The Internet of Things Study

(UPWP Task No. 5.8)

June 21, 2019

Developed for:

North Florida TPO

Transportation Planning Organization

PLAN • FUND • MOBILIZE

Table of Contents

List of Figures

1. Introduction

1.1 Project Purpose

This study's purpose is to perform a review of Internet of Things (IoT) devices and provide a strategy to deploy IoT devices in North Florida based on the 2017 Smart Region plan and the data entered into the Integrated Data Exchange's (IDE), that has had its first phase deployed in 2019.

The IoT is the incorporation of sensors and communications into everyday devices and objects that creates a system of interlinked devices that communicate and transfer data over a network without human-to-human or human-to-computer interaction. These devices can be remotely monitored and controlled and provide data to multiple users for a variety of purposes.

2.1 Background

In 2017, the North Florida TPO completed a Smart Region Plan that included the identification of 33 strategies to advance the region in the areas of smart mobility and infrastructure to achieve the goals of enhanced safety, mobility, reduced greenhouse gas emissions, economic development and providing ladders of opportunity.

A smart region collects information from a wide variety of IoT technologies and merges data from multiple sources into one data management system. With a diverse and widespread dataset, in-depth analyses can be conducted, and new connections can be made that haven't previously been discovered within the region. A smart region brings with it a hotbed of activity surrounding emerging technologies that draw in tech startups and other businesses.

In 2018, the North Florida TPO completed the initial concept planning for a regional data management system called the Integrated Data Exchange (IDE), and it is a major component in enabling North Florida to become a Smart Region. The first phase of the IDE was deployed in 2019 with traffic data from the North Florida Transportaiton Planning Organization (TPO).

1.1.1 IDE Vision

The IDE is a platform at the heart of the North Florida Smart Region master plans. The IDE is a cloud-based open data platform for data repository and display, that integrates data and data services from multiple sources and tenants. It provides the ability for public and private entities to leverage data in innovative ways through performance metrics for program monitoring and evaluation; serving the needs of public agencies, researchers, and entrepreneurs; providing practical guidance and lessons learned to other potential deployment sites; and assisting health service providers, human service organizations and other agencies to provide more effective services to their clients.

The vision is for all the data from existing and future IoT devices to flow into the IDE. The IDE will service as both a data repository for historical analyses and gathering location to allow for data aggregation and connection from multiple sensors.

1.1.2 IoT Vision

The Smart Region plan identified the need for additional data sources to feed the IDE to enable new applications and analytics. One of the initial major IoT deployments as part of the Smart Region plan, the St. Augustine Smart Parking program, has deployed intelligent payment systems and parking sensors as well as a remote parking enforcement system that has allowed a new level of data analytics that the City is using to develop new parking policies. The TPO envisions adding IoT devices throughout the region to enhance transportation efficiencies and meet the overall objectives of the Smart Region program.

IoT devices are typically low-cost devices or low-cost add-ons to existing devices that can be easily deployed and integrated into a regional data exchange program. The TPOs vision is to identify a number of potential IoT technologies that can have an impact on the transportation system in North Florida.

1.1.3 Existing IoT Devices

To fully understand applicable IoT devices for North Florida, a review was performed of the existing available devices.

The City of Jacksonville maintains an existing network on environmental sensors to collect the following air quality and water quality information:

Air Quality

The Jacksonville metropolitan statistical area is classified as a maintenance area in accordance with national ambient air quality standards of the Clean Air Act. The ambient air monitoring program collects data and provides historic Air Quality Index data for the City of Jacksonville. There are currently eleven air quality monitoring stations strategically located throughout Duval County. The specific air pollutants currently monitored are: sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2) and particulate matter .

Water Distribution and Quality

To monitor the condition of Jacksonville's water supply, JEA, the mucipality owned power and water utility, maintains a network of sensors to monitor the water and wastewater networks. IoT devices include sensors for: well water level monitoring. pressure monitoring, flow monitoring, leak detection monitoring, and water quality monitoring. The water level sensors are used to monitor the Floridan aquifer and can identify, drought conditions and when to implement water use restrictions.The pipe sensors identify where flows are restricted because of leaking pipes which could contaminate groundwater. When flows are blocked it is necessary to activate lift stations to assist wastewater flow.

Groundwater Levels

The U.S. Army Corp of Engineers provides instantaneous, daily values and groundwater level data that can be used to monitor groundwater quality and levels.

Weather and Flood Warning Sensors

Several agencies maintain weather sensors or flood stage sensors that can be used to improve flood detection.

The FDOT maintains weather information stations on 22 bridges throughout North Florida. These sensors are used to monitor wind speed and precipitation. They were deployed through a partnership with the National Oceanic and Atmospheric Administration (NOAA). The data collected at the sensors are transmitted to NOAA's satellites and then shared with FDOT at the Regional Traffic Management Center.

NOAA has a network of weather information systems deployed throughout the region to monitor surface weather conditions. This network is also used by the University of North Florida for research.

The St. Johns River Water Management District maintains a network of river stage gauges and rainfall weather stations to monitor and improve stormwater and flood modeling and permits within the region. Their 2,000 monitoring stations throughout the district (which includes an area that extends south to Indian River County along the St. Johns River basin). The District also processes data from approximately 350 additional sites collected by county and municipal agencies through a mutual agreement or by the U.S. Geological Survey under contract to the district. More than 8 million measurements are collected, verified, processed and stored each year. This data is disseminated to district staff and are made available on this page.

Jacksonville Electric Authority (JEA) maintains about 40 weather information sensors to monitor rainfall and wind conditions.

The City of Jacksonville maintains sensors at each of their stormwater pump stations that can be used to monitor street flooding conditions.

2. IOT Devices Review

A review was conducted of existing IoT devices that are beneficial in the individual projects mentioned in the North Florida TPO's Smart Region Plan. The plan consists of over forty emerging technologies and individual projects that can be implemented over time as funding becomes available and as the technology matures.

The IoT investments that may provide some of the most benefits for the region and are recommended to install in the region are discussed in the following subsections and are as follows:

- Flood Sensors
- Bridge Strain Gauges
- Pavement Monitors
- Pedestrian and Bicycle Sensors
- Weather Sensors
- Emissions Sensors
- Smart Lighting Sensors

2.1 Flood Sensors

Flood sensors, also known as high water warning systems, give real-time readings of water level or provide an alarm when water is detected where none is typically present. This is particularly usefully in areas of North Florida prone to flooding, such as the City of St. Augustine and along the St. Johns River and the beaches (Atlantic Beach, Neptune Beach, Ponte Vedra Beach, etc.). Hurricanes over the past five years have caused significant flooding in these areas, washing out homes, businesses and roadways. In St. Augustine, high tides cause regular flooding resulting in property damage.

Flood sensors deployed in these areas can provide advanced warning of imminent flooding as the water level starts to rise. These warnings can be sent to the Regional Transportation Management Center (RTMC) via wireless or fiber network. Initally, a RTMC operator can analyze the data and predict when a flood condition is imminent. With further development , the analytics could be done automatically with little to no RTMC operator interaction. Once the flood conditions are validated, residents can be altered to the danger and appropriate responses using warning messages posted to Florida 511 or data sent to resident's mobile application to provide a visual map of flooded areas. Drivers and first responders can be notified of alternitve routes via mobile alerts, digital message signs (DMS).

Figure 1: Senix ToughSonic® Level and Distance Sensor

2.1.1 Data Generated from Flood Sensors

Flood sensors are often placed in outfall pipes or key drainage structures and would relay the water presence and/or water height information directly to the IDE through wireless or fiber communication. This information can be provided both in real time and stored historically at specified time interval for later analysis.

2.1.2 Current Potential Flood Sensor Deployment Sites

There are no flooding sensors current deployed in North Florida. Potential areas flood prone areas that may include the sensors are the following:

- Black Creek in Clay County
- McCoys Creek in Duval County
- Jacksonville Beaches in Duval County

- San Marco in Duval County
- Fernandina Beach in Nassau County
- St. Augustine in St. Johns County

2.1.3 Estimate of Cost

Flood monitoring systems average around $25,000 per location and $150,000 one time expense to configure the RTMC to display and monitor the information. Operations and maintenance costs average around $5,000.00 per year. The addition of devices to existing networks are much cheaper.

With the extent of the existing network sensors in the region, opportunities for integration of existing devices from multiple agencies into the IDE may be sufficient to meet the needs for the region. Additional analysis and agency coordination is needed.

2.2 Weather Sensors

Weather sensors and weather stations provide a plethora of data including but not limited to precipitation, relative humidity, barometric pressure, temperature, wind speed and direction and solar radiation. Companies can offer these sensors to measure individual elements or combine elements into one sensor.

Precipitation data can be used in determining roadway conditions such as the pavement being wet or dry and for flash flooding. Fog/visibility sensors can collect data and notify the appropriate parties of dangerous conditions. Cloud/ceiling data is needed in aviation. This data gives cloud heights, which is important for airports to use for determining flying conditions. If clouds are too low, certain planes cannot fly without proper instrumentation.

Wind data is important in identifying dangerous driving conditions. Wind sensors help verify severe thunderstorm warnings and special marine warnings if the sensors are located near the water. If winds are higher than 50 MPH, damage may occur, and powerlines may be down.

When there is high wind speed bridges need to be closed. Wind sensors work by utilizing a set threshold. When the wind speed exceeds the threshold, messages are sent to the RTMC to verify and closure, and alternate route messages are pushed to DMSs and cellular devices.

High span bridges in the area currently have wind sensors installed in 2015, but the data is not accurate enough to use for severe thunderstorm verification or for closure decisions during evacuations. During the Hurricane Irma evacuations, the Operations Section of the Duval Emergency Operation Center relied on alternate weather systems to determine this information. The sighting of the bridge sensors at an appropriate altitude is important, so turbulent flow from vehicles on the bridge does not give false readings. Flagler County, part of the River to Sea TPO, is having conversations with the National Weather Service about placing a sensor on the Palm Coast bridge at an altitude that doesn’t have turbulent flow issues. Even better are locations far enough away from the road surface along the approaches to get a realistic measurement of surface winds and then adjust for the altitude of the bridge based on an average adjustment. Many of these measurements would be best along the oceanfront, since many areas near the bridges in North Florida have trees that would cause measurement issues. Oceanfront sitings would also help during northeasters and tropical systems.

2.2.1 Data Generated from Weather Sensors

The weather sensors and weather stations can produce wind, precipitation, visibility, cloud/ceiling data and other weather data. These sensors would be placed in critical areas where dangerous conditions could cause harm and need to be properly sighted to ensure data accuracy and quality. This data will be both stored historically and used in real time at the RTMC for decision making. The data from existing sites should be collected and stored centrally to permit better decision making and save on investment cost of the different agencies in North Florida.

2.2.2 Current and Potential Weather Sensor Deployment Sites

There are a number of weather sensors implemented by different agencies across North Florida including: FDOT, St. Johns River Water Management District, City of Jacksonville, JEA and NOAA. However, there is currently a large data gap in wind reports and severe weather from Lake City to Duval County. There are no observations for weather coming into Duval County from the west (Baker County) and northwest (Nassau County). I-10 and US 301 are in this coverage area and have unknown roadway conditions during weather events due to lack of data.

Potential areas for data collection include:

- Baker County, Macclenny, I-10 / US 90
- Baker County, Sanderson, I-10 / US 90
- Duval County, Big Talbot Island, A1A/Nassau Sound Bridge Approach
- Nassau County, Fernandina Beach, Ocean Blvd, Main Beach
- Nassau County, Fernandina Beach, A1A/Eagen's Creek Park (Alternative to Main Beach)
- Nassau County, Hilliard, US 1
- Nassau County, Bryceville, US 301
- Putnam County, Bostwick, US 17 at Palmetto Bluff Road
- St. Johns County, Summerhaven, SR A1A
- St. Johns County, St. Augustine, Vilano Boat Ramp/A1A/Vilano Causeway
- St. Johns County, S. Ponte Vedra Bch, A1A/S. Ponte Vedra Bch Rec
- St. Johns County, Guana, SR A1A/Six Mile Landing Boat Ramp
- St. Johns County, Mickler's Landing, Micklers Road
- St. Johns County, World Golf Village, International Golf Parkway and SR 16

2.2.3 Weather Sensors Estimate of Cost

The cost of an IoT weather sensor/station can range between $5,000 and $20,000. Traditional RWIS deployment ranges between $75,000-$125,000 depending on the configuration and location of deployment.[1] Thousands of RWIS stations were deployed in the mid-1900s, but only hundreds are functional. IoT sensors can provide a much lower-cost and scalable fixed observation solution, allowing for a denser fixed station network and better observational coverage.

Figure 2: Davis Vantage Pro2 Sensor Suite

2.3 Bridge Strain Gauges

North Florida has over twenty-two bridges, and significant resources are needed to maintain and repair each of these bridges. The addition of sensors to measure the strain of the bridges can help gather real-time information on bridge fatigue and failure points directing maintenance and prolonging life.

A strain gauge measures the amount of deformation experienced by the structureThis deformation, or strain, can be axial, bending, shear and torsional, but most strain gauge configurations measure axial and bending strain.[2] Alternatively, there are also camera technologies available that can record the amplitude of motion and deflection of a bridge. The frequency, type and amount of strain can be used to evaluate fatigue, or weakness in the bridge structure.

---

[1] https://fathym.com/2018/09/moving-on-from-rwis-the-next-generation-of-fixed-roadway-weather-observations/

[2] http://www.ni.com/en-us/innovations/white-papers/07/measuring-strain-with-strain-gages.html

Information reported from the strain gauges can detect potential bridge failures before they occur and allow for a precise preventative maintenance plan. In the event of a vessel or vehicular collision with the bridge, the strain information can be used in determine the extent of the damage and what is needed in the bridge repair. Advanced notice of potential bridge failures can give authorities enough time to safely close the bridge and reroute traffic.

There are also camera technologies available that can record the amplitude of motion and deflection of a bridge.

2.3.1 Data Generated from Bridge Strain Gauges

Each bridge would contain many strain gauges located a key points to measure the deflections across the structure. For each sensor the axial and bending strain data would be sent to the IDE and stored over time to provide historical data. This historical data would allow for alerts when movement is outside historical limits or to support data analytics for fatigue failures. Data analytics supported by the data would be crucial in determining the failure point of the bridges and in activating a warning system that disseminates information to the appropriate parties. If the strain surpasses set thresholds, the authorities and RTMC would be notified with recommended actions. Decision makers can plan long-term for maintenance and bridge construction. They can also act quickly in a failure emergency.

Figure 3: HBM Strain Gauge

2.3.2 Current and Potential Strain Gauge Deployment Sites

There are no bridge sensors current deployed in North Florida. There are a number of bridges that would have higher priority to have sensors installed. These include:

Major bridges over the St. Johns River (Mathews Bridge, Acosta Bridge, Hart Bridge, Main Street Bridge,Fuller Warren Bridge,Dames Point Bridge and Henry H. Buckman Bridge) and the Bridge of Lions in St. Augustine over San Sebastian Inlet

- Overpasses that are regularly struck by trucks to monitor their condition during collisions (overpass of I-95 at US 1 MLK Expressway).
- The most traveled bridges that are structurally significant in the region. The year the bridge was built is also listed[3]:

Duval County

- I-95 northbound and southbound over Nassau River, 1967
- SR 115 (Lem Turner Road) over the Trout River, 1957
- I-10 westbound over the CSX R/R, 1961

St. Johns County

- US 1 over Oyster Creek, 1958

2.3.3 Bridge Strain Gauges Estimate of Cost

Depending on the type of gauge purchased, a fully instrumented bridge cost $50,000 for the sensors with $250,000 for software and data storage. Some manufacturers also give a discount depending on the number of devices purchased.If implementated on the 22 bridges in North Florida, operations and ongoing analytics would cost $100,000.

2.4 Pavement Monitors

Currently, monitoring the condition of the pavement requires specialized vehicles with dedicated staff. This can be a lengthly and costly process with only infrequent testing across the state. Better systems will permit more frequent testing and testing on more of our roadways across the region. Better understanding of road conditions permit better planning and spending of limited maintenance budgets. Currently pavement condition monitoring is done via pavement condition surveys[4]. IoT cameras installed on regular county and city fleet vehicles enables machine learning based pavement monitoring, permiting greater testing with less resources.

Currently, the Florida Department of Transportation (FDOT) collects data consistent with FHWA requirements for the Highway Performance Monitoring System each year on the entire state highway system. The data is collected using customized vehicles fitted with multiple sensors to measure cracking, patching, raveling, rutting and ride. Each vehicle can only collect data on one lane at a time. They drive the right lane for a multilane road. The vehicle must travel each roadway twice.FDOT

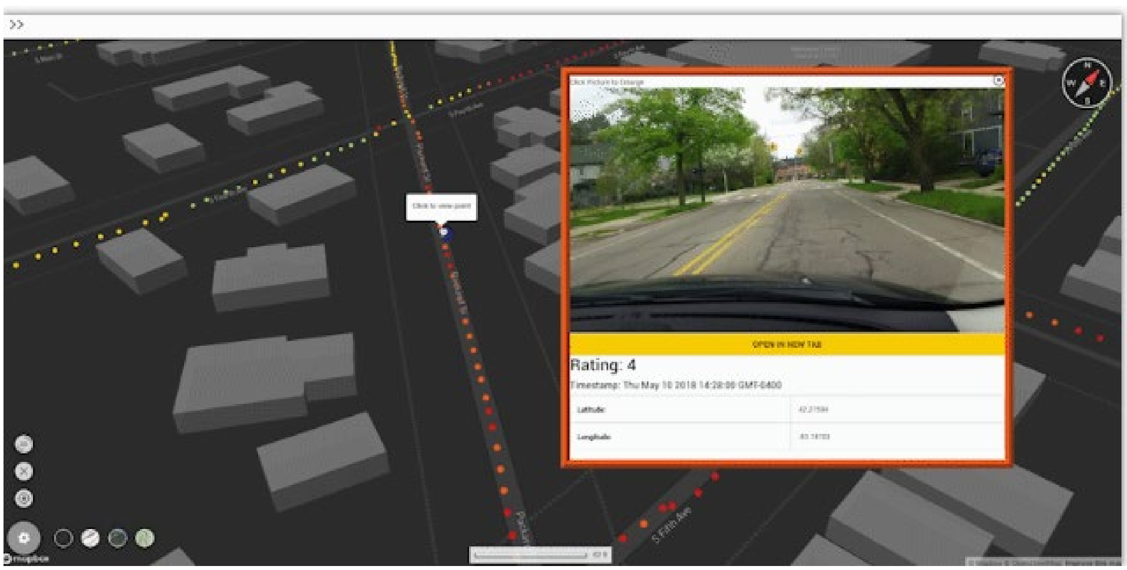
[3] https://artbabridgereport.org/state/profile/FL. Data from the Federal Highway Administration (FHWA) National Bridge Inventory (NBI), released March 15, 2019

[4] https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/content/materials/administration/resources/library/publications/researchreports/pavement/flexiblehandbook.pdf?sfvrsn=3735e826_0

maintains several vehicles which are driven on state-routes each year. Manual (objective) assessments are also made manually by an operator in the vehicle.

Using IoT cameras mounted on vehicles and machine learning algorithms can be used to identify important information about pavement condition. The software can analyze pixel color differences and patterns taken from the images. Typically, 1080p resolution once every 10-ft to identify alligator cracking, pavement edge wear and pot hole locations. The images are geocoded and provided in a cloud-based interactive mapping format. The video can capture all lanes within the image. If it is a two-lane road, only one pass is needed. If the roadway is divided, then the video may need to be collected in both directions. Several companies including Roadbotics (US), ROMDAS (Australia) and other companies have developed the technology to collect and analyze this data for condition monitoring.

Figure 4: Roadbotics Wed Based Application



2.4.1 Data Generated from Pavement Monitors

The cameras and data analytics from an automated condition monitoring system will be location indexed high resolution images and a road condition rating created using the machine vision algorithms. This data can then be mapped using a third party tool or in the IDE for trending on monitoring. The data can be sent wirelessly in real-time or polled on a daily basis.

2.4.2 Current and Potential Pavement Monitor Deployment Strategy

Currently FDOT provides testing for state and federal highways throughout the state and region using dedicated data collection vehicles.

Using video surveys, an in pilot project with a dedicated vehicle would permit better selection of roadways for direct comparison to current methods. From this intial testing usibility and an optimal testing frequency can be developed. Ultimately, the system can be deployed on existing fleet vehicles potentially including, trash collection, city and county maintence vehicles or city buses. These would permit testing on all the regions roadways beyond where current testing is currently being performed.

2.4.3 Pavement Monitors Estimate of Cost

Current data collection vehicles costs about $1 million to equip and for the two operators are required in each vehicle during the condition assessment. These costs are prohibitive for municipal and county governments.

With video surveys, the costs of data processing are about $100 per mile and vary based on the size (centerline miles) of the data being processed. With the potential high frequencies permitted by using fleet vehicles, only a subset of the data could be stored but only analyzed at a longer frequency to save on collection cost.

A pilot project is planned for 2019 that will inventory the City of St. Augustine’s street (approximately 70 miles) and 100 miles in Clay County. The estimated cost for the pilot project is $35,000.

2.5 Pedestrian and Bicycle Sensors

The Jacksonville metropolitan region was ranked the third worst region in the nation for pedestrian safety according to Smart Growth America and the National Complete Streets Coalition (2014) and the worst city in the nation for fatalities per pedestrian commuters and fatalities per bicycle commuters by the Bike Walk Alliance.

FDOT and local agencies include bicycle and pedestrian safety as a primary consideration in the design of highways and streets. However, there are limitations to the extent that infrastructure design alone can prevent bicycle and pedestrian crashes. Educational efforts haven’t eliminated crashes, so sensors are becoming more widely used that will assist bicyclists, pedestrians and drivers in better identifying conflicts and reduce crashes.

Sensors can be used to increase pedestrian walk times and even shorten walk times if the pedestrian has already traversed the intersection. Ultimately, this data can be integrated with DSRC V2I radios to broadcast alerts to vehicles. These same sensors could used to provide pedestrian and bicycle counts for analysis and planning.

Multiple types of pedestrian sensors are available ranging from infrared to thermal or video imaging. Sensors for bicyclists are even more readily available, such inductive loops and magnetometers, since they can detect a bicyclist more easily than a pedestrian. However, both thermal and video imaging sensors can detect both bicyclist and pedestrians.

2.5.1 Data Generated from Pedestrian and Bicycle Sensors

Due to the need to provide real time response to pedestrians and bicycles, the processing for for the sensors will be done locally in the sensor. Potential data that could be stored historically include, the raw video or thermal data, activation events and durations, video from unsafe vehicle movements and pedestrian and bicycle counts.

The historical sensor data can be used in signal timing plans or real time data integrated with congestion and traffic data to dynamically optimize the pedestrian and signal timing based on need. Drivers would receive the pedestrian data to be more alert and also adjust their speed based on the signal timing to achieve better travel times to their destination.

2.5.2 Current and Potential Pedestrian and Bicycle Sensor Deployment

Sensors should be installed at intersections with high pedestrian traffic including:

- St. Augustine near the Old City along SR A1A (Avenida Menendez)
- US 90 State and Union Street in downtown Jacksonville near the Rosa Parks transit station
- SR A1A (3^{rd} Street) in Jacksonville, Neptune and Atlantic Beach from SR 202 J. Turner Butler Boulevard to SR 10 Atlantic Boulevard

2.5.3 Pedestrian and Bicycle Sensors Estimate of Cost

The approximate cost for the pedestrian sensor and visual pedestrian alert is $10,000 per signal.

2.6 Emissions Sensors

One of the five main objectives of the North Florida Smart Region Plan is to reduce greenhouse gas emissions. This involves providing multi-modal options and reducing congestion. To achieve this goal, emissions metrics are needed as a baseline and to create an appropriate mitigation plan. Traditionally, estimating the carbon emissions of a city can be difficult and makes it challenging to set realistic goals for emission reduction. Emissions sensors are used to gather air quality data. Combining the sensor data with analytical tools can help a city better understand and improve their air quality and carbon emissions.

Areas with high emissions readings can have a plan of action developed such as making other modes of transportation more accessible. Data from emission sensors can also be used as a metric to determine if a transportation plan is having the desired result. For example, emissions sensors may be used around the City of St. Augustine to determine if the City's smart parking goal of reducing trips is met. The City wants to reduce excess vehicle circulation by directing vehicles to available parking instead of the vehicle driver searching for parking aimlessly. This results in less trips and would be shown by less emissions.

Ultimately, the data may be used to educate the public, so that they may do things differently to reduce emissions and limit their exposure to harmful pollutants.

2.6.1 Data Generated by Emissions Sensors

Emissions sensors could be integrated near or at intersections in traffic controller cabinets and even placed on mobile units such as city vehicles. The sensors would send information wirelessly to the IDE.SCarbon Dioxide (CO2), sulfur dioxide (SO2), carbon monoxide (CO), ozone (O3), nitrogen dioxide (NO2) and particulate matter data may be analyzed to determine hot spots for emissions and to understand how emissions are changing throughout the day. The data can also be combined with weather data, traffic data, construction and other air quality data within the IDE to get an understanding of factors that influence the air quality and predict emissions under certain conditions and future emissions.

2.6.2 Current and Potential Emissions Sensor Deployment Sites

There are eleven exisiting air quality monitoring stations throughout Duval County. The existing locations do not detect carbon dioxide and have limited deployment. Potenial new deployements could be included in new projects to test for effectiveness of emissions reductions measures including smart parking, electric vehicles or reduced idling of vehicles. Additionally, sensors can be placed near major emissions generating locations including I95, I10, transit hubs and industries to test for air quality of nearby residents. City and regional officials could use this emissions data to allocate funding to areas with high emissions and would take appropriate measures to ensure the welfare of the public.

2.6.3 Emissions Sensors Estimate of Cost

Emissions sensors may cost upwards of $6,000 depending on the particulates and gases to be measured.

Figure 5: Digi-Key T6615 Carbon Dioxide Sensor

2.7 Smart Lighting Sensors

Smart Street Lighting Systems provide connectivity of street lights to either a cloud or centralized server to allow monitoring and remote configuration or control of individual street lights. These systems allow agencies to turn on/off, or dim lights during certain conditions. These settings may be controlled remotely or activated by local sensors. This ability provides agencies an opportunity to minimize energy usage and provide custom functionality. The majority of these systems are easily integrated into existing infrastructure by connecting devices into the standard socket on top of the fixtures.

Light polls provide excellent platforms for other sensors integrated with the smart lights. Many vendors provide integrated systems including sensors to detect pedestrian or vehicle presence and illuminate the roadway or sidewalk on demand. When combined with connectivity these street lights can coordinate to illuminate the roadway in advance of an oncoming vehicle or pedestrian/bicycle. Broadband Wi-Fi can be included in systems to provide public internet coverage for outdoor areas.The street light can also serve as a hub for communicating additional sensor information to a centralized server through fiber or wireless communication. Sensors include video, radar, lidar, Bluetooth beacons, and environmental sensors. Possible applications from these sensors include parking monitoring, congestion identification, vehicle classification and counts, crash and near miss information, origin-destination information, and user warning systems. The applications are nearly endless. A connected network of street lights provides an opportunity for cities monitor and react to different events.

Smart lighting systems today are marketed as a turn-key solution to provide connectivity to street lights allowing remote configuration and monitoring of LED equipped street lights. It is unclear whether the installation of third-party devices such as video cameras, Bluetooth devices, radars, and other sensors will be able to leverage the mesh communication platform of these proprietary installations. The use of a separate network switch for fiber connected locations, or wi-fi/cellular communications may be required to connect additional sensors to a centralized cloud or server system.

Considerations must be made for regulations that limit the number and size of devices installed on street lights.

2.7.1 Data Generated by Smart Lighting Sensors

The basic physical infrastructure already exists to outfit street lights sensors and connect the information to a network. The amount of type of data generated by smart lighting systems depends on the amount of type of sensors attached as part of the platform. The lights themselves can send maintenance information, brightness, events, as well as electricity availability and usage.

2.7.2 Current and Potential Smart Light Deployment Sites

The potential to leverage street lights for additional sensor monitoring provides a platform for numerous use-cases. Each sensor combination will have different deployment strategies. Due to the ability to install smart lights on exisiting light infrastructure, smart lights can be installed as part of normal replacement maintenance. Integrated system deplyement should be done in areas where the smart lights could work in combination with other smart systems. These include: Bay Street in Jacksonville, Spanish Quarter in St. Augustine and at Jackonville Beach.

2.7.3 Smart Lighting Sensors Estimate of Cost

Smart street lighting can cost around $1,200 but can cost more depending the number of integrated systems. This does not include the installation, operations or maintenance costs.

3. Conclusion

IoT devices allow for communication and interaction between other devices, mechanical and digital machines, objects, animals or people without outside interaction. These devices are crucial to providing data in the IDE. With a diverse and widespread dataset, in-depth analyses can be conducted, and new connections can be made that haven't previously been discovered within the region. This will lead to improvements in improving safety, mobility and reliability.

Additional devices can be added to current agency programs that are underway for quick implementation into the IDE. Additional devices would be ideal in the City of Jacksonville's air monitoring program, and additional wind and flood sensors could be added to support NOAA's, FDOT's, JEA's, City of Jacksonville and the St. Johns Water Management District's programs.

All the devices discussed would have a quick implementation timeline from one to three years. The funding available to deploy these devices would help determine which of the devices are deployed first. Smaller areas such as the City of St. Augustine or Bay Street could be used as a pilot for many of these sensors, and the system could expand as more funding becomes available.

4. Appendix