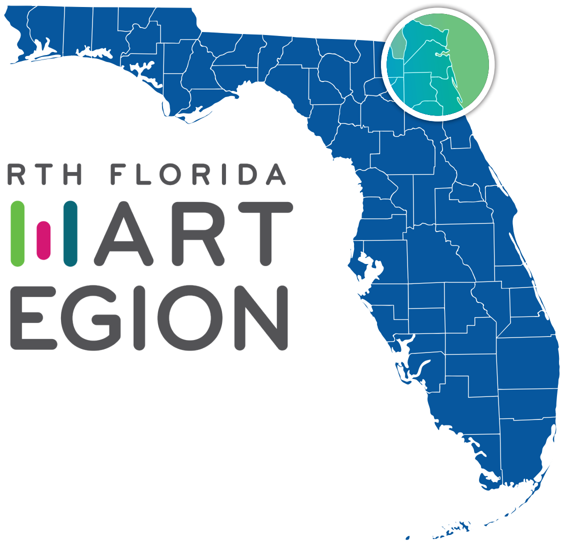
THE BAY JAX innovation corridor

NORTH FLORIDA SMART REGION



June 25, 2019

THE BAYJAX INNOVATION CORRIDOR

Project Description and Benefit: Cost Analysis

UPWP TASK 5.1 SMART REGION COALITION SUPPORT

Prepared for

North Florida TPO
Transportation Planning Organization
PLAN • FUND • MOBILIZE

Prepared by

HNTB

June 25, 2019

Executive Summary

This project's purpose is to use proven TSM&O strategies and technologies to improve traffic flow and safety by using vehicle detection sensors, street flood warning sensors, smart lighting and wayfinding. The limits of the project are along Bay Street from the Jacksonville Region Transportation Center (JRTC) at Lee Street and A. P. Randolph Street intersection and Gator Bowl Boulevard from A. P. Randolph Street to East Duval Street. Neither Bay Street nor Gator Bowl Boulevard are on the state-highway system. The corridor intersects SR 23 (Acosta Bridge ramps), US 1/US 17 (Main Street) and SR 228 (Hart Bridge ramps).

The project is needed to address the mobility and infrastructure management needs within the corridor. The BayJax Innovation Corridor is the heart of downtown. Significant developments are currently proposed along the corridor and the corridor is the primary access to downtown and the Sports Complex during special events. This corridor is a prime candidate for the integration of TSM&O strategies and technologies considering the unique needs in this corridor. The BayJax Innovation Corridor is intended to be the initial "signature" project for mobility as part of the Smart Region Plan adopted in 2017 by the North Florida Transportation Planning Organization (North Florida TPO) and partner agencies.

The following components are proposed as part of the project.

- **Conversion to a Two-Way Road -** Micro-resurfacing, signing, pavement markings and signalization changes to convert the sections of Bay Street from one-way to two-way.
- **Public Broadband Network -** Wireless communications infrastructure to be provided by the private sector through a license agreement allowing use for public sector applications.
- **Integrated Data Exchange -** Foundational activity for the sharing of information for all internet-of-things devices and stakeholders
- **Smart and Connected Signals -** Connected vehicle technologies to improve travel times, reliability and safety for vehicles and pedestrians within the corridor.
- **Pedestrian Sensors -** Identify pedestrians crossing at the mid-block to provide enhanced lighting at night and to notify drivers through connected vehicle technologies
- **Street Flood Notification System -** Identifies locations where street flooding is eminent or occurring to route travelers around this safety hazard.
- **Solar Path -** Use of solar panels to generate the power needed for the smart technology in the corridor.
- **Public Safety and Surveillance -** Surveillance and detection of safety conditions within the corridor.
- **Wayfinding and Event Management -** Provide applications, on-street kiosks and in-vehicle information for travelers to optimize their route and minimize congestion.
- **Smart Lighting -** Use of sensors and LED to optimize power consumption and improve safety.
- **Smart Waste Management** - Use smart trash cans to optimize resources for the handling and removing waste in the street environment.

The costs to deploy the full vision of this project (excluding the integrated data exchange and broadband wireless) is anticipated to be $20.8 million. A life-cycle cost analysis was performed for the project and although the benefits for some of the strategies are difficult to estimate and were not included, a positive benefit-cost ratio of 1.85 was estimated supporting the justification for the project.

A phased-approach is proposed. The first phase of the project will include deployment of public broadband network, smart and connected signals, pedestrian sensors, street flood notifications, solar path, public safety, wayfinding and event management and smart lighting on a more limited deployment (locations and complexity) than the project as fully envisioned. It is estimated to cost $0.8 million in construction. Funding is currently programmed in fiscal year 2019-2020.

Opportunities to leverage other ongoing deployments should be explored. Examples include flood warning, environmental sensors and connected signals.

Next steps for the implementation were identified and include: developing a formal memorandum of understanding, systems engineering, establishing policies and procurement strategies, hiring of a systems management, integration with the Smart North Florida Integrated Data Exchange and performing before-after studies to refine the approach over time.

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Acronyms

AV	Autonomous Vehicles
CV	Connected Vehicles
FDOT	Florida Department of Transportation
LED	Light Emitting Diode
North Florida TPO	North Florida Transportation Planning Organization
HPS	High Pressure Sodium
IDE	Integrated Data Exchange
IoT	Internet of Things
ITS	Intelligent Transportation Systems
JRTC	Jacksonville Region Transportation Center
JTA	Jacksonville Transportation Authority
RSU	Roadside Units
TPO	Transportation Planning Organization, as in the North Florida TPO
TSM&O	Transportation Systems Management and Operations
TTS	Traffic Technology Services
U^2C	Ultimate Urban Circulator
V2I	Vehicles to Infrastructure, Vehicle Communication Platform for Cooperative ITS
V2X	Vehicles to other devices (X), Vehicle Communication Platform for Cooperative ITS

The BayJax Innovation Corridor

Purpose

This project's purpose is to use proven Transportation Systems Management and Operations (TSM&O) strategies and technologies to improve traffic flow and safety by using vehicle detection sensors, street flood warning sensors, smart lighting and wayfinding.

The BayJax Innovation Corridor is a three-mile business, residential and entertainment segment of Bay Street in the heart of downtown Jacksonville, Florida. The vision is to create a new main street through downtown connecting the Jacksonville Regional Transportation Center (JRTC) at the west end, through the central business district to TIAA Bank Field and entertainment district at the east end.

The BayJax will serve as a test bed for selected Smart North Florida strategies and technologies. This corridor will include projects that improve mobility, safety, access to opportunities and the quality of life for residents, employees and visitors. Key projects are in the planning stages and additional expertise will help identify best practices and early lessons learned to refine plans before implementation.

Limits

Bay Street from the Jacksonville Region Transportation Center (JRTC) being constructed by the Jacksonville Transportation Authority (JTA) to the Bay Street intersection with A. P. Randolph Street, where the name changes to Gator Bowl Boulevard, and Gator Bowl Boulevard from A. P. Randolph Street to East Duval Street. Neither Bay Street nor Gator Bowl Boulevard are on the state-highway system and managed by the Florida Department of Transportation (FDOT). The corridor intersects SR 23 (Acosta Bridge ramps), US 1/US 17 (Main Street) and SR 228 (Hart Bridge ramps). The limits are shown on **Figure 1.**

Need

This project is needed to create an innovation corridor where new technologies and strategies for smart communities within the region can be tested. The corridor was selected because of its urban location, the different operating conditions within the corridor (one-way, two-way and reversible lanes), the need for smart and connected signals, wayfinding and event management, smart lighting and pedestrian sensors to manage mobility during recurring traffic and special events, street flooding, the availability of an existing path to convert to a solar path for testing, crime and homelessness in the area creating a need for enhanced public safety. With its downtown location it can be a showcase for these technologies and how the technologies can be integrated with new development for technology-savvy consumers.

Downtown Jacksonville is the central business district with major corporate offices. It is also the hub for regional sport stadiums, arts centers, the convention center and hotels. City of Jacksonville (CoJ) government and other government agencies are clustered in this urban core, as well as many social service agencies. Condominiums and apartments provide homes for over 8,000 residents. Currently, there are more than $3.5 billion in projects under construction or proposed. The largest of these projects is a new $2.5 billion development near the sports complex to bring a new convention center, new hotels, commercial and residential high rises. This project is critical to connecting this project to the rest of downtown and the surrounding area to make our city more efficient, responsive and technologically prepared for our growing needs.

Context within the Smart Region Plan

The Bay Street Innovation Corridor is intended to be the initial "signature" project for mobility as part of the Smart Region Plan adopted in 2017 by the North Florida Transportation Planning Organization (North Florida TPO) and partner agencies. The vision of the Smart Region is shown in **Figure 2.**

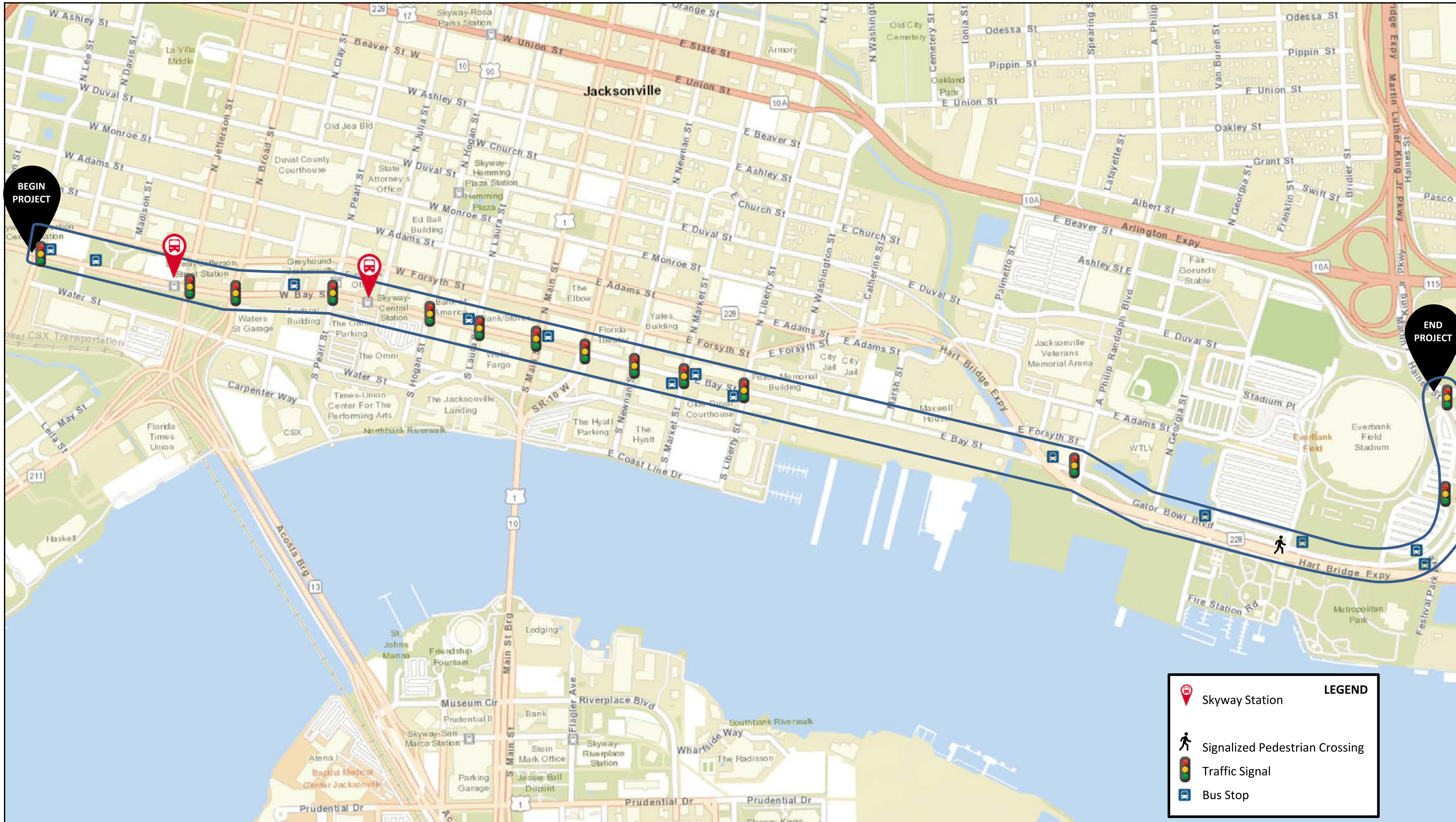
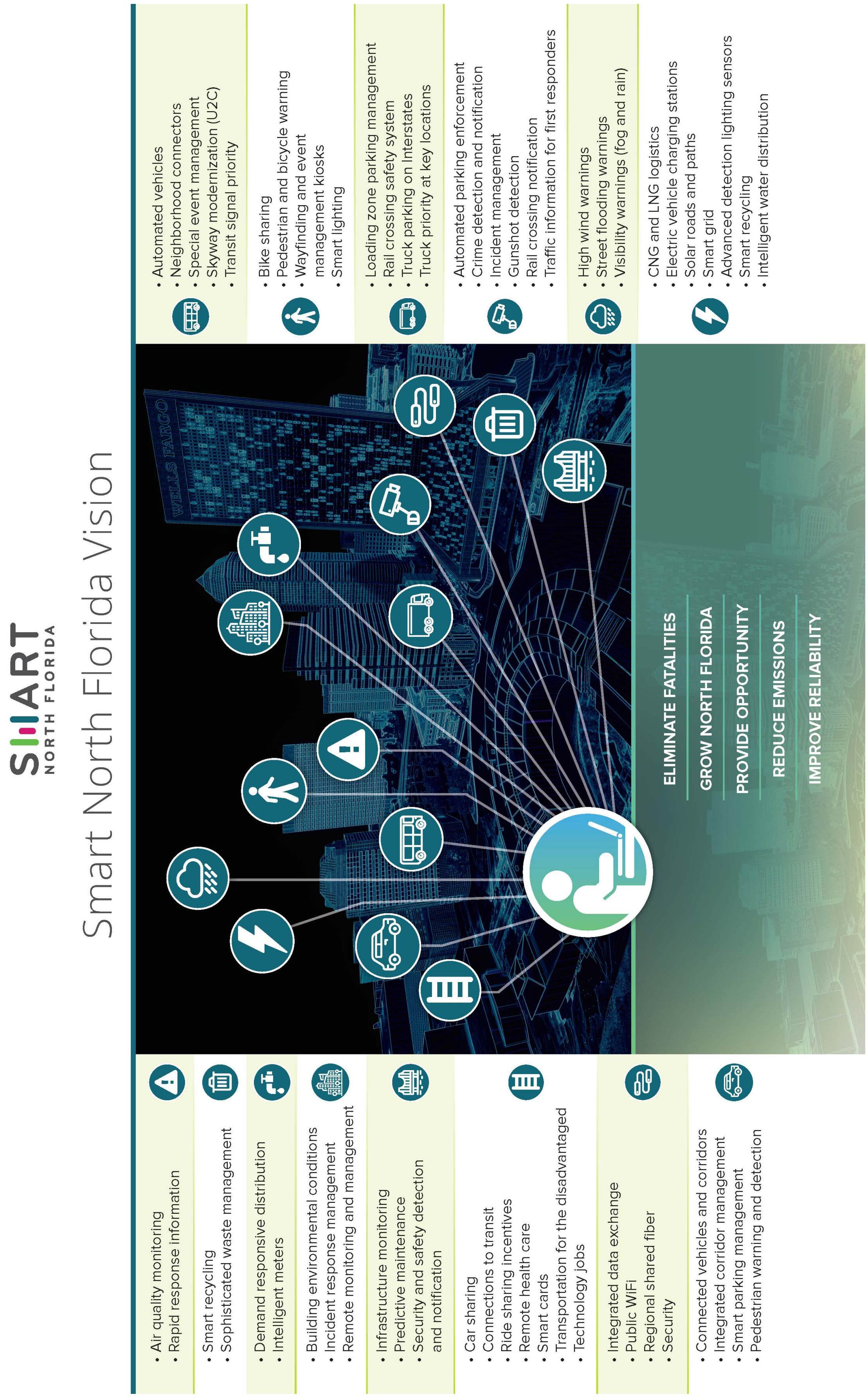


Figure 1 - TheBayJax Corridor Map

0 0.05 0.1 0.2 0.3 0.4 Miles

Document Path: J:\Kennedy\Bay Street\GIS\Bay_Overall.mxd

Figure 2 - Smart Region Vision



The Innovation Corridor rendering below shows several of the mobility, public safety and electrification strategies in the Smart Region Vision are proposed. Each icon shown in the rendering is explained in the Smart Region Vision in **Figure 2.**

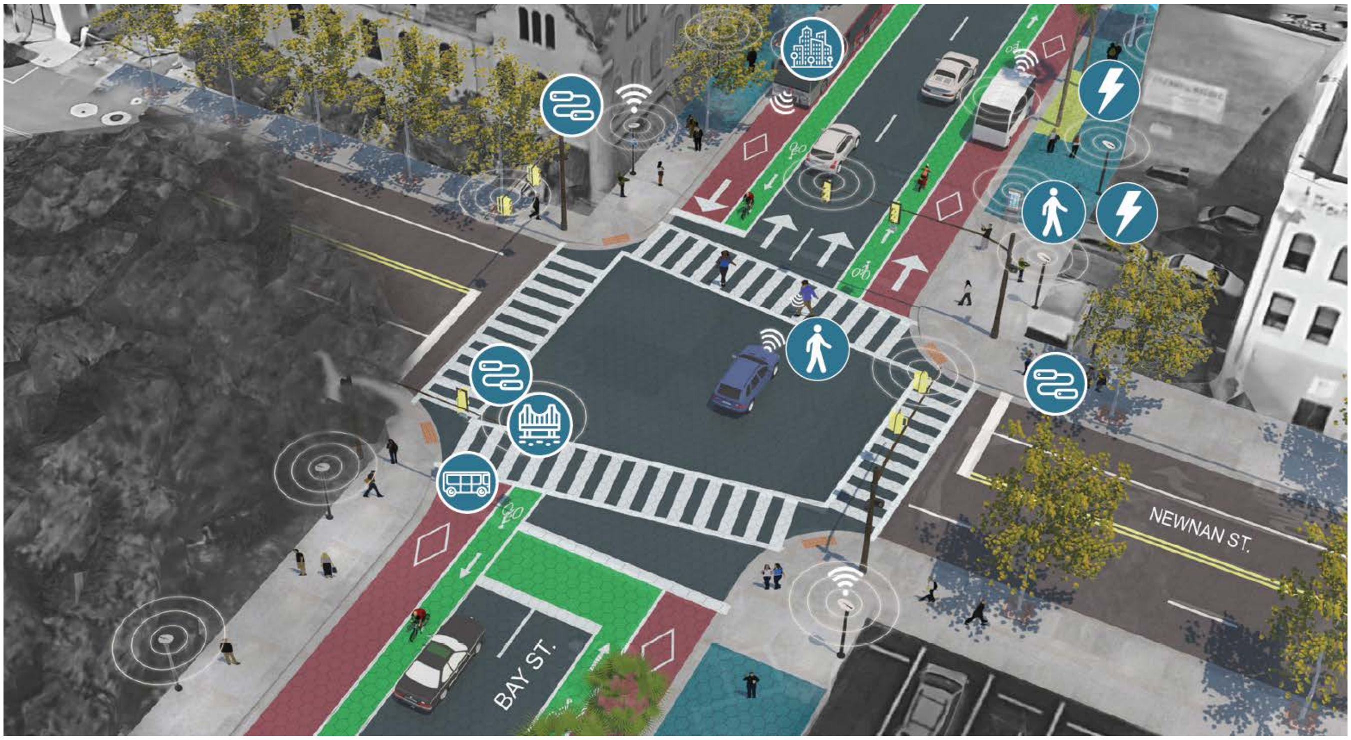


Figure 3 - Rendering of a Typical Intersection along The Bay Street Innovation Corridor

Context within the JTA's Ultimate Urban Circulator (U^2C)

The Jacksonville Transportation Authority (JTA) is proposing to develop the nation's first transit network to be implemented in the country using Autonomous Vehicles (AV) shuttles along Bay Street in Downtown Jacksonville from the JRTC to Daily's Place on Gator Bowl Boulevard. The Ultimate Urban Circulator (U^2C) autonomous transportation network will utilize and leverage multiple existing federal investments, including the elevated Automated Skyway Express (Skyway) infrastructure and street level roads through the urban core.

The downtown Jacksonville network may ultimately connect the JRTC to the Baptist Medical Center complex, UF (University of Florida) Health teaching hospital and Veterans Administration Outpatient Clinic. This will expand access to health care by allowing residents to use public transportation to reach these health centers that would not otherwise be accessible. The future network will connect the downtown business district to adjacent residential and retail zones allowing for less use of personal vehicles now required for even short trips in downtown Jacksonville. Beyond downtown Jacksonville. The final configuration of Bay Street as a standalone deployment or with the U^2C is to be determined.

This project will equip Bay Street with advanced, connected communication technology, safety sensors, and other smart features that can support the AV shuttles, economic development opportunities and connectivity for people along this revitalizing corridor.

The analysis in this report assumes the technologies needed beyond those shown to support the AV shuttle functions will be quantified, defined and estimated separately since this project has a standalone utility.

Roles and Responsibilities

The project will require support and involvement from multiple agencies. The following agencies will lead each element:

Broadband Wireless for Internet of Things (IoT) and Public Use..JEA

Integrated Data Exchange... North Florida TPO

Smart and Connected Signals .... FDOT / JTA / CoJ

Ultimate Urban Circulator (U^2C) ....JTA

Public Safety and Surveillance System..Jacksonville Sheriff's Office (JSO)

Pedestrian and Bicycle Sensors...FDOT / CoJ

Solar Paths ....JEA

Wayfinding and Event Management .... CoJ/ Downtown Investment Authority (DIA)

Smart Lighting..CoJ/DIA

Smart Waste Management..CoJ/DIA

Street Flood Notification System .... CoJ/ DIA/ FDOT

Basis of Cost Estimates

Cost estimates were prepared using unit prices paid by the Florida Department of Transportation (FDOT) on recent deployments. Where recent project prices were not available within FDOT (such as solar paths), research was performed by contacting other agencies and manufacturers.

The proposed development will consist of the elements shown in **Table 1**. These costs are not mutually exclusive. For example, the costs for smart signals includes the costs for conversion of several of the signals from one-way to two-way operations.

Basis of Benefits Analysis

The economic impacts of crashes were analyzed based on the recommendation in the FDOT's Design Manual.[1] The values are summarized below:

- Fatality $10,560,000
- Severe Injury $599,040
- Moderate Injury $162,240
- Minor Injury $100,800
- Property Damage Only $7,600

The travel time savings benefits were estimated at $13 per vehicle per hour and $0.55 per vehicle-mile. Energy costs were estimated at $111.66 per 1,000 kilo-watt hour. Other benefits were estimated using the Federal Highway Administration estimates. Where the benefits could not be estimated directly, the benefit-cost ratio from peer studies were used.

[1] http://www.fdot.gov/roadway/fdm/current/2018FDM122VarExcept.pdf

Table 1 - Summary of Proposed Deployment

Element	Costs	O&M/year	What is It?	How it Will Support the U2C
Conversion from One-way to Two-way	$918,000	$0	Micro-resurfacing, signing, pavement markings and signalization changes to convert the sections of Bay Street from one-way to two-way	Enhance accessibility and improve route efficiency
Broadband Wireless	$0	$0	Wireless communications infrastructure to be provided by the private sector through a license agreement allowing use for public sector applications	Provide the communications platform needed for IoT and U^2C V2X communications
Integrated Data Exchange (IDE)	$2,500,000	$150,000	Foundational activity for the sharing of information for all IoT devices and stakeholders	Provide information from multiple stakeholders to enhance the quality of service provided by the U^2C
Connected Signals	$400,000	$4,800	Connected vehicle technologies to improve travel times, reliability and safety for vehicles and pedestrians within the corridor	Improve travel times, reliability and safety
Pedestrian Sensors	$136,500	$1,700	Identify pedestrians crossing at the mid-block to provide enhanced lighting at night and to notify drivers through connected vehicle technologies	Improve safety for use of AV
Street Flood Warnings	$43,538	$255	Identifies locations where street flooding is eminent or occurring to route travelers around this safety hazard	Information to avoid unsafe conditions.
Solar Path	$9,240,000	($120,218)	Use of solar panels to generate the power needed for the smart technology in the corridor	Reduce the cost of operations through using green technology
Public Safety Street Surveillance	$282,294	$282,000	Surveillance and detection of safety conditions within the corridor	Enhanced safety and security
Wayfinding and Event Management	$720,000	$9,600	Provide applications, on-street kiosks and in-vehicle information for travelers to optimize their route and minimize congestion	Improved efficiencies, demand prediction and responsiveness.
Smart Lighting	$628,125	($20,321)	Use of sensors and LED to optimize power consumption and improve safety	Improve safety
Smart Street Waste Management	$49,300	($16,433)	Use smart trash cans to optimize resources for the handling and removing waste in the street environment	Providing more attractive station areas to enhance quality of service
TOTAL	**$14,917,757**	**$291,383**		

Convert to Two-Way Operations

Proposed Deployment

Bay Street is operated today as a mix of one-way westbound (JRTC to Main Street), three/one-lane reversible lane system from (Main Street to Talleyrand Avenue) and two-way road (Talleyrand Avenue to East Duval Street). As part of this project, and consistent with other improvements proposed from Lafayette Street to Talleyrand Avenue, this project proposes to convert Bay Street to a two-way street west of Newnan Street.

No changes to the existing curb-line is proposed. Micro-resurfacing will be used to allow new pavement markings and signing. Traffic signals will be modified, or new mast arms constructed where needed and street signs will be modified.

Costs

The total costs to convert Bay Street to two-way operations includes several of the components of the overall Innovation Corridor concept. The strategies related to the micro-resurfacing, connected signals, connected signals and smart street lighting are all integral to the approach.

Benefits

Although no detailed analysis on the benefits of the conversion of the corridor to two-way operations are available, the benefits include:

- Increase property values and property taxes from creating a more development-friendly street environment and supporting new development
- Reduce the severity of crashes for vehicles, reduce pedestrian crashes and enhance the attractiveness for bicycle use.
- Operate more consistent with the typical average operating speeds of the U^2C

Creation of The Bay Innovation Corridor will involve smart city technologies in addition to conversion to a continuous two-way corridor.

As a two-way corridor an environment is generally considered to be friendlier to economic development as travel distances are reduced, access to storefronts is simplified and speeds are reduced. Slower speeds are also more attractive to bicyclists and may reduce the severity of crash.

Slowing the traffic and posting lower speed limits enhances the viability of Automated Vehicle (AVs) in mixed traffic environments since the speeds will more consistent with the recommend running speeds of AVs (25-30 mph).

Although the final configuration of the AV operations is still to be determined, the typical section identified above shows how the smart city and connected vehicle technologies could be integrated into a typical design.

Broadband Wireless

Proposed Deployment

The ubiquitous presence of smart phones and other smart devices demands high-speed and reliable broadband wireless to create a more attractive street environment and to support Connected Vehicle (CV) technologies.

The proposed approach for deploying broadband wireless communications within the corridor is to solicit private-sector providers the opportunity to provide the services in exchange for the shared-use of the broadband services for public-sector applications in the IoT ecosystem such as the wayfinding kiosks and street flood warning systems.

This model has been successful in other cities such as New York City, Kansas City and San Diego.

This deployment may be implemented with the proposed wayfinding kiosks or independently through shared-use of the street rights of way.

Costs

Since a public-private partnership is proposed for the deployment of broadband wireless, no implementation or operating costs were considered. A fiber optic network is in place within the corridor which will also reduce the costs of implementation.

Benefits

The benefits of the broadband wireless are difficult to quantify but there are significant benefits not only to travelers, but broadband wireless also provides economic benefits to communities and individuals

- A digital divide still occurs with a sizable portion of those with income in the lowest quintile having limited access to the internet. Providing a public access network will allow more people to apply to jobs which has proven to lead to better labor outcomes (higher wages). Unemployed workers with internet access were 4 percent more likely to be employed within one month.[2]
- Broadband empowers visitors to downtown to learn more about what is happening and available within the region. Local businesses have a greater opportunity to advertise to a targeted demographic.
- Enhanced data analytics are available to assess where visitors arrive from and to allow the region to target marketing for tourism in other regions.
- With “urban canyons” where cell phones may not be as reliable because of taller buildings interfering with signals, providing broadband enhances the quality of access.
- Many new CV technologies can use broadband to enhance positional accuracy and V2X communications.

[2] https://bozemanfiber.com/news/the-digital-divide-and-economic-benefits-of-broadband-access

Integrated Data Exchange

Proposed Deployment

Although not a highly-visible component, the deployment of an Integrated Data Exchange (IDE) is a fundamental building block in the Innovation Corridor. Without the development of a way for information to be shared and data analytics to be performed the implementation of the field equipment and operation of an AV system will not function to its full potential.

The initial conceptual North Florida Region IDE architecture is shown in **Figure 4**. A data-centered architecture featuring a repository capable of storing big data in various format, a data lake, is proposed. Components of the system are described below:

- **Source System:** Data from other data warehouses, managed document repositories, file shares, databases, and other cloud/external sources including social media and third-party can act as data source. The raw data from these sources can be in its native format including structured, semi-structured, and unstructured data. The raw data can flow into the data lake by either batch processing or real-time processing of streaming data through APIs.
- **Enterprise Data Lake**: The data from multiple source systems are stored in the data lake in its native format. Curation takes place through capturing metadata and lineage and making it available in the data catalog. Security policies and data quality are also applied. Business rules and dictionaries are applied on the data repository. Models and dictionaries are developed as necessary.
- **Data Analytics and Reporting:** Stakeholders and users can self-service their data and analytics needs. Users browse the data lake's data catalog to find and select available data to work with. Once data is provisioned, users can use the analytical tools of their choice to develop models and reports.
- **Consumption Zone:** Users can gain valuable information from the models and reports, which can be accessed through web browser, mobile web, apps, and other business user interfaces.

It is anticipated that this architecture will change over time as the design and requirements are refined.

An initial proof-of-concept of the IDE is planned for development in July 2019. This initial phase will focus on the collection of data for congestion, mobility and safety analytics to support the North Florida TPO's Congestion Management Process.

Costs

The implementation of this data portal is estimated to cost $2.5 million[3]. This estimate is based on the overall smart data portal for the City of Columbus system that will integrate data from 1,100 data sources and provide access portals to the public and private sector. This cost does not include the final design, operations or the outreach activities. While an initial implementation at a reduced cost can be done, to fully realize the potential benefits of the IDE, funding that includes a full implementation, outreach and operations needs to ultimately be identified.

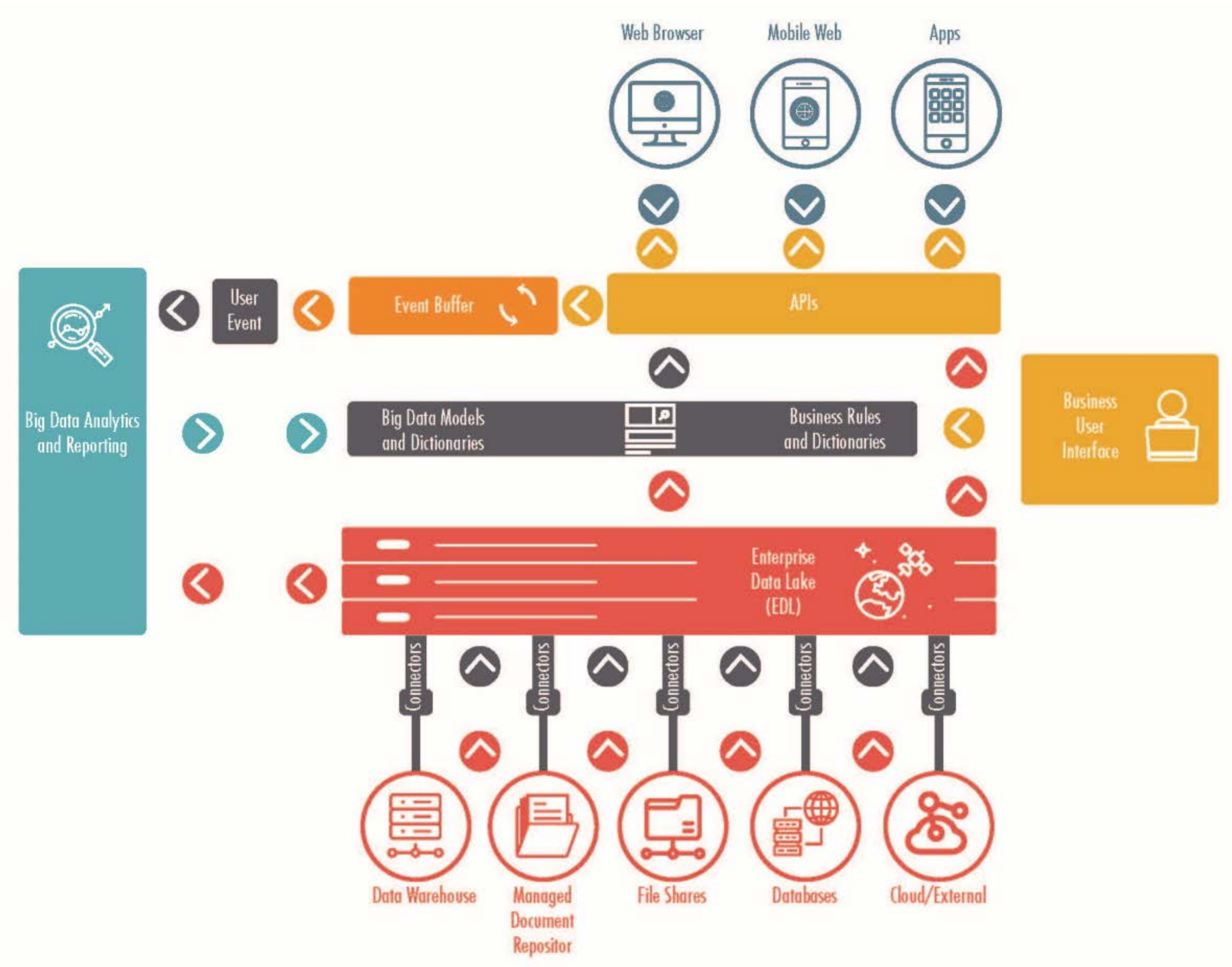
Benefits

It is difficult to quantify the benefits of an IDE, but the following are some of the benefits that may be achieved:

- Big data offers the potential for the city to obtain valuable insights from a considerable amount of data collected through various sources.
- The IDE proposes a data lake that will use heterogeneous data from water, energy, traffic and buildings to provide a common format for use of machine learning, semantic web, data mining and distributed system communities that can be leveraged by the public and private sector to create efficiencies and serve as a catalyst for innovation.

[3] http://www.dispatch.com/news/20180416/council-hires-local-firm-to-create-operating-system-for-smart-columbus-project.

Figure 4. Concept for North Florida Region IDE Architecture



Smart and Connected Signals

Proposed Deployment

Traffic signals cannot deliver the data they collect on phasing and timings, volumes, delays and queues to vehicles and other infrastructure if they are not connected. The signals communicate with each other and adapt to changing traffic conditions to reduce the amount of time that cars spend idling. Smart and connected signal technology monitors vehicle and makes changes in real time to avoid congestion wherever possible. The smart and connected signals application proposed for this project include the following elements:

- Video surveillance and detection of bicyclists and pedestrians at intersections to enhance safety.
- Deployment of Roadside Units (RSUs) to provide V2I communications for mobility, safety and reduce idle times through predictive light changes. Examples of these technologies include Traffic Technology Systems.
- Implementation of transit signal priority that will reduce delays and enhance the reliability of bus and AV operations within the corridor.
- JTA equips it BRT and other transit service vehicles with 3M Opticom devices reducing the costs for implementing new transit signal priority technologies.
- Smart signals can use Bluetooth™ data and video data collection to provide:
  - Schedule-driven intersection control to enhance the coordination of traffic signals.
  - Speed control by slowing or stopping speeding vehicles to create a more uniform traffic flow which is more efficient.

Costs

The costs for deploying smart and connected signals within this corridor will be minor compared to other corridors because the following infrastructure already exists within the corridor.

- A fiber optic backbone exists along Bay Street from Liberty Street and is connected to the City of Jacksonville signal interconnect system that provides coordinated traffic signals throughout downtown Jacksonville. This network is shown in **Figure 5.**
- Naztec 980 signal controllers exist within the corridor which can integrate the RSUs, video, pedestrian detection and transit signal priority applications. The signal cabinets have the capacity to accommodate additional control equipment.
- Mast arms are in place throughout the corridor which simplify the mounting, communication connections and wiring of the RSUs and cameras.
- The City of Jacksonville uses ATMS.NOW control software which can operate these new technologies.
- An agreement is currently being processed for the deployment of TTS Green Wave which provide for V2I communications to optimize vehicle travel times for vehicles with the software installed (e.g., Audi and Volkswagen).

Benefits

Pilot projects have shown connected signals reduce travel times by 40 percent. Vehicle maintenance and operations costs were also reduced by 25 percent.

No traffic studies are available now to fully quantify the benefits of deploying smart and connected signals.

HNTB

Figure 5 – Downtown Fiber Optic Network

N

0 0.05 0.1 0.2 0.3 0.4 Miles

Safety

Proposed Deployment

Within the corridor there were 413 vehicle crashes, four bicycle crashes and eight pedestrian crashes between May 2015 and May 2018. **Figure 6** summarizes the crashes by severity and type. The crash locations are shown on **Figure 7**. On Figure 7 the blue circles on the top panel show the vehicle crashes with the number of crashes by location and the bottom panel shows the number of bicycle and pedestrian crashes.

The technologies that will be deployed include:

- Bluetooth™ technologies to identify the location of buses and pedestrians along the corridor and provide notify drivers using time-activated warning signs and signal preemption.

- The ITS pedestrian detection devices will be placed at a mid-block traffic signal crossing Gator Bowl Boulevard near Lot J. The detection information will be used in conjunction with reduced minimum green time adjustments to improve pedestrian safety.

- To prevent bicycle and pedestrian crashes that occur at the mid-block where there are not designated crossings, infrared pedestrian detectors will be installed along the corridor and connected to smart lighting devices to intensify street lights when a pedestrian is making the mid-block crossing at night.

- A new mid-block pedestrian crossing signal will be installed at the unsignalized mid-block crossing near Market Street and Liberty Street for deployment of ITS pedestrian technologies if funding permits.

- Connected signal devices will be installed to identify bicyclists approaching intersections. Volunteers will be sought to participate in an intelligent bicycle demonstration where if there is a high-risk for a collision between the vehicle and cyclist is detected, cyclist will receive warnings on a device attached to the bicycle (display and the handlebars will vibrate).

Costs

The costs for deployment of these technologies are $136,500 for the mid-block crossings detection systems. The smart signal technologies include the software and hardware needed for the pedestrian safety technologies proposed. Demonstration of the intelligent bicycles technologies is anticipated to be provided by a vendor and the volunteer cyclists will install the devices.

Benefits

If only one pedestrian or bicyclist injury ($162,240) is avoided over the life-cycle cost of the project, the benefits of the project will exceed the costs of this deployment.

Pedestrian detection sensor (FLIR™) installed at the SR 13 and Haley Road Intersection in 2015.

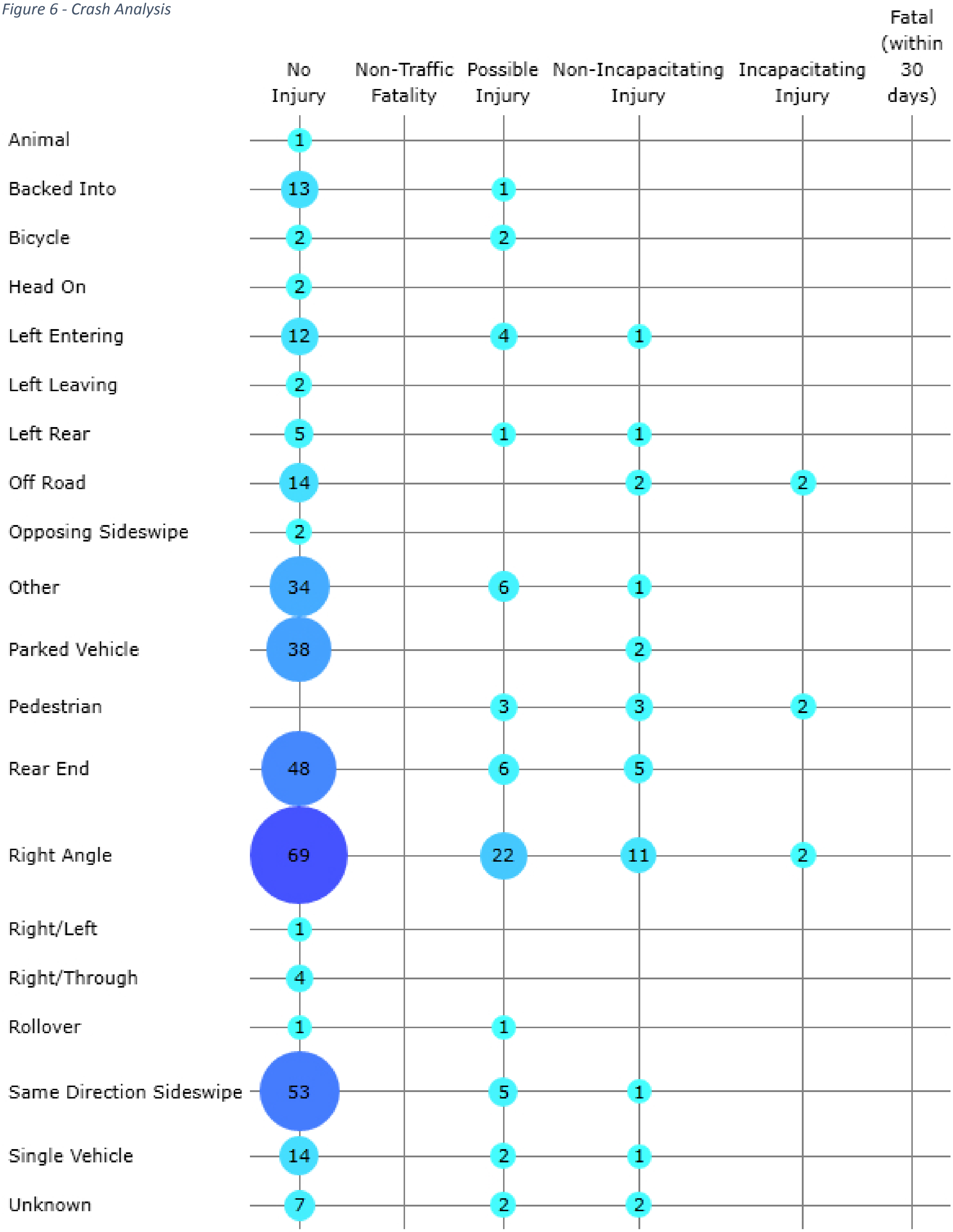
In 2015, FDOT District 2 installed smart pedestrian sensors at SR 13 and Haley Road in Jacksonville.

Two pedestrian crashes occurred at this intersection in 2013. The intersection is located near the Etz Cham Synagogue. The two pedestrians killed in these crashes were Orthodox Jews who attend this temple and cannot operate any electronic equipment during the Sabbath (Friday at dusk to Saturday at dusk).

Pedestrian detection sensors were installed to automatically activate the walk signal without having to press the crossing button and to increasing the pedestrian walk time when needed.

Since the pedestrian detection technologies were installed, no pedestrian-related crashes occurred at the intersection.

Figure 6 - Crash Analysis



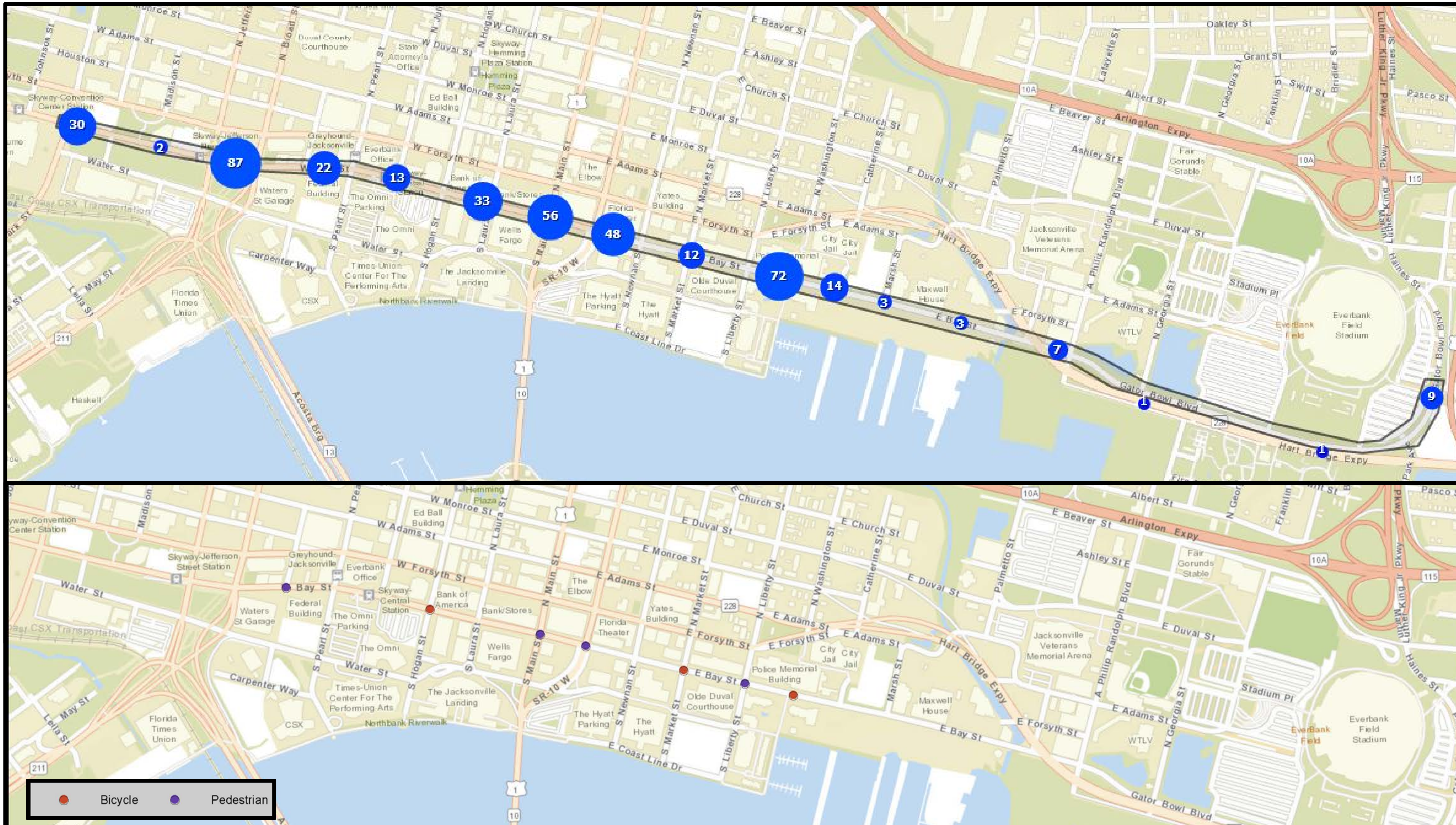


Figure 7 – Crash Locations

0 0.05 0.1 0.2 0.3 0.4 Miles

Flood Warning Sensors

Proposed Deployment

Flood warning sensors are commonly used to measure water levels at bridges and levees. There are a wide range of technologies available including ultrasonic, pressure detectors and radar. The devices can be installed as standalone weather information sensors or under a man-hole cover. The devices used today are Wi-Fi and a key component of the Internet of Things (IoT) ecosystem.

Other cities on the east coast are advancing these technologies and are using them specifically to monitor and predict street flooding.

The proposed deployment will occur at the four main outfall locations for the roadway storm drainage in downtown Jacksonville. When flood stages are approaching, the City of Jacksonville Traffic Management Center, Regional Traffic Management Center (FDOT, Florida Highway Patrol (FHP) and others) and the JTA's Transit Management Center will be notified.

FDOT with the City of Jacksonville, Florida of Highway Patrol, Jacksonville Sherriff's Office, NOAA and other key partners entered into an agreement that resulted in the installation of Road Weather Information Systems (RWIS) sensors at all 22 of the bridges over major waterways in North Florida and created standard operating procedures for bridge and road closures during inclement weather in 2013.

These RWIS sensors avoid the need for first responders to physically measure the wind conditions on each bridge during extreme storm events. Prior to the installation, important resources were diverted to the bridges and remained idle measuring wind conditions. Now those resources deployed where needed and are more effective.

The missing piece of the puzzle in safely managing mobility during these events is predicting street closures due to flooding. Installing sensors will allow the remote collection of this information that will be shared with the major stakeholders to prepare for and manage the diversion of traffic from these unsafe conditions.

Costs

The estimated costs for the installation of the flood warning sensors are $43,538.

Benefits

The benefits associated with these technologies include improving safety for the public, first responders and other stakeholders. The devices will also allow agencies to more effectively managing resources. No studies are available to quantify the benefits of this strategy.

Street flooding in downtown Jacksonville during Hurricane Matthew in September 2016 near the approach to the Main Street Bridge.

Flooding is occurring more frequently in downtown Jacksonville as from storm events and sea-level change. Street flooding is occurring during northeastern fronts during the winter, extreme high tides (king tides) and tropical storm events.

Maintenance of existing system of sensors that report the stage in the St. Johns River by the Jacksonville Marine Transportation Authority are unfunded and no warnings of when water levels will approach flood stages on roadways or the bridges that approach downtown are available.

One of the Road Weather Information System (RWIS) devices installed on all 22 bridges over waterways. The street flood warning sensors will be integrated to provide water stages and predict street flooding in downtown Jacksonville.

Solar Path

Proposed Deployment

Solar roads and paths collect solar energy using structurally-engineered solar panels that can be driven-upon, to be placed in parking lots and roadways in lieu of petroleum-based asphalt surfaces. Some manufactures also have embedded Light Emitting Diode (LED)s that "paint" the road lines from beneath to provide safer nighttime driving, as well as to give up to the minute instructions (via the road) to drivers (i.e. "detour ahead"). Test projects are occurring in 14 countries, Georgia, Idaho and Missouri in the U.S.

A new multi-use path will be constructed along Bay Street from Liberty Street to the Bay Street bridge over Hogan Creek to replace an existing sidewalk using solar panels.

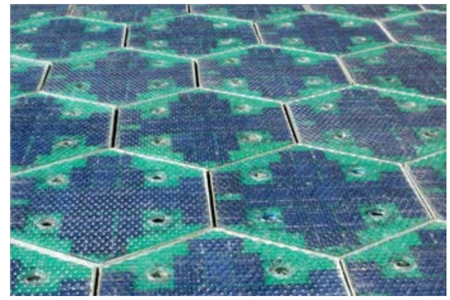
Other technologies may be explored on the path including photo-luminescing pavement markings that could glow at night.

Costs

The solar power panels proposed for this project are anticipated to cost $70 square foot for a total cost of $9.2 million.

Benefits

The proposed deployment will consist of placing 132,000 square feet of solar panels that are predicted to generate $120,218 worth of electricity. This power is anticipated to be sufficient to power the street lights, signals and other equipment within the corridor.



Source: Newsweek.com

The proposed solar path will allow the City of Jacksonville to assess the first use of solar road panels in Florida. These emerging technologies may generate sufficient energy to power the street lightings, signals and other equipment proposed in this project.

Solar road panels can also be installed with LED lights integral to the panel. This will allow for dynamic coloring of the panels and a future application could be to dynamically change lane assignments in a more demonstrable way that overhead "**X**" and "**🡅**" signals that are currently used on the reversible lane segments of this corridor.

Source: engineersgarage.com

Public Safety and Surveillance

Proposed Deployment

Technologies are available that can be installed as part of lighting or signal systems that notify law enforcement when gunshots are fired. These notifications will alert law enforcement officers before a phone call or other alerts are received. By being able to respond sooner to assess an incident and determine if rescue services are needed, there is potential to improve the survivability of the victims of violent crimes. The systems are also helpful to law enforcement when shots were fired at the scene.

Other sensors can be deployed in lighting or signal systems that detect various gasses or chemicals, which can be used to both detect these types of events and to track the spread of a gas, supporting law enforcement activities and evacuation efforts. This data could be conveyed to law enforcement and the traffic management center to support coordinated response efforts in the event of an incident.

The pan-tilt-zoom surveillance cameras proposed at each intersection can also be used to verify reported incidents and identify crimes that may occur within the street environment along Bay Street.

Crime is regularly reported as one the deterrents for people to work, live and play in Jacksonville's downtown.

Costs

The costs of deployment within this area are $282,000 for deployment and in each subsequent year. This cost is based on deployment at 10 locations on light poles within the corridor to cover the full linear length of the project. However, the actual range of the coverage will extend to cover much of downtown Jacksonville.

Benefits

Although difficult to quantify, the benefits experienced by JSO during the first phase of deployment include.[4]

- Expedited response to shooting victims
- Proactive gun crime pattern analysis
- Enhanced situational awareness
- Faster evidence collection and witness identification
- Court-admissible data
- Cost-effective force multiplier

ShotSpotter sensor with pan-tilt-zoom surveillance camera at an intersection in Washington, DC.

The Jacksonville Sherriff's Office recently deployed ShotSpotter sensors in a 5-square mile area in Northwest Jacksonville. This area represents 13.4 percent of firearm related murders and over 10 percent of the firearm related calls although it is about 0.67 percent of the city's land. In the first year of operations, 462 incidents were identified.

[4] http://www.coj.net/departments/sheriffs-office/docs/reports/sheriff-williams-shotspotter-presentation-web-(10.aspx

Wayfinding and Event Management

Proposed Deployment

The proposed deployment will provide roadside kiosks with information for travelers to optimize their route and minimize congestion, Wi-Fi, charging stations and emergency call buttons.

Costs

The estimated costs for deployment were based on 16 deployments assuming the initial phase may require 100 percent public investment. A public-private partnership will be pursued with this grant that will allow vendors to capture revenue through advertising and other sources. This component of the project was considered separate from the proposed broadband deployment based on their independent utility but implementing together may substantially reduce the costs for deployment and operations and maintenance.

Benefits

Although the benefits of this strategy are difficult to quantify, providing wayfinding and event management kiosks will leverage big data collection, collect new data for analytics and provide special event information for visitors.

LinkNYC's offers a mean download speed of 158.98 Mbps and a mean upload of 123.01 Mbps. This free network is faster by 74% and 165%, respectively, than New York City's average download and upload speeds over mobile Wi-Fi. New York's mobile Wi-Fi download and upload speeds for all networks combined are respectively 249% and 312% faster than those over cellular networks. That means LinkNYC users are seeing download speeds 511% faster than they would be if they were connecting on cellular networks. LinkNYC's mean upload speed was 996% faster than cellular.[5]

Other benefits are consistent with the proposed broadband network.

LinkNYC smart kiosks are very popular and provide high-speed broadband service. Over 1,700 kiosks are active and another 135 will be operational in 2018.

Smart kiosks provide information and serve as a platform for other IoT technology integration. These kiosks will result in significant public benefit and will brand Bay Street as an Innovation Corridor.

[5] https://www.speedtest.net/insights/blog/linknyc-2017/

Smart Lighting

Technologies

Each year, the city spends $11 million on electricity for street lights. The City of Jacksonville is in the process replacing street lights from High Pressure Sodium (HPS) bulbs and fixtures to LED bulbs and fixtures on it 113,000 street lights. The current rate of replacement is approximately 21,500 lights per year and the anticipated energy use reduction is approximately 50 percent over the life-span of the LED lights.

As part of this project, street lights will be converted to LED and connected vehicle systems and detectors to change light intensity based on the presence of pedestrians and vehicles.

In addition to the conversion to LED, the smart lighting system will include the installation of control unit and sensor(s) in each lamp pole or group of lamp poles, communication units and a management center application/system. These components are connected through a reliable and secured wired or wireless network that enables two-way communications - for monitoring and control functions. These sensors will provide data to enhance the predictive maintenance functions, reduce outages and save resources when maintaining the system.

Other IoT sensors could also be deployed based on vendor interests.

Costs

The estimated costs for the smart lighting installation is $628,000 for the corridor.

Benefits

In addition to the benefits associated with lower life-cycle costs from energy consumption, predictive maintenance and operating analytics, the improved visibility creates a safer environment for pedestrians and bicycles.

One innovative approach to be deployed in this project is when a pedestrian is identified as crossing in a mid-block, the lighting levels will be increased to be more consistent with the lighting standards at intersections where pedestrians are anticipated.

The ability to dynamically brighten and dim lights on demand could be a significant public safety resource for first responders, or to provide temporary lighting for special events such as One-Spark (Jacksonville's annual innovation and entrepreneur fair) or events in the Sports Complex.

The benefits associated with the reduced energy consumption and predictive analytics for maintenance and operations are estimated to result in a benefit-cost ratio of 4:1.

Source: https://www.illuminatingconcepts.com/intellistreets/

The deployment of smart lighting on this project will support the sustainability goals of the City of Jacksonville to reduce energy consumption.

The smart lighting sensors can improve safety and by interconnecting the light poles through Wi-fi, new opportunities for installation of IoT devices will be available.

In 2017, the City of Jacksonville withdrew from a GE pilot on smart lighting because of limited private sector partnerships and to focus on LED replacement. With this project we will create the critical mass of IoT demand needed to fully support smart lighting and the IoT ecosystem.

Smart street light installed in Jacksonville by GE as part of a pilot in 2015.

Smart Waste Management

Proposed Deployment

The perception of the safety and security of the street environment is highly influenced by its cleanliness. The proposed deployment includes using smart trash cans to optimize resources for the handling and removing waste in the street environment. The deployment will place smart trash cans at intersections and bus stops or stations.

Costs

The estimate costs for placing these smart trash cans are $49,300.

Benefits

In addition to proving a cleaner and more attractive street environment, the costs for maintaining the and removal of the trash collected is estimated to be $16,400 less than conventional systems.

Smart trash cans in New York and Pittsburg have contributed to a cleaner street environment at a lower cost than conventional waste collection.

Life-Cycle Cost Analysis

Costs

The following table summarizes the net present value of the proposed life-cycle costs for the deployment. A 10-year life cycle was assumed with a 4 percent price escalation (inflation) rate and 7 percent time-value of money (discount) rate. Preliminary Engineering or Design (PE) and Construction Engineering Inspection (CEI) were estimated at 8 percent of construction. PE will occur in 2019 and CEI and construction (CST) will occur in 2020. Operations and Maintenance (O&M) will occur in each subsequent year.

Table 2 - Life Cycle Cost Analysis

Year		Implementation (PDC)	Operations and Maintenance (PDC)	Total Life-Cycle Costs (YOE)	Total Life-Cycle Costs (NPV)
2019	PE	$1,432,105		$1,432,105	$1,432,105
2020	CST/CEI (1)	$19,333,412		$20,106,749	$18,791,354
2021	O&M		$291,382	$315,159	$529,776
2022	O&M		$291,382	$327,765	$505,409
2023	O&M		$291,382	$340,876	$482,347
2024	O&M		$291,382	$354,511	$460,513
2025	O&M		$291,382	$368,691	$439,835
2026	O&M		$291,382	$383,439	$420,245
2027	O&M		$291,382	$398,777	$401,679
2028	O&M		$291,382	$414,728	$384,077
2029	O&M		$291,382	$431,317	$367,383
	Total	**$20,765,517**	**$2,622,439**	**$24,874,116**	**$24,214,722**

CEI = construction engineering and inspection which is in addition to the costs in Table 1.

PDC = present day costs

YOE = year of expenditure

NPV = net present value

Benefits

No detailed engineering analysis of the benefits was performed and as noted many of the benefits of the deployment are difficult to quantify. **Table 3** and **Table 4** summarize the benefits analysis. These are the external economic benefits from the proposed project. The benefits from the solar path, smart lighting and smart waste management are quantified as reductions in the annual operating and maintenance costs.

The resulting benefit-cost ratio is 1.85 meaning the project is justified.

Table 3 - Benefits Evaluation

Deployment	Assumption	Annual Benefits
Conversion to two-way roadway	Based on peer studies (1.5:1)	$1,377,000
Smart and Connected Signals	Based on peer studies (7:1)	$2,800,000
Flood Warning	Provide a benefit: cost ratio of 1:1 which is equivalent to avoiding an average of 5.73 vehicles with property damage (minor crash)	$43,538
Pedestrian Sensors	Avoid on major injury per year	$162,240
Public Safety and Surveillance	Avoid on major injury per year	$162,240
	Subtotal	$4,545,018
Others Unable to Quantify	20 percent of the subtotal	$909,004
	TOTAL	**$5,454,022**

Table 4 – Summary of Benefits Analysis

Year	Benefits (PDC)	Benefits (YOE)	Benefits (NPV)
2019			
2020			
2021	$5,454,022	$5,899,070	$5,152,476
2022	$5,454,022	$6,135,033	$5,008,014
2023	$5,454,022	$6,380,434	$4,867,602
2024	$5,454,022	$6,635,651	$4,731,128
2025	$5,454,022	$6,901,077	$4,598,479
2026	$5,454,022	$7,177,120	$4,469,550
2027	$5,454,022	$7,464,205	$4,344,235
2028	$5,454,022	$7,762,773	$4,222,434
2029	$5,454,022	$8,073,284	$4,104,048
2030	$5,454,022	$8,396,216	$3,988,982
TOTAL	**$54,540,216**	**$70,824,863**	**$45,486,949**

Phased Implementation

Phase 1

A first phase of implementation is funded for an implementation cost of $1 million in Fiscal Year 2019/20 beginning July 1, 2019. With this approach the scale and complexity of the project was reduced but as many of the elements of the ultimate vision for the corridor were included. The first phase of the project will consist of:

- Smart and connected signals at 17 locations as summarized in **Table 5**
- Street flood warning sensors at four locations as summarized in **Table 6**
- Smart lighting from Liberty Street to Talleyrand Avenue as summarized in **Table 7**
- Wayfinding smart kiosks at six locations as summarized in **Table 8**

These locations are shown in **Figure 8**.

Concurrent with this implementation, the removal of the Hart Bridge Expressway ramp and associated construction along Bay Street is anticipated to occur through a BUILD Grant issued to the CoJ.

Phase 2

Phase 2 will include the deployment of the

- The initial phase of the U^2C from Hogan Street to Daily's Place (and the associated improvements along Bay Street)
- The phase 2 of the BayJax Innovation Corridor improvements.

The implementation of this phase is anticipated in the 2021-2022 timeframe.

Phase 3

Phase 3 of the project will include the deployment of the remaining elements of the U^2C and The BayJax Innovation Corridor.

Table 5 – Smart and Connected Signals

Bay Street Intersection with		Type	Vehicle Detection Systems	Pedestrian Detector	Transit Priority System
1	Park Street/Lee Street	Signal	3	2	1
2	Jefferson Street	Signal	3	1	1
3	Broad Street	Signal	3	1	1
4	Clay Street	Signal	2	2	1
5	Pearl Street	Signal	2	2	1
6	Julia Street	Signal	2	2	1
7	Hogan Street	Signal	2	2	1
8	Laura Street	Signal	3	2	1
9	Main Street	Signal	2	2	1
10	Ocean Street	Signal	3	2	1
11	Newnan Street	Signal	4	4	1
12	Midblock Pedestrian Crossing at Law Library	Unsignalized			
13	Market Street	Signal	4	2	1
14	Liberty Street	Signal	4	2	1
15	Catherine Street	Unsignalized			
16	Marsh Street	Unsignalized			
17	Lafayette Street	Unsignalized			
18	A. P. Randolph Street	Signal	3	2	1
19	North Georgia Street	Unsignalized			
20	Lot J Pedestrian Signal	Signal		2	1
21	Festival Park Drive	Unsignalized			
22	Talleyrand Avenue	Signal	3	2	
23	East Duval Street	Signal	3	2	
			46	**34**	**15**

Table 6 - Flood Warning Sensors

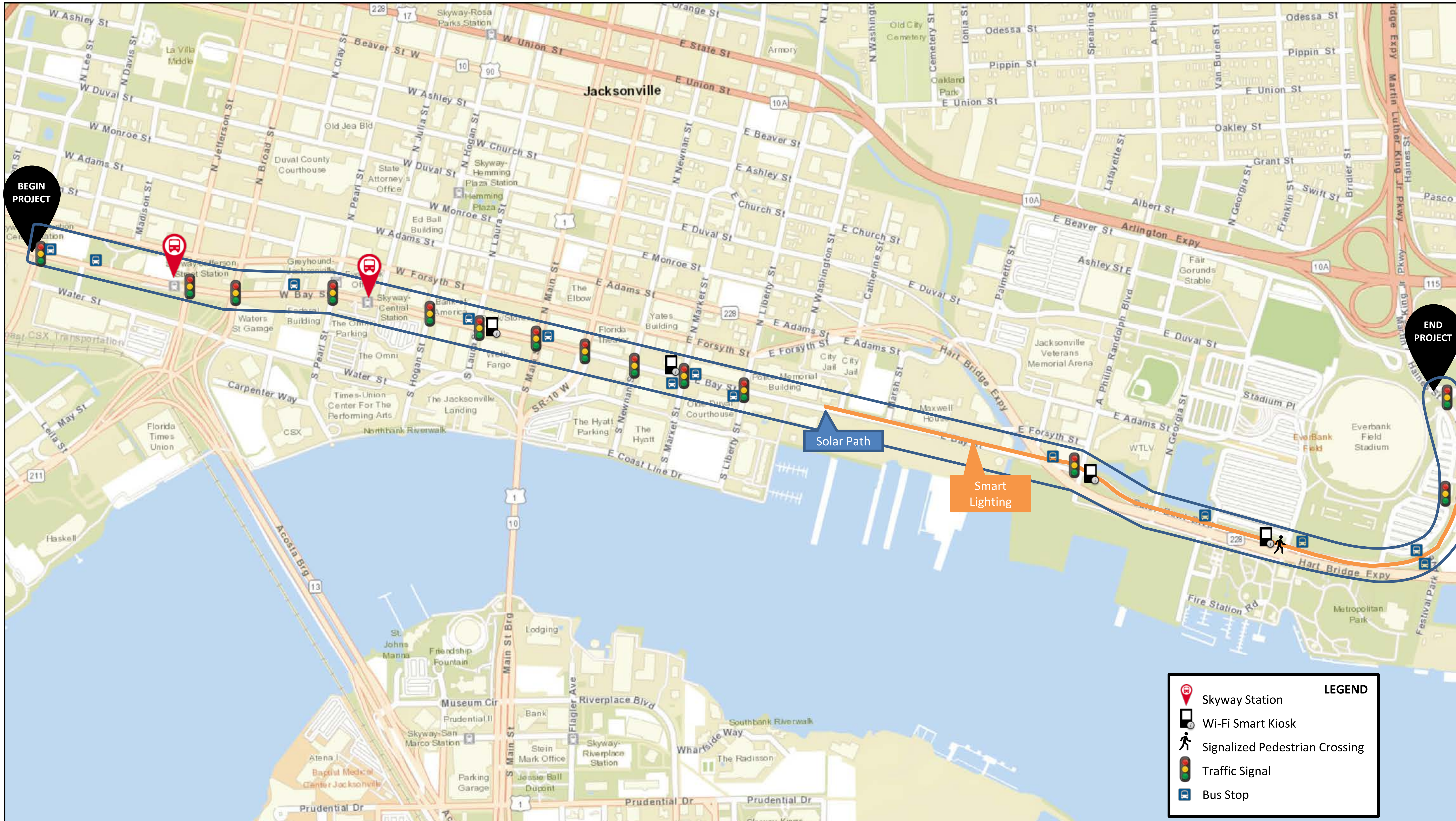
Locations		Sensors
1	Coastline Drive at Pearl Street	1
2	Coastline Drive at Newnan Street	1
3	Coastline Drive at Liberty Street	1
4	Bay Street Bridge over Hogan Creek	1
		4

Table 7 - Smart Lighting Locations

	Within each block beginning with the following intersection (north/east bound)	Poles
1	Liberty Street	22
2	Catherine Street	5
3	Marsh Street	20
4	Lafayette Street	5
5	A. P. Randolph Street	6
6	North Georgia Street	9
7	Lot J Pedestrian Signal	12
8	Festival Park Drive	4
9	Talleyrand Avenue	
	Total	**83**

Table 8 – Wayfinding and Broadband Smart Kiosk Locations

	Within each block beginning with the following intersection (north/east bound)	Kiosks
1	Laura Street	2
2	Market Street	2
3	A. P. Randolph Street	1
4	Lot J	1
	Total	**6**



HNTB

Figure 8 - TheBayJax Phase 1

Opportunities

Several opportunities to leverage active deployments within The BayJax Innovation Corridor include:

- Smart parking management to address the needs associated with the development of Lot J for special events in the sports complete. About 4,100 parking spaces will be lost with the development and alternate access is needed for the 12,000 people who will not be able to park. Smart parking applications were deployed in the City of St. Augustine and integrated into the regional IDE. Integration with the Jaguars ticketing app and City's tourism and parking apps are needed.

- Leverage FDOT's BlueTOAD RSU and TTS (Greenwave) deployments to implement connected signals and share information through the regional IDE.

- Leverage existing Internet of Things (IoT) deployments within the region by multiple agencies to accomplish the goals of The BayJax Innovation Corridor. Examples include:

    - Use real time flood stage sensor data that exist in the St. Johns River and data available from Federal Emergency Management Agency on flood zones and stages, hurricane stormwater models and National Pollutant Discharge Elimination Systems (NPDES) instead of installing new sensors.

    - Share waste management deployment sensor information with private sector to enhance the efficiency and efficacy of the waste management in downtown.

    - Integrate emissions data collected by the CoJ as part of the State Implementation Plan for air quality as a source of data to determine if traffic delays are changing (more delays, result in greater emissions).

Next Steps

The next steps recommended for the implementation of Phase 1 of The BayJax Innovation Corridor include:

1. Prepare a Memorandum of Understanding (MOU) that will establish governance and institutionalize roles and responsibilities. An initial draft of the leadership roles are provided in an earlier section of this report. A sample of a MOU developed for San Mateo's Smart Corridor program is provided in Appendix A.

2. Develop a formal concept of operations and systems engineering management plan using the Agile Systems Engineering Approach for Phase 1 of The BayJax Innovation Corridor to ensure the deployment is consistent with other deployments and establishes a baseline for future deployments to ensure interoperability. This effort is underway and is anticipated to be completed in FY 19/20 following the completion of the MOU. The concept of operations and systems engineering management plan are a requirement for use of federal funds in the deployments under FHWA Rule 940. This process will include the vetting and approval of the concept plans developed as part of this effort included in Appendix B.

3. Work with CoJ City Council to develop an Ordinance that will designate the corridor as an Innovation Corridor with streamlined procurement and selection procedures for vendors to allow public-private partnerships to test and evaluate new technologies within the corridor. A summary of the I-STREET Innovation Corridor deployment that is ongoing by UF, City of Gainesville and FDOT approach is provided in Appendix C.

4. Issue a request for proposals or assign internal staff to hire a systems manager who will be responsible for the integration and technical coordination of deployments within the corridor and ensure testing and acceptance plans are implemented. A copy of the scope of work from the FDOT's I-75 FRAME project that is ongoing in Alachua and Columbia County is provided in Appendix D.

5. Perform before-after technology assessments and leverage these demonstrations to deploy on a regional level as part the Smart North Florida initiative.

6. Using the agile systems engineering approach continue to refine, improve and update the technology, systems engineering, integration and data sharing of the deployments in The BayJax.