# Phase 2 Comprehensive Installation Plan (CIP)

## Georgia Department of Transportation: ITS4US Deployment Project

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**Final Report — August 26, 2024**

ITS4US

IT'S TRANSPORTATION FOR ALL OF US

U.S. Department of Transportation

Produced by the Georgia Department of Transportation (GDOT)
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Intelligent Transportation Systems Joint Program Office
Federal Highway Administration
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Federal Transit Administration

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**16. Abstract**

The Georgia Department of Transportation ITS4US Deployment project, Safe Trips in a Connected Transportation Network (ST-CTN), is leveraging innovative solutions, existing deployments, and collaboration to make a positive impact using transportation technology to support safety, mobility, sustainability, and accessibility. The ST-CTN concept is comprised of an integrated set of advanced transportation technology solutions (connected vehicle, transit signal priority, machine learning, predictive analytics) to support safe and complete trips, with a focus on accessibility for those with disabilities, older adults, and those with limited English proficiency.

The Comprehensive Installation Plan (CIP) provides a high-level overview of the installation approach and schedule necessary to install equipment for the ST-CTN project. The CIP will be a living record of the ST-CTN project installation process for the purpose of transparent reporting to project sponsors and stakeholders about the methods and status of these installation efforts.

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# 1 Introduction

The Georgia Department of Transportation (GDOT) and Atlanta Regional Commission's (ARC) Safe Trips in a Connected Transportation Network (ST-CTN) project was selected by the U.S. Department of Transportation (USDOT) as a part of the ITS4US Deployment Program. The project seeks to enhance the traveler's complete trip travel experience by enhancing mobility, accessibility, reliability, and safety for system users, particularly for underserved communities, including people with disabilities, older adults, and users with limited English proficiency (LEP). This is done by leveraging innovative solutions, existing deployments, and team collaboration such as integrating connected vehicle (CV) data with an open-source software-based trip planner that is used to provision web-based and mobile application user access. The trip planner will provide users with the ability to create a personalized trip plan with information regarding the navigation of physical infrastructure, the ability to resolve unexpected obstacles, and ensure users' visibility throughout the trip. The proposed deployment will provide targeted users with the ability to dynamically plan and navigate trips based on their specific needs and preferences.

## 1.1 Intended Audience

The intended audience for this document is the USDOT, the project team which includes the GDOT, the Atlanta Regional Commission (ARC), its consultants and partners. This document may be used as a reference for the future selected vendor team, including their systems and software support, installation team, and others supporting the success of this project deployment. In addition, it is expected that other agencies or industry professionals interested in deploying a project of similar nature may reference this document to understand how the acquisition methods and processes were completed for the ST-CTN project deployment.

## 1.2 Project Background

### 1.2.1 USDOT'S ITS4US Deployment Program

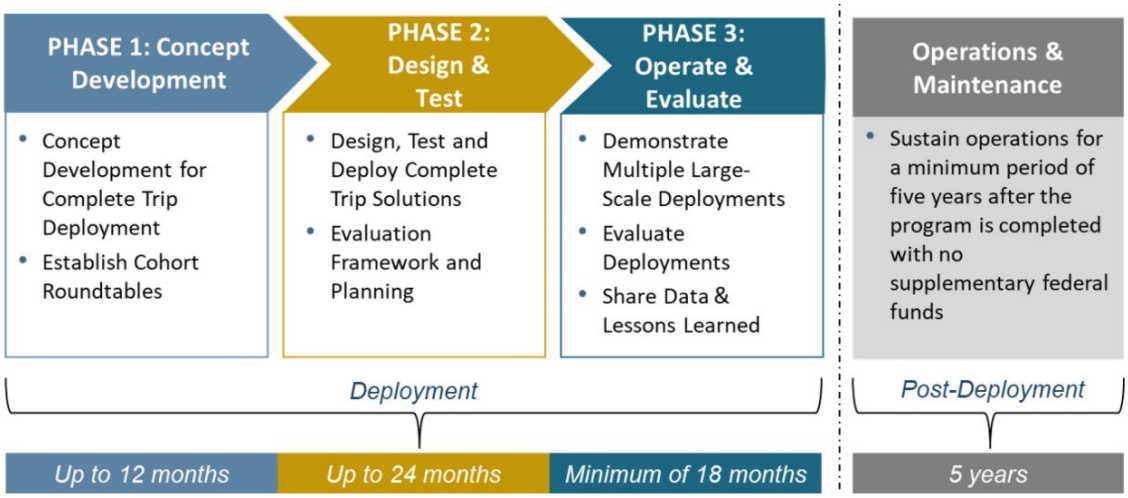
The USDOT's ITS4US Deployment Program seeks to identify ways to provide more efficient, affordable, and accessible transportation options for underserved communities that often face greater challenges in accessing essential services. The program aims to solve mobility challenges for all travelers with a specific focus on underserved communities, including people with disabilities, older adults, low-income individuals, rural residents, veterans, and limited English proficiency travelers. The program will enable communities to build local partnerships, develop and deploy integrated and replicable mobility solutions to achieve complete trips for all travelers.

The vision for the program is to foster an innovative and integrated complete trip deployment to support seamless travel for all users across all modes, regardless of location, income, or disability. The goals of USDOT's ITS4US Deployment Program are to:

- Spur high-impact integrated Complete Trip deployments nationwide

- Identify needs and challenges by population
- Develop and deploy mobility solutions that meet user needs
- Measure impact of integrated deployments
- Identify replicable solutions and disseminate lessons learned

The ITS4US Deployment Program will be executed in three phases. As depicted in **Figure 1**, deployment sites are expected to go through a Concept Development Phase (Phase 1), followed by a Design and Test Phase (Phase 2), and then an Operate and Evaluate Phase (Phase 3). Post deployment, sites are expected to sustain operations for a minimum period of five years without supplementary federal funds. Phase 1 has been completed and Phase 2 is underway.

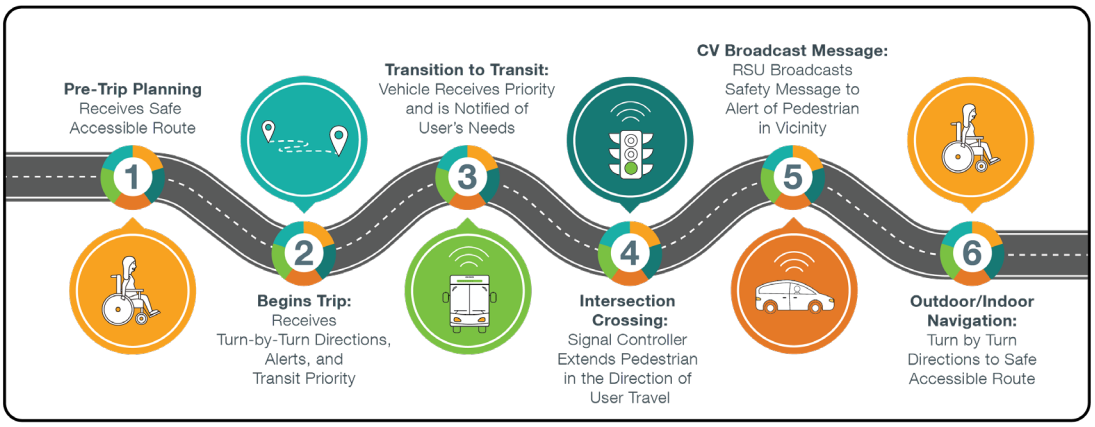



*Source: USDOT, 2021*

**Figure 1. Phases of the ITS4US Deployment Program**

## 1.2.2 Project Scope

The ST-CTN project aims to upgrade and integrate existing technologies and services to assist underserved populations with completing their complete trip successfully, safely, and reliably. The vision of the project is to provide users complete trip functionality with directions, conditions, and status on the links between trip legs that are personalized based on the user's profile, while connecting the user to CV infrastructure to provide safer trips and more transportation network awareness. As an illustration of how the ST-CTN system will be used, transit-based trips were delineated into six segments (as depicted in **Figure 2**) to allow for easier understanding and a greater breakdown of priorities and goals.




*Source: ARC, 2020*

**Figure 2. Traveler's Complete Trip**

The delineated trip segments include the following steps and project components:

- **Step 1 Pre-Trip Planning.** The traveler plans for and receives a safe accessible route.
  - The ability to customize trip preferences based on the user's abilities.
- **Step 2 Begins Trip.** The traveler begins their trip and receives turn by turn directions, alerts, remote pedestrian activation, and can trigger transit signal priority (TSP) if the user requires additional time boarding or alighting a transit vehicle, is unable to stand for long periods, or is sensitive to weather conditions.
  - Turn by turn, shortest path, directions along pathways that meet user defined preferences.
  - Provides support services for users if they become disoriented or have issues accessing defined paths.
  - Activates TSP for buses if the user requires additional time boarding or alighting a transit vehicle, is unable to stand for long periods, or is sensitive to weather conditions.
- **Step 3 Transition to Transit.** The traveler transitions to transit and the transit vehicle receives priority and is notified of users' needs. TSP can be triggered if the bus is running behind schedule due to a longer boarding time needed by a user.
  - Provides users with transit trips that have accommodations that meet user defined preferences.
  - Sends alerts to transit vehicles when users need additional time to board, navigate internally, or alight the transit vehicle.
  - Remotely requests service from transit vehicles while waiting to board or alight.
  - Triggers TSP if the bus is running behind schedule due to a user needing additional time to board or alight.
- **Step 4 Intersection Crossing.** When crossing a signalized intersection, the traveler indirectly interacts with the signal controller in that an authorized system call is made to the controller which extends the pedestrian phase in the direction of user travel.

- Allows the user to communicate with connected intersections if they are unable to reach or press the crosswalk button.
- Provides the user with information about the intersection crossing and adds time to the crossing if needed.

- **Step 5 CV Broadcast Message.** Roadside units (RSUs) broadcast safety message to alert CVs of pedestrians in the intersection.
  - Provides the ability for users to remotely request service from transit vehicles while waiting to board or alight.
  - Provides communications to CVs from pedestrian crossing signal system (via RSUs) to make them aware of pedestrians crossing a roadway.
  - Provides communications between transit vehicles and travelers waiting at a transit stop to make them aware of each other.
- **Step 6 Outdoor/Indoor Navigation.** The traveler is provided with turn-by-turn directions to a safe accessible route.
  - Hands-free navigation via mobile apps and/or wearables and accessible channels (haptic, voice, text).
  - Alerts and dynamic rerouting in response to changes in path conditions.
  - Provides the user with accessible routes into and through transit hubs within the project area.
  - Provides users with updates on the operating status of indoor infrastructure such as elevators and escalators.

System development and system integrations completed within the scope of this project will enable travelers – specifically those in the underserved community – to program and safely complete single mode or multimodal trips that are based on their abilities; improve the transition between modes by providing additional details to users and transit service operators; suggest dynamic routing changes based on infrastructure condition and calculated delay.

The existing initiatives that are being leveraged to support the proposed ST-CTN system are defined in more detail below as well as those components that will be developed specifically to support ST-CTN project evaluation. The icons and colors depicted below are used throughout the SAD to clearly identify the critical components of ST-CTN. In some cases, partner agencies are upgrading the services within their current systems to create a more robust data set or toolset for the ST-CTN program.



**OTP for G-MAP (Georgia Mobility and Accessible Planner).** Atlanta Rider Information and Data Evaluation System (ATL RIDES) includes an Open Source Software (OSS) multi-modal trip planning and mobile application, integrated mobile fare payment options, and a Connected Data Platform (CDP) using regional General Transit Feed Specification (GTFS) transit service data. The tool supports multi-agency context, multilingual support, and mobile app turn-by-turn directions. The OpenTripPlanner (OTP) architecture facilitates integration with additional OSS tools including a data analytics engine, call center module with application programming interfaces (APIs), and account management system. The existing ATL RIDES application will be modified and enhanced based on ST-CTN project needs and leveraged to create a new, independent application which will be differentiated as the *OTP for G-MAP* subsystem (hereafter referred to as G-MAP).



**SIDEWALKSIM.** SidewalkSim is an asset management system and shortest path (lowest impedance) routing tool for pedestrian pathways. Site inspections provide more detailed Americans with Disabilities Act (ADA) and inclusive design and condition data for use in pathway accessibility analysis. SidewalkSim identifies the best path between any two points in the pedestrian network, given the set of pathway characteristics and any user-specified needs and route penalties.



**CV1K.** The Atlanta region is home to one of the largest CV deployments in the United States – Regional Connected Vehicle Infrastructure Deployment Program (CV1K). CV1K is deploying interoperable CV technologies at signalized intersections throughout the Atlanta region using both Dedicated Short-Range Communications (DSRC) and Cellular Vehicle to Everything (C-V2X) technologies to deliver safety and mobility-based applications. The program provides support to configure, operate, and maintain CV infrastructure and applications, including TSP. Gwinnett County is one of the largest recipients of the first phase of this deployment.



**CVTMP**. Gwinnett County's Connected Vehicle Technology Master Plan (CVTMP) sets out to develop and improve economic viability and quality of life, address the needs and challenges to motorized and non-motorized modes, establish guidelines for deploying technology, and have broad applicability to Gwinnett, other local jurisdictions, and across the state—to set the standard for implementing CVs. Among the high priorities is establishing a mobile accessible safety program and alternative strategies for TSP in Gwinnett County.



**STM**. The Space Time Memory (STM) platform processes traffic volume and speed data from multiple monitoring and modeling sources, tracks network performance measures, and predicts evolving route conditions using traditional and machine learning techniques. The STM projects trip trajectories through the transportation network, as network conditions change in space and time. This tool will be applied to analyze and predict performance through the multi-modal transportation network. The shortest path analysis will be applied to the combined roadway, transit, sidewalk, and shared-use path networks, allowing routing decisions to incorporate travel time, safety, and other impedances into path selection.

In addition, the ST-CTN system will include the development of a Performance Measurement Dashboard (PMD) that is not currently in use.



**PMD.** The PMD is a data storage and distribution tool that archives operational, survey and performance metrics of the system. The PMD is envisioned to ingest, quality check, and curate all types of data – static and dynamic, structured and unstructured, open and private datasets. The PMD will store the datasets so that they can be viewed and accessed based on user roles. The PMD will include a public PMD for the public to access open data presented on an interactive dashboard to the public.

## 1.3 Purpose of the Plan

The Comprehensive Installation Plan (CIP) provides a high-level overview of the installation approach and schedule necessary to install equipment for the ST-CTN project. During project planning, outreach was conducted with the vendor community to understand the equipment capabilities. Systems engineering documents were developed to document desired capabilities of

the system, system requirements, system interfaces, and system architectures. Moving forward, equipment will be procured and integrated with existing and future systems.

This document identifies the necessary equipment that will be deployed for the project and how it will be installed. The CIP will be a living record of the ST-CTN project installation process for the purpose of transparent reporting to project sponsors and stakeholders about the methods and status of these installation efforts. Throughout the document, there are sections identifying unknowns which will be updated as the project team works to develop specific installation procedures incorporating the related organization's installation policies and procedures. Other items will be finalized as the project completes the deployment phase.

For consistency, this document includes the acquisition approach that was used to procure the equipment and engage the vendors. Following the Acquisition Overview (Section 2), the document describes the Installation Overview (Section 3), that includes the Asset Management Plan, format for the installation plan, and proposed installation schedule. Section 4 details the installation plan for the beacons at each facility, and the Bill of Materials (BOM). The Appendices provides vendor specifications, guidance and auxiliary materials needs by the installation teams.

# 2 Acquisition Overview

This section provides a high-level overview of ST-CTN methods of acquisition. It provides a description of the internal acquisition policies and how they will meet federal, state, and local regulations.

## 2.1 Acquisition Approach

The ST-CTN is composed of four subsystems – 1. G-MAP (OTP for G-MAP), 2. STM Platform, 3. Connected Vehicles, and 4. PMD. Several applications will be integrated with the G-MAP subsystem. Although all the subsystems are leveraging existing infrastructure or services, additional acquisitions may be needed to augment the enabling technology. To that end, there are several approaches to acquire equipment or services for the ST-CTN deployment, as listed below:

- **Purchase Order (PO).** A purchase order is a contract between GDOT, or lead agency, and the supplier. The supplier has an existing contract with the agency prior to a purchase order being considered. The ST-CTN project team utilizes the Traffic Signal Electrical Facility (TSEF) parts contract administered by GDOT

- **Request for Information (RFI).** The RFI is a means of advertisement that will describe the needs and purpose of the acquisition, identify the desired information, and provide the method for responding to the request. Vendors are not required to respond to the RFI; however, they are strongly encouraged as this is a way to ensure the agency is aware of the vendors' ability to respond to the RFP. The RFI period is typically 30 days and followed by the posting of the RFP. Vendors will submit their proposals and bids at that time. See process schedule in **Section 2.3**.

- **Request for Qualifications (RFQ).** The RFQ identifies the minimum requirements or products and provides performance specifications, design specifications, references to particular products, use of qualified products lists, and/or performance and services. To be considered responsive, the vendor's bid must meet all specifications and requirements. The vendor will respond with a Statement of Qualifications (SOQ). The pool of qualified vendors will then submit a proposal and bid at such a time the RFP is posted.

- **Request for Proposal (RFP).** The RFP is the process that allows for vendors to propose their own solutions to the state's needs as described in the RFP. The RFP describes specific requirements or metrics that are required to be met by the vendor and includes a series of questions to which the vendor must respond to be considered responsive. Categories of questions may include some or all following:

    1. Mandatory Requirement: A vendor must demonstrate they meet this requirement to be eligible for participation. This could be a qualification or a performance requirement.

2. Mandatory Scored Requirement: Similar to the mandatory requirement, however the response will be graded. For example, this could be a schedule to demonstrate that the vendor can meet a project deadline.
3. Additional Scored Requirement: This can refer to a service that is desirable but not required or could open the vendor to demonstrate an optional service that would set them apart from other vendors. The vendor is not required to respond to these and will not receive additional points to their overall score.

The proper procurement methodology is determined in partnership between the lead agency, GDOT, and the ST-CTN project team. Determining factors may include budget, project schedule, vendor interest and experience, requirements, and specifications. For additional information, see the GDOT Procurement Manual – For the Procurement, Management and Administration of Engineering and Design Related Consultant Services: TSPManual.pdf (ga.gov).

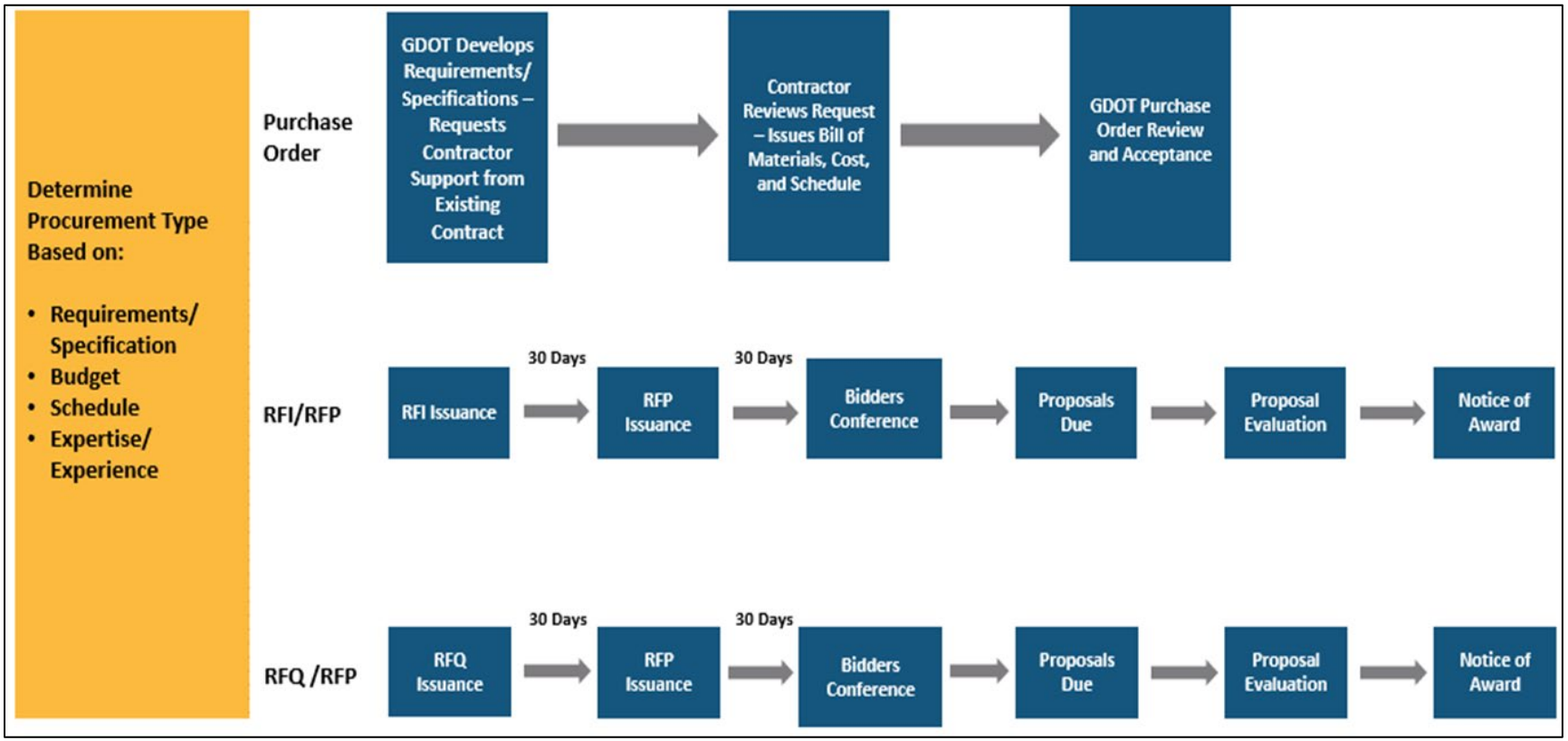
The primary method of acquisition for system design, development, and deployment is through the Phase 2 / Phase 3 ITS4US Deployment Program award. Equipment and services required for the ST-CTN project use the PO, RFQ/RFP, or RFI/RFP acquisition approaches as described above. Information about the acquisition of components and equipment is provided in Section 3.1 of the Comprehensive Acquisition Plan (CAP). Responding vendors are required to comply with detailed provisions of the PO request, describing their plan to meet the specifications, including a listing of the parts and quantities needed.

The ST-CTN project team considered the potential services and/or equipment on a case-by-case basis to determine the appropriate acquisition approach to employ.

## 2.2 Vendor Outreach Approach

Vendors are encouraged to participate in all implemented acquisition approaches to ensure an equitable and competitive environment. The vendor outreach process varies based on acquisition type—**Figure 3** shows the vendor engagement workflow for each acquisition type. For POs, vendors with an existing TSEF contract will be contacted by the agency to negotiate pricing for outright purchase of a system. For RFQ/RFP and RFI/RFP, advertisement and schedule will be published on the Georgia Procurement Registry (GPR) for vendors to track and respond to opportunities. GDOT will then reach out to potential vendors if they deem their response satisfactory.

The ST-CTN project team conducted high-level research of prospective vendors during Phase 1 of the project to better understand the current technology and readiness of INS. The informational meetings served to inform the Integrated Complete Trip Deployment Plan (ICTDP) and Phase 2 budget, as well as input to the RFI. Per the workflow, the RFI was advertised via the GPR and notifications of this event were sent to those registered to the GPR. In addition, the project team contacted known vendors in this space and those interviewed during Phase 1.




*Source: GDOT*

**Figure 3. Vendor Engagement Instances within Acquisition Workflows**

## 2.3 Acquisition Schedule

The indoor navigation system (INS) and connected vehicle roadside units (RSUs) were the only acquisition that was needed at the time of this document. GDOT used the Purchase Order procurement type. **Table 1** provides the INS acquisition schedule for the procurement of all devices, ancillary equipment and materials, software, and labor.

**Table 1. Acquisition Schedule – INS Solution Vendor Procurement**

| Tasks | Date | Status |
|---|---|---|
| Vendor Review | March 2023 | Completed |
| Refine Requirements | April 2023 | Completed |
| Vendor Interviews | April/May 2023 | Completed |
| INS Vendor Estimate | June 9, 2023 | Completed |
| Vendor Selection | July 24, 2023 | Completed |
| Vendor Notification | June 30, 2023 | Completed |
| Vendor scope of work | August 10, 2023 | Completed |
| Contracting | August 18, 2023 | Completed |
| RSU Equipment Purchase Order Issued | June 10, 2024 | Completed |
| RSU Installation Purchase Order Issued | July 15, 2024 | Completed |

# 3 Indoor Navigation System Installation Overview

The acquisition of the INS was procured via a PO acquisition approach, which involves selecting a vendor that meets specifications for the provision of commodities based on the list of requirements, including equipment specifications, provided in the CAP. Following the PO process, CXApp was selected as preferred vendor and will support the installation of the INS in coordination with the ST-CTN project team.

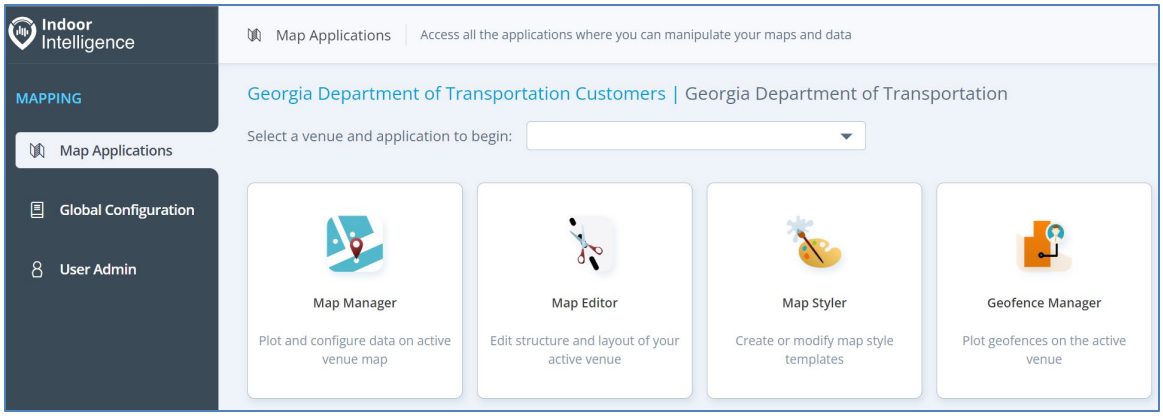
This section provides a high-level overview of the installation plan for the INS, detailing the asset management plan, installation approach, and installation schedule.

## 3.1 Asset Management Plan

This section presents the approach for managing the equipment inventory and configuration settings. This includes managing the location and settings of the beacons. To understand the beacon locations, an accurate representation of the facility layout is needed. To that end, the facility content (see **Section 3.1.1**) and device management (see **Section 3.1.2**) constitute the inventory and configuration plan of the INS. The content and device management approach provides supporting artifacts for installing the beacons (e.g., map locations), and during installation, beacon locations and attributes will be recorded for operations and maintenance purposes.

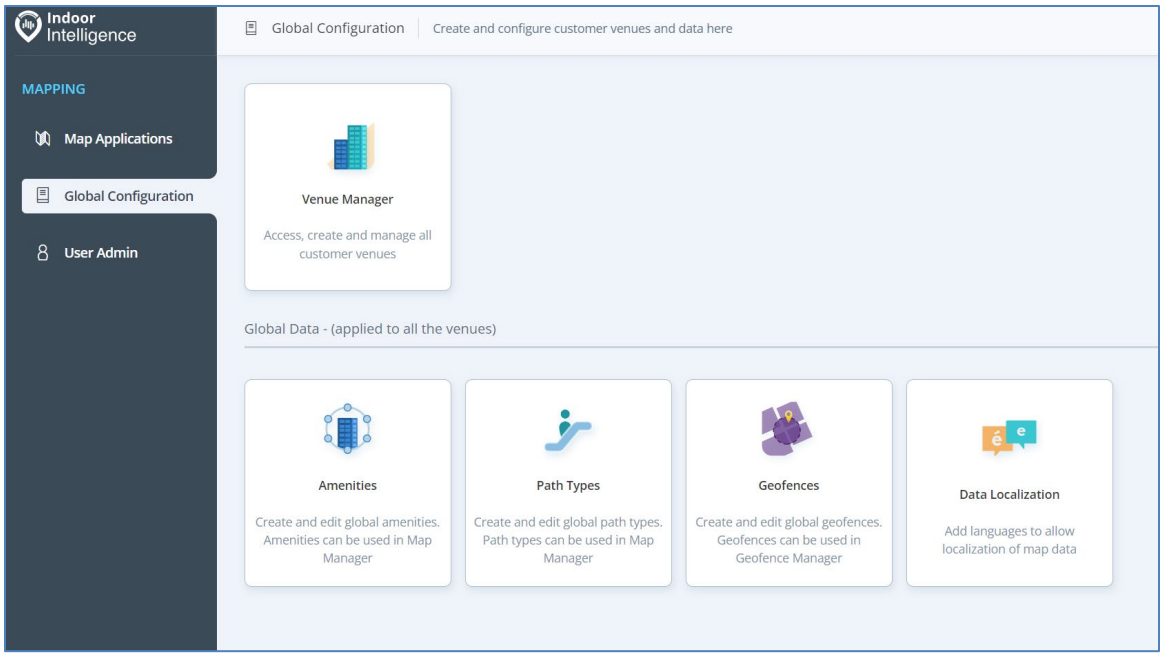
### 3.1.1 Content Management

The vendor for INS (CXApp) provides an online portal (jibestream) that allows users to add, edit and modify map data. Common features of the maps include venues, amenities, destinations, and path types. All these features and related attributes (e.g., geofence and alternate language) can be inputted and maintained using the CXApp's portal different tabs and tools, such as the for Map Applications (**Figure 4**) Global Configuration (**Figure 5**) and User Admin (**Figure 6**). Information on the process for managing and maintaining amenities and destinations will be included in the Comprehensive Maintenance and Operations Plan (CMOP). The plan will include who, what, and how improvements to the map will be incorporated.



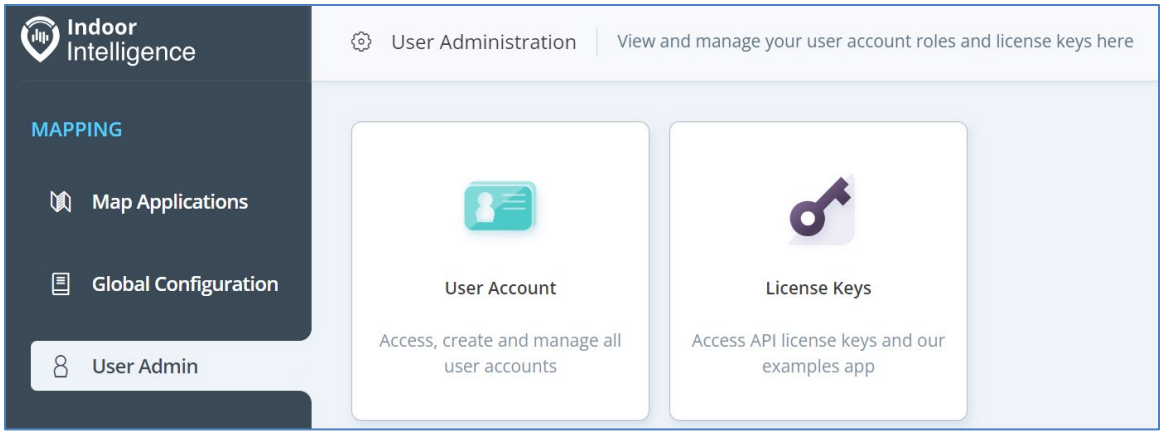

*Source: CXApp*

**Figure 4. CXApp Map Applications Tab**




*Source: CXApp*

**Figure 5. CXApp Global Configuration Tab**




*Source: CXApp*

**Figure 6. CXApp User Admin Tab**

The following subsections describe in more detail the venues, amenities, destinations, and paths features.

#### *3.1.1.1 Venues*

Venues are general locations that can be located in a map, such as a building. Within the Global Configuration tab of online portal, venue maps can be created, managed, and updated within the Venue Manager pane. Venue information contain:

1. Venue's name, ID, address.
2. Default floor's name, abbreviation, external ID and map.
3. Location of the venue on the world map by selecting a location on a map or providing exact coordinates.
4. The venue template style, label type (in-lay or Point), and label clustering (on or off).

#### *3.1.1.2 Amenities*

Amenities are non-unique points of interest, such as washrooms, parking lots, bank machines, and printer areas. They are classified as non-unique because a floor can contain multiples of these and they would not have a specific name. These are typically represented by dedicated icons to visually show users their locations.

To be visible on the map, an amenity must first be created then associated with a waypoint on the map. Note that amenities cannot be created or edited in Map Manager. Amenity setup can be done in the Content Management System (CMS) Global Configuration. All information related to amenities is provided via an Amenity List.

#### *3.1.1.3 Destinations*

In contrast to amenities, destinations represent a singular waypoint on a map for a user to navigate to. For a destination to appear on a map, it must be plotted and associated with a waypoint.

Destinations can be added individually or via bulk import (CSV file) to the venue map directly from the Map Manager tab. A Destination List provides the information needed to describe the desired location. A destination contains the following data:

- **Name:** A mandatory field with the destination name that will appear on the map and in the CMS.
- **Description:** An optional field with details about a destination that you may want to reveal on implementation.
- **Destination ID**: A unique identifier assigned to a destination.
- **Label**: A text or image associated with the destination.
- **External ID:** An optional field with information that helps match/integrate data from an external database that may already exist.
- **Keywords**: Alternative names assigned to the destination. For example, if a restaurant is commonly referred to colloquially by an abbreviated form, a keyword containing the abbreviated form could be assigned.
- **Tags**: Used to categorize or group destinations with common characteristics. For example, within a warehouse, if more than one destination sells sporting goods and clothing, assigned tags could be *Men's Sporting Goods, Women's Apparel,* and *Sports Equipment.*
- **Instance Count**: The total number of plotted instances on the map. For example, if a hospital contains four sets of escalators, the instance count would be 4.
- **Destination location**: The location of a destination (e.g., floor location if assigned).
- **Properties:** Users can add up to 10 properties to destinations, with each property and value field supporting up to 1024 characters. This extends map object properties beyond existing fields (for tags and keywords) and allows the manager to cater properties to a variety of uses, including Apple's Indoor Mapping Data Format (IMDF properties).

#### *3.1.1.4 Global Path and Path Types*

As described by CXApp documentation related to factors that affect path types, "[p]ath types are connectors to standard paths that move people from one point to another, often between floors." Path Types designate the type of path such as stairs, elevators, escalators, and moving walkways. Note that path types cannot be created or edited in Map Manager. Instead, path type setup and editing must be done in CMS Global Configuration. Path types can assume factors characterized by accessibility, weight (impedance), vertical weight, and speed.

## 3.1.2 Device Management

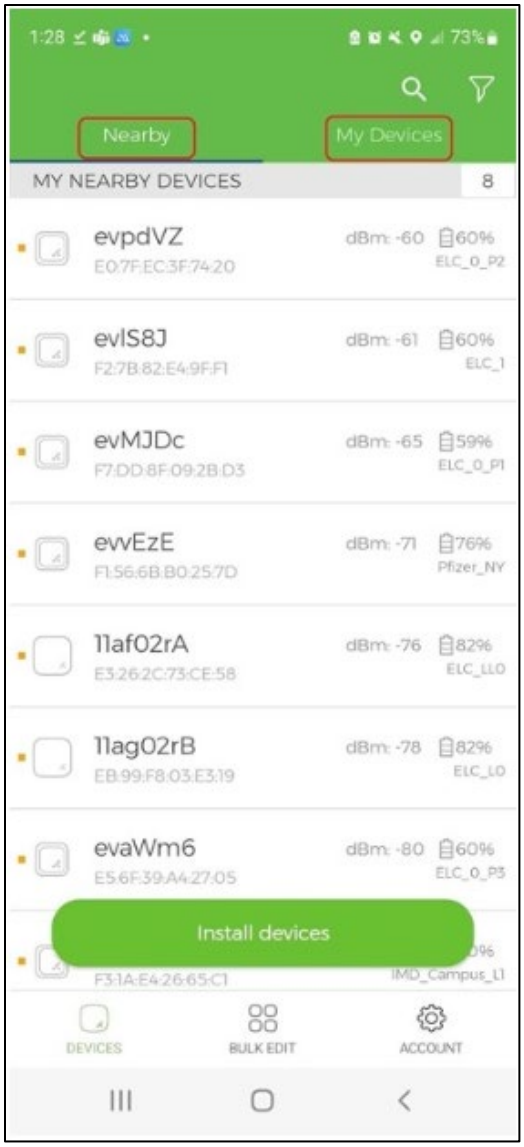
This subsection describes the setup and configuration approach along with device inventory management for INS.

#### *3.1.2.1 **Setup and Configuration***

The Kontakt IO (Kio) mobile app from CXApp allows users to scan, configure and upgrade beacons using the app. The Kio app scans all devices within a 10-meter diameter and allows the user to view individual beacons and gateway portals. Gateways are devices connected to the power socket that serve as a bridge between nearby beacons and the cloud environment. Status of the beacons along with remaining battery life can be viewed using the app—note that replacement of batteries is part of the maintenance and operations plan and not included in this document. Once devices are identified, they can be installed using “Install Devices” option from the app. **Figure 7** shows a screenshot of the Kio app interface.

Upon scanning the installed beacons using the app, a particular beacon can be selected to modify its configuration. After clicking on a scanned beacon, the app will allow user to view device preview and update specific settings. Beacon overview presents current reading such as RSSI (Signal Strength), unique ID, battery life and the device time. Beacons can be configured individually or in bulk.

If a beacon needs to be upgraded upon direction from CXApp, that can be performed using the app as well. Beacons that need an upgrade will be presented with a yellow dot to the left of its icon, as shown in **Figure 7**. Users can select an individual beacon and go to the settings menu to upgrade the firmware.




*Source: CXApp*

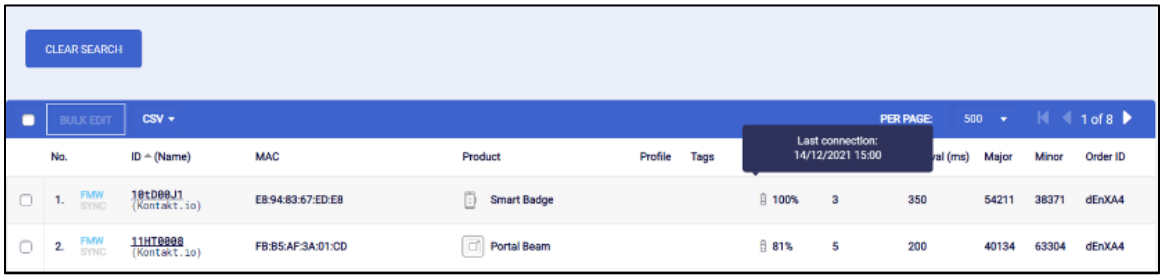
**Figure 7. Screenshot of Kio App Interface**

### *3.1.2.2 **Device Inventory Management***

The online portal for CXApp allows the administrator(s) to view a full list of beacons. The list of beacons can be exported along with all the settings using the CSV (comma separated value) drop down menu of the portal. Beacons can also be configured individually or in bulk by the administrator.

Beacon administration can be delegated or completely changed to a different panel user through the online portal as well. **Figure 8** shows the device management interface. The information presented for each beacon includes ID and name, type of product, profile, and tags. Tags are

used to classify beacons to their correct location. The battery field shows the remaining percentage of battery as per last scan performed.




*Source: CXApp*

**Figure 8. Screenshot of Device Inventory Management Interface**

## 3.2 Installation Procedure Format

The installation approach for beacons will generally follow the CXApp's placement guidelines. Beacons should be positioned and spaced in such a way that the best overall system performance is achieved for a given density of beacon laydown. CXApp's beacon placement guidelines are attached in **Appendix B**.

The installation approach for Gwinnett Justice and Administration Center (GJAC) and Gwinnett County OneStop Norcross will be formatted to provide a comprehensive view of what, where, and how install is to be done, as well as the resources allocated to do so. Each field is described below.

1. **Description**: A description of the location where the equipment is being installed.
2. **Resources**
    a. **Bill of Materials (BOM) for site:** A description and list of the equipment and materials that is being installed, configurated and commissioned.
    b. **People:** Roles and responsibilities of people needed to install and test the equipment. The content of this field may depend on the facility's policies and procedures.
    c. **Tools:** A list of the tools used to install, configure, and commission the equipment. This might include hand-held and back -office tools.
    d. **Policies and Procedures**: These include specific policies related to this installation. In particular, safety and security warnings that must be applied during installation should be listed in this section.
3. **Mounting approach**

a. **Location Diagrams:** A reference to the diagrams needed to locate and secure the devices. These include the maps provided by CXApp and position instructions on where to affix the devices.

b. **Mounting Requirements:** Instructions for reviewing each device and checking that all the securements are included, and battery is fully charged. Also includes ensuring that proper wiring, power, and any needed resource is available.

c. **Safety Procedures:** A list of safety procedures that are applied during installation. For example, cones and their placement around the installation location.

d. **Step by Step Directions for Installation:** Directions for how to affix the device to the surface.

4. **Configuration and Commissioning**

    a. **Step by Step Software Configuration, Data Prep / Quality Control and Test**

        i. A checklist for configuring and testing each beacon.

    b. **Step by Step Communications Commissioning**

        i. A checklist for optimizing the signal strength of the beacon-set configuration and assessing the signal strength of the beacon set.

5. **Notes Associated with Each Device:** A spreadsheet of the all the beacons with notes on their location and any issues that arise during their installation, configuration, and commissioning.

The installation approach for each location should also be approved by their respective installation manager and the facility owner. The approval may be provided by a manually or e-signed document.

### 3.2.1 General Guidance for Beacon Placement

In general, a denser beacon network will lead to more accurate *on-device position* (location), on average. To achieve uniform accuracy over an area, beacons should be placed with approximately uniform coverage over the entire area. CXApp recommends varying by less than 30% in the grid spacing from beacon to beacon. Additional beacons can be placed for areas that require a higher level of location accuracy.

Additional Beacon placement considerations include at a minimum the following:

- Optimization considerations
    - Facility coverage
    - Location positioning accuracy

  - Minimizing interference (line of sight) between beacon position and end user
  - Budget (BLE beacons cost on the order of $50 per unit for indoor and $80 per unit for indoor/outdoor)

- Physical constraints
  - Obstacles (to beacon placement and future maintenance tasks)
  - Security – placement to detour theft or tampering
  - Signal propagation characteristics

- The beacon installation should include only areas relevant to the end-user's access, use case, and the overall purpose of the wayfinding application. For example, if the mobile application is to be used only by the public, beacons should only be installed in areas where the public can physically access signal.
- Recommended initial beacon installation spacing is on a 7 by 8 meter grid (approx. 56 square meters per beacon).
- Additional beacons may be desired for potentially increased location accuracy, for example, at high-traffic hallways, intersections of hallways, doorways to heavily used rooms and more.
- Recommended installation height is less than 5 meters (16.5 feet) above the floor.

## 3.3 High Level Installation Schedule

**Table 2** is the high-level schedule for acquiring, installing, and field-testing beacons for INS.

**Table 2. Installation Schedule**

| Task | GJAC Installation Est. Dates | Gwinnett County OneStop Norcross Installation Est. Dates |
|---|---|---|
| Kick off Meeting | August 11, 2023 | June 11, 2024 |
| Develop Draft CIP | October 16, 2023 | October 16, 2023 |
| Map Generation from CAD file and Destination List | November 1, 2023 | July 29, 2024 |
| Acquire beacons from distributor | October 30, 2023 | October 30, 2023 |
| Beacon Planning -- Assign and log position in facility map (CXApp) | November 15, 2023 | August 12, 2024 |

| | | |
|---|---|---|
| Identify facility policies and procedures | November 15, 2023 | June 11, 2024 |
| Test beacons for configuration | November 15, 2023 | September 13, 2024 |
| Develop site installation plan and train installers | December 1, 2023 | July 29, 2024 |
| Installation Activities | December 15, 2023 – January 31, 2024 | September 16, 2024 – October 4, 2024 |
| Update and Submit Final CIP | August 26, 2024 | August 26, 2024 |
| Field Test (Alpha tests with G-MAP application) | February 1, 2024- March 1, 2024 | October 4, 2024 – October 28, 2024 - |

# 4 Installation Plan for Beacons

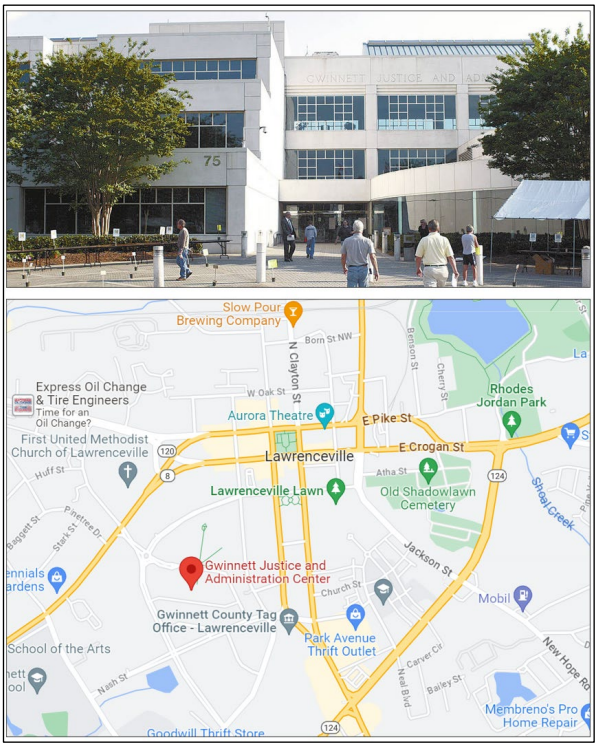
This section provides the basic information that is included for each installation site based on the installation procedure format described in **Section 3.2**. This section will be updated once all the devices and site plans are ready for installation.

## 4.1 Gwinnett Justice and Administration Center Facility

### 4.1.1 Description

The Gwinnett Justice and Administration Center (GJAC) serves as the primary facility to support justice and administrative activities for the county. The building is frequently used for public meetings, exhibits, and events. GJAC is located Lawrenceville, Georgia at the address 75 Langley Drive, as noted in **Figure 9**.

The building configuration and layout is complex and difficult to navigate, especially for those with disabilities making it ideal for inclusion in the ST-CTN -project. Guests are required to enter through a secure entrance and navigate to their destination on one of three floors. There are stairs, escalators, and two elevator towers that are used depending on the intended destination with limited access to parts of the building depending on the elevator that is used from the first floor




*Source: Gwinnettdailypost.com (top) and Google Maps (bottom)*

**Figure 9. Gwinnett Justice and Administration Center (top) and its Location (bottom)**

## 4.1.2 Resources

The following resources will be utilized for the installation of the INS in the GJAC building.

### *4.1.2.1 Bill of Materials for GJAC*

The GJAC will be equipped with approximately 250 Anchor Beacon 2 devices (**Figure 10**). The Anchor Beacon 2 is a Bluetooth LE beacon, approximately 2-inch by 2-inch in size which is battery operated. Batteries are rated to have an expected life of eight-plus years. Technical specification details can be found in **Appendix C.**



*Source: Kontakt.io*

**Figure 10. Anchor Beacon 2 Device**

#### 4.1.2.2 *People*

The Gwinnett County Facilities Department will lead the installation of the beacons with coordination and direction from the INS vendor and support from the ST-CTN project team. The following staff are expected to provide support:

- ST-CTN Gwinnett County Local Agency Lead – Responsible for the primary coordination between the ST-CTN project team and Gwinnett County Facilities Department. In addition, he will keep all parties informed of schedule and key milestones, i.e., equipment delivery, training availability, etc.

- Gwinnett County Facilities Director – Responsible for coordinating the installation and testing of beacons, training for system updates and maintenance activities.

- Gwinnett County Facilities Staff – Responsible for the installation and testing of beacons, on-going INS map updates (i.e., elevator outages, etc.), and system maintenance which is expected to be minimal (i.e., battery changes or replacement).

- INS Vendor – Responsible for delivery of the beacons to the INS Distributer, mapping the GJAC INS spaces within the navigation software, configuration of the beacons, as well as directing where beacons are to be installed within the facility. Training on the tools and installation plan will be provided prior to commencement of installation procedures.

- INS Distributer – Responsible for beacon ordering, delivery, and coordination of any faulty hardware during warranty period.

- ST-CTN Technical Staff – Will provide support to the Gwinnett County Facilities team to help place, configure, and commission (test and validate) the beacons.

#### 4.1.2.3 *Tools*

Installation tools such as ladders and safety signs will be documented in the site installation plans.

In addition, people configuration and commissioning the beacons will need to download the Kontakt IO (Kio) mobile app from CXApp portal. Special login and activation credentials will be provided to the installers (Gwinnett County Facilities Director, Staff, and ST-CTN Technical Staff).

#### 4.1.2.4 *Policies and Procedures*

Specific agency installation policies and procedures will be included in the final version of this Comprehensive Installation Plan. It should be noted that all federal, state, and local safety, security, and installation policies and procedures will be adhered to by the installation and deployment teams.

### 4.1.3 Mounting Approach

The following subsections provide an overview of the GJAC building beacon mounting approach.

#### 4.1.3.1 *Location Diagrams*

The GJAC facility map is included in **Appendix D**.

#### *4.1.3.2 Mounting Requirements*

Mounting requirements include:

- **Mounting Height:** It is recommended that the Anchor Beacon 2 be inconspicuously placed such that it is beyond reach of the traveling public but below 15 feet in height.
- **Securement:** The Anchor Beacon 2 should be mounted on a clean, dry, flat surface, secured with mounting adhesive or mounting clip.
- **Power:** The Anchor Beacon 2 arrives powered ON. If there is a yellow tab extended out from the top of the Anchor Beacon, this is a battery separator tab. To power on the beacon, remove this tab.

#### *4.1.3.3 Safety*

Mounting the beacons will require the use of a ladder and mounting adhesive (or drill). Gwinnett County safety policies and procedures will be followed during mounting at all times. Qualified and knowledgeable Gwinnett County Facilities Staff will be responsible for the mounting of the beacons.

#### *4.1.3.4 Guidelines for Placing Beacons*

The following guidelines are summarized from the CXApp Bluetooth Beacons – Placement Guidelines.

- Uniform coverage of the area should be ensured. Uniform coverage over the entire area, varying by less than 30% in the grid spacing from beacon to beacon should be ensured. Additional beacons can be placed for areas that require higher value for accuracy.

- Beacons should be placed in high-traffic hallways, intersections of hallways, doorways to heavily used rooms etc. where more foot traffic is recognized.

- Adequate coverage out to the perimeter of the facility should be ensured. Beacons should be placed at desires spacing along exterior walls to ensure that this criterion is met.

- Obstructions should be avoided. Bluetooth beacons use a radio frequency signal and perform best when the signal is received clearly by the user's phone or table. Beacons should be placed in such a way that the signal can directly travel from the beacon to the user's device without having to pass through, around, or reflected from any material in/around the physical straight-line path between then.

- Placement of beacons too high above users should be avoided. For locations with high ceilings, placement of beacons above 15 feet should be avoided.

#### 4.1.3.5 *Directions for Installation*

The following are guidelines for installation.

1. The initial setup of beacons should use a 0dB broadcast signal strength, and a 5-HZ (200ms) broadcast repetition rate.

2. Uniform coverage of the area should be ensured. Uniform coverage over the entire area, varying by less than 30% in the grid spacing from beacon to beacon should be ensured. Additional beacons can be placed for areas that require higher value for accuracy.

3. Beacons should be placed in high-traffic hallways, intersections of hallways, doorways to heavily used rooms etc. where more foot traffic is recognized.

4. Adequate coverage out to the perimeter of the facility should be ensured. Beacons should be placed at desires spacing along exterior walls to ensure that this criterion is met.

5. Obstructions should be avoided. Bluetooth beacons use a radio frequency signal and perform best when the signal is received clearly by the user's phone or table. Beacons should be placed in such a way that the signal can directly travel from the beacon to the user's device without having to pass through, around, or reflected from any material in/around the physical straight-line path between then.

6. Placement of beacons too high above users should be avoided. For locations with high ceilings, placement of beacons above 15ft should be avoided.

### 4.1.4 Configuration and Commissioning

The following configuration and commissioning steps will be completed to install the GJAC INS.

#### 4.1.4.1 *Software Configuration, Quality Control, and Testing*

Gwinnett County Facilities Department will provide Computer Aided Design (CAD) drawings to the INS vendor with the public spaces identified. The INS vendor will position the beacons to be accessed by the vendor's software development kit (SDK) providing 1 to 3 meter accuracy to the G-MAP application. The map will provide the locations for the installers to place the beacon. The vendor provided Kontakt IO (Kio) mobile app (downloaded from CXApp portal) will provide a means for the installer to manage the device inventory (see Section 3.1.2.2). The INS vendor will coordinate with the ST-CTN project team, Gwinnett County Facilities Director, and Staff to verify the quality and accuracy of beacon placement by comparing the expected functionality within the vendor mapping software. After the vendor has verified the quality of the placement, on-site testing will commence, led by the ST-CTN project team, Gwinnett County Facilities Director, and Staff.

Upon successful completion of the INS testing, the INS will be integrated within the G-MAP application and further tested to ensure proper functioning and accomplishment of requirements. All system testing will be documented within the System Test Plan (STP)

#### 4.1.4.2 *Communications Commissioning*

The initial setup of beacons should use a 0dB broadcast signal strength, and a 5-HZ (200ms) broadcast repetition rate. The Kontakt IO (Kio) mobile app will be used to verify communication is functioning properly. Special login and activation credentials will be provided to the installers (Gwinnett County Facilities Director, Staff, and ST-CTN Technical Staff).

### 4.1.5 Notes on Installation

This section will provide any information related to installation that may be useful for others upon completion of installation.

## 4.2 Gwinnett County OneStop Norcross

### 4.2.1 Description

The Gwinnett County OneStop Norcross facility is shown in Figure 11**.** OneStop Norcross is a multi-level indoor facility that provides social and medical services as well as a Senior Center for Gwinnett residents.

People served by the Gwinnett County OneStop Norcross facility include people of varying demographic, age, and income levels. Because there are many separate organizations housed in one facility, finding and navigating to a visitor's destination may be confusing and complicated. The facility is served by two elevators and several stairways.

The Gwinnett County OneStop Norcross is located in Norcross, Georgia at the address 5030 Georgia Belle Ct., Norcross, GA 30093 as shown in the Google Maps screenshot in **Figure 11**.




*Source: Gwinnettcounty.com (top) and Google Maps (bottom)*

**Figure 11. Gwinnett County OneStop Norcross (top) and its Location (bottom)**

## 4.2.2 Resources

The following resources will be utilized for the installation of the INS in the Gwinnett County OneStop Norcross.

### *4.2.2.1 Bill of Materials for Gwinnett County OneStop Norcross*

The Gwinnett County OneStop Norcross facility will be equipped with approximately 75 Anchor Beacon 2 devices (Figure 12). The Anchor Beacon 2 is a Bluetooth LE beacon, approximately 2-inch by 2-inch in size which is battery operated. Batteries are rated to have an expected life of eight-plus years. Technical specification details can be found in **Appendix C.**



*Source: Kontakt.io*

**Figure 12. Anchor Beacon 2 Device**

#### 4.2.2.2 *People*

The Gwinnett County Facilities Group will lead the installation of the beacons with coordination and direction from the INS vendor and support from the ST-CTN project team. The following staff are expected to provide support:

- ST-CTN GDOT INS Lead – Responsible for the primary coordination between the ST-CTN project team and Gwinnett County Facilities Group. In addition, he will keep all parties informed of schedule and key milestones, i.e., equipment delivery, training availability, etc.

- Gwinnett County Facilities Director – Responsible for coordinating the installation and testing of beacons, training for system updates and maintenance activities.

- Gwinnett County Facilities Staff – Responsible for the installation and testing of beacons, on-going INS map updates (i.e., elevator outages, etc.), and system maintenance which is expected to be minimal (i.e., battery changes or replacement).

- INS Vendor – Responsible for delivery of the beacons to the INS Distributer, mapping the Gwinnett County OneStop Norcross INS spaces within the navigation software, configuration of the beacons, as well as directing where beacons are to be installed within the facility. Training on the tools and installation plan will be provided prior to commencement of installation procedures.

- INS Distributer – Responsible for beacon ordering, delivery, and coordination of any faulty hardware during warranty period.

- ST-CTN Technical Staff – Will provide support to the Gwinnett County Facilities Group to help place, configure, and commission (testing and validating) the beacons.

#### 4.2.2.3 *Tools*

Installation tools such as ladders and safety signs will be documented in the site installation plans. In addition, people configuration and commissioning the beacons will need to download the

Kontakt IO (Kio) mobile app from CXApp portal. Special logon and activation credentials will be provided to the installers.

#### 4.2.2.4 *Policies and Procedures*

Specific agency installation policies and procedures will be included in the final version of this Comprehensive Installation Plan. It should be noted that all federal, state, and local safety, security, and installation policies and procedures will be adhered to by the installation and deployment teams.

### 4.2.3 Mounting Approach

The following subsections provide an overview of the Gwinnett County OneStop Norcross beacon mounting approach.

#### 4.2.3.1 *Location Diagrams*

The Gwinnett County OneStop Norcross map is included in **Appendix D**.

#### 4.2.3.2 *Mounting Requirements*

Mounting requirements include:

- Mounting Height: It is recommended that the Anchor Beacon 2 be inconspicuously placed such that it is beyond reach of the traveling public but below 15 feet in height.
- Securement: The Anchor Beacon 2 should be mounted on a clean, dry, flat surface, secured with mounting adhesive or mounting clip.
- Power: The Anchor Beacon 2 arrives powered ON. If there is a yellow tab extended out from the top of the Anchor Beacon, this is a battery separator tab. To power on the beacon, remove this tab.

#### *4.2.3.3 Safety*

Mounting the beacons will require the use of a ladder and mounting adhesive (or drill). Gwinnett County safety policies and procedures will be followed during mounting at all times. Qualified and knowledgeable Gwinnett County Facilities Staff will be responsible for the mounting of the beacons.

#### *4.2.3.4 Guidelines for Placing Beacons*

The following guidelines are summarized from the CXApp Bluetooth Beacons – Placement Guidelines.

- Uniform coverage of the area should be ensured. Uniform coverage over the entire area, varying by less than 30% in the grid spacing from beacon to beacon should be ensured. Additional beacons can be placed for areas that require higher value for accuracy.

- Beacons should be placed in high-traffic hallways, intersections of hallways, doorways to heavily used rooms etc. where more foot traffic is recognized.

- Adequate coverage out to the perimeter of the facility should be ensured. Beacons should be placed at desires spacing along exterior walls to ensure that this criterion is met.

- Obstructions should be avoided. Bluetooth beacons use a radio frequency signal and perform best when the signal is received clearly by the user's phone or table. Beacons should be placed in such a way that the signal can directly travel from the beacon to the user's device without having to pass through, around, or reflected from any material in/around the physical straight-line path between then.

- Placement of beacons too high above users should be avoided. For locations with high ceilings, placement of beacons above 15ft should be avoided.

#### 4.2.3.5 *Directions for Installation*

The following are guidelines for installation.

1. The initial setup of beacons should use a 0dB broadcast signal strength, and a 5-HZ (200ms) broadcast repetition rate.

2. Uniform coverage of the area should be ensured. Uniform coverage over the entire area, varying by less than 30% in the grid spacing from beacon to beacon should be ensured. Additional beacons can be placed for areas that require higher value for accuracy.

3. Beacons should be placed at high-traffic hallways, intersections of hallways, doorways to heavily used rooms etc. where more foot traffic is recognized.

4. Adequate coverage out to the perimeter of the facility should be ensured. Beacons should be placed at desires spacing along exterior walls to ensure that this criterion is met.

5. Obstructions should be avoided. Bluetooth beacons use a radio frequency signal and perform best when the signal is received clearly by the user's phone or table. Beacons should be placed in such a way that the signal can directly travel from the beacon to the user's device without having to pass through, around, or reflected from any material in/around the physical straight-line path between then.

6. Placement of beacons too high above users should be avoided. For locations with high ceilings, placement of beacons above 15ft should be avoided.

### 4.2.4 Configuration and Commissioning

The following configuration and commissioning steps will be completed to install the Gwinnett County OneStop Norcross & Senior Center INS.

#### 4.2.4.1 *Software Configuration, Quality Control, and Testing*

Gwinnett County Facilities Group will provide CAD drawings to the INS vendor with the public spaces identified. The INS vendor will position the beacons to be accessed by the vendor's software development kit (SDK) providing 1 to 3 meter accuracy to the G-MAP application. The map will provide the locations for the installers to place the beacon. The vendor provided Kontakt IO (Kio) mobile app (downloaded from CXApp portal) will provide a means for the installer to manage the device inventory (see Section 3.1.2.2). The INS vendor will coordinate with the ST-CTN project team, Gwinnett County Facilities Director and Staff to verify the quality and accuracy of beacon placement by comparing the expected functionality within the vendor mapping software. After the vendor has verified the quality of the placement, on-site testing will commence, led by the ST-CTN project team, and Gwinnett County Facilities Director and Staff.

Upon successful completion of the INS testing, the INS will be integrated within the G-MAP application and further tested to ensure proper functioning and accomplishment of requirements. All system testing will be documented within the STP.

#### 4.2.4.2 *Communications Commissioning*

The initial setup of beacons should use a 0dB broadcast signal strength, and a 5-HZ (200ms) broadcast repetition rate. The Kontakt IO (Kio) mobile app will be used to verify communication is functioning properly. Special login and activation credentials will be provided to the installers (Gwinnett County Facilities Director, Staff, and ST-CTN Technical Staff).

### 4.2.5 Notes on Installation

This section will provide any information related to installation that may be useful for others upon completion of installation.

## 4.3 Bill of Materials – Equipment Summary

**Table 3** lists the asset types procured and configured for the INS.

**Table 3. Equipment Summary**

| Asset Type | Quantity Procured | Quantity Configured and Installed |
|---|---|---|
| CXApp-Annual Subscription | 1 | |
| Beacons for GJAC | 250 | 105 |

| Asset Type | Quantity Procured | Quantity Configured and Installed |
|---|---|---|
| Beacons for Gwinnett County OneStop Norcross | 75 | |
| CXApp Portal | 1 | |
| CXApp Mobile App | 1 | |

# 5 RSU Installation

## 5.1 Resources

The following resources will be utilized for the installation of the RSUs for the support of the connected vehicle Personal Safety Message (PSM) broadcast and enhanced TSP.

GDOT has procured the devices through the utilization of the Traffic Signal Electrical Facilities (TSEF) contract. A purchase order was issued to the vendor 360NS for the purposes of acquiring 31 RSU devices.

Installation of the devices was performed by Atkins North America. This Regional Connected Vehicles (RCV) contractual agreement was established to contract with a qualified offeror to facilitate work including but not limited to project management, device procurement, device testing, configuration, licensing, deployment, testing, validation, and software application development. For the purposes of this project, Atkins performed the project management and oversight to install the devices purchased through the previously mentioned TSEF contract.

## 5.2 Bill of Materials for RSU

**Figure 13** provides an illustration of the connected vehicle RSU equipment installed to support additional PSM broadcast and enhanced TSP locations. In addition, the link to the technical specification for the RSU details can be found in **Appendix D.**

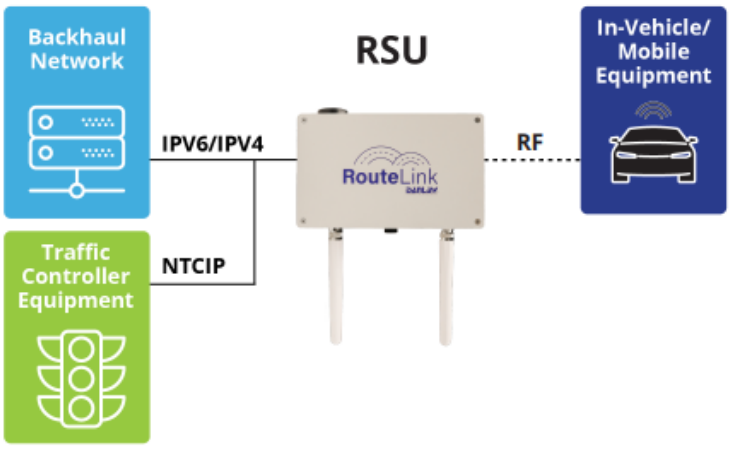



**Figure 13. Danlaw RouteLink Roadside Unit (RSU)**

Thirty-one RSUs will be deployed at locations listed below in **Table 4.**

**Table 4: RSU Equipment Summary**

| FID | MVID | Intersection |
|---|---|---|
| 1 | 736 | SR 120 at Dons Way |
| 2 | 173 | West Crogan Street at Langley Drive |
| 3 | 238 | SR 20 at Nash Street |
| 4 | 241 | SR 20 at Gwinnett Drive SW |
| 5 | 422 | SR 120 at Phoenix High School |
| 6 | 42 | SR 20 at Hurricane Shoals Road NW |
| 7 | 719 | Phillip Boulevard at Hurricane Shoals Road NW |
| 8 | 293 | SR 120 at Phillip Boulevard |
| 9 | 718 | SR 8/Lawrenceville Suwanee Road NW at Medical Center Boulevard |
| 10 | 375 | SR 8 at Old Norcross Road |
| 11 | 562 | Collins Hill Road at University Center Lane/Melody Lane |
| 12 | 696 | Collins Hill Road at Collins Industrial Way/Lendon Connector |
| 13 | 695 | Collins Hill Road at SR 316 EB Ramp |
| 14 | 548 | Collins Hill Road at Park Access Drive |
| 15 | 549 | Hurricane Shoals Road NW at Hillcrest Green Drive NW |
| 16 | 184 | Sugarloaf Parkway at Old Norcross Road |
| 17 | 310 | Sugarloaf Parkway at Marathon Boulevard/Cruse Road NW |
| 18 | 464 | Sugarloaf Parkway at QuikTrip Driveway |
| 19 | 465 | Sugarloaf Parkway at SR 316 EB Ramp |
| 20 | 192 | Sugarloaf Parkway at SR 316 WB Ramp |
| 21 | 266 | Sugarloaf Parkway at Lakes Parkway |
| 22 | 622 | Sugarloaf Parkway at Gwinnett Technical College Driveway |
| 23 | 405 | Riverside Parkway at Lakes Parkway |
| 24 | 720 | Old Norcross Road at Brass Key Court |
| 25 | 402 | Old Norcross Road at Riverside Parkway |
| 26 | 240 | Old Norcross Road at Monfort Road/Raco Drive |
| 27 | 373 | Lawrenceville Suwanee Road NW at Greenvale Road NW |
| 28 | 365 | Lawrenceville Suwanee Road NW at central Lawrenceville Market Driveway |
| 29 | 364 | Lawrenceville Suwanee Road NW at southern Lawrenceville Market Driveway |
| 30 | 172 | SR 120 at SR 8/Lawrenceville Suwanee Road |
| 31 | 426 | SR 120 at Parkside Walk Court |

# 6 References

**Table** 5 lists the documents that were used to support the development of the ST-CTN CIP. References to these documents are identified with the acronym provided in brackets.

**Table 5. Referenced Documents**

| ID | Referenced Documents |
|---|---|
| [CVTMP] | AECOM. "Gwinnett County Connected Vehicle Technology Master Plan (CVTMP)." Duluth: Gwinnett County Department of Transportation. (2019). |
| [ARCRTP] | Atlanta Regional Commission. (2021). “The Atlanta Region’s Plan: Regional Transportation Plan” Atlanta: Atlanta Regional Commission. |
| [UNIRP] | Atlanta Regional Commission. Deliverable Task 1.B User Needs Identification and Requirements Planning. Atlanta: U.S Department of Transportation. (2021). |
| [SyRS] | Atlanta Regional Commission. Deliverable Task 6.1 System Requirements and Specifications Document. Atlanta: U.S Department of Transportation. (2021). |
| [NS] | Atlanta Regional Commission. Deliverable Task 2.2 Needs Summary. Atlanta: U.S Department of Transportation. (2021). |
| [BBPG] | CXApp. Bluetooth Beacons Placement Guidelines. |
| [CAP] | Georgia Department of Transportation. Deliverable Task 2D Comprehensive Acquisition Plan. (2023). |
| [CV1K] | Georgia Department of Transportation. "The Regional Connected Vehicle Program Scope of Work." Atlanta: Georgia Department of Transportation. |
| [GPM] | Georgia Department of Transportation. Procurement Manual: For the Procurement, Management and Administration of Engineering and Design Related Consultant Services. |
| [PSRG] | Gwinnett County Transit. Paratransit Service Rider's Guide. Duluth: Gwinnett County Government. (2018). |
| [IEEE-1362] | IEEE. Guide for Information Technology - System Definition - Concept of Operations (ConOps) Document. IEEE. IEEE Std 1362-1998 |
| [IEEE-1028] | IEEE. Guide for Software Reviews and Audits. IEEE. IEEE Standard 1028-2008. |

| ID | Referenced Documents |
|---|---|
| [IEEE-29148] | IEEE. ISO/IEC/IEEE International Standard - Systems and Software Engineering -- Life Cycle Processes -- Requirements Engineering, IEEE/ISO/IEC 29148-2018 |
| [IEEE-1609] | IEEE. Wireless Access in Vehicular Environment. IEEE. IEEE Standard 1609.2-2016. |
| [NTCIP-1211] | National Transportation Communications for ITS Protocol 1211 Object Definitions for Signal Control and Prioritization. (2014) Washington, D.C.: AASHTO, ITE, NEMA. |
| [SAE-J2735] | SAE J2735-2020 C2X Message Set. Warrendale: SAE International. |
| [SAE-J2945] | SAE J2945-2017 On-Board System Requirements for V2V Safety Communications. Warrendale: SAE International. |
| [IMISOW] | The ATL. (2020). Integrated Mobility Innovation Statement of Work - Atlanta-Region Rider Information and Data Evaluation System. Atlanta: Federal Transit Administration. |
| [IVR] | TTEC. (2021). Interactive Voice Response (IVR). Englewood: TTEC. |
| [FAST] | U.S. Department of Transportation Federal Highway Administration. (2015). Fixing America's Surface Transportation Act. |
| [ARC-IT v9.1] | U.S. Department of Transportation Federal Highway Administration. (2022). Architecture Reference for Cooperative and Intelligent Transportation, ARC-IT v9.1. https://www.arc-it.net/index.html (accessed May 10, 2022). |
| [SE-ITS] | U.S. Department of Transportation, Federal Highway Administration, Federal Transit Administration. (2007). Systems Engineering for Intelligent Transportation Systems - An Introduction for Transportation Professionals. Washington D.C.: Department of Transportation, Office of Operations. |
| [BAA] | U.S. Department of Transportation, Federal Highway Administration. (2020). ITS4US Broad Agency Announcement. Washington D.C.: U.S. Department of Transportation. |
| [ACS] | United States Census Bureau. (2017). American Community Survey. Washington D.C.: U.S. Department of Commerce. |
| [ADA] | United States Department of Justice, Civil Rights Division. (2009). Americans with Disabilities Act of 1990. Washington D.C.: United States Government. |

# Appendix A. Acronyms

**Table 6** provides a summary of key acronyms and abbreviations used throughout the document.

**Table 6. Acronyms and Abbreviations**

| Acronym/Term | Description |
|---|---|
| ADA | Americans with Disabilities Act |
| API | Application Programming Interfaces |
| ARC | Atlanta Regional Commission |
| ATL RIDES | Atlanta Rider Information and Data Evaluation System |
| BOM | Bill of Materials |
| CAD | Computer Aided Design |
| CAP | Comprehensive Acquisition Plan |
| CDP | Connected Data Platform |
| CIP | Comprehensive Installation Plan |
| CMS | Content Management System |
| CV | Connected Vehicle |
| CVTMP | Connected Vehicle Technology Master Plan |
| CV1K | Regional Connected Vehicle Infrastructure Deployment Program |
| C-V2X | Cellular Vehicle to Everything |
| G-MAP | Georgia Mobility and Accessible Planner |
| GDOT | Georgia Department of Transportation |
| GJAC | Gwinnett Justice and Administration Center |
| GPR | Georgia Procurement Registry |
| GTFS | General Transit Feed Specification |

| Acronym/Term | Description |
|---|---|
| ICTDP | Integrated Complete Trip Deployment Plan |
| IMDF | Indoor Mapping Data Format |
| IMI | Integrated Mobility Innovation |
| INS | Indoor Navigation System |
| ITS | Intelligent Transportation Systems |
| Kio | Kontakt IO |
| LEP | Limited English Proficiency |
| OSS | Open-source Software |
| OTP | OpenTripPlanner |
| PMD | Performance Measurement Dashboard |
| PO | Purchase Order |
| RFI | Request for Information |
| RFP | Request for Proposal |
| RFQ | Request for Qualifications |
| RSUs | Roadside Units |
| SDK | Software Development Kit |
| ST-CTN | Safe Trips in a Connected Transportation Network |
| STP | System Test Plan |
| STM | Space Time Memory |
| TMC | Traffic Management Center |
| TSEF | Traffic Signal Electric Facilities |
| TSP | Transit Signal Priority |
| USDOT | United States Department of Transportation |

# Appendix B. Beacon Placement Guidelines

**The following content is sourced from the *CXApp Bluetooth Beacons – Placement Guidelines* document and provided herein in an accessible format.**

## Introduction

While CXApp On-Device Positioning's SDKs are built to be very flexible with respect to the locations of individual Bluetooth low-energy transmitters ('Beacons'), a developer or facility manager may desire to improve location performance by judiciously selecting the number and a priori locations of these devices to achieve better accuracy in some or all an indoor site. This section aims to provide generalized guidance for selecting the positioning and spacing of beacons in order to achieve best overall system performance for a given density of beacon laydown. In general, a more denser beacon network will lead to more accurate position on average, but through the use of our dead reckoning sensor fusion engine and proprietary Bluetooth signal location algorithms, the effectiveness of beacons at a location will be maximized by adhering to these guidelines.

## Placement

Key attributes of a 'good' beacon placement are explained in this section. Summary images are provided, but are not meant to suggest specific sites, specific beacon density or spacing. They offer a visual representation of the principles that should be adhered to when choosing beacon locations. The initial setup of beacons should use a 0dB broadcast signal strength, and a 5-Hz (200ms) broadcast repetition rate. These values will yield optimal levels of performance as a default laydown and correspond to a value of '0' in the XML file for the beacon 'power' field.

### Approximately Uniform Coverage

To achieve uniform accuracy over an area, it is strongly advised that beacons be placed with approximately uniform coverage over the entire area, varying by less than 30% in the grid spacing from beacon to beacon. Additional beacons can be placed for areas that requires 'higher value' for accuracy. However, no large gaps should be left in other areas if location service coverage is desired everywhere in the facility.

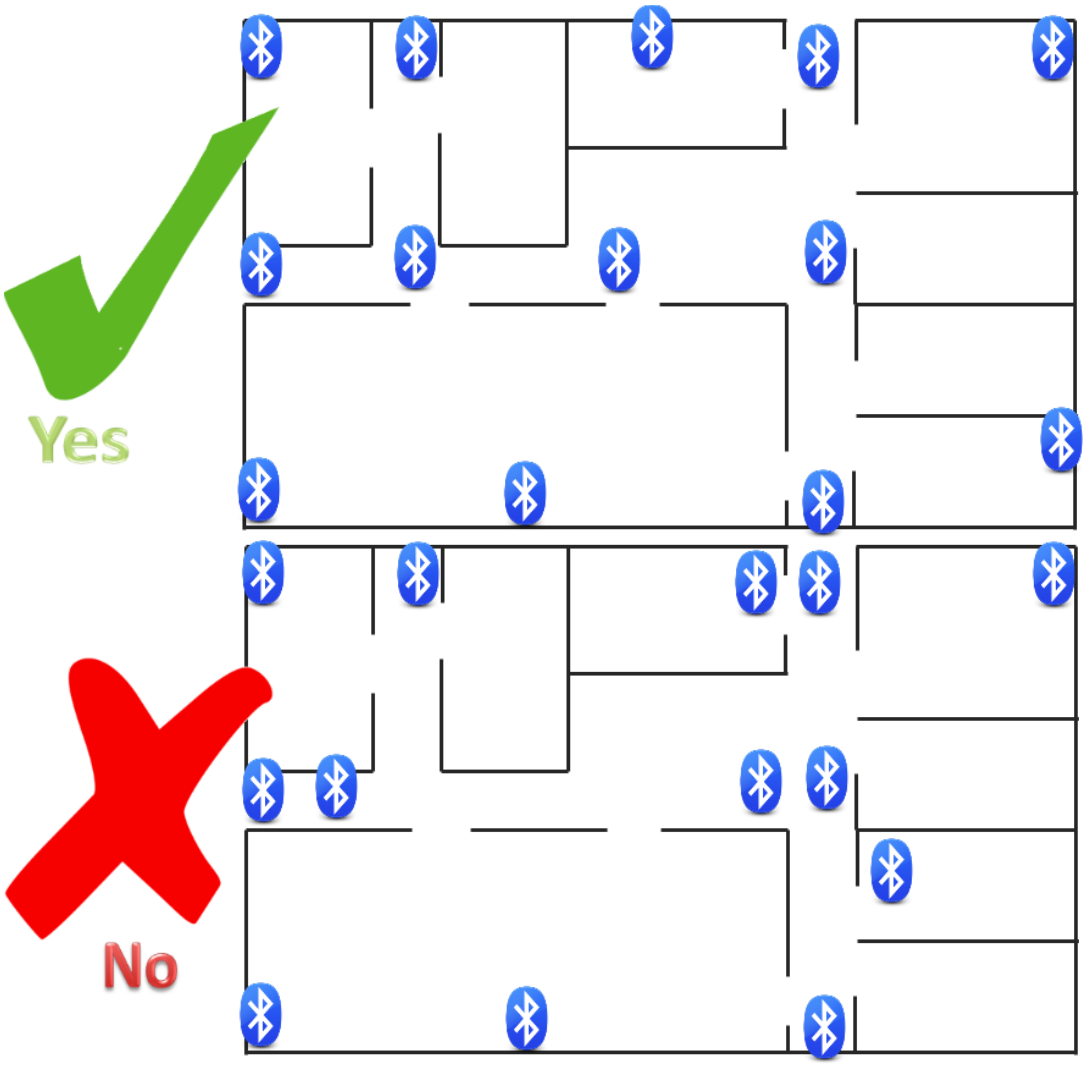



**Figure 14. Uniform Coverage**

### Focus on Junctions and High Traffic Areas

The dead reckoning / sensor fusion component of CXApp On-Device Positioning works very well to bridge the gaps between beacon receptions by accurately estimating user strides and directional motion. The periodic recalibrations that it performs will limit the drift on this sensor-based part of the solution, and the more times beacons are seen with high strength, the better the fusion algorithms will do in calibrating out / resetting biases. Beacons should be placed at high-traffic hallways, intersections of hallways, doorways to heavily used rooms etc. The more foot traffic a beacon sees walking past it, the more useful it will be to a facility's location solution accuracy. While attempting to maintain approximately uniform coverage, beacons should be placed in traffic areas and junctions where possible.

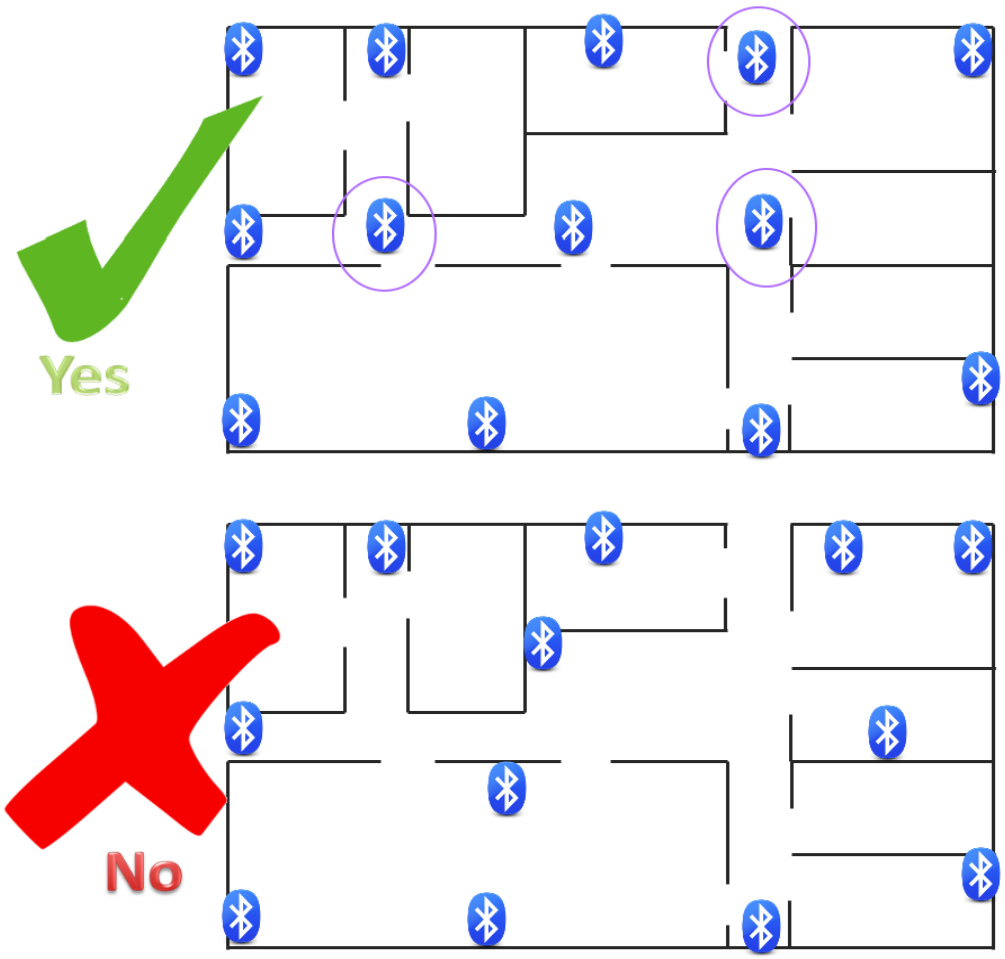



**Figure 15. Junctions and High Traffic Areas**

**Ensure Adequate Coverage Out to Perimeter of Facility**

Another functionality that CXApp On-Device Positioning offers is to see a wide geometric spread of beacon reception, from different directions around the user. The primary way to achieve this is to make sure that the beacon coverage extends out to the edges/walls of an indoor facility. Putting beacons at the desired spacing right along exterior walls is an effective way to ensure that this criterion is met to the greatest degree possible.

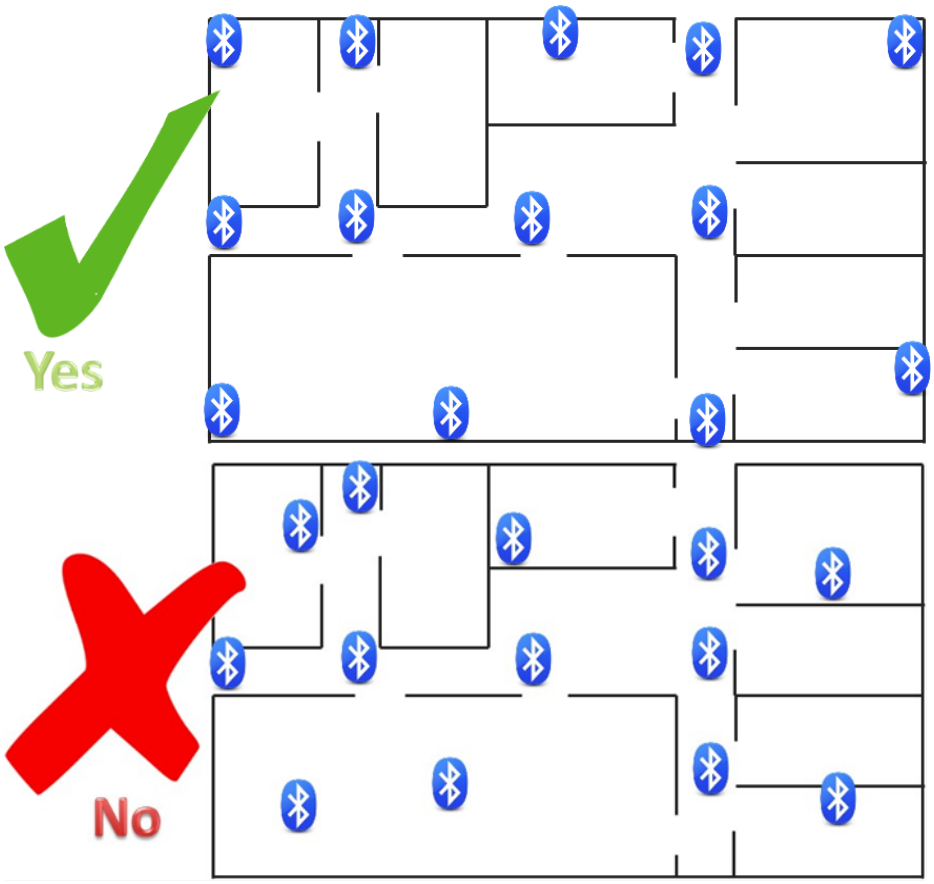



**Figure 16. Adequate Coverage**

### Avoid Obstruction

Bluetooth beacons use a radio frequency signal that performs best when it is received 'cleanly' by the user's phone or tablet, meaning that it travels directly from the beacon to the user's device without having to pass through, around, or reflected from any material in/around the physical straight-line path between them.

Objects, most notably ones containing significant metal, in this signal path can degrade performance. Beacons should be placed in a location where the clearest path possible between the beacon and any likely user locations, is maintained. Typically, this means placing beacons on the ceiling of a facility, but hiding them under wood furniture, plastic racking, behind gypsum or foam wall panels is also acceptable. CXApp's algorithms are actually resistant to some level of obstruction due to how beacons are sensed and incorporated into the position solution, but care should be taken to make sure that a signal is not fully blocked to the point that it cannot be reliably used. Some examples of 'good' placement practices are shown here, as well as one 'bad' example that could result in much higher errors.




**Figure 17. Example 1 of Placement Avoiding Obstructions**




**Figure 18. Example 2 of Placement Avoiding Obstructions**

### Avoid Placement Too High Above Users

While a ceiling installation has the most flexibility and appeal to most users, some facilities will have ceiling heights in excess of 15 feet (~5 meters) or more. For instance, large warehouses, which would require placing beacons in places where a user would never pass close enough to them to fully calibrate the position solution accurately. In these cases, choosing beacon locations on outward-facing pieces of racking/shelving, on support structures for the building, or on lower-hanging light fixtures, are all viable alternatives that will keep beacons near enough for users to pass by them and receive them reliably with high strength.

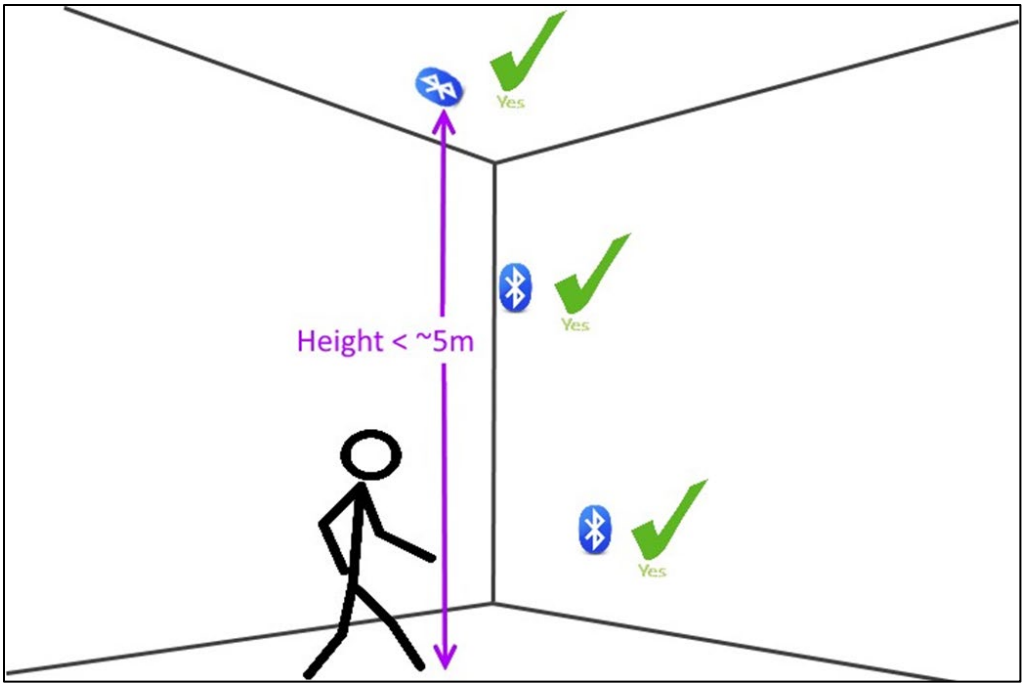



**Figure 19. Placement too High Above User**

Many of these criteria and guidelines will conflict and some judgement is still required to strike a good balance for optimal navigation/positioning performance. These sections have been arranged with likely highest priority coming first, though compromises will have to be made to find suitable yet logistically feasible placements for all beacons in a facility that will meet desired criteria for uniform coverage, placement at junctions and high traffic corridors, good perimeter coverage, lack of signal obstructions, and at an acceptable height above users.

In general, beacon strengths should be kept at the default value (0 dBm) independent of the placement height. However, it is expected that the average user will receive beacons at a slightly lower power when the transmitters are placed at a higher physical height. So, when adjustments are made to beacon strength parameters in the site XML file, using either the Laydown Tool or a manual editing approach. A lower value can be used to reflect this strength reduction. The adjustment in beacon strength due to height is expected to be no more than 3dB (so 3dB lower than the default value in the file) if the constraints above are followed. This would be needed only when beacons in a facility are set at different heights relative to one another.

**Maximum and Minimum Density**

Beacons work adequately with as closely spaced as 7-8 meters apart, yielding a density of approximately 600 square feet (56 sq.m.) per beacon coverage. Beacons as sparse as 20 meters apart yields for a coverage density of approximately 4500 square feet (400 sq.m.) per beacon. Our preferred density in retail stores, which yields aisle-level typical accuracy (1-3 meters), is a placement of beacons on a grid with about 10-11 spacing between beacons, for a coverage density of approximately 1200 square feet (110 sq.m.) per beacon. In a facility of 100,000 square feet (9300 sq.m.) in size, this would require 80 beacons to achieve full coverage at this accuracy level.

### Adjustment after installation

The basic use case for beacons in CXApp On-Device Positioning aims to require no special tuning on a per- beacon basis after the laydown is complete. Some facilities, due to unavoidable blockages of beacon signals, placement of beacons at drastically different heights from the floor, and other device-to-device variation, have benefitted from adjusting the individual strength corrections for each beacon. These strength corrections are supported by the site XML file that is produced by both our Mobile Laydown Tool in Android™ and on a PC through our Web Interface to our Map Server.

The primary use case for adjusting individual beacons comes from the desire to have the location solution more or less readily drawn to specific beacon locations by modifying the perceived reception power. To maintain a clean, low-noise, reception of the beacon signal, it is not recommended that the beacons themselves be set to broadcast lower power. In fact, the default configuration for beacons used, should always be maintained (0dBm transmit power, 5Hz broadcast rate / 200ms interval). Instead, the ‘power’ field of the XML file can be adjusted by a few dB at a time to change system behavior, making the value higher (more positive) if a user wants to see the computed location (in the app) not move to the beacon location as responsively, and making the value lower (more negative) if a user wants to see the computed location drawn to the beacon location with higher authority. A typical step size for trying to make minor modifications to system behavior is +/- 2dB.

A user can make these adjustments to the XML file and then attempt to re-test the system in real time using the Converge™ application or their own app that employs the Extend™ indoor location SDK, or they can make updates to the XML file on a Windows PC and then use the playback/simulation capabilities of the NavSim tool to rerun location algorithms on a collected log file with the new parameters and display the location performance on a map image. In this case, a log file only needs to be collected once, and a user can attempt multiple combinations of beacon strengths for arriving at the best tuning combination for location accuracy. It is recommended that multiple log files be used with this tool to ensure that a site is not too tightly tuned for what might be random signal fluctuations within a single scenario or log file. The ‘plot beacons’ option in the NavSim tool can be used to help indicate which beacons in the XML file correspond to specific transmitter locations on a map, as shown in **Figure 20** below.

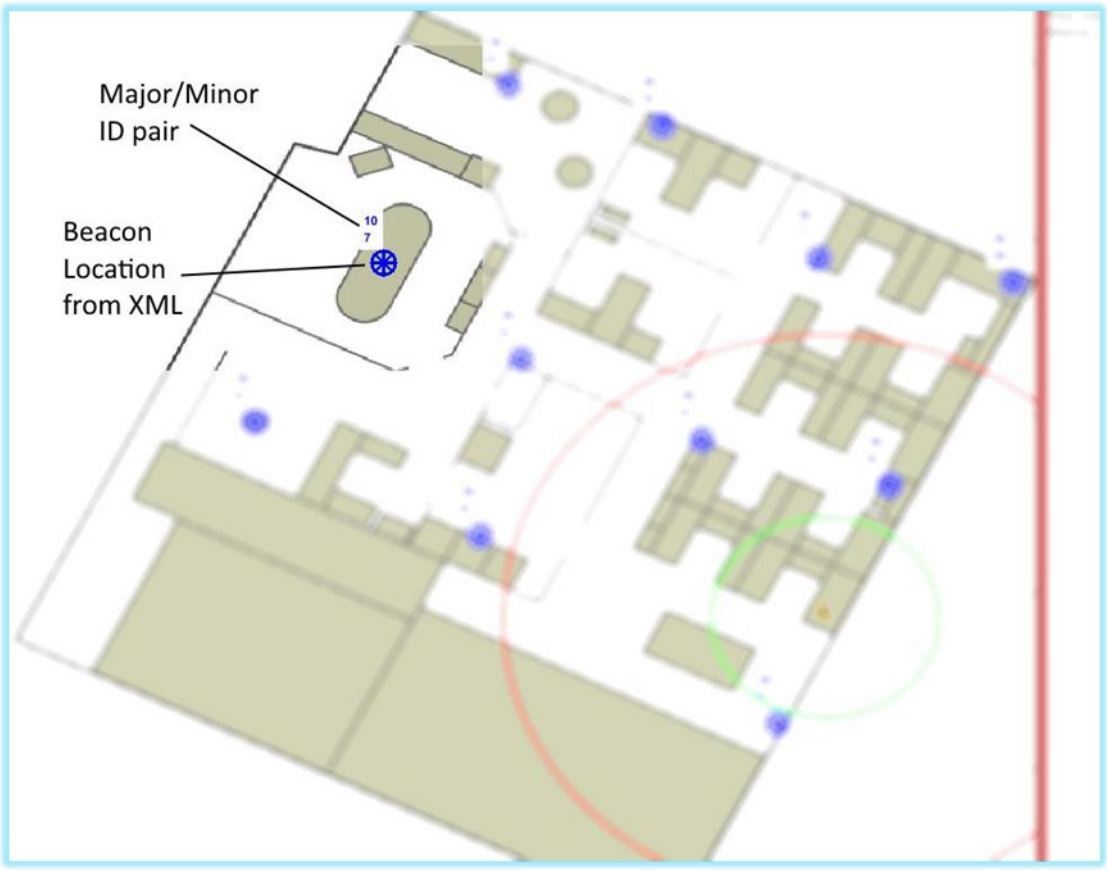



**Figure 20. Screen Sample from NavSim with Beacon Location and Major/Minor ID Indicated**

# Additional Caution

Different phone models will receive Bluetooth beacons at different strengths. It is strongly recommended that a phone that has seen successful navigation performance in the past be used when tuning individual beacon strengths. If it is found that EVERY beacon must be turned up or down in order to achieve best performance. Then it is likely that the phone being used for testing should have a different bias value entered. This bias value, on a per-phone model basis, is set in a file that is downloaded from CXApp map server and testing with alternate values can also be done in playback using the NavSim tool.

# Appendix C. Technical Specifications

## Beacon Technical Specifications

The technical specifications of anchor beacon can be found here:

Anchor Beacon specification: https://support.kontakt.io/hc/en-gb/articles/4413238409234-Anchor-Beacon-2-technical-specifications

Puck Beacon specification: Kontakt.io_-Puck-Beacon_Technical-Specification.pdf

## RSU Technical Specifications

The technical specifications of the RSU are shown below:

Danlaw C-V2X RSU:
https://www.danlawinc.com/hubfs/documents/datasheets/DS_RouteLink_RSU_V14.pdf?hsLang=en

# Appendix D. Location Diagrams

## Gwinnett County Justice and Administration Center Location Maps

Gwinnett County provides directions and parking information on their website here: [Gwinnett Justice And Admin Center - Gwinnett | Gwinnett County]. The following location diagrams represent the installed beacon locations.

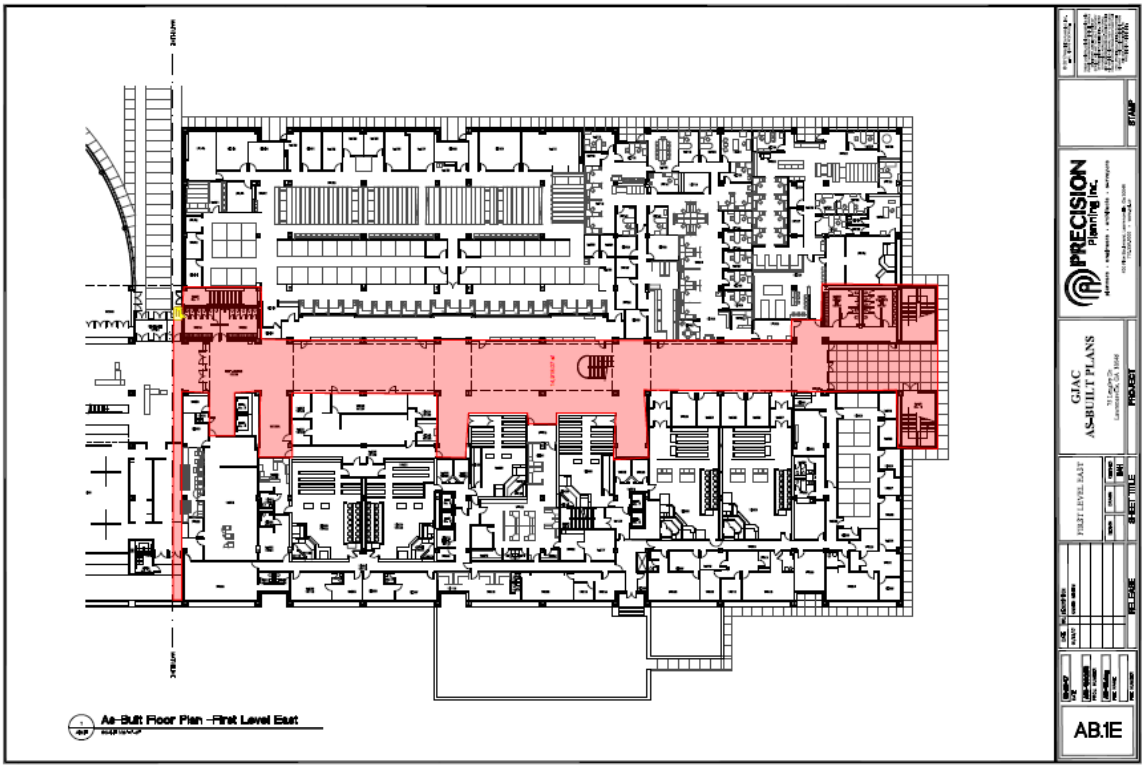



**Figure 21. GJAC – First Level**

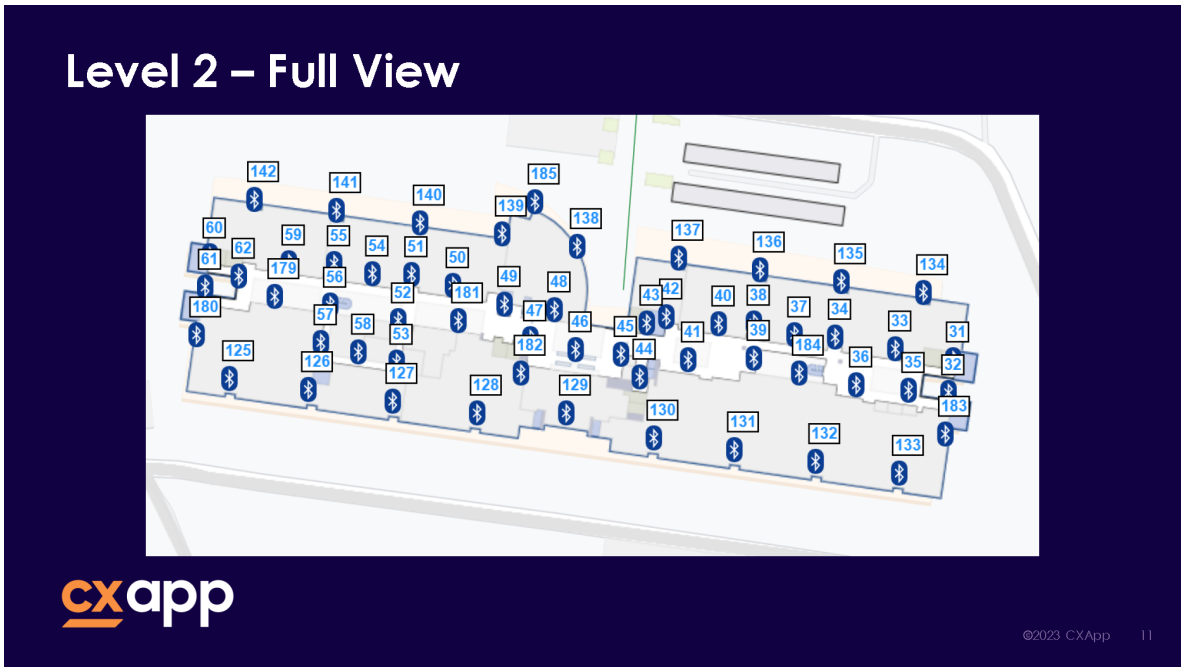



**Figure 22. GJAC – Second Level**

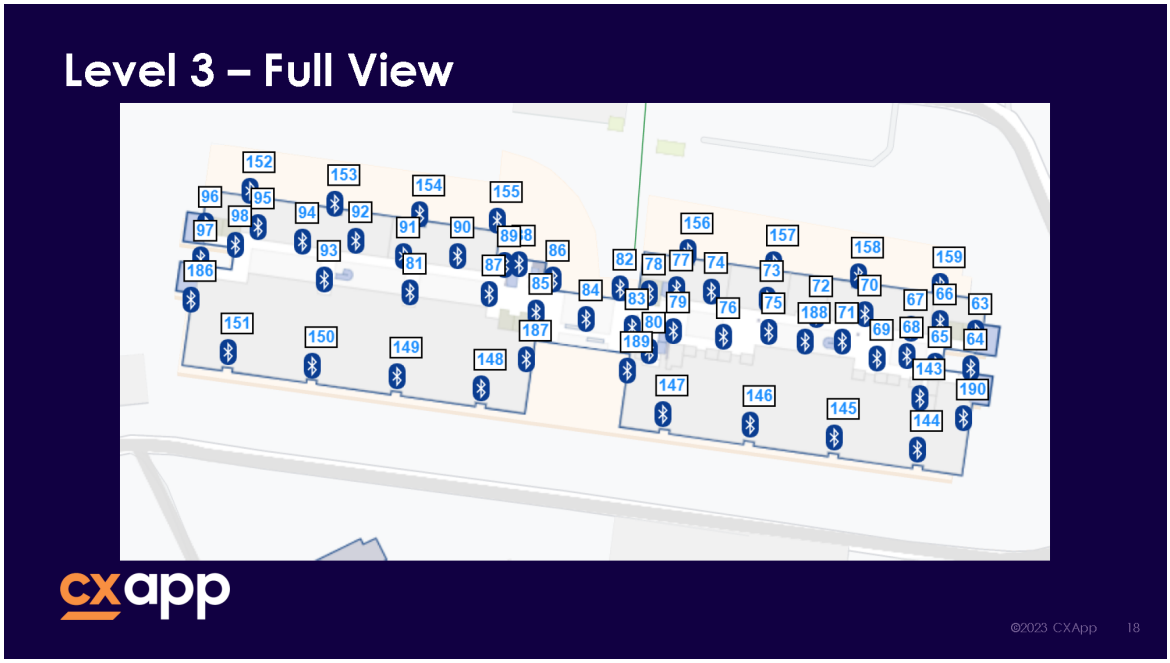



**Figure 23. GJAC – Third Level**

# Gwinnett County OneStop Norcross Location Maps

The following location diagrams represent the locations that will be serviced by the ST-CTN system. These diagrams will be updated with beacon locations denoted upon installation completion.




**Figure 24. Gwinnett County OneStop Norcross – Lower Level**

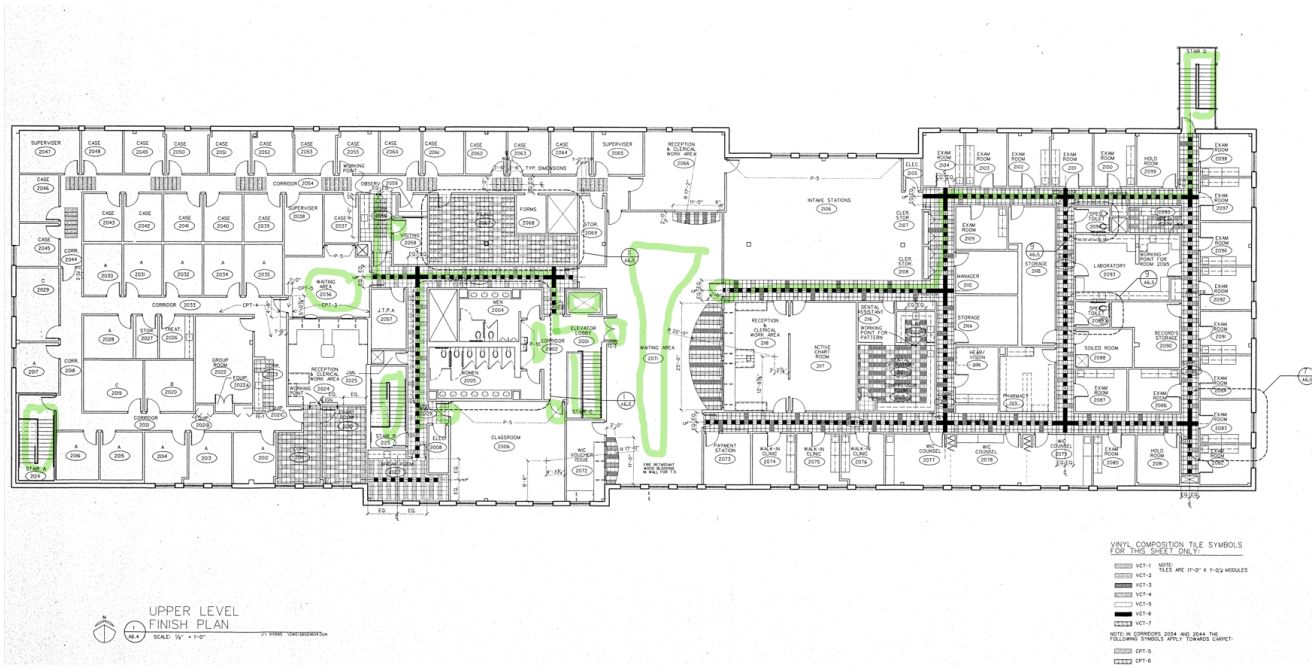



**Figure 25. Gwinnett County OneStop Norcross – Upper Level**

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FHWA-JPO-23-992



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