# Buffalo Main Street: Smart Corridor Plan

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# Buffalo Main Street: Smart Corridor Plan

***Final Report***

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# Notice



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16. Abstract

Smart City technological applications have been employed in several cities worldwide to help improve functionality of transportation infrastructure. The information collected through the distribution of sensors inform applications that optimize city life. The Steering Committee for this project, led by the Buffalo Niagara Medical Campus (BNMC), envisions the utilization of Smart City technology along Main Street between Goodell Street and Ferry Street. This study is divided into three tasks; the first section is an evaluation of existing conditions of the corridor, the second draws from case studies across the globe to inform a best practice report, and the last is a recommendation of Smart City implementation. The Steering Committee can influence the City of Buffalo's Smart City efforts to promote the Main Street corridor as a Smart City and innovation corridor. It is advised that the Steering Committee advocates for a Smart City corridor in the short term, during the development of the City of Buffalo's RFP process for lighting vendors and the redevelopment of the Main Street corridor. The long-term objective of the project is to pilot various Smart City applications within the corridor which will improve transportation and have the ability to be adapted citywide.

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# Keywords

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# Table of Contents

# List of Figures

# List of Tables

# Acronyms and Abbreviations

| | |
|---|---|
| APS | Accessible Pedestrian Signals use a pushbutton that assists pedestrian guidance of a crosswalk in a non-visual way through audio cues or communicative vibrations; assists the visually impaired to navigate crosswalks. |
| AV | Automated or Autonomous Vehicles are self-driving or driverless vehicles capable of sensing its environment and navigating without human input. |
| CV | Connected vehicles use any of a number of communication technologies to communicate with the driver, other cars (vehicle-to-vehicle [V2V]), roadside infrastructure (vehicle-to-infrastructure [V2I]), and/or Vehicle-to-Everything (V2X). |
| DSRC | Dedicated Short Range Communications is a two-way short- to medium-range wireless communications technology that permits very high data transmission critical in Smart Corridor applications. |
| IoT | Internet of Things is the interconnection via the Internet of computing devices embedded in everyday objects, including vehicles and transportation devises, enabling them to send and receive data. |
| MaaS | Mobility as a Service is a combination of public and private transportation services within a given geography that provides holistic, preferred, and optimal travel solutions to enable end-to-end journeys paid for by the user as a single charge. |
| OBE | Onboard equipment allows for vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-everything wireless communications. |
| RSU | Roadside units are a small device placed along the roadway that facilitates data exchange with another device (motor vehicle, smart phone, etc.) using DSRC. The device is usually situated on other infrastructure such as street lights or traffic lights. |
| SPaT | Signal Phase and Timing refers to the communications associated with the operations of signalized intersections, which can include preemptions and priorities for certain mobility elements. |
| TNC | Transportation Network Company, or a company that provides Mobility as a Service (i.e., Uber, Lyft). |
| TSP | Transit signal priority is a responsive traffic signal system that gives priority to transit or emergency vehicles, thus improving travel times. |
| UCD | Universal Crosswalk Diagram is a street sign designed to aid the visually impaired and blind to navigate a crosswalk safely. |
| V2V | Vehicle-to-vehicle data sharing. |
| V2I | Vehicle-to-infrastructure data sharing. |
| V2X | Vehicle-to-everything data sharing (cloud-based data sharing). |
| VMT | Vehicle Miles Travelled. |

# Executive Summary

Buffalo Main Street: Smart Corridor Plan provides guidance to the project steering committee, led by the Buffalo Niagara Medical Campus (BNMC), on Smart City development along the Main Street corridor— utilizing new and emerging technology to create a safer, greener, more efficient, and more equitable multimodal street. The plan is designed to make a "futureproof" corridor, adaptable to changes and updates in technology. The ultimate objective of the plan is to create a corridor to pilot smart city transportation projects that can be expanded after an initial testing period. The BNMC is Buffalo's premier innovation district—a hub of medical and technological advancements—and creating a learning lab along this corridor will strengthen its ability to drive regional economic development and improve overall quality of life.

The plan is divided into three main sections:

- A review of existing plans and conditions in which existing plans, infrastructure, data collection, and sharing methods within the study area are reported on and inventoried. These conditions are registered in addition to the redevelopment of Main Street in the study area.
- A best practice report, which evaluates active smart city projects or projects in development to offer a palette of ideas for possible application in the Main Street corridor. As Smart City development is novel, many practices are still in the planning and development phase.
- Lastly, the plan offers suggestions for smart city development in the corridor. The suggestions are organized to coordinate (1) development during the Main Street redevelopment (short term) and (2) applications once a data management system is developed and operational (long term).

The plan defines the study area as the length of Main Street between Goodell, the southern boundary, and Ferry Street, the northern boundary. In summary, the plan provides the following insights and suggestions:

- The City of Buffalo should partner with the steering committee to identify the Main Street corridor as a pilot testing ground for the deployment of smart city applications.
- Smart city development ideas to be rolled into the Middle Main Street Reconstruction Project should be immediately submitted to the City of Buffalo.
- In the short term, the steering committee should influence the smart city request for proposal (RFP) for smart lighting and advocate for the city to deploy smart sensors with greater capability along the Main Street corridor to enable the smart city project piloting.

- In the long term, the steering committee should partake in advocating for Niagara International Transportation Technology Coalition (NITTEC) to act as the data management center (DMC) for the Buffalo-Niagara Region. The presence of a DMC improves and expands potential for future smart city applications such as smart parking systems and the rollout of connected and autonomous vehicles.

The following smart city applications are recommended for deployment as part of the Main Street: Smart Corridor Plan:

- Install smart city sensors primarily through streetlight replacement
- Implement a Smart Cycle Track
- Implement curbside management techniques, including active and smart parking management features, and the installation of DC electric vehicle charging stations
- Develop systems architecture/concept of operations
- Deploy dynamically controlled traffic signals
- Develop a smart mobility hub
- Create a Universal Design Testing Intersection to pilot new and emerging universal design technology
- Ready corridor with AV/CV infrastructure for pilot testing

## ES.1 Introduction

BNMC was awarded $75,000 from the New York State Energy Research and Development Authority (NYSERDA) and New York State Department of Transportation (NYSDOT) to develop a Smart Corridor Plan for Main Street in the City of Buffalo. The Main Street: Smart Corridor Plan involved a collaborative and proactive approach to identifying opportunities for the implementation of smart transportation infrastructure and technology throughout the Main Street Corridor between Goodell Street and Ferry Street.

Main Street in the City of Buffalo is a densely populated, mixed-use, and multimodal corridor that runs northeast through the heart of the city. In recent years, the city has witnessed a tremendous amount of new development along the Main Street Corridor, due in part to the continued growth of the BNMC and the City's Central Business District (CBD). In tandem with this growth, there is a strong push to repair and enhance the aging infrastructure of Main Street, including traffic calming measures, improving pedestrian and bicyclist accommodations, and improving access to Metro Rail—the city's subway system that runs along Main Street. Multiple planning efforts over the past years have all identified Main Street as a top priority for reconstruction, and the City of Buffalo has recently secured over $18 million to improve the street infrastructure of Middle Main Street (between Goodell Street and Humboldt Parkway). The city anticipates a full-street reconstruction between Goodell and Ferry, and mill and overlay between Ferry and Humboldt, until more funding is identified to continue full reconstruction to Humboldt. This section of Main Street is adjacent to the BNMC and includes four Metro Rail Stations. The city started the design process for a large-scale streetscape improvement project in the fall of 2019. A project steering committee was formed, led by BNMC, which worked together with the City of Buffalo and their selected design subcontractor to develop the Main Street: Smart Corridor Plan.

The primary objective of the Main Street: Smart Corridor Plan is to identify ways new and emerging technology can facilitate a safer, green, more efficient, and more equitable multimodal street. To achieve this, the steering committee conducted an in-depth exploration of potential IoT applications as part of the city's Middle Main Street Reconstruction Project. The final deliverables of this plan include a blueprint for the utilization and management of IoT applications in the Main Street corridor.

A detailed list of the three phases for the corridor plan are as follows:

Phase I: Integrate immediate elements into the City of Buffalo’s Middle Main Reconstruction Project to futureproof the corridor:

- Install infrastructure needed for Smart City Communications (underground conduit and hand boxes; Wi-Fi enabled communications within traffic signal control boxes; public Wi-Fi routers).
- Coordinate with the City of Buffalo on their ongoing Smart City Plan (purchasing of City streetlights from National Grid; selection of a vendor for deployment of smart city sensors on streetlights; future deployment of sensors along the Smart Corridor).
- Pilot a Smart Cycle Track utilizing existing sensor technology that gives intersection priority to cyclists and micro-mobility users.
- Install Electric Vehicle Charging Stations and pilot curbside management flex zones using static signs to control different uses of parking spaces for specific times of day.
- Install the infrastructure needed for Smart Mobility Hubs at key locations (kiosks that display real-time transit information, provide a Wi-Fi hotspot, etc.). Seek funding for installation of Smart Mobility Hubs.

Phase II: Develop the systems architecture (governance/data management/communications network/concept of operations) and get the needed smart city framework in place and operating. This will essentially become the backbone of the smart city network.

- Support NITTEC’s efforts toward establishing a regional Smart Operating System responsible for data storage, processing and distribution to collaborative entities.
- Coordinate with the City of Buffalo and NITTEC to channel data collected from the City’s Smart City sensors to NITTEC’s Smart Operating System.

Phase III: Use the Smart Corridor to pilot additional smart city applications, building on the infrastructure and framework put in place during Phases I and II. Priorities identified to date include:

- Pilot an expansion of the City's Buffalo Roam parking application—integrate real-time data to display available spaces; create dynamic pricing that fluctuates based on demand to better manage parking space utilization.
- Deploy Dynamically Controlled Traffic Signals to assist in congestion mitigation, improve transit service times, and prioritize emergency response vehicles at intersections.
- Pilot a universally designed intersection—create a living lab along the Smart Corridor for Universal Design Technology that improves the mobility of vulnerable populations. Collaborate with BNMC healthcare institutions and the University at Buffalo's IDEA Center.
- Pilot Connected Vehicles and Autonomous Vehicles along the Smart Corridor in collaboration with University at Buffalo CV/AV research entities.

# 1 Existing Plans and Conditions

## 1.1 Introduction

This section acts as a summation of key findings derived from the review of existing plans and conditions in the Main Street corridor and aligns the current local and regional plans with the scope of the Main Street: Smart Corridor Plan to coordinate planning, policy, and financing goals. Further, the section outlines the local inventory of utilities and data owned by regional, private, and public entities. In the process of this task, the organization of stakeholders into subcommittees has been evaluated to coordinate specific elements of the project, ranging from data management, utilities, parking, and planning. With input from stakeholders, this section has also evaluated current standing of local assets and plans to move forward in the implementation of smart city applications in the Main Street corridor.

## 1.2 Review of Relevant Existing Plans, Studies, and Grants

The section summarizes existing plans, studies, and/or grants that are relevant to the Main Street corridor and development of a Smart Corridor in and around the Buffalo Niagara Medical Campus (BNMC).

### 1.2.1 Buffalo Bicycle Master Plan (2016)

Buffalo can leverage its radial grid street pattern to create a safer, more inclusive and connected biking network around the city. Buffalo has an existing 72 miles of bike lanes, 400 bike racks, 1.6% of commuter mode share by bicycle, and a “Bronze” bike friendly community status according to the League of American Bicyclists. The long-term goal is to create a rim and spoke network where multiuse trails would act as the rim, and key bikeway corridors would act as the spokes, while improving accessibility to underserved communities. A series of catalyst projects are characterized including design and cost specifications. Among the catalyst projects is a proposal for a Main Street road diet project in which Main Street would be downsized and include a two-way cycle track. The goal of the plan is to make Buffalo a “Platinum” bike friendly status with 300 miles of bike facilities and a 10% bicycle commuter mode share by 2025 with increased data gathering and performance measures to build and upkeep a more sustainable community. Using smart city technology will help promote bicycle use and safety.

### 1.2.2 BNMC Master Plan Update (2010)

The BNMC is prioritizing "smart growth" as the campus is exceeding even the most aggressive expansion forecasts. The BNMC is trying to navigate innovative solutions to bolster transit ridership and other modes of transportation to address parking constraints for the campus. The BNMC has extensive plans of development possibilities along the east side of the Main Street corridor. The interface between the BNMC and Main Street is a top priority as it is the city's primary address and hosts the cities only light rail line. Along with medical institutional expansion, BNMC envisions an influx of residential and retail activity. Proper redevelopment strategies and initiatives regarding the existing station will provide viable alternatives to students and employees traveling to/from the BNMC. Mid-rise heights and densities should be promoted to increase density along the corridor. Retailers along the corridor should maintain facades and storefronts and consider shared future parking assets with the BNMC. The storefronts on the west side of Main Street should act as a buffer to the Allentown district. The plan seeks to leverage current transit infrastructure and include any other solutions to limit the number of automobiles commuting to the campus. Using smart city technology will help promote transportation options and sustainable growth.

### 1.2.3 Downtown Buffalo Infrastructure and Public Realm Master Plan (2015)

As development grows in Downtown Buffalo, a smart investment framework for new public realm infrastructure is needed to foster private investment and establish a network of attractive streets and open spaces. The city should adopt a complete streets policy along the Main Street corridor to include the needs of pedestrians, cyclists, and automobiles. The BNMC is a major asset to the "investment spine," a clustering of investment activity that continues to generate private sector interest downtown. The investment in the "spine" will eventually spill east-west outward from the corridor. It is proposed that the four lanes of car traffic get reduced to two lanes with a planted median/left-turn lanes. With the narrowing street, bike lanes on both sides of the street as well as improved designated pedestrian crossings are suggested to promote pedestrian and biking activity to increase connectivity between Allentown and the BNMC. Streetscape enhancement along the corridor is underway to improve connectivity of Allen Street to the employees on the BNMC. The plan focuses on more active streetscapes, to reduce the prominence of parking through the promotion of transit, and to focus infrastructure investment along the Metro Rail corridor. An integrated transit and parking strategy for downtown with a focus on improving transit use. Connectivity of multimodal transportation must be promoted to make the most of public transit infrastructure and support future investment in existing systems. Using smart city technology can help implement many of the multimodal opportunities outlined in the plan.

### 1.2.4 Greater Buffalo Niagara Regional Transportation Council (GBNRTC) Central Business District North Transportation Study (2017)

The BNMC will have a substantial impact on surrounding neighborhoods due to rapid development, an updated transportation system will need to be put in place to support a diverse community with multimodal options. It is suggested that the city slim Main Street down to two travel lanes with a two-way center left-turn lane, two bicycle lanes (one on each side of the road), and two parking lanes. Implementation of new crosswalks, curb bulb-outs, and curb ramps will increase pedestrian safety between Allentown and the BNMC. Updated optimized signal plans are to be phased in during peak periods along the corridor. Currently, there are high peak period pedestrian counts and a perceived barrier along the corridor. Using smart city technology will help peak hour traffic flow to/from BNMC.

### 1.2.5 GBNRTC Moving Forward 2050 (2018)

This document is a vision of the future of regional transportation. It highlights innovative ways of "building, planning and financing our transportation system." The plan mentions the need for MaaS (Mobility as a Service) rollout in the region as well as a smart payment system to accommodate it. The plan defines SEMAs (Smartly Enhanced Multimodal Arterials) that offer multimodal transportation options that communicate real-time information by implementing Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) data sharing technologies. The idea is a marriage between smart streets and complete streets, as it emphasizes a shared street between pedestrians, bicyclists, transit, connected vehicles and autonomous vehicles. The plan outlines ways in which to utilize flexible curb space in which curbs serve several different purposes during different times of the day. This would be coordinated with SEMA communications as to which use would be optimal at which time of day. There are sections dedicated to international freight network, including methods of border crossing for autonomous vehicles, integrated corridor traffic management, faster border crossings with e-tolls and pre-clearance. Regionally, the plan promotes new governance structures to coordinate "smart" technology deployment of I2V, traffic management, smart lighting, internet access, energy grids and EV charging. Lastly, the plan delivers opportunities for increased efficiency in the freight network by utilizing smart corridor technologies.

### 1.2.6 NITTEC 2017 Strategic Plan (2017)

Niagara International Transportation Technology Coalition (NITTEC) is a local coalition of agencies developed to improve traffic congestion and roadway safety in the Buffalo-Niagara region. NITTEC has a high capacity for ITS management and work but is under resourced. If NITTEC became a separate entity, and budgeting is managed in house, operating capacity of the agency will be robust. If given the resources, NITTEC plans to upgrade its current outdated traffic management system to an Advanced Traffic Management System (ATMS). The upgrade would include many operational abilities conducive to the Main Street corridor project. Some of these include; real-time traffic coordination through a cloud based mobile access and functionality, comprehensive and extensible live map, Robust center-to-center subsystem to allow interagency data sharing and its device command and control to support NITTEC stakeholders as needed either on site or from remote locations, interoperable video feeds, automated data feeds integrated into NITTEC operated data warehouse, and various other smart city Intelligent Transportation Systems (ITS) systems. The Main Street corridor project can serve as a pilot corridor for the extensive upgrades in ITS listed in the strategic plan.

### 1.2.7 NITTEC ATCMTD Grant, Buffalo-Niagara Region (2016)

NITTEC and NYSDOT were recently awarded a $7.8 million Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) program grant from the United States Department of Transportation (U.S. DOT) Federal Highway Administration. The grant is aimed at reducing traffic at the border crossing and key corridors in the City of Buffalo by deploying new technologies and promoting "smart mobility" in the region. The grant proposal includes plans to improve V2I applications, create a real-time parking application, create a data platform with real-time data interfaces and interactive traffic signals, rollout a real-time Integrated Incident Management System (IIMS), a real-time weather advisory and dissemination system, and promote overall smart mobility in the region. The grant is seeking pilot projects to test the deployment of these smart city elements and gain performance measures to build upon. The Main Street corridor could fall under one of the key corridors to be considered for pilot projects. Many of the objectives of the grant line up with the essentials of the smart corridor project. NITTEC has potential to fill the role of host to a dynamic, real-time data management and dissemination system; however, there would need to be someone to take responsibility for ownership and maintenance. Much of the V2I infrastructure and sensors needed for a real-time open data platform are included in the grant. Not only is this a funding opportunity for the project, but also an opportunity to format a data management structure and plan for a new transportation information system.

### 1.2.8 NYSERDA Improving the Efficiency of New York's Transportation System (2019)

New York State Energy Research and Development Authority (NYSERDA) is seeking proposals that have potential to reduce greenhouse gas (GHG emissions and associated energy consumption of the existing multimodal transportation system). There is a total of $3 million that will be awarded statewide. NYSERDA identifies the main focuses of the project to be efficient mobility solutions, efficient infrastructure, operations, and system planning. In the request for proposal (RFP), NYSERDA highlights the use of innovations and technologies that build or enhance efficiency, innovative information and communications technologies, and innovative practices that support the integration and improvement of multiagency operation of the transportation system. The grant category that relates to this project is the demonstration of underutilized commercial technologies ($500,000 max).

### 1.2.9 University at Buffalo Olli Bus

The University at Buffalo is currently piloting and testing an eight-passenger autonomous bus to explore the technology, safety, and reliability. The Olli is equipped with IBM Watson IoT and LIDAR. Testing of the Olli will help determine whether it is feasible to incorporate the technology into the BNMC. The challenges revolving around the use of autonomous buses include laws and regulations in New York State that do not allow autonomous vehicles on public roads as well as the need at minimum for a $5 million insurance policy. Testing of Olli is expected to wrap up in the spring of 2020 at which point researchers will determine whether the autonomous vehicle is something compatible with an urban environment. If feasible, additional grant funding could go towards piloting the autonomous bus around BNMC.

## 1.3 Stakeholder Input

### 1.3.1 Smart Corridor Steering Committee

The Main Street: Smart Corridor Plan was guided by a project steering committee, consisting of members of BNMC, the City of Buffalo, campus member institutions (Roswell Park Cancer Institute, Kaleida Health, University at Buffalo), Niagara Frontier Transportation Authority (NFTA), Greater Buffalo Niagara Regional Transportation Council (GBNRTC), New York State Department of Transportation (NYSDOT), New York State Energy and Research Development Authority (NYSERDA), Niagara International Transportation Technology Coalition (NITTEC), GObike Buffalo, Shared Mobility, Inc., National Fuel, National Grid, and Buffalo Sewer Authority. The City of Buffalo's design contractor for the Middle Main Street Reconstruction Project was also invited to participate in steering committee meetings. The steering committee met four times over the course of the project.

### 1.3.2 Smart Corridor Subcommittee

In March 2019, the BNMC decided to assemble a subcommittee of key stakeholders to discuss existing smart city efforts and discuss a game plan for smart city applications. This subcommittee consisted of stakeholders from BNMC, NITTEC, and City of Buffalo. At this meeting, the City of Buffalo indicated that they are working on a smart city strategic plan that will guide the city in its goal of becoming a smart city by 2023. This would include increasing capabilities of the Buffalo Roam Application, expanding internet opportunities to school communities, working with the University at Buffalo on drone technology for public safety, and expanding Wi-Fi across the city as a result of the city's partnership with Blue Wireless.

The subcommittee discussed opportunities for a data management core communications center housed in a "smart city hub" either at NITTEC or in City Hall. The subcommittee agreed that there needs to be a business model for funding infrastructure and a need to establish a "backbone" of sensors in the corridor to prepare for smart city applications. The city indicated they would like to piggyback on the Middle Main Street Reconstruction Project and hopes the smart corridor project can be transferable to other parts of the city.

### 1.3.3 National Grid

A meeting was held with representatives from National Grid to discuss the opportunities and challenges with installing smart city applications to streetlights. National Grid indicated that it is generally willing to work out agreements with municipalities that wish to install smart city applications on National Grid owned poles, or is willing to sell streetlight poles to the municipality to allow them to negotiate their own agreements with vendors. National Grid would look to have each application separately metered, and it shared an example of the City of Schenectady Smart Streetlight pilot project.

### 1.3.4 City of Buffalo

A meeting was held between the City of Buffalo, BNMC, GBNRTC, and NITTEC to present the project to the city and collaborate with the city's ongoing smart city initiative. The City of Buffalo has developed a smart city committee consisting of members from various departments to manage smart city development. The committee is underway with a smart city plan as well as a business case for purchasing streetlights from National Grid for the deployment of Smart City sensors.

## 1.4 Review of Existing Conditions

A key element to most successful smart city projects is the ability to emphasize and build on existing assets and infrastructure in a corridor. In this section, current corridor conditions relevant to facilitating smart transportation systems are collected and analyzed to highlight leverageable corridor assets. Much of the information comes from the City of Buffalo and its consultant, who undertook the design of the Middle Main Street Reconstruction Project. Other sources include BNMC, GBNRTC, NFTA, and NYSDOT. A set of utility plans that were developed for the Middle Main Street Reconstruction Project were reviewed, but because the project is still in the design phase, the plans were withheld from this memo. Below is a summary of findings from those plans.

### 1.4.1 Utilities

Utility information was obtained from the City of Buffalo based on survey information collected as part of the Middle Main Street Reconstruction Project. Relevant utility sheets are attached as an appendix to this memo. Throughout the course of obtaining input from respective utility stakeholders, no agencies indicated there were any capacity issues with any utilities in terms of accommodating smart city applications. In terms of fiber availability, most communications companies (i.e., AT&T, Sprint, T-Mobile, Blue Wireless, etc.) prefer to use their own dedicated fiber network for 5G and other smart city applications. There is potential to leverage current infrastructure for the retrofitting of smart city devices. The light poles along the corridor are owned by the city but are energized by National Grid. Any devices situated to light poles along the corridor can be connected to the grid and metered by National Grid.

Below is a summary of utilities existing along the Main Street corridor.

- *Electric:* According to information provided by the City of Buffalo, on the west side of Main Street, there are three separate electric lines running parallel within the right-of-way including traffic conduit, lighting conduit, and multiple electrical manholes supplying the Metro Rail. On the east side of Main Street, there is a single lighting conduit line that terminates approximately 130 feet south of Carlton Street. The lighting conduit continues just past Carlton Street north to Best Street. There is an electric line that crosses Main Street and connects lines at the following intersections: Goodell Street, Virginia Street, Carlton Street, Allen Street, High Street, North Street, Old Best Street, and twice at Best Street. There is also a traffic line conduit along the west side of Main Street.
- *Storm/Sanitary Sewer:* According to information provided by the City of Buffalo, there are existing combined Storm/Sanitary Sewer line running along both sides of Main Street the entire length of the study area. The CS line on both sides of the street contains multiple manholes along the line. The CS line on the west side of Main Street continues the length of the corridor. The CS line to the east of Main Street begins again at North Street and continues to St. Paul Place. The line crosses the street and connects at High Street and Old Best Street. There is also a dedicated storm sewer that runs along portions of both sides of Main Street (not a consistent length).
- *Gas:* There is an existing gas line that runs parallel on each side of Main Street. The gas line crosses Main Street 30 feet south of Burton Street and 20 feet north of Burton Street and 120 feet north of High Street.

- *Water:* There is a water line that runs generally down the east side of Main Street, transitioning to the center of Main Street in some areas. The line has numerous supply lines that cross the street to individual properties. There are multiple hydrants, water service boxes, water valves, and water manholes along the corridor.
- *Telephone:* There is no continuous telephone line running along Main Street. There is however, a line that crosses Main Street at Goodell Street, a pole at the intersection of Virginia Street, a line at Carlton Street that runs along the east side of Main Street and crosses to the west side of the street at Allen Street. There is a line that starts 80 feet south of High Street on the east side of Main Street that continues north until crossing to the west side of Main Street at Goodrich Street, which continues to North Street.

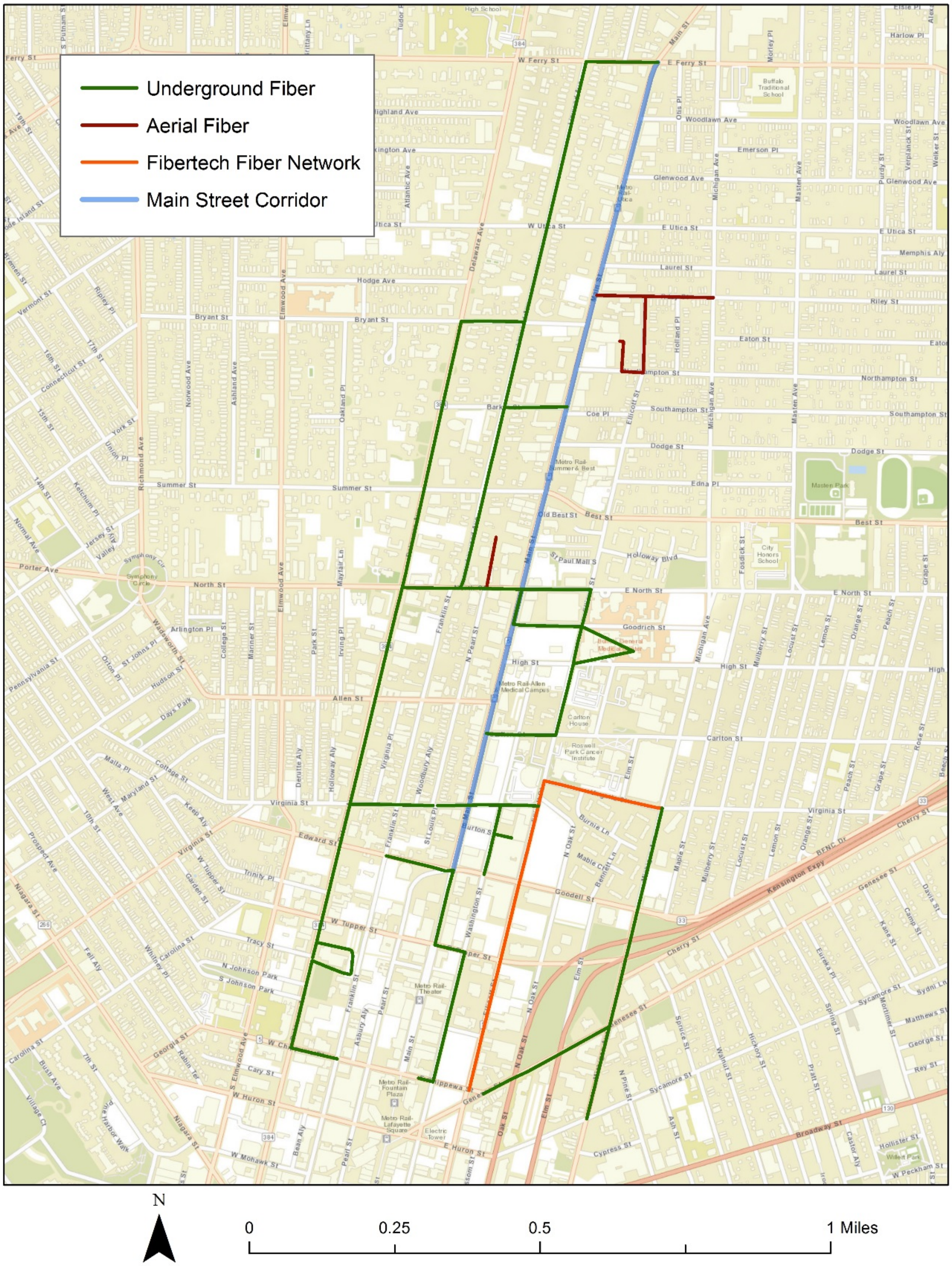
### 1.4.2 Fiber Network and Wireless Connectivity

The City of Buffalo indicated that there are some 600 miles of fiber across the city (300 miles owned by Buffalo Public Schools and another 300 of privately owned fiber). There are several fiber networks that exist along the Main Street corridor that are owned and operated by several different agencies. The City of Buffalo may be able to leverage rights of access to these fiber lines through provisional agreements with service providers madeduring the installations of fiber lines on city owned property. The University at Buffalo has domain rights to fiber throughout the BNMC and as a BNMC member institution may be willing to share capacity. Figure 1 portrays the existing fiber network in the project area, as provided.

There are underground fiber lines running along Delaware Avenue and Ellicott Street, and lines that cross or intersect the Main Street corridor on Barker Street, North Street, Goodrich Street, Carlton Street, Virginia Street, and Edward Street. The majority of the fiber lines are underground, and only a small portion of the fiber runs along the Main Street corridor, including a section between North Street and Goodrich Street and between Edward Street and Tupper Street. A section of fiber along Ellicott Street is part of the Buffalo Public School fiber ring (Fibertech).

There is no public Wi-Fi along the corridor. Public Wi-Fi devices are being installed on Jefferson Avenue between Best Street and East Delevan Avenue by Blue Wireless as an initiative for economic promotion in the city's east side.

**Figure 1. Fiber Network along Main Street Corridor**



## 1.5 Transportation

Currently, Main Street in the study area is a six-lane street (three lanes northbound and three lanes southbound) with no bike lanes. There is on-street parking available along most of the corridor. The current condition of the street itself is poor, containing poor pavement conditions and lacking in pedestrian aids at intersections. There are several sections of sidewalks that are cracking and crumbling. The corridor has an annual average daily traffic count of 22,405. The Main Street corridor is a served area by NFTA Metro Bus routes 7, 8, 19, 29, 64, 66, 67, and 145. The project area contains a bicycle storage container located at Ellicott Street and N. Oak Street and two Reddy Bike Share hubs, one located at the bicycle storage and the other at Allen/Medical Campus Station. The project area is also home to two NFTA Metro Rail stations: Summer-Best Station and Allen/Medical Campus Station. At peak, the trains run every ten minutes. Figure 2 portrays the transportation infrastructure along Main Street.

There is on-street, two-hour, metered parking available on both sides of Main Street throughout the project area. The following are average speeds of vehicles along Main Street in the project:

- Westbound—20.2 mph
- Eastbound—26.3 mph

**Figure 2. Streetlights, Traffic Signals, and Police Cameras along Main Street Corridor**

Light Poles: 84  Parking Meters: 60  Kiosks, Shelters, Benches: 6  Traffic Signals: 34

## 1.6 Current Data Collecting and Sharing Methods

Meetings were held with numerous stakeholders and agencies to gauge their data collection efforts and sharing methods in relation to smart city applications. The following is a summary of efforts across agencies.

### 1.6.1 NITTEC

- Central traffic control (wireless communications) system housed at NITTEC. Data is collected and stored but not currently used for any dynamic traffic control.
- There is fiber connectivity between NITTEC and City Hall.
- City has the capability for dynamic signal timing on certain routes. The servers and platform to implement dynamic signal timing are housed at NITTEC but is yet to be implemented by the City.
- Produces an annual report containing various traffic datum collected.[1]
- NITTEC hosts a Mobile App that provides traffic and roadway information 24 hours a day, 7 days a week to improve traffic flows and enhance emergency assistance for motorists. The application allows users to access traffic maps, camera images, travel advisories, border-crossing times, and construction alerts.
- NYSDOT houses their own traffic control, but NYSDOT and the city could feed to a center-to-center system housed at NITTEC.

### 1.6.2 GBNRTC

- Takes multimodal traffic counts and turning movement counts along the Middle Main Street corridor (has counted all intersections between 2016 and 2018).
- Data is in Vistro but can be imported to VisSim for microsimulation models that output level-of-service (LOS), delays, multimodals LOS, and signal timing optimization. As part of Middle Main Street Reconstruction Project, GBNRTC modeled Main Street as a three-lane roadway.
- GBNRTC is working with NYSDOT on improving signal timings for routes in and out of BNMC such as Goodell and Tupper to be dynamic for morning and evening peak traffic flows.

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1 Latest located here: https://www.nittec.org/download/file/8813

### 1.6.3 NFTA

- Hosts ridership, passenger per vehicle mile, route information, and various bus system performance metrics.
- There are global positioning satellite (GPS) units on busses and metro cars; allows ability for real-time traffic monitoring.

### 1.6.4 City of Buffalo

- Hosts Buffalo Open Data, an open data platform providing city specific data.
- Department of Public Works (DPW) has the capability to use intersection and police cameras to review parking turnover.

### 1.6.5 BNMC

- Hosts a database of traffic and parking data of the Medical Campus.

# 2 Best Practices

## 2.1 Introduction

This section acts as a summation of key findings derived from a review of peer city best practices, highlighting examples of urban transportation corridors where smart cities strategies and technologies have been, or are being, adopted. Further, this section describes how examples can be adapted for the Buffalo Main Street: Smart Corridor Plan. The examples provided herein are based on input from members of the steering committee regarding the priorities for smart city elements along the Main Street corridor.

## 2.2 Smart Cities Applications

Many cities have looked to innovative technological applications and infrastructure to address increased congestion, improve safety, and enhance overall quality of transportation networks. The basis of most of these technologies is the IoT, or the "Internet of Things," which reference the ability of devices (i.e., cars, streetlights, mobile phones) to be in communication with each other within a network. The data exchange within these networks allows for dynamic decision making in traffic signaling, parking, and safety.

Connected vehicles (CVs) and the infrastructure that supports them are a way in which cities are "futureproofing" their streets. The establishment of a smart corridor network requires the implementation of communicating devices both on the street, and in the vehicle. The on-street communicators can be facilitated through dedicated short-range communication devices (DSRCs) which are placed in traffic signal cabinets and other roadside structures along the corridor. The data exchange between devices can be vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), or vehicle-to-everything (V2X). The data that is broadcasted from both vehicles and roadside units (RSU), goes to a cloud based data management system that can evaluate real-time traffic conditions, broadcast safety messages, display parking opportunities, and offer a wide range of applications.

Automated Vehicles (AVs) are an emerging technology, yet already a highly influential facet of smart cities. Though much of the AV technology is established and efficient, the policy and road adaptation still face many barriers. Public acceptance is a major inhibiting factor for AVs as many individuals have indicated they are uncomfortable with the thought of driverless vehicles. Automotive companies have been pushing self-driving technology, urging cities from Austin, Texas to Detroit, Michigan to run pilot tests to evaluate the vehicles operating in real-road conditions. The implementation of CV infrastructure along smart corridors increases the communicative ability of AVs. By implementing such infrastructure, cities are addressing the current need of CV data while preparing for the possible future of an AV dominated road network.

Aside from infrastructure and vehicles, cities are leveraging mobile technology to address transportation needs. To make transportation networks more efficient, cities are developing personalized applications to show real-time parking opportunity, payment schemes, traffic information, and transit service scheduling, to name a few. The rise of Mobility as a Service (MaaS) is also being explored to meet people's first/last mile transportation needs and to limit the need for parking by promoting car and rideshare. These options are intended to diminish the need for personal car ownership and travel and to better manage how curbsides are used.

Innovations and implementations of transit technology are carving a new aspect to how people connect and interact with their cities. As private industry drives innovation in the field, public entities must keep up with policy and implementation, discussed in further detail later in this memo. This public-private relationship coupled with the infancy of the technologies has led many cities and states to pilot projects that test the success and viability of this "new mobility." Each city's pilot project is uniquely implemented to address city needs and demands. Below is a compilation of pilot smart corridor projects, applications of new mobility technologies, and some ideas of how these technologies can be adaptable to the Main Street corridor.

### 2.2.1 Smart City Sensors Application

The use of smart sensors, either affixed to roadside objects such as traffic light poles or streetlight poles, embedded in pavement, or used onboard vehicles, has greatly enhanced the ability to deploy smart city applications and corridors. Below is a sampling of applications that can be implemented through the use of smart sensors.

Overhead Sensors

- Parking management
- Vibration analysis
- Noise and acoustics
- Smartphone detection
- Electromagnetic fields
- Traffic congestion
- Lighting
- Waste management (monitor levels of garbage)
- Forest fires/smoke detection
- Air pollution monitoring
- Snow level and snow melt
- Soil moisture
- Earthquake detection
- Stormwater monitoring
- Chemical leak detection
- Leakage detection
- Flood level detection
- Energy consumption monitoring
- PV performance
- Water pressure
- Radiation levels
- Safety/security monitors

Underground Sensors

- Parking availability
- Ground moisture
- Water pressure
- Ground temperature

**Figure 3. Embedded Sensor in Pavement**

*Source: Smartparking.com*

## 2.3 Complete Streets Infrastructure

Complete Streets are streets for everyone. They are designed and operated to enable safe and comfortable access for all users, including pedestrians, bicyclists, motorists, and transit riders of all ages and abilities.

### 2.3.1 Sidewalk Project Toronto, Canada

The City of Toronto is partnering up with Sidewalk Labs (an Alphabet company, which is the parent company of Google) to design and build a visionary new sustainable urban waterfront on the eastern shore of the city. The new project at Quayside will put a heavy emphasis on mobility, accessibility, and AV technologies.

**Figure 4. Sidewalk Labs' Rendering of a Quayside Street**

*Source: Sidewalk Labs*


The new project will reduce the need of private car ownership in promoting shared, electric vehicle services, increased bus service from Quayside to the fixed trolley car line, and most innovatively, a fleet of "taxibots" and "vanbots," or automotive vehicles catered to travel on-demand passengers. The automotive fleet will service the local neighborhoods first/last mile transportation needs and help deplete the amount of private vehicle ownership. As part of a holistic neighborhood plan, Sidewalk Labs is proposing a Digital Layer, which keeps the city running smoothly but also encourages residents, staff, startups, and larger companies to bring their most creative ideas. The Digital Layer consists of four components:

1. A sense feature knits together a distributed network of sensors to collect real-time data about the surrounding environment, enabling people to measure, understand, and improve conditions.
2. A model component that simulates scenarios for city operations and can inform long-term planning decisions.
3. A map component collects location-based information about the infrastructure, buildings, and shared resources in the public realm.
4. An account component provides a highly secure, personalized portal through which each resident can interact with the city.

### *2.3.1.1 Benefits to Main Street Corridor:*

The model of public engagement and involvement would give an inclusive voice on how the corridor community responds to visions of the "smart corridor." A corridor built with private-public cooperation can be replicated between the BNMC and the City of Buffalo and Erie County. The idea of creating this digital layer that exists beyond the physical components of a city can be transferrable to the Main Street corridor.

## 2.3.2 North Avenue Project, Atlanta, GA

Partnering with The Georgia Institute of Technology, the City of Atlanta has deployed smart technology along a 2.3 mile stretch of roadway—North Avenue. The city is looking to create a public demonstration and "living lab" for smart technology deployment. The project includes the instillation of hundreds of IoT sensors along with 26 signalized intersections to serve an array of applications ranging from adaptive signal timing to the framework for connected/autonomous vehicle rollout. The sensors serve to make North Avenue a Complete Street in coordination with the Travel Safely Application. The innovative application allows users to sign in as a pedestrian, cyclist, or driver to connect the user to a mobility network that sends real-time traffic updates and safety messages using the information of the IoT sensors.

**Figure 5. Smart City Sensors and Traffic Management Infrastructure on North Avenue in Atlanta**

*Source: Atkins Global*

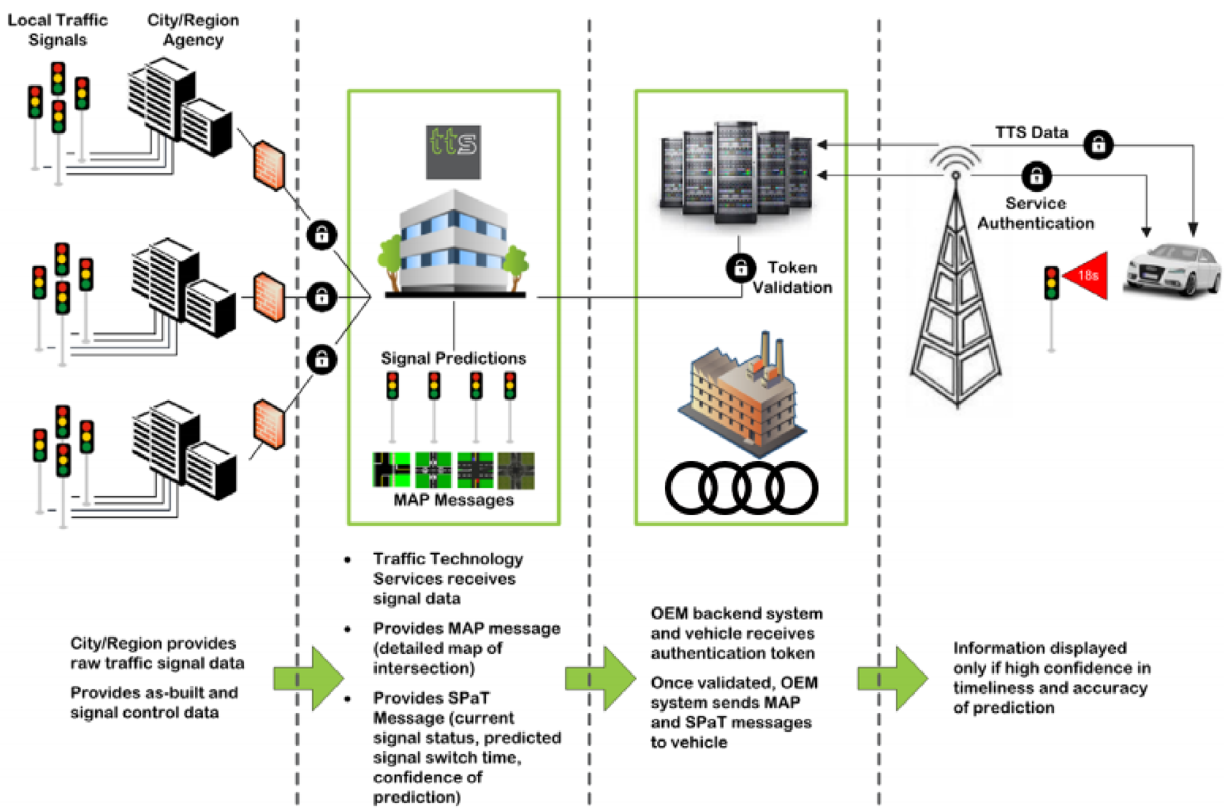
The corridor is lined with a video detection system that feeds a traffic analytics application, Travel Safely Application. The application combines artificial intelligence with traffic theory and is funneled through a Digital Mobility Center, operated by the City of Atlanta, to allow for the most efficient traffic management and safety information. The application looks to connect everything to everything, and real-time alerts can not only be relayed to residents, but to city departments, and including the following:

- Identification of stolen vehicles
- Traffic light or streetlight malfunction
- Abnormal vehicle congestion
- Obstruction of the roadway (i.e., fallen trees or wires)
- An unusually large crowd gathering
- Watermain break
- Rising water level, possible combined sewer overflow event

Below is a diagram of how the data is collected, managed, and disseminated.

**Figure 6. Smart City Sensors and Traffic Management Infrastructure on North Avenue in Atlanta**

*Source: Atkins Global*



### *2.3.2.1 Benefits to Main Street Corridor:*

The integration of multiple sensors along the corridor provides safety and efficiency for a variety of modes of transportation. The project has placed new lines on the road meant to be used as guidance for autonomous vehicles. This innovative street design and lining system revisits the Complete Street with a scope that includes the implementation of CAV technology. Also, the development and use of an application by multiple modes of travel could bring a new Complete Streets solution to the Main Street corridor.

## 2.3.3 Spragins Street Smart Cycle Track, Huntsville, AL

In a push towards "complete streets" design to accommodate multimodal transportation, Huntsville, Alabama has completed a 1,000-foot smart cycle track. The cycle track size is modest, but it connects riders to a 1.5 multiuse path that runs through the heart of the city. The cycle track includes connected infrastructure technology that contains sensors that detect bicyclists and trigger traffic signals to respond to the presence of bicyclists and gives them priority to navigate the intersection by having a bicycle silhouette signal turn green prior to the vehicle signal.

To minimize the cost of the cycle-track construction, the city coordinated the work to coincide with a resurfacing project and upgrades to traffic signals, rendering the actual cost of the cycle track and smart infrastructure to about $250,000. The project is a pilot project to see if the technology and infrastructure could be used in other areas of the city.

**Figure 7. Huntsville Cycle Track in Huntsville, Alabama**

*Source: Hutsvilleal.gov*

#### *2.3.3.1 Benefits to the Main Street Corridor:*

The City of Buffalo has piloted bicycle sensors in the roadway at the intersection of Linwood Avenue and North Street that sense bicyclists in the bicycle lane to trigger the traffic signal; however, the traffic signal only triggers a contra-flow facing traffic signal and doesn't offer specific priority to bicyclists. The next step would be to take the sensor technology and apply it to signal priority along an extended corridor and use the sensors to provide real-time bicycle counts.

## 2.4 Curbside Management

Curbside activity and the subsequent demand for balancing needs for all roadway users is growing dramatically with the development of transportation network companies (TNCs) like Uber and Lyft, online shopping and associated deliveries, and ultimately, automated vehicles as well as the demand for curbside pickups, drop-offs, and dwell times.

### 2.4.1 Carshare Parking, Washington, DC

Washington, DC is promoting rideshare to limit the number of vehicles commuting into downtown areas. Washington, DC has put into place several designated on-street parking spots for rideshare vehicles. Special parking permits are issued to the vehicles that allow for parking and metered spaces free of charge.

**Figure 8. Carshare Parking in Washington, DC**

*Source: Myparkingpermit.com*

### *2.4.1.1 Benefits to Main Street Corridor:*

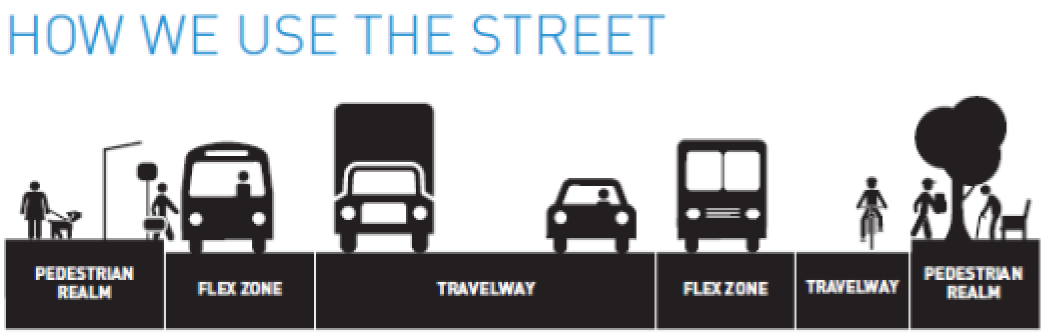
On-street parking throughout the BNMC could be reserved for rideshare/carshare vehicles. The promotion of ridesharing to a major employer such as the BNMC will limit vehicle congestion and parking demand in the corridor.

## 2.4.2 Flex Zone Curbside Management, Seattle, WA

The City of Seattle has put in place a "flex zone" that prioritizes certain curbside uses (passenger loading, delivery, etc.) and designates curbsides according to their particular best use. This flex zone replaces many metered and unmetered parking spaces along the curbside that would otherwise inefficiently occupy other spaces. The "flex zone" parking is open to change based on land use, and is not yet, but can be malleable by time of day.

**Figure 9. Flex Zone Diagrams for Seattle Street Operations**

*Source: Seattle.gov*




"Flex zone" functions are prioritized based on surrounding land uses, as follows:

| | Residential | Commercial & Mixed Use | Industrial |
|---|---|---|---|
| 1 | Support for Modal Plan Priorities | Support for Modal Plan Priorities | Support for Modal Plan Priorities |
| 2 | Access for People | Access for Commerce | Access for Commerce |
| 3 | Access for Commerce | Access for People | Access for People |
| 4 | Greening | Activation | Storage |
| 5 | Storage | Greening | Activation |
| 6 | Activation | Storage | Greening |

- Examples of the category Support for Modal Plan Priorities include pedestrian infrastructure, bus or streetcar lanes, bike lanes, general purpose travel lanes, and right- or left-turn lanes.
- Examples of the category Access for People include bus or rail stops, bike parking, curb bump outs, passenger load zones, short-term parking, and taxi/rideshare zones.
- Examples of the category Access for Commerce include commercial vehicle load zone and truck load zone.
- Examples of the category Activation include food trucks, parklets, public art, and street festivals.
- Examples of the category Greening include plantings, rain gardens, and bio-swales.
- Examples of the category Storage include bus layover, long-term parking, reserved spaces (i.e., for police or government vehicles), and construction.

#### *2.4.2.1 Benefits to Main Street Corridor:*

The proper use of curbsides along the corridor can reflect priorities in certain areas and can be used to target patient drop off and pick up, curbside delivery, and increase multimodal opportunities as a few examples. The "flex zone" can be dynamic to adjust to different mobility needs and the needs of nearby land uses.

## 2.5 Parking Management

Parking Management includes a variety of strategies that encourage more efficient use of existing parking facilities, improve the quality of service provided to parking facility users, and optimize parking facility design.

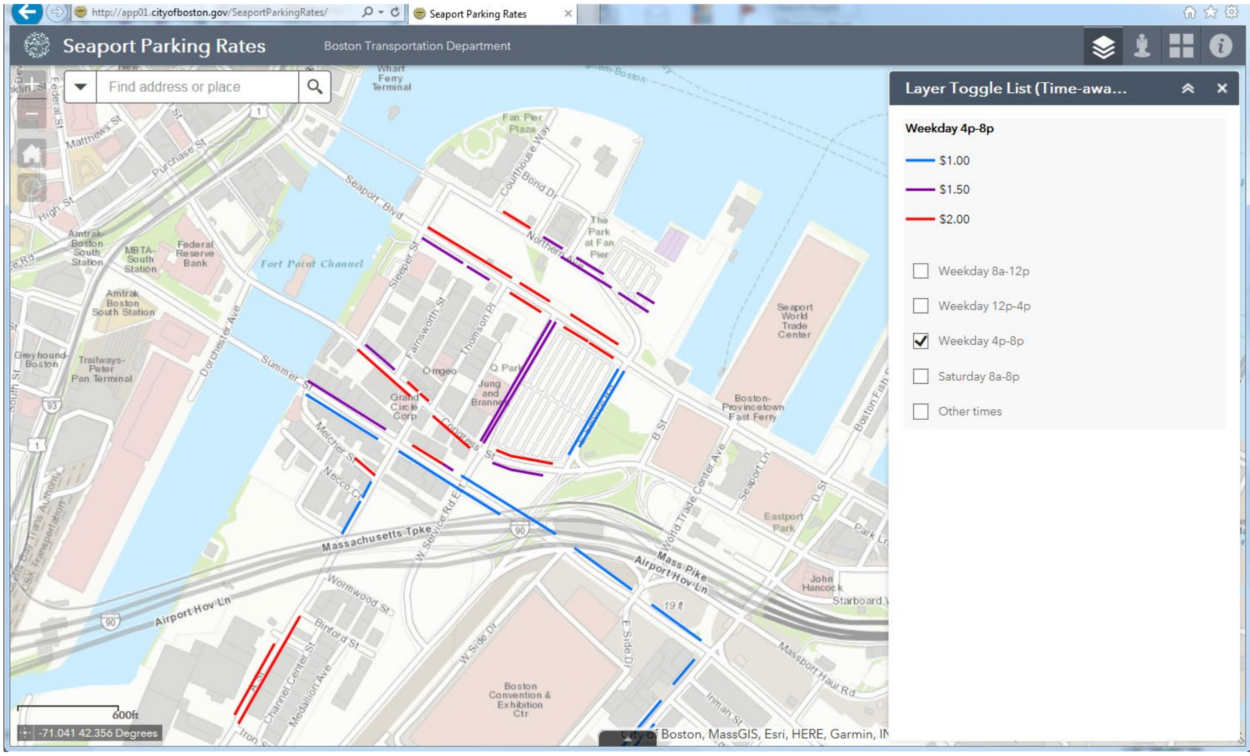
### 2.5.1 Boston Parking, Boston, MA

Boston has a program targeting the increasing demand for parking experienced in urban neighborhoods. The Park App Boston utilizes smart phone technology to provide interactive payment options for on-street parking. After the user downloads the application and creates an account, the user may utilize the smart metering system to pay for parking. Once the car is parked, the user then locates the Park Boston street sign or decal on the parking meter indicating the zone number of their location. The application will prompt for the zone number, license plate of the vehicle, and the length of time desired (as allowed). Once confirmed, the parking session begins. When there are ten minutes remaining, the app will notify the user and, if allowable, provide the option to extend the meter time.

The Performance Parking initiative (boston.gov/transportation/performance-parking-pilot) seeks to increase the number of available on-street parking spaces in some of Boston's busiest neighborhoods. It also aims to reduce the time spent on finding a parking spot, thus reducing traffic and congestion. With flexible meter pricing, the parking fee may increase or decrease depending on the availability of spaces. As the number of spaces decreases, the price will increase within a set limit. This will encourage parkers to seek other areas with lower rates. As the number of spaces increases, the price will decrease within a set limit, thus encouraging more spaces to be utilized. The use of the flexible meter pricing has been known to direct motorists from congested areas to less busy streets where parking is more readily available. In addition, the number of double-parking violations are likely to be reduced. By using an ArcGIS application, users can view a map in real-time that indicates the current pricing of parking areas.

**Figure 10. Park Boston Web Interface Showing Parking Availability in Real Time**

*Source: park.boston.gov*



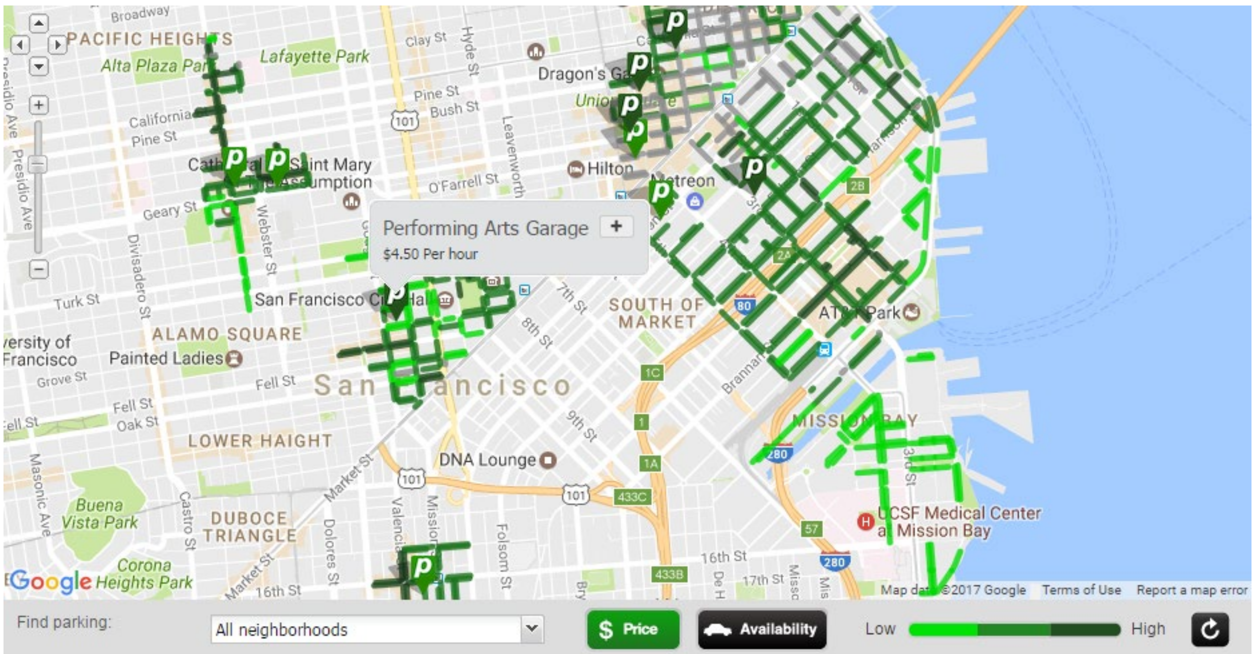

In an effort to reduce the number of personal vehicles from on-street parking, the City of Boston is piloting a carshare program in certain neighborhoods. A mix of municipal lots and reserved curb space will host the carshare to encourage more residents to utilize the program. These spaces were selected based on their proximity to transit stations and main street districts. In addition to reducing the number of personal vehicles on the street, the carshare seeks to provide additional mobility options and make better connections to neighborhoods.

## 2.5.2 SF Park, San Francisco, CA

The SF*park* pilot program utilizes new parking technology to monitor on-street parking availability along with variable pricing strategies to manage both on- and off-street parking. By using parking sensors installed on the street, the system can monitor the number of available spaces and will adjust the parking rates based on the number of open spaces. As spaces decrease, the cost will incrementally increase until at least one space is available most of the time. On those streets with more availability, the rates will decrease until most of the empty spaces are filled or the price floor has been reached. The parking garage rates will also adjust accordingly to encourage off-street parking and increase on-street parking availability. Information on the availability of on-street parking can be found through the SF*park* website, mobile application, or via text message sent to the registered user. The pilot program is testing 7,000 of the 28,000 metered parking spaces on the street and 12,250 spaces in 15 of the 20 city-owned parking garages. Data on the available spaces are displayed on interactive, real-time maps.

**Figure 11. SF Park Web Interface Displaying Real-Time Parking Demand**

*Source: sfpark.org*




## 2.5.3 U.S. Bank Stadium, Minneapolis, MN

U.S. Bank Stadium in Minneapolis developed a parking strategy that sought to utilize both public and private parking infrastructure to service the facility. By utilizing parking inventory technology, users can plan their trip according to a desired route and determine the most convenient parking facilities in route to the stadium. Through the use of online or web applications, a user can select the desired parking facility, prepay for parking, and drive to the facility. Once there, a QR barcode is scanned at the entrance and the user is granted access. This process eases the uncertainty of searching for parking that typically results in searching for available lots or facilities with desired parking fees. By providing the parking facility in real time, users can reduce their time spent on the road and thus reducing traffic. Preplanning the trip also provides the user with information on lots that may have been overlooked or unknown to a driver.

There are several considerations that should be made when planning for this strategy. With regard to proprietary software and applications, a single vendor is required as multiple vendors prevent streamlined integration among the parking facilities as well as to the public systems. Integration software is available that allows different parking vendors to communicate information, but it tends to slow the "real-time" applicability. A uniform approach will provide a platform across the various infrastructures and organizations and the system will appear seamless for the user. With a single system in place, inventory and price management are streamlined to provide users with up-to-date information on parking facilities, such as number of spaces available and pricing. Operators can adjust the number of available spaces and pricing (within allowable limits of agreements) in real-time. Such inventory management provides lot operators with the ability to accommodate various parking agreements or commitments while also maximizing the number of available spaces to the general public.

#### *2.5.3.1 Benefits to Main Street Corridor:*

Parking demand has continued to increase, both on and off street around the Medical Campus. A BNMC parking management system could help relieve this demand by offering dynamic pricing schemes and identifying available parking. Strategies to reduce the number of vehicles on BNMC could be employed to encourage carshare by allocation of certain parking spots.

The Buffalo Roam application used throughout the City of Buffalo could be upgraded to allow for a flex parking program. This would require a policy decision from the city and launch of an upgraded application.

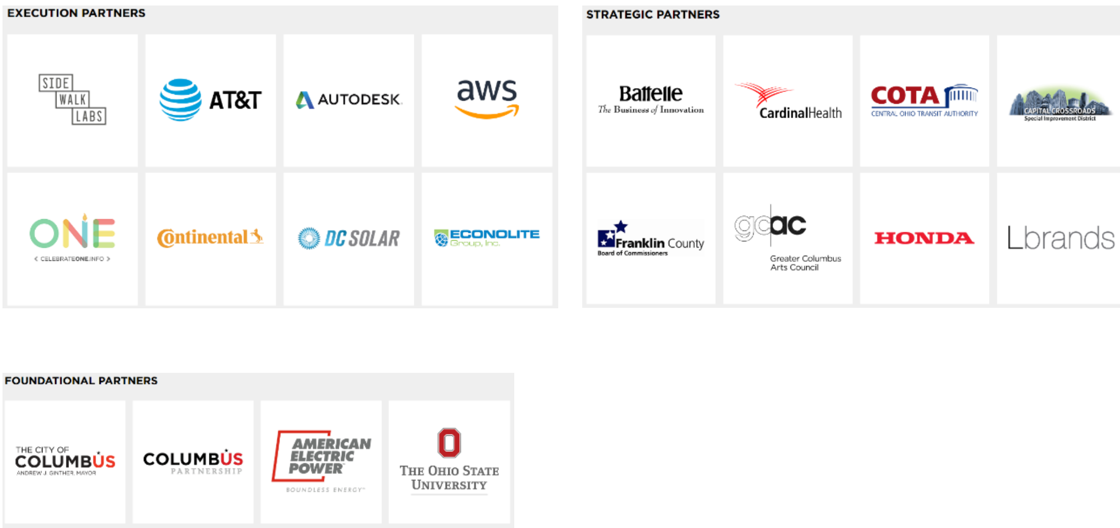
## 2.6 Connected, Autonomous, Electric Vehicles

### 2.6.1 Smart Columbus, Columbus, OH

Columbus is the recipient of a $40 million grant from the U.S. DOT after winning the Smart Cities competition in 2016. The city has since leveraged the original $40 million in grant funding into a current $510 million in both private and public funding, including $10 million from Vulcan Inc., $93 million for research from The Ohio State University, and $367 million investment from local and national businesses and partners in the government, financial, tourism, and economic development, as well as energy, mobility, academic, technology and research, manufacturing, and philanthropic sectors.

**Figure 12. Smart Columbus Partners**

*Source: smartcolumbus.org*




### *2.6.1.1 Smart Columbus Partners—The Categorized Current List of Business Partners:*

Foundational Partners: All local

- Columbus Partnership
- The Ohio State University
- American Electric Power Ohio
- Battelle
- Cardinal Health
- Capital Crossroads
- Greater Columbus Arts Council
- Honda
- LBrands
- Nationwide
- The Columbus Foundation

Execution Partners: Most are not local

- Sidewalk Labs
- AT&T
- Autodesk
- Amazon AWS
- Celebrateone (Local health information) provider
- Continental
- DC Solar
- Econolite
- Experience Columbus
- Fleetcarma
- Inrix
- NXP
- Orange Barrel Media

Original Equipment Manufacturers

- BMW
- Ford
- Honda
- Nissan
- Mercedes Benz

The applications of new mobility technology in this pilot are vast and among the most extensive in the United States. There are four enabling technologies associated with Smart Columbus:

- Columbus Connected Transportation Network (CCTN)—consists of DSRC placement along 50 miles of roadway, at 175 traffic signals, and on 3,000 vehicles. Additionally, the entire Central Ohio Transit Authority (COTA) bus fleet will be equipped with technology that will provide visual collision avoidance and roadway condition data, AVs will be deployed on three routes in the Eastern Commercial District, and active parking management will be deployed. The communication devices will be monitored and controlled through a new advanced Traffic Management Center, operated jointly by the City of Columbus and Ohio Department of Transportation (ODOT) in what is known as the Columbus Traffic Management Group. The Traffic Management Center provides traffic management and emergency management, and interfaces with multiple city, county, and state departments, COTA, freight rail operators, local 911 call centers and emergency responders, local maintenance, construction contractors, Mid-Ohio Regional Planning Commission (MORPC), National Weather Service, The Ohio State University, private traveler information systems, and regional event promoters.

- Columbus Operating System (SCOS)—a web-based smart city data management and open-data platform that integrates data and data services from multiple sources and tenants to enable better decision-making and problem solving for all users to support a replicable, extensible, sustainable platform for data ingestion and dissemination.

  The SCOS will "ingest, aggregate, fuse, and disseminate" mobility data from a multitude of sensors and other sources across the city. Data collection on project success will be monitored in an open source information portal from integrated data to serve the needs of internal and external users.

  The SCOS will be used to generate metrics on Smart Columbus project success. Metrics are first developed and shared with stakeholders, then made available to the public. Smart Columbus uses a ten-step approach to evaluating project success:

  - Identify stakeholders and operational needs
  - Define goals and objectives
  - State hypotheses and assumptions
  - Identify evaluation indicators and set targets
  - Frame evaluation using logic models
  - Develop evaluation design
  - Collect, process, and archive data
  - Measure evaluation indicators
  - Conduct benefits/costs analyses
  - Report performance

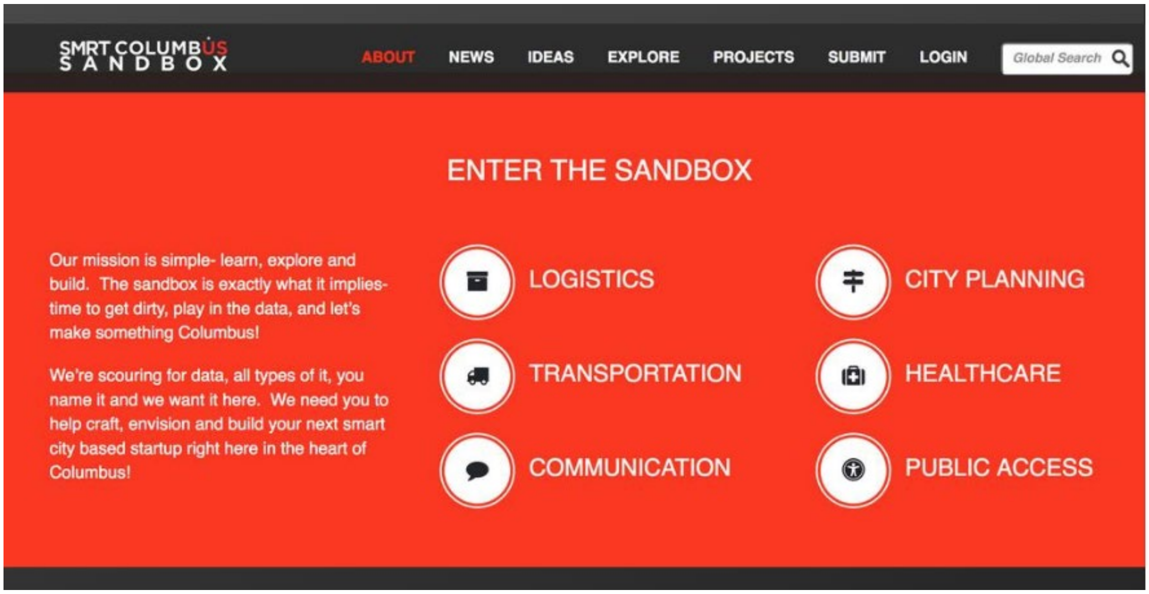
  A Smart Columbus Developer Network is being created to leverage the data generated through Smart Columbus to encourage third-party developer participation to create innovative applications and services. Smart Columbus has issued an extensive Data Privacy Plan (DPP) to provide a framework for the ways in which Smart Columbus will protect privacy of users and the immense flow of data that is involved in smart ity connected technologies. The plan is derived from Ohio legislation on data privacy as well as the National Institute of Standards and Technology (NIST) privacy control catalog contained in special publication 800-53(r4) Security and Privacy Controls for Federal Information Systems and Organizations. The plan breaks down data into degrees of privacy and addresses the appropriate use and management of each type based on information sensitivity. Certain data types require "scrubbing" and must go through a filter processes for de-identification to assure anonymity of data. The plan involves measures in privatizing and protecting the data through the scope of collection, aggregation, and dissemination. Applications of the data will help serve the needs of public agencies, businesses, residents, etc. of Columbus to drive economic growth, improve quality of life, foster sustainability, and improve safety.

  Open data is then made available through the Smart Columbus Sandbox where users can sift through pertinent data as well as upload their own data to be integrated with the Smart Columbus Operating System.

The process for developing the IDE took approximately 12 months, beginning with the product vision, followed by the governance and conceptual architecture, platform framework, data exchange, and product launch and evaluation. The governance and conceptual architecture and platform framework were developed over two-day workshops with stakeholders.

**Figure 13. Smart Columbus Sandbox Interface**

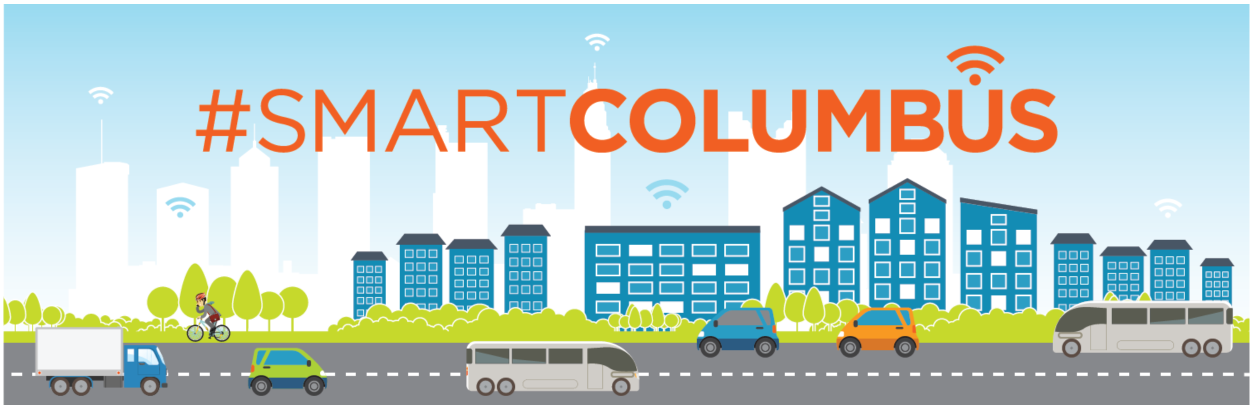
*Source: smartcolumbus.org*




- Enhanced Human Services—Will include multimodal trip planning applications, Smart Pass payment system to allow residents to pay for all the transportation options in the city (like bus, taxi, ridesharing, carshare, and bike share). This includes health services discussed in a later section. The city will deploy kiosks that can provide transit and transportation information, Wi-Fi, internet access, access to social services, and ability to add money to Smart Pass. Further, Neighbor "Hubs" will be set up to provide Wi-Fi and access to first/last mile mobility options.
- Electric Vehicle Infrastructure—Includes the electrification of city vehicle fleets as well as implementing EV charging infrastructure. Columbus is to phase in up to 790 electric vehicles into operation in fleets, and up to 990 charging ports and Electric Vehicle supporting infrastructure.
- The contribution of $10 million investment from Vulcan Inc. in the Smart Columbus project targets the bolstering of EV infrastructure. The current plan lists 1,275 charging stations to be built; 275 of these will be public stations, the remaining 1,000 will be distributed amongst parking ramps, multiunit dwellings, apartment parking lots, and office parking lots. Incentive grants are available to businesses and homeowners. Up to $25,000 can be allotted per facility; however, the applicant must provide 35% match so that they have stake in the upkeep of the charging infrastructure.

**Figure 14. Smart Columbus IoT Design**

*Source: smartcolumbus.org*




The City of Columbus is looking for the Smart Columbus project to improve safety, enhance mobility, enhance the ladders of opportunity, and address climate change.

### *2.6.1.2 Benefits to Main Street Corridor:*

A payment system where transportation credits can be bought with cash at a "Hub," like the one being developed in Columbus, would expand mobility options for the large population in Buffalo. Neighborhood "hubs" can be created along the Main Street corridor to provide first/last mile travel services to residents and visitors.

The Transit Signal Priority for emergency vehicles would be extremely beneficial to the Buffalo Niagara Medical Campus, a corridor defined by hospitals and healthcare providers.

The Smart Columbus Operating System can act as a model to how Buffalo may create an open data sharing portal. Companies that develop the array of software products to complement the open data sharing (i.e., multimodal transportation application) can be headquartered in the Innovation Center. NITTEC, which currently monitors traffic and acts as a traffic and data management center for the region could take on an expanded role to manage Smart City data, similar to the IDE in Columbus.

The way Columbus was able to leverage their initial grant money with additional investment from local and national industry and philanthropic organizations is a model for funding a smart city project. The GBNRTC Smart City grant application should be used as a foundation for developing a smart city network framework that could be used to leverage additional participation and investment.

### 2.6.2 nuTonomy, Singapore

Looking internationally, Singapore is on the forefront of researching and piloting AV technology with the Center of Excellence for Testing and Research of Autonomous Vehicles-NTU(CETRAN). In 2016, a pilot project that shuttled passengers on routes through the University Campus at Nantang Technological University as well as the One-North District, a business district designated testbed for AVs. Currently, there are 14 self-driving vehicles with "black box" data recorders operating on the roads to collect data that will inform AV policy going forward in the city-state. Data collection and evaluation will be related to system performance, vehicle routing efficiency, vehicle booking process, and overall passenger experience.

Recently, nuTonomy launched the first ever public trial of a robo-taxi service along Singapore's One-North business district. By 2022, the city-state plans to roll out AV shuttles, buses, taxis, and street sweepers based upon the findings in the research that is currently under completion. In addition to Singapore, nuTonomy is operating self-driving cars in Michigan and United Kingdom in partnerships with automotive manufacturers.

#### *2.6.2.1 Benefits to Main Street Corridor:*

The Main Street project can use the plans and policy, as well as lessons learned, of Singapore's AV use to model a pilot on BNMC campus or along the Main Street corridor. To date, much of the specific policy and programming information is not available.

**Figure 15. nuTonomy Vehicle Operating in Singapore**

*Source: smartnation.sg*

## 2.7 Public Safety, Health, and Emergency Services

### 2.7.1 Smart Columbus, Columbus, OH

Columbus struggles with an infant mortality rate four times the national average. The city realized this issue stems from the deficiency of access of neighborhoods to healthcare providers and prenatal care. To target this health issue, the city is using signal priority to connect emergency vehicles to traffic signaling systems, aiding their passage through traffic in emergency situations.

#### *2.7.1.1 Benefits to Main Street Corridor:*

As a major healthcare provider for the region, the BNMC, could benefit largely from signal priority by aiding the passage of emergency vehicles through the corridor.

**Figure 16. Emergency Vehicle Preemption Communication System**

*Source: fhwa.dot.gov*

### 2.7.2 MNDOT Connected Corridor, Minneapolis, MN

The Minnesota Department of Transportation (MNDOT) is retrofitting two limited access highways, TH-55 and I-394, between downtown Minneapolis and I-494, with connected vehicle infrastructure to allow for various applications of integrated corridor management. The implementation is aimed at the broadcast of traffic signal phasing and timing (SPaT) information to vehicles directly from traffic signal controllers along the corridor in what is known as vehicle-to-infrastructure (V2I) communications. Equipment deployed in vehicles or vehicle equipped with CV technology will receive messages from roadside equipment. The data exchange system will enable the merging of data from multiple sources, as well as sharing of agency data with third parties, to improve information-sharing and enable more efficient system management.

The CV infrastructure and data management systems support a range of existing and future technologies and applications that aim to improve safety and efficiency of roadway users. For example, the project is using CV infrastructure and signaling systems to give priority to snowplows during the winter for more efficient road clearance.

**Figure 17. A Connected Plowing Fleet Operating on I-494 in Minneapolis, MN**

*Source: startribune.com*

### *2.7.2.1 Benefits to Main Street Corridor:*

The technology and infrastructure associated with the MNDOT Connected Corridor project can be applied to corridors across Buffalo. Buffalo often experiences snowy winters. The corridor can draw on the V2I communications to snowplows to upgrade the efficiency of snow removal services in the winter.

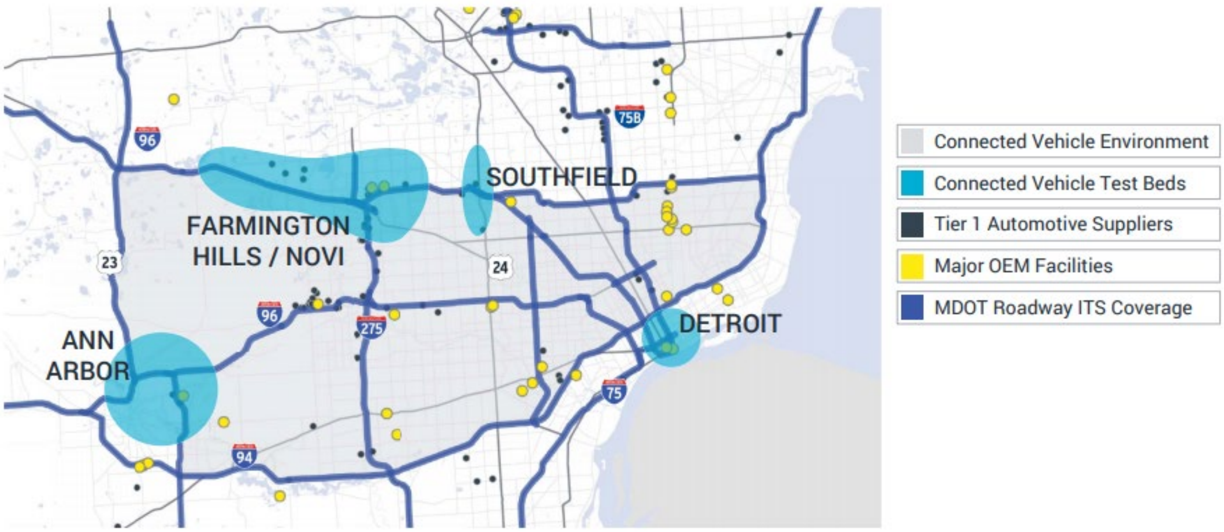
## 2.8 Data Management/Data Exchange

### 2.8.1 UMTRI Safety Pilot Model, Ann Arbor, MI

The University of Michigan Transportation Research Institute has created the largest connected field deployment in the world. The extensive network consists of up to 9,000 vehicles with onboard equipment (OBE) and 70 RSUs, the geographic bounds of which are outlined in the graphic below.

**Figure 18. Connected Vehicle Testing Areas in Southeast Michigan**

*Source: startribune.com*




The expansive pilot has tested the utility of basic safety messages to vehicles as well as large-scale database management. The infrastructure supports SPaT information broadcasting as well as a backhaul communications network to facilitate data exchange and archiving. The pilot has the most complex information network, integrating signal system data, vehicle data, device data, equipment/ power upgrades, fiber, splicing/termination, communications (network wireline and wireless devices), traffic signal controller upgrades, central control software upgrades, big data analytics and data capture methods, and SCOOT (real-time, online model that continuously monitors traffic flow), adaptive signal control deployment, and integration to support the DSRC wireless equipment for the project.

Vehicles in the pilot are equipped with one of the following:

1. Vehicle Awareness Device (VAD)—A wireless device that securely and privately transmits vehicle speed and location to other vehicles.
2. Aftermarket Safety Device (ASD)—Similar to a VAD but also receives speed and location data from other vehicles. It uses the position of other vehicles to provide drivers with warning detection.
3. ASD + Data Acquisition System (DAS)—In addition to being an ASD, a DAS collects video and data on driver performance so researchers can learn how drivers interact with ASD and how they respond to warning detection.

The pilot project is a success in basic safety message signaling and a template of CV infrastructure deployment and management. Data from the pilot program is kept internal for researchers to study and analyze. Eventually, this type of data can be made available to third parties. The data and infrastructure are currently being transitioned to the Ann Arbor Connected Vehicle Test Environment for further pilot testing.

#### *2.8.1.1 Benefits to Main Street Corridor:*

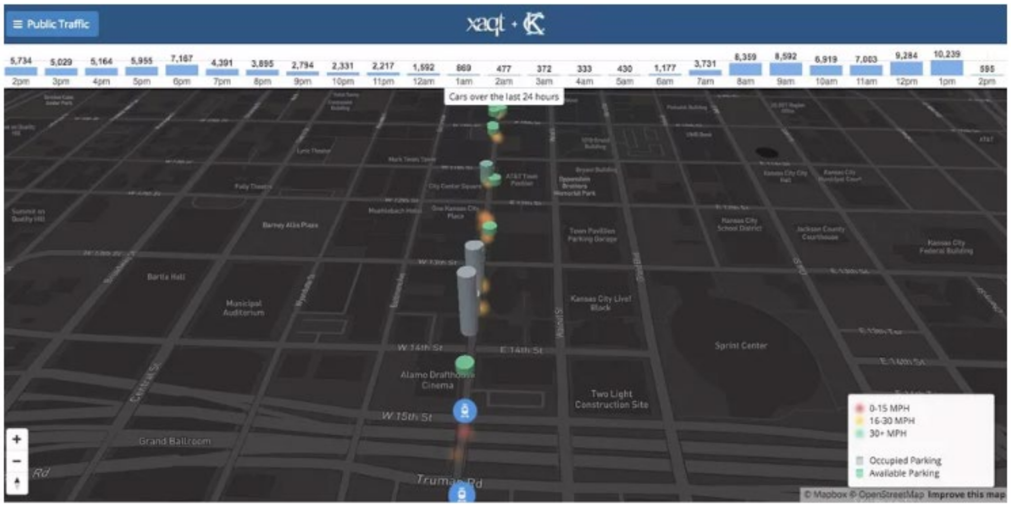
This safety pilot study can serve as a direct reference to the implementation and management of CV infrastructure and management along the corridor. The infrastructure is designed to promote future development with CV and AV technologies within the corridor.

### 2.8.2 Smart City, Kansas City, MO

Kansas City, Missouri has outfitted its 2.2-mile long streetcar line with an array of new mobility technology including free public Wi-Fi, smart streetlights, smart traffic signals, and interactive kiosks. The city made an exemplary private-public partnership with Cisco and Sprint to complete the $15.7 million project. The data collection is sourced from video cameras that capture traffic and pedestrian activity. The data collected is anonymous, and all video captured is processed and overwritten. The data collected is used to source a public data portal that allows anyone to view real-time traffic data, streetcar location, and open parking spots. The city owns the data and will soon migrate it to the Open Data Catalog. The following is a screenshot of the online dashboard of the corridor.

**Figure 19. Kansas City's Xact Interface Displays Real-Time Traffic Information**

*Source: Techcrunch.com*




In addition to these amenities, LED streetlights are placed along the corridor to increase energy efficiency. The LED lights have sensors and will automatically adjust light based on activity in the area. Further, these streetlights are equipped with sensors that detect gunshot sounds and can notify emergency responders immediately with location of response.

Kiosks placed along the corridor provide real-time travel information about the Kansas City Streetcar. A series of 25 interactive kiosks will be placed along the corridor for accessing services, current events, transportation, business information, public digital art, local history, and entertainment. As part of the smart network, each kiosk will have content specific to its location and can dynamically change content based on the needs of the users. Transactions made on the kiosks can also be linked to a smart device.

Kansas City partnered with Cisco Systems and Sprint to install a new public Wi-Fi network downtown. The network will be used to support IoT and smart city applications as well as allow access to the internet for all users. Sprint built and currently operates 328 Wi-Fi transmitters that provide Wi-Fi along the entire 2.2-mile streetcar route.

The city just issued an RFP for a Comprehensive Smart City Partnership with Kansas City, Missouri. The city seeks a partner to provide a fully integrated suite of sensors, networks, and data and analytic platforms that will result in the city becoming the first true smart city in the world.

#### *2.8.2.1 Benefits to Main Street Corridor:*

The Kansas City corridor is very like the Main Street corridor. The kiosk and Wi-Fi system draws people to the corridor and could be used to promote the use of Buffalo's existing Metro Rail and link residents with attractions and information in the area. The city is partnering with technology and communications companies to bring smart city technology to Kansas City.

### 2.8.3 Smart London, London, UK

The City of London is taking a transparent approach to its data management by way of the London Datastore, a free open-access data platform. The free-flowing data platform informs city decisions and has been used to create close to 450 smartphone applications using open source data, with no user fees for application users. The city has created the London Office for Data Analytics (LODA), which will manage this open source data and coordinate with entities such as the National Health Service (NHS) to enhance decision making and productivity. In terms of policy, the city will be implementing fiber optic requirements to new developments, as well as expanding connectivity to the London Underground system. In all, London will be spending 34.6 billion pounds on updated smart infrastructure involving data transfer and management.

#### *2.8.3.1 Benefits to Main Street Corridor:*

London is making a massive effort to increase the data management structure and oversight to prepare for the volume of data that will be exchanged by way of smart transportation infrastructure. This effort can be used as a model for creating a data management entity for Buffalo Main Street: Smart Corridor.

## 2.9 Mobility as a Service

Mobility as a Service (MaaS) is a combination of public and private transportation services within a given geography that provides holistic, preferred, and optimal travel solutions to enable end-to-end journeys paid for by the user as a single charge.

### 2.9.1 Seattle Sandbox Program, King County, WA

King County Metro is participating in a research project to test the use of Transportation Network Companies (TNC) as a Mobility-on-Demand (MOD) tool. The county will partner with *Via*, a TNC, to create an on-demand system that takes passengers heading in the same direction and books them in the same shared vehicle. This is especially targeted to workers travelling to and from park-and-rides of the fixed transit line as a means of first/last mile travel. The project serves as an example of private-public partnership to implement new mobility options, policy, and promotion.

#### *2.9.1.1 Benefits to Main Street Corridor:*

The promotion of ridesharing to major employers throughout BNMC could limit vehicle congestion and parking demand within the corridor.

## 2.10 Inclusive and Universal Design

### 2.10.1 Universally Designed Crosswalks

In updating current streetscapes and infrastructure, it would be prudent to emphasize the needs of visually impaired as well as hearing-impaired pedestrians. As the complexity of streets increase, so does the danger to the impaired pedestrian population that tries to navigate crosswalks. Universally designed crosswalks utilize tactile and mobile technologies to make crosswalks more adaptable to this population.

### 2.10.2 Universal Crosswalk Diagrams New York, NY

New York City's Department of Transportation has partnered with Touch Graphics Inc. to test Universal Crosswalk Diagrams (UCD) on a busy and notoriously hazardous crosswalk at 7th Avenue and 23rd Street in New York's Chelsea neighborhood. The UCDs are plate fixtures situated atop Accessible Pedestrian Signals (APS) that allow individuals with visual impairments to read tactile layouts of the crosswalk they wish to traverse. The diagrams are street specific and contain the relative location of the pedestrian (a raised circle), the crosswalk direction (dotted line), the number of lanes, the direction of traffic in each lane, and even bike and bus lanes all symbolized by the tactile surface. This is accompanied by audio cues from the APS linked to the crosswalk signal from across the street. Going forward, Bluetooth beacons embedded in the UCDs may be able to interact with smartphone applications to send cues for interactive signaling, provide wayfinding, and cross assistance for the visually impaired. This gives the impaired user a sense of comfort in understanding how the intersection they are about to cross is laid out.

**Figure 20. Universal Crosswalk Diagrams Affixed to an Accessible Pedestrian Signals in New York City**

*Source: Touchgraphics.com*


### *2.10.2.1 Benefits to the Main Street Corridor:*

A conglomerate of several healthcare entities, the BNMC has a major stake in making the campus accessible to all pedestrians. Also, the Olmsted Center for Sight is located along the study corridor. The intersection of Summer-Best and Main street could prove to be a worthwhile test bed for a UCD and universal crosswalk design due to its proximity to, and in partnership with, the Olmsted Center for Sight.

## 2.11 Smart City Energy and Utilities

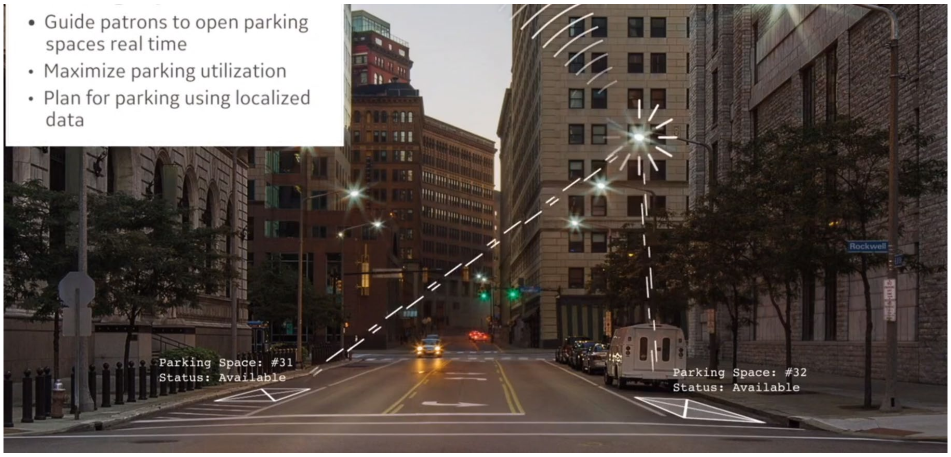
Energy and utility infrastructure will need to be reshaped in the advent of IoT mass implementation and an increasingly electric vehicle fleet. Broadband and cabling will need to expand immensely to facilitate the data exchange, and microgrid electric management will be necessary to support the charging of electric vehicles. Sensors throughout the grid will determine the best allocation of energy output to limit shortages and waste. The changes in this field are expansive and will need to be undertaken by the communication, utility, and energy companies at citywide levels. Though much of the implementation of this infrastructure is facilitated at a high level, there are some cities applying smart utilities.

### 2.11.1 Smart Streetlights, San Diego, CA

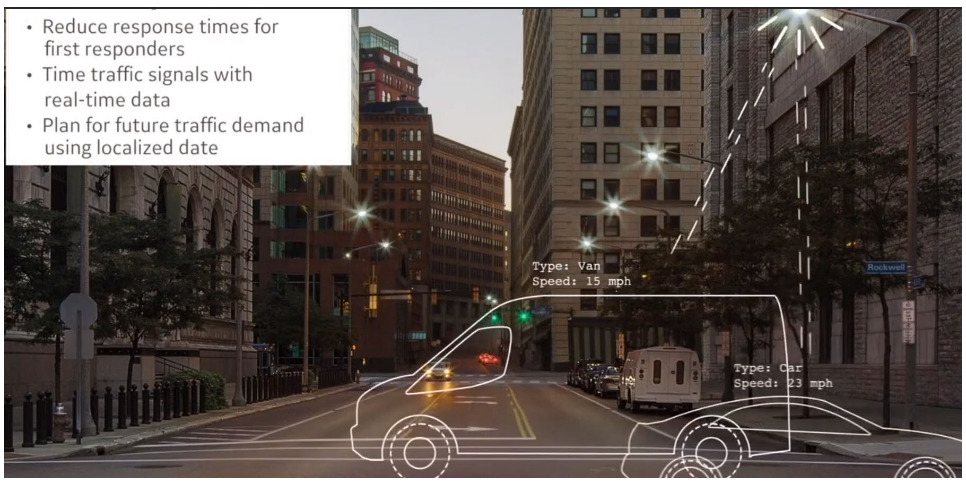
The City of San Diego has rolled out a network of 4,000 smart streetlights in what is reported as the world's largest network of IoT sensors on city streetlights. In 2014, the city started working with GE and AT&T to install streetlights with wireless network connections. By networking the lights, the city was able to remotely control and monitor street lighting, ultimately saving the city $2.8 million a year in electricity and maintenance costs. Thousands of these smart streetlights are equipped with complex sensors that can monitor parking spots, criminal activity, and temperature and air quality. Some of the more advanced lights include Intel processors, video cameras, microphones, Wi-Fi, Bluetooth, and sensors that capture temperature, pressure, humidity, vibration, and magnetic fields. The smart streetlights can optimize parking by guiding patrons to open parking spots, optimize traffic operations by sensing peak traffic volumes and incidents and subsequently timing traffic signals accordingly, and improving citizen safety by communicating when pedestrians are in a crosswalk or when drivers are speeding, parked illegally, or not obeying traffic controls. Law enforcement could also use the sensors to detect gun shots and to increase response time. Below are some screenshots depicting how the smart streetlights work in each environment.

**Figure 21. Parking Management, Traffic Management, and Pedestrian Safety Applications through Smart Sensors in San Diego, CA**

*Source: Sandiego.gov*




Parking Management




Traffic Management


Pedestrian Safety

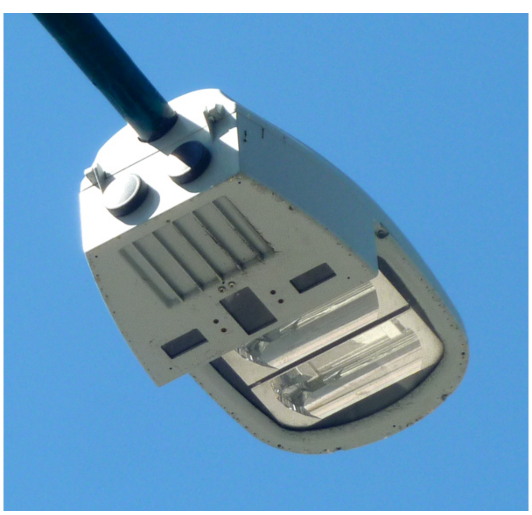
The smart streetlight program involves collaboration with private sector businesses, such as Current (a GE company), AT&T, and Qualcomm, and will soon involve Waze to leverage real-time traffic related data to provide information on traffic congestion, location of road construction, dangerous wildlife crossings, and presence of pedestrian crossings. Data is communicated via cellular networks so there is no need for hardwire communication lines. Streetlights are powered by 480, 240, or 120 volts depending on the capability of the streetlight.

Most of the data received by the streetlights is channeled to an open-source data platform. By opening up some of the information for public use, the city hopes to help local residents and visitors by encouraging the development of applications, such as a smartphone application for the visually impaired that could make crossing streets and navigate the city more manageable. The winning application chosen from a competition is called DreamBiz, which uses data from the open platform to help businesses make better decision based on current conditions, such as where to locate a particular business, hours of operations, and when to launch promotions. Other such applications are Colored Bars and Toy Cars which uses open data to create a data visualization platform where pedestrians and drivers can be better informed of their surroundings; Digital Cane which helps visually impaired citizens navigate the city; and GoGoKart which helps food trucks find prime locations based on where crowds are located.

Additionally, the city hopes to use the information to identify the most dangerous intersections and those that need to be redesigned, based on information of near misses and accidents detected by smart streetlights.

**Figure 22. LED Light and Sensor Unit in San Diego**

*Source: Sandiego.gov*



#### *2.11.1.1 Benefits to the Main Street Corridor:*

Smart streetlights act as an alternative to sensors placed within the roadway and can be used to enhance the safety of employees and visitors, assist with parking and traffic management, and can be used to monitor environmental conditions. Sufficient power exists along Main Street to power smart streetlights and there may not be a need for a duct bank or conduit for hard communications lines as the use of wireless communication transmission is trending on smart streetlights.

## 2.12 Funding Models

Deloitte released a publication titled *The Challenge of Paying for Smart Cities Projects* which outlines a variety of business models and options for funding and financing smart city projects. Revenue models were sourced by third parties or the public sector and methods ranged from financing model payments, savings sharing, and availability payments to rate-type payments, user payments, and advertising. A combination of these approaches could be used to fund or finance a project.

The public-sector financing consists of the public sector providing payments for an agreed upon amount with an agreement that they will be paid back with interest; payments based on performance of the services to be provided; savings sharing in which payments are made in exchange for cost savings provided by the smart city project; and shadow tolls in which payments are made for using the services provided by the smart city project.

Third-party payment options consist of rate-type payment in which the public-sector charges users for services and then uses the revenue to pay the private sector for services such as utilities; paying for services such as users paying directly for services (such as tolling on roads), a “pay-as-you-go” system which can include mobile billing, or a subscription-based system which includes a fixed amount regardless of usage; and advertising-based in which the assets and infrastructure that are part of the smart city contain advertising paid for and used to fund the project.

The Smart Cities Council administered an article titled Three Smart City Funding Sources You May Not Have Thought About, outlining different ways in which cities have raised money to complete smart city projects. Public private partnerships (PPPs) have continued to be used more frequently as a funding solution for smart cities. Following this model, both the public and private entities share the responsibilities of the project and the returns on it. The level of financial and design contributions from the public and private sectors fluctuate based on each agreement. There are a variety of agreements that can be made, and ownership and maintenance of the assets can be the responsibility of the private entity or the public sector depending upon the agreement. Specific examples of funding models are outlined below.

### 2.12.1 Kansas City, MO

An example of a smart city project that implemented a PPP business model is Kansas City where the public sector partnered with Cisco Systems and Sprint in a $15.7 million partnership (Cisco and Sprint receive exclusive access to usage data from the kiosks). In public funds, Kansas City has received a $50 million TIGER (Green Impact Zone Infrastructure Improvements) grant. The grant supports urban core infrastructure improvements within a "Green Impact Zone." The new Kansas City streetcar that runs along the smart corridor has received $20 million from the TIGER grant, $16 million from Surface Transportation Funds, and $1.2 million in Congestion Mitigation and Air Quality Improvement Program funds. Trying to build on the PPP and the public funds already received, the city issued a RFP to attract further private investment in the project.[2]

### 2.12.2 Atlanta, GA

After a special election in 2015, the citizens of Atlanta approved two ballot initiatives to authorize repairs, improvements, and upgrades to transportation and municipal facilities. The city issued a $250 million bond to create Renew Atlanta, the infrastructure improvement program for the city. A portion of this program is aimed at completing smart city applications, such as the North Avenue project. A year later, the city instituted the Transportation Special Purpose Local Options Sales Tax (TPLOST) that is projected to raise approximately $300 million in a five-year period. Overall, the city has leveraged nearly $750 million in state and federal funds. Since most of the current funding of the project is public, the City of Atlanta is looking to local businesses and Georgia Tech to create PPPs for both funding and research. The city wants to establish the "backbone" infrastructure of these projects using public funds (Renew Atlanta/TPLOST) to draw private businesses to invest in technologies that utilize the backbone infrastructure. The city has issued a RFP trying to attract local business investment.[3]

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2 http://kcmo.gov/wp-content/uploads/2018/06/RFP-ComprehensiveSmartCityPartnershipwithKCMO-Final.pdf

3 http://procurement.atlantaga.gov/wp-content/uploads/2018/02/FC-10361-Atlanta-SMART-City-Strategic-Infrastructure-Initiative-RFP-FINAL-Rev.2.28.18.pdf

## 2.12.3 NITTEC ATCMTD Grant, Buffalo-Niagara Region

NITTEC is a local coalition of agencies developed to improve traffic congestion and roadway safety in the Buffalo-Niagara region. NITTEC and NYSDOT were recently awarded a $7.8 million Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) program grant from the U.S. DOT Federal Highway Administration. The grant is aimed at reducing traffic at the border crossing and key corridors in the City of Buffalo by deploying new technologies and promoting "Smart Mobility" within the region. The grant proposal includes plans to improve V2I applications, create a real-time parking application, create a data platform with real-time data interfaces and interactive traffic signals, rollout a real-time incident management system (IIMS), a real-time weather advisory and dissemination system and promote overall Smart Mobility in the region. The grant is seeking pilot projects to test the deployment of these smart city elements and gain performance measures to build upon.

### *2.12.3.1 Benefits to the Main Street Corridor:*

The Main Street corridor would fall under one of the key corridors to be considered for pilot projects. Many of the objectives of the grant line up with the essentials of the Main Street: Smart Corridor Plan. NITTEC has potential to fill the role of host to a dynamic, real-time data management and dissemination system, and there would need to be someone to take responsibility for ownership and maintenance. Much of the V2I infrastructure and sensors needed for a real-time open data platform are included in the grant. Not only is this a funding opportunity for the project, but it is also an opportunity to format a data management structure and plan for a new transportation information system.

Grants are another potential funding source. There are both public and private grants available from entities such as the U.S. DOT and IBM. While there are grants specifically available for smart city projects, there are more possibilities depending upon the specific nature of the project. For example, if parts of the project include parks or registered historic locations, there may be additional grant options or tax credits available. Below are some examples of how different regions are using grant money to implement smart city elements.

**Table 1. Grant Allocation and Project Descriptions**

*Source: WSP USA Inc.*

| Grant | Cities | Grant Amount | Additional Funding | | Grant Used For |
|---|---|---|---|---|---|
| | | | Amount | Source | |
| **U.S. DOT Smart Cities Challenge** | Columbus (Winner) | $40 m | $100 mil | Private Sector | Identified a key public health issue (infant mortality rate in African American communities) and created a plan for improving transportation efficiency, payment, and safety using technology to improve access to healthcare for the city's at-risk population. |
| | Denver | $6 m | | | Upgrade traffic management center, build a connected vehicle network, and install automated pedestrian detection at difficult crosswalks. |
| | Pittsburgh | $11 m | | | Deploy smart traffic signal technology. |
| | Portland | Unspecified | | | To integrate shared mobility options into its existing trip planning application. |
| | San Francisco | $11 m | | | To implement connected vehicle technologies to allow the signal system to detect red light violating vehicles. |
| **Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)** | Virginia Port Authority | $1.5 m | | | Advanced congestion management grant for a "Truck Reservation System." |
| | Pittsburgh | $10.8 m | | | The technologies will include expanding the network of connected, real-time adaptive signal controllers to promote more optimized transit operations. |
| | Houston | $8.9 m | | | Integrate transportation management systems across the various modes of transportation to benefit drivers and carpoolers, transit riders, and bicyclists. |
| | Cleveland | $6 m | | | To upgrade software and improve communications infrastructure, enhance rider and passenger safety, and reduce rider travel time–as part of the community revitalization of the Cleveland area. |

**Table 2. Available Grant Opportunities for Smart City Projects**

*Source: WS USA Inc.*

| Grant | Amount Available | About Grant |
|---|---|---|
| U.S. DOT BUILD Grants | $1.5 Billion | Replaces TIGER Grant project. Projects for BUILD will be evaluated based on merit criteria that include safety, economic competitiveness, quality of life, environmental protection, state of good repair, innovation, partnership, and additional non-Federal revenue for future transportation infrastructure investments. |

**Table 3. Alternate Funding Sources for Smart City Projects**

*Source: WSP USA Inc.*

| Alternate Funding Sources | Example Cities | Example projects |
|---|---|---|
| Selling data from the smart system | | |
| Ad Revenue | New York | $200 million project that will replace phone booths with 7,500 digital kiosks that will provide Wi-Fi, throughout the city. |
| Private Sector Partners willing to match/exceed grant funding | Columbus | $100 million from private sector partners who matched a $40 million federal grant. |
| Public-Private-Partnerships | Kansas City | $12.3 million from Cisco and Sprint and $3.6 mil from the city to install 25 Wi-Fi kiosks along the city's downtown streetcar route. Cisco and Sprint to receive exclusive access to usage data from the kiosks. |

## 2.13 Legal and Policy Issues

There are a variety of legal and policy issues regarding smart cities ranging from insurance and liability concerns to data ownership and exchange issues. Many of these issues are intertwined and dependent on the others.

Insurance and liability are major issues, especially with respect to connected and automated vehicles. When a driver is removed from the equation, the question of who is responsible for crashes becomes important. This question of liability impacts insurance coverage.

Privacy issues are a concern for the public in smart cities applications, particularly with the collection of real-time and GPS data, the public may be uncertain and weary about how their data is being used. Even if users are aware that the public sector may have access to the data collected about them, there are still privacy concerns if the data is not being protected properly. Ownership of data is another issue, particularly when it comes to data exchange and any dissemination or sale of data. Often the data used by public agencies is collected by private entities under contract. These contracts are critical in defining ownership and rights to avoid potential legal action.

Security and enforcement issues are closely linked to the liability issues. Without a clear determination of who is liable, enforcement is a challenge. Cybersecurity is a potential risk; with technology at the core of smart cities, the threat of systems being hacked is a concern. Data leaks and the security of data storage could also ultimately lead to litigation.

A wide span of laws and policies must be considered when planning a smart city. From a project management and planning perspective, financial regulations and procurement rules must be considered. The implementation of smart cities require compliance with energy regulation, environmental legislation, IP regulation, and the regulation of technologies.

Below are some specific policies relating to smart city infrastructure.

### 2.13.1 New York State Policy on Autonomous Vehicles

Policies relating to autonomous vehicles in New York State are found in the following bills that have been adopted or proposed by State Assembly or Senate members:

- NY S 7508—Associated with the submission of reports relating to motor vehicles equipped with autonomous vehicle technology.
- NY A 452—Relates to the testing and operation of autonomous vehicles on public highways and directs the commission of NYSDOT develop a policy on such testing and operation.
- NY A 7243—Amends the vehicle and traffic law to impose strict liability on manufacturers, owners, and operators of unmanned motor vehicles.
- NY A 9647—Establishes a pilot program for testing vehicle-to-infrastructure technology.

### 2.13.2 New York State Policy on Data Privacy Issues

Each state has its own policy on data privacy, use, and security. Below are the laws in New York State pertinent to data privacy and management.

- New York State Personal Privacy Protection Law (Public Officers Law, Article 6-A, section 91-99).
- General Business (GBS)/Article 39-F—Notification of Unauthorized Acquisition of Private Information/Section 899-aa. —Notification; person without valid authorization has acquired private information.
- State Technology Law (STT)/Article 2—Internet Security and Privacy Act/ Section 208— Notification; person without valid authorization has acquired private information.
- 399-dd. Consumer communications records privacy.
- 399-h. Disposal of records containing personal identifying information.
- "New York Data Security Act"—Stop Hacks and Improve Electronic Data (SHIELD)
    - Organizations with ISO 270001 would not be subject to prosecution by the Attorney General unless there is evidence of "willful misconduct, bad faith, or gross negligence"
- New York State Information Security Breach and Notification Act

### 2.13.3 Kansas City, MO

The City of Kansas City is a strong promoter of transparency and data-driven government. The city has taken extra steps to help citizens see the value of the data it makes available. The city partnered with a group of MBA students from Rockhurst University to help launch its open data portal. These students also created a series of Open Data KC videos available on YouTube that help citizens understand the concept of open data and how to use the city's open data portal. Videos include instruction on how businesses and neighborhoods can use the data, how to use the city's financial and health data, and a tutorial on how to work with a potholes data set. The students then helped create a tool that gathers citizen input on publishing new data sets. While most city data portals provide a means for users to request data sets that don't appear on the site, Kansas City polls its portal users about which submitted ideas they like best. The poll uses the wiki survey tool All Our Ideas.

### 2.13.4 United States Department of Transportation

Issued Automated Vehicles 3.0 Preparing for the Future of Transportation. The document Advances U.S. DOT's Commitment to Supporting the Safe, Reliable, Efficient, and Cost-Effective Integration of Automation into the Broader Multimodal Surface Transportation System. The U.S. DOT supports the continued advancement of AV technology. The priorities the agency targets are safety, technological neutrality, modernize regulations, encourage a consistent regulatory and operational environment, proactive preparation for automation, and to protect and enhance the freedoms enjoyed by Americans.[4]

## 2.14 Smart City Technologies

Below is a listing of some of the smart city technologies that were used in the peer city examples that could be incorporated into the Buffalo Main Street: Smart Corridor Plan.

- Smart city sensors (such as those used by Gridsmart or Miovision) to detect conditions along a smart corridor, collect data on such conditions, and communicate with equipment to dynamically adjust to changing conditions. Overhead sensors are preferable to sensors embedded in pavement and concrete to avoid challenges with weather and reconstruction. Section 2.2.1 outlines all the features a smart city sensor can be deployed for. Miovision is currently being deployed in the region by NYSDOT and might be a good vendor to consider for facilitating collaboration.
- The communications backbone consists of conduit and hand boxes that allow fiber networks to be fished through that allow communication between smart city sensor and a smart city hub. This also consists of the information/data hub that becomes the smart city hub of a region. There are several vendors, ranging from companies like AT&T, Verizon, and Sprint to companies that focus on smart city communications, such as First Light.
- Smart parking technology is mainly based off using sensors that offer a real-time view of conditions, collects data that can provide insight into behaviors and trends and help communities make planning decisions about parking, and assist government in maximizing profits from parking revenues.
- Technology of connected and autonomous vehicles relies on short-range communications devices (DSRCs) that are placed in traffic signal cabinets and other roadside structures. Data exchange can be vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), or vehicle-to-everything (V2X), with data broadcast between vehicles and roadside units going to a cloud based data management system. The V2X system is used in creating smart intersections and specifically universally designed intersections.

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4 Further information on policy, legal issues, and open data, see the following links:
https://cyber.harvard.edu/publications/2017/02/opendataprivacyplaybook
https://smartcitiescouncil.com/article/smart-cities-council-privacy-policy
https://smartnet.niua.org/sites/default/files/resources/Open-Data-Guide-8-24-2015.pdf

# 3 Smart City Metrics

## 3.1 Introduction

This section reviews and refines project performance measures that will help BNMC track the effectiveness of smart city applications in achieving project goals and objectives.

## 3.2 Smart City Performance Metrics

The following metrics have been outlined to measure the performance of smart city applications to reach overall project goals. The implementation of smart sensors within the corridor will allow for a capacity for large scale data capture. The data captured would be used to develop and continually improve on smart city operations in the corridor. Each of the performance metrics below will be expanded, and can be revised based on input from the steering committee.

**Figure 23. Smart City Performance Metrics**

### 3.2.1 Safety Measures

1. The integrated network of smart sensors and vehicles is largely applied to the safety of drivers, bicyclists, and pedestrians alike.
    - Number of automobile, bicycle, and pedestrian accidents (looking for reduction/improvement to safety with smart city applications)
    - Number of signalized pedestrian intersections/walkways
    - Number of bicycle priority intersections

### 3.2.2 Mobility Measures

Smart Corridor technologies are designed to make movement of goods, services, and people in a corridor more efficient.

- Emergency Response Times (looking for reduction in response times)
- Feet of bicycle priority facilities
- Feet of transit priority facilities
- Metro Rail ridership, boarding, and alighting numbers (Allen/Medical Campus and Summer-Best stations).
- Number of coordinated/dynamically controlled traffic signals or lane miles of coordinated/ dynamically controlled traffic signals.
- Number of first-mile/last-mile applications/transactions (combination of ride-share, bike share, transit, other applications)

### 3.2.3 System Efficiency Measures

The efficiency of a smart city operations is measured through the capture, dissemination, and usability of information. These metrics can be used to create an iterative operations system that can evolve with the desires of stakeholders and users.

- Number of new users (smart city applications)
- Number of return users (smart city applications)
- Duration of use (smart city applications)
- Number of accessible data sets produced
- Number of data sets used in applications developed by city/NITTEC or other third party
- Usage of mobility hubs (including transactions)

### 3.2.4 Environmental Measures

Using smart city applications can make transportation systems more efficient, changing the environmental impact of transportation activity.

- Number of kilowatt-hours per hour (kW/hr) saved from lighting (with use of smart/ LED street lighting)
- Reduction in vehicle emission through more efficient travel/mode choices
- Number of hours used at electric vehicle charging stations

### 3.2.5 Smart Cities Infrastructure Measures

A network of smart sensors is the backbone of any smart city project. Measuring the quantity of infrastructure implemented in the corridor will provide insight on the capacity and extent of the smart city network.

- Number of roadside units installed (for V2V, V2I, and V2C applications)
- Number of sensors installed
- Number of coordinated traffic signals/intersections
- Lane miles of AV/CV future-ready roadway
- Number of smart cameras installed

### 3.2.6 Equity Measures

Smart city applications can be used to bridge gaps of access to transportation and economic opportunity.

- Number of inclusively designed crosswalks (using universal design features)
- Area of public Wi-Fi provided

# 4 Smart City Implementation Framework

## 4.1 Introduction

This section develops recommendations for implementing smart city applications for the Buffalo Main Street: Smart Corridor Plan Development. Site-specific design and technology recommendations are offered with the objective to develop a smart and highly integrated, multimodal urban transportation corridor based on earlier findings and feedback from multiple stakeholder and subcommittee meetings. The suggestions provided below are based on the conceptual design of the Middle Main Street Reconstruction Project. These concepts are subject to revision in accordance with public feedback. Baseline figures of concepts displayed below are the latest Main Street conceptual design provided by DiDonato Associates and the City of Buffalo.

This section also provides planning level cost assessments for recommendations to measure viability of implementation. Further, the section develops an implementation plan that addresses the timing and phasing of recommendations based on feasibility of new technologies, legal restrictions, and costs. Lastly, the section outlines stakeholder roles and responsibilities as well as recommendations for governance and funding mechanisms to manage smart transportation networks.

## 4.2 Smart City Recommendations

Based on the goals and objectives identified by the steering committee and project stakeholders, the following smart city applications are recommended for deployment as part of the Main Street: Smart Corridor Plan:

- Install smart city sensors
- Implement Smart Cycle Track
- Incorporate green infrastructure
- Install electric vehicle charging stations
- Implement curbside management techniques
- Develop systems architecture/concept of operations
- Expand smart parking features
- Deploy dynamically controlled traffic signals
- Develop a smart mobility hub
- Create a Universally Designed intersection using technology applications
- Ready corridor with AV/CV infrastructure for pilot testing

Smart City developments are ongoing projects that require feedback and input from infrastructure. The data input from smart infrastructure will be used to develop a smart operating system.

Due to the imminent reconstruction project of Middle Main Street and the need to first establish a smart city framework, it is unlikely that smart city features will be fully functional with the near-term reconstruction of Main Street. Thus, to accommodate the project schedule, the implementation of the Main Street: Smart Corridor Plan is broken into three phases.

- Phase 1: Identify immediate elements that can be included as part of the Middle Main Street Reconstruction Project and get the necessary infrastructure in place as part of the Middle Main Street Reconstruction Project to lay the framework and futureproof the corridor to allow for future deployment and expansion of desired smart city applications. This should also include several high-profile, pilot projects that build excitement for future smart city applications.
- Phase II: Develop the systems architecture (governance/data management/communications network/concept of operations) and get the needed smart city framework in place and operating, to include systems architecture and concept of operations. This will essentially become the backbone of the smart city network.
- Phase III: Involves full deployment of smart city applications, building on the infrastructure and framework put in place during Phases 1 and II, and further enhancing the Main Street corridor as a smart corridor for the region.

## 4.3 Phase 1—Middle Main Street Immediate Smart City Elements

Based on discussions with the steering committee, it is understood that the Middle Main Street Reconstruction Project does not have much flexibility in construction budget to begin implementing numerous smart city elements. Further, the steering committee and subcommittee agreed that the system for managing such smart city elements is not yet set up, and the best option is to futureproof the Main Street corridor now by installing necessary infrastructure and communications infrastructure as well as hand boxes along Main Street to be ready for smart city applications. Such instillations could potentially be used to install fiber and other communications networks for future smart city installations and focus in the near-term on a systems architecture. Most vendors are likely to install their own fiber and communications networks anyway, so a conduit allows for this function. In the future, many smart city applications will be able to communicate wirelessly.

The steering committee would like to incorporate a couple higher profile smart city applications in the near-term to get people excited about the potential and build momentum towards further smart corridor applications.

The following explains the smart city elements that are recommended for implementation as part of the Middle Main Street Reconstruction Project and are discussed in more detail in the following sections.

### 4.3.1 Install Infrastructure for Smart City Communications

Any smart corridor requires an integrated network of sensors and communication devices to establish the backbone of a smart city network and maximize the potential for smart city applications. These sensors are devices that collect data on anything from temperature to car movement. The implementation of such sensors dictates the ability to develop and operate smart city applications. Sensors are usually placed on existing infrastructure such as light poles or traffic signals and are connected to a data management center. Once the infrastructure and operations structure are in place, there are a myriad of smart city applications that can follow.

Therefore, with the Middle Main Street Reconstruction Project, it is recommended that conduit and hand boxes be installed as part of the project, at least through the study area of Virginia Street to just north of Summer Street/Best Street, to accommodate future smart city communications networks. The conceptual designs for Main Street show a median feature separating the vehicle travel lanes from a cycle track, consisting of relocated streetlights to this median. Installation of conduit should be along the median where streetlights will be relocated to and include up to eight, 2-inch diameter conduits in a single 12-inch diameter duct bank. At intersections, the conduit should be extended to all curbs to allow for tie-in to traffic signals and curbside elements in the future. Additionally, 18-inch by 18-inch hand boxes should be buried under the median and in sidewalk areas alongside and adjacent to conduit at intersections and at a mid-block location to allow for installation of fiber or other communications networks as well as for splicing and tying in communications lines. An additional amenity that could be installed are Wi-Fi enabled communications within traffic signal control boxes to ready traffic signals for dynamic and coordinated control.

The installation of public Wi-Fi routers should be included in the initial rollout of smart city infrastructure. This section of the project can resemble the rollout of free public Wi-Fi provided by Blue Wireless along Jefferson Avenue in 2018. Free public Wi-Fi is essential to create equal and ubiquitous access to the smart city developments and applications developed as a part of the Smart City Plan.

Incorporating these features as part of the near-term Middle Main Street Reconstruction Project will allow for the infrastructure to be in place and ready for future deployment of smart corridor applications, thus futureproofing the corridor.

### 4.3.2 Coordination with City of Buffalo on Smart City Plan

The City of Buffalo is in the process of acquiring all of the streetlights in the city from National Grid, which would enable the deployment of smart city applications city-wide. The City of Buffalo is partnering with AT&T, Smart City Capital, and New York Power Authority (NYPA) to develop a business plan for acquiring all streetlights from National Grid and deploying smart sensors. This business plan will be presented to the Buffalo City Council in early 2020, and then a decision will be made as to whether to post a bond to purchase the streetlights. Purchase of the streetlights would then allow for deployment of smart city sensors in select areas, allowing the city to retrofit light poles and fixtures to begin building the network of sensors needed to capture data for smart city applications. If desirable, the city would then develop an RFP for vendors for the deployment of smart city sensors and network. Smart sensors initially would perform basic tasks such as traffic control, weather observation, public safety surveillance, and control of lights for energy efficiency. The capability of sensors would eventually be expanded to allow for greater potential of smart city applications. The city is also working with AT&T and NYPA on the establishment of a data and communications hub to be housed in a yet to be determined location. The combination of the city's deployment of smart sensors and data/communications hub would provide the framework for expanded deployment of smart city applications.

Currently there is an inventory of 98 light poles and 34 traffic signals along the Main Street corridor in the study area that can be utilized for the retrofit of smart city sensors. Including the infrastructure outlined in section 4.3.1 as part of the Middle Main Street Reconstruction Project would allow for the installation of sensors and associated communications networks along the Main Street corridor.

The city has established a smart city cabinet to ensure citywide projects are coordinated with the deployment of smart city applications. It is recommended that the BNMC collaborate with the city and their smart city cabinet on the development of the RFP and selection of a vendor to influence the type of sensors used and deployment of sensors to accommodate the Main Street corridor as a pilot for innovation and smart city applications, which will require the implementation of higher quality sensors with more capability along the Main Street corridor to accommodate advanced applications. The partnership between the BNMC and the City of Buffalo is crucial to establish a corridor to act as a formal testing ground for the city's smart city efforts. The BNMC can help identify, find funding for, and implement pilot projects. Piloting smart city sensors and applications in the Main Street corridor allows for stakeholder collaboration opportunities through the BNMC, and condensed, cost-effective rollout measures.

### 4.3.3 Smart Cycle and Micro-Mobility Track/Intersection Priority Project

The BNMC is a major employment hub in the region and requires a high capacity for bicycle commuters. The Main Street Corridor is currently a poor road for cycling, with no bike lane and frequent on-street parking along both sides of the road. The Main Street conceptual improvements proposed by the City of Buffalo for the Middle Main Street Reconstruction Project display a dedicated cycle track to be constructed along the east side of Main Street. The cycle track is a bi-directional bike facility that extends from Virginia Street to Ferry Street. South of Virginia Street, the cycle track terminates and splits into two on-street bike lanes that run along each side of Main Street. The cycle track design is in the conceptual stage and is subject to revision. Proposed smart city suggestions are based on the conceptual design of the cycle track.

As one of the high-profile pilot projects to be implemented in the near-term with the Middle Main Street Reconstruction Project, there are two intersections along the conceptual cycle track identified in which a smart signal system for the cycle track should be implemented—the intersection of Main Street and Allen Street and the intersection of Main Street and Virginia Street.

A smart bicycle signal utilizes a sensor embedded in the ground (until overhead sensors are deployed) to recognize bicyclists approaching an intersection and manages intersections accordingly to allow for efficient bicycle travel. The sensor communicates with the intersection traffic signals to provide priority to the bicycle through a special signal head dedicated to cyclists.

### *4.3.3.1 Allen Street*

One location proposed is located at the intersection of Main Street and Allen Street. There is currently a high level of pedestrian, bicycle, and vehicle traffic prevalent at this intersection due to the location of Allen/Medical Campus NFTA Metro Rail station. At the intersection of Main Street and Allen Street, sensors would be embedded in the cycle track to sense when a bicyclist is approaching the intersection, triggering the traffic signal to provide the appropriate green light through movement to the cycle track, while holding all other conflicting traffic movements. Parallel through traffic on Main Street could also be given a green to proceed. A properly placed sensor can sense a bicyclist prior to reaching the intersection and provide the opportunity for a bicyclist to proceed without stopping.

### *4.3.3.2 Virginia Street*

The second opportunity for a smart cycle track is at the intersection of Virginia Street and Main Street. As the cycle track continues south of Virginia Street, it splits from a two-way cycle track to bike lanes on either side of Main Street. The intersection of Virginia Street is used to bring southbound bicyclists across Virginia Street and then across Main Street to continue on the bike lane. Here, sensors would be embedded in the cycle track and bike lanes (until overhead sensors are deployed) to sense when a bicyclist is approaching the intersection. Once a bicyclist is detected, the sensor would communicate with the traffic lights at the intersection to hold all approaches in an all-red interval, allowing only the bicyclist to proceed through the intersection. This would allow a bicyclist to safely maneuver between the cycle track on the east side of Main Street, north of Virginia Street, and the bike lanes south of Virginia Street, triggering the traffic signal. Again, a properly placed sensor can sense a bicyclist prior to reaching the intersection and provide the opportunity for a bicyclist to proceed without stopping. Figure 24 depicts this concept overlaid on the proposed Main Street reconstruction plan, and Figure 25 shows two examples of this concept in operation in Vancouver, BC.

**Figure 24. Smart Cycle Track Deployment at Intersection of Main Street and Virginia Street**

*Source: WSP USA Inc., baseline conceptual drawings by DiDonato Associates, City of Buffalo*

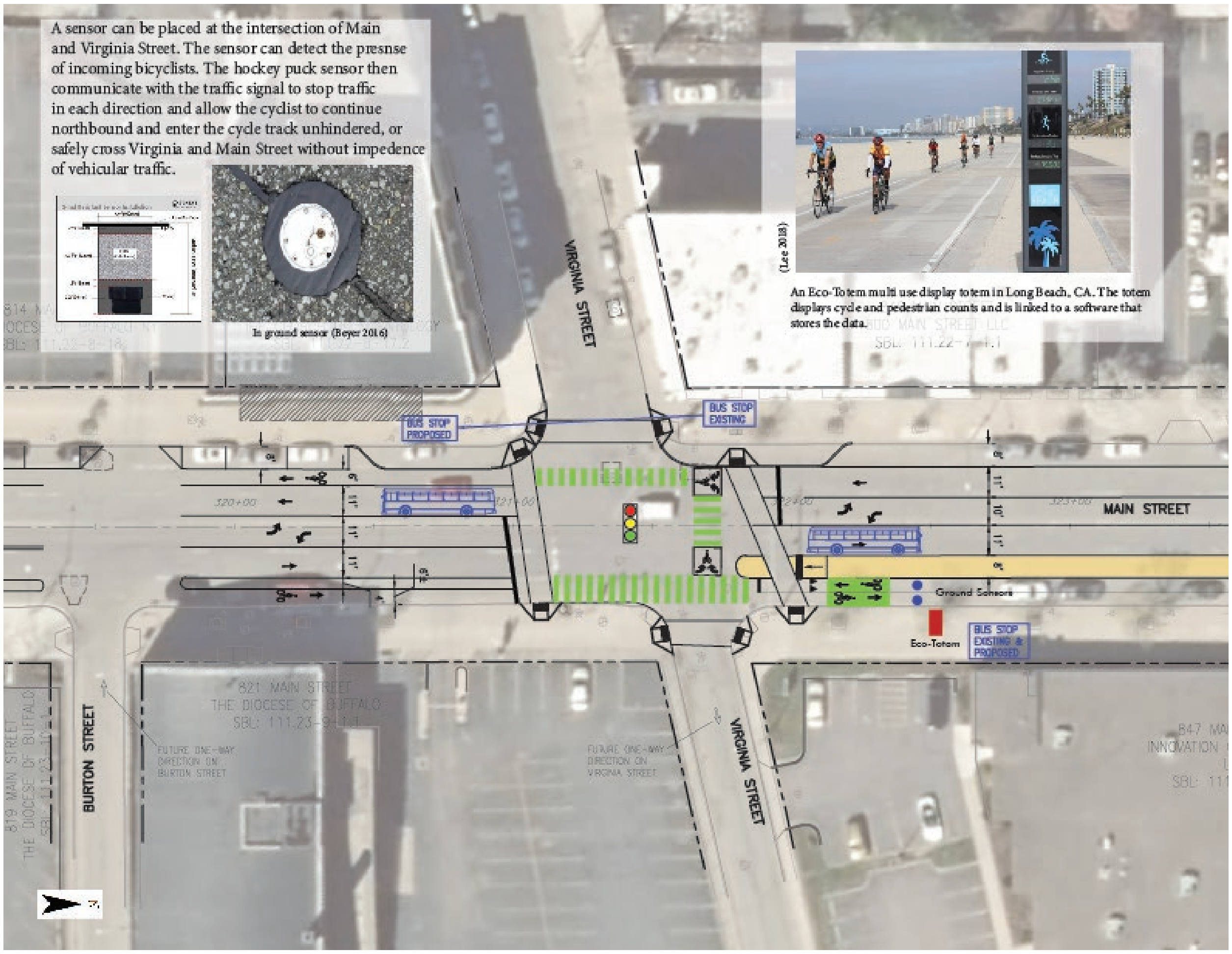
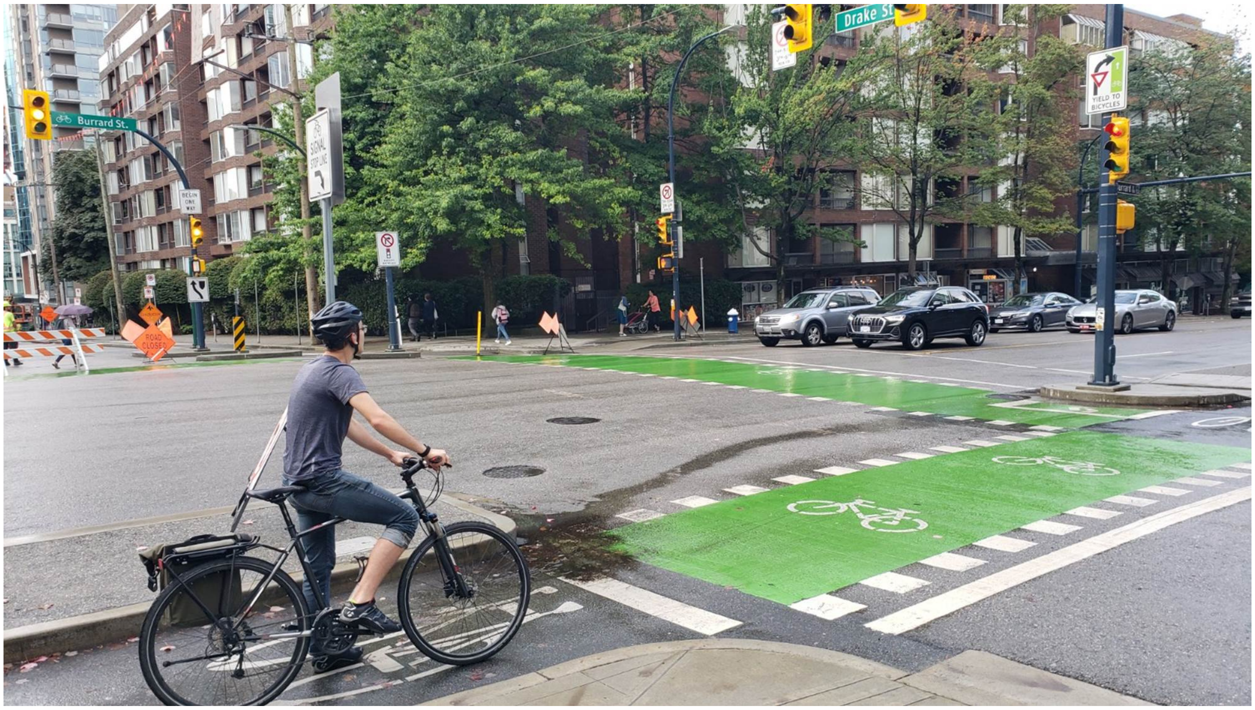


**Figure 25. Bicycle Priority Intersection**

*Source: WSP USA Inc.*




Another element that should be employed in the near-term in association with the smart cycle track is a real-time bike totem counter. The totem counter is a system that counts bicycle traffic, displays real-time bicycle counts, and stores it within an accompanying software for analytics. The system can be connected to a smart city operating system to bolster the data collection period and inform several different applications. The totem offers an intriguing smart city element that is visible and appealing, bringing a "coolness" factor and helping to establish interest to expand smart city applications. A totem can be placed along the cycle track around the Allen/Medical Campus station. An example of a totem counter is shown in Figure 26.

**Figure 26. Example of a Bicycle/Pedestrian Totem Counter**

*Source: Velo Club*

The use of multimodal facilities for micro-mobility such as e-bikes and e-scooters in combination with bicycles is becoming increasingly popular. While initially, the Main Street cycle track would be for bicycles only, its construction should not preclude the future use of other micro-mobility modes. The steering committee would need to work with the city and New York State on enabling policies to allow use of cycle tracks for micro-mobility options. Future adaptation of the cycle track would require alternations such as signage and lane markings on the cycle track to designate shared lanes (see Figure 27).

**Figure 27. A Shared Bike and Scooter Lane in Kansas City**

*Source: www.kshb.com*

## 4.3.4 Incorporate Green Infrastructure

Green Infrastructure allows for developed surfaces to maintain natural processes in an urban landscape. The use of porous pavement in the paving and development of a certain stretch of the cycle track can be used to allow stormwater to naturally seep into the ground rather than being directed to stormwater sewers. Rain gardens can be incorporated along the sidewalk to divert surface runoff from the storm drains, recharging the groundwater and helping to reduce sewer overflows, similar to those constructed further south on Main Street as part of the Cars on Main Street project. A stormwater sensor can be embedded in the pavement to monitor the volume of water being diverted from the storm sewer system. Additional sensors can be placed in storm or sanitary storm sewers to create a smart sewer system that can monitor things like system overflows and peak usage, as well as any reduction of discharge from users through the use of other best practices. These environmental sensors can be used to inform further green infrastructure development and provided data for analysis by the Buffalo Sewer Authority and Buffalo Niagara Water Keeper. Displaying this information on a totem can help educate the public on the importance of green infrastructure. These elements should be incorporated into the Middle Main Street Reconstruction Project.

### 4.3.5 Electric Vehicle Charging Stations

The Deployment Guide for On-Street Electric Vehicle (EV) Charging put out by WXY Studios, with funding from NYSDOT, NYSERDA, and NYCDOT, singles out Medical Campuses as a top consumer of curb side parking spaces. The excerpt of the analysis is as follows: "Medical campuses tend have a largely car-dependent workforce amplified by shift workers who have fewer and less frequent off-hours public transit options. Often, parking for visitors and employees spills out of garages onto the curb" (p.21).

With this in mind, it is important to expand the ability for employees and visitors to park and charge electric vehicles on the curbside as well as identify opportunities for ride sharing options to provide mobility to BNMC patrons and employees. With regards to curbside management, the option to use ride hailing service provided by transportation network companies (TNC's), is becoming increasingly popular with young professionals and is seen as an important mobility option for BNMC employees and patrons.

In the near-term implementation, as part of the Middle Main Street Reconstruction Project, an area along the west side of Main Street just south of Allen Street has been identified as an area to consider for the allocation of electric vehicle parking based on the following specs of implementation. There is enough area for roughly four on-street EV charging spots. The proposed locations for these EV charging areas are found in Figure 28. Steps for implementing EV charging stations as part of the Middle Main Street Reconstruction Project are outlined below.

EVs use the following three categories of EV supply equipment classified according to power levels and circuit requirements:

- AC Level 1, up to 120-volt single-phase circuit with either 15-ampere (amp) or 20-amp configuration.
- AC Level 2, 208-volt to 240-volt single-phase circuit with an 80-amp maximum, but often using 40-amp rated circuits.

- DC fast charger converts AC power levels rated at 208 volts to 480 volts (three-phase) to DC power to deliver up to 50 kilowatts at the EV's battery voltage.

Public EV stations use either Level 2 or DC Fast Charging, with DC Fast Charging becoming more popular as it allows for much faster charging, freeing up stations for more turnover.

The following are general recommendations for all EV charging equipment:

- Compliance with Society of Automotive Engineers J-1772 and/or CHAdeMO standard for EV charging plug connector dimensions and operational requirements.
- Nationally Recognized Testing Lab (e.g., Underwriters Laboratories) listed for outdoor use.
- NEMA Type 3R or 4 certification for outdoor electrical enclosures.
- Ability to operate in extreme temperature conditions (-20 to +100 degrees F).
- Americans with Disabilities Act (ADA) accessible buttons and components.
- Warranty—minimum one year, longer is desired.

Additional recommendations for public EV charging equipment:

- Charging amperage from 30 to 80 amps to support vehicles with higher charging power capabilities (7.2–19.2 kW).
- Modular Field serviceable parts, particularly for cord and J1772 connector:
    - Minimum cord length of 20 feet.
    - Cord management system to keep cord off the ground and comply with National Electric Code (NEC) Article 625 as it applies to cord management systems.
- Network monitoring capability for status and fault reporting:
    - Current status of charging station equipment (in-use, malfunction, etc.).
    - Reporting on power consumption and usage patterns.
- Fee collection system using credit cards, access codes, phone operation, and/or contactless RFID cards from widespread charging network(s) with customer service assistance available 24 hours a day, seven days a week by phone.

Choices for connecting to electric power include opening a new service with the utility (including a new meter) or using an existing meter with a new or existing electrical panel. If a new electrical panel is not already being planned as part of the EV charging station installation, existing infrastructure will need an electrical load study to determine if it has adequate capacity for the EV supply equipment. Upgrades could require a new electrical panel or transformer.

Installation of an EV charging station typically requires a dedicated cable in conduit from an electrical panel to the EV supply equipment. Level 1 and Level 2 EV supply equipment installations are most cost-effective if the service load evaluation supports using an existing electrical panel and the charging station can be located nearby.

### 4.3.6 Curbside Management

Current conceptual plans show that on-street parking on the east side of Main Street will be eliminated in the implementation of the Middle Main Street Reconstruction Project. To accommodate for these spaces, it is suggested that two parking spaces on the west side of Main Street, south of Allen Street, be allocated to rideshare vehicles, such as Zipcar, to incentivize the service. Zipcars are frequently used by University at Buffalo students, which makes the placement of these spots appropriate across from the Jacobs School of Medicine. As noted above, up to four parking spaces on the west side of Main Street, south of Allen Street can be used for electric vehicle charging.

Two parking spots on Main Street, north of Allen Street, can be dedicated to a flex zone. The flex zone can act as a dedicated delivery vehicle spot during early morning and midday hours and can act as a ride hailing drop-off/pick-up zone during peak hours and late night hours. The flex zone is marked with clear signage and pavement or curb markings to designate use during particular hours and requires stringent enforcement. The proposed curbside management uses are found in Figure 28.

### 4.3.7 Futureproofing for a Smart Mobility Hub

The Allen/Medical Campus NFTA Metro Rail station is centrally located on the Main Street corridor. With access to the institutions of the BNMC to the east, Downtown Buffalo to the south, and Allentown to the west, the station is utilized for multiple destinations. There is a Reddy bike share station at the location along with a NFTA Metro Bus stop location. The station is well equipped to become a Smart Mobility Hub. A Smart Mobility Hub is a central node, usually a kiosk, that allows for real-time identification, scheduling, and payment of mobility options. An LED screen display can be synced with GPS units on NFTA trains and buses to display real-time location and inform transit users of arrival time. The kiosks that can be used to order ride shares, rent bikes, and pay for transportation, as well as promote businesses and restaurants in Allentown and nearby BNMC, offer smart device charging and Wi-Fi, and share news and events going on in the area to help generate revenue. As part of Phase 1, the conduit duct banks should be extended to a pad reserved for a Smart Mobility Hub located near the Allen/Medical Campus station, as shown in Figure 28 overlaid on the Middle Main Street Reconstruction Project concept. Figure 29 depicts a Smart Mobility Hub in Columbus, OH.

**Figure 28. Location of EV Charging, Curbside Management, and Mobility Hub**

*Source: WSP USA Inc., baseline conceptual drawings by DiDonato Associates, City of Buffalo*

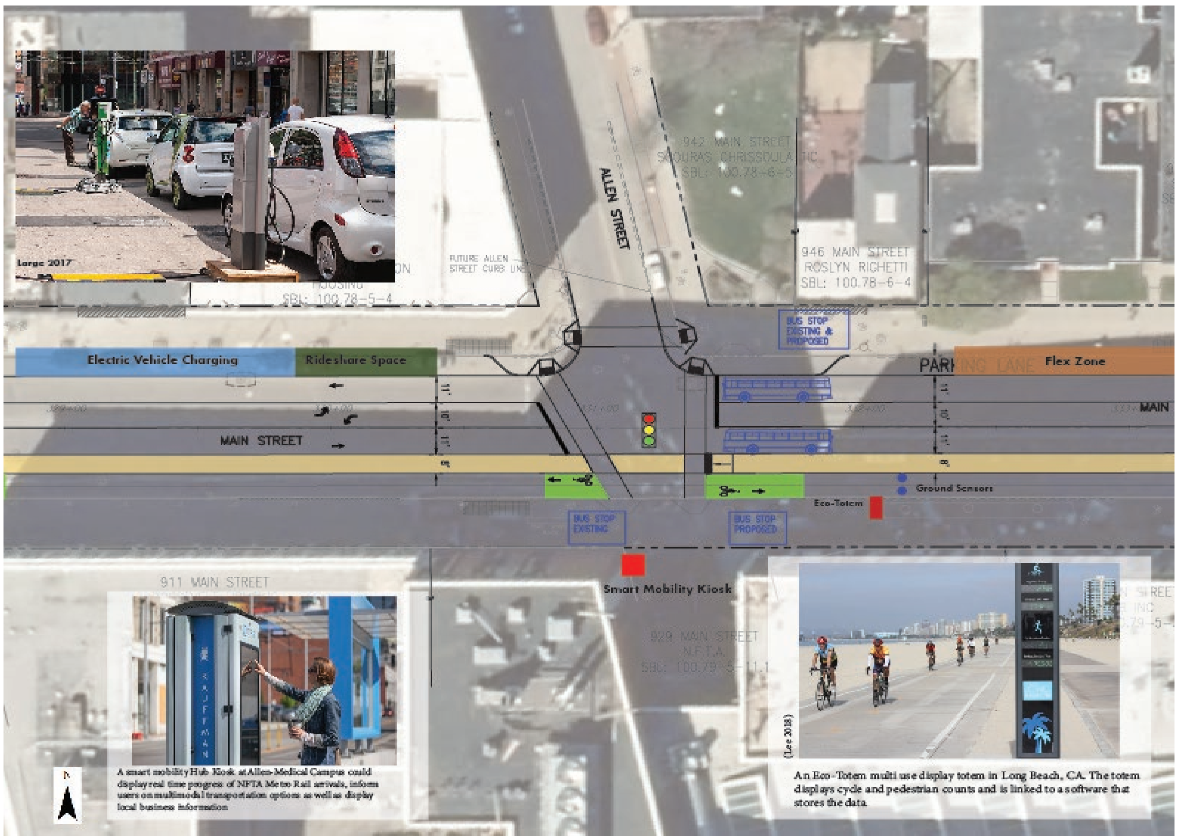


**Figure 29. Smart Mobility Hub in Columbus, OH**

*Source: www.cota.com*


## 4.4 Phase II—Connectivity of Smart City Elements

### 4.4.1 Systems Architecture/Concept of Operations

As many of the stakeholders involved in this project have indicated, the smart city communications and data management backbone needed to function with smart city applications is not yet in place. Thus, many of the recommendations outlined in Phase I would essentially act independently and not be optimized until a smart city communications and data management framework are in place. Much of the details of this Phase are still to be worked out and steering committee should remain involved in the smart city plan administered by the City of Buffalo as well as NITTEC's concept of operations effort that will begin shortly. Both have the potential to develop the smart city framework needed to optimize the use of smart city applications recommended for the Main Street corridor.

Data management infrastructure is an essential function of the smart city environment. The smart city system is the repository and disseminator of the mass quantity of data generated by myriad sensors spanning corridors and cities. Each data management system is tailored to the needs of the cities collecting data and the citizens using the data. Each system is a complex requiring processes in data collection, aggregation, storage and processing and distribution. In order for the smart city applications identified as part of this project to become fully functional, the smart city communications network and data management structure need to be constructed.

NITTEC contains the capacity for housing and managing the systems architecture for smart city applications on a region-wide basis. As outlined in section 2, the ATCMTD grant, which allotted NITTEC $7.8 Million for ITS development, can be used to build and operate the system needed to optimize smart city applications. This system will store and manage data, refine data, and deliver refined data for application. The data collected can also be used to inform smart city metrics as outlined in section 3 in order to maintain an efficient smart city operations system. The metrics can be used to determine which data is being utilized, and where smart city operations and applications have the most impact.

## 4.5 Phase III—Future Smart City Elements

This section outlines Smart City applications that can be implemented over time that lack the immediacy of implementation in the scope of the Middle Main Street Reconstruction Project and will be best optimized if implement after the smart city communications and data management system outlined in Phase II is up and running. These applications can be informed by data collected from sensors and are meant to be dynamic to changing conditions.

### 4.5.1 Smart Parking

The BNMC is a major employment center and requires a high-parking capacity. The conceptual drawings of the Middle Main Street Reconstruction Project display on-street parking available along the west side of Main Street, but not along the east side of Main Street, which would cut the amount of current on-street parking in half. In turn, the demand for parking will continue to increase around the BNMC.

To help mitigate the parking constraints in BNMC, it is suggested that the steering committee partner with the City of Buffalo to update the Buffalo Roam Application, which is currently a single-use parking payment application. The application can expand its capability by implementing real-time data to display available parking spaces as well as eventually create dynamic pricing that fluctuates throughout the day based on parking demand. The update can be piloted using data collected from overhead sensors piloted on the Main Street corridor on where parking demand is greatest and where supply is available. The BNMC can utilize its resources to sponsor a hackathon or tech challenge to attract developers for the project. This dynamic parking application requires partnership with the City of Buffalo as well as the implementation of smart sensors frequent enough to cover the on-street and off-street parking along corridor and across BNMC.

### 4.5.2 Deploy Dynamically Controlled Traffic Signals

Dynamic traffic signal control, or advanced traffic control, is among the top applications for data collection in smart city transportation systems. Sensors and cameras allow for mass quantity data capture of roadway use to inform peak travel time and congestion to the operations system. The operation system uses algorithms to process the most efficient flow of traffic based on the input data from sensors. This process generates better traffic flow throughout the corridor for all users. The application of dynamic signaling would generate optimal traffic flow at peak hours, diverting certain intersections to different roads based on real-time congestion analysis.

Implementation of smart traffic signals requires infrastructure including state-of-the-art traffic signal controllers, vehicle detection sensors, and communication from a central management facility to the signalized intersections. All three elements are required to operate a smart corridor; however, a phased approach can provide improved operation immediately by replacing the outdated controllers with new state-of-the-art advanced traffic controllers. These can be placed into the existing cabinets immediately (with some wiring modification), and utilizing the existing detection infrastructure can provide improved traffic control through added functionality. With the onset of communication to/from the intersections, there would be an added benefit of the ability to collect traffic data for performance measurement and improvement.

Once the smart city sensor framework is in place, the Main Street corridor can be piloted for dynamic traffic signaling as it exists as a major thoroughfare in the city and functions as a hub for vehicular traffic, emergency vehicle traffic, transit vehicles, bicycles, and pedestrians. Currently, NITTEC owns the software to enable traffic signal control and has the capacity necessary to operate a smart traffic signal network. The instillation of controllers by the City of Buffalo is required to initiate the system. Figure 30 portrays the intersections along the Main Street corridor that would be key to an optimized dynamic signalization.

Dynamic traffic control can also be used to increase the efficiency of transit vehicles, improving Metro Bus on-time performance, and decreasing travel times. Emergency vehicle preemption is another application in dynamically controlled signals. Ambulances with onboard devices have the ability to communicate with roadside units (RSU) to signal the approach of the vehicle. The signals respond appropriately by closing off traffic coming from adjacent streets and giving the greenlight to the emergency vehicle traveling down the corridor. The Main Street corridor can benefit from emergency vehicle preemption due to the proximity of emergency care hospitals such as Gates Vascular Institute, Oishei Children's Hospital, and Buffalo General Medical Center.

**Figure 30. Intersections Targeted for Dynamic Traffic Control**

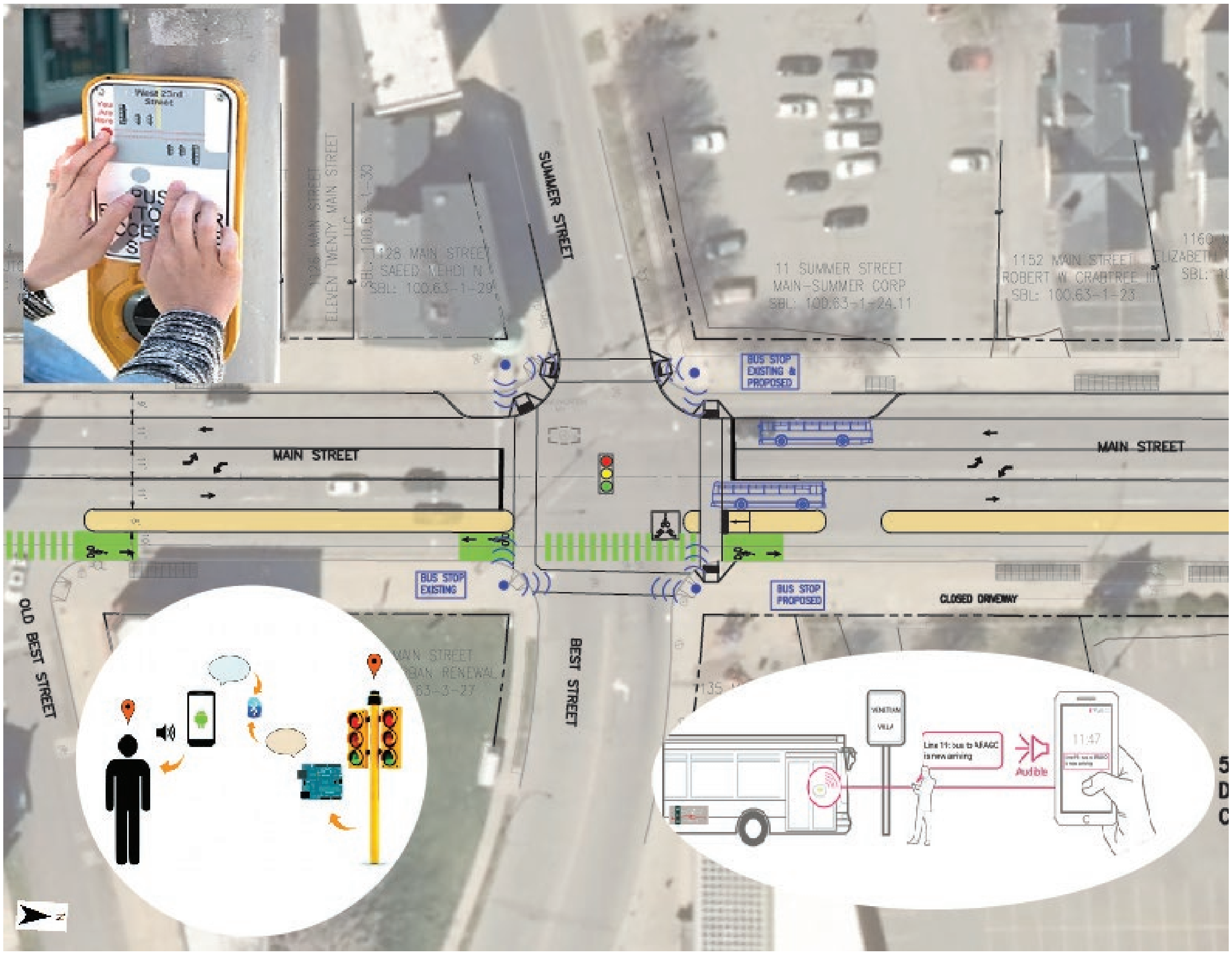
*Source: WSP USA Inc.*

### 4.5.3 Pilot a Universally Designed Intersection

Smart city applications can also be used as assistive technology to make streets and intersections more accessible and navigable for persons with disabilities. Beacon devices mounted to infrastructure, such as pedestrian crossing lights or busses, can communicate with smart phones or other devices to audibly aid the visually impaired to safely cross the street. The same application can be used to aid the visually impaired to use the bus and transit system. As a pilot project, the intersection of Main Street and Summer Street/Best Street would be a high-profile site to implement a universally designed intersection due to the proximity of the Olmsted Center for Sight (just 300 feet from the intersection on Main Street). The intersection would require installation of communication boxes that can communicate real-time audible directions to a smart device held by someone approaching the intersection. This Living Lab for Universal Design Technology can be used as an ongoing testing ground in collaboration with the IDEA Center and member institutions.

**Figure 31. Universally Designed Intersection Diagram**

*Source: WSP USA Inc., baseline conceptual drawings by DiDonato Associates, City of Buffalo*




## 4.5.4 Connected Vehicle/Autonomous Vehicle Infrastructure Readiness

In the development of the Main Street: Smart Corridor, DSRCs can be implemented along the Main Street corridor to create a pilot corridor for CV/AV technology in Buffalo once permitted by New York State on public roads. There is potential for coordination with the University at Buffalo's Department of Civil, Structural, and Environmental Engineering, which has been working on an autonomous shuttle and other CV/AV research. The department has access to OLLI autonomous shuttle that is being used to test vehicular operations under various conditions around the University at Buffalo North Campus. The OLLI shuttle is prefabricated and has engrained and unmalleable software that runs its operating system. The department also possesses a Lincoln MKZ, which has been retrofitted with software created by the department. This vehicle is being used to develop software on a Linux operating system and can help develop national standards for AV operations. The vehicle can also act as a campus shuttle and has potential to work as a people mover in the medical campus corridor. To pilot the autonomous vehicle along the corridor, thicker striping along with implementation of roadside units (RSU) must be completed along the designed route. The department has also applied for an Automated Driving System grant that has potential to be linked to the pilot corridor. The testing period for the grant funding coordinates with the Middle Main Street Reconstruction Project.

Since much of the future of CV/AV is unknown, it only makes sense to "ready" the corridor in the near-term with the previously mentioned conduit and sensors. Then, once the smart city framework is in place and once testing of autonomous vehicles is permitted on public roads, additional infrastructure can be added along the corridor, such as RSUs that allow for V2V, V2I, and V2X communication. It is likely that these units and associated CV/AV infrastructure will continue to evolve, so placing roadside units as part of the Middle Main Street Reconstruction Project does not make sense at the moment. Further, the Federal Highway Administration (FHWA) is looking at developing standards for roadway signage and striping that would accommodate CV/AV vehicles. This infrastructure can be retrofitted along Main Street once this guidance is available.

### 4.5.5 Expanded Mobility Hub

The area around the Metro Rail Utica Station should be considered for a secondary Smart Mobility Hub in the future once infrastructure is in place, as this location experiences a high volume of users. Mobility options provided by a Smart Mobility Hub would mitigate long and crowded waiting areas inside and outside of the station and increase the menu of mobility options as well as provide real-time data to make mobility decisions and improve efficiency. To become a reality, smart city applications and infrastructure would need to be expanded beyond the initial study area further north on Main Street. With the volume of traffic, the intersection of Main Street and Utica Street would also be a great option for a second universally designed intersection in the future.

## 4.6 Governance

A smart city project requires a certain governance structure to facilitate productive, efficient, and protected systems. Under this plan, the proposed major stakeholders in the Main Street corridor are NITTEC, the potential operations manager, City of Buffalo, the regulator and administrator of the system, GBNRTC, the regional coordinator and fund identification partner for smart technology efforts, and the BNMC (acting as a facilitator and funding partner along the corridor). In previous sections, there was much discussion regarding the ongoing City of Buffalo Smart City efforts. The City of Buffalo has established a smart city cabinet to assist in implanting its smart city plan. The other stakeholders of the Main Street: Smart Corridor Plan should be invited to this committee so that smart city applications are coordinated not only citywide, but regionwide. Much is still to be determined regarding the ultimate governance of a smart city and will come out of the City of Buffalo Smart City plan as well as NITTEC's concept of operations project.

**Table 4. Buffalo Smart City Roles/ Responsibilities**

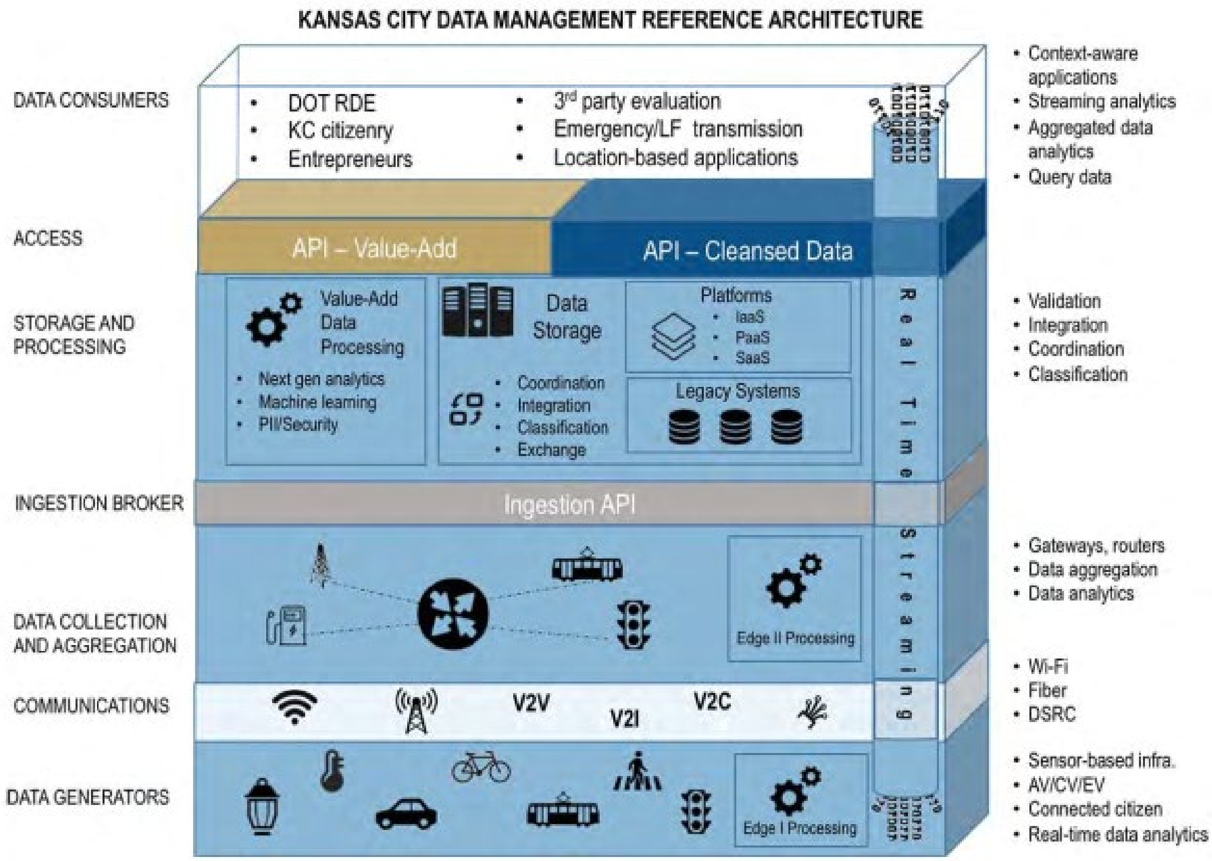
| Stakeholder | Role |
|---|---|
| **BNMC** | Project Facilitator |
| **City of Buffalo** | Regulator |
| **NITTEC** | Operations Manager |
| **GBNRTC** | Regional Coordinator/Funding Partner |
| **Other Stakeholders** | University at Buffalo, National Grid, Erie County, NYSDOT, NYSERDA |

In order to create the envisioned smart city system, there must be a mass collection of data. The City of Buffalo, in coordination with its partners in the smart city plan, will acquire the data for the system through the sensors it will own along the corridor. The sensors will feed information to the smart operating system. This data will then be channeled into the smart operating system, suggested to be housed and managed by NITTEC. NITTEC would then be responsible for data storage, processing, and distribution. There will need to be data privacy and management plans in place for the collection, dissemination, and usage of data. The BNMC would act as a facilitator of smart city applications, as well as a conduit for grant funding for ongoing project development and maintenance.

This need for data creates an uncertainty for mismanagement and misuse of public information. There is a need to create and enforce data management and data privacy plans for assurance of public privacy protection. A data management plan ensures that the system has a structure that is secure and organized in a way to create an efficient and responsive product. The management plan includes metrics that determine whether information is worth collecting based on application use. The privacy plan is used to ensure that any data collected is anonymized and creates a safe and secure data management system. Cities such as Columbus and Kansas City have produced extensive policies relating to data privacy and management. Each outlines the data management process from ingestion to distribution. Figure 32 displays Kansas City's data management reference architecture, which the City of Buffalo can use as a model.

**Figure 32. Organization of the Kansas City Data Management System**

*Source: Kansas City's Capital Improvements Projects Smart Infrastructure Update*




## 4.7 Private-Public Partnerships and Funding

As outlined in section 2, all productive smart city projects start with grant/public funding, then leverage this funding to attract private investment in smart city development. This investment generally comes from telecommunications, automotive, and software development companies. The smart city development gives a platform for revenue generation in these given sectors, supporting the concept that if a city builds the smart city backbone which can generate profit, the private investors will participate. To entice private investment, the City of Buffalo could create a request for information (RFI) to receive options for smart sensor development, which is proposed as part of their smart city plan once the business case is approved by Council. A model for a smart light RFI is the City of Pittsburgh RFI, which received 29 responses. The responses included a wide variety of smart city services from lighting to Wi-Fi under various funding models. The responses provide ways in which to implement a foundational network at a competitive cost. Through partnerships with Verizon, Cisco Systems, and sensors from Sensitivity, Kansas City has already implemented 2.2 miles of city streets with IoT Smart City technology.

The BNMC can leverage its reputation as a startup and tech hub by hosting a "hackathon" for smart city application development. Goals for city projects, such as a multimodal transportation application, can be administered and cash prizes/partnerships in application development can be offered to a winning team. The civic "hackathon" is a common practice in smart city application development that allows for local talent to get involved with local development. The "hackathon" can be held at the innovation center, and a winning development team can be hosted to complete further work in the tech hub.

Working with the City of Buffalo to promote Main Street between BNMC and downtown as a tech hub can also help bring private investment. Kansas City was successful in doing this with their downtown.

## 4.8 Economic Development

The initial investment in a smart city corridor generates higher functioning city services and infrastructure that can be leveraged into further long-term private investment. These investments create vibrancy and make streetscapes interactive, also making transportation options more efficient and robust. Smart city investment often attracts job growth in the technology sector and can be used to create a tech hub that can attract talent to the region.

The City of Buffalo/BNMC can establish a competition or "hackathon" that rewards teams that pitch successful smart city application ideas. The results of the "hackathon" can spark initiatives for data use and management and aid in the development of an advanced multimodal transportation or parking application. The BNMC can coordinate with local startups such as SparkCharge, an electric vehicle charging manufacturer, to involve local tech startups in the development of the corridor.

## 4.9 Planning-Level Costs Assumptions

While it is difficult to price many of the smart city applications until the time comes to design each element, the following outlines typical costs of similar smart city applications, as taken from other similar projects, that could be used to help anticipate the costs related to the Middle Main Street Reconstruction Project and for applying for future grants.

- Conduit, six 2-inch conduits in a duct bank typically costs around $30.00 per linear foot along the length of the corridor for furnishing and installation since road will be open, rather than saw cutting the trench.
- The cost to retrofit an intersection to accommodate smart city applications for elements such as pedestrian and bicycle detection, smart cycle tracks, universally designed intersections, and dynamic traffic control is around $30,000$50,000 per intersection. If there is a desire to have new traffic signal mast arms, streetlight fixtures, and cabinets, this cost can increase to $150,000–$200,000 per intersection.
- The cost of installing a smart mobility hub as described as part of the project can range from $4,000 to the more basic hubs to over $20,000 for more complex hubs.
- The cost of installing an electric vehicle charging station can range from $3,000 to $12,000.
- The cost to develop a connected corridor, with instruments to ready a corridor for connected and autonomous vehicles, ranges from $100,000–$150,000 per mile.

# 5 Conclusions and Next Steps

## 5.1 Introduction

This section acts as a conclusion of the project, identifying final observations and findings, outlining lessons learned, and describing potential environmental and economic benefits of the project.

## 5.2 Observations, Findings, and Lessons Learned

Based on the goals and objectives identified by the steering committee and project stakeholders, the following smart city applications are recommended for deployment as part of the Main Street: Smart Corridor Plan:

- Install smart city sensors
- Implement Smart Cycle Track
- Incorporate green infrastructure
- Install electric vehicle charging stations
- Implement curbside management techniques
- Develop systems architecture/concept of operations
- Expand smart parking features
- Deploy dynamically controlled traffic signals
- Develop a smart mobility hub
- Create a Universally Designed intersection using technology applications
- Ready corridor with AV/CV infrastructure for pilot testing

Throughout the project and following the final presentation of the project recommendations to a group of involved and interested stakeholders, the Buffalo Niagara Medical Campus has received strong support for moving this Main Street: Smart Corridor Plan forward.

Throughout the course of the project, the following observations, findings, and lessons learned were derived, which can be used to assist other project sponsors progress similar smart corridor projects:

- There are several agencies that collect and process data, but very little opportunity to share this data across consistent platforms or to use the data to dynamically adjust conditions of a corridor.
- In the case of this project sponsor—Buffalo Niagara Medical Campus—there was the opportunity for BNMC to play a role as project facilitator and promoter, but since BNMC does not own the roadway or communications networks, there needed to be a commitment from numerous stakeholders, such as the roadway's owner and operator (City of Buffalo), owner and operator of the streetlights (National Grid), owner and operator of communications networks, and a location for a communication hub (potentially NITTEC).

- Using examples from smart city approaches in other cities to helped guide which smart city elements should be pursued for the Main Street: Smart Corridor Plan and how they should be implemented.
- Beyond the actual smart city elements, there are a number of legal and policy issues that often need to be worked through in order to allow for many smart city applications to become functional.
- For smart city applications to become fully functional, an initial phase that involves implementation of corridor-wide sensors and communications infrastructure is needed to develop the smart city backbone. These elements do not offer the appeal and glamour of other smart city applications but are necessary components in order for the highly appealing smart city applications to function correctly.
- Full implementation of a smart corridor will likely require implementation in phases, with coordination among numerous stakeholders and the use of unique funding sources.

The project presented a proactive approach to smart city planning and also helped stakeholders determine the real-world practicality of new and emerging smart city technologies as well as barriers to implementation. On a larger scale, the Main Street: Smart Corridor Plan establishes a blueprint for expanding smart city applications across the city and region.

## 5.3 Environmental and Economic Benefits

The Main Street: Smart Corridor Plan will help improve the effectiveness and efficiency of the transportation system, which in turn is also expected to enhance safety, improve energy efficiency, provide emissions reductions, enhance access and mobility, and make for a more equitable transportation system. Section 3 outlines the smart city performance measures for this project; however, there are expected additional benefits, as outlined below:

- Mitigate traffic congestion to reduce vehicle miles travelled (VMT), GHG emissions, other pollutants, and gasoline consumption.
- Enhance safety by reducing the number of crashes and making a more comfortable environment for all transportation users.
- Reduce overall parking demand.
- Actively manage on-street parking demand and supply to reduce VMT and improve turnover rates.
- Enhance traveler information systems so travelers can make informed decisions on their mode choice and availability.
- Improve public transit efficiencies and system reliability to enhance mobility and increase ridership.
- Improve pedestrian and bicycle efficiencies to enhance mobility and increase cycling and walking mode shares.

- Improve energy infrastructure to increase energy efficiencies and utilize renewable energy sources.
- Prepare for new and emerging transportation technologies that will have additional environmental, economic, and social benefits.
- Enhance data collection efforts that can assist with dynamically controlling the transportation system and can affect future planning and decision making.
- Promote economic development by generating higher functioning city services and infrastructure that can be leveraged into further long-term investment.
- Promote economic development by creating a tech hub that can attract talent to the region.

## 5.4 Next Steps

Due to the imminent reconstruction project of Middle Main Street and the need to first establish a smart city framework, it is unlikely that smart city features will be fully functional with the near-term reconstruction of Main Street. Thus, to accommodate the project schedule, the implementation of the Main Street: Smart Corridor Plan is broken into three phases.

- Phase 1: Identify immediate elements that can be included as part of the Middle Main Street Reconstruction Project and get the necessary infrastructure in place as part of the Middle Main Street Reconstruction Project to lay the framework and futureproof the corridor to allow for future deployment and expansion of desired smart city applications. This should also include a number of high-profile, pilot projects that build excitement for future smart city applications.
- Phase II: Develop the systems architecture (governance/data management/communications network/concept of operations) and get the needed smart city framework in place and operating, to include systems architecture and concept of operations. This will essentially become the backbone of the smart city network.
- Phase III: Involves full deployment of smart city applications, building upon the infrastructure and framework put in place during Phases 1 and II, and further enhancing the Main Street corridor as a smart corridor for the region.

Additionally, continued coordination with agencies should be ongoing, as follows:

- The city's smart city plan—ensuring this project is rolled into larger planning efforts by the city and that the project committee remains active partners in the city's larger planning efforts.
- Leveraging additional planning efforts, such as NITTEC's planning and implementation grant, to address the barriers identified in this project.
- Supporting legislation that would allow for expanded piloting and advancement of new and emerging transportation technologies, including micro-mobility options and C/AV options.

Further detail on the next steps and phasing of the project is provided in section 4.

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