SMART CITY TESTBED: CONCEPT AND OPERATIONS

Deliverable #1

Submitted To:

Center for Innovative Technology (CIT)

OST®
CONVERGING MISSION,
INNOVATION, AND TECHNOLOGY

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1. Executive Summary

OST's Smart City Testbed approach will strengthen the Center for Innovative Technology (CIT) vision and plan to develop smart communities across Virginia. The Stafford Smart City Testbed will become a "live laboratory" to test new smart technology and generate practical, proven knowledge that can be used by cities and counties across Virginia. Additionally, the intent is to transfer of testbed-generated technology, knowledge and the proof-of-concept to support the development of Downtown Safford and other similar projects across Virginia.

The testbed has evolved as a true Public-Private Partnership (P3). In addition to CIT, Stafford County and Arlington County as well as several industry partners have joined the testbed, which will focus on relevant and practical use cases to produce implementable solutions using emerging and smart technologies.

2. Background

The Smart City Testbed in Stafford County, Virginia is a unique approach to foster the growth of smart cities in the Commonwealth of Virginia. This testbed has been designed as a "shared knowledge platform" with the specific objective to develop practical and relevant solutions for smart cities.

CIT and Stafford County are the primary testbed sponsors. OST, Inc. (OST) is the prime systems integrator and testbed manager. The Smart City Testbed is a true P3 endeavor involving multiple industry partners that are making significant contributions.

A Commonwealth of Virginia funded entity, CIT is playing a leading role in promoting and assisting the development of smart and connected communities throughout Virginia. According to CIT, "Building on the work of the Virginia Smart Communities Working Group and related efforts, Virginia now has a Smart Communities State Action Plan. The plan calls for pilot projects to begin building smart technology capacity and expertise throughout the Commonwealth. The pilots rely on 'community-driven innovation' to identify topics relevant to each community, including a technology partner and support to initiate 'agreed-upon priorities.'"

CIT also has collaborated with the United States Department of Homeland Security (DHS) Science and Technology Directorate (S&T) First Responders Group (FRG), Smart City Works, and TechNexus to launch SCITI Labs - an effort to prototype the Internet of Things (IoT) and smart city technologies for emergency response and management. SCITI Labs creates an accelerated pathway to market through prototype funding and access to first responders (end users) across America.

The Smart City Testbed is an extension of the Vision, Strategy and Operations plan developed by OST and CIT for the Stafford Smart Town Center. The Smart City Testbed is located in Stafford County and a secondary pilot project site has been selected in Arlington County. Stafford is a rural county, poised to emerge as a leading smart city model for the Commonwealth. Arlington is a developed, technologically advanced county ready to move to the next level of smart city development using new technologies. The Smart City Testbed and related pilot projects in Stafford and Arlington County will provide insights into the new ways of using smart technologies to meets citizen's needs and provide Return on Investment (ROI) for the county and the state government.

3. Testbed Concept

3.1. Vision

- Make the Commonwealth of Virginia a leading state in Smart City implementation, focusing on the economic and social benefits of digital transformation

3.2. Mission

- Help develop Stafford County and specifically Downtown Stafford as a "Model Smart City" that can be replicated in other parts of the Commonwealth of Virginia
- Develop practical solutions based on new and emerging technologies that can be implemented across the Commonwealth of Virginia

3.3. Testbed Objectives

- Conduct pilot projects to advance Smart City development in the Commonwealth of Virginia
- Engage with Stafford and Arlington Counties to develop relevant and practical use cases based on their needs
- Develop Smart City solutions based on new technology such as IoT, 5G, drones and other advancements that can be used across Commonwealth of Virginia
- Test new and emerging Smart City solutions for IoT security, public safety, smart health, intelligent transportation systems, Smart Agriculture, and other community development applications
- Develop P3 agreements with a collaborative framework
- Involve testbed partners with specific solutions related to IoT, 5G, drones, Cloud, security, etc.
- Involve university partners such as Old Dominion University (ODU) and George Mason University (GMU) on the specific pilot project
- Develop relevant guidelines, compliance templates, and an IoT framework that can be used in Stafford and Arlington Counties, as well as other counties and cities.
- Strategically utilize the Smart City Testbed to maintain continuity for Smart City development in the Commonwealth of Virginia.

4. Operational Concept

A testbed is a controlled experimentation platform that supports technology and application testing and deployment in an environment that resembles real-world conditions. Experimentation explores untested technology or existing technologies working together in new environments. Ultimately, testbeds should lead to innovative products and services. The proposed Smart City Testbed involving Stafford and Arlington Counties will provide insights into new ways of using smart technologies to enhance the quality of life in communities throughout Virginia.

Stafford County is the primary location for the testbed. Arlington County and other satellite locations will serve as pilot project sites. All locations will be fully supported by OST's Center for Engineering and Innovation (CoEI) and OST's Smart Airport Lab. The CoEI is located at OST headquarters in McLean, VA, and the Smart Airport Lab is in Atlantic City, supported by the Federal Aviation Administration (FAA) Tech Center. OST has assembled leading industry partners to support the testbed and ensuing pilot projects.

OST, Inc. is proposing to conduct a series of pilot projects using the IoT platform and other technologies to create relevant solutions that can be utilized in the Stafford County Smart Town Center project and beyond. The model, architecture, data governance and other templates developed through the proposed pilot projects can be used by other cities in the Commonwealth of Virginia. This is the first comprehensive Smart City Testbed involving the IoT platform fully integrated with 5G and other new and emerging technologies for Smart Cities.

OST uses its established testbed methodology to establish the site and conduct pilot projects, as presented in Figure 1.

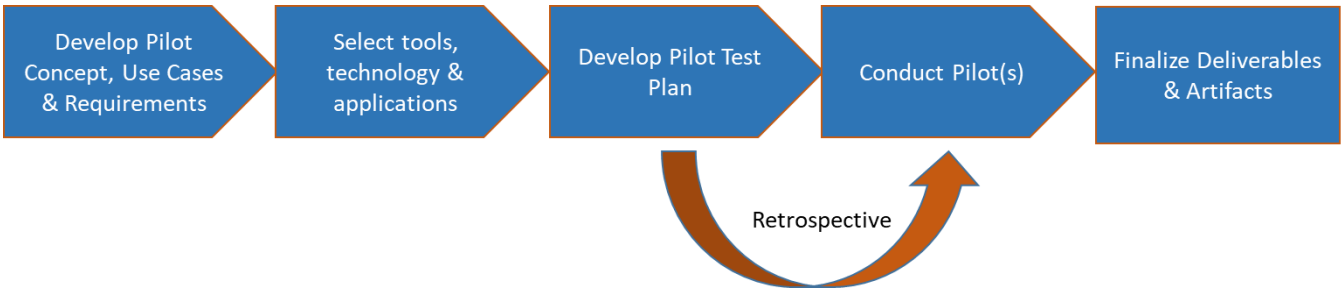

Figure 1: OST Smart City Testbed Pilot Implementation Approach

Testbed use cases and pilot projects will generate knowledge and artifacts that will have wide application for Smart City development in the Commonwealth of Virginia. Some examples of related artifacts and solutions are presented below:

- An implementable model and framework to effectively use IoT in Smart Cities
- IoT-based technical architecture for Smart Cities
- IoT security architecture for Smart Cities
- Smart City data governance, privacy model, and template
- IoT compliance templates for Smart Cities
- An integrated IoT pilot incorporating IoT platform, 5G, and drone technology for public safety and emergency management
- Cybersecurity proof-of-concept for IoT security

Additional innovations will be added as the testbed evolves over time

5. Collaborative Framework

Testing complex solutions involving multiple technologies requires multiple knowledgeable partners. Figure 2 presents our collaborative framework. We have involved many industry partners along with counties and the federal government. Our industry partners bring expertise in IoT security, 5G network, Cloud infrastructure and services, cybersecurity, data sensors, drone technology, data analytics, Artificial Intelligence (AI), Machine Learning (ML), and network integration solutions. The testbed operating framework is collaborative in its approach, as each industry partner provides “best-of-breed” solutions.

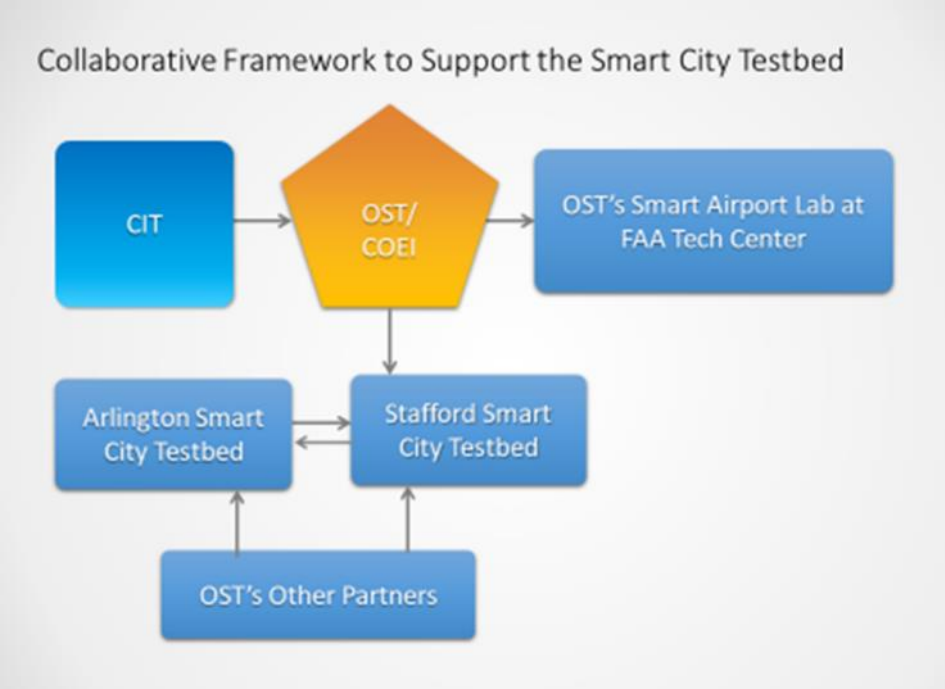

Figure 2: Smart City Testbed Collaborative Framework

The team of partners has been carefully selected according to capabilities, roles and expertise in implementing Smart Cities around the world, and their willingness to contribute to our collective success. Current partners' specific roles and responsibilities are presented in the table below:

Partner Name	Role & Responsibility
CIT	Primary sponsor
OST, Inc.	System integrator, testbed manager, data analytics, client management
Verizon	5G system provider, video analytics system
Onclave Network, Inc.	IoT security platform
Zones, Inc.	Microsoft Cloud IoT, network infrastructure, solution engineering
Axis Communications	Cameras, video management system
Arlington County	Testbed site, use case requirements, et al
Stafford County	Physical laboratory space, fiber connectivity, et al
Old Dominion University	Drone pilot, support on other pilots
MutualLink	Interoperational solutions
AWS	Cloud services, connectivity, et al

Figure 3: Current Partners' Specific Roles and Responsibilities

6. Testbed Requirements

The Smart City testbed is a common environment and framework underpinning and enabling Smart City IoT based pilots. The two key components that make up the Smart City testbed are: (1) an onsite physical location that will house the testbed lab and operations center equipment, and (2) an IoT platform that can be hosted off-site in a centralized manner in the Cloud or in a data center. The onsite location will require a dedicated network circuit to connect local lab equipment with the central IoT processing platform, while providing the necessary security and bandwidth. In addition to housing the equipment to communicate wirelessly with IoT devices, the onsite location will house the servers that will perform all necessary pre-processing of IoT device data "at the edge."

As a common platform providing the basics for any Smart City IoT pilot or solution, the testbed setup must be flexible and extensible. It must also be able to support multiple concurrent pilot implementations.

The available IoT platforms to be tested can be divided into two broad categories. The first category includes the IoT platform offerings from the two major Cloud service providers (AWS IoT Core from Amazon Web Services and Azure IoT Hub from Microsoft). These offerings are provided as managed Cloud services with specific administration and integration interfaces; they do not require administering the underlying infrastructure and typically have a flexible usage based cost structure. The second category includes Commercial Off-the-Shelf (COTS) products that can be licensed and deployed in a data center or on a set of servers in the Cloud. Examples include OneMind from World Sensing, IMPACT from Nokia, and other COTS solutions.

6.1. Technology

Although specific technology requirements will be determined by the nature of the pilot projects, at the fundamental level, we envision the infrastructure and facility requirements presented in this section.

6.1.1. IoT Platform

To improve outcomes by connecting the various disparate ecosystem segments, cities need to adopt a horizontal IoT platform that can handle everything from device management and data collection to event processing and end-to-end security – while including applications that address each city's unique needs. Early experiences have proven that fully harnessing the power of IoT requires cities to break down existing information silos and combine massive quantities of data from multiple sources. For example, Smart Parking initiatives will not only impact traffic patterns, but will also create efficiencies for the public transportation system. If this kind of holistic approach is adopted, cities can reap the benefits of using IoT.

The primary advantages of implementing such an IoT platform include the visibility of all county operations on a centralized system connecting various departments, staff and devices. The officials would be able to view data in real time and leverage the analytical capabilities of the platform for to improve insights and decision-making.

A secure communication platform with NextGen911 features can simplify reporting and information gathering during an emergency response. Some features of the IoT platform include:

- Collect and integrate data from sensors (including third-party sensors for parking, lighting, etc.)
- Real-time visualization and monitoring using geolocation for collected data

- Monitor external system and asset status
- Integrate remote external system maintenance and management (e.g., LED light settings)
- Automate workflows and connect with workforce via calls or text messages
- Report functionality using data analytics, Business Intelligence (BI), and dashboard tools

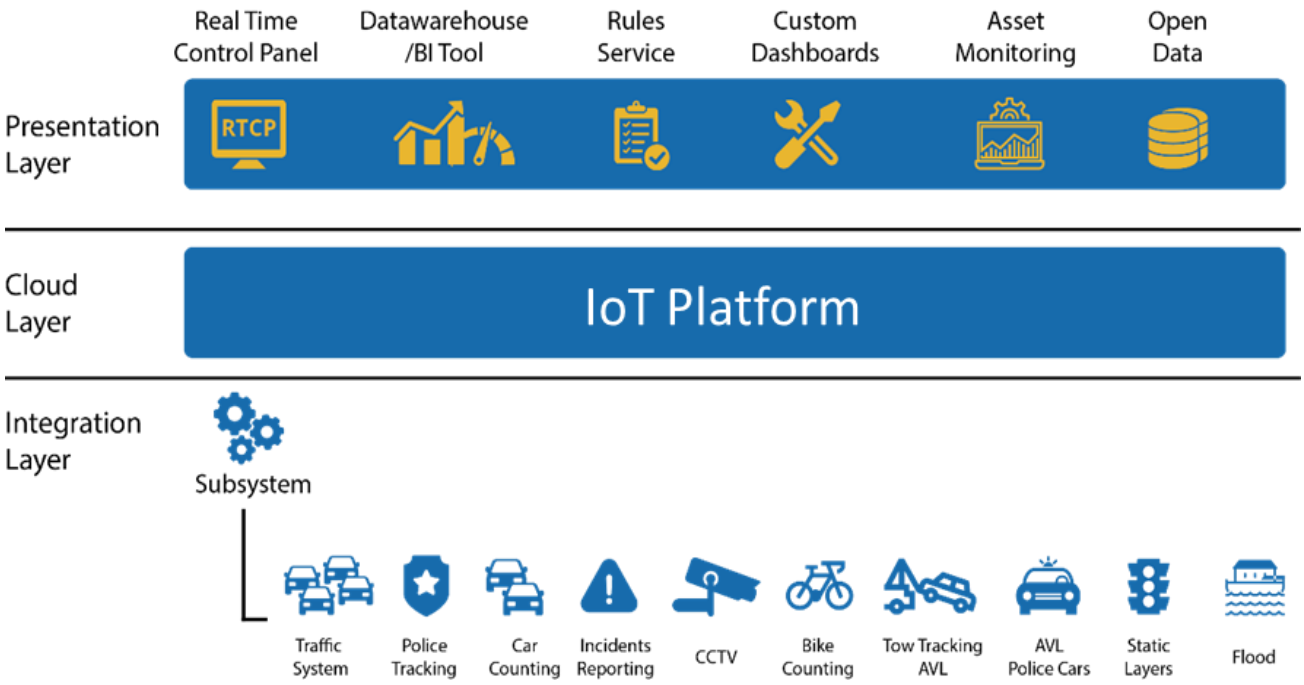

Figure 4: Integrated IoT Platform Architecture

6.1.2. Emerging 5G Networks & Services

Each successive generation of wireless network technology has delivered new and exciting services to consumers and businesses. For example, 2G delivered voice transmission, 3G spurred the growth of new applications and services, and 4G contributed significantly to higher transmission speeds. 5G is expected to replace the wired home broadband network and help develop complex systems such as autonomous cars and real-time virtual reality. 5G will make the Internet of Everything (IoE) possible by using shorter-frequency radio waves to interconnect all electronic devices, vastly increasing the data reach for Internet connectivity.

Figure 5: Telecommunication Tower with 5G Antenna

Designing the Stafford Smart Town Center and other smart cities in Virginia will include 5G technology and systems. Although it is too early to predict all the benefits of 5G, market analysis and trends indicate great improvements to applications in synchronized urban transportation,

education, healthcare, manufacturing, etc. The Smart City Testbed will develop multiple pilot projects with 5G technology.

6.1.3. Drones

We will use drone-based fleets equipped with multiple optical and laser sensors (high-resolution cameras and 3D scanners) to perform public safety surveillance and response activities in Smart Cities. Drones are a highly effective tool for high-definition imaging, 3D scanning, and optical/LIDAR (Light Detection and Ranging) components designed to help public safety chiefs and emergency operations managers use real-time situational awareness.

Police, fire, disaster recovery and other emergency services benefit from this awareness to make informed decisions on emergency management. For example:

- Provide aerial imagery for fire investigation
- On-scene personnel accountability
- Incident Safety Officer awareness
- Fire hydrant location
- Storm damage assessment
- Missing person search
- Police suspect search and tracking
- Locate access to wildland fires
- Fatality auto accident investigation
- Crime scene investigation
- Post incident analysis and training
- Police perimeter aerial reinforcement
- Bomb threat assessment
- Unprecedented situational awareness to Emergency Operations Center via live stream
- Emergency Management planning

Figure 6: Drone Deployed to Tackle Forest Fires

In the Smart City Testbed, we intend to develop several use cases based on some of the applications outlined above and conduct pilot projects.

6.1.4. Data Analytics and Tools

Smart technologies generate a lot of data that can generate insights through data analytics on how better to manage and operate the city. For example, sensors that detect air quality can lead to faster intervention and remediation. Data from energy-use sensors on buildings and other infrastructure can improve energy management and reduce costs. Data analytics takes advantage of the smart data that is generated and collected in real time so city managers can rapidly react to real-time data.

Unlocking the capabilities of IoT and data analytics to gather, aggregate and normalize information from siloed applications will pave the way for the cities to be “smart” in everything from lighting, parking, traffic, waste management, citizen engagement, safety and security, in a new and comprehensive ecosystem that enables county managers to make better, data-driven decisions.

Data analytics plays a pivotal role in creating a Smart City, which depends on how well organizations can analyze and share vast amounts of data constantly being generated by new technologies. Intelligent automation and data analytics (especially advanced predictive and prescriptive analytics) are what make a city "smart." The data generated by multiple sources has no benefit unless it is turned into actionable information by analytic methods and tools. In smart cities, data conveys the message – data analytics provides the meaning.

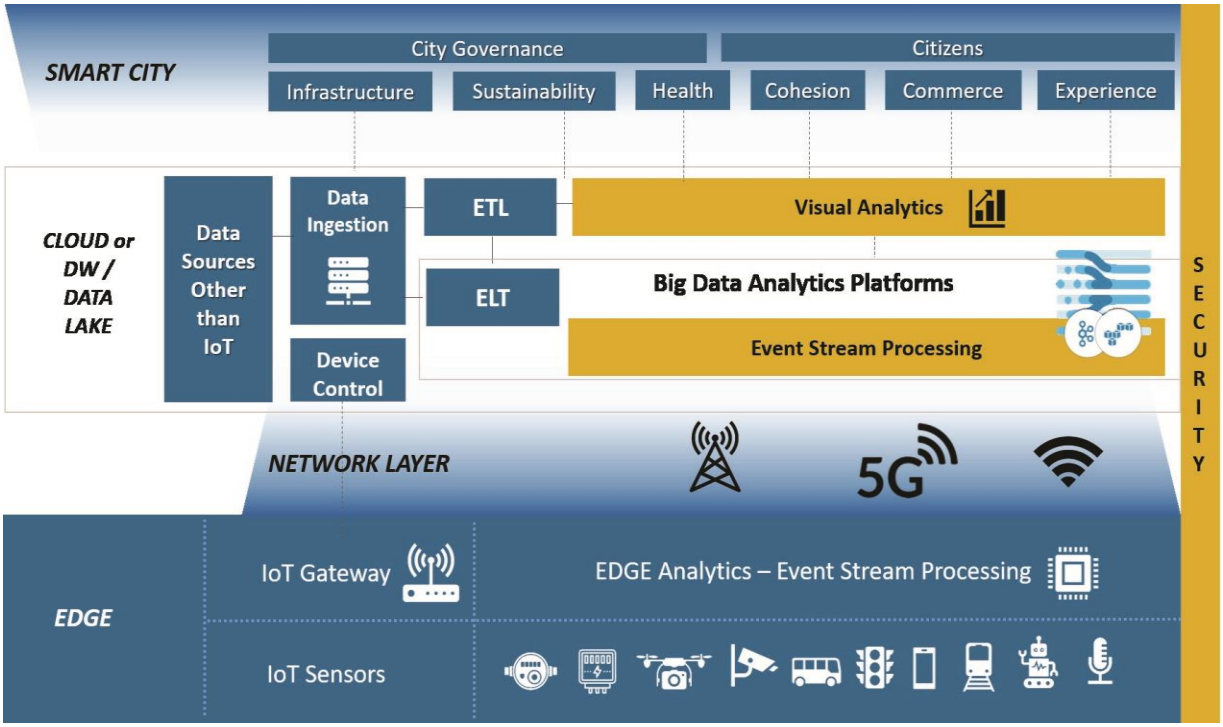

Figure 7: Smart City Integrated Data and Analytics Architecture

Predictive Analytics can leverage state-of-the-art platforms and technologies to solve complex city problems by evaluating past and current performance to predict future requirements and potential problems. Cloud computing and technologies such as Hadoop/HDFS, Spark, Hive, and other proprietary tools are used to capture, manage, and analyze immense amounts of Big Data. AI and ML algorithms evaluate this data and create effective situational models related to traffic, parking, waste management, facility management, energy, water, and emergency management. These models and predictive forecasts help city managers to improve the efficiency of city operations and services.

6.1.5. Sensors, Cameras & Video Management System

Sensors, cameras and video surveillance technologies that leverage the broadband backbone can deliver real-time data for transportation, public safety initiatives, education and training, etc.

A centrally located intelligent command center with connections to cameras and sensors can enhance the safety and security of everyone in the area. Sensors in buildings, on light poles, and other tactical locations can alert officials to potential emergencies. Flood sensors can send alerts when stream or sewer water levels rise rapidly. Fire alarms can provide the exact location of a fire. Traffic sensors can send an alert if traffic stops moving completely for too long, indicating a possible accident or roadway

obstruction. Integrated road sensors, cameras and traffic lights can use AI and ML to optimize traffic flow, reduce carbon emissions and commute time, while eliminating gridlock.

Modern sensors can tell city officials when trash receptacles are full and require attention. They can also identify excessive levels of odor and potential problems with trash equipment. Alerts from these sensors reduce costs by proposing the most efficient route to empty the trash (rather than waste time visiting empty cans) and helping to maintain a clean environment for everyone to enjoy. First responders can manage a local command center with access to cameras and sensor data, reducing response time to medical, fire or other emergencies and ensure a safe environment.

6.1.6. Smart poles

Counties are looking to modernize public lighting infrastructure by installing Smart Streetlights on roads and sidewalks to improve the quality and reliability of public lighting, while at the same time reducing operating and maintenance costs. Some functions of Smart Poles include:

- Convert all outdoor street lighting to LED
- Connect all LED lights to an IoT platform for monitoring and maintenance
- Provide remote monitoring and programming, adaptable dimming and brightening, intelligent energy metering and billing, and reporting
- Ensure interoperability between devices to collect and transmit data to the community, utilities, and government departments
- Smart Poles can integrate LED lighting with other features and smart devices such as security cameras, environmental sensors, EV charging outlet, Wi-Fi connectivity, digital kiosks, etc.

Figure 8: Smart pole with Smart Lighting, EV charger, Wi-Fi, Security Camera, and Environmental Sensors

6.1.7. Smart Buildings

Maximizing building efficiency helps manage decreasing budgets against increasing requirements. Intelligent buildings can create and maintain a safer and more secure, productive and comfortable environment as cost-effectively as possible. Smart Building Management Solutions can help achieve these goals through a holistic approach to building, security and life safety management systems.

It takes more time and resources to manage stand-alone applications and separate monitoring and control systems. An automated building control process improves performance and operational efficiency, and increases the ROI of systems over the entire building life cycle.

Smart Building Management systems leverage sensors and IoT advanced technologies for:

- Energy management
- Air quality monitoring
- Occupancy monitoring

- HVAC retrofit
- Fire detection systems
- Closed Circuit Television (CCTV)
- Access control system
- Lighting

6.2. Network Infrastructure and Systems

The following network infrastructure components will be required in the testbed (these may change depending on the type of pilot projects):

- Wireless connectivity to IoT devices within the perimeter of the Smart City test environment
  - NB-IoT
  - LoRa
  - Wi-Fi HaLow
  - MAV link
  - Wi-Fi
  - Communication gateways
  - Switches and Routers
- On-site edge processing
  - Internal Lan processing using gigabit switches
    - Multiple devices with built-in servers
  - Servers to process transactions and upload to the Cloud
    - On site hosted components of IoT platform
    - Components to manage IoT security using blockchain technology
- Dedicated fiber connectivity for fast and secure connection to the Cloud and the internet
  - Fiber connectivity to the 5G wireless platform
- Display monitors and Interactive display monitors
- Wireless Access Points

6.3. Physical Facility

- Laboratory Space (provided by Stafford County)
- Laboratory furnishing
- Wall mounted display systems
- Equipment racks
- Rack-mounted systems

6.4. Staffing Requirements

The table below shows the minimum requirement for resources needed to manage the testbed. However, we believe additional resources will be required specific to the pilot projects.

	OST	Partners	Counties
Dedicated Staff	Smart Infrastructure Engineer (1)		
	Consultants (1)		
	Test Engineer (1)		
	Project Manager (1)		
Part Time Staff		Specific to the pilot	Specific to the

		projects	county pilot projects

Figure 9: Minimum Testbed Staffing Requirements

7. Conclusion

To achieve the Smart City goals set by the Commonwealth of Virginia, this Smart City Testbed will be an essential piece of the larger puzzle. The testbed will provide the ability to test, maintain and manage all the various devices, sensors, and underlying technologies provided by various partners. This will require a transformational approach, meticulous planning, stakeholder involvement, and support from the leaders and governments concerned. The Smart City Testbed project will bring into reality the ability for people, business and government in Stafford and Arlington counties to connect and communicate with one another anytime, anywhere, in an environment of social cohesion and economic development cooperation.

This testbed will establish a standards-based framework in which all vendors – from startups to established, global players – can build solutions that leverage shared information. It will enable solutions that combine diverse data products and processing services to deliver value that cannot be delivered in restricted proprietary environments. Immense economic opportunities will result from this testbed: new markets, innovation, integration, technology convergence, and more.