteristics of the City of Virginia Beach align well with the USDOT's ideal Smart City characteristics.

Existing Public Transportation System

HRT is the public transit provider for the cities of Chesapeake, Hampton, Newport News, Norfolk, Portsmouth, and Virginia Beach, VA. Transit services in Virginia Beach are further categorized into year-round bus transit, seasonal bus transit, and paratransit. Virginia Beach's year-round bus service (Figure 12) consists of portions of two routes that operate with a peak hour frequency of 15 minutes, which is typical for dense urban areas, four routes that operate on a 30-minute frequency, and five routes that operate on a 60-minute peak hour frequency, which is more typical for a spread-out suburban community.

The TC is considered the Central Business District of the City, and several of the key components of the Smart City project are proposed in this district. The TC is served by three bus routes that operate year round, and the entire area receives mandated on-call paratransit services. The following three bus routes intersect at the Pembroke East Transfer Center.

Route 20: This east-west route serves close to 5,000 customers per day and is the busiest in the Hampton Roads region. It provides peak hour service every 15 minutes from Downtown Norfolk to the TC; it generally follows Virginia Beach Boulevard (US-58) and continues to the Oceanfront with 30-minute service intervals. Evening service (after 7 pm) and weekend service is offered every 60 minutes.

Route 1: Serving over 3,000 customers daily, this route provides hourly peak hour service north along Independence Boulevard from TC to Pleasure House Road transfer center, which is located just outside the Joint Expeditionary Base Little Creek – Fort Story (the largest employer in the City). From the transfer center, this route turns west into the City of Norfolk.

Route 36: This relatively short route provides service to close to 1,000 customers daily to the areas south of TC along Independence Boulevard and Holland Road. This route terminates at the Tidewater Community College transfer center, where access is provided to four additional bus routes within the city.

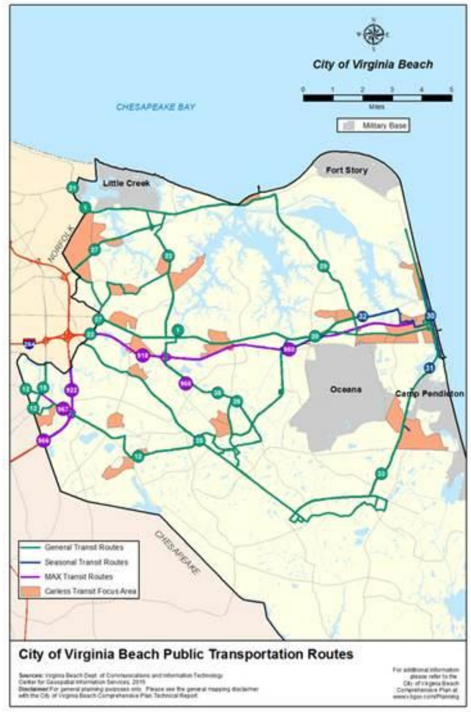

Figure 12. HRT Transit Services in Virginia Beach and Focus Areas for Users without Cars

The TC / Pembroke area receives on-demand paratransit service as the entire area is within ¾ mile of each of the three year-round bus routes described above. In partnership with the Commonwealth of Virginia and the City, HRT has programmed the extension of the Tide Light Rail Transit (LRT) line eastward from the current terminus at Newtown Road (western city limits) to Constitution Avenue (at a proposed Union Station in the heart of the TC). The extension is projected to open by the end of 2019 and will connect TC with Downtown Norfolk along the former Norfolk Southern Railroad line. Future plans are addressing extending fixed-guideway transit (LRT or alternative) to the Resort Area near the Oceanfront, again following the former rail line.

Environment Conducive to Demonstrating Proposed Strategies

We believe Virginia Beach is the ideal city to undertake a Smart Cities demonstration project. Our City collaborated with the business community, non-profits, and its citizens to complete Envision Virginia Beach 2040, resulting in our vision of *"a well planned community of exciting, diverse neighborhoods, each offering unique opportunities to live, work, play, and grow in a culturally rich and safe environment. Our neighborhoods and residents find interconnectivity through our award-winning multi-modal transportation system, the ubiquitous presence of broadband communication technologies, and most importantly by building a deep sense of community."* Envision 2040 is already being implemented through our eight SGAs with efforts focused on transit-oriented development and numerous technology programming efforts (see Section 9). The Draft 2016 Comprehensive Plan (expected to be adopted in April 2016) recommends a robust array of intelligent transportation systems (ITS) and transportation demand management strategies that specifically address the technology, Smart City, and innovative approaches to urban transportation elements outlined in the Smart City Challenge NOFO. We understand and embrace the fact that our region and county are part of the "Technology Economy of the 21st Century." Most notably, the City's Town Center-Pembroke SGA project builds upon the great success we have already achieved in developing a first-class central business district that is geographically close to the center of the City's populated areas and convenient to both east-west and north-south transportation facilities. The City has developed a "Connected Community" transit concept (Figure 13) that will create major transit corridors extending east, north, and south from the Town Center by 2040. The City is also considering alternatives to light rail for future fixed-guideway investments to provide similar or better levels of service at lower cost. Technologies such as maglev and bus rapid transit along with automated and advanced propulsion strategies will be considered.

Of key interest is that the City of Virginia Beach maintains its government offices and courthouse in the south-central portion of the City (the historic center of the former Princess Anne County). If the City is able to realize its vision of implementing a transportation hub in the TC, the government offices and courthouses would likely relocate to the TC, making it both the central business district and the seat of government for modern Virginia Beach.

Figure 13. Connected Community Transit Corridors.

The Commonwealth of Virginia VTRANS2040 supports the City in its smart land use/transportation activities, as evidenced by its recent funding of up to $155 million (50% of the total cost) of the TC Light Rail extension.

Continuity of Committed Leadership and Capacity to Carry Out Demonstration through the Period of Performance

The City has successfully demonstrated its ability to deliver state and federally-funded projects for over 24 years. We were the first locality in Virginia to be approved under the state's Urban Construction Initiative (UCI) Certification Program, a Federal Highway Administration (FHWA)-approved program. Under the UCI, VDOT delegates authority to qualified participating localities to carry out projects under streamlined VDOT oversight. The City has successfully managed both urban projects and externally funded projects with budgets of up to $120 million. The City boasts substantial experience in program and project delivery, has appropriate program delivery systems in place, and utilizes an organizational structure to successfully manage our own program and projects with oversight from VDOT, in compliance with the applicable state and federal regulations.

Virginia Beach is also one of the best financially managed cities in the nation. We have retained an AAA bond rating from Moody's, Fitch, and Standard and Poor for the past six years. During the City's 2016 General Obligation bond sale that occurred on Jan 27, 2016 all three rating agencies were highly complementary of the City's financial management strength.

- *Moody's Investors Service*: Moody's reports a history of "strong" financial management.
- *Standard & Poor*'s: S&P characterizes the City's management conditions as "very strong" with

strong financial practices and a consistent ability to maintain balanced budgets.

- *Fitch Ratings:* In the key rating drivers, Fitch describes financial management as "sound" with strong financial flexibility.

Commitment to Integrating with the Sharing Economy

Virginia Beach is a national leader in sharing information with the business community and residents. For example, 21 organizations have joined our Smart Cities team. By way of example of our information sharing mindset (further detailed in Section 9), our Center for GIS uses Pictometry, scanning technology for aerial photography, enabling frequent GIS updates that are shared openly with major map providers such as Google. Furthermore, both Uber and Lyft are already deployed in the City, providing on-demand transportation services from smart phones.

The City also has a strong web and social media presence; VBgov.com registered over 5 million sessions in 2015, consisting of over 2 million users, nearly 14 million page views, over 2 million new visitors, and over 3 million returning visitors. In addition to basic information, VBgov.com provides an open data portal to share data sets with the public. Budget and mapping data are available for consumption and distribution, and plans are in place to share more data sets. The City has approximately 20,000 Likes on Facebook and over 33,000 Twitter followers. Finally, the City has a Virginia Beach Television (VBTV) station and staff through which video content can be created and accessed directly from homes and business with cable television (130,000+ subscribers).

Clear Commitment to Making Data Accessible

The City takes pride in the transparency and availability of its information to the public. Previous mention has been made of its GIS data update process, which allows for more frequent updates than for most other government agencies. Additionally, budget and capital planning data along with quarterly spending data are freely available in a standardized machine-readable format. The City Manager appointed an open data board to continue making the datasets maintained by the city, including traffic, accident, parking, permit, and licensing data, available through its data platforms. The City's Data Board will soon establish comprehensive inventories of city-held data, establish procedures to review and release datasets, and monitor dataset usage for possible improvements.

New data on automated vehicle usage, road bed factors (temperature, vehicle traffic flow, drop-off zone, and average speed), and GPS locations of buses, transit, and delivery services will be collected through this Smart City demonstration project and made available through the City's platforms. Through our partnership with VMASC, the City further envisions using these data to model traffic flows and make signal modifications using predictive modeling. We also plan to work with developers (citizen-based) to create citizen-oriented applications that track bus and transit arrival times to minimize user wait times. In-road sensors could be designed to notify public works crews of potholes and roadway flooding to provide more immediate responses to these issues.

The City is committed to open data availability and looks to expand its sources of data for operational and analytical use. The Smart City initiative also offers the opportunity to utilize vehicle-based operations data while protecting the privacy of individual users by removing personal information from data. The Envision 2040 report projects future cases in which real-time data could be used to implement paratransit and convenient shuttle services to serve residents. Such services are core activities proposed within the Smart City initiative.

4. PROJECT MAP

The project map is shown in Figure 14 on page 15 and provides the following information:

- A corridor-focused map and summary of related project components;
- Town Center-focused maps (overall and focused) with example locations for roadside equipment, smart parking sites, and candidate shuttle routes and a summary of Town Center-focused project components; and
- A text box summarizing the citywide, non-location-specific activities to be implemented during the project.

5. PROJECT ALIGNMENT WITH VISION ELEMENTS

The Virginia Beach Smart City project components were expressly developed to reflect the City's vision to develop a highly livable and sustainable connected community with ubiquitous transportation services and mobility options. Every Smart City Vision Element defined by the USDOT in its NOFO is addressed in the City's vision for the future, as highlighted below. In addition, our partnering scheme (Section 7, Figure 15) provides the City with tremendous expertise in the various vision areas.

Vision Element #1 Urban Automation

Envision 2040: The City will have Smart Shuttle and transit services to reduce/eliminate the use of personal vehicles and will rely heavily on the use of automation, robotics, and artificial intelligence.

Smart City Challenge: Automated shuttle services with dynamic routing will be deployed in the Town Center area, serving the Pembroke Mall, TC area, and light rail station (to be opened in 2019). Automated package dispatch and delivery applications using automated services and e-bikes will also be demonstrated in the TC.

Vision Element #2 Connected Vehicles

Envision 2040: The City will proactively manage transportation demand to improve travel safety and security and use data to support seamless intermodal connections and parking services.

Smart City Challenge: The City will build on its current ITS infrastructure and high-speed fiber networks to deploy wireless V2I and V2V communications using RSEs at signalized intersections and at strategic locations along I-264. These technologies will support in-vehicle collision warning (including transit vehicles) and dynamic routing applications and will utilize vehicle data to support active traffic management applications (e.g., dynamic lane use, ramp metering, smart parking, vehicle data collection) as part of the performance analytics functions.

Vision Element #3 Intelligent, Sensor-Based Infrastructure

Envision 2040: The City will deploy smart sensors and robotics throughout its infrastructure.

Smart City Challenge: Smart parking space sensors and vehicle location data along with the networking of existing infrastructure data (traffic and weather) will enable real-time dynamic ride requests, adjustments to traffic signal timings, protection of transit connections at light rail and other transfer locations, and the adjustment of street lighting based on traffic demand and environmental conditions.

Vision Element #4 User Focused Mobility Services and Choices

Envision 2040: The City will provide transportation options (e.g., automated car-sharing services) enabling residents to travel without personal vehicles and improve/expand pedestrian and bicycle facilities between residential and non-residential districts. The City will also provide intermodal, seamless connections between road-based travel modes, light rail, and alternative transit options (e.g., automated vehicles).

Smart City Challenge: The city will work with service providers to implement dynamic personal mobility and navigation services to arrange paratransit, rideshare, car-sharing and other services; reserve parking; book taxis and trains; assist in dynamic routing based on anticipated conditions; provide multi-modal traffic information and trip planning; and communicate pedestrian presence and needs at signalized intersections (e.g., pedestrians need more time to cross). Charging stations for electric vehicles will also be available in the City.

Vision Element #5 Urban Analytics

Envision 2040: Video and data traffic will travel seamlessly between individuals, homes, and businesses, supporting data and social media sharing needs. Smart infrastructure sensors and vehicle data will support activities related to transportation infrastructure planning.

Smart City Challenge: The city will implement services to manage corridor traffic and evacuation activities and influence traffic signal operation, street lighting, and the use of city facilities. Building on the City's advanced IT infrastructure, collected data will be used to address key performance indicators and monitor the effectiveness of the services deployed as part of the Smart City initiative.

Vision Element #6 Urban Delivery and Logistics

Envision 2040: Numerous manual tasks and delivery services will be automated through robotics.

Smart City Challenge: The City will deploy low-energy, small-scale delivery vehicles (e.g., e-bikes and automated delivery vehicles) in the TC area to minimize traffic disruption. The City will also implement smartphone-based dispatch systems for pick-ups and deliveries (e.g., groceries).

Vision Element #7 Strategic Business Models & Partnering

Envision 2040: The City has long prided itself on its business-friendly climate and will leverage its historic military role and related technology expertise in creating specialized job opportunities for both private sector employees and military personnel.

Smart City Challenge: The City has already engaged numerous public- and private-sector partners to assist its Smart City efforts; these partnerships are discussed in Section 7.

Vision Element #8 Smart Grid, Roadway Electrification, and EVs

Envision 2040: The City envisions a series of guideway-based transportation services using advanced technologies (e.g., automated vehicles, maglev) with a focus on automated and low energy-consumption vehicles and services. Low-cost computer chips embedded within building infrastructure will enable reductions in energy consumption.

Smart City Challenge: The city will implement a network of electric vehicle charging stations interconnected into a single system to show station availability for users using dynamic mobility applications (see Vision Element #4 above). Automated shuttle services in the TC will serve as a prototype for expanded electric vehicle services that could eventually be used in other areas of the City, including the Resort Area and Convention Center region.

Vision Element #9 Connected, Involved Citizens

Envision 2040: By examining the needs of individual citizens, the City will focus the effects of its technology and sustainability initiatives on the daily lives of its citizens.

Smart City Challenge: The City will implement applications and technologies (whether smartphone applications, consistent with Vision Element #4 above, or enhanced transit connectivity or pedestrian/bicycle mobility throughout the city) that allow residents and visitors to tailor their mobility activities to their needs.

Vision Element #10 Architecture and Standards

Envision 2040: The City will develop networks that offer near-instantaneous computer and processing speeds and a grid in which data travel seamlessly between individuals, homes, and businesses, supporting informational and social media sharing needs.

Smart City Challenge: As per Section 10, the Smart City applications in Virginia Beach will be implemented using standard processes and tools, including emerging applications such as the Connected Vehicle Reference Implementation Architecture (CVRIA). The implementation will incorporate security and privacy considerations as well as wireless communication standards, enabling the deployed solutions to be expanded (e.g., from the TC to the entire City) and adapted for other U.S. cities.

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

Envision 2040: See also Vision Element #10. The City will leverage a world-class IT infrastructure that includes citywide fiber-optic networks connecting businesses, the government, and homes.

Smart City Challenge: The City will leverage its advanced GIS mapping technologies to provide up-to-date map information for service providers. Existing traffic and asset management systems will also be used, as outlined in detail in Sections 8 and 9.

Vision Element #12 Smart Land Use

Envision 2040: The City will implement SGAs in the northern section of the City while preserving its bayfront areas, parks, and inland waterways along with the largely rural environment in the southern region of the City.

Smart City Challenge: The project will address citywide enhancements to mobility; implement corridor-based strategies and technologies to connect Virginia Beach with the neighboring City of Norfolk, the TC/Pembroke SGA, and the Resort Area; and implement various automated mobility services and infrastructure components within the TC area.

6. RISK ANALYSIS AND MITIGATION

Technical Feasibility

The City is fully committed to obligating all Smart City funds before September 30, 2016. A risk management plan was developed to describe the internal and external sources of risk involved with a Smart City implementation for Virginia Beach. The risks identified within this section are classified with ratings for three aspects of each individual risk: the impact on the project cost, schedule, or scope; the probability of that risk occurring; and the ability of that risk to be mitigated. Risks are identified along a taxonomy including technical, institutional, and policy risks. The identified potential risks, their ratings,[1] and the planned mitigation strategies are given in Table 1 on page 16.

[1] The risks have been rated using the ITS JPO standard which may be found at: http://www.its.dot.gov/project_mang/index.htm

Figure 14. Map of Virginia Beach

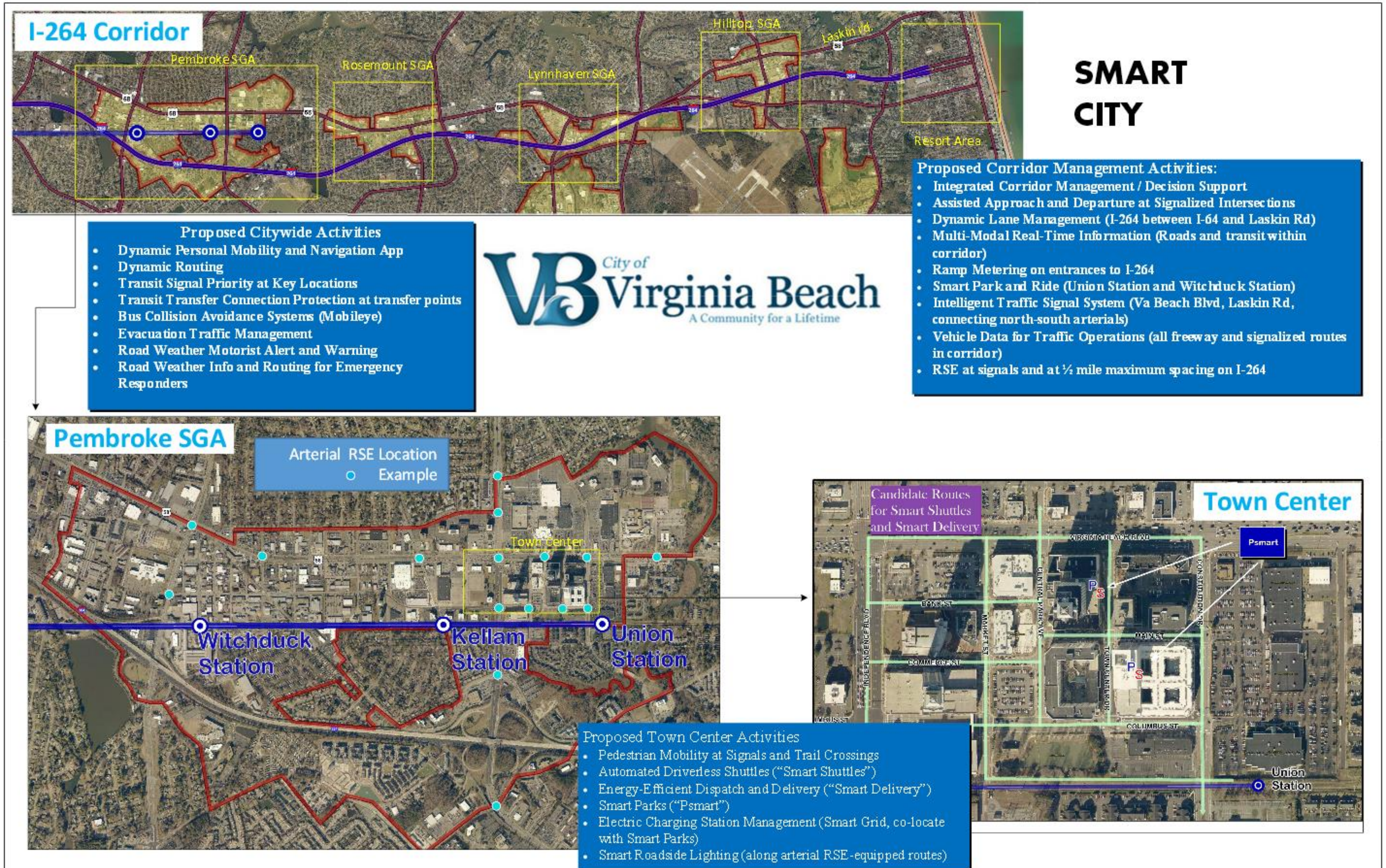

Table 1. Risk Matrix

Category	Description	Risk Probability	Risk Impact	Approach
Technical	Partners not able to support planned vision	1	3	Mitigate risk with strong coordination
Technical	New developments in connected or automated vehicle technology or standards	5	2	Accept risk and integrate new technology
Technical	Surrounding areas deploy technologies which are not compatible with vision	2	2	Mitigate risk by working with surrounding communities
Policy	Federal laws enacted which restrict automated vehicle, connected vehicle, or infrastructure deployment	1	2	Contingency plan to reduce consequences
Policy	State laws enacted which restrict automated vehicle, connected vehicle, or infrastructure deployment	1	2	Contingency plan to reduce consequences
Policy	Surrounding region enacts policies which do not align with the Virginia Beach vision	1	2	Mitigate risk by engaging with other cities in the region
Institutional	Rail development is delayed	2	3	Contingency plan by identifying how rail affects other components
Institutional	Significant changes in local tourism industry	1	5	Mitigate risk by minimizing environmental impacts throughout vision
Institutional	Loss of key personnel	1	2	Avoid risk by keeping a broad range of personnel focused on the project goals

7. PROJECT PARTNERS AND STAKEHOLDERS

The City of Virginia Beach has proposed a core technical team of itself, Iteris and VTTI, along with numerous public and private sector partners for planning, development and deployment of its Smart City Vision (Figure 15). The organization chart is presented and discussed further below. Table 2 details the expertise of each of the City's partners in the vision areas.

Technical Team

The **City of Virginia Beach Public Works Department** will serve as overall program manager and oversee the funding allocations and contracting activities associated with the project. The Public Works Department will work in close consultation with the Traffic Engineering Department.

As a key partner, **Iteris** will assist the City in the overall delivery of the demonstration project, including responsibility for systems engineering, design, and testing activities. With over 200 employees, Iteris is a leading firm in the planning, design, and deployment of ITS, including arterial, freeway management and integrated transit operations strategies utilizing signal priority. Iteris has been the lead contractor for USDOT in development of the Connected Vehicle Reference Implementation Architecture (CVRIA) along with the National ITS Architecture.

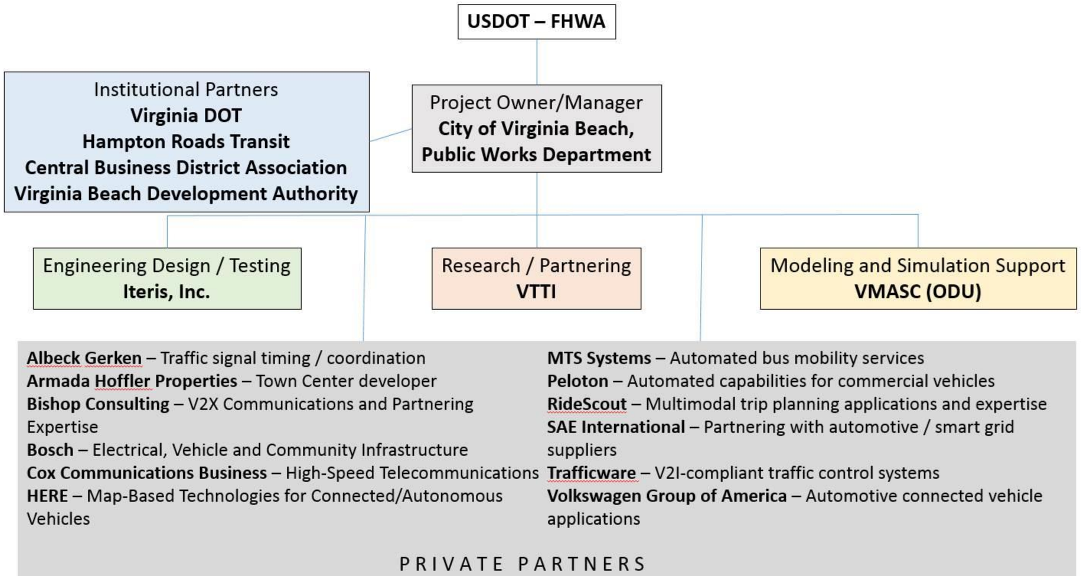

Figure 15. Virginia Beach Smart City Organization Chart

The Virginia Tech Transportation Institute (VTTI) routinely develops state-of-the-art tools, techniques, and technologies to solve transportation challenges. Their work has led to improved driver-vehicle interfaces and enhanced communications, positioning, and integration capabilities. VTTI works closely with university researchers, industry and government partners including VDOT, FHWA, National Highway Traffic Safety Administration, original equipment manufacturers, and suppliers to promote the state of knowledge regarding connected and automated vehicle systems and to understand the potential benefits of full-scale system deployment. VTTI will assist in the overall delivery of the research program and in the investigation of key technical and institutional aspects of connected/automated vehicle deployment along with potential public sector and industry outcomes.

The Virginia Modeling, Analysis, and Simulation Center (VMASC) will support the City to simulate ITS including advanced traveler information systems, adaptive traffic signals, the operability and effectiveness of V2V and V2I, and forecasts of freight distribution planning and control.

Institutional Partners

The Virginia Department of Transportation (VDOT) builds and maintains the roads, bridges, and tunnels that are vital to the region's economy. VDOT is committed to improving safety and being responsive to the needs of Virginia's citizens. VDOT will be a valuable resource to help Virginia Beach develop innovative solutions to meet the long-term needs of its citizens. VDOT will coordinate with the City on corridor management strategies implemented as a result of the Smart Corridor, including integrated corridor management and decision support, evacuation management, and other applications as appropriate. The City will also work with VDOT for all necessary deployment activities proposed within this document, including ramp metering, dynamic lane management, and the installation of RSE's along I-264.

Hampton Roads Transit (HRT) provides public transportation services to 1.3 million residents throughout the Hampton Roads region. HRT strives to provide efficient, customer-driven transportation. HRT will work with Virginia Beach to test and deploy new innovations for improving the flow of people within the city and throughout the region.

The Virginia Beach Development Authority (VBDA) is charged with expanding and diversifying the tax base and employment opportunities for the City through business development. As such, the VBDA will coordinate closely with City in the development of opportunities that will enable new and existing business to maximize their economic potential.

The Central Business District Association (CBDA) will support transportation infrastructure development, strategic planning, and public/private development investment and opportunities that promote "Smart, Clean and Connected" growth within the SGAs of the city.

Supporting Partners

The following entities will assist Virginia Beach in the development of materials needed for the Phase II response, including any appropriate planning, outreach, and educational efforts needed to further develop the City's implementation plan.

Albeck Gerken, Inc. will work in support of Transportation Systems Management and Operations (TSM&O) initiatives using various traffic management strategies to optimize the performance of the transportation network in a cost-effective manner to help address increased traffic demands and the resulting congestion and delays.

Armada Hoffler provides professional services for the construction, development, and management of mixed-use town centers along with other urban properties. Their expertise will help ensure that Virginia Beach's vision to urbanize the town center and increase both residential and commercial traffic is economically viable.

Bishop Consulting will work with the City to support the development of fruitful partnerships related to connected and automated vehicles and sensor-based infrastructure. Bishop Consulting has supported the USDOT in projects related to V2X communications and vehicle automation.

Bosch will deliver mobility innovations and technology integration solutions. The City will draw upon Bosch's expertise in a number of the vision elements to offer unique, data-driven ideas to improve lives by making all modes of transportation safer, easier, and more reliable.

Cox Business will bring its experience working with municipal organizations across the Commonwealth and the nation in support of next-generation telecommunications services and infrastructure in Virginia Beach.

ESRI will assist the City by providing the necessary GIS technical platforms to implement smart initiatives in Virginia Beach.

HERE will work with the City to provide cutting edge technologies for connected and automated driving, including the provision of HD maps, real-time traffic and dynamic data, cloud connectivity, data analytics, and multi-modal in-dash and mobile traveler applications. HERE will also provide services to reach travelers via in-dash navigation systems; HERE data powers 9 out of 10 vehicles in the U.S. equipped with mapping systems.

MTS will work with the City to apply automation, connectivity, and advanced technology to improve the safety and efficiency of its bus-based mobility services. The current bus-only shoulder service operations will be expanded and enhanced through the application of MTS driver assist system technology, which was pioneered over the past six years in Minnesota.

Peloton is a leader in the development and deployment of automated and connected vehicle systems for commercial vehicles. Peloton is driving the adoption of technologies such as advanced collision avoidance systems, truck platooning, V2V and V2I communications, and cloud-based fleet management.

RideScout will work with the City to advance public transportation systems based on their expertise in multimodal trip planning, mobile transit payments, and integrated solutions for public transit and shared mobility services.

SAE International is currently engaged in many vision elements for a Smart City including:

- ITS/connected vehicle technology advancement and standards development;
- Autonomous vehicle technology advancement and standards development;
- Driver assistance system vehicle technology advancement and standards development;
- Electric vehicle technology advancement and standards development;
- Roadway electrification technology advancement and standards development; and
- Smart Grid technology advancement and standards development.

Socrata understands that **e**ffective use of transportation data is quintessential to commerce and economic growth, quality of life, planning, and inclusivity. Access to and analysis of transit data is essential for high performing cities. Socrata will help the City and its partners connect existing and future infrastructure and associated data into user-friendly and application-ready solutions that drive engagement and adoption.

Trafficware is the traffic control industry's leader in ITS including connected V2I development. Trafficware will work with the City to share and develop solutions that will benefit the ecosystem of connected and autonomous vehicles, the motoring and cycling public, and pedestrians.

Volkswagen Group of America will employ its expertise and capabilities in the area of connectivity, automation, and automotive electrification to develop a concept to achieve mutually agreeable safety, mobility, and environmental targets set by the City for this project.

Table 2. Partner Expertise in the Smart City Challenge Vision Elements

TEAM MEMBER	SMART CITY CHALLENGE VISION ELEMENTS											
	Technology Elements			Innovative Approaches to Urban Transportation Elements						Smart City Elements		
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Virginia Beach	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ITERIS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
VirginiaTech. Transportation Institute	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
VMASC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
VDOT	✓	✓	✓	✓				✓		✓		✓
HAMPTON ROADS TRANSIT	✓	✓	✓	✓	✓			✓	✓		✓	✓
VIRGINIA BEACH				✓		✓	✓		✓			✓
AG	✓	✓	✓		✓				✓	✓		
ARMADA HOFFLER												✓
BISHOP CONSULTING	✓	✓	✓			✓	✓			✓		
BOSCH Invented for life	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
				✓		✓	✓		✓			✓
COX Business			✓	✓			✓	✓	✓	✓		
esri	✓	✓	✓	✓						✓	✓	
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MTS	✓	✓	✓	✓	✓			✓	✓			
PELOTON	✓	✓	✓	✓	✓	✓		✓				
RIDESCOUT			✓	✓	✓				✓			
SAE	✓	✓					✓	✓		✓		
Socrata		✓	✓	✓	✓							
Trafficware	✓	✓	✓		✓							
VOLKSWAGEN GROUP OF AMERICA	✓	✓	✓	✓		✓	✓					

8. CURRENT TRANSPORTATION SYSTEM

The City of Virginia Beach's existing transportation infrastructure includes 750 miles of major and minor arterials and 15 freeway miles (four to eight lane configurations). Our existing transit service provided by HRT is quite extensive, with the TC/Pembroke SGA being served by three bus routes providing year round service including on-call paratransit services. Additional information is provided in Section 3. Shared-use mobility services are provided in two areas:

- Bike sharing
  - City Public Schools sponsors beach cruisers at municipal center
  - Build out of Bike Ways and Trail Plan will further facilitate this evolution
- Traffic-transportation matching service provided by HRT
  - Provides bus, rail, and ferry services
  - Provides carpool-matching services

Information and communication technology play a significant role in the transportation communications arena. The Next-Generation Network project is underway and will transform the City into a connected community by providing high-speed connectivity to any traffic signal infrastructure along its path. The base fiber-optic network currently exceeds 100 miles and will expand by 20% this year.

Figure 16. Virginia Beach traffic signal control cabinet installation

ITS components are an integral part of the City transportation network. Constructed in 2006, the City's TMC spans 5,000 square feet and is equipped with a video wall, 54 CCTV cameras, four video operator work stations, and a conference room. The TMC also serves as the Emergency Operations Center during major weather events. The TMC has a direct fiber optic cable connection to VDOT, allowing the sharing of CCTV video.

The traffic signal control network is controlled from the TMC. The majority of the traffic signal network is interconnected either by fiber optic cable (100 miles with 1.0 GHz Ethernet capability) or copper cable (45 miles). The traffic signal network is dedicated short-range communications (DSRC)-ready and capable of handling the deployment of V2I/V2V infrastructure.

The ITS network also includes seven permanently mounted dynamic message signs in critical areas, which allow real-time dissemination of traffic information to the motoring public. In an effort to reduce congestion, travel time, and vehicle emissions, the TMC has an active traffic signal retiming program, and critical corridors are typically retimed every 3-4 years (Figure 16). The TMC is also preparing to do a traffic-adaptive installation on a 28-intersection corridor.

The smart grid infrastructure is a developing entity; nine electric vehicle charging stations are found at various locations within the City and in the immediate region. Most of the stations are strategically positioned along the I-264 and Route 58 corridors.

9. DATA AND INFORMATION TECHNOLOGY

The City protects and values its data as a core business asset and works to make data-driven decisions that improve overall city services. Traffic and geographic data are collected from a variety of sources and used to address transportation and mobility challenges. Public Works and Communications and Information Technology (ComIT) are committed to addressing these challenges and will support and design systems that capture, leverage, and share data to better our community.

Virginia Beach collects a host of data such as information on parking (locations, use, and meter rates); bike, nature, and water trails systems; road systems; traffic flow; traffic accidents; crime; speed limits; solid waste collection; bus stop locations; and local points of interest. The City is moving towards opening as many datasets as possible in order to aid in day-to-day decision-making and to provide citizens with access to the data they need. The City has already partnered with Socrata to provide a platform to release data for both internal and external use. This platform is machine-readable but provides capabilities for users to perform analysis within the platform or to export it to the platform of the user's choice.

Transportation and Public Works Data

Virginia Beach operates a transportation management network that collects data from a variety of traffic sensors around the City. Networks of in-ground sensors at 33 intersections wirelessly relay real-time vehicle volume, occupancy, and speed data back to the TMC, which uses technology to manage traffic and to disseminate traffic-related information via dynamic messaging signs to drivers throughout the City. This network consists of a 100-mile fiber optic backbone and 54 CCTV cameras and controls all of the City's 380 traffic signals. The network is connected to VDOT's Traffic Operations Center (TOC), providing the City with direct access to video from the TOC's interstate cameras. The TMC includes seven changeable message signs and 50 system detectors to detect instantaneous changes in traffic flow and features traffic data collectors to provide information for analysis.

The City developed a citywide traffic count program to annually count traffic at 300+ locations. These vehicle count data are collected, displayed on Google maps, and made publically accessible via a link to the Public Works Department web site. Fresh traffic count data are a great asset in the road construction and land use arenas, allowing the City to prioritize and implement road infrastructure improvements with the greatest cost benefits.

The City is migrating to vehicle detection cameras that track every object in the roadway, including bicycles and pedestrians. The cameras collect vehicle volume, turning movement counts, and vehicle classification reports. Intersection performance reports are also generated, such as green and red occupancy, which are used to adjust traffic signal timings.

GIS Data

Virginia Beach has a vast GIS data catalog containing 400 different GIS layers and over 20 million GIS elements from agricultural reserve properties to zoning. The City's base-map layers contain 210,000 addresses, 160,000 tax parcels, 270,000 planimetric features, traffic routing networks, storm water drainage system, water distribution network, sanitary sewer disposal, waste management routes, topographic, and administrative areas. The City image library includes geo-referenced images from 1935 and bi-annual color aerial and satellite imagery since 2000. The City uses the base maps and remotely sensed imagery to generate vehicle routing and tracking, environmental protection areas, zoning, flood hazard, land use and demographic layers. Beginning in 2016, the City will perform annual aerial captures using Pictometry services, which shortens the update cycle from 2 years to every 1 year.

The City also has used Lidar technology on previous occasions to help build base models that we can validate against. The City has a goal of supplementing Pictometry services with Lidar on a more regular basis, which could help accelerate Google updates. The information will be used to assist in monitoring and detecting environmental impacts from sea level rise, new development, or storm surges. The City's GIS system is extremely capable and can provide services around the clock to support real-time location tracking and data functions.

Using Existing and New Data to Address Transportation Challenges

Some of the challenges the City of Virginia Beach is facing include traffic congestion, emergency vehicle flow, road construction, land use, and greenhouse gas emissions. The City's traffic sensors can help with management of government and business vehicle fleets by rerouting vehicles around closed or congested streets. The City will be able to monitor the movement of traffic, which could support the use of autonomous vehicles. Much of the technology infrastructure needed to handle data streams is in place now. The City's traffic signals and traffic cameras in TC are connected by fiber networks to the TMC to monitor and control traffic movements. GIS web services also are in place to create interactive map-enabled dashboards showing congestion and recommending new routes to the City's vehicle fleet. Traffic count data provide trends on traffic volume and indicate whether future construction is needed and public transit needs to be expanded.

Integration with VDOT is possible via a direct fiber optic connection from the City of Virginia Beach transportation network to the VDOT TOC. Integration with VDOT also is possible by sending alerts on our electronic traffic message boards. This information would be helpful for evacuations by allowing many vehicles to be safely routed from an event and avoid flooded areas. Smart cars could be connected to the transportation network, could broadcast their position by communicating with the map server, and then be rerouted to avoid congested areas. Road condition and temperature data collected from autonomous vehicles could be relayed through the transportation network to the TMC. The TMC could use this data to deploy staff to fix potholes, man road de-icing vehicles, and adjust traffic signal timings in inclement weather.

The City is proposing a new flood sensor network and plans to implement this in the summer of 2016. As part of its flood sensor project, the City is installing up to 50 additional sensors around urban areas, including TC. The sensors will be used to detect and predict flooding around roadways and bridges. The TMC can use the flood sensor data to post high water warnings on dynamic message signs on affected roads and to relay road closure warnings to first responders, operational staff, and citizens. Data will be streamed out to the cloud as a RESTful web service for public awareness.

As part of our adaptive traffic control technology effort, the City is integrating Bluetooth-based technology into our traffic signal control software. This effort will incorporate real-time travel technology into the City's existing active traffic management central management system. The Bluetooth application will provide real-time speed and travel time information, along with statistical data reports covering speed, travel time, and origin-destination. This data will help in resolving challenges related to reducing congestion and travel times, reducing emissions, reducing the need to widen roadways through efficient traffic management, facilitating emergency vehicle responses, reducing secondary accidents, and changing driver habits by getting up-to-date information to motorists in a timely manner.

The City also desires to elevate traffic signal timing to an advanced technique utilizing adaptive signal control on a priority corridor within the city. Upgrading to adaptive operation will provide the following benefits:

- Adjust signal timing to accommodate changing traffic patterns and ease traffic congestion;

- Continuously distribute green time equitably for all traffic movements;
- Provide critical addition to hurricane evacuation corridors;
- Improve travel time reliability by progressively moving vehicles through corridors;
- Reduce congestion and delay by creating smoother flow; and
- Reduce emissions and increase fuel savings.

Sensors required to accomplish this element of the demonstration include wireless in-ground vehicle detectors, Bluetooth device detectors, and vehicle-tracking detection cameras.

Using Transportation Data to Improve Other City Operations

Integrating transportation data with other functions such as public safety will help support public safety initiatives by improving response times and enhancing coordination of public safety services. Available travel time data would allow better route selection to an incident. Making all traffic CCTV video available to first responders would allow them the opportunity to see an accident scene prior to responding units arriving on-site. The City of Virginia Beach is already moving in this direction.

The Virginia Beach Police Department is in its initial phase ($2.6 million) effort to expand the Security Camera System at the Virginia Beach oceanfront and increase the number of cameras to improve organizational video management capabilities. This project includes interfacing the oceanfront cameras with the current Public Works Traffic Operations Intelligent Transportation System local area network and camera network. Having access to transportation data improves decision-making and improves situational awareness with respect to public safety.

Good transportation data also helps with economic development efforts, truck freight operations, city evacuation operations, and tourism and visitor movement.

Using Other Data to Improve Transportation

Likewise, integrating public safety data with transportation data could help improve transportation operations by allowing unimpeded interagency communication, which is vital among first responders. This technology will facilitate the quick establishment of emergency operations centers anywhere in the City. Traffic video can be used in decision-making and be readily accessible through VBgov.com. Direct communications with the TMC would provide an effective means of rerouting traffic around an incident, notifying VDOT, and notifying our neighboring cities that could be affected by the incident.

Existing Policies

Data and network security is of paramount importance to the City of Virginia Beach. The City established Administrative Directive 2.09 to provide policy on the confidentially, integrity, availability, and security of City data. ComIT also established an Information Security Office (Info Sec) to actively monitor the environment and respond to threats or instances with the highest priority.

Cross-Cutting Partnerships

The City of Virginia Beach has a memorandum of understanding (MOU) with VDOT for the integration of Traffic Management Operations. The agreement, managed by the Hampton Roads Transportation Planning Organization (HRTPO) Transportation Technical Advisory Committee (TTAC), allows the sharing of video images, changeable message sign information, traffic count data, and control capabilities between our TMC and the VDOT TOC. VDOT has similar agreements with other localities in the region, allowing them to be a repository for regional traffic data and video. Having this MOU in place with VDOT enables the City to demonstrate how cross-cutting partnerships can be successful.

Using Data from Outside Organizations

The data captured and available from our partners will be merged with City data sets and made available to the public as open-source data.

Using Data for Other Purposes

The data captured and available from the traffic system/network will be made available to the public as open data to allow leveraging of the data, which can be used to determine best routes and/or transit method (car, bus, LRT) to traverse Virginia Beach to neighboring cities. Examples of data that the City of Virginia Beach collects and that can be shared, used, or used for other purposes include travel time data, which can be used for best route determination or transit method determination, and traffic count data, which can be used for determining the need and priority of infrastructure improvements.

Establishing and Maintaining Systems and Interfaces

Upon successful award, the City will work to develop agreements with our partners to determine what data will be available, shared, and accessed. We will also create data repositories that can be made available to the public, intra-city agencies, intercity agencies and partner organizations as desired. Our data will follow all legally required data retention schedules, and all hardware and database infrastructure will be placed on a lifecycle maintenance program.

10. INTELLIGENT TRANSPORTATION SYSTEMS

The City of Virginia Beach will follow the USDOT standard processes related to systems engineering and architecture for both ITS and connected vehicles, along with emerging national and international standards for communications, certification, and data exchange. Our partner SAE has been heavily involved in connected vehicle standards development and will be a key resource in this effort. The various components of this approach are presented below.

Project Management

The City will follow the Project Management Institute's Project Management Body of Knowledge best practices to meet FHWA-specified project management requirements for this program. This will include an initial development of a Program Management Plan following project kickoff, including scope, project schedule with critical path, schedule management approach, work breakdown structure, cost management, quality/configuration management, and risk management.

The risk management approach will follow City and USDOT Risk Register techniques and will be documented monthly. Progress reporting would also be handled on a monthly basis or as directed by USDOT upon award and contracting of the Smart City project. The high-level risk assessment, based on ISO 26262, will be conducted at the application level to identify hazards, assess risks, and examine safety goals. Consistent with the USDOT Systems Engineering process (see below), the results of this assessment will then be used to adjust the Concepts of Operations (ConOps) and contribute to the system requirements as necessary. The implementation of a wide range of applications across different modes and different locations within the Smart City project will help advance the state of knowledge regarding safety risks and mitigation techniques of the deployed applications.

Systems Engineering Process

The Systems Engineering process will follow the USDOT guidance. It is focused on a needs-based design effort which begins with a ConOps (based on IEEE Standard 1362-1998, FHWA Systems Engineering Guidebook for ITS version 3.0, and VDOT ConOps process as needed), and results in a set of project requirements, procurement documents and a process of procurement, installation, verification and validation testing, and upon installation and start of operations, full system validation and evaluation activities. The City will utilize the USDOT's Systems Engineering Tool for Intelligent Transportation (SET-IT) to create tables listing the goals, objectives and needs that will be used to produce system requirements.

The ConOps will describe the stakeholders' roles and responsibilities for system operations, along with a set of operational scenarios which provide "day in the life" descriptions of how the system will work and how the City and its citizens will benefit from daily use of the system, including how the applications will address safety, mobility, and environmental goals. Additionally, a Security Operations Plan will be developed to address specific areas of vulnerability and where privacy and security need to be addressed, and will define the requirements associated with these interfaces, developing the needed security architecture, and integrating this with the overall project architecture through the CVRIA, as discussed further below.

System Architecture

The Smart City detailed design and standards framework will utilize the newest tool, the CVRIA, developed by Iteris for USDOT. Currently built on some 88 applications, the architecture leverages from the ITS architecture paradigm to provide a multi-dimensional definition of system applications, including functional, physical, communications and institutional views. The physical architecture will be done based on the CVRIA, utilizing the SET-IT tool, which can readily be adopted to the specific applications and regional entities that underpin the proposed deployments in Virginia Beach. Updates will be made as needed to the Hampton Roads Regional ITS Architecture to reflect this framework.

V2I and V2V Technologies

Several wireless communications options are being considered internationally for V2I and V2V communications, including the DSRC standard set in the 5.9 GHz band (75 MHz in bandwidth) and conforms to the IEEE 802.11p wireless standard. RSEs for V2I communication are typically installed at signalized intersections and on freeways with ITS equipment at ¼ to ½ mile intervals such as detectors, CCTV and dynamic message signs. There are already RSE installations in the Commonwealth of Virginia implemented by partners Iteris and VTTI in both Northern Virginia (44 RSE locations installed to date with 22 more proposed) and on the Smart Road test facility in Blacksburg. Similar technologies for V2I and V2V applications will likely be deployed within Virginia Beach, including under the Smart City initiative. Further, we are willing to serve also as a test bed for other communication methods that emerge as an alternative to DSRC technologies.

11. PROJECT GOALS AND OBJECTIVES

Virginia Beach's goals for the Smart City Challenge are ambitious. Through implementation of the Smart City initiative proposed in this document, we will be able to demonstrate how advanced data and ITS technologies and applications can be used for the following goals and related objectives (Table 3).

The methodology to assess the potential impacts of the Smart City project may use a combination of modeling and simulation techniques (as applied by our partner VMASC) for operations and transit use, user surveys, and collection of real-time data from sensors, vehicles, HRT, and other sources that would allow comparison of data in support of the above objectives. Such data would be made available, as necessary, to any independent evaluators used by USDOT to review the work developed under this Smart City project.

Table 3. Smart City Goals and Objectives

OBJECTIVE	METHODOLOGY FOR ASSESSMENT
GOAL: Reduce Congestion	
Reduce Average Travel Time (in minutes)	TT direct measurements (Bluetooth) plus floating car runs before and after improvements made, during peak and off-peak periods.
Increase Travel Time Reliability (reduce the average daily differential between normal and peak travel times)	Compare changes in peak travel times and changes in off-peak travel times day to day.
Increase the percent of residents who commute using alternate forms of transportation	Identify transit ridership data compared with population, perform resident surveys, both before and after improvements made.
Increase citizen satisfaction with the flow of traffic	Perform resident surveys, both before and after improvements made.
Reduce percentage of key roads at Level of Service D and below	Determine percentage of days in which specific roads reach LOS D and below using traffic flow and count data.
GOAL: Improve Traveler Safety	
Reduce accidents per million vehicle miles traveled	Compare VDOT / police accident rates and vehicle miles traveled for 6 month to 1 year periods before and after improvements made, over same time period during year.
Reduce accident severity (number of injuries, fatalities, cost)	Compare VDOT / police accident statistics (injuries, incident type, etc.) For 6 month to 1 year periods before and after improvements made, over same time period during year.
Reduce pedestrian and bicycle related collisions	Number of pedestrian and bicycle injuries and fatalities per year.
GOAL: Reduce GHG / Environmental Impacts	
Reduce fuel consumption	Perform network simulation before and after improvements made to estimate fuel consumption, taking into consideration percentage of alternative energy-powered vehicles.
Reduce GHG emissions	Perform network simulation before and after improvements made to estimate fuel consumption, taking into consideration percentage of alternative energy-powered vehicles.
Increase market penetration of alternative energy vehicles (e.g., EV's) as percentage of all vehicles sold in region	Identify sales figures for alternative-powered vehicles, before and after project is implemented. Additional user survey should be performed in order to assess whether the Smart City project was responsible for any increase in this market penetration.
Percent of days the Air Quality Index Exceeds 100	Survey of AQ index days for comparative 1 year periods before and after project is deployed.
Reduce to Ratio of Vehicle Trips to Person Trips	Compare vehicle travel in and out of designated cordon area (e.g., Town Center SGA) before and after project implemented, compare transit ridership before and after, compare population of Town Center SGA before and after, develop user survey to determine number of passengers per vehicle, all done before and after.
GOAL: Connect Underserved Transportation Communities	
Increase percentage of communities within close proximity to transit services	Review of routes and paratransit revisions before and after improvements made.
Reduce number of trips requiring transfers	Review of routes and paratransit revisions before and after improvements made. Base on predetermined origins and destinations of trips, generally should involve Town Center.
Increase percentage of communities within close proximity of continuous walkways or bike trails offering safe access to Town Center, Resort Area, hospitals, shopping or dining areas.	Review of walkways/bike trails before and after improvements made.
Reduce average wait time for transit or requested mobility service	Review vehicle location, arrival, and departure information from AVL/CAD dispatch records for specific transfer points, along with user surveys indicating amount of time they have to wait at bus stops, all before and after improvements made.

GOAL: Support Economic Vitality	
Reduce transportation costs as percent of household income	Conduct user surveys before and after improvements made.
Increase population in areas within walking distance to business, shopping and entertainment	Review population statistics before and after improvements made.
Provide opportunities to create businesses that develop or implement transportation technologies which support greater personal mobility	Through city economic development agency, identify new businesses and employment generated before and after improvements made and identify their involvement in the transportation technology center.
Reduce travel times between home and work or other destination (e.g., doctor's office) for local residents.	Use TT data developed above, plus user surveys before and after improvements made.

12. CAPACITY TO COMPLETE THE PROJECT

The City of Virginia Beach is uniquely skilled and well positioned to support the Smart Cities Vision. We are fiscally responsible, managing over $300 million annually in projects, with the ability to manage large-scale projects and to successfully execute our smart cities initiatives if selected for award. We succeed through the proper management of programs and resources to enhance the health, safety, and welfare of the residents, businesses, and visitors of the City of Virginia Beach. We take an enterprise approach to our work, optimizing and aligning all of our resources to achieve maximum efficiency and sustainability. We take pride in our role as stewards of the City's fiscal and physical assets. We invest in technology to become more efficient and ensure citizens and visitors have convenient access to our programs and services.

The City manages 273 capital improvement projects valued at $2.7 billion. Capital projects include buildings, water, sewer, storm water, coastal, and communications and information technology projects. All aspects of project administration including right-of-way acquisition, permitting, construction management, budget administration, and project inspection are conducted for small and large-scale projects. Residents can track the progress of projects on the City's Public Works website (click "Show Projects" to see all projects). Various project delivery methods are employed based on the size project, financing options, and project schedule. Several public-private partnerships projects have been successfully completed, such as several parking structures constructed in the TC and the oceanfront.

In addition to the day-to-day operations of mission-critical IT services, ComIT oversees a robust portfolio of IT projects for its partner agencies. With a full-time dedicated staff of 195 employees and contractors and a broad skill set from IT engineering, networking, applications development, ComIT effectively manages a Capital Information Technology Portfolio with over $99 million of programmed funding. An example of a large project that ComIT manages is the Next Generation Network. This $4.5 million effort will connect 75 off-campus locations with new fiber and bring the entire city fiber network under a support and maintenance contract.

Aside from the basic support services of Public Works and IT, we are one of the few municipal organizations to have an in-house mobile application development team. The mobile team's primary function is the development of mobile applications and integration of commercially produced mobile applications into our IT environment. Another strength of Virginia Beach is our GIS. We utilize the Esri ArcGIS Server, Esri Image and GeoEvent processing to publish real-time enabled GIS data to the cloud and open GIS data sites using GIS RESTful web services and Open GIS Web Mapping Tiled Services.

Finally, the City is in its second year of implementing its citywide Master Technology Plan. This comprehensive technology strategic plan and roadmap includes 32 initiatives based on the principles of Transforming Service Delivery, Building Better Business Solutions, Strengthening Governance, and Improving Infrastructure and Operations.

13. FINANCIAL LEVERAGING

From Envision 2040 to the Governor's Declaration of support for the VTTI Center for Automated Vehicle Systems' research of automation in the Commonwealth, the Virginia Beach team provides the experience performing and visualizing what it takes to be a Smart City. We are a prime location to invest in the future of mobility. Towards that goal, city staff estimated the fiscal contribution of Transit Oriented Development (TOD) to the financing of possible LRT infrastructure within a ½-mile radii of the light rail. For the TOD redevelopment build-out metrics, staff relied upon several sources. Planned redevelopment[2] for the Newtown existing station used Urban Design Associate's SGA plan. To derive the three Town Center/Pembroke area station improvement valuations (Witchduck, Kellam, and Union Stations), city staff from multiple departments used various documents from Kimley-Horn, CBDA, CMSS Architects, and Miles Agency. Table 4 below illustrates the potential land-use net change. The marginal change quantifies new improvements and subtracts the existing improvements for each parcel.

The present value (5.5%) of this net redevelopment over 50 years is approximately $256.3 million. Applying person per unit data from the American Community Survey, the apartments would generate over 8,000 new residents. Staff analyzed potential job creation from the aforementioned redevelopment as well as employment gains from benchmark localities that have recently began operating light rail. Staff findings indicate net business development could generate a net increase of 10,970 jobs.

Table 4. Potential Land Use Net Change from Redevelopment

Net Increase in Redevelopment	
Units/Rooms	
Apartments	5,110
Hotel	1,460
Square Feet	
Office	3,259,200
Commercial	1,650,300
Industrial	-874,600

There are many other opportunities with the team partners to obtain in-kind and cost share contributions. For example, VTTI has a very diverse portfolio where facilities and vehicles could be used for piloting some of the technological solutions in a safe environment before they are implemented on real-world operations. The following represents a few additional areas for leveraging partner resources. Systems engineering, performance measurement, evaluation, modeling and simulation, stakeholder engagement and outreach, human use approval, connected vehicle technologies (Virginia Connected Corridor), connected vehicle applications, automated vehicle technologies (Virginia Automated Corridors), freight-related activities, and infrastructure resiliency.

[2] Apartments, office square feet, commercial square feet, and mixed-use square feet.

Further, we welcome Mobileye's proposal to provide to the winning Smart City candidate a $10 million collision avoidance system. Upon an award to the City of Virginia Beach, such a system would be installed in HRT busses. HRT has committed to undertake a phased bus replacement program that will include smart systems technologies; connected vehicles, onboard tracking, and a Wi-Fi integrated fare system. As such, the Mobileye technologies could be included as part of the new rolling stock, as well as being retrofitted to existing rolling stock that will remain on the system in the coming years.

We will also work to develop projects that encourage institutional cooperation and the sharing of information to enhance peer-to-peer projects. Currently, Dr. Gerardo Flintsch of VTTI serves as the Principal Investigator of National Sustainable Pavements Consortium (TPF-5(268)), sponsored by the Federal Highway Administration and several state Departments of Transportation. This project is part of the LCE4ROADS project, a "Life Cycle Engineering approach to develop a novel EU-harmonized sustainability certification system for cost-effective, safer and greener road infrastructures" – project and was selected by the FHWA in the first set of projects to twin with the European Commission. Building on existing relationships with the Conference of European Directors of Roads, the Forum of European National Highway Research Laboratories, the European Commission, Transport Systems Catapult, and others, the City will work to develop a Twinning project that builds upon the lessons learned by others actively engaged in the pursuit of Smart City-related technology implementation. Potential project areas include, but are not limited to: automation pilots for passenger cars (which would build upon the partners ability to integrate and test enabling technologies as well as to complete large scale field operational tests), safety and end-user acceptance aspects of road automation in the transition period (which would build upon VTTI's experience conducting human factors evaluations of users' acceptance of Level 2 and Level 3 autonomous vehicles), and road infrastructure to support the transition to automation and the coexistence of conventional and automated vehicles on the same network (which would build upon the partners vast experience in road infrastructure modeling and performance assessment).

Finally, the City's significant investment in Intelligent Transportation Systems (ITS) to date, as highlighted in Section 8, including a traffic management center, video cameras, traffic sensors, electronic signs, detection, citywide computerized signal control and fiber optic communications, provides much of the background infrastructure needed to support implementation of wireless V2I and V2V connected vehicle communications on major arterials. VDOT's commensurate development of traffic operations systems on I-264 includes a regional operations center, fiber network, traffic sensors, video cameras, electronic signage, and managed lane / active traffic management tools such as part-time HOV lane operations and part-time hard-shoulder running strategies. That too provides a strong background infrastructure for V2I / V2V deployment.