Phase 2 System Requirements Specification (SyRS)

Georgia Department of Transportation ITS4US Deployment Project

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Phase 2 Update – October 21, 2024

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16. Abstract

The GDOT 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.

This document serves as the System Requirements Specification (SyRS) for the deployment project. The SyRS is the next step of the systems engineering process in which the system needs of the ConOps are broken down to develop system requirements. The SyRS also defines the functional, physical, performance, data and interface requirements for the subsystems and system. The requirements also incorporate the datasets in the Data Management Plan, the safety needs and scenarios of the Safety Management Plan, and the performance measures for system monitoring in the Performance Measurement and Evaluation Support Plan. These requirements will be used in Phase 2 of the project to drive the design and deployment of the ST-CTN system.

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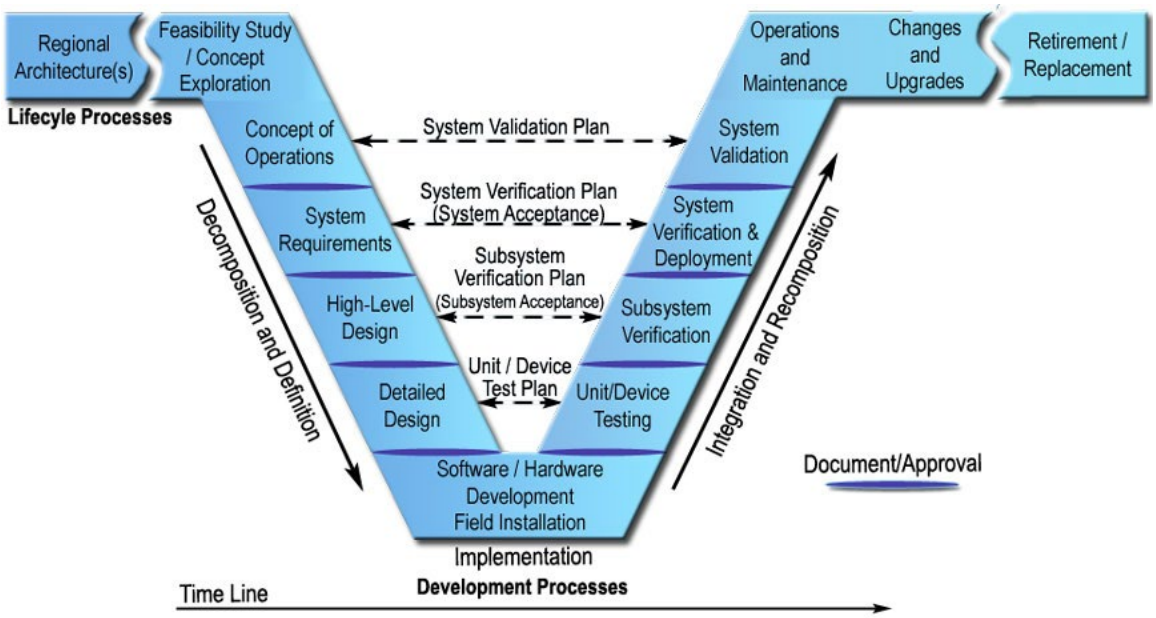
1. Introduction

This document serves as the System Requirements Specifications (SyRS) for the Safe Trips in a Connected Transportation network (ST-CTN) project led by Atlanta Regional Commission (ARC) in Gwinnett County, Georgia as part of U.S. Department of Transportation's (USDOT's) Complete Trip – ITS4US Deployment Program. The ST-CTN concept is comprised of an integrated set of advanced transportation technology solutions – connected vehicles (CV), transit signal priority (TSP), machine learning, and predictive analytics – to support safe and complete trips. The project seeks to enhance accessibility for travelers in underserved communities including those with disabilities, older adult populations, low-income communities, and limited English proficiency (LEP) communities.

Systems engineering focuses on defining customer needs and required functionality early in the development cycle; documenting requirements; and then proceeding with design synthesis and system validation while considering the complete problem. The "Vee" Diagram, shown in **Figure 1** , illustrates the systems engineering process beginning with a focus of defining user needs and required functionality early in the development cycle, documenting requirements, and then tracing those decisions throughout the implementation process.



Source: FHWA, 2005

Figure 1. The "Vee" Systems Engineering Process

The SyRS is based on the approved Concept of Operations (ConOps) document for the ST-CTN project. The SyRS uses end user needs, infrastructure owner operator (IOO) needs, and system needs to build requirements that describe the features and behavior of the system. Stakeholder needs identified in the ConOps are reviewed, analyzed, and transformed into verifiable

requirements that define what the system will do but not how the system will do it. Well identified requirements minimize risks to the deployment and allows for thorough testing of the system.

As the ST-CTN project progresses from concept definition (and planning) to design and testing, most components of the project will follow the systems engineering process outlined in **Figure 1 .** As such, the needs and desired capabilities identified in the ConOps drive the requirements outlined in this document. Several ST-CTN subsystems and their components will follow the "Vee" process while others will pivot to an agile process where requirements and solutions are refined through collaboration between self-organizing cross-functional teams. An agile method has been chosen for a subset of the requirements where flexibility, adaptive planning, and iterative design are needed to deploy the system quickly and effectively.

During Phase 2, several components of the system underwent a name change due to refinements in the system concept and as the team developed the concept design.

The multimodal trip planner ST-CTN application was previously named ATL RIDES because the existing application used for core functionality is called ATL RIDES. However, for simplicity for users, the ST-CTN application name was changed to the Georgia Mobility and Accessibility Planner (G-MAP).

The integration element, Connection Protection, was renamed to Ride Request for clarity on the element's purpose, which is to remotely request a ride and send an operator information about the traveler such as boarding and alighting a transit vehicle.

Gwinnett County's transit service underwent a name change and is now referred to as Ride Gwinnett. For simplicity, the acronym will remain GCT.

Since the inception of this project, VRU categories for impedance calculations are now referred to as mobility categories.

1.1 System Purpose

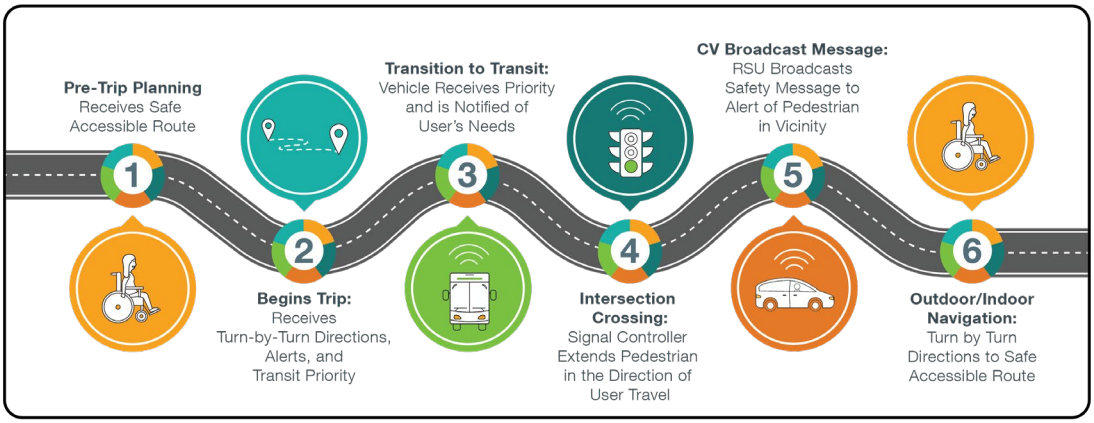
During the creation of the ST-CTN ConOps, the ST-CTN team identified what project stakeholders, specifically those from the underserved community, need from the proposed system. The end user group of stakeholders were introduced to the Complete Trip – ITS4US Deployment Program; provided with a high-level description of the ST-CTN concept; given a brief summary of existing known challenges; and then asked to identify challenges within their typical trips. From these discussions, user needs were created to describe what users needed out of the proposed system. Infrastructure owner/operators (IOO) were also interviewed, and their challenges were described and guided the development of IOO needs. Following those interviews, the System Needs were derived from the end user needs and IOO needs. These System Needs reflect the needs that drive system requirements and ensure consistency and traceability between the two sets of needs.

The SyRS document takes the needs created during the ConOps and transforms them into verifiable requirements that define what the ST-CTN system will do. They represent the means to define system acceptance (as shown in the line connecting the system requirements and system

verification and deployment stages in Figure 1). The system requirements do not define solutions to the issues identified in the system needs (i.e., type of hardware or software), but instead define what the system will do to provide a solution to meet the needs (i.e., receive data, process data, transform data, etc.). The system requirements that are developed in this document are traceable to the needs identified in the ST-CTN ConOps. Moving forward, test cases and system verification documents will be traced to the requirements to ensure the system requirement is implemented successfully.

1.2 System Scope

The ST-CTN project aims to upgrade and integrate existing technologies and services to assist underserved populations with completing their 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. 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 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 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/bicyclists in the vicinity.

    - Provides the ability for users to remotely request service from transit vehicles while waiting to board or alight.

    - Provides communications between CVs and users to make them aware of each other when crossing a roadway or waiting at a transit stop.

- **Step 6 Outdoor/Indoor Navigation.** The traveler is provided with turn-by-turn directions to a safe accessible route.

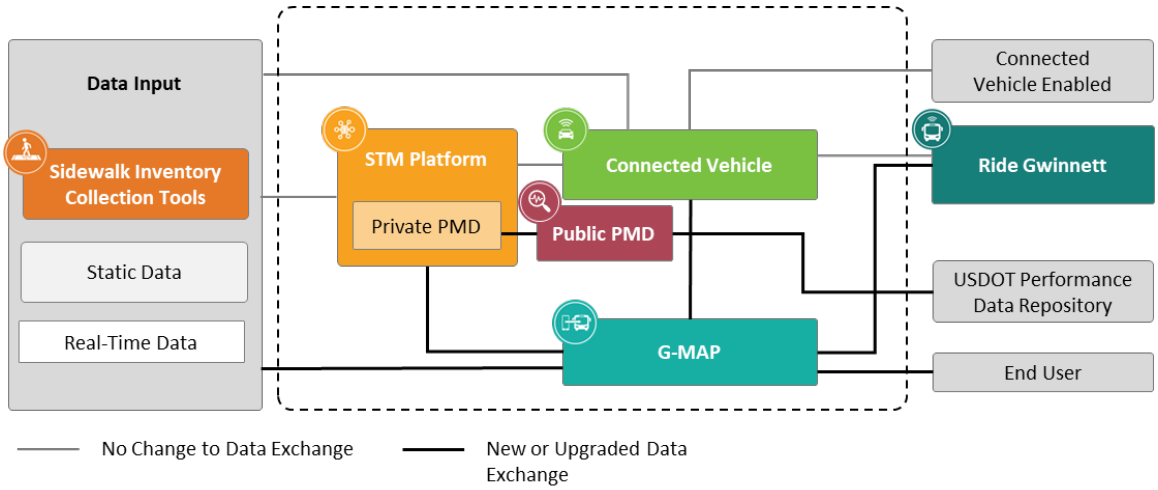
    - Hands-free navigation via mobile apps and/or wearables and accessible channels (haptic, voice, text).

    - 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 ST-CTN can be thought of as a *system of systems*; the scope of work required to develop, design, and deploy ST-CTN is focused on the expansion or enhancement of current systems and added connectivity between those systems. **Figure 3** provides a simplified context diagram of the proposed system – indicating the system of interest and added subsystem connectivity. Each subsystem is indicated by color and icon: Sidewalk Inventory Collection Tools is burnt orange; STM Platform is peach; CV is green; G-MAP is turquoise; Public PMD is maroon; and Ride Gwinnett (GCT) is teal. The STM Platform, ATL RIDES, and CV subsystems will each require expanded capability and added connectivity to support the proposed ST-CTN system. The Sidewalk Inventory Collection Tools and GCT existing independent systems will serve to support the proposed ST-CTN system. Data exchanges between subsystems are denoted by a gray or black line. A gray line indicates an existing and unchanged data exchange between subsystems. A black line indicates a new or upgraded data exchange between subsystems.



Source: GDOT, 2023

Figure 3. ST-CTN High-Level Context Diagram

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 document 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. Atlanta-Region 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). The tool supports multi-agency context, multilingual support, and mobile app turn-by-turn directions. The Open Trip Planner (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 will be 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 transit signal priority (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 costs 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,

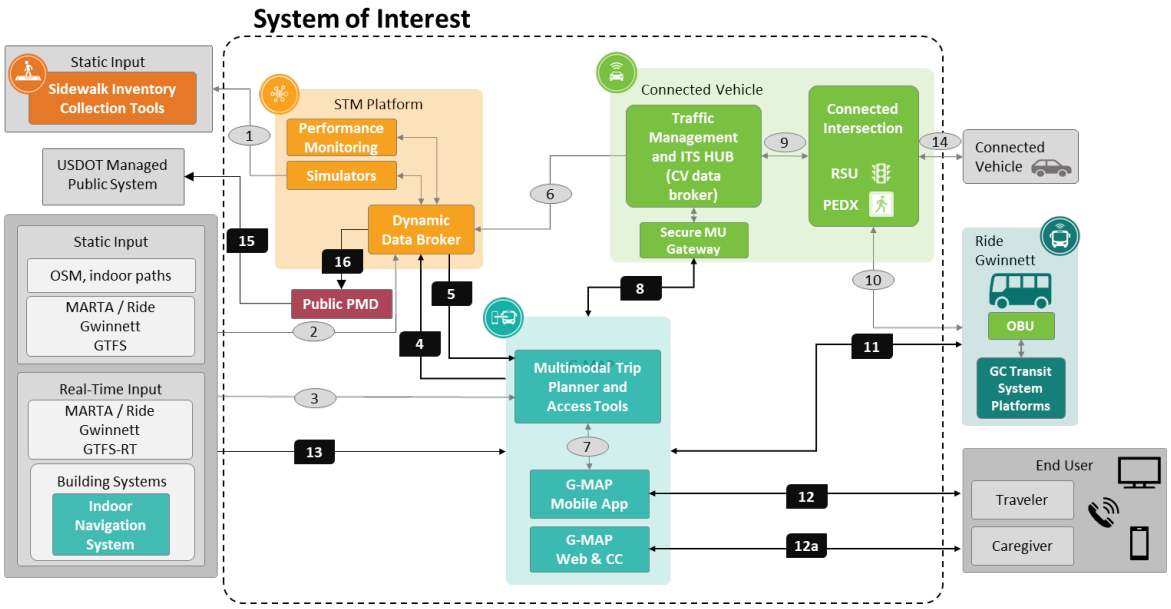
open and private datasets. The PMD will store the datasets so that they can be viewed and accessed based on user roles. The PMD will include a public PMD for the public to access open data presented on an interactive dashboard to the public.

2. General System Description

Section 2 provides a more detailed overview of the ST-CTN system, who the users are, and how each subsystem interacts with each other.

2.1 System Context

The five subsystems described in **Section 1.2** gave a broad overview of the system context. **Figure 4** provides more detail about how the subsystems will interact and be brought together under the ST-CTN system. The context diagram defines the internal and external subsystems as well as the data exchanges, interfaces to external systems, and interactions between the various components.



Source: ARC, 2021

Figure 4. Safe Trip in a Connected Transportation Network Data Exchange Flow Diagram

The G-MAP subsystem is contained within the light blue box in the lower-middle of the System of Interest. The G-MAP subsystem will contain the ST-CTN application and will be the subsystem that the end users interact with. The CV subsystem is contained within the green box in the upper-right of the System of Interest. The CV subsystem contains the components needed to receive and send CV messages and TSP or pedestrian crossing requests to connected signal controllers. The STM Platform subsystem is contained within the orange box in the upper left of the System of Interest. The STM Platform contains the processing system which evaluates routing choices and assigns impedance values. The GCT subsystem is contained within the teal box to the right of the System of Interest. The GCT subsystem contains on-board units (OBUs)

and the GCT central system. Other external inputs include the static or real-time (RT) input of data, represented by the grey boxes on the left side of the System of Interest; vehicles with CV hardware, represented by the grey box on the upper-right side of the System of Interest; and the end user, represented by the grey box on the lower-right side of the Systems of Interest.

Additional information and context on all of the subsystems, data exchanges, and external interfaces can be found in **Section 2.3**.

Critical ST-CTN data exchanges are identified by number in the context diagram above and described in **Table 1**. The grey oval labels indicate existing data exchanges that will be utilized with no change to the current data exchange. Black rectangular labels indicate data exchanges that will be new or upgraded to support the ST-CTN system.

Table 1. Critical ST-CTN Connection Descriptions

Data Exchange ID (EX ID)	Description
1	Sidewalk inventory data, including accessibility features to the STM Platform simulators
2	Static and dynamic data from various existing sources to the STM Platform dynamic data broker
3	Static and dynamic data from various existing sources to the G-MAP multimodal trip planner
4	G-MAP Mobile App logs and trip feedback
5	STM Network Impedance API
6	CV and Traffic Operations Messages: NaviGAtor intelligent transportation system (ITS), road characteristics, traffic data
7	Open Trip Planner APIs and G-MAP APIs
8	Mobile Accessible Pedestrian Signal System (PED-SIG)
9	CV messages
10	Transit signal priority and other CV application messages
11	Ride Request messages
12	G-MAP Mobile App APIs and Traveler exchange – profile, trip plan, settings, notifications, feedback, etc.
12a	Similar data flows to Data Exchange ID 12 with restrictions on viewing and changing certain data.

Data Exchange ID (EX ID)	Description
13	Dynamic information from building facilities (including beacons to G-MAP mobile app) and INS vendor cloud SDK
14	CV Data
15	Project data for USDOT-managed Public System
16	Public facing data and visualizations for reporting on system operations and performance

2.2 System Modes and States

This section describes the modes of operation for the proposed system.

Normal Operation: During normal operations the full system is functional and available to front facing and backend stakeholders. All objects in the environment are functioning normally and are being monitored by specified personnel.

Degraded Modes: In degraded mode, some or all of the subsystems are not functioning as intended. As the proposed system is a "system of systems," several degraded modes are explained below.

- If the Gwinnett County Department of Transportation (GCDOT) and/or GDOT communications network experience a loss of communications, the ST-CTN system will function with limited functionality depending on where the communications loss occurs. Degraded functionality could include the lack of STM real-time routing updates, TSP, and PED-SIG.
- If the STM Simulator experiences a loss of functionality, impedance values will not be provided to the G-MAP subsystem. The G-MAP subsystem, including the G-MAP Mobile App will be able to function in a degraded mode by providing routing information to the end user, but will not be able to provide accurate impedance values.
- If communication between the Sidewalk Inventory and the STM Platform is interrupted, accurate, real-time, impedance values for travel will not be provided to the G-MAP subsystem. The G-MAP subsystem, including the G-MAP Mobile App will be able to function in a degraded mode by providing routing information and historical impedance values for travel to the end user.
- If the Dynamic Data Broker experiences a loss of functionality, impedance values for travel and CV functionality will not be available for the G-MAP subsystem. The G-MAP subsystem, including the G-MAP Mobile App will be able to function in a degraded mode by providing routing information to the end user, but will not be able to provide accurate impedance values for travel. Additionally, connection to the CV subsystem will be severed if the Dynamic Data Broker experiences a loss of functionality. GCT will still be able to issue TSP commands, but pedestrian safety messages or pedestrian signal requests will not be available.

- If the Traffic Management or ITS Hub experience a loss of functionality, CV functionality will not be available to the G-MAP subsystem or the GCT subsystem. The G-MAP subsystem, including the G-MAP Mobile App will be able to function in a degraded mode by providing routing information and impedance values for travel to the end user, but pedestrian safety messages, pedestrian signal requests, and TSP will not function. When communication loss to the CV subsystem is detected, the STM subsystem will be able to add a penalty to the impedance value for travel.
- If the connected intersection portion of the CV subsystem experiences a loss of functionality, through device failure or communication loss, CV functionality will not be available for all or part of the G-MAP subsystem or GCT subsystem. Communication or device malfunction can impact the performance of isolated parts of the CV subsystem or can be widespread throughout the entire project area. Regardless of the scale, the G-MAP subsystem, including the G-MAP Mobile App will be able to function in a degraded mode by providing routing information and impedance value for travel to the end user, but pedestrian safety messages, pedestrian signal requests, and TSP will not function for all or part of the network. When communication loss to the CV subsystem is detected, the STM subsystem will be able to add a penalty to the impedance value for travel.
- If GCT OBUs experience a loss in functionality, through device malfunction or communication loss, TSP functionality will be interrupted. The G-MAP subsystem, including the ATL RIDES Mobile App will be able to function in a degraded mode by providing routing information, impedance value for travel, pedestrian safety messages, and pedestrian signal requests, but the full functionality of TSP will be interrupted. The scale of the outage (i.e., a single OBU vs multiple OBU malfunctions) will determine the level of degradation the system experiences.
- If the GCT System Platform experiences a loss in function, travel requests for service will be interrupted. TSP functionality operates independent of the subsystems ability to connect with the G-MAP subsystem, meaning TSP will still be available for buses running behind schedule. The G-MAP subsystem, including the G-MAP Mobile App will be able to function in a degraded mode by providing all services outside of travel requests for service.
- If the Building Access Wayfinding Assets experience a loss in functionality that is not able to be supported through use of the building beacons, either through malfunction of communication loss, indoor wayfinding functionality will be interrupted. The G-MAP subsystem including the G-MAP Mobile App will be able to function in a degraded mode by providing all services outside of indoor navigation. (Note: beacons were added following publication of ConOps 1.0 and will be included in subsequent versions).

Failure Mode: In failure mode, the ST-CTN application is not available to the end user in an operational or degraded mode. There are several scenarios that could cause the system to operate in failure mode, these include:

- If the G-MAP Mobile App experiences a loss of functionality, end users will not have functional access to the ST-CTN application. Trip feedback will not be provided to the STM Platform during this time, but all other system functions may remain operational.
- If the G-MAP Multimodal Trip Planner and Access Tools experiences a loss in functionality, the ST-CTN application will not function. Subsystems that push information

to G-MAP Multimodal Trip Planner and Access Tools may still be able to communicate and provide data without any loss.

2.3 Major System Capabilities

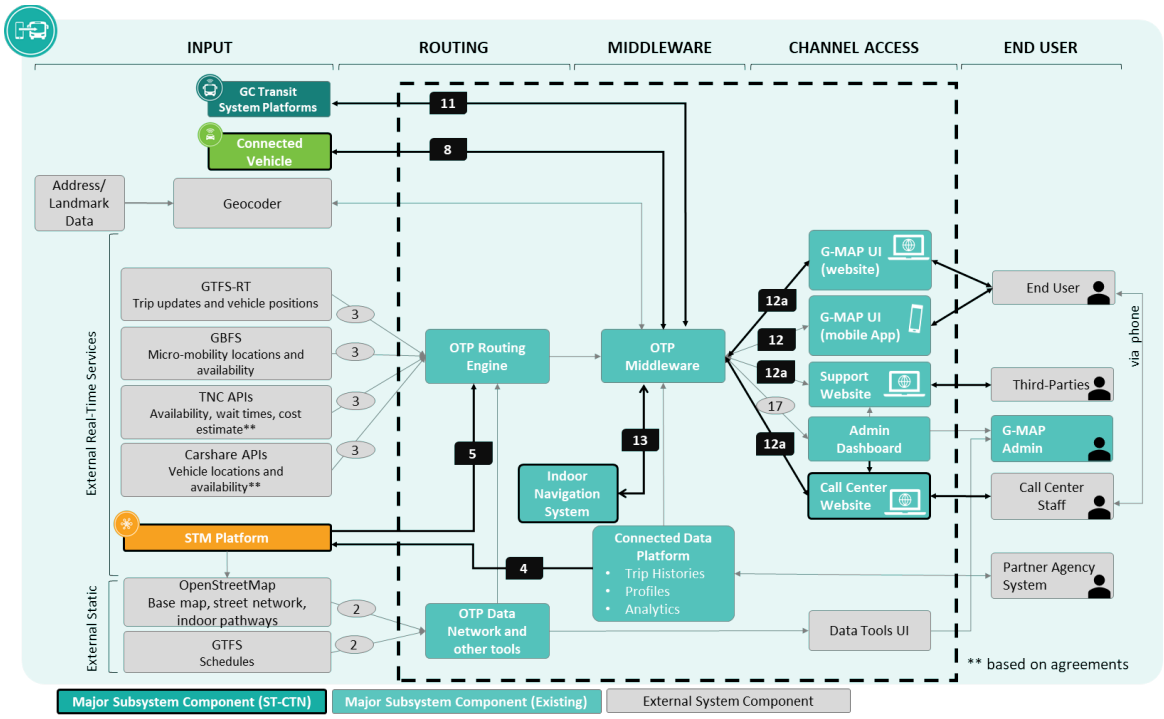
This section highlights the major capabilities of the ST-CTN system and introduces the groupings for the system requirements. This section expands on **Figure 4** and provides in depth descriptions of the subsystems, external interfaces, and data exchanges. All subsystem context diagrams with added functionalities and connectivity presented in bold. Existing capabilities may ***utilize*** existing functions with new functions, or ***leverage*** functionality by adapting existing functions with new or upgraded capabilities. These terms are used throughout this document to identify the different methods by which the system will be developed. The term ***augment*** indicates a generic method that does not differentiate between utilize or leverage.

2.3.1 G-MAP Multimodal Trip Planner Subsystem

ATL RIDES is being developed with the support of FTA's Integrated Mobility Innovation (IMI) Grant program and is a journey planning application to provide more reliable and easier to access transit data to all travelers making it easier to utilize the region's transit services.

Description. As described in the ConOps, the G-MAP context diagram will be augmented to support more infrastructure features, user routing and accessibility preferences and notifications, and ingest dynamic information from the STM Platform and output personally identifiable information (PII)-free and performance measures to the STM Platform for evaluation purposes.

Functions. Figure 5 provides the current G-MAP architecture major subsystem components along with the proposed augmentations that will be required to address system needs as described in the ConOps. The current functionality will continue to operate, and these extensions will drive additional fields, configurations, and algorithms already implemented in the software. Specifically, the extensions are listed by functional components in this section.



Source: ARC, 2021

Figure 5. Proposed ATL RIDES Subsystem Extension

Channel Access (responsive web application, native mobile app, and call center) – New features that augment the current functionality for the ST-CTN include the following:

- Additional user preference settings such as through path dimension, features, and condition of shared use paths (sidewalk and intersections), indoor navigation needs (elevators/escalators), assistive device types (wheelchair type) and support aides (service dog, caregiver), sensory delivery of event triggers and notifications (for hands-off operation), third-party user support (e.g., dial caregiver or guardian), and turn by turn direction support will be added to the existing profile description and routing engine.
- Specific notifications to additional recipient(s) (e.g., arrived at destination).
- Synchronization with user device(s).
- Presentation of mobile app notifications to users based on their preferences (e.g., voice, text, haptic).
- Trigger settings to connect to infrastructure and transit assets (pedestrian crossing request, bus stop request) as well as sending notifications to a specified asset when approach / arrive at transition point.

It is expected that additional features may be added based on the Agile processes during Phase 2 of the ST-CTN project.

Middleware – New features that augment the current functionality for the ST-CTN include the following (Note: "*" indicates that the interface was identified after developing the ConOps):

- Interface with call center to handle calls from phones.
- Interface with the STM Platform and STM Network Impedance API for real-time network impedance for feedback on user trip itineraries and obstacles to travel.
- Interface with SMUG and traffic signal controller for PED-SIG.*
- Interface with GCT CAD for Ride Request*
- Interface with beacons for indoor navigation.*

Routing – New features that augment the current functionality for the ST-CTN include the following:

- Incorporate Open Street Map (OSM) graph for sidewalks and roadways using impedance value updates from STM impedance API (update frequencies to be defined in Phase 2 of the ST-CTN project). This new feature will incorporate the information from the STM Network Impedance API and use that network for routing in the OTP routing module.

Data and Administration Tools – The data and administration tools provide data management and curation services for specific data such as GTFS and GTFS-Flex, as well as generate performance metrics and business to business communications with agency partners. These functions will not be augmented as part of this project except for generating and accessing new performance measures which will be shared with the STM Platform to generate evaluation measures.

Interfaces. Current and new interfaces will be deployed in the G-MAP subsystem. New interfaces will include (Note: "*" indicates that the interface was identified after developing the ConOps):

- Static Data Input
  - Beacon location for indoor navigation.*
  - Connected signal system.*
- Real-time Data Input
  - STM Network Impedance API.
- Output APIs and Services
  - Performance data output to the STM Performance Measurement Dashboard.
  - Data exchange between the mobile app and the GCT mobile data terminal (MDT).
  - Data exchange between the mobile app (mobile unit (MU)) and other CV applications including the PED-SIG application.
  - Traveler input of asset conditions submitted through G-MAP.

Description of these interfaces are included in **Section 2.3.4** (System Interfaces and Interoperability) and **Section 2.3.5** (External System Interfaces).

Operating Environment. Given the production needs of G-MAP, the infrastructure will be hardened to ensure subsystem reliability, scalability, and availability. The G-MAP routing engine and middleware are cloud hosted on Amazon Web Services and sit behind a load balancer, allowing for scaling of resources to match level of use of the system.

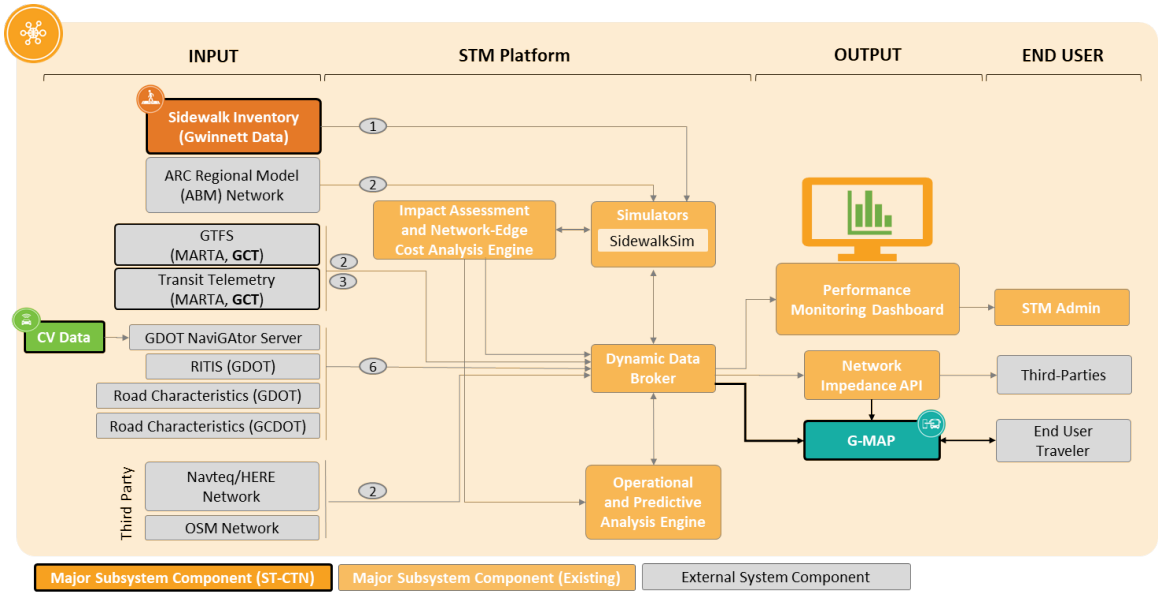
The G-MAP mobile app will be available for users to download via the Apple AppStore and Google Play stores. These App Stores also manage upgrade distribution for G-MAP to help ensure users are running the most recent version of the app available.

Modes. The modes of operation will not change from the current system and are further described in **Section 2.2** (System Modes and States).

2.3.2 Space Time Memory Platform Subsystem

The STM Platform predicts trajectories through the multimodal network based on network characteristics as congestion evolves in time and space and to provide users with more realistic estimates of commute duration, impedance value, and energy use across alternative departure times, routes, and transportation modes.

Description. The STM Platform Subsystem will be deployed with the current functionality and the extended functionality as described in its roadmap (see the ConOps). Developed as a research platform, the platform will be hardened to be deployed as a production system to work in conjunction with the CV ITS Hub and work in collaboration with the G-MAP subsystem to generate walking and traffic graphs personalized for traveler preferences and abilities. The production model will be updated to increase the origin-destination shortest path query response speed and will be integrated with new real-time data streams. **Figure 6** provides the proposed STM Platform subsystem context diagram with added functionalities and connectivity presented in bold.



Source: ARC, 2021

Figure 6. Proposed STM Subsystem Extension

The overall architecture and functionality of the system will not change, rather, additional input, such as completing an inventory of the sidewalk network within the project area, and output data flows will be added or updated, and some component functionality will be upgraded. The upgrades are described for functions, interfaces, support environment, and modes.

Functions. Upgraded and expanded functions are described below.

Dynamic Data Broker – The dynamic data broker will be extended to ingest additional data sources. The expanded data sources include the following:

- GTFS and General Transit Feed Specification – Real Time (GTFS-RT) data from GCT
- CV data from the GDOT CV ITS Hub
- Augmented static sidewalk data from the sidewalk inventory tools
- Augmented dynamic asset condition data feeds from new public facing Sidewalk Scout API (which will be incorporated into G-MAP mobile app)
- Feedback from G-MAP on traveler trips (and travel pathways)
- Traffic, wayfinding and safety assets located in pathways
- Indoor pathways and obstacles including vertical conveyances (elevators, escalators, and stairs)

Simulators – After creating an inventory of the infrastructure in the study area, the SidewalkSim simulator processes will be upgraded to generate routing graphs (navigable maps) customized for various underserved groups identified among the user classes. These graphs will be capable of including indoor navigation features such as locating the most appropriate accessible entrance, navigating to operating elevators, and more. The graphs will depend on the information available to generate the graphs. To ensure compatibility with the current G-MAP app, the OSM network will be regularly updated to reflect changes in static network elements identified via SidewalkSim inventory and inspection tools outlined in the ConOps and as machine-learning processes identify network refinements that can increase route efficiency.

- Sidewalk network changes will be updated by Gwinnett County, regular sidewalk inspections, and agency field inspections and crowdsourced reporting via the G-MAP feedback function.
- Sidewalk infrastructure conditions will be associated with sidewalk links, ramps, curb cuts, and other elements that are explicitly tracked. These elements will be updated regularly via regular Sidewalk MV and Sidewalk Sentry inspection, and via agency field inspection and crowdsourced reporting from the G-MAP adapted Sidewalk Scout content.

Impact Assessment and Network-Edge Cost Analysis Engine – The Network-Edge Cost Analysis Engine will undergo the most critical upgrade because these algorithms calculate the customized impedance value for traveling on a segment of the trip.

Impact Assessment and Network-Edge Cost Computing Engine – The Network-Edge Cost Computing Engine will undergo the most critical upgrade because these algorithms calculate the customized impedance values for traveling on a segment of the trip. Different penalties will be associated to sidewalk features based on different user class vulnerabilities. For example, rough sidewalks, crosswalks without curb cuts (or narrow curb cuts), debris or potholes in pathways will score high impedances for people with mobility challenges. Permanent protrusions (i.e., architectural features) and temporary protrusions (i.e., low hanging branches) will narrow the walking path and score high impedance values for people with vision loss. Permanent protrusions will be documented during the sidewalk inventory and temporary protrusions will be crowd sourced and removed when obstacle is unverified or expired.

The algorithms will be upgraded to assign impedance values to different features based on an enumerated set of preferences that are consistent with the G-MAP user created profiles (see **Section 2.3.1** Channel function). The functionality of the proposed system will be worked out in the design phase of this project and will be highly adaptive, allowing GA Tech to specify any set of impedance functions for various disabilities and ranges, mode, or sub-mode.

Operational and Prediction Analysis Engine – As noted in the existing STM platform, Operational and Prediction Analysis Engine serves as the machine learning function of the STM Platform. This module will consume feedback from traveler's execution of their trip plans and will update the Cost Analysis Engine edge costs based on changes made by users of the tools. The processes are already implemented in the platform, the extension will be to interpret planned versus actual travel of various user classes.

Performance Monitoring Dashboard – The performance monitoring dashboard will serve as the performance monitoring engine for the project both for evaluation of the pilot as well as computing and tracking performance and safety measures. The performance monitoring engine will track performance characteristics, such as volume and frequency of requests, response speeds, and data throughput. Comprehensive performance monitoring metrics will be developed and included in the Performance Measurement and Evaluation Support Plan (PMESP).

Interfaces. The STM Platform will add or upgrade two interfaces, represented by Data Exchange ID 4 and 5 in **Figure 6.**

OSM updates (new) – The STM Platform will transform the continuously updated simulations (transit, traffic and sidewalk Sim models) to an OSM network model that can be ingested into the G-MAP OTP engine. The updated SIM graphs will include awareness of current impedance penalties by integrating real-time information about disruptions, obstacles, and traffic on roads and pathways. The frequency of the update and shared storage of the OSM model will be at a rate and location available for G-MAP to consume.

STM Network Impedance API (new) – The STM Network Impedance API will communicate changes in network impedance values in OSM/OTP data structures that can be used by the G-MAP app. The API will be developed during the Agile development phase in collaboration with STM and G-MAP platform developers.

Operating Environment. Given the production needs of the STM Platform, the infrastructure will be hardened to ensure subsystem reliability, scalability and availability. The system requires a dedicated server environment in a cloud-based infrastructure. This will ensure scalability and redundancy to meet reliability and expansion needs.

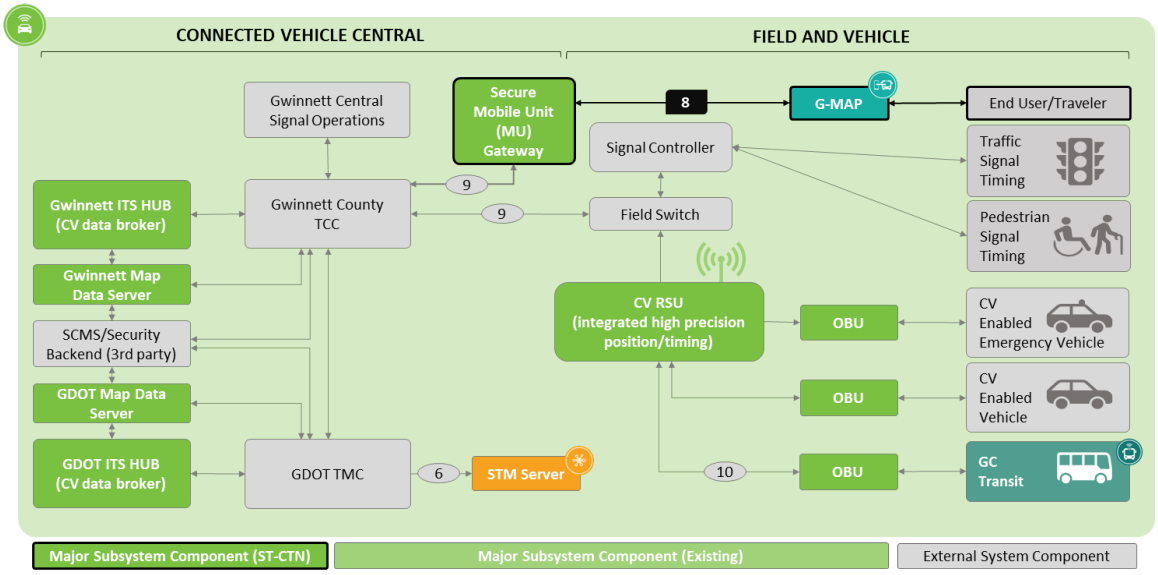
Modes. The STM Platform will include the current modes of operation with additional modes to ensure operations in the broader system. The ST-CTN modes of operation are described in **Section 2.2** (System Modes and States).

2.3.3 Connected Vehicle Subsystem

The CV Subsystem is composed of the systems included as a part of the Gwinnett County and GDOT CV programs. Gwinnett County and GDOT are leaders in the deployment of CV infrastructure.

Description. The subsystem will leverage the current CV components deployed in the Gwinnett County Connected Corridor and the GDOT CV1K projects including all the center, roadside, and vehicle components. Additional RSUs may need to be purchased to accommodate the full ST-CTN project area or if transit routes are changed. Devices that are currently deployed have been transitioned to comply with Federal Communication Commission (FCC) Report & Order and are operating on a single channel (Channel 180). Existing services are operating sufficiently on a single channel. Additional testing will need to occur in Phase 2 of the ST-CTN project to determine if operating on a reduced set of channels will have an impact on new services. As described in the current system, the center components consist of components located at the GDOT Traffic Management Center (TMC) and Gwinnett County Transportation Control Center (TCC) – Navigator TMC, MaxTime/View signal operations, Security Credential Management System (SCMS), MAP Server and ITS Hub connected through GDOT communications network. The roadside components consist of traffic signal systems owned and operated by GDOT and Gwinnett County. The equipment and operations of the subsystems will not be changed in the ST-CTN project.

To achieve the goals of this project, that is, more effectively integrating the MUs (pedestrian and other vulnerable road users (VRU)) into the CV environment, this project will deploy a center to center communications that will connect the CV Subsystem's pedestrian signal system through the Secure Mobile Unit Gateway (SMUG) with the Traveler supported by G-MAP as depicted in **Figure 7.**



Source: ARC, 2021

Figure 7. Proposed CV Subsystem Extension

Functions. The functions will be driven by the applications that are deployed by the CV Smart Corridor project, as detailed further in the ConOps, which include the following:

- Transit Signal Priority (TSP)
- Generation and collection of MAP, SPaT and PSM messages
- Pedestrian in Signalized Crosswalk Warning

An additional component, the SMUG will be deployed in the proposed system to enable communications between the MU and pedestrian signal system equipment which will implement the Mobile Accessible Pedestrian Signal System (PED-SIG).

Secure Mobile Unit Gateway – The SMUG will serve as a secure means of exchanging information between an MU (or proxy such as the G-MAP subsystem) and the CV environment. The MU Gateway serves to provide authenticated access, validate messages, transform and direct the messages to the appropriate destination.

Additionally, each application will include additional logic to ensure conformant message exchange protocols are deployed. An initial set of applications are proposed, the highest priority ones include TSP, PED-SIG, and Pedestrian in Signalized Crosswalk Warning. These applications along with the medium and low priority applications are described further in **Table 5** (located in **Section 2.6.2**).

Interfaces. Interfaces used to exchange information between the CV components (RSU and OBU) will be based on SAE J2945 series messages. Additional message sets will use NTCIP standards including NTCIP 1201 and 1202.

The interfaces will occur between the following CV components:

- RSU and OBU on Gwinnett Transit bus (for TSP)
- RSU and OBU on vehicles (for pedestrian safety applications)

The pathways between the MU and field components (RSU) and transit bus (OBU) may be channeled through various subcomponents of the G-MAP and CV subsystems.

All communications between the CV subsystem and other subsystems will only be accepted and trusted if the appropriate security headers have been applied through a trusted security credentialing system or application of firewall rules and procedures (if not explicitly a CV component, e.g., SMUG end-point).

Operating Environment. The CV subsystem support environment consists of communications network infrastructure, OBUs, RSUs, and TMC/TCC/ITS Hub as described below.

Communications Network – The CV subsystem will be supported by the existing communications infrastructure which consists of fiber optic cable and wireless devices.

OBU – The OBU is supported by the router and onboard equipment (automatic vehicle location (AVL) and processor) already deployed in the transit vehicles, in addition to the wireless communications radios that connect the bus systems back to the transit computer aided dispatch (CAD).

MU – The MUs may be supported by several communications technologies including Bluetooth, WiFi and cellular, and navigational sensors such as GPS and accelerometers which support location positioning. The MUs will only communicate through the G-MAP backoffice which acts as its proxy. This ensures a trusted end-point for accessing the CV subsystem.

TMC/TCC – The TMC/TCC will support the proposed CV subsystem as is consistent with the existing CV infrastructure. The ST-CTN system will not impact day-to-day TMC operations but will

offer the ability to provide TMC/TCC staff more data through the STM Platform to use for performance monitoring within the transportation network within the ST-CTN deployment area.

ITS Hub – The ITS Hub will support the proposed CV subsystem as is consistent with the existing CV infrastructure.

Modes. The modes of operation will not change from the current system and are further described in **Section 2.2** (Major System Capabilities).

2.3.4 System Interfaces and Interoperability

All system interfaces to be exchanged between subsystems in the ST-CTN and external sources are identified by numbered links in **Table 1** and **Figure 4.** These system interfaces are described more comprehensively below in **Table 2**. Several of these interfaces are already developed and implemented. During the design phase, they may be updated to accommodate additional functionality.

Table 2. ST-CTN System Interfaces and Interoperability

Interface	Description
Data Exchange 1	Sidewalk inventory data, including accessibility features to the STM Platform simulators
Subsystems Involved	From Sidewalk Inventory Collection Tools external to the system (see for source details) to STM simulators
Exchange Description	No major change. Sidewalk and pedestrian path asset characteristics within the ST-CTN deployment area which include accessibility features like sidewalk roughness, slope, curbs, obstructions, etc.
Data Exchange 2	Static and dynamic data from various existing sources to the STM Platform dynamic data broker
Subsystems Involved	From various existing data sources external to the system (see for source details) to STM
Exchange Description	No major change. May be expanded to accept additional data sources as available outside the scope of the ST-CTN project.
Data Exchange 3	Static and dynamic data from various existing sources to the G-MAP multimodal trip planner and access tools
Subsystems Involved	From various existing data sources external to the system (see for source details) to G-MAP
Exchange Description	No major change. May be expanded to accept additional data sources as available outside the scope of the ST-CTN project.

Interface	Description
Data Exchange 4	G-MAP Mobile App logs and trip feedback
Subsystems Involved	From G-MAP to STM
Exchange Description	New data exchange. G-MAP Mobile app log files which include all the trips, trip preferences and travel results will be forwarded to the STM dynamic data broker for analysis and aggregation into performance measures.
Data Exchange 5	STM Network Impedance API
Subsystems Involved	Between STM and G-MAP
Exchange Description	New data exchange. The STM Network Impedance API will communicate changes in network impedance values in OSM/OTP data structures that can be used by the G-MAP app. The API will be developed during the Agile development phase in collaboration with STM and G-MAP platform developers.
Data Exchange 6	CV and Traffic Operations Messages: NaviGAtor ITS, road characteristics, traffic data
Subsystems Involved	From GC ITS Hub and NaviGAtor to STM
Exchange Description	No major change. The information provided to the STM dynamic data broker from the GC ITS Hub will include traffic operations messages from the NaviGAtor ITS, road characteristics, and second-by-second traffic data acquired from all the upstream data sources fused by the TMC and CV platforms.
Data Exchange 7	OTP APIs and G-MAP APIs
Subsystems Involved	Between G-MAP middleware and UI, internal to the G-MAP subsystem
Description	No major change. May be configured differently or add additional user preferences and options.
Data Exchange 8	Mobile Accessible Pedestrian Signal System
Subsystems Involved	Between G-MAP and CV / Signal Controller through the SMUG

Interface	Description
Description	New data exchange between the G-MAP mobile app and SMUG. This message identifies the signal controller, approach ID, and a flag if the traveler needs extra time. The message to the controller conforms to NTCIP 1201/1202
Data Exchange 9	CV Messages
Subsystems Involved	Between RSU and TMC/ITS CV back center system, internal to the CV subsystem
Description	No change to existing message sets.
Data Exchange 10	TSP and other CV application messages
Subsystems Involved	Between RSU and OBU on transit bus
Description	No major change. Messages that request priority service for transit vehicles.
Data Exchange 11	Ride Request messages
Subsystems Involved	From G-MAP mobile app to bus operator display in the external GCT subsystem
Description	New data exchange. Information on traveler request for next bus and boarding bus to alert operator about their accessibility needs and accommodations.
Data Exchange 12	G-MAP Mobile App APIs and Traveler exchange – profile, trip plan, settings, notifications, feedback, etc.
Subsystems Involved	To and from G-MAP mobile app to end user, external to the system
Description	Upgraded data exchange. Information exchange from end user to G-MAP regarding trip planning requests, profile, preferences, and feedback. Enhancements include expanded accessibility profile and trip planning settings, notification options, feedback options, and UI. Information exchange from G-MAP to end user regarding turn by turn directions, rerouting, accessible routes, transit status and request, etc. Enhancements include expanded interface notification preferences on mobile app (voice, text, haptic), application type, caregiver notifications, etc.

Interface	Description
Data Exchange 13	Dynamic information from building facilities (including beacons to the G-MAP mobile app) and INS vendor cloud SDK
Subsystems Involved	Facility-deployed beacons to G-MAP
Description	New data feed. Provides fixed location mapping data on pathways and destinations in the facility, and near real time information on conditions and status of pathways including elevator/escalator operations.
Data Exchange 14	CV data
Subsystems Involved	From CV subsystem via broadcast messages to the CVs.
Description	No change to existing message sets. (part of GDOT CV program). Provides EVPs at specific intersections, major incidents, work zones, lane closures and delays. In particular, when the pedestrian signal is activated a PSM will be broadcast. PSM messages will conform to SAE J2945 message sets Part 9 for VRUs.
Data Exchange 15	Project data for USDOT-managed Public System
Subsystems Involved	Public PMD and public data access
Description	Summary performance metrics in a tabular and visual representation. The public can download the data in a comma separated format.
Data Exchange 16	Public facing data and visualizations for reporting on system operations and performance
Subsystems Involved	Private PMD (STM) to Public PMD
Description	Anonymized summary performance metrics from the private to public PMD.

2.3.5 External System Interfaces

The system interfaces to be exchanged between external sources and ST-CTN subsystems are identified in each of the detailed subsystem context diagrams in **Section 2.3.1** to **Section 2.3.3**.

The types of data flows are identified by categorized by inputs and outputs, and further detailed by static and real-time data sets. Different subsystems require various data sources. The

specifics are listed in the description of each subsystem. The data exchange ID associated with the input or output is included for each interface (associated with **Figure 4**). The organization that will provide the data and destination of each interface is provided as well. **Table 3** summarizes the external system interfaces that input to specific ST-CTN subsystems.

Table 3. External System Interfaces – Inputs (source: Data Management Plan Version 2)

EX-ID	Input Data	Static / RT	Description	Org	Destination (subsystem)
2	Facility Assets	Static	The location of wayfinding signs and announcements in facilities including transit hubs and stations.	GCDOT	STM
2	Facility Conveyance Status	RT	The status of current obstructions and vertical conveyances status (e.g., operating, out of order, under maintenance).	GCDOT	STM
2, 3	GTFS	Static	General Transit Feed Specification data including accessibility attributes for GCT and Metropolitan Atlanta Regional Transit Authority (MARTA).	GCT MARTA	G-MAP, STM
2, 3	GTFS-RT	RT	GTFS-RT data including for GCT and MARTA. The telemetry data will be used for STM and the comparison between the static and real-time GTFS data will be used to generate on-time performance measures particularly when signal priority was granted.	GCT MARTA	G-MAP, STM
1, 3, 13	Indoor Pathways	Static	The description of indoor pathways including the location and description of vertical conveyances and planned or permanent obstructions.	GCDOT	STM, G-MAP
I, 2, 3	OpenStreetMap	Static	Open Street Map network needed to support G-MAP OTP engine and STM simulator component.	OSM ATL	G-MAP, STM
1	Sidewalk Inventory	Static	Sidewalk collected by sidewalk inventory tools.	GA Tech	STM

EX-ID	Input Data	Static / RT	Description	Org	Destination (subsystem)
1	Sidewalk Data Updates	RT	Using the sidewalk inventory tools that provide crowdsourced updates on obstacles and changes to the pathways, this information will be used to update the sidewalk asset inventory.	Crowdsource Data GA Tech Data	STM
2	Traffic Assets	Static	The location of assets located for managing intersections particularly crosswalk characteristics and asset features that cater to pedestrians (e.g., ped crossing signals).	GCDOT	STM
2	VRU Categories	Static	List of categories and their related edge impedance values. The enumerated list will correspond to the list of disabilities and assistive devices offered in the G-MAP preference menu.	ATL ARC GA Tech	STM

Table 4 identifies the output interfaces that are offered by subsystem.

Table 4. External System Interfaces – Outputs (source: Data Management Plan Version 2)

EX-ID	Output Data	Static / RT	Description	Source (subsystem)	Destination
10, 15	CV Messages, Alerts and Warnings	RT	Based on GC CV applications (including pedestrian awareness)	CV	CV GCT
12	Travel Notifications and Alerts	Static and RT	Trip planning and turn by turn travel notifications based on their preferences	G-MAP	End User
15, 16	Performance Data	RT	Performance measurement data collected and aggregated by the ST-CTN system. The details will be described in the PMESP.	STM	Public PMD

2.4 Major System Conditions, Constraints, Assumptions and Dependencies

Some key assumptions were made when defining the features of the proposed system, including the following:

- During the testing period, there will be enough testers from the underserved communities to ensure that functionality exists for users of all abilities.
- The CV1K and Gwinnett County CVTMP goals, such as RSU and OBU deployment, are accomplished as described in order for the ST-CTN project to utilize these assets.
- The network edge impedance algorithm processing time can be managed in an environment with changing characteristics, such as road or sidewalk closures, curb cut or ADA ramp changes, etc.
- Existing field devices, infrastructure, and key systems that will interact with the new system will remain operational in the project limits.
- No significant changes to transit service/routes.
- Existing subsystem project progress as planned and on-schedule with all the capabilities needed to support the ST-CTN project.
- All CV infrastructure and applications will adhere to GDOT's SCMS which is compliant with IEEE 1609.2.
- All institutional Review Board Human Use and PII rules will be followed.

The following constraints have been identified during the development of the proposed system and will need to be addressed prior to or during the deployment.

- The ST-CTN application shall abide by agency IT policies.
- The deployment of the ST-CTN project will not require additional agency staff to operate and maintain the system.
- Too many preferences will reduce the options for trip planning. Some restrictions on preference choices may need to be put in place to address the end user's major accommodations yet still provide options for travel. Even if end user preferences are included in the scenarios, the priority for implementing them will be driven by ensuring that the data to address the preferences can be economically collected and a complete trip plan can be generated.
- CV technologies shall adhere to the FCC rules for the use of the Safety Band.
- GDOT's network security policies forbid any devices directly connected to their signals from also connecting to the cloud. This constraint has been addressed through the use of a SMUG in the CV diagram as seen in , CV Subsystem. It is anticipated that G-MAP will continue to be hosted via Amazon Web Services with 24/7 hours of operation.

2.5 User Characteristics

The following section describes the user groups for the ST-CTN system and their interactions with the system and other user groups. There are three primary user groups associated with the ST-CTN system: End Users, Infrastructure Owner/Operators, and System developers. Within these primary user groups there are individual users that will interact with the system and other user groups in unique ways. Both the primary user groups and the users within those groups are described in detail below.

2.5.1 End Users

The end user group consists of all travelers that will directly interact with the front end of the system to program and complete trips. The end user group includes, but is not limited to, persons with a disability, older adults, persons with LEP, and persons considered to have low income. Information on end users will be utilized to better calculate their impedances including which of the 7 VRU types they belong to listed below.

- Walking with no mobility limitations
- Walking with minor mobility limitations (potentially greater impact of pavement disjoints)
- Walking with a mobility device (cane, walker, stroller) or pushing a stroller
- Use of standard manual wheelchairs
- Use of electric wheelchairs (by wheelchair technology level)
- Use of a mobility scooter
- Walking with some vision limitations (limited vision, white cane)
- Walking with major vision limitations (legally blind)
- School children
- Other (no speed impedances)

End users will interact with the system through the provided UI to plan and complete trips based on their preferences and abilities. End users will be responsible for installing the mobile application on a personal cell phone, or accessing the application through a web browser, and maintaining a cellular connection throughout their trip for turn-by-turn directions. They will be responsible for entering their preferences and abilities into their user profile in order for their trips to be accessible and for trip feedback (i.e., hands free settings, haptics, text to speech, etc.) to be properly communicated. End users will also be responsible for providing feedback and input needed to enhance the functionality and accuracy of the system.

The end users will interact with other user groups primarily through the use of the call center support services, which will aid with planning or completing a trip. If the end user is involved with an incident while using the ST-CTN application, they may also interact with safety managers in order to understand and prevent future occurrences.

Person with Disability

Persons with a physical disability may be unable to, or have trouble, performing specific tasks (i.e., boarding a bus, navigating a sidewalk, or hearing specific broadcast messages or alerts) without the use of a device such as a wheelchair, crutches, hearing aid, or white cane. A disability is the state in which an individual has a limitation in independent, purposeful physical movement of the body or of one or more extremities, and substantially limits one or more major life activities.

Older Adult

Older adults may have trouble performing specific tasks within a set time (i.e., crossing a road or boarding a transit vehicle), standing for an extended period of time, or be more sensitive to the elements (i.e., waiting for transit in excessive heat). Older adults are people (typically 60 years of age or older) who may have mobility limitations that impact their ability to perform daily activities. They may also have difficulty understanding how to use certain assistive technology.

Person with Limited English Proficiency

Persons who have LEP may have trouble understanding directions and alerts when delivered in their non-native language, may have different culture norms that make it difficult to follow directions others would feel are standard, or may have difficulty understanding wayfinding signs. A person with LEP refers to a person who is not fluent in the English language.

Person Considered to have Low Income

Persons who fall into the low-income category may be single or no-vehicle households, may have trouble accessing different forms of technology (i.e., cellphone or personal computer), may be on reduced payment or fixed payment transit plans, may be unbanked (i.e., not have access to a bank account or credit card), or may use transit as their sole means of transportation. A person who has low income has a median household income that is at or below the Department of Health and Human Services poverty guidelines. Poverty guidelines designate $26,500 as the threshold for a household of four in the state of Georgia in 2021.

2.5.2 Infrastructure Owner Operator

The IOO user group represents infrastructure owners and operators within the project area. Their interactions, roles, and responsibilities vary between each entity and are described below.

Ride Gwinnett (GCT)

The GCT user group includes the administrative staff, maintenance staff, drivers, and operators that work with the GCT organization. Their role in the ST-CTN system is the owner and operator of the GCT system. They are responsible for maintaining and operating the bus service within the project area, maintaining and monitoring the transit schedule, providing transit data generation to the ST-CTN system, and maintaining bus stops, signage, and stations.

The GCT user group will interact with the system and other user groups in several ways. GCT will send transit data to the G-MAP Subsystem for ingestion and use. The CV subsystem will send and receive data from the OBUs equipped within GCT vehicles, allowing for remote stop requests and TSP. Finally, the GCT user group will interact with end users through their role as call center operators, providing en-route guidance, assisting with profile set up, and addressing service requests.

Gwinnett County Department of Transportation – Traffic and Operations

The Gwinnett County Traffic and Operations user group includes administrative staff, engineering staff, Traffic Control Center operators, and technicians who work with the Gwinnett County Traffic and Operations organization. Their role in the ST-CTN system is the owner and operator of Gwinnett County Traffic Operations. They are responsible for managing and operating the

infrastructure that supports traffic operations including the Gwinnett County TCC, the traffic signal system, field traffic signal equipment, CV infrastructure including servers and RSUs, and closed circuit television (CCTV) servers.

The Gwinnett County Traffic and Operations user group will interact primarily with the CV subsystem. The Gwinnett County TCC will send and receive messages from the G-MAP subsystem as well as the GCT OBUs. The Gwinnett County TCC will also send and receive messages from traffic signal controllers, allowing for remote pedestrian operation. The Gwinnett County TCC and the GDOT TMC will be connected through MAXVIEW servers and allow for data transfer between the two agencies.

Gwinnett County Department of Transportation

The GCDOT user group includes administrative staff, engineering staff, and field staff who work with the GCDOT organization. Their role in the ST-CTN system is the owner and maintainer of sidewalks, ramps, and roadways within Gwinnett County. They are responsible for constructing and maintaining sidewalks, ramps, and roadways within the system limits. Additionally, they are responsible for completing and uploading construction permit final inspection reports when sidewalk, ramp, or roadway improvements are completed.

The GCDOT user group will primarily interact with the ST-CTN system through the STM subsystem by uploading inspection reports in order to allow for accessible route generation and impedance functions.

Gwinnett County Information Technology

The Gwinnett County Information Technology user group includes administrative staff, engineering staff, IT support staff, and programmers who work with the Gwinnett County Information Technology organization. Their role in the ST-CTN system is the owner and operator of the Gwinnett County Information Technology Department. They are responsible for managing and operating Gwinnett County communications, security, data management, and all server systems.

The Gwinnett County Information Technology user group will primarily interact with the ST-CTN system through server maintenance, security services, and data sharing processes.

The Atlanta-Regional Transit Link Authority (The ATL)

The ATL user group includes administrative staff, engineering staff, operators, and support personnel who work with the ATL organization. Their role in the ST-CTN system is the owner and operator of ATL RIDES. They are responsible for managing and operating ATL RIDES along with supporting infrastructure.

The ATL user group will interact with the ST-CTN system in several ways. As the responsible agency for maintaining and funding ATL RIDES, The ATL user group will interact primarily with the G-MAP subsystem. The ATL will be responsible for protecting the security of any data flowing into or out of the G-MAP subsystem and coordinating with other agencies when maintenance or upgrades need to be completed on ATL RIDES.

Georgia Department of Transportation

The GDOT user group includes administrative staff, engineering staff, TMC operators, and technicians who work with the GDOT organization. Their role is the owner and operator of the GDOT TMC, statewide Advanced Traffic Management System (ATMS) platform, and existing CV infrastructure. The GDOT user group is responsible for collaborating with Gwinnett County to manage and operate traffic operation infrastructure, CV infrastructure, including RSUs, the GDOT NaviGAtor server, and the GDOT ITS Hub.

The GDOT user group will primarily interact with the CV subsystem, receiving and sending data between the GDOT TMC and Gwinnett County TCC. The GDOT TMC will also pass data to the STM Server.

Atlanta Regional Commission

The ARC user group includes administrative staff, engineering staff, operators, and support personnel who work with the ARC organization. Their role is the owner and operator of the ST-CTN application extension and the MPO for the Atlanta Region responsible for funding development and oversight. They will be responsible for maintaining the ST-CTN application extension and encouraging the coordination and expansion of the ST-CTN concept throughout the region.

The ARC user group will interact primarily with the G-MAP subsystem by maintaining the functionality and funding for the ST-CTN application extension.

2.5.3 System Developers

Georgia Institute of Technology

The Georgia Institute of Technology user group includes engineering staff, IT support staff, and operators from the Georgia Institute of Technology. Their role in the ST-CTN system is the system developer for the STM Platform and sidewalk inventory tools. GA Tech will be responsible for the STM Platform processing, operations, and maintenance. They are also responsible for the operations, processing of enhanced pedestrian data collection with the sidewalk inventory tools.

The Georgia Institute of Technology will interact with the ST-CTN system in developing the STM Platform and ensuring the connection between the sidewalk inventory tool and the STM Platform simulators to process information from the different subsystems and relay that information to the multimodal trip planner within G-MAP.

Gwinnett County Information Technology

The Gwinnett County Information Technology user group includes administrative staff, engineering staff, IT support staff, and programmers who work with the Gwinnett County Information Technology organization. They are responsible for the Gwinnett County Information Technology network operations, maintenance, uptime, and security.

The Gwinnett County Information Technology will interact with the ST-CTN system by ensuring the security of the system components and maintaining the network's operations.

Gwinnett County Connected Vehicles

The Gwinnett County Connected Vehicles user group includes administrative staff and engineering staff who work with the GCDOT. They are responsible for the Gwinnett County Connected Vehicle functions and technologies.

The Gwinnett County Connected Vehicles interacts with the STM Platform by ensuring connection between the traffic management and ITS HUB (CV data broker) to the STM Platform's dynamic data broker. It also provides two-way connection between the G-MAP system to ensure information is sent between the user's app and the CV data broker. Lastly, they will also interact with the system by ensuring that the Connected Vehicle information is delivered to the CVs and to the connected transit vehicles.

Ride Gwinnett

The GCT user group includes the administrative staff, maintenance staff, drivers, and operators that work with the GCT organization. They are responsible for the GCT elements such as the vehicles, OBUs and RSUs.

The GCT interacts with the ST-CTN system by ensuring and maintaining two-way connections with the connected intersection system as well as the G-MAP subsystem. The information exchanged between the G-MAP and GCT subsystems include Ride Request and TSP.

ATL RIDES

ATL RIDES user group includes administrative staff, engineering staff, operators, developers, and support personnel who work with the ATL organization. They serve as the system developer, operator and maintenance manager for the subsystem. They are responsible for the data management, application function and processing, and mobile of the subsystem.

ATL RIDES interacts with the ST-CTN system by receiving information from all systems as well as input from GTFS and building systems to incorporate into the multimodal trip planner and access tools which is fed into the G-MAP mobile app.

Georgia Department of Transportation

The GDOT user group includes administrative staff, engineering staff, TMC operators, and technicians who work with the GDOT organization. They will operate as the system developer, operator and maintenance manager of the GDOT CV system and the GDOT traffic signal system. They will be responsible for the GDOT CV elements such as ITS HUB, signal RSUs, ATMS software, and MaxView.

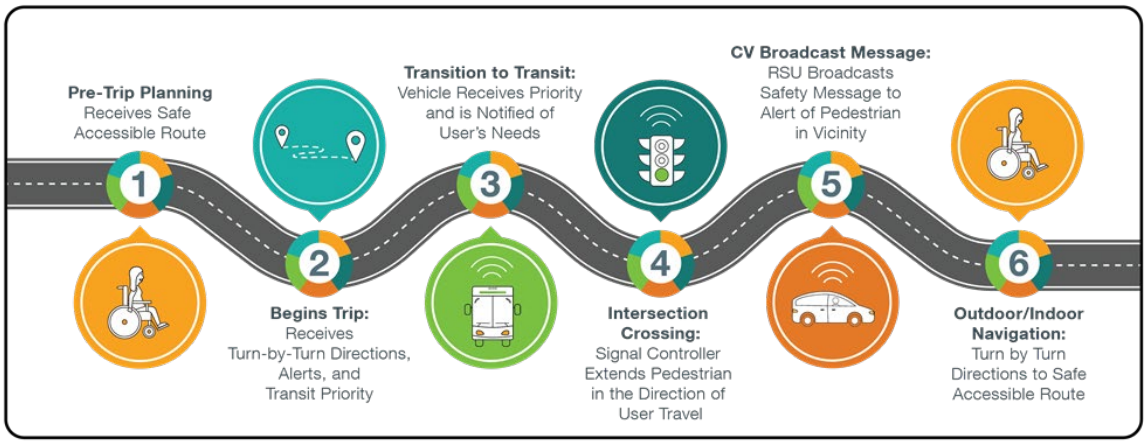
The Georgia Department of Transportation interacts with the ST-CTN system by maintaining communication between the GDOT CV data broker and the STM Platform. This connection allows for information to be sent to the CV and transit operators.

2.6 Operational Scenarios

Two use cases were developed as a part of the ST-CTN ConOps document to describe the operational flow of the proposed system. This section provides a summary of both use cases as well as the relationship between the goals and objectives and the use cases.

2.6.1 Use Case 1: Traveler's Complete Trip with ST-CTN

Use Case 1 describes how a traveler will plan and navigate their complete trip with the ST-CTN system. The use case identifies the major actions by trip segment from the trip planning through completion. In this asynchronous operational flow, the traveler can personalize, select, and activate information on directions, conditions, and status along their trip. The traveler will also be able to leverage their device to communicate with CV infrastructure to experience a safer trip. The six steps of the complete trip are shown in **Figure 8** and the steps are listed below.



Source: ARC, 2020

Figure 8. End User's Complete Trip with ST-CTN

Step 1 **Pre-Trip Planning.** The traveler plans and receives a safe accessible route.

Step 2 **Begins Trip.** The traveler receives turn by turn directions, alerts, and transit priority.

Step 3 **Transition to Transit.** The traveler transitioned to transit. The transit vehicle receives priority and is notified of users' needs.

Step 4 **Intersection Crossing.** The traveler interacts with the signal controller which extends pedestrian phase in the direction of user travel.

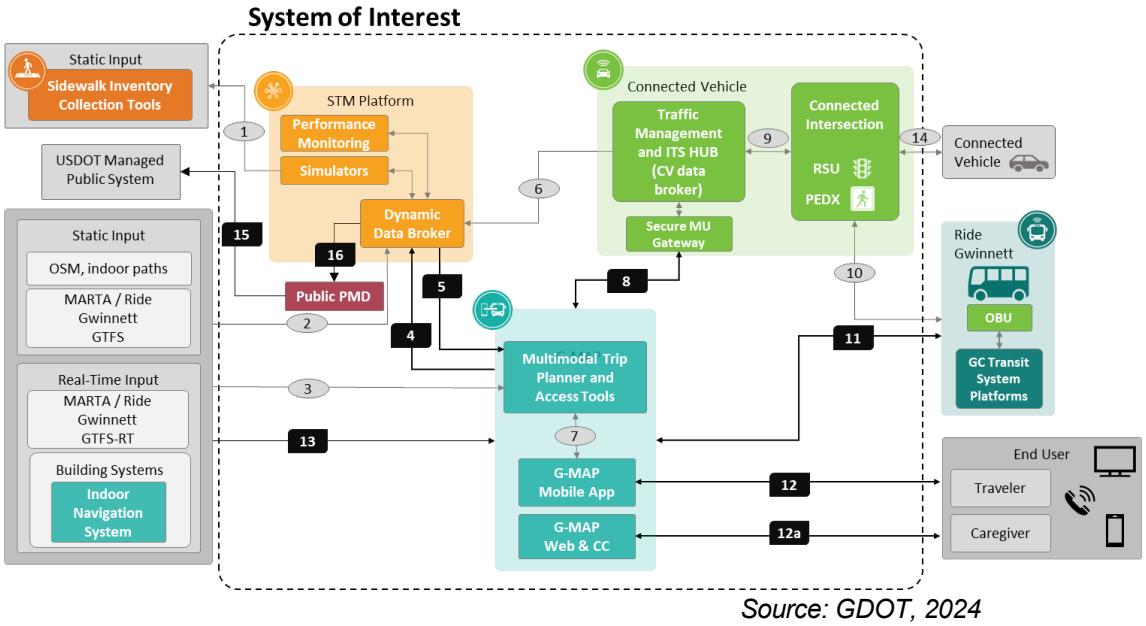
Step 5 **CV Broadcast Message.** Roadside units broadcast safety message to alert of pedestrian in vicinity.

Step 6 **Outdoor/Indoor Navigation.** Turn by turn directions are provided to the traveler to enable a safe accessible route.

This use case was formed around the system's end user needs, which can be found in detail in the Phase 1 ConOps. The end user needs were elicited from end users to describe their needs for a complete trip scenario. This process enabled validation of end user needs against the use

case actions to ensure completeness. In addition, the end user needs were elicited to identify what the users need from the system. The system needs, subsystem interactions, and their operational flow are driven by what the traveler needs from the system. All end user needs identified for this study are associated with this use case.

Figure 9 contains the information flows for Use Case 1. A detailed breakdown of the information flows can be found in Section 6 of the Phase 1 ConOps along with the operational flows.



Source: GDOT, 2024

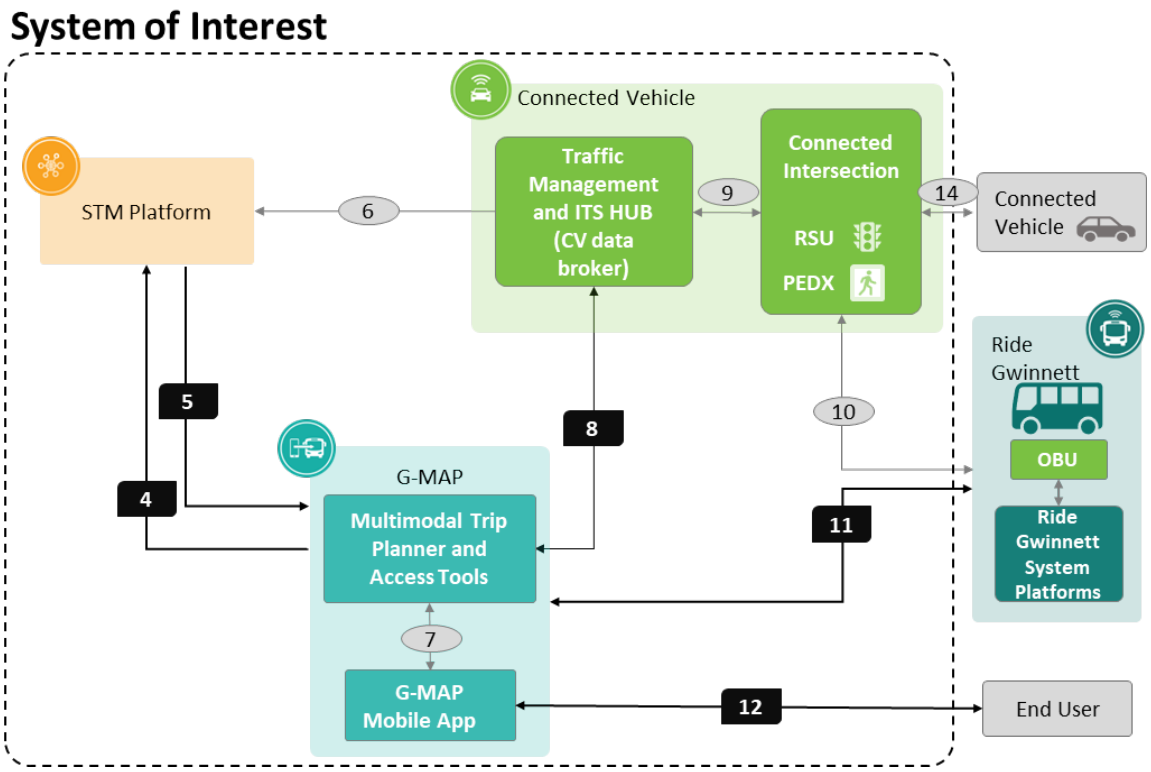
Figure 9. Use Case #1 Information Flow in the ST-CTN System

2.6.2 Use Case 2: Connected Vehicle

The ST-CTN proposed system leverages the area's current CV Program to connect the end user to the surrounding transportation infrastructure and broadcast safety messages to enabled CVs. Use Case 2 describes how the CV subsystem will operate to provide functionality and support for system actions. CV applications being implemented are included in **Table 5**. **Figure 10** illustrates the information flow between the traveler (represented by G-MAP mobile app) and the field or vehicles represented by the RSU and OBU equipment. **Table 6** provides the descriptions of the associated data exchanges shown in **Figure 10**. A detailed breakdown of the user and system needs associated with Use Case 2 as well as the operational flows and be found in the Phase 1 ConOps. The Phase 1 ConOps will be updated to reflect the changes to the system concept due to refinement of system of interest. Many of these new or updated capabilities and interfaces are described in subsequent Phase 1 documents including the DMP, SMP, PMESP and this document.

Table 5. CV Application Descriptions

CV Application	Description	Priority
Mobile Accessible Pedestrian Signal System (PED-SIG)	An application that allows for an automated call via the SMUG from the smart phone of [any authorized] pedestrian [using the MU – G-MAP app] to the traffic signal, as well as audio cues to safely navigate the crosswalk. Note: The pathway between the MU to RSU must go through the SMUG as described in **Section 2.3.3**.	High
Pedestrian in Signalized Crosswalk Warning (Transit)	An application that warns transit bus operators when pedestrians within the crosswalk of a signalized intersection are in the intended path of the bus. Since the warning is broadcast, any vehicle with onboard equipment may receive the alert. This application will be deployed by the CV Smart Corridor Project.	High
Ride Request	The Ride Request application allows a transit passenger to send a stop request to an approaching transit vehicle. This application allows a transit vehicle to know that a passenger has requested a transit stop from an infrastructure device.	Medium
Transit Signal Priority	An application that provides signal priority to transit vehicles at intersections and along arterial corridors. The TSP application uses V2I communications to allow a transit vehicle to request a priority at one or a series of intersections. The application includes feedback to the transit driver indicating whether the signal priority was granted or not. This application can contribute to improved operating performance of the transit vehicles by reducing the time spent stopped at a red light. This application will be deployed by the CV Smart Corridor Project.	High



Source: ARC, 2021

Figure 10. Use Case 2 CV Applications Information Flow in the ST-CTN System

Table 6 provides CV connection descriptions for each data exchange ID illustrated in the figure above.

Table 6. Critical ST-CTN Use Case 2 CV Connection Descriptions

EX ID	Description
1	Not relevant for Use Case 2
2	Not relevant for Use Case 2
3	Not relevant for Use Case 2
4	G-MAP Mobile App logs and trip feedback
5	STM network impedance API
6	CV and traffic operations messages: NaviGAtor ITS, road characteristics, traffic data
7	OTP APIs and G-MAP APIs
8	PED-SIG

EX ID	Description
9	CV messages
10	TSP and other CV application messages
11	Ride Request messages
12	G-MAP Mobile App APIs and traveler exchange – profile, trip plan, notifications, feedback, etc.
13	Not relevant for Use Case 2
14	CV data
15	Not relevant for Use Case 2
16	Not relevant for Use Case 2

3. System Capabilities, Conditions, and Constraints

Stakeholder needs identified in the ConOps have been reviewed, analyzed, and transformed into verifiable requirements that define *what* the system will do but not *how* the system will do it. A well-formed requirement can be defined as: a statement of system functionality (a capability) that can be validated, and that must be met or possessed by a system to solve a customer problem or to achieve a customer objective and is qualified by measurable conditions and bounded by constraints (IEEE 1233:1998). Functional requirements are necessary, concise (minimal, understandable), attainable (achievable or feasible), complete (standalone), consistent, unambiguous, and verifiable.

The ST-CTN System Development Lead (SDL) developed the preliminary set of system requirements with input from subsystem developers. The ST-CTN Technical Team held weekly work sessions to collaborate, verify, answer questions, and provide input during the development process. ST-CTN Technical Team members also provided an independent review to verify they were comfortable with the system requirements they would be responsible for demonstrating during Phase 2 of the ST-CTN project.

System requirement development was led by the comprehensive set of system needs identified within the ConOps. System needs were developed based on end user and IOO needs and provide the ability to trace and verify that the set of system requirements described below addresses all user needs identified for the system.

In addition, the Data Management Plan (DMP), Safety Management Plan (SMP), PMESP, and Enabling Technology Readiness Assessment (ETRA) were cross-referenced to ensure that a comprehensive set of system requirements were developed.

System needs were organized to be consistent with the end users' complete trip process as described in **Section 1.1**. Trip segments were delineated by: Step 1 – Pre-Trip Planning, Step 2 – Begin Trip, Step 3 – Transition to Transit, Step 4 – Intersection Crossing, Step 5 – CV Broadcast Message, Step 6 – Outdoor/Indoor Navigation, and Step 7 – Reporting. System requirements were assigned unique identifiers based on the closest associated system need as follows.

A.B.C-DEF, where:

- A = Trip Segment Step 1 – 7
- B.C = System Need Number
- DEF = System Requirement Number

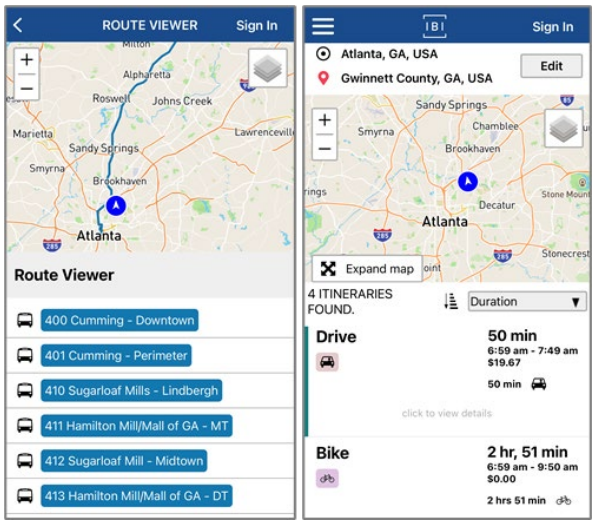
The following sections describe the comprehensive set of system requirements. Sections are organized based on the following logical structure:

- **Subsystem** functional, infrastructure, data, operational performance, and physical requirements.
- **Application** based functional, data, and operational performance requirements.
- **System performance** reliability, scalability, and performance measurement requirements.
- **System security and privacy** requirements.
- **System information management** requirements.
- **System operations and maintenance** requirements.
- **System policy and regulation** requirements.
- **System lifecycle sustainment** technical and non-technical requirements.

In addition, **Appendix A** provides the Needs-to-Requirements Traceability Matrix which is organized by system need and is consistent with how the requirements were developed.

3.1 G-MAP Subsystem

ATL RIDES is being developed with the support of FTA's IMI Grant program and is a journey planning application that leverages the OTP to provide more reliable and easier to access transit data to all travelers making it easier to utilizes the region's transit services. **Figure 11** shows a screenshot of the ATL RIDES route viewer and trip planner application.



Source: The ATL, 2021

Figure 11. ATL RIDES Route Viewer and Trip Planner Application

ATL RIDES core functionality will continue to operate, and the ST-CTN project will expand and enhance the features and functions already available in the software to provide additional fields, configurations, and algorithms. The system will leverage the OTP and ATL RIDES (IMI grant) functionality, interfaces, architecture and infrastructure as the core G-MAP for the ST-CTN system.

The G-MAP website and mobile app core functions will provide hands-free, turn-by-turn directions based on trip plans confirmed by a traveler or their authenticated third party. The traveler will receive trip execution functions that automatically deliver notifications and wayfinding instructions based on traveler's confirmed preferences.

The traveler account registration and management processes that will be augmented by the ST-CTN system include the following functions:

- Load mobile app
- Register for mobile app account
- Set up contact information
- Set up preferences for travel, notifications and navigation instructions
- Review trip histories
- Opt-in / opt-out of tracking
- Link to third party access
- Grant access to trusted (authenticated) third parties (e.g., care givers, call center)

The traveler trip planning processes that will be leveraged by the ST-CTN system include the following functions:

- Select trip and preferences
- Confirm trip and preferences
- Simulate trip and update preferences (optional)
- Save trip (with preferences (optional)

When the traveler begins a trip, the ST-CTN system will leverage the following ATL RIDES core functions:

- Verify communications is enabled (e.g., Bluetooth, data, Wi-Fi) and peripheral devices (e.g., wearable, assistive devices) are coupled to the mobile app
- Load trip on mobile app
- Activate trip
- Receive updated notifications about stored trip (e.g., updated transit, facility, pathway information)

3.1.1 Functional

The ST-CTN system will enhance the G-MAP subsystem to achieve the following functional system requirements provided in **Table 7**.

Table 7. G-MAP Functional Requirements

Requirement ID	Requirement Title	Requirement Statement
1.2.0-018	G-MAP Core Functionality	The system shall utilize the OTP and ATL RIDES (IMI grant) functionality, interfaces, architecture and infrastructure as the core G-MAP for the ST-CTN.
1.1.0-012	Opt-in to Store and Use PII	G-MAP shall provide an option for travelers to "opt-in" and sign user agreement to allow the system to store and use specific PII. The opt-in and agreement enables the G-MAP account management and mobile app to register, select preferences and track travelers. Planning functions that do not need registration services will still be available for travelers. The Use Agreement will outline the data that will be kept in the account management system but not shared (e.g., name, home address, phone) and data that will be shared (e.g., trip trace and trip plan with preference choices).
1.1.0-013	Opt-out After Opt-in Option	G-MAP shall provide an option for travelers to "opt-out" of a previously selected "opt-in" state. Specifically, the system shall wipe (permanently delete) any PII travel and preference data from any storage system in the ST-CTN when a traveler transitions from opt-in to opt-out. Note: a traveler must delete their account to remove their contact information from the system.
1.2.0-022	Support Service Options	The system shall provide travelers the option to select support services they prefer to access during their journey. The types of support services and their deployment priority will be designated during the Agile Development Process in collaboration with the end-user stakeholder group. At a minimum, support services include selecting and configuring notifications, identifying triggers, directions, communications channels, and user interface (UI) methods (e.g., text, voice, haptic sensor, other).
1.2.0-023	Trip Planning Communication Channel Options	The system shall provide travelers the option to select the communication channel(s) they use to access services to plan their trip including mobile app, call center, telephone, SMS, and online (via web application). The functions and information provisioned through each channel will be driven by stakeholder input during the Agile Development Process.

Requirement ID	Requirement Title	Requirement Statement
1.2.0-024	Trip Execution Communication Channel Options	The system shall provide travelers the option to select the communication channel they use to access services to execute their trip including mobile app, call center, telephone, SMS, and online (via web application). The channels will support communications using data serialization and non-data methods (e.g., call center agent). The functions and information provisioned through each channel will be driven by stakeholder input during the Agile Development Process.
1.2.0-025	Service Preferences and Communication Channel Matching	The system shall provide travelers communications channels that support their service preferences based on their defined preferences and abilities. The functions and information provisioned through each channel will be driven by specific stakeholder input during the Agile Development Process.
1.4.0-039	Notification and UI Method	G-MAP shall allow travelers to save their preferred method by which they receive notifications and navigation directions in their profile settings. The UI methods include but are not limited to voice, text or haptic/vibration. (See Req: 2.4.0-071)
1.4.0-040	Selection of Notification by UI Method	When planning a trip, G-MAP shall allow travelers to select the preferred method by which they receive specific notifications including when, how and how often the information is transmitted to them. The specific notifications and the types of notification methods will be driven by stakeholder input during the Agile Development Process.
1.4.0-041	Update Selection of Notification by UI Method	G-MAP shall allow travelers to update their trip plan notification selections when actuating a saved trip plan.
1.5.0-043	Trip Planning -- Traveler Companion	G-MAP shall be enhanced to allow a traveler planning a trip to include a companion using their combined preferences and abilities in the trip settings. The impedance values used to calculate the shared trip shall use VRU categories as defined in Section 2.5.1.
1.5.0-044	Trip Planning – Group Travel Preference Confirmation	When traveling in a group, G-MAP shall request that the traveler rank and confirm the most critical preferences to include in the group trip plan. For example, when a traveler plans a trip with children or with companions with different abilities, G-MAP will ask the traveler to alter their default preferences to align with the preferences for the group travel needs.

Requirement ID	Requirement Title	Requirement Statement
1.6.0-045	Trip Planning - Practice Mode	G-MAP shall allow travelers to set a practice mode wherein they can simulate their turn-by-turn directions before the trip using their preferred notifications, device, or methods. The practice mode functionality will be driven by stakeholder input during the Agile Development Process.
2.1.2-075	Continuous Trip Planning	G-MAP shall recalculate trip plans at periodic intervals to identify dynamic challenges that may disrupt travelers enroute. The periodic interval (i.e., duration between recalculations) is subject to dynamic information that impacts travel plans (e.g., real time bus status updates,). See Req 2.1.2-076 for related requirement.
2.1.2-076	Network Impedance API Ingestion	G-MAP shall base the recalculated trip plans on the updated impedance values in the STM published Network Impedance API and data that is integrated from other sources as available.
2.2.0-078	G-MAP Mobile and Web Applications	G-MAP mobile app shall provide the same functionality as described by the core functionality included in the web application (Section 3.1) for traveler account management and trip planning functions.
2.5.0-086	Traveler's Trusted Support	G-MAP shall allow a traveler to designate trusted persons and their role(s). Roles may include receiving notifications or can accessing their account. The specific information collected to confirm authenticity of the person will be driven by stakeholder input during the Agile Development Process.
2.5.0-087	Role Based Access by Trusted Person	G-MAP shall implement role-based access for trusted persons based on the roles assigned by the account holder. The roles will include access to account details, provision of real time notifications, and other functions designated by the account holder. The types of roles and information access will be driven by stakeholder input during the Agile Development Process. Note: a call center agent or transit operator may be included as a “trusted person.”
2.5.0-088	Track Travelers for Trusted Support	G-MAP shall allow a traveler to create triggers to alert trusted persons with notifications as they travel. Triggers may occur at transition points such as arriving at a waypoint or if a condition of the trip plan changes (i.e. delayed transit bus). More triggers will be identified through the Agile Development Process.

Requirement ID	Requirement Title	Requirement Statement
2.5.0-089	Help Call Number	G-MAP shall provide the traveler with a help call number that is easily accessible to the traveler in the case that they are lost or confused. Help call number placement and access will be driven by stakeholder input during the Agile Development Process.
2.6.0-090	Automated Activation Messages	G-MAP shall trigger alerts and messages based on a traveler's approach to a location near a trip transition (from indoor to outdoor, sidewalk to transit stop or crosswalk, etc.). The activation function should be configurable to adjust what constitutes "near" and to extend its use to new applications. At a minimum, the transition type applications include Ride Request, PED-X, and other CV applications. Additional trip transitions will be identified and ranked by the stakeholder group during the Agile Development Process.
2.6.0-091	Automated Rerouting	G-MAP shall recommend reroute to the traveler's active trip plan if warranted by a traveler's pre-selected [trigger] conditions (e.g., sidewalk closure or detour, transit delay, major obstacle impacting trip coordination). The conditions will be driven by stakeholder input during the Agile Development Process.
6.2.0-181	Beacons Pairing	G-MAP shall provide information for travelers to pair with [interconnect to] facility-deployed beacons enabled by transceivers (communications devices) that provide indoor wayfinding and navigation support.
6.2.0-182	Indoor Navigation Using Beacons	G-MAP shall interface with beacons using communications technologies including Wi-Fi, Bluetooth, or near field communication (NFC) available on mobile devices to provide supplemental location data for indoor navigation.
6.2.0-183	Indoor Tracking Using Beacons	G-MAP shall use facility-deployed beacon fixed location mapping data to supplement MU native navigation sensors commonly available on cell phones such as, WiFi, Bluetooth, or NFC, to track performance of indoor navigation and wayfinding. Note: The assumption is that the mobile app will integrate the vendor’s SDK used to detect the local beacons and present to the user the complete workflow for indoor navigation.

Requirement ID	Requirement Title	Requirement Statement
6.2.0-184	Indoor Navigation	G-MAP shall provide wayfinding instructions indoors at selected facilities. Wayfinding includes navigation, orientation, and destination finding through notifications to the traveler.
7.2.0-206	Traveler Impact Form	G-MAP shall provide a traveler feedback form in which travelers can report on impediments of travel. Impediments include obstacles and sidewalk conditions.
7.2.0-207	Trip Feedback Reports	G-MAP shall request that users provide feedback on their complete trip travel experience through a survey. Response to the survey shall be limited such that a traveler is not requested to respond after every trip. Survey questions shall include topics such as, complete trip experience, features and functions, useability, caregiver support, call center support, persons with LEP useability, employment, quality of life, trip type, traveler perception of safety, traveler non-incident experiences, and missed connections.

3.1.2 Infrastructure

The ST-CTN system will enhance the G-MAP subsystem to achieve the following infrastructure system requirements provided in **Table 8**.

Table 8. G-MAP Infrastructure Requirements

Requirement ID	Requirement Title	Requirement Statement
2.3.0-080	Common Communications	G-MAP shall use an open communications protocol such as Bluetooth (4 or 5), NFC (ISO/IEC 18000-3), Wi-Fi (4, 5 or 6), or LTE 4, 4G or 5G in order to pair with infrastructure devices/system (e.g., beacons).
2.3.0-082	Native Software Development Kit (SDK)	The G-MAP mobile app shall use native SDK and implement the accessibility guidance recommended by the handset and operating system manufacturers.
2.3.0-083	WCAG 2.1 or Higher	The system shall comply with Web Content Accessibility Guidance (WCAG) 2.1 or higher for all user interfaces (web and mobile app).
2.4.0-085	Notification Channels	G-MAP shall allow travelers to select which notifications are delivered via voice (by phone or mobile app voice), text or icon (SMS or on screen), vibration (to alert to text message or signal a "turn"). The mapping of notification types to UI methods will be driven by stakeholder input during the Agile Development Process. (See Req 2.4.0-084)

3.1.3 Data

The ST-CTN system will enhance the G-MAP subsystem to achieve the following data system requirements provided in **Table 9**.

Table 9. G-MAP Data Requirements

Requirement ID	Requirement Title	Requirement Statement
2.4.0-084	Notification Types	G-MAP shall allow travelers to customize the types of notifications they prefer to receive as they journey on a planned trip. The set of notifications will be driven by stakeholder input during the Agile Development Process.
6.1.0-167	G-MAP – Signal Locations	G-MAP shall ingest the traffic signal control locations that provide PED-X services into the network used to generate trip itineraries.
7.1.0-199	Store Planned Trip Histories	G-MAP shall store the trip history for trips planned with the ST-CTN system. Trip history data shall include at a minimum: • Planned route including modes, crossing, pathways • Preferred notifications, navigation instructions and automated requests • Support services including notification to third parties and companions accompanied on travel The types of trip history information will be driven by stakeholder input during the Agile Development Process and the PMESP metric needs.
7.1.0-200	Store Actual Trip Histories	G-MAP shall store the trip history for trips taken with the ST-CTN system. Trip history data shall include at a minimum: • Origin trip plan identifier for loaded and actuated (begin) • Actual (deviations from) trip pathways, modes and crossings taken, including time and condition of travel • Notifications and direction instructions received (by channel) • Automated messages for rerouting or requests (PED-X, Ride Request) • Notifications sent to third parties • Additional services requested or received (e.g., emergency call, call center help) The types of actual trip history information will be driven by stakeholder input during the Agile Development Process and the PMESP metric needs.

Requirement ID	Requirement Title	Requirement Statement
7.1.0-201	Traveler Trip Tracking Data	G-MAP shall acquire traveler trip tracking data at a frequency sufficient for the STM Performance Measure module to analyze metrics in accordance with the PMESP. The rate of collection will be developed during Phase 2. The data will be stored and forwarded as part of Req 7.3.0-209 Publish Travel Statistics.
7.1.0-204	Generate Travel Statistics	G-MAP shall provide account holders with general statistics on their trips. The types of statistics will be driven by stakeholder input during the Agile development process. The statistics may include: • Average duration (by leg) and standard deviation of saved trips (e.g., typical commute) • Miles traveled (by each mode) • Number of notifications received by different communication channels and UI methods • Deviations from planned trip plans for actual trips taken • Trip histories • Complete trip travel times Number and variety of destination types

3.1.4 Operational Performance

The ST-CTN system will enhance the G-MAP subsystem to achieve the following operational performance system requirements provided in **Table 10**.

Table 10. G-MAP Operational Performance Requirements

Requirement ID	Requirement Title	Requirement Statement
1.4.0-042	Notification Latency	G-MAP shall limit end-to-end transmission from trigger event to transmission to traveler's device of less than 1 second. Note: traveler's carrier and personal device are not calculated in this latency budget.
2.1.1-066	G-MAP Subsystem	G-MAP shall monitor G-MAP component health and operational status. The specific measures will be identified during Phase 2 of the ST-CTN project.
2.1.1-067	G-MAP Subsystem Self Logging	G-MAP shall log G-MAP component health and operational status. The specific measures will be identified during Phase 2 of the ST-CTN project.

Requirement ID	Requirement Title	Requirement Statement
2.1.1-072	G-MAP Subsystem Self-Monitoring Transmission	G-MAP shall transmit health and operational status logs to the STM Performance Measurement Dashboard on an as needed basis. The specific metrics will be identified during Phase 2 of the ST-CTN project.

3.1.5 Indoor Navigation System

The ST-CTN system will deploy beacon technology at key waypoints to aid indoor wayfinding and navigation by the G-MAP subsystem. For example, the Bluetooth Low Emitting (BLE) beacon offers low power usage, variable range broadcast, and configurable message sets to support travelers. G-MAP will use the beacon information to aid navigation algorithms onboard mobile apps and on-line in the G-MAP routing engine.

Additional indoor navigation system requirements, provided in **Table 11,** were refined and developed upon procurement of the system and better understanding of how the indoor navigation system would be integrated with the G-MAP subsystem.

Table 11. G-MAP –Indoor Navigation System Requirements

Requirement ID	Requirement Title	Requirement Statement
6.2.0-194	Beacon	A beacon technology shall be deployed at key waypoints to aid indoor wayfinding and navigation by G-MAP.
6.2.0-185	Beacon Asset Inventory Collection	The INS Vendor (system) shall collect asset information on beacons that are installed in facilities to support indoor navigation.
6.2.0-186	Beacon Asset Inventory	The Beacon Asset Inventory shall contain at a minimum, beacon identifier, location relative to facility map, location attributes, date installed, last maintenance date, and other pertinent information to support traveler navigation and wayfinding as well as asset maintenance. The details of the asset information will be determined in Phase 2 of the ST-CTN project.
6.2.0-187	Access to Beacon Asset Inventory	The INS shall provide access to the beacon asset inventory to authorized users including G-MAP, STM, and building owners.
6.2.0-188	Acquire Beacon Asset Inventory	G-MAP shall acquire beacon asset inventory to support indoor mapping. The curation process, as described by Req 6.1.0-148, will be developed in Phase 2 of the ST-CTN project, including processing, integration and application in the routing service.

Requirement ID	Requirement Title	Requirement Statement
6.2.0-189	Beacon Environmental Conditions	The beacon shall operate in the following environment conditions without degradation: • Operational temperature (-20 to +60ºC) • Waterproof (IP67)
6.2.0-190	Beacon Power	The beacon shall be powered by replaceable battery power with an average life of 5 years (depending on usage).
6.2.0-191	Beacon Communication Channel and Pairing	The beacon shall support Bluetooth Low Energy (BLE) 5 or above.
6.2.0-192	Beacon Transmission Small Space Distance	The beacon shall have a broadcast range of between 50-100 meters.
6.2.0-193	Beacon Transmission Large Space Distance	The beacon shall be able to be configured to have a broadcast range for between 200-300 meters.
6.2.0-195	Beacon Installation and Mounting	The beacon shall be constructed to be installed using adhesive or screws for mounting the device.
6.2.0-196	Beacon App SDK	The beacon/INS shall include an SDK to interface with iOS and Android to receive and resolve message content.
6.2.0-197	Beacon Message Configuration	The beacon/INS shall provide an administration module to configure the content and operations of each beacon.
6.2.0-198	Beacon Broadcast	The beacon shall broadcast its message (or identifier) at configurable intervals or when connected to a mobile app.
6.2.0-239	INS Wayfinding	The SDK shall provide G-MAP app via SDK with wayfinding instructions and door to door (facility entrance to indoor navigation destination) including notifications. Notifications should include alerts via audio, text, and visual navigation instructions to support hands off and vulnerable communities (e.g., older adults, people with disabilities).
6.2.0-240	Re-routing	The SDK should be capable of re-routing users if the user navigates away from the initial defined route.

Requirement ID	Requirement Title	Requirement Statement
6.2.0-241	SDK Navigation Experience	The SDK shall support the ability to fully integrate the navigation experience (audio, visual, text based commands) within third party apps developed using native technology.
6.2.0-242	SDK Support and Maintenance	The SDK shall be maintained and updated to support future maintenance releases of operating systems from Apple and Google, as well as meet compliance with Apple App Store and Google Play policies and procedures.
6.2.0-243	Location Positioning and Beacon Configuration	The beacons shall be installed and configured to provide accurate positioning in multiple architectural layouts.
6.2.0-244	Beacon Configuration to Support Accurate Position Multiple Floors	The beacon deployment shall ensure that positioning determination can differentiate different floors in an open space (i.e., as laid out in the Gwinnett Justice and Administration Center – GJAC).
6.2.0-245	Beacon Configuration to Support Accurate Positioning	The beacon deployment shall ensure positioning determine can precisely (within 2-4 meters) describe the pathways between and around the two facilities.
6.2.0-246	Generate Facility Map	The vendor shall develop the facility map inclusive of routable/connected paths through the facility and between floors. The indoor network shall include features such as entrances, conveyances (elevator, escalator, stairs), rooms, destination and special areas. Features shall also include attributes that describe condition and status including time-based access and accessibility (e.g., for people in wheelchairs). Places shall include attributes that describe their condition and status.
6.2.0-247	Map Updates	The vendor shall provide a web-based mapping tool for facility owners to manage and update facility map updates and feature status (e.g., special events in geofenced areas, elevator outages, etc.).
6.2.0-248	Map Download	The vendor mapping tool shall export map data in a standard-based map format (e.g., shape files, OGC map service / OGC feature service, Open Street Map, KML).

3.2 Space Time Memory Platform Subsystem

The STM Platform predicts travel trajectories through the multimodal network based on existing model networks, real-time, and predictive analytics. As congestion evolves in space and time, the STM Platform provides users with more realistic estimates of commute duration, impedance value, and energy use across alternative departure times, routes, and transportation modes.

The ST-CTN system will leverage work completed through the Department of Energy Advanced Research Projects Agency – Energy (ARPA-E) project as the core STM Platform for the ST-CTN system. The STM Platform core functionality will continue to operate, and the ST-CTN project will expand and enhance the features and functions already available in the system to provide additional input sources, enhanced impedance values, and reduced speed resolution.

The overall architecture and functionality of the STM Platform will not change. The STM Platform core functions augmented by ST-CTN include the following:

- Common network coding across all transportation models (regional travel demand, dynamic traffic assignment, Vissim microscopic simulation, energy and emissions, etc.)
- Five-minute temporal resolution
- Stores modeled results (ABM15, DTA, Vissim®, etc.) for events observed infrequently (or 'not yet' observed)
- Deep learning algorithms use STM data to predict evolving congestion and resulting shortest (time) path network trajectories

The STM Platform's ability to ingest data from multiple sources will be augmented by the ST-CTN system including the following sources:

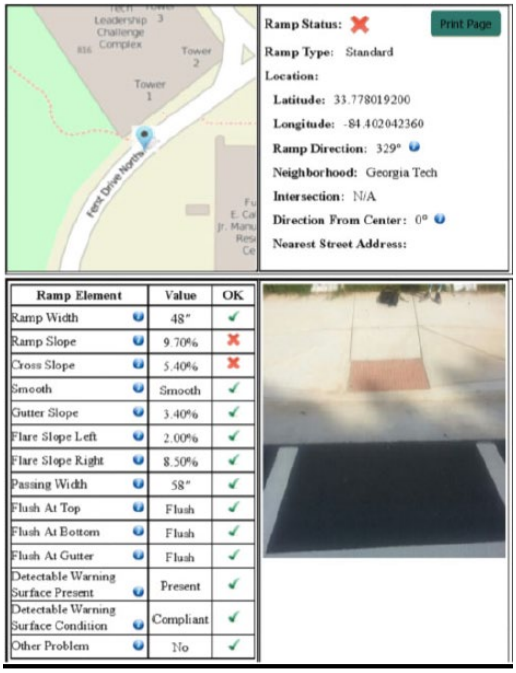
- Georgia NaviGAtor ITS traffic operations data feeds
- Private, licensed data source (data source TBD) for cell phone tracking data
- Private, licensed data source (data source TBD) for fleet data
- GTFS data feeds from GCT (DMP ID 34)
- GTFS data feeds from MARTA (DMP ID 35)

The STM Platform simulator processes that will be augmented by the ST-CTN system include the following functions:

- Python-based network simulators identify 'shortest path' origin destination trajectories through the STM Platform (with congestion)
- 203,000-link roadway network at 5-minute speed resolution
- Includes all MARTA fixed rail routes, 90 MARTA bus routes, and Georgia Regional Transportation Authority (GRTA) express bus routes (speeds derived from schedules)
- Connectivity between the transit simulation model and the distributed network simulation model supports the integration of transit and carpool park-and-ride options
- Predicts travel times, energy consumption, and cost for each alternative pathway (departure time, route, mode, etc.)

The STM Platform Sidewalk Scout (**Figure 12**) API processes that will be augmented by the ST-CTN system include the following functions:

- Sidewalk Scout allows users to photograph, mark locations, and check boxes about status and obstacles to provide dynamic updates on asset's current condition
- Ingestion and integration into STM network impedance (whole network model)
- REST-ful (REpresentational State Transfer) API for client integration of crowdsourced data



Source: GA Tech, 2019

Figure 12. Sidewalk Scout Inspection Report

3.2.1 Functional

The ST-CTN system will enhance the STM Platform subsystem to achieve the following functional system requirements provided in **Table 12**.

Table 12. STM Platform Functional Requirements

Requirement ID	Requirement Title	Requirement Statement
1.3.0-026	STM Core Functionality	The system shall leverage the existing STM functionality and interfaces as the core STM subsystem for the ST-CTN. Leverage implies that we adapt and enhance existing functionality.

Requirement ID	Requirement Title	Requirement Statement
1.3.0-027	Logical Mobility Categories	The system shall define logical groupings of "VRU categories" that will be used to tailor impedance values based on transportation network features, attributes and conditions (as selected by travelers of similar abilities and preferences). Specifically, the VRU categories are characterized by their severity of movement with respect to ADA design features.
1.3.0-028	Impedance Factor Algorithms	The STM Platform shall implement processes (algorithms) that produce impedance values that apply to VRU group abilities and are associated with the Whole Road Network (see DMP Data ID-3).
1.3.0-029	Learning Impedance Factors	The STM Platform shall incorporate feedback from traveler choices including but not limited to deviations from planned trip and traveler comments on trip plan to update the coefficient impedance values.
1.3.0-030	Updating Network Impedance Factors	The STM Platform shall incorporate feedback on updated static features including but not limited to from work zone, event data, to tailor the impedance values in the operational engine (using existing algorithms).
1.3.0-031	Updating Real-Time Impedance Factors	The STM Platform shall incorporate feedback on updated dynamic features, attributes, and conditions, including but not limited to from work zone and event data, to tailor the impedance values in the operational engine (using existing algorithms).
1.3.0-032	Static Generating Impedance Factors	The STM Platform shall regenerate the impedance values for each Mobility Category by incorporating any updated dynamic changes to the network features, attributes or conditions at a frequency that is commensurate with the incoming information.
1.3.0-033	Dynamic Generating Impedance Factors (Pedestrian Network)	The STM Platform shall regenerate the impedance values for each Mobility Category by incorporating any updated dynamic changes to the network features, attributes or conditions at a frequency that is commensurate with the incoming information. The rate of regeneration will be identified during Phase 2 of the ST-CTN project.
2.1.3-077	Continuous Publication of Network Impedance API	The STM Platform shall publish, at periodic intervals, the Network Impedance API that disseminates updated impedance values based on complete paths updates. At a minimum, the duration between distribution will be at 15 minutes intervals.

Requirement ID	Requirement Title	Requirement Statement
7.3.0-214	STM Ingestion of GCT Registered Inaccessibility Complaints	The STM Platform shall ingest GCT provided anonymized complaints on inaccessibility.
7.3.0-215	STM Ingestion of GCT Fixed Route Ridership	The STM Platform shall ingest GCT fixed-route ridership data daily. At a minimum, ridership data includes the local service and may include the express routes.
7.3.0-217	STM Ingestion of GCT GTFS	The STM Platform shall ingest GCT GTFS data feeds as the updated files are published.
7.3.0-218	STM Ingestion of GCT GTFS-RT	The STM Platform shall ingest GCT GTFS-RT data feeds as published.

3.2.2 Infrastructure

The ST-CTN system will enhance the STM Platform subsystem to achieve the following infrastructure system requirements provided in **Table 13**.

Table 13. STM Platform Infrastructure Requirements

Requirement ID	Requirement Title	Requirement Statement
1.3.0-034	Publish Impedance Factors (network impedance API)	The STM Platform shall publish impedance values by VRU group via the Network Impedance API (DMP Data ID-25) to subscribers including ATL RIDES. The rate of publication will be identified during Phase 2 of the ST-CTN project.

3.2.3 Data

The ST-CTN system will enhance the STM Platform subsystem to achieve the following data system requirements provided in **Table 14**.

Table 14. STM Platform Data Requirements

Requirement ID	Requirement Title	Requirement Statement
1.3.0-035	Complete Paths Network Composition	The STM Platform shall reconcile multiple transportation networks to generate a Whole Road Network (DMP Data ID-3). The Whole Road Network (DMP Data ID-3) will relate planning, operations, transit, public right of way, public transportation networks, their features, assets, attributes, and conditions. Specific transportation networks that will be conflated to generate the Whole Road Network are listed in the DMP Table 6. Details of the reconciliation will be documented in the data curation plan associated with the Whole Road Network as specified by Req 6.1.0-148.
1.3.0-037	Complete Paths Network and OSM: Related to Ped Network	The system shall employ the same link-and-node structure for the Whole Road Network and OSM such that all network links tracked in the STM are mapped to routing links in the OSM for impedance data flow. Use of the OSM nodes and attributes will provide scalability beyond the ST-CTN project and also be compatible with the OTP upon which the G-MAP subsystem is based.
1.3.0-038	Import Road Network Data	The STM Platform shall apply a curation process for each network road dataset. The curation process shall consist of the following processes: import (acquisition), extract, validate, transform, and load functions. (See data curation Req 6.1.0-148).
7.3.0-208	Ingest Travel Statistics	The STM Platform shall ingest general trip statistics for account holders. The types of statistics will be driven by PMESP and stakeholder input during the Agile development process. The general trip statistics may include: • Average duration (by leg) and standard deviation of saved trips (e.g., typical commute) • Miles traveled (by each mode) • Number of notifications received by different communication channels and UI methods • Deviations from planned trip plans for actual trips taken • Anonymized trip histories (planned, actual) • Complete trip travel times • Number and variety of destination types

Requirement ID	Requirement Title	Requirement Statement
7.3.0-210	Subscribe and Ingest CV Message Logs	The STM subsystem shall ingest message logs from the central signal control system which includes PED-X application transactions on a daily basis at a minimum.
7.3.0-211	STM Ingestion of ATL RIDES Subsystem Monitoring	The STM Platform shall ingest the G-MAP subsystem health and operational status logs (defined in Req 2.1.1-063) to the STM performance measurement dashboard on a daily basis.
7.3.0-212	STM Ingestion of STM Subsystem Monitoring	The STM Platform shall ingest the STM subsystem health and operational status logs (defined in Req 2.1.1-064) to the STM performance measurement dashboard on a daily basis.
7.3.0-213	STM Ingestion of CV Subsystem Monitoring	The STM Platform shall ingest the CV subsystem health and operational status logs (defined in Req 2.1.1-065) to the STM performance measurement dashboard on a daily basis.
6.1.0-249	STM Ingestion of Traffic Information Data	The STM Platform shall ingest traffic information data, which includes Waze and TMC data.

3.2.4 Operational Performance

The ST-CTN system will enhance the STM Platform subsystem to achieve the following operational performance system requirements provided in **Table 15**.

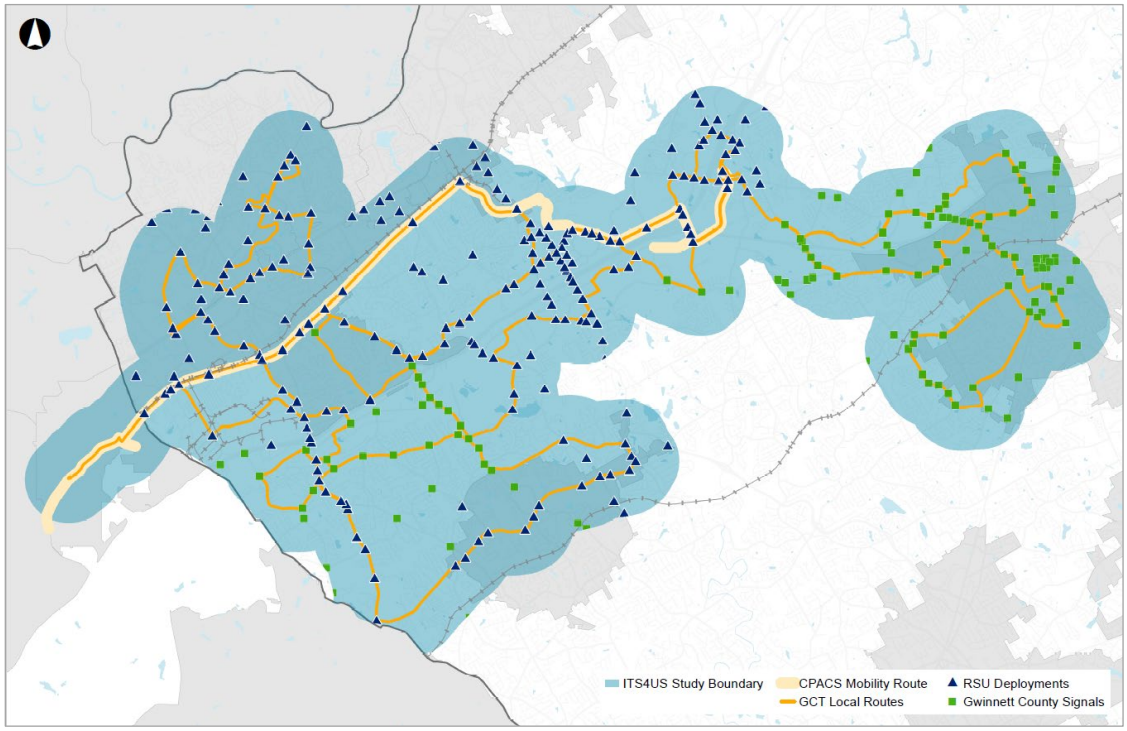
Table 15. STM Platform Operational Performance Requirements

Requirement ID	Requirement Title	Requirement Statement
1.3.0-036	Whole Road Network Attributes Update	The STM Platform shall update the Whole Road Network attributes as new conditions are ingested. The updated datasets that contribute to the road network include at a minimum: 1. signal control data, and 2. traffic congestion
2.1.1-068	STM Subsystem Self-Monitoring	The STM Platform shall monitor STM component health and operational status. The specific metrics will be identified during Phase 2 of the ST-CTN project.

Requirement ID	Requirement Title	Requirement Statement
2.1.1-069	STM Subsystem Self Logging	The STM Platform shall log STM component health and operational status. The specific metrics will be identified during Phase 2 of the ST-CTN project.
2.1.1-073	STM Subsystem Self-Monitoring Transmission	The STM Platform shall transmit health and operational status logs to the STM Performance Measurement Dashboard on an as needed basis. The specific metrics will be identified during Phase 2 of the ST-CTN project.

3.3 Connected Vehicle Subsystem

The CV subsystem is being developed by Gwinnett County and GDOT. Gwinnett County will be one of the largest recipients of the first phase of the GDOT CV1K deployment program with approximately 400 planned C-V2X RSUs throughout the county (see **Figure 13**). In addition, Gwinnett County is in the process of selecting a vendor to supply OBUs for county vehicles and support application development. Gwinnett County's CV operational environment relies on infrastructure and support from GDOT.



Source: Gwinnett County, 2019

Figure 13. Gwinnett County CV Program RSU Deployment Locations

Gwinnett County is currently broadcasting SPaT and MAP from signalized intersections along key corridors throughout the county. The county is working toward the deployment of EVP and TSP through a separate project (referred to as the Smart Corridor project) and will purchase OBUs for

emergency and transit vehicles prior to deployment of ST-CTN. EVP is a priority application for the County and will be deployed with the Smart Corridor project. TSP hardware components will be purchased, deployed, and configured through the Smart Corridor project.

The core functionality of the CV system will continue to operate, and the ST-CTN project will expand and enhance the features and functions already available in the software to support TSP, communications channels between the traveler MU and the signal system to support PED-SIG, and other applications supporting pedestrian safety.

The CV hardware that will be utilized by the ST-CTN system includes the following:

- Gwinnett County ITS Hub
- GDOT ITS Hub
- Gwinnett County Map Data Server
- GDOT Map Data Server
- Roadside units (RSUs)
- Onboard units (OBUs)
- Gwinnett County communications network
- Gwinnett County signal infrastructure
- Gwinnett County MaxView Server
    - Signal controller data

3.3.1 Functional

The ST-CTN system will enhance the CV subsystem to achieve the following functional system requirements provided in **Table 16**.

Table 16. CV Functional Requirements

Requirement ID	Requirement Title	Requirement Statement
5.1.0-137	CV Core Functionality	The system shall utilize the existing core CV functionality, interfaces, architecture, infrastructure (including RSU, OBU, communications and security).
6.1.0-150	CV Signal Control Data Access	The CV subsystem shall provide access to traffic management system data and control data including: 1. PSM, 2. signal control data.

3.3.2 Data

The ST-CTN system will enhance the CV subsystem to achieve the following data system requirements provided in **Table 17**.

Table 17. CV Data Requirements

Requirement ID	Requirement Title	Requirement Statement
7.3.0-209	Display Travel Statistics	Public PMD shall display general trip statistics. The types of statistics will be driven by PMESP and stakeholder input during the Agile development process. The general trip statistics may include: • Average duration (by leg) and standard deviation of saved trips (e.g., typical commute) • Miles traveled (by each mode) • Number of notifications received by different communication channels and UI methods • Deviations from planned trip plans for actual trips taken • Anonymized trip histories (planned, actual) • Complete trip travel times • Number and variety of destination types

3.3.3 Operational Performance

The ST-CTN system will enhance the CV subsystem to achieve the following operational performance system requirements provided in **Table 18**.

Table 18. CV Operational Performance Requirements

Requirement ID	Requirement Title	Requirement Statement
2.1.1-070	CV Subsystem Self-Monitoring	The CV subsystem shall monitor CV component (as described in Section 2.3.3) health and operational status. The specific metrics will be identified during Phase 2 of the ST-CTN project.
2.1.1-074	CV Subsystem Self-Monitoring Transmission	The CV subsystem shall transmit health and operational status logs to the STM Performance Measurement Dashboard on an as needed basis. The specific metrics will be identified during Phase 2 of the ST-CTN project.

3.4 System Applications

Many applications will be implemented as part of ST-CTN and its subsystems. The ST-CTN system will connect the traveler to the infrastructure, the infrastructure to the traveler, and expand transit efficiency through Ride Request. The applications and associated priority in which they will be implemented are listed below.

- Mobile Accessible Pedestrian Signal System (PED-SIG) | Priority – High
- Pedestrian in Signalized Crosswalk Warning (Transit and Vehicles) | Priority – High
- Ride Request | Priority – Medium
- Transit Signal Priority (TSP) | Priority – High

3.4.1 Mobile Accessible Pedestrian Signal System (PED-SIG)

Mobile Accessible Pedestrian Signal System is an application that allows for an automated request via the SMUG from G-MAP to the traffic signal to request the pedestrian signal (PED-X) at a specific intersection crossing. The G-MAP mobile app provides confirmation of the request and status information on the walk and don't walk cycles to the traveler to safely navigate the crosswalk. The application will also extend pedestrian walk time, if necessary.

Note: The pathway between the G-MAP mobile app traverses the G-MAP through the SMUG to the traffic signal controller (via MaxTime) as described in **Section 2.3.3 Connected Vehicle Subsystem**.

The ST-CTN system will enhance the PED-SIG CV application to achieve the following system requirements provided in **Table 19**.

Table 19. Mobile Accessible Pedestrian Signal System Application Requirements

Requirement ID	Requirement Title	Requirement Statement
4.1.0-111	CV and ATMS Core Functionality	The system shall utilize the existing core CV and ATMS functionality, interfaces, architecture, infrastructure (including RSU, OBU, communications and security) to provide mobile accessible pedestrian features at signalized intersections. CV and ATMS core functionality will be documented and published during Phase 2.
4.1.0-112	Identify Intersection and Crossing	G-MAP shall generate navigation directions for crossing intersections using the intersection reference, crossing direction, and traveler orientation.
4.1.0-114	Track Traveler Location	G-MAP shall track the traveler's approach to an intersection crossing from the trace data collected from their G-MAP mobile app.

Requirement ID	Requirement Title	Requirement Statement
4.1.0-115	Trigger to Send PED-X Request (for intersection crossing)	G-MAP shall trigger a request to generate a PED-X message when the traveler arrives at the intersection.
4.1.0-116	Generate and Transmit PED-X Priority Request Message	G-MAP shall generate and transmit to the ATMS a PED-X Priority request message to alert the signal controller that a traveler has arrived at a signalized crosswalk.
4.1.0-120	Verify and Forward Pre-Defined Messages	The SMUG shall serve as a gateway to exchange messages between G-MAP and specific signal controllers to authenticate and forward pre-defined message(s).
4.1.0-121	Activate PED-X Walk Request	Upon receipt of the PED-X Priority Request message, the signal controller shall activate the pedestrian crossing signal during its next cycle (by crosswalk direction).
4.1.0-132	PED-X Priority Status Buffer Message	The PED-X buffer message shall adapt the prgPriorityStatusBuffer information and the signal control status information. The message content the status of the phase information from the signal controller.
4.1.0-133	PED-X Priority Cancel Message	The PED-X cancel message shall adapt the prgPriorityCancel message and is used to indicate that the request is no longer needed.
4.1.0-134	PED-X Priority Clear Message	The PED-X priority clear message shall adapt the prgPriorityClear message and is used to indicate that the requesting pedestrian has cleared the intersection and priority is no longer needed.
4.2.0-135	Traveler Notification of PED-X Request Receipt	Upon receipt of the PED-X Priority Status message, G-MAP shall send a notification to traveler that request was received.
4.1.0-238	PED-X Message Interface	The system shall provide interface for the PED-X message that will include information about the intersection, the path through the intersection, and whether the traveler would need the extended crossing time.

3.4.2 Pedestrian in Signalized Crosswalk Warning (Transit and Vehicle)

Pedestrian in Signalized Crosswalk Warning is an application that warns transit bus operators when pedestrians within the crosswalk of a signalized intersection are in the intended path of the bus. Since the warning is broadcast, any vehicle with onboard equipment may receive the alert. These messages are triggered by a pedestrian crossing signal. To that end, the requirements are initiated when the pedestrian crossing signal is in its Walk cycle, or until the SRM Clear message is received by the Traffic Signal Controller (see **Section 3.4.1**).

The ST-CTN system will enhance the Pedestrian in a Signalized Crosswalk Warning CV application to achieve the following system requirements provided in **Table 20**.

Table 20. Pedestrian in Signalized Crosswalk Warning Application Requirements

Requirement ID	Requirement Title	Requirement Statement
3.3.0-109	Smart Corridor Pedestrian Presence Core Functionality	The system shall utilize the Smart Corridor Pedestrian Presence functionality, interfaces, architecture and infrastructure as the core CV platform for the ST-CTN. Smart Corridor core functionality will be documented and published during Phase 2.
3.3.0-110	Smart Corridor Pedestrian Presence Alert Enhancements	The system shall enhance the Pedestrian Presence Alert by identifying additional strategies. Strategies include but are not limited to remote activation of pedestrian crossing request.

3.4.3 Ride Request

The Ride Request application allows a transit passenger to send a stop request to an approaching transit vehicle. This application allows a transit vehicle to know that a passenger has requested a transit stop from an infrastructure device. This application will use the GCT Transit Ride Request application as the core functionality that G-MAP uses to alert a transit operator to a traveler's presence and stop request at a transit stop.

The ST-CTN system will enhance the Ride Request CV application to achieve the following system requirements provided in **Table 21**.

Table 21. TSR Application Requirements

Requirement ID	Requirement Title	Requirement Statement
3.1.0-092	Ride Request Core Functionality	The ST-CTN system shall leverage the existing GCT CAD Ride Request core functionality and interfaces for the purpose of providing ST-CTN travelers with the ability to request transit stops. Leverage implies that we adapt and enhance existing functionality.

Requirement ID	Requirement Title	Requirement Statement
3.1.0-093	Next Bus Request	The GCT CAD shall send out messages when a ride is requested by a traveler via their G-MAP. The request message includes the following: 1. alert an approaching vehicle of their presence at a bus stop; 2. alert operator of any special need such as additional time for boarding or alighting;
3.1.0-095	Ride Request Trigger	G-MAP shall generate a ride request message to the GCT when a traveler opts in their trip plan (or preferences) for the next bus to be made aware of their presence at a stop. The message content will be developed with stakeholder input during the Agile Development Process including how much personal information about the traveler will be included in the message.
3.1.0-096	Ride Request Acknowledgement	The GCT CAD shall send a notification to G-MAP that the transit operator confirmed receipt of the request for next stop pickup.
3.1.0-097	Log Ride Request Transactions	The GCT CAD shall log ride request event information including trip identification, time, and location. Other pertinent information will be identified by the GCT and G-MAP developers during Phase 2 of the ST-CTN project.
3.1.0-098	Ride Request Performance	G-MAP shall transmit a request to the GCT CAD at a time convenient for an operator to stop at the next stop (prior to the expected arrival of the bus to the transit stop where the traveler waits). The time duration maximum and minimum time will be driven by the GCT and G-MAP developer during Phase 2 of the ST-CTN project.
3.1.0-099	Ride Request Transaction Latency	For the ride request transaction, the system shall minimize latency to within 1 minute from G-MAP message generation to receipt by vehicle's mobile data terminal (MDT).

3.4.4 Transit Signal Priority

Transit Signal Priority is an application that provides signal priority to transit vehicles at intersections and along arterial corridors. The TSP application uses V2I communications to allow a transit vehicle to request a priority at one or a series of intersections. This application can contribute to improved operating performance of the transit vehicles by reducing the time spent stopped at a red light.

The ST-CTN system will enhance the TSP CV application to achieve the following system requirements provided in **Table 22**.

Table 22. TSP Warning Application Requirements

Requirement ID	Requirement Title	Requirement Statement
3.3.0-107	Smart Corridor TSP Core Functionality	The system shall utilize the Smart Corridor TSP functionality, interfaces, architecture and infrastructure as the core CV platform for the ST-CTN. Smart Corridor core functionality will be documented and published during Phase 2.

3.5 System Performance Characteristics

System performance characteristics include quantitative measures that the system requirements must meet to fulfill the user needs. This includes both time-based functions and dynamic actions. The requirements for performance characteristics leveraged the PMESP to support system performance measurements and monitoring.

3.5.1 System Reliability

This section elaborates on how the modes of operation for the proposed system, described in **Section 2.3**, are used to maintain reliability and safeguards. It also describes quantitative reliability requirements (see **Table 23**) and the conditions under which the requirements should be met. System reliability is essential to this project due to the number of end users and the coordination between all subsystems.

Table 23. System Reliability Requirements

Requirement ID	Requirement Title	Requirement Statement
2.1.0-048	System Normal (Operational) Mode	The system and subsystems shall support normal mode of operation (as described in Section 2.2, which will be updated during Phase 2. Corresponding requirements will be updated accordingly).
2.1.0-049	System Degraded (Operational) Mode	The system and subsystems shall support degraded mode fallback operations to continue working (as described in Section 2.2).
2.1.0-050	System Failure (Operational) Mode	The system and subsystems shall support failure mode fallback operations to ameliorate any fault in the system (as described in Section 2.2).

Requirement ID	Requirement Title	Requirement Statement
2.1.0-051	Service Level Agreement (SLA) and Uptime	The system and system dependencies shall be designed to provide uptime operations and other SLAs for core and ancillary functionality. These SLAs will be described following preliminary system design (Phase 2 of the ST-CTN project).

3.5.2 System Scalability

The ST-CTN system will be designed such that it is able to be scaled and expanded regionally to meet the needs of a greater number of end users. The ST-CTN system will achieve the following system requirements, provided in **Table 24**, to enhance system scalability.

Table 24. System Scalability Requirements

Requirement ID	Requirement Title	Requirement Statement
2.1.0-046	Scalable Platform	The system and subsystems shall be deployed on a scalable platform to manage and meet processes and loads of all users trying to access the system simultaneously to minimize latency or disruption.
2.1.0-047	STM Scalable Cloud Environment	The STM subsystem shall implement a scalable cloud infrastructure.
2.1.1-061	Functional Process Capacity	The system shall provide processing capacity to meet demand to execute all the functions to meet service level threshold parameters. Parameters will be defined and incorporated into the service level agreement in Phase 2.
2.1.1-062	Data Process Capacity	The system shall provide processing capacity to meet demand to process real-time, operational, and persistent data. Capacity will be defined and incorporated into the service level agreement in Phase 2.

3.5.3 System Performance Measurement

The PMESP measures were leveraged in determining which metrics must be monitored to assess system performance. The ST-CTN system will achieve the following system requirements provided in **Table 25** to facilitate system performance measurement.

Table 25. System Performance Measurement Requirements

Requirement ID	Requirement Title	Requirement Statement
3.1.0-100	GCT Registered Inaccessibility Complaints	GCT shall provide anonymized inaccessibility complaints when received by their existing customer complaint systems to the STM Performance Measurement Dashboard.
3.1.0-101	GCT Fixed Route Ridership	GCT shall provide fixed-route ridership data to the STM Performance Measurement Dashboard at a minimum on a monthly basis. The specific content and frequency of the dataset shall be specified during Phase 2 of the ST-CTN project.
3.1.0-103	GCT GTFS	GCT shall provide GTFS data feeds to the STM Performance Measurement Dashboard.
3.1.0-104	GCT GTFS-RT	GCT shall provide GTFS-RT data feeds to the STM Performance Measurement Dashboard.
7.3.0-219	Analyze Trip Performance	The STM performance measurement computation engine shall generate measures that show traveler behavior based on the planned and actual trips. The details of the statistics will be driven by the Performance Measurement and System Evaluation Plan (PMESP).
7.3.0-250	Public PMD Display	The public PMD shall display summary of performance measures in graphic and tabular format.
7.3.0-251	Public PMD Access	The public PMD shall provide access to public of the summary performance measures.

3.6 System Security and Privacy

System security and privacy involves both the cyber and physical security of the ST-CTN system, specifically addressing protection from external actors. The work completed in the Phase 1 DMP was leveraged to understand and develop the requirements needed to support security and privacy policies and procedures of the existing systems, which can be found in Table 9 and Table 12 of the Phase 1 DMP.

The ST-CTN system will achieve the following system requirements provided in **Table 26** to ensure system security and privacy.

Table 26. System Security and Privacy Requirements

Requirement ID	Requirement Title	Requirement Statement
1.1.0-004	Enforce Privacy Policy	The system shall implement and enforce provisions of the system privacy policy (see **Section 3.9**). Details of policies will be developed with ST-CTN partners and IRB provisions in Phase 2.
1.1.0-005	Enforce Security Policies	The system shall implement and enforce provisions of the system security policies (see **Section 3.9**). Details of policies will be developed with ST-CTN partners and IRB provisions in Phase 2.
1.1.0-006	Assign User Access	The system shall assign user access rights to all data collected by data source and classification.
1.1.0-007	PII Policies	The system shall align all PII policies to comply with IRB protocols. PII data includes all data that can directly or in combination with other data sources be used to identify a participant including, but not limited to as determined by the IRB protocol: • data inserted by the traveler such as registration, contact, preferences, correspondence from G-MAP platform; • data generated by the system including trip plans (including origin/destination), trip tracking during execution, transactions with beacons, intersections, and other infrastructure devices; or • data derived by the system including trace data (even with generalized zone to zone).
1.1.0-008	PII Policy Enforcement	The system shall implement PII policies for compliance.
1.1.0-009	PII Management Adherence	The system shall monitor data access any breaches in PII security in conformance with IRB protocols.
1.1.0-010	PII Reporting Adherence	The system shall report data access and report any breaches in PII security in conformance with IRB protocols.
1.1.0-011	PII Lifecycle Tracking	The system shall track PII data usage throughout its lifecycle in order to comply with future user “opt-out” requests.
1.1.0-014	Account Contact Information	The system shall not use contact information collected for registration for purposes other than G-MAP registration. The data will remain in G-MAP and will not be shared with the research or PII servers.

Requirement ID	Requirement Title	Requirement Statement
1.1.0-015	No Share PII	The system shall not share PII data generated by the system to any external data storage system as designated in the ST-CTN DMP Section 2.2.
1.1.0-016	Secure Storage for PII	The system shall store PII in a secure environment on premises at Georgia Tech, which is protected from physical access, cyberattacks, and infiltration.
1.1.0-017	Network Security	The system shall provide end-to-end encrypted and secure communications including at intermediate points within the wireless and wired infrastructure when exchanging information between subsystems (CV-STM; CV-G-MAP; G-MAP-GCT; and RSU-OBU). The design of the network security features will be developed in Phase 2.
5.1.0-252	SMUG Security Protocols	G-MAP operator, SMUG Server operator, and Signal Control operator shall agree upon and implement security procedures, policies and protocols to authenticate, validate and restrict traffic between G-MAP, SMUG and signal controllers.

3.7 Information Management

Information management requirements involve protecting and managing data within the ST-CTN system such as user privacy (passwords, encryption, and access levels). The ST-CTN system's information management will be enhanced through the following system requirements provided in **Table 27**.

Table 27. Information Management Requirements

Requirement ID	Requirement Title	Requirement Statement
2.1.0-052	Data Backup System	The system shall provide backup systems that protect various datasets including transactional, operational and archived data.
2.1.0-053	PII Data Backup	The system shall provide a separate back up system for PII data consistent with IRB protocols.
2.1.0-054	Manual and Automated Backup Functions	The system shall provide automated and manual functions for a system administrator to schedule and execute full and interim backups.

Requirement ID	Requirement Title	Requirement Statement
2.1.0-055	Backup Recovery	The system shall provide tools for the system administrator to load and recover data from the backup facility. The backup system shall be configured to provide optimal data backups as part of a disaster recovery plan or the equivalent.

3.8 System Operations and Maintenance

System operations and maintenance relates to interactions between the user and the system, such as usability and ergonomics.

3.8.1 System Human Factors

System human factors pertain to those interactions between the user and the system. The ST-CTN system will leverage the existing functionality and interface provided by the G-MAP subsystem. The G-MAP subsystem usability and ergonomic functionality is being designed and will be enhanced through this project to serve all users, and specifically underserved communities. System requirements dedicated to supporting system human factors are integrated throughout; specifically, within **Section 3.1.2**, requirement 2.3.0-083 pertains to the use of WCAG 2.1, requirement 2.3.0-080 pertains to the notification channels necessary to support all users, and requirement 2.4.0-082 pertains to the use of Native SDK and accessibility recommendations published by the operating system vendors and handset manufacturers.

3.8.2 System Operations

The following requirements provided in **Table 28** enhance ST-CTN system operations.

Table 28. System Operations Requirements

Requirement ID	Requirement Title	Requirement Statement
2.1.0-056	Detect Degraded Mode	Each subsystem shall alert related/dependent subsystems to subsystem degradation or failure immediately when detected. The degraded and failure modes are described in Section 2.2. The system alert message will be developed as part of Phase 2 of the ST-CTN project.
2.1.0-060	Coordinated Universal Time	The system shall exchange time using the Coordinated Universal Time (UTC). The system shall use ISO 8601 Date and Time Format to describe UTC.

Requirement ID	Requirement Title	Requirement Statement
2.1.1-063	STM Health and Operational Status Logs	The STM Subsystem shall log their health and operational status in a subsystem log file. Although each log file will document different operational statuses, at a minimum, the files will include the following types of information: • Subsystem uptime, downtime, recovery, maintenance activity • Operational mode (normal, degraded, failure) status and duration • Route impedance value calculation update time
2.1.1-064	G-MAP Health and Operational Status Logs	The G-MAP Subsystem shall log their health and operational status in a subsystem log file. Although each log file will document different operational statuses, at a minimum, the files will include the following types of information: • Subsystem uptime, downtime, recovery, maintenance activity • Operational mode (normal, degraded, failure) status and duration • Number of ST-CTN registered users • Number of ST-CTN unique users per day • Number of ST-CTN trip plan requests per day • Number of ST-CTN user connection time-outs • Number of ST-CTN dropped users

3.8.3 System Maintainability

This section contains requirements regarding maintenance activities and support of the system. The ST-CTN system will achieve the system requirements provided in **Table 29** to ensure system maintainability.

Table 29. System Maintainability Requirements

Requirement ID	Requirement Title	Requirement Statement
2.1.0-057	Software Patches and Updates	Each subsystem shall publish a system change notification when system maintenance, software changes or interface changes are anticipated and completed. These include scheduled and unscheduled patches, version updates, or system upgrades.

Requirement ID	Requirement Title	Requirement Statement
2.1.0-058	Mobile App Software Updates	The G-MAP mobile app shall be updated as needed to ensure operations with updated mobile device system operating software. The SLA related to how soon after the OS update or patch is applied by the vendor will be included in the SLAs (see Req 2.1.0-051).

3.9 Policy and Regulation

Each agency involved in ST-CTN has their own IT and communications policies. GDOT's network security policies are the strictest and forbid any devices directly connected to their signals from also connecting to the cloud. This constraint has been addressed through the use of a SMUG in the CV diagram as seen in **Section 2.3.3**, CV Subsystem. It is anticipated that G-MAP will continue to be hosted via Amazon Web Services with 24/7 hours of operation. It is anticipated that the ST-CTN project will continue to work within the partner agency operational policies and constraints.

The following requirements provided in **Table 30** meet the elaborate policies in Section 5.6 of the ConOps. These policies include organization policies, external regulatory requirements, or constraints of the system's operations.

Table 30. Policy and Regulation Requirements

Requirement ID	Requirement Title	Requirement Statement
1.1.0-001	System Privacy Policy	ST-CTN project privacy policy shall be developed for all project subsystems that is consistent with the IRB provisions.
1.1.0-002	System Security Policy	System security policies shall be developed that ensures end-to-end data protection and is consistent with each subsystem's internal security provisions.
1.1.0-003	Data Use Agreement	An end-user data use agreement shall be developed that describes the effective uses of the data and the rights of persons using the ST-CTN tools and functions.

3.10 System Lifecycle Sustainment

The following requirements describe system lifecycle sustainment. This is also known as quality control and quality assurance in the form of review and measurement collection and analysis. As new system enhancements emerge, measurement collection and analysis will be done to determine full impact.

3.10.1 Technical System Requirements

Table 31 describes the technical system requirements for lifecycle sustainment.

Table 31. Technical System Requirements

Requirement ID	Requirement Title	Requirement Statement
2.3.0-081	Open Architecture	The system shall exchange data using open APIs including but not limited to REST, JavaScript Object Notation (JSON), XML or comma delimited separated datasets.
3.2.0-106	ST-CTN and GCT Ride Request Testing Coordination	The ST-CTN project team shall coordinate GCT Ride Request testing, including elements related to end-to-end timing, security, message processing and management.
5.1.1-143	Smart Corridor Pedestrian at Intersection - for Bus Alerts	The ST-CTN project team shall coordinate testing to verify Smart Corridor implementation of pedestrian bus alerts. The CV RSU shall send a safety warning to a transit vehicle via its OBU as it approaches or turns at an intersection where the RSU received a PSM or PED-X SRM. The Smart Corridor project will implement this function as part of the Smart Corridor core functionality.
5.1.1-144	Smart Corridor Pedestrian at Intersection - for Vehicle Alerts	The ST-CTN project team shall coordinate testing to verify Smart Corridor implementation of pedestrian vehicle alerts. The CV RSU shall send a safety warning to vehicles via their OBUs as it approaches or turns at an intersection where the RSU received a PSM or PED-X SRM. The Smart Corridor project will implement this function as part of the Smart Corridor core functionality.
5.1.2-145	ST-CTN and CV Applications Testing Coordination - PED-SIG	The ST-CTN project team shall coordinate CV PED-SIG testing, including elements related to end-to-end timing, security, message processing and management.
6.1.0-148	Data Curation	The data stewards and custodians shall establish a data curation process for each dataset that they manage that meets the provisions of DMP and PMESP. The curation process will include data collection (ingestion, acquisition), verification and quality checking, storage (extraction, transformation, loading), and distribution procedures.
6.1.0-149	Data Quality Processes	The data steward for each derived dataset shall document quality checking procedures for cleaning and verifying their dataset. That includes each step from acquisition through storing, providing access and deprecating.

Requirement ID	Requirement Title	Requirement Statement
6.1.0-152	Import Indoor Asset Condition Data	The system shall implement the data curation process for static and dynamic indoor asset data including elevator outages, escalator outages, and building entrance closures.
6.1.0-153	Import Traffic / Transit Asset Data	The system shall implement a data curation process for IOO asset information (e.g., traffic light locations, RSU locations) as described by the DMP. Note: The requirement for a curation process for each dataset is described in Section 3.10.1.
6.1.0-154	Import Transit Data (static and real time)	The system shall implement a data curation process for static and dynamic transit data including GTFS and GTFS-RT (from MARTA and GCT). Note: The requirement for a curation process for each dataset is described in Section 3.10.1.
6.1.0-158	STM Manage Signal Control Data	The STM Platform shall subscribe to and implement a data curation process for signal control data from the CV subsystem.
6.1.0-164	ST-CTN and CV Publish and Subscribe Testing Coordination - MAP	The ST-CTN project team shall coordinate CV publish and subscribe testing to verify receipt of existing published CV subsystem MAP data.
6.1.0-180	ST-CTN and CV Publish and Subscribe Testing Coordination - PSM	The ST-CTN project team shall coordinate CV publish and subscribe testing to verify receipt of existing published CV subsystem PSM data.
8.1.1-220	Provision for Future Growth	The system shall be capable of expanding capacity, load, and demand over several years to process all the functions and store real-time and persistent data to meet the maximum load. Consideration should extend to each architecture tier including data (real-time and persistent data), processing/functions, and presentation, channelization, and transaction throughput.

3.10.2 Non-Technical System Requirements

Table 32 describes the non-technical system requirements for lifecycle sustainment.

Table 32. Non-Technical System Requirements

Requirement ID	Requirement Title	Requirement Statement
1.2.0-019	Agile Backlog	The Agile Development Process shall define how software developers will develop, publish and schedule epics and user stories that will be used as part of their Agile process, in coordination with the stakeholder review team (SRT). The Agile Development Process will be defined in the Systems Engineering Management Plan (SEMP).
1.2.0-020	Agile Sprint Tracking	The Agile Development Process shall define how software developers will provide access for stakeholders to view sprint assignments and performance statistics including but not limited to sprint schedules, progress, and bug tracking.
1.2.0-021	Agile Stakeholder Engagement	The Agile Development Process shall define a process to assign end-users to a Stakeholder Review Team which will review user stories and drive priority development.
6.1.0-146	Disaster Recovery Plan	A Disaster Recovery Plan, or the equivalent, shall be developed and project administrators trained in its implementation. The DRP shall cover data breach, cyberattacks, and other major disruptions to the service.
6.1.0-147	Data Governance	The data stewards and custodians shall set up an enterprise data governance committee (EDG) to discuss rules and procedures to manage and align datasets created and used through the system as referenced in the DMP Section 2.3.

4. System Interfaces

The ST-CTN system will rely heavily on new or modified interfaces between internal and external system components. The ST-CTN system is made up of several existing subsystems with existing interfaces. Interfaces that are not changed in the proposed system have no requirements defined. Interfaces that are changed or are new are denoted by dark black lines in context diagrams for the ST-CTN system and subsystems in **Figure 4, Figure 5, Figure 6,** and **Figure 7.** All external interfaces for inputs and outputs are included in **Table 3** and **Table 4**.

Interface requirements for the ST-CTN system are broken into two tables. **Table 33** provides system requirement that are necessary in order to support other system requirements and operations. The Requirement IDs listed in **Table 33** are tied to other requirements with similar IDs.

Table 34 provides system requirements that are necessary in order to the ST-CTN system interfaces in general. Requirements for interfaces in **Table 34** are simply required to follow the existing standard as listed.

Table 33. System Specific Interface Requirements

Requirement ID	Requirement Title	Requirement Statement
2.2.0-079	Call Center User Interface	G-MAP shall provide UIs (APIs) that support and provide call center operators with access to traveler account management and trip planning functions. The UI services are implemented in ATL RIDES (IMI) and specified in https://fdot-support.s3.amazonaws.com/index.html Note: processes will be implemented, and services customized to support the existing GCT call center that allows call takers to be "trusted" third parties to access traveler account information.
3.1.0-094	Ride Request APIs	The GCT CAD system shall provide transaction services (APIs) for G-MAP to request transit ride request.

Table 34. General Interface Requirements

Requirement ID	Requirement Title	Requirement Statement
0.0.0-221	Interface Profiles and Guidance	Each internal and system interface, data feed, API, message set shall include published implementation guidance that describes the data formats, content, encoding, organization, mandatory / optional data, use, orchestration and communications protocols used for exchanging the interface. The implementation guidance may be documented as a Protocol Requirements List (PRL), PICS, ICD, data dictionary with best practices examples, or sample schema.
0.0.0-222	Standards Compliance -- NTCIP 1103	See Req 0.0.0-221. NTCIP 1103 v03 – Transportation Management Protocols, December 2016, AASHTO/ITE/NEMA.
0.0.0-223	Standards Compliance -- NTCIP 1201	See Req 0.0.0-221. NTCIP 1201 v03 – Global Object Definitions, March 2011, AASHTO/ITE/NEMA.
0.0.0-224	Standards Compliance -- NTCIP 1202	See Req 0.0.0-221. NTCIP 1202 v02 – Object Definitions for Actuated Signal Controllers, November 2005, AASHTO/ITE/NEMA.
0.0.0-226	Standards Compliance -- SAE 731.1	See Req 0.0.0-221. SAE EIA-731.1 – Technical Report, Systems Engineering Capability Model, August 2002, SAE International.
0.0.0-228	Standards Compliance -- SAE J2945 part 1	See Req 0.0.0-221. SAE J2945-1:20204 - On-Board System Requirements for V2V Safety Communications, April 2020, SAE International
0.0.0-229	Standards Compliance -- SAE J2945 part 2	See Req 0.0.0-221. SAE J2945-2:201810 - Dedicated Short Range Communications (DSRC) Performance Requirements for V2V Safety Awareness, October 2018, SAE International
0.0.0-230	Standards Compliance -- SAE J2945 part 9	See Req 0.0.0-221. SAE J2945-9:201703 - Vulnerable Road User Safety Message Minimum Performance Requirements, March 2017, SAE International
0.0.0-231	Standards Compliance -- IETF RFC 791	See Req 0.0.0-221. IETF RFC 791, Internet Protocol

Requirement ID	Requirement Title	Requirement Statement
0.0.0-232	GTFS	See Req 0.0.0-221. GTFS. General Transit Feed Specification Reference. Washington D.C.: GTFS. (2024).
0.0.0-233	GTFS realtime	See Req 0.0.0-221. GTFS Realtime. GTFS Realtime Reference v2. Washington D.C.: GTFS Realtime. (2019)
0.0.0-236	OSM	See Req 0.0.0-221. OpenStreetMap Foundation. Open Street Map. Washington D.C.: UCL, ByteMark. (2021).
0.0.0-237	OTP	See Req 0.0.0-221. OTP core functionality is described on https://github.com/opentripplanner/OpenTripPlanner and ATL RIDES (IMI grant) and requirements are listed at: https://github.com/opentripplanner/OpenTripPlanner and https://docs.google.com/spreadsheets/d/1nnx0TUl-l8z94mqJgx7i3PxZ3GZ3YCj9_AabDFKNytc/edit#gid=0.

Appendix A. Needs-to-Requirements Traceability Matrix

The Needs-To-Requirements Matrix (NRTM) (as shown in **Table 35**) is a critical tool for ensuring that system requirements cover all of the user needs. ST-CTN end user needs and IOO needs drive system needs. The ST-CTN project team developed requirements based on system needs and use cases. Traceability exists between each end user, IOO, and system need. Traceability further exists between system needs and system requirements.

This traceability will form the basis of the traceability to design, test cases and test procedures as the system engineering process continues. Those system needs that were developed as future and designated as optional have not been included within this table as the requirements will be out of scope for this project. The NTRM traceability will be maintained through the entire process as it is the first link from the user needs into the details of the system. Without this traceability it becomes impossible to determine if the system fulfills the user needs when complete. The ID and statement in bold text and grey cells are the system needs followed by the corresponding system requirements. The most up to date end user needs, IOO needs, system needs, and system requirements can be found in the Requirements Traceability Matrix excel spreadsheet.

Table 35. Needs-to-Requirements Traceability Matrix

System Need ID/ Requirement ID	System Need/Requirement
PT-SY-1.1	**The system needs to protect traveler safety and privacy by ensuring tracking services are optional (opt-in) and any PII is secure.**
1.1.0-001	ST-CTN project privacy policy shall be developed for all project subsystems that is consistent with the IRB provisions.
1.1.0-002	System security policies shall be developed that ensures end-to-end data protection and is consistent with each subsystem's internal security provisions.

System Need ID/ Requirement ID	System Need/Requirement
1.1.0-003	An end-user data use agreement shall be developed that describes the effective uses of the data and the rights of persons using the ST-CTN tools and functions.
1.1.0-004	The system shall implement and enforce provisions of the system privacy policy (see Section 3.9). Details of policies will be developed with ST-CTN partners and IRB provisions in Phase 2.
1.1.0-005	The system shall implement and enforce provisions of the system security policies (see Section 3.9). Details of policies will be developed with ST-CTN partners and IRB provisions in Phase 2.
1.1.0-006	The system shall assign user access rights to all data collected by data source and classification.
1.1.0-007	The system shall align all PII policies to comply with IRB protocols. PII data includes all data that can directly or in combination with other data sources be used to identify a participant including, but not limited to as determined by the IRB protocol: • data inserted by the traveler such as registration, contact, preferences, correspondence from G-MAP platform; • data generated by the system including trip plans (including origin/destination), trip tracking during execution, transactions with beacons, intersections, and other infrastructure devices; or • data derived by the system including trace data (even with generalized zone to zone).
1.1.0-008	The system shall implement PII policies for compliance.
1.1.0-009	The system shall monitor data access any breaches in PII security in conformance with IRB protocols.
1.1.0-010	The system shall report data access and report any breaches in PII security in conformance with IRB protocols.
1.1.0-011	The system shall track PII data usage throughout its lifecycle in order to comply with future user “opt-out” requests.

System Need ID/ Requirement ID	System Need/Requirement
1.1.0-012	G-MAP shall provide an option for travelers to "opt-in" and sign user agreement to allow the system to store and use specific PII. The opt-in and agreement enables the G-MAP account management and mobile app to register, select preferences and track travelers. Planning functions that do not need registration services will still be available for travelers. The Use Agreement will outline the data that will be kept in the account management system but not shared (e.g., name, home address, phone) and data that will be shared (e.g., trip trace and trip plan with preference choices).
1.1.0-013	G-MAP shall provide an option for travelers to "opt-out" of a previously selected "opt-in" state. Specifically, the system shall wipe (permanently delete) any PII travel and preference data from any storage system in the ST-CTN when a traveler transitions from opt-in to opt-out. Note: a traveler must delete their account to remove their contact information from the system.
1.1.0-014	The system shall not use contact information collected for registration for purposes other than G-MAP registration. The data will remain in G-MAP and will not be shared with the research or PII servers.
1.1.0-015	The system shall not share PII data generated by the system to any external data storage system as designated in the ST-CTN DMP Section 2.2.
1.1.0-016	The system shall store PII in a secure environment on premises at Georgia Tech, which is protected from physical access, cyberattacks, and infiltration.
1.1.0-017	The system shall provide end-to-end encrypted and secure communications including at intermediate points within the wireless and wired infrastructure when exchanging information between subsystems (CV-STM; CV-G-MAP; G-MAP-GCT; and RSU-OBU). The design of the network security features will be developed in Phase 2.
PT-SY-1.2	**The system needs to provide support services to all travelers during their journey, including those who do not have access to data (e.g., cellular connection or access to the internet) during travel.**

System Need ID/ Requirement ID	System Need/Requirement
1.2.0-018	The system shall utilize the OTP and ATL RIDES (IMI grant) functionality, interfaces, architecture and infrastructure as the core G-MAP for the ST-CTN.
1.2.0-019	The Agile Development Process shall define how software developers will develop, publish and schedule epics and user stories that will be used as part of their Agile process, in coordination with the stakeholder review team (SRT). The Agile Development Process will be defined in the Systems Engineering Management Plan (SEMP).
1.2.0-020	The Agile Development Process shall define how software developers will provide access for stakeholders to view sprint assignments and performance statistics including but not limited to sprint schedules, progress, and bug tracking.
1.2.0-021	The Agile Development Process shall define a process to assign end-users to a Stakeholder Review Team which will review user stories and drive priority development.
1.2.0-022	The system shall provide travelers the option to select support services they prefer to access during their journey. The types of support services and their deployment priority will be designated during the Agile Development Process in collaboration with the end-user stakeholder group. At a minimum, support services include selecting and configuring notifications, identifying triggers, directions, communications channels, and user interface (UI) methods (e.g., text, voice, haptic sensor, other).
1.2.0-023	The system shall provide travelers the option to select the communication channel(s) they use to access services to plan their trip including mobile app, call center, telephone, SMS, and online (via web application). The functions and information provisioned through each channel will be driven by stakeholder input during the Agile Development Process.
1.2.0-024	The system shall provide travelers the option to select the communication channel they use to access services to execute their trip including mobile app, call center, telephone, SMS, and online (via web application). The channels will support communications using data serialization and non-data methods (e.g., call center agent). The functions and information provisioned through each channel will be driven by stakeholder input during the Agile Development Process.

System Need ID/ Requirement ID	System Need/Requirement
1.2.0-025	The system shall provide travelers communications channels that support their service preferences based on their defined preferences and abilities. The functions and information provisioned through each channel will be driven by specific stakeholder input during the Agile Development Process.
PT-SY-1.3	**The system needs to generate a framework to transform values assigned to travel preferences into impedance values for the simulation models (e.g., SidewalkSim).**
1.3.0-026	The system shall leverage the existing STM functionality and interfaces as the core STM subsystem for the ST-CTN. Leverage implies that we adapt and enhance existing functionality.
1.3.0-027	The system shall define logical groupings of "VRU categories" that will be used to tailor impedance values based on transportation network features, attributes and conditions (as selected by travelers of similar abilities and preferences). Specifically, the VRU categories are characterized by their severity of movement with respect to ADA design features.
1.3.0-028	The STM Platform shall implement processes (algorithms) that produce impedance values that apply to VRU group abilities and are associated with the Whole Road Network (see DMP Data ID-3).
1.3.0-029	The STM Platform shall incorporate feedback from traveler choices including but not limited to deviations from planned trip and traveler comments on trip plan to update the coefficient impedance values.
1.3.0-030	The STM Platform shall incorporate feedback on updated static features including but not limited to from work zone, event data, to tailor the impedance values in the operational engine (using existing algorithms).
1.3.0-031	The STM Platform shall incorporate feedback on updated dynamic features, attributes, and conditions, including but not limited to from work zone and event data, to tailor the impedance values in the operational engine (using existing algorithms).
1.3.0-032	The STM Platform shall regenerate the impedance values for each Mobility Category by incorporating any updated dynamic changes to the network features, attributes or conditions at a frequency that is commensurate with the incoming information.

System Need ID/ Requirement ID	System Need/Requirement
1.3.0-033	The STM Platform shall regenerate the impedance values for each Mobility Category by incorporating any updated dynamic changes to the network features, attributes or conditions at a frequency that is commensurate with the incoming information. The rate of regeneration will be identified during Phase 2 of the ST-CTN project.
1.3.0-034	The STM Platform shall publish impedance values by VRU group via the Network Impedance API (DMP Data ID-25) to subscribers including ATL RIDES. The rate of publication will be identified during Phase 2 of the ST-CTN project.
1.3.0-035	The STM Platform shall reconcile multiple transportation networks to generate a Whole Road Network (DMP Data ID-3). The Whole Road Network (DMP Data ID-3) will relate planning, operations, transit, public right of way, public transportation networks, their features, assets, attributes, and conditions. Specific transportation networks that will be conflated to generate the Whole Road Network are listed in the DMP Table 6. Details of the reconciliation will be documented in the data curation plan associated with the Whole Road Network as specified by Req 6.1.0-148.
1.3.0-036	The STM Platform shall update the Whole Road Network attributes as new conditions are ingested. The updated datasets that contribute to the road network include at a minimum: 1. signal control data, and 2. traffic congestion
1.3.0-037	The system shall employ the same link-and-node structure for the Whole Road Network and OSM structure such that network links tracked in the STM are mapped to routing links in the OSM for impedance data flow. Use of the OSM nodes and attributes will provide scalability beyond the ST-CTN project and also be compatible with the OTP upon which the G-MAP subsystem is based.
1.3.0-038	The STM Platform shall apply a curation process for each network road dataset enumerated in the DMP. The curation process shall consist of the following processes: import (acquisition), extract, validate, transform, and load functions. (See data curation Req 6.1.0-148).
PT-SY-1.4	**The system needs to allow travelers to customize the UI of the application based on their abilities or preferences.**

System Need ID/ Requirement ID	System Need/Requirement
1.4.0-039	G-MAP shall allow travelers to save their preferred method by which they receive notifications and navigation directions in their profile settings. The UI methods include but are not limited to voice, text or haptic/vibration. (See Req: 2.4.0-071)
1.4.0-040	When planning a trip, G-MAP shall allow travelers to select the preferred method by which they receive specific notifications including when, how and how often the information is transmitted to them. The specific notifications and the types of notification methods will be driven by stakeholder input during the Agile Development Process.
1.4.0-041	G-MAP shall allow travelers to update their trip plan notification selections when actuating a saved trip plan.
1.4.0-042	G-MAP shall limit end-to-end transmission from trigger event to transmission to traveler's device of less than 1 second. Note: traveler's carrier and personal device are not calculated in this latency budget.
PT-SY-1.5	**The system needs to provide travelers with an option of adding additional travelers and their accessibility needs when planning a trip.**
1.5.0-043	G-MAP shall be enhanced to allow a traveler planning a trip to include a companion using their combined preferences and abilities in the trip settings. The impedance values used to calculate the shared trip shall use VRU categories as defined in Section 2.5.1.
1.5.0-044	When traveling in a group, G-MAP shall request that the traveler rank and confirm the most critical preferences to include in the group trip plan. For example, when a traveler plans a trip with children or with companions with different abilities, G-MAP will ask the traveler to alter their default preferences to align with the preferences for the group travel needs.
PT-SY-1.6	**The system needs to allow travelers to practice their turn-by-turn directions before the trip with their preferred notifications, device, or methods to reduce disorientation and discomfort during the trip.**
1.6.0-045	G-MAP shall allow travelers to set a practice mode wherein they can simulate their turn-by-turn directions before the trip using their preferred notifications, device, or methods. The practice mode functionality will be driven by stakeholder input during the Agile Development Process.

System Need ID/ Requirement ID	System Need/Requirement
BT-SY-2.1	**The complete trip system functions (STM and ATL RIDES) need to be scalable to generate and accommodate multiple personalized trip plans and journeys for travelers simultaneously in order to be reliable and responsive to traveler requests and preferences.**
2.1.0-046	The system and subsystems shall be deployed on a scalable platform to manage and meet processes and loads of all users trying to access the system simultaneously to minimize latency or disruption.
2.1.0-047	The STM subsystem shall implement a scalable, cloud infrastructure.
2.1.0-048	The system and subsystems shall support normal mode of operation (as described in Section 2.2, which will be updated during Phase 2. Corresponding requirements will be updated accordingly).
2.1.0-049	The system and subsystems shall support degraded mode fallback operations to continue working (as described in Section 2.2).
2.1.0-050	The system and subsystems shall support failure mode fallback operations to ameliorate any fault in the system (as described in Section 2.2).
2.1.0-051	The system and system dependencies shall be designed to provide uptime operations and other SLAs for core and ancillary functionality. These SLAs will be described following preliminary system design (Phase 2 of the ST-CTN project).
2.1.0-052	The system shall provide backup systems that protect various datasets including transactional, operational and archived data.
2.1.0-053	The system shall provide a separate back up system for PII data consistent with IRB protocols.
2.1.0-054	The system shall provide automated and manual functions for a system administrator to schedule and execute full and interim backups.

System Need ID/ Requirement ID	System Need/Requirement
2.1.0-055	The system shall provide tools for the system administrator to load and recover data from the backup facility. The backup system shall be configured to provide optimal data backups as part of a disaster recovery plan or the equivalent.
2.1.0-056	Each subsystem shall alert related/dependent subsystems to subsystem degradation or failure immediately when detected. The degraded and failure modes are described in Section 2.2. The system alert message will be developed as part of Phase 2 of the ST-CTN project.
2.1.0-057	Each subsystem shall publish a system change notification when system maintenance, software changes or interface changes are anticipated and completed. These include scheduled and unscheduled patches, version updates, or system upgrades.
2.1.0-058	The G-MAP mobile app shall be updated as needed to ensure operations with updated mobile device system operating software. The SLA related to how soon after the OS update or patch is applied by the vendor will be included in the SLAs (see Req 2.1.0-051).
2.1.0-060	The system shall exchange time using the Coordinated Universal Time (UTC). The system shall use ISO 8601 Date and Time Format to describe UTC.
BT-SY-2.1.1	**ATL RIDES needs to be accessed simultaneously by all travelers who are interested in planning a trip so as not to lose or drop their requests or notifications.**
2.1.1-061	The system shall provide processing capacity to meet demand to execute all the functions to meet service level threshold parameters. Parameters will be defined and incorporated into the service level agreement in Phase 2.
2.1.1-062	The system shall provide processing capacity to meet demand to process real-time, operational, and persistent data. Capacity will be defined and incorporated into the service level agreement in Phase 2.

System Need ID/ Requirement ID	System Need/Requirement
2.1.1-063	The STM Subsystem shall log their health and operational status in a subsystem log file. Although each log file will document different operational statuses, at a minimum, the files will include the following types of information: • Subsystem uptime, downtime, recovery, maintenance activity • Operational mode (normal, degraded, failure) status and duration • Route impedance value calculation update time
2.1.1-064	The G-MAP Subsystem shall log their health and operational status in a subsystem log file. Although each log file will document different operational statuses, at a minimum, the files will include the following types of information: • Subsystem uptime, downtime, recovery, maintenance activity • Operational mode (normal, degraded, failure) status and duration • Number of ST-CTN registered users • Number of ST-CTN unique users per day • Number of ST-CTN trip plan requests per day • Number of ST-CTN user connection time-outs • Number of ST-CTN dropped users
2.1.1-066	G-MAP shall monitor G-MAP component health and operational status. The specific measures will be identified during Phase 2 of the ST-CTN project.
2.1.1-067	G-MAP shall log G-MAP component health and operational status. The specific measures will be identified during Phase 2 of the ST-CTN project.
2.1.1-068	The STM Platform shall monitor STM component health and operational status. The specific metrics will be identified during Phase 2 of the ST-CTN project.

System Need ID/ Requirement ID	System Need/Requirement
2.1.1-069	The STM Platform shall log STM component health and operational status. The specific metrics will be identified during Phase 2 of the ST-CTN project.
2.1.1-070	The CV subsystem shall monitor CV component (as described in Section 2.3.3) health and operational status. The specific metrics will be identified during Phase 2 of the ST-CTN project.
2.1.1-072	G-MAP shall transmit health and operational status logs to the STM Performance Measurement Dashboard on an as needed basis. The specific metrics will be identified during Phase 2 of the ST-CTN project.
2.1.1-073	The STM Platform shall transmit health and operational status logs to the STM Performance Measurement Dashboard on an as needed basis. The specific metrics will be identified during Phase 2 of the ST-CTN project.
2.1.1-074	The CV subsystem shall transmit health and operational status logs to the STM Performance Measurement Dashboard on an as needed basis. The specific metrics will be identified during Phase 2 of the ST-CTN project.
BT-SY-2.1.2	**ATL RIDES needs to respond and regenerate trip plans for all travelers simultaneously based on their trip routing and mode preferences, notification preferences, and accessibility preferences in order to be reliable and responsive to their requests.**
2.1.2-075	G-MAP shall recalculate trip plans at periodic intervals to identify dynamic challenges that may disrupt travelers enroute. The periodic interval (i.e., duration between recalculations) is subject to dynamic information that impacts travel plans (e.g., real time bus status updates). See Req 2.1.2-076 for related requirement.
2.1.2-076	G-MAP shall base the recalculated trip plans on the updated impedance values in the STM published Network Impedance API and data that is integrated from other sources as available.
BT-SY-2.1.3	**STM needs to respond and generate updates based on the ATL RIDES routing engine needs to the predictive networks (e.g., SidewalkSim), and produce an appropriately formatted network that can be ingested for trip planning and journeying purposes.**

System Need ID/ Requirement ID	System Need/Requirement
2.1.3-077	The STM Platform shall publish, at periodic intervals, the Network Impedance API that disseminates updated impedance values based on complete paths updates. At a minimum, the duration between distribution will be at 15 minutes intervals.
BT-SY-2.2	**The ATL RIDES Mobile App needs to be capable of providing hands-free, turn-by-turn directions based on user preferences and abilities to meet user needs.**
2.2.0-078	G-MAP mobile app shall provide the same functionality as described by the core functionality included in the web application (Section 3.1) for traveler account management and trip planning functions.
2.2.0-079	G-MAP shall provide UIs (APIs) that support and provide call center operators with access to traveler account management and trip planning functions. The UI services are implemented in ATL RIDES (IMI) and specified in https://fdot-support.s3.amazonaws.com/index.html Note: processes will be implemented, and services customized to support the existing GCT call center that allows call takers to be "trusted" third parties to access traveler account information.
BT-SY-2.3	**The system needs to be compatible with open standards including those that are embedded or used in devices such as mobile phones and connected assistive devices.**
2.3.0-080	G-MAP shall use an open communications protocol such as Bluetooth (4 or 5), NFC (ISO/IEC 18000-3), Wi-Fi (4, 5 or 6), or LTE 4, 4G or 5G in order to pair with infrastructure devices/system (e.g., beacons).
2.3.0-081	The system shall exchange data using open APIs including but not limited to REST, JavaScript Object Notation (JSON), XML or comma delimited separated datasets.
2.3.0-082	The G-MAP mobile app shall use native SDK and implement the accessibility guidance recommended by the handset and operating system manufacturers.

System Need ID/ Requirement ID	System Need/Requirement
2.3.0-083	The system shall comply with Web Content Accessibility Guidance (WCAG) 2.1 or higher for all user interfaces (web and mobile app).
BT-SY-2.4	**The system needs to be designed such that travelers will be able to customize how notifications are received based on their abilities or preferences.**
2.4.0-084	G-MAP shall allow travelers to customize the types of notifications they prefer to receive as they journey on a planned trip. The set of notifications will be driven by stakeholder input during the Agile Development Process.
2.4.0-085	G-MAP shall allow travelers to select which notifications are delivered via voice (by phone or mobile app voice), text or icon (SMS or on screen), vibration (to alert to text message or signal a "turn"). The mapping of notification types to UI methods will be driven by stakeholder input during the Agile Development Process. (See Req 2.4.0-084)
BT-SY-2.5	**The system needs to be able to track travelers who opt-in to provide more support during their trip through a call center or their caregiver.**
2.5.0-086	G-MAP shall allow a traveler to designate trusted persons and their role(s). Roles may include receiving notifications or can accessing their account. The specific information collected to confirm authenticity of the person will be driven by stakeholder input during the Agile Development Process.
2.5.0-087	G-MAP shall implement role-based access for trusted persons based on the roles assigned by the account holder. The roles will include access to account details, provision of real time notifications, and other functions designated by the account holder. The types of roles and information access will be driven by stakeholder input during the Agile Development Process. Note: a call center agent or transit operator may be included as a “trusted person.”
2.5.0-088	G-MAP shall allow a traveler to create triggers to alert trusted persons with notifications as they travel. Triggers may occur at transition points such as arriving at a waypoint or if a condition of the trip plan changes (i.e. delayed transit bus). More triggers will be identified through the Agile Development Process.

System Need ID/ Requirement ID	System Need/Requirement
2.5.0-089	G-MAP shall provide the traveler with a help call number that is easily accessible to the traveler in the case that they are lost or confused. Help call number placement and access will be driven by stakeholder input during the Agile Development Process.
BT-SY-2.6	**The system needs to activate automated messages and alerts, as well as re-routing based on real-time information consistent with the traveler's preferences while the traveler is executing their travel.**
2.6.0-090	G-MAP shall trigger alerts and messages based on a traveler's approach to a location near a trip transition (from indoor to outdoor, sidewalk to transit stop or crosswalk, etc.). The activation function should be configurable to adjust what constitutes "near" and to extend its use to new applications. At a minimum, the transition type applications include Ride Request, PED-X, and other CV applications. Additional trip transitions will be identified and ranked by the stakeholder group during the Agile Development Process.
2.6.0-091	G-MAP shall recommend reroutes to the traveler's active trip plan if warranted by a traveler's pre-selected [trigger] conditions (e.g., sidewalk closure or detour, transit delay, major obstacle impacting trip coordination). The conditions will be driven by stakeholder input during the Agile Development Process.
TT-SY-3.1	**The system needs to provide a method for a traveler to send a stop request to an approaching transit vehicle. The stop request may also identify special needs of the traveler.**
3.1.0-092	The ST-CTN system shall leverage the existing GCT CAD Ride Request core functionality and interfaces for the purpose of providing ST-CTN travelers with the ability to request transit stops. Leverage implies that we adapt and enhance existing functionality.
3.1.0-093	The GCT CAD shall provide send out messages when a ride is requested by a traveler via their G-MAP. The request message includes the following: 1. alert an approaching vehicle of their presence at a bus stop; 2. alert operator of any special need, such as additional time for boarding or alighting;

System Need ID/ Requirement ID	System Need/Requirement
3.1.0-094	The GCT CAD system shall provide transaction services (APIs) for G-MAP to request transit ride request.
3.1.0-095	G-MAP shall generate a ride request message to the GCT when a traveler opts in their trip plan (or preferences) for the next bus to be made aware of their presence at a stop. The message content will be developed with stakeholder input during the Agile Development Process including how much personal information about the traveler will be included in the message.
3.1.0-096	The GCT CAD shall send a notification to G-MAP that the transit operator confirmed receipt of the request for next stop pickup.
3.1.0-097	The GCT CAD shall log ride request event information including trip identification, time, and location. Other pertinent information will be identified by the GCT and G-MAP developers during Phase 2 of the ST-CTN project.
3.1.0-098	G-MAP shall transmit a request to the GCT CAD at a time convenient for an operator to stop at the next stop (prior to the expected arrival of the bus to the transit stop where the traveler waits). The time duration maximum and minimum time will be driven by the GCT and G-MAP developer during Phase 2 of the ST-CTN project.
3.1.0-099	For the ride request transaction, the system shall minimize latency to within 1 minute from G-MAP message generation to receipt by vehicle's mobile data terminal (MDT).
3.1.0-100	GCT shall provide anonymized inaccessibility complaints when received by their existing customer complaint systems to the STM Performance Measurement Dashboard.
3.1.0-101	GCT shall provide fixed-route ridership data to the STM Performance Measurement Dashboard at a minimum on a monthly basis. The specific content and frequency of the dataset shall be specified during Phase 2 of the ST-CTN project.
3.1.0-103	GCT shall provide GTFS data feeds to the STM Performance Measurement Dashboard.
3.1.0-104	GCT shall provide GTFS-RT data feeds to the STM Performance Measurement Dashboard.

System Need ID/ Requirement ID	System Need/Requirement
TT-SY-3.2	**The system needs to confirm receipt and status of the request for a transit stop request so that the traveler knows that their request has been received by the system.**
3.2.0-106	The ST-CTN project team shall coordinate GCT Ride Request testing, including elements related to end-to-end timing, security, message processing and management.
TT-SY-3.3	**The system needs to provide priority for transit vehicles based on priority conditions to improve speed and reliability of transit service for travelers.**
3.3.0-107	The system shall utilize the Smart Corridor TSP functionality, interfaces, architecture and infrastructure as the core CV platform for the ST-CTN. Smart Corridor core functionality will be documented and published during Phase 2.
3.3.0-109	The system shall utilize the Smart Corridor Pedestrian Presence functionality, interfaces, architecture and infrastructure as the core CV platform for the ST-CTN. Smart Corridor core functionality will be documented and published during Phase 2.
3.3.0-110	The system shall enhance the Pedestrian Presence Alert by identifying additional strategies. Strategies include but are not limited to remote activation of pedestrian crossing request.
IC-SY-4.1	**The system needs to connect to traffic signal system infrastructure to enable travelers to activate crosswalk signals using a hands-free method, or automatically using their trip plan and location so that the traveler is able to complete their trip based on their preferences and abilities.**
4.1.0-111	The system shall utilize the existing core CV and ATMS functionality, interfaces, architecture, infrastructure (including RSU, OBU, communications and security) to provide mobile accessible pedestrian features at signalized intersections. CV and ATMS core functionality will be documented and published during Phase 2.
4.1.0-112	G-MAP shall generate navigation directions for crossing intersections using the intersection reference, crossing direction, and traveler orientation.

System Need ID/ Requirement ID	System Need/Requirement
4.1.0-114	G-MAP shall track the traveler's approach to an intersection crossing from the trace data collected from their G-MAP mobile app.
4.1.0-115	G-MAP shall trigger a request to generate a PED-X message when the traveler arrives at the intersection.
4.1.0-116	G-MAP shall generate and transmit to the ATMS a PED-X Priority request message to alert the signal controller that a traveler has arrived at a signalized crosswalk.
4.1.0-120	The SMUG shall serve as a gateway to exchange messages between G-MAP and specific signal controllers to authenticate and forward pre-defined message(s).
4.1.0-121	Upon receipt of the PED-X Priority Request message, the signal controller shall activate the pedestrian crossing signal during its next cycle (by crosswalk direction).
4.1.0-132	The PED-X buffer message shall adapt the prgPriorityStatusBuffer information and the signal control status information. The message content the status of the phase information from the signal controller.
4.1.0-133	The PED-X cancel message shall adapt the prgPriorityCancel message and is used to indicate that the request is no longer needed.
4.1.0-134	The PED-X priority clear message shall adapt the prgPriorityClear message and is used to indicate that the requesting pedestrian has cleared the intersection and priority is no longer needed.
4.1.0-238	The system shall provide interface for the PED-X message that will include information about the intersection, the path through the intersection, and whether the traveler would need the extended crossing time.
IC-SY-4.2	**The system needs to confirm receipt and status of the request for a pedestrian crossing request so that the traveler knows that their request has been received by the system.**

System Need ID/ Requirement ID	System Need/Requirement
4.2.0-135	Upon receipt of the PED-X Priority Status message, G-MAP shall send a notification to traveler that request was received.
IC-SY-4.3	**The system needs to connect to traffic signal system infrastructure to enable travelers to receive additional information about the crossing time and other characteristics of the signalized crossing (e.g., countdown clock).**
CV-SY-5.1	**The system needs to connect travelers to the connected infrastructure to increase safety.**
5.1.0-137	The system shall utilize the existing core CV functionality, interfaces, architecture, infrastructure (including RSU, OBU, communications and security).
5.1.0-252	G-MAP operator, SMUG Server operator, and Signal Control operator shall agree upon and implement security procedures, policies and protocols to authenticate, validate and restrict traffic between G-MAP, SMUG and signal controllers.
CV-SY-5.1.1	**The system needs to identify and communicate traveler presence at RSU-deployed signalized intersections to nearby connected vehicles for the safety of the traveler(s).**
5.1.1-143	The ST-CTN project team shall coordinate testing to verify Smart Corridor implementation of pedestrian bus alerts. The CV RSU shall send a safety warning to a transit vehicle via its OBU as it approaches or turns at an intersection where the RSU received a PSM or PED-X SRM. The Smart Corridor project will implement this function as part of the Smart Corridor core functionality.
5.1.1-144	The ST-CTN project team shall coordinate testing to verify Smart Corridor implementation of pedestrian vehicle alerts. The CV RSU shall send a safety warning to vehicles via their OBUs as it approaches or turns at an intersection where the RSU received a PSM or PED-X SRM. The Smart Corridor project will implement this function as part of the Smart Corridor core functionality.
CV-SY-5.1.2	**The system needs to detect that a traveler needs additional crossing time at a signalized intersection.**

System Need ID/ Requirement ID	System Need/Requirement
5.1.2-145	The ST-CTN project team shall coordinate CV PED-SIG testing, including elements related to end-to-end timing, security, message processing and management.
NV-SY-6.1	**The system needs to ingest static and real-time data about indoor and outdoor assets and conditions (e.g., sidewalk blockages, elevator/ escalator outages) to ensure accuracy in the accessibility of routes.**
6.1.0-146	A Disaster Recovery Plan, or the equivalent, shall be developed and project administrators trained in its implementation. The DRP shall cover data breach, cyberattacks, and other major disruptions to the service.
6.1.0-147	The data stewards and custodians shall set up an enterprise data governance committee (EDG) to discuss rules and procedures to manage and align datasets created and used through the system as referenced in the DMP Section 2.3.
6.1.0-148	The data stewards and custodians shall establish a data curation process for each dataset that they manage that meets the provisions of DMP and PMESP. The curation process will include data collection (ingestion, acquisition), verification and quality checking, storage (extraction, transformation, loading), and distribution procedures.
6.1.0-149	The data steward for each derived dataset shall document quality checking procedures for cleaning and verifying their dataset. That includes each step from acquisition through storing, providing access and deprecating.
6.1.0-150	The CV subsystem shall provide access to traffic management system data and control data including: 1. PSM, 2. signal control data.
6.1.0-152	The system shall implement the data curation process for static and dynamic indoor asset data including elevator outages, escalator outages, and building entrance closures.

System Need ID/ Requirement ID	System Need/Requirement
6.1.0-153	The system shall implement a data curation process for IOO asset information (e.g., traffic light locations, RSU locations) as described by the DMP. Note: The requirement for a curation process for each dataset is described in Section 3.10.1.
6.1.0-154	The system shall implement a data curation process for static and dynamic transit data including GTFS and GTFS-RT (from MARTA and GCT). Note: The requirement for a curation process for each dataset is described in Section 3.10.1.
6.1.0-158	The STM Platform shall subscribe to and implement a data curation process for signal control data from the CV subsystem.
6.1.0-164	The ST-CTN project team shall coordinate CV publish and subscribe testing to verify receipt of existing published CV subsystem MAP data.
6.1.0-167	G-MAP shall ingest the traffic signal control locations that provide PED-X services into the network used to generate trip itineraries.
6.1.0-180	The ST-CTN project team shall coordinate CV publish and subscribe testing to verify receipt of existing published CV subsystem PSM data.
6.1.0-249	The STM Platform shall ingest traffic information data, which includes Waze and TMC data.
NV-SY-6.2	**The system needs to interface with facility or third-party communications assets using protocols available on smartphones (e.g., near-field communication (NFC), Bluetooth, Wi-Fi) and also use standardized navigation or wayfinding messages to communicate with travelers.**
6.2.0-181	G-MAP shall provide information for travelers to pair with [interconnect to] facility-deployed beacons enabled by transceivers (communications devices) that provide indoor wayfinding and navigation support.

System Need ID/ Requirement ID	System Need/Requirement
6.2.0-182	G-MAP shall interface with beacons using communications technologies including Wi-Fi, Bluetooth, or near field communication (NFC) available on mobile devices to provide supplemental location data for indoor navigation.
6.2.0-183	G-MAP shall use facility-deployed beacon fixed location mapping data to supplement MU native navigation sensors commonly available on cell phones such as, WiFi, Bluetooth, or NFC, to track performance of indoor navigation and wayfinding. Note: The assumption is that the mobile app will integrate the vendor's SDK used to detect the local beacons and present to the user the complete workflow for indoor navigation.
6.2.0-184	G-MAP shall provide wayfinding instructions indoors at selected facilities. Wayfinding includes navigation, orientation, and destination finding through notifications to the traveler.
6.2.0-185	The INS vendor (system) shall collect asset information on beacons that are installed in facilities to support indoor navigation.
6.2.0-186	The Beacon Asset Inventory shall contain at a minimum, beacon identifier, location relative to facility map, location attributes, date installed, last maintenance date, and other pertinent information to support traveler navigation and wayfinding as well as asset maintenance. The details of the asset information will be determined in Phase 2 of the ST-CTN project.
6.2.0-187	The INS shall provide access to the beacon asset inventory to authorized users including G-MAP, STM, and building owners.
6.2.0-188	G-MAP shall acquire beacon asset inventory to support indoor mapping. The curation process, as described by Req 6.1.0-148, will be developed in Phase 2 of the ST-CTN project, including processing, integration and application in the routing service.
6.2.0-189	The beacon shall operate in the following environment conditions without degradation: • Operational temperature (-20 to +60ºC) • Waterproof (IP67)
6.2.0-190	The beacon shall be powered by replaceable battery power with an average life of 5 years (depending on usage).

System Need ID/ Requirement ID	System Need/Requirement
6.2.0-191	The beacon shall support Bluetooth Low Energy (BLE) 5 or above.
6.2.0-192	The beacon shall have a broadcast range of between 50-100 meters.
6.2.0-193	The beacon shall be able to be configured to have a broadcast range for between 200-300 meters.
6.2.0-194	A beacon technology shall be deployed at key waypoints to aid indoor wayfinding and navigation by ATL RIDES.
6.2.0-195	The beacon shall be constructed to be installed using adhesive or screws for mounting the device.
6.2.0-196	The beacon/INS shall include an SDK to interface with iOS and Android to receive and resolve message content.
6.2.0-197	The beacon/INS shall provide an administration module to configure the content and operations of each beacon.
6.2.0-198	The beacon shall broadcast its message (or identifier) at configurable intervals or when connected to a mobile app.
6.2.0-239	The SDK shall provide G-MAP app via SDK with wayfinding instructions and door to door (facility entrance to indoor navigation destination) including notifications. Notifications should include alerts via audio, text, and visual navigation instructions to support hands off and vulnerable communities (e.g., older adults, people with disabilities).
6.2.0-240	The SDK should be capable of re-routing users if the user navigates away from the initial defined route.
6.2.0-241	The SDK shall support the ability to fully integrate the navigation experience (audio, visual, text based commands) within third party apps developed using native technology.
6.2.0-242	The SDK shall be maintained and updated to support future maintenance releases of operating systems from Apple and Google, as well as meet compliance with Apple App Store and Google Play policies and procedures.
6.2.0-243	The beacons shall be installed and configured to provide accurate positioning in multiple architectural layouts.

System Need ID/ Requirement ID	System Need/Requirement
6.2.0-244	The beacon deployment shall ensure that positioning determination can differentiate different floors in an open space (i.e., as laid out in the Gwinnett Justice and Administration Center – GJAC).
6.2.0-245	The beacon deployment shall ensure positioning determine can precisely (within 2-4 meters) describe the pathways between and around the two facilities.
6.2.0-246	The vendor shall develop the facility map inclusive of routable/connected paths through the facility and between floors. The indoor network shall include features such as entrances, conveyances (elevator, escalator, stairs), rooms, destination and special areas. Features shall also include attributes that describe condition and status including time-based access and accessibility (e.g., for people in wheelchairs). Places shall include attributes that describe their condition and status.
6.2.0-247	The vendor shall provide a web-based mapping tool for facility owners to manage and update facility map updates and feature status (e.g., special events in geofenced areas, elevator outages, etc.).
6.2.0-248	The vendor mapping tool shall export map data in a standard-based map format (e.g., shape files, OGC map service / OGC feature service, Open Street Map, KML).
RP-SY-7.1	**The system needs to store and provide access to an ATL RIDES account holder about their trip histories so that the traveler or the traveler's guardian is able to review their trip history for verification and safety purposes.**
7.1.0-199	G-MAP shall store the trip history for trips planned with the ST-CTN system. Trip history data shall include, at a minimum: • Planned route including modes, crossing, pathways • Preferred notifications, navigation instructions and automated requests • Support services including notification to third parties and companions accompanied on travel The types of trip history information will be driven by stakeholder input during the Agile Development Process and the PMESP metric needs.

System Need ID/ Requirement ID	System Need/Requirement
7.1.0-200	G-MAP shall store the trip history for trips taken with the ST-CTN system. Trip history data shall include at a minimum: • Origin trip plan identifier for loaded and actuated (begin) • Actual (deviations from) trip pathways, modes and crossings taken, including time and condition of travel • Notifications and direction instructions received (by channel) • Automated messages for rerouting or requests (PED-X, Ride Request) • Notifications sent to third parties • Additional services requested or received (e.g., emergency call, call center help) The types of actual trip history information will be driven by stakeholder input during the Agile Development Process and the PMESP metric needs.
7.1.0-201	The G-MAP shall acquire traveler trip tracking data at a frequency sufficient for the STM Performance Measure module to analyze metrics in accordance with the PMESP. The rate of collection will be developed during Phase 2. The data will be stored and forwarded as part of Req 7.3.0-209 Publish Travel Statistics.
7.1.0-204	G-MAP shall provide account holders with general statistics on their trips. The types of statistics will be driven by stakeholder input during the Agile development process. The statistics may include: • Average duration (by leg) and standard deviation of saved trips (e.g., typical commute) • Miles traveled (by each mode) • Number of notifications received by different communication channels and UI methods • Deviations from planned trip plans for actual trips taken • Trip histories • Complete trip travel times • Number and variety of destination types

System Need ID/ Requirement ID	System Need/Requirement
RP-SY-7.2	**The system needs to collect user input about disruptions and obstructions to their travel during or after their travel.**
7.2.0-206	G-MAP shall provide a traveler feedback form in which travelers can report on impediments of travel. Impediments include obstacles and sidewalk conditions.
7.2.0-207	G-MAP shall request that users provide feedback on their complete trip travel experience through a survey. Response to the survey shall be limited such that a traveler is not requested to respond after every trip. Survey questions shall include topics such as, complete trip experience, features and functions, useability, caregiver support, call center support, persons with LEP useability, employment, quality of life, trip type, traveler perception of safety, traveler non-incident experiences, and missed connections.
RP-SY-7.3	**The system needs to provide anonymized information about trip performance to the performance monitoring module (in the STM subsystem) that details traveler behavior to help improve trip plan customization for users.**
7.3.0-208	The STM Platform shall ingest general trip statistics for account holders. The types of statistics will be driven by PMESP and stakeholder input during the Agile development process. The general trip statistics may include: • Average duration (by leg) and standard deviation of saved trips (e.g., typical commute) • Miles traveled (by each mode) • Number of notifications received by different communication channels and UI methods • Deviations from planned trip plans for actual trips taken • Anonymized trip histories (planned, actual) • Complete trip travel times • Number and variety of destination types

System Need ID/ Requirement ID	System Need/Requirement
7.3.0-209	Public PMD shall display general trip statistics. The types of statistics will be driven by PMESP and stakeholder input during the Agile development process. The general trip statistics may include: • Average duration (by leg) and standard deviation of saved trips (e.g., typical commute)Miles traveled (by each mode) • Number of notifications received by different communication channels and UI methods • Deviations from planned trip plans for actual trips taken • Anonymized trip histories (planned, actual) • Complete trip travel times • Number and variety of destination types
7.3.0-210	The STM subsystem shall ingest message logs from the central signal control system which includes PED-X application transactions on a daily basis at a minimum.
7.3.0-211	The STM Platform shall ingest the G-MAP subsystem health and operational status logs (defined in Req 2.1.1-063) to the STM performance measurement dashboard on a daily basis.
7.3.0-212	The STM Platform shall ingest the STM subsystem health and operational status logs (defined in Req 2.1.1-064) to the STM performance measurement dashboard on a daily basis.
7.3.0-213	The STM Platform shall ingest the CV subsystem health and operational status logs (defined in Req 2.1.1-065) to the STM performance measurement dashboard on a daily basis.
7.3.0-214	The STM Platform shall ingest GCT provided anonymized complaints on inaccessibility.
7.3.0-215	The STM Platform shall ingest GCT fixed-route ridership data daily. At a minimum, ridership data includes the local service and may include the express routes.
7.3.0-217	The STM Platform shall ingest GCT GTFS data feeds as the updated files are published.

System Need ID/ Requirement ID	System Need/Requirement
7.3.0-218	The STM Platform shall ingest GCT GTFS-RT data feeds as published.
7.3.0-219	The STM performance measurement computation engine shall generate measures that show traveler behavior based on the planned and actual trips. The details of the statistics will be driven by the Performance Measurement and System Evaluation Plan (PMESP).
7.3.0-250	The public PMD shall display summary of performance measures in graphic and tabular format.
7.3.0-251	The public PMD shall provide access to public of the summary performance measures.
FT-SY-8.1 **FT-SY-8.1.1**	**The system needs to allow for future scalability or development in order to address user needs that are not within the scope of this project and will not be implemented in the initial roll out.** **The system needs to be scalable to accommodate future growth, modifications, or integration with multiple services, including those that may be needed to buy transit tickets or passes from public agencies.**
8.1.1-220	The system shall be capable of expanding capacity, load, and demand over several years to process all the functions and store real-time and persistent data to meet the maximum load. Consideration should extend to each architecture tier including data (real-time and persistent data), processing/functions, and presentation, channelization, and transaction throughput.
	Interface Requirements
0.0.0-221	Each internal and system interface, data feed, API, message set shall include published implementation guidance that describes the data formats, content, encoding, organization, mandatory / optional data, use, orchestration and communications protocols used for exchanging the interface. The implementation guidance may be documented as a Protocol Requirements List (PRL), PICS, ICD, data dictionary with best practices examples, or sample schema.
0.0.0-222	See Req 0.0.0-221. NTCIP 1103 v03 – Transportation Management Protocols, December 2016, AASHTO/ITE/NEMA.

System Need ID/ Requirement ID	System Need/Requirement
0.0.0-223	See Req 0.0.0-221. NTCIP 1201 v03 – Global Object Definitions, March 2011, AASHTO/ITE/NEMA.
0.0.0-224	See Req 0.0.0-221. NTCIP 1202 v02 – Object Definitions for Actuated Signal Controllers, November 2005, AASHTO/ITE/NEMA.
0.0.0-226	See Req 0.0.0-221. SAE EIA-731.1 – Technical Report, Systems Engineering Capability Model, August 2002, SAE International.
0.0.0-228	See Req 0.0.0-221. SAE J2945-1:20204 - On-Board System Requirements for V2V Safety Communications, April 2020, SAE International
0.0.0-229	See Req 0.0.0-221. SAE J2945-2:201810 - Dedicated Short Range Communications (DSRC) Performance Requirements for V2V Safety Awareness, October 2018, SAE International
0.0.0-230	See Req 0.0.0-221. SAE J2945-9:201703 - Vulnerable Road User Safety Message Minimum Performance Requirements, March 2017, SAE International
0.0.0-231	See Req 0.0.0-221. IETF RFC 791, Internet Protocol
0.0.0-232	See Req 0.0.0-221. GTFS. General Transit Feed Specification Reference. Washington D.C.: GTFS. (2024).
0.0.0-233	See Req 0.0.0-221. GTFS Realtime. GTFS Realtime Reference v2. Washington D.C.: GTFS Realtime. (2019)
0.0.0-236	See Req 0.0.0-221. OpenStreetMap Foundation. Open Street Map. Washington D.C.: UCL, ByteMark. (2021).
0.0.0-237	See Req 0.0.0-221. OTP core functionality is described on https://github.com/opentripplanner/OpenTripPlanner and ATL RIDES (IMI grant) and requirements are listed at: https://github.com/opentripplanner/OpenTripPlanner and https://docs.google.com/spreadsheets/d/1nnx0TUl-l8z94mqJgx7i3PxZ3GZ3YCj9_AabDFKNytc/edit#gid=0.

Appendix B. Acronyms

ADA – Americans with Disabilities Act

API – application programming interface

ARC – Atlanta Regional Commission

ARPA-E – Advanced Research Projects Agency – Energy

ATIS – Advanced Traveler Information System

ATL – Atlanta-Region Transit Link Authority

ATL RIDES – Atlanta-Region Rider Information and Data Evaluation System

ATMS – Advanced Traffic Management System

AVL – automatic vehicle location

BLE – Bluetooth Low Energy

CAD – computer aided dispatch

CCTV – closed circuit television

ConOps – Concept of Operations

CV – connected vehicle

CV1K – Regional Connected Vehicle Infrastructure Deployment Program

C-V2X – Cellular Vehicle to Everything

CVTMP – Connected Vehicle Technology Master Plan

DMP – Data Management Plan

DSRC – Dedicated Short-Range Communications

EDG – enterprise data governance

ETRA – Enabling Technology Readiness Assessment

EVP – emergency vehicle preemption

FCC – Federal Communication Commission

GCDOT – Gwinnett County Department of Transportation

GCT – Gwinnett County Transit

GDOT – Georgia Department of Transportation

GRTA – Georgia Regional Transportation Authority

GTFS – General Transit Feed Specification

GTFS-RT – General Transit Feed Specification – Real Time

ICD – Interface Control Document

IMI – Integrated Mobility Innovation

IOO – infrastructure owner operator

ITS – Intelligent Transportation System

IVR – interactive voice response

JSON – JavaScript Object Notation

LEP – limited English proficiency

Map Data – MAP

MARTA – Metropolitan Atlanta Regional Transit Authority

MDT – mobile data terminal

MIB – Management Information Base

MPO – metropolitan planning organization

MU – mobile unit

MVP – Minimum Viable Product

NFC – near-field communication

NOAA – National Oceanic and Atmospheric Administration

NRTM – Needs-to-Requirements Traceability Matrix

NTP – Network Time Protocol

OBU – on-board unit

OSM – Open Street Map

OSS – open-source software

OTP – Open Trip Planner

PED-SIG – Mobile Accessible Pedestrian Signal System

PICS – Profile Implementation Conformance Statement

PII – personally identifiable information

PMESP – Performance Measurement and Evaluation Support Plan

PRG – Priority Request Generator

PRL – Protocol Requirements List

PRS – Priority Request Server

PSM – personal safety message

RSU – roadside unit

SCMS – Security Credential Management System

SDK – software development kit

SDL – System Development Lead

SLA – service level agreement

SMP – Safety Management Plan

SMS – Short Message Service

SMUG – Secure Mobile Unit Gateway

SPaT – signal phasing and timing

SRM – signal request message

SRT – stakeholder review team

SSM – signal status message

ST-CTN – Safe Trips in a Connected Transportation Network

STM – Space Time Memory

SyRS – System Requirements Specifications

TCC – Transportation Control Center

TMC – traffic management center

TSP – transit signal priority

TSR – transit stop request

UI – user interface

USDOT – U.S. Department of Transportation

UTC – Coordinated Universal Time

VRU – vulnerable road user

WCAG – Web Content Accessibility Guidelines

Appendix C. Glossary

Advanced Traveler Information System (ATIS) – a system that collects, aggregates and disseminates transportation information, such as traffic, transit, weather, and connected vehicle data. This data is aggregate into data environments allowing for the dissemination of this information to travelers via mobile devices. [ATIS]

Agile Development Process – a set of frameworks and practices used to be better develop software through individual interactions, working software, collaboration, and responses to change as opposed to comprehensive documentation and contract negotiations. (https://www.agilealliance.org/agile101/)

Americans with Disability Act (ADA) – An act to "provide a clear and comprehensive national mandate for the elimination of discrimination against individuals with disabilities." The act provides enforceable standards to address discrimination against individuals with disabilities and requires public facilities to be readily accessible and usable by individuals with disabilities [ADA].

Application Programming Interface (API) – Enables companies to make available the data of their products and services to external developers and business partners. This allows multiple services and products from different companies to communicate and leverage each other's data for improved collaboration, innovation, and added security [API].

Basic Safety Message (BSM) – Data content that is broadcasted through V2V or V2I at a 10 Hz frequency. The data elements are vehicle position (latitude, longitude, elevation) and motion (heading, speed, acceleration). [CAV]

Cellular – Vehicle to Everything (C-V2X) – A connected vehicle platform that works over the cellular network to provide vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-pedestrian communication. It is similar to DSRC but uses the cellular network instead of a short-range spectrum. It is a 3GPP standard describing a technology to achieve the V2X requirements. C-V2X is an alternative to 802.11p, the IEEE specified standard for V2V and other forms of V2X communications. [CVTMP]

Commute advisor API – provides STM near-real-time updates to transportation network impedances. [ConOps]

Computer aided dispatch (CAD) – software used to monitor transit operations and help with the management of transit operations. The software takes in information on transit routes, schedules, trip orders and vehicle assignments so that dispatchers are aware of their agency's transit vehicles' locations. [CAD]

Connected Vehicle (CV) – A vehicle (car, truck, bus, etc.) that is equipped with a wireless communication device (1). A CV uses any of the available wireless communication technologies to communicate with other cars on the road (vehicle-to-vehicle [V2V]), roadside infrastructure (vehicle-to-infrastructure [V2I]), and other travelers and the cloud. [CAV]

Connection protection – also known as transit stop request, this technology will be modified to allow a third party, such as ATL RIDES, to request a connection rather than a transit operator. An example of this would be to ensure that a transit operator waits so that the user can complete a transfer.

Coordinated Universal Time (UTC) – the primary standard for time to regulate world clocks. It used to determine time for all time zones with the center in Greenwich, England. It is not adjusted for daylight savings time. [UTC]

General Transit Feed Specification (GTFS) – A data specification that allows public transit agencies to publish their data to be consumed by a variety of transit-related applications. This data includes schedule, fare, and vehicle position which can be used to predict arrival times and display real-time information [GTFS].

Interactive Voice Response (IVR) – Automated phone system that allows users to access information using a voice response system of pre-recorded messages to convey information without having to speak to an agent. [IVR].

Mobile data terminal (MDT) – a data collection device on transit vehicles with several functions including two-way data communication and GPS location services. [MDT]

Mobile Unit (MU) – [A device that] performs the data exchange between the infrastructure and a road user. MUs may be integrated with cellular phones or otherwise be carried by pedestrians, cyclists, other travelers, or workers in the roadway. [CI]

Mobile Accessible Pedestrian Signal System (PED-SIG) - A mobile application system that exchanges information between roadside or intersection sensors and mobile devices carried by a pedestrian. The system is used to inform impaired pedestrians when to begin traversing a crosswalk and how to remain within the crosswalk. [CAV]

Near-field communication (NFC) – contactless communication and exchange of information between devices. [NFC]

Network Impedance API – communicates changes in network impedance values in OSM/OTP data structures that can be used by the ATL RIDES app. The API will be developed during the Agile development phase in collaboration with STM and ATL RIDES platform developers. [ConOps]

Network Time Protocol (NTP) – an Internet protocol that synchronizes computer clocks to a time reference. [NTP]

Onboard Unit (OBU) – An ITS related hardware that performs the data exchange between the infrastructure and a vehicle and installed in a vehicle (includes an after-market device). An OBU may contain applications that process the data received from the infrastructure and other sources such as another OBU. [CI]

Personal Safety Message (PSM) – A data broadcast by a vulnerable road user (such as pedestrians) to announce their presence to approaching vehicles. [CAV]

Personally Identifiable Information (PII) – Information on an individual's identity such as name, address, identifying number, telephone number, email address, etc.

Priority Request Generator (PRG) – a signal request message is sent to this device on the transit vehicle. Using automatic vehicle location, the PRG determines if the vehicle is at its scheduled location and determines if a priority request should be sent. [NACTO]

Priority Request Server (PRS) – If a priority request is determined, the priority request is sent to the PRS which is part of the roadside unit. This will contact the signal controller to provide priority to the transit vehicle. [NACTO]

Privacy – The ability of an individual or group to seclude themselves or seclude information about themselves, thereby revealing themselves selectively. [CAV]

Profile Implementation Conformance Statement (PICS)

Roadside Unit (RSU) -- A transportation field device that performs the data exchange between OBUs, MUs, and other infrastructure elements. [CI]

SCMS/Security Backend -- A system that provides and manages security certificates to support trust within the CI system. [CI]

Secure Mobile Unit Gateway (SMUG) – serves as a secure means of exchanging information between a mobile unit (or proxy such as the ATL RIDES subsystem) and the CV environment. The MU Gateway serves to provide authenticated access, validate messages, transform and direct the messages to the appropriate destination. [ConOps]

Signal Phase and Timing (SPaT) – The signal state of the intersection and how long this state will persist for each approach and lane that is active, according to the SPaT Benefits Report. The SPaT message sends the current state of each phase, with all-red intervals not transmitted. Movements are given to specific lanes and approaches by use of the lane numbers present in the message. In a connected vehicle environment, the message is sent from the roadway infrastructure to approaching vehicles. [CAV]

Signal request message (SRM) – broadcast message sent by vehicle to request priority at a signal. [CAV]

Signal Status Message – Broadcast sent out by an RSU to announce a preemption request. [CAV]

Beacon – a facility-deployed device in buildings (such as transit stations) enabled by transceiver to provide indoor wayfinding and navigation support. Communication is in the form of Wi-Fi, Bluetooth and NFC.

Native mobile software development kit (SDK) - tools specific to the platform of the mobile unit to develop software and associated interfaces.

Transit Signal Priority (TSP) – A part of a signal system that allows transit agencies to manage service by prioritizes buses and granting their right of way based on schedule adherence or passenger loads. [CAV]

Vulnerable road user (VRU) – road users that are most at risk in traffic. This includes those who are unprotected by an outside shield. Examples are pedestrians and bicyclists. [ConOps]

Web Content Accessibility Guidelines (WCAG) 2.1 – recommendations for making Web content accessible to people with disabilities such as low vision, hearing loss, limited movement, and accommodations for those with cognitive limitations. [W3C]

Appendix D. References

Documents referenced during the development of the SyRS are provided in **Table 36**.

Table 36. 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).
[SRCRP]	Atlanta Regional Commission. Deliverable Task 2.1 Stakeholder Registry and ConOps Review Panel Roster. Atlanta: U.S Department of Transportation. (2021).
[NS]	Atlanta Regional Commission. Deliverable Task 2.2 Needs Summary. Atlanta: U.S Department of Transportation. (2021).
[MDT]	Harman, Lawrence and Shama, Uma. Capital costs for transit vehicle mobile data terminals typically range $1,000 and $4,000 per unit with installation costs frequently between $500 and $1,000. Tyler: Transit Cooperative Research Program, Transportation Research Board. (2007).
[CPACS]	Center for Pan Asian Community Services. Transportation. Atlanta: Center for Pan Asian Community Services, Inc. (2021).
[BCS]	Ferrel, Christopher E. The Benefits of Transit in the United States: A Review and Analysis of Benefit-Cost Studies. San Jose: Mineta Transportation Institute. (2015).
[CV1K]	Georgia Department of Transportation. "The Regional Connected Vehicle Program Scope of Work." Atlanta: Georgia Department of Transportation.
[GBFS]	GitHub. General Bikeshare Feed Specification. Washington D.C.: GTFS. (2019).
[GTFS-Flex]	GitHub. GTFS Flex. Washington D.C.: GTFS (2019).
[GTFS-RT]	GTFS Realtime. GTFS Realtime Reference v2. Washington D.C.: GTFS Realtime. (2019)

ID	Referenced Documents
[GTFSP]	GTFS. General Transit Feed Specification Pathway. Washington D.C.: GTFS. (2019).
[GTFS]	GTFS. General Transit Feed Specification Reference. Washington D.C.: GTFS. (2024).
[CGCT]	Gwinnett County Department of Transportation. Connect Gwinnett Transit Plan - Existing Conditions Technical Memorandum. Duluth: Gwinnett County Government. (2017).
[PSRG]	Gwinnett County Transit. Paratransit Service Rider's Guide. Duluth: Gwinnett County Government. (2018).
[MARTA4GC]	Gwinnett County Transit. The Plan - MARTA for Gwinnett. Duluth: Gwinnett County Government. (2021).
[SS-GC]	Gwinnett County. Senior Services. Duluth: Gwinnet County Government. (2021).
[API]	IBM Cloud Education. Application Programming Interface (API). Armonk: IBM. (2020).
[CI]	ICF, Wyoming Department of Transportation. Connected Intersection - Concept of Operations. Cheyenne: USDOT (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.
[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.
[CAD]	Intelligent Transportation Systems, Joint Program Office. ITS Transit Fact Sheets – Technology Overview. Washington D.C.: U.S. Department of Transportation. (2021).
[GCTP-1]	Kimley-Horn, Bleakly Advisory Group, Pond, Sycamore, VHB, & Debra Semans. (2017). Gwinnett County Destination 2040 - Gwinnett's Comprehensive Transportation Plan - Executive Summary. Atlanta: Gwinnett County.
[GCTP-2]	Kimley-Horn, Bleakly Advisory Group, Pond, Sycamore, VHB, & Debra Semans. (2017). Gwinnett County Destination 2040 - Gwinnett's Comprehensive Transportation Plan - Existing Conditions. Atlanta: Gwinnett County.

ID	Referenced Documents
[GCTP-3]	Kimley-Horn, Bleakly Advisory Group, Pond, Sycamore, VHB, & Debra Semans. (2017). Gwinnett County Destination 2040 - Gwinnett's Comprehensive Transportation Plan - Needs Assessment. Atlanta: Gwinnett County.
[GCTP-4]	Kimley-Horn, Bleakly Advisory Group, Pond, Sycamore, VHB, & Debra Semans. (2017). Gwinnett County Destination 2040 - Gwinnett's Comprehensive Transportation Plan - Recommendations Report. Atlanta: Gwinnett County.
[NACTO]	Li, Yue; Koonce, Peter; Li, Meng; Zhou, Kun; Li, Yuwei; Beaird, Scott; Zhang, Wei-Bin; Hegen, Larry; Hu, Kang; Skabardonis, Alex; Sonja Sun, Z. Transit Signal Priority Research Tools. Sacramento: California Department of Transportation. (2008).
[NTP]	Mills, David. The Network Time Protocol (NTP). Newark: University of Delaware. (2014).
[UTC]	National Hurricane Center and Central Pacific Hurricane Center. (2017). What is UTC or GMT Time?. Miami: National Oceanic and Atmospheric Administration.
[W3C]	National Institute on Disability, Independent Living, and Rehabilitation Research. Web Content Accessibility Guidelines (WCAG) 2.1 W3C Recommendations. Washington D.C.: U.S. Department of Health and Human Services. (2018).
[NTCIP-1211]	National Transportation Communications for ITS Protocol 1211 Object Definitions for Signal Control and Prioritization. (2014) Washington, D.C.: AASHTO, ITE, NEMA.
[NFC]	Near Field Communication. Near Field Communication. San Francisco: Square, Inc.. (2017).
[NOBLIS]	Noblis, Inc. (2017). Applying Scrum Methods to ITS Projects. Washington D.C.: U.S. Department of Transportation.
[OSM]	OpenStreetMap Foundation. Open Street Map. Washington D.C.: UCL, ByteMark. (2021).
[CAV]	Park, Hyungjun; Khattak, Zulqarnain; Smith, Brian. Glossary of Connected and Automated Vehicle Terms *Version 1.0*. Charlottesville.: University of Virginia Center for Transportation Studies. (2018).
[ICS]	Rusnak, Sean. (2019). How an Insufficient Public Transportation System Decelerates Economic Mobility. Washington D.C.: Institute for Child Success.
[OSEP]	Ryen, Ed. (2008). Overview of the System Engineering Process. Bismarck: North Dakota Department of Transportation.

ID	Referenced Documents
[PSWPCCS]	Saad, Wasan Kadhim; Hashim, Yasir; Jabbar, Waheb A. (2020). Design and Implementation of Portable Smart Wireless Pedestrian Crossing Control System. Najab: IEEEAccess.
[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.
[DW]	Schrade, Brad. (2014). Deadly walk: a spike in Georgia's pedestrian deaths. Atlanta: The Atlanta Journal-Constitution.
[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.
[CONOPS]	U.S Department of Transportation, Federal Highway Administration, California Division. (2016). Concept of Operations Template. Washington D.C.: Federal Highway Administration.
[FAST]	U.S. Department of Transportation Federal Highway Administration. (2015). Fixing America's Surface Transportation Act.
[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.
[QF]	United States Census Bureau. (2019). QuickFacts - Fulton County, Georgia; DeKalb County, Georgia; Gwinnett County, Georgia. 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 E. Change Control Log

Table 37. Requirements Change Control Log

ID	Justification	Status	Change Type
0.0.0-221		Unchanged	
0.0.0-222		Unchanged	
0.0.0-223		Unchanged	
0.0.0-224		Unchanged	
0.0.0-225	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
0.0.0-226		Unchanged	
0.0.0-227	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets will be J2945 only.	Deprecated	Deprecation
0.0.0-228		Unchanged	
0.0.0-229		Unchanged	
0.0.0-230		Unchanged	
0.0.0-231		Unchanged	
0.0.0-232	Updated data stream to be the most recent year of data	Updated	Refinement
0.0.0-233		Unchanged	

ID	Justification	Status	Change Type
0.0.0-234	GTFS Flex is integrated into GTFS, however it is the preference of the provider if they want to include this data.	Deprecated	Deprecation
0.0.0-235	GTFS Pathways is integrated into GTFS, however it is the preference of the provider if they want to include this data.	Deprecated	Deprecation
0.0.0-236		Unchanged	
0.0.0-237		Unchanged	
1.1.0-001		Unchanged	
1.1.0-002		Unchanged	
1.1.0-003		Unchanged	
1.1.0-004		Unchanged	
1.1.0-005		Unchanged	
1.1.0-006		Unchanged	
1.1.0-007		Unchanged	
1.1.0-008		Unchanged	
1.1.0-009		Unchanged	
1.1.0-010		Unchanged	
1.1.0-011		Unchanged	
1.1.0-012		Unchanged	
1.1.0-013		Unchanged	
1.1.0-014		Unchanged	
1.1.0-015	Updated section number based on Phase 2 edits to the DMP.	Updated	Clarification
1.1.0-016		Unchanged	
1.1.0-017		Unchanged	

ID	Justification	Status	Change Type
1.2.0-018	The backup for the requirement was previously included and determined not to be necessary within the requirement itself.	Updated	Clarification
1.2.0-019		Unchanged	
1.2.0-020		Unchanged	
1.2.0-021	Defined SRT, which is stakeholder review team	Updated	Clarification
1.2.0-022		Unchanged	
1.2.0-023		Unchanged	
1.2.0-024		Unchanged	
1.2.0-025		Unchanged	
1.3.0-026		Unchanged	
1.3.0-027	VRU groups (now called Mobility Categories) have been refined. To that end the requirement has been refined. Stakeholder input was solicited to refine requirement during an Agile stakeholder meeting.	Updated	Refinement
1.3.0-028		Unchanged	
1.3.0-029		Unchanged	
1.3.0-030	Crowdsourced data was removed because it was determined by ADA experts that the data needs to be consistent and verified. Consistent and verified data requires trained data collection personnel. The requirement was updated to relfect data sources that provide information on changes to the OSM data.	Updated	Design Adjustment
1.3.0-031	Crowdsourced data was removed because it was determined by ADA experts that the data needs to be consistent and verified. Consistent and verified data requires trained data collection personnel. The requirement was updated to relfect data sources that provide information on changes to the OSM data.	Updated	Design Adjustment

ID	Justification	Status	Change Type
1.3.0-032	VRU groups (now called Mobility Categories) have been refined. To that end the requirement has been refined. Stakeholder input was solicited to refine requirement during an Agile stakeholder meeting. Rate of regeneration is no longer part of the process.	Updated	Refinement
1.3.0-033	VRU groups (now called Mobility Categories) have been refined. To that end the requirement has been refined. Stakeholder input was solicited to refine requirement during an Agile stakeholder meeting. This is specifically for pedestrians.	Updated	Refinement
1.3.0-034		Unchanged	
1.3.0-035	Whole Road Network and OSM is redefined to Complete Paths in order to build the relationship between the networks. The Whole Road Network will only relate public transportation networks.	Updated	Refinement
1.3.0-036	Real time transit information will be incorporated through the G-MAP application instead. The system will access signal control data directly from the central signal system and it will not be stored, rather, when ingested it will be converted to the STM database. Study area is not near railroad tracks so ATIS data is not needed.	Updated	Design Adjustment
1.3.0-037	The underlying map network for the STM and OSM need to use the same link/node structure in order for the impedance values to be associated with the OTP graph.	Updated	Refinement
1.3.0-038	Data curation process is described in the DMP but further refined for specific cases in later parts of the project. For this reason, the reference to the DMP was removed. Removed public and private roadways from title. The data were imported as necessary.	Updated	Clarification
1.4.0-039		Unchanged	
1.4.0-040		Unchanged	
1.4.0-041		Unchanged	

ID	Justification	Status	Change Type
1.4.0-042		Unchanged	
1.5.0-043		Unchanged	
1.5.0-044		Unchanged	
1.6.0-045		Unchanged	
2.1.0-046		Unchanged	
2.1.0-047	The STM subsystem was designed as a scalable cloud infrastructure during Phase 2. It will not need to be migrated in Phase 3.	Updated	Refinement
2.1.0-048		Unchanged	
2.1.0-049		Unchanged	
2.1.0-050		Unchanged	
2.1.0-051		Unchanged	
2.1.0-052		Unchanged	
2.1.0-053		Unchanged	
2.1.0-054		Unchanged	
2.1.0-055		Unchanged	
2.1.0-056		Unchanged	
2.1.0-057		Unchanged	
2.1.0-058		Unchanged	
2.1.0-059	Originally, the system concept was set up to provide the traveler with the time to cross/the countdown clock, however during the system architecture discussion it was decided that the pedestrian signal would provide a safer and more reliable description of the time to cross which eliminated the need to synchronize the signal controller clock and the users' mobile device clock. When the controller receives the PED-X request, it will fulfill the PED-X request. The trigger is the message not time.	Deprecated	Deprecation

ID	Justification	Status	Change Type
2.1.0-060		Unchanged	
2.1.1-061		Unchanged	
2.1.1-062		Unchanged	
2.1.1-063		Unchanged	
2.1.1-064		Unchanged	
2.1.1-065	The CV system doesn't collect system health and operational status data.	Deprecated	Deprecation
2.1.1-066		Unchanged	
2.1.1-067		Unchanged	
2.1.1-068		Unchanged	
2.1.1-069		Unchanged	
2.1.1-070		Unchanged	
2.1.1-071	The system will only receive post-processed data from the CVs within the system. This is because this feature is already a part of an existing system through the Smart Corridor project.	Deprecated	Deprecation
2.1.1-072		Unchanged	
2.1.1-073		Unchanged	
2.1.1-074		Unchanged	
2.1.2-075	Removed crowdsourced obstacles because they are not verified by data collection methods.	Updated	Design Adjustment
2.1.2-076		Unchanged	
2.1.3-077	The change that was made removed the reference to "Whole Road Network" to reduce the confusion with the network impedance API. The impedance values will be stored in the STM/whole road network database, but the API will be formatted to match the OSM network.	Updated	Refinement

ID	Justification	Status	Change Type
2.2.0-078		Unchanged	
2.2.0-079	The change provides specificity that this requirement is for the call center component of the system	Updated	Clarification
2.3.0-080		Unchanged	
2.3.0-081		Unchanged	
2.3.0-082		Unchanged	
2.3.0-083	The system will not have a mobile web option. Attempts to access the website via a mobile device will be redirected to the mobile app.	Updated	Clarification
2.4.0-084		Unchanged	
2.4.0-085		Unchanged	
2.5.0-086		Unchanged	
2.5.0-087		Unchanged	
2.5.0-088		Unchanged	
2.5.0-089		Unchanged	
2.6.0-090	Updated naming for the functionality now known as Ride Request and the function now known as PED-X.	Updated	Refinement
2.6.0-091	G-MAP will not automatically update a route. Traveler will need to agree to the re-route.	Updated	Refinement
3.1.0-092	Updated naming for the functionality now known as Ride Request.	Updated	Refinement

ID	Justification	Status	Change Type
3.1.0-093	In design, the approach was changed so that the system now knows when the traveler has arrived at the stop instead of making assumptions about the traveler's behavior. The trigger for stop request is when the traveler arrives enters the geofence of the stop. It is not possible to know how long it will take the traveler to get to the bus stop. Alerting operators of any special needs is no longer optional. Requiring this functionality will cover Requirement 3.3.0-108 which was deprecated.	Updated	Design Adjustment
3.1.0-094	Updated naming for the functionality now known as Ride Request.	Updated	Refinement
3.1.0-095	Updated naming for the functionality now known as Ride Request.	Updated	Refinement
3.1.0-096	Updated naming for the functionality now known as Ride Request.	Updated	Refinement
3.1.0-097	Updated naming for the functionality now known as Ride Request.	Updated	Refinement
3.1.0-098	Updated naming for the functionality now known as Ride Request.	Updated	Refinement
3.1.0-099	Updated naming for the functionality now known as Ride Request.	Updated	Refinement
3.1.0-100		Unchanged	
3.1.0-101		Unchanged	
3.1.0-102	The ST-CTN system only handles fixed-route service.	Deprecated	Deprecation
3.1.0-103		Unchanged	
3.1.0-104		Unchanged	
3.2.0-105	Not required since notification of ETA will be sent to traveler.	Deprecated	Deprecation

ID	Justification	Status	Change Type
3.2.0-106	Updated naming for the functionality now known as Ride Request.	Updated	Refinement
3.3.0-107		Unchanged	
3.3.0-108	This requirement is redundant with other Ride Request requirements such as 3.1.0-093 - Next Bus Request.	Deprecated	Deprecation
3.3.0-109		Unchanged	
3.3.0-110		Unchanged	
4.1.0-111		Unchanged	
4.1.0-112	Remove MAP data from requirement title because OpenStreetMaps include more information on sidewalk crossing information than MAP data.	Updated	Design Adjustment
4.1.0-113	Potential safety concern due current technology constraints. Potential to implement in future iterations after technology readiness is acceptable.	Deprecated	Deprecation
4.1.0-114		Unchanged	
4.1.0-115	Modified language to remove algorithm approach from the event. Trigger timing depends on external (mobile capabilities) and traveler tracking functionalities.	Updated	Clarification
4.1.0-116	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Updated	Refinement
4.1.0-117	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation

ID	Justification	Status	Change Type
4.1.0-118	The SMUG will be replaced with Kinetic. The G-MAP will collect log data on the interactions about PED-X transactions.	Deprecated	Deprecation
4.1.0-119	The SMUG will be replaced with Kinetic. The G-MAP will collect log data on the interactions about PED-X transactions.	Deprecated	Deprecation
4.1.0-120	The requirement was originally deprecate because the SMUG was meant to be replaced with Kinetic. The G-MAP was meant to collect log data on the interactions about PED-X transactions. This requirement was reinstated because design was updated to use the SMUG.	Updated	Refinement
4.1.0-121		Unchanged	
4.1.0-122	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211,but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
4.1.0-123	Combined with Req 4.1.0-116	Deprecated	Deprecation
4.1.0-124	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
4.1.0-125	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation

ID	Justification	Status	Change Type
4.1.0-126	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
4.1.0-127	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are… not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
4.1.0-128	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
4.1.0-129	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
4.1.0-130	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
4.1.0-131	The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation

ID	Justification	Status	Change Type
4.1.0-132		Unchanged	
4.1.0-133		Unchanged	
4.1.0-134		Unchanged	
4.1.0-238	To clearly define the functionality of PED-X and what it will provide the traveler. This is to replace all of the NTCIP 1211 message requirements we had to deprecate due to its lack of ability to support the PED-X functionality. PED-X is currently not a formalized standard.	Added	Addition
4.2.0-135		Unchanged	
4.3.0-136	Potential safety concern if the system provided delayed information	Deprecated	Deprecation
5.1.0-137		Unchanged	
5.1.0-138	The messages sent through the SMUG/proxy server will not recorded.	Deprecated	Deprecation
5.1.0-139	The messages sent through the SMUG/proxy server will not recorded.	Deprecated	Deprecation
5.1.0-140	The messages sent through the SMUG/proxy server will not recorded.	Deprecated	Deprecation
5.1.0-141	The messages sent through the SMUG/proxy server will not recorded.	Deprecated	Deprecation
5.1.0-142	The security measures including procedures, policies and protocols are part of the Gwinnett IT existing security protocols. Since the PED-X Gateway will be implemented in the Gwinnett server, it is in the process of being negotiated.	Deprecated	Deprecation
5.1.0-252	Requirement was developed to cover components in Requirement 5.1.0-142 regarding security protocols.	Added	Addition
5.1.1-143		Unchanged	
5.1.1-144		Unchanged	
5.1.2-145		Unchanged	

ID	Justification	Status	Change Type
6.1.0-146		Unchanged	
6.1.0-147		Unchanged	
6.1.0-148		Unchanged	
6.1.0-149		Unchanged	
6.1.0-150	G-MAP (aka ATL RIDES) will not ingest any CV data. The STM only requires a limited number of datasets from the CV system that are related to intersection information. The list of 3 datasets now represents the data that is needed to generate impedances and analyze performance.	Updated	Refinement
6.1.0-151	This is covered by Req 7.2.0-206. The data will be managed by current functions in the app.	Deprecated	Deprecation
6.1.0-152	No longer the correct reference in SyRS	Updated	Clarification
6.1.0-153		Unchanged	
6.1.0-154		Unchanged	
6.1.0-155	The data is no longer needed. OSM provide more information on the intersection accessibility features.	Deprecated	Deprecation
6.1.0-156	The system will access signal control data directly from the central signal system and it will not be stored, rather, when ingested it will be converted to the STM database. The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation

ID	Justification	Status	Change Type
6.1.0-157	The system will access signal control data directly from the central signal system and it will not be stored, rather, when ingested it will be converted to the STM database. The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
6.1.0-158	CV system will provide access to the central signal system to obtain data. Data is not required for processing, so subscription on a bulk basis may be preferred.	Updated	Design Adjustment
6.1.0-159	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-160	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-161	MAP messages are no longer needed to implement PED-X.	Deprecated	Deprecation
6.1.0-162	Collecting signal control data directly from the central signal system. The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
6.1.0-163	MAP messages are no longer needed to implement PED-X.	Deprecated	Deprecation
6.1.0-164		Unchanged	

ID	Justification	Status	Change Type
6.1.0-165	Collecting signal control data directly from the central signal system. The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
6.1.0-166	Collecting signal control data directly from the central signal system. The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
6.1.0-167	RSUs are not needed for the PED-X functionality so the PED-X locations do not need to align with RSU locations.	Updated	Refinement
6.1.0-168	The G-MAP can ingest PED-X signal locations through the central signal system. The interface is proprietary and consequently this requirements has been removed.	Deprecated	Deprecation
6.1.0-169	Collecting signal control data directly from the central signal system. The technology for signal control will be done through a new centralized signal control system (Kinetic) which will manage the interface to MaxTime. The interface and message sets are not based on NTCIP 1211, but are based on NTCIP 1202 MIBs. To that end, mention of NTCIP 1211 will be removed.	Deprecated	Deprecation
6.1.0-170	The signal control system is proprietary and used proprietary APIs. To that end, NTCIP 1211 is no longer needed. The messaging will be based on NTCIP 1202.	Deprecated	Deprecation

ID	Justification	Status	Change Type
6.1.0-171	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-172	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-173	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-174	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-175	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-176	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-177	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-178	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-179	The ATIS data includes highway-rail warning information. Since there are no railroad crossings in the project area, the data won't be used or needed.	Deprecated	Deprecation
6.1.0-180	Updated requirement to clarify that the broadcast message will be a PSM not a BSM	Updated	Refinement

ID	Justification	Status	Change Type
6.1.0-249	This is a related requirement to 6.1.0-150 above.	Added	Addition
6.2.0-181		Unchanged	
6.2.0-182		Unchanged	
6.2.0-183	Clarification of the INS function. Need to account for the vendor's SDK.	Updated	Clarification
6.2.0-184		Unchanged	
6.2.0-185	Clarification of the INS vendor's function.	Updated	Clarification
6.2.0-186		Unchanged	
6.2.0-187	Clarification of the INS function.	Updated	Refinement
6.2.0-188		Unchanged	
6.2.0-189		Unchanged	
6.2.0-190		Unchanged	
6.2.0-191		Unchanged	
6.2.0-192		Unchanged	
6.2.0-193		Unchanged	
6.2.0-194		Unchanged	
6.2.0-195		Unchanged	
6.2.0-196	Requirement applies to both the beacon and INS.	Updated	Clarification
6.2.0-197	Requirement applies to both the beacon and INS.	Updated	Clarification
6.2.0-198		Unchanged	
6.2.0-239	Clarification of the INS function. Expanded to clearly state functions required for accessible users including both audio, text-based, and visual navigation instructions.	Added	Addition

ID	Justification	Status	Change Type
6.2.0-240	Travelers need to be re-routed within the INS locations.	Added	Addition
6.2.0-241	Clarification of the INS function.	Added	Addition
6.2.0-242	Clarification of the INS function.	Added	Addition
6.2.0-243	Clarification of the INS function.	Added	Addition
6.2.0-244	Clarification of the INS function.	Added	Addition
6.2.0-245	Clarification of the INS function.	Added	Addition
6.2.0-246	Clarification of the INS function.	Added	Addition
6.2.0-247	Clarification of the INS function.	Added	Addition
6.2.0-248	Clarification of the INS function.	Added	Addition
7.1.0-199		Unchanged	
7.1.0-200	This is a name change from "next bus request" to "ride request". The funcitonality will not change from the original description.	Updated	Clarification
7.1.0-201		Unchanged	
7.1.0-202	History information will not be stored or available for viewing by account holders. These are removed from storage to reduce Personally Identifiable Information (PII) from the system.	Deprecated	Deprecation
7.1.0-203	History information will not be stored or available for viewing by account holders. These are removed from storage to reduce Personally Identifiable Information (PII) from the system.	Deprecated	Deprecation
7.1.0-204		Unchanged	

ID	Justification	Status	Change Type
7.2.0-205	The requirement describes the format of crowdsourced data collected by G-MAP and transmitted to the STM Platform. The current approach is to collect feedback in freeform and then a custodian will verify the information. Information on what to collect will be described in the feedback form but will not conform to the sidewalk scout API. This is no longer a requirement on the STM.	Deprecated	Deprecation
7.2.0-206	The requirement describes the format of crowdsourced data collected by G-MAP and transmitted to the STM Platform. The current approach is to collect feedback in freeform and then a custodian will verify the information. Information on what to collect will be described in the feedback form but will not conform to the sidewalk scout API. This is no longer a requirement on the STM.	Updated	Design Adjustment
7.2.0-207		Unchanged	
7.3.0-208		Unchanged	
7.3.0-209	Data will still be collected and aggregated but will be displayed in the PMD with all PII removed. The public PMD was added as a subsystem in Phase 2. This was identified as a function of the public PMD not G-MAP.	Updated	Refinement
7.3.0-210	CV system will provide access to the central signal system to obtain data	Updated	Design Adjustment
7.3.0-211		Unchanged	
7.3.0-212		Unchanged	
7.3.0-213		Unchanged	
7.3.0-214		Unchanged	
7.3.0-215		Unchanged	
7.3.0-216	The ST-CTN system only handles fixed-route service.	Deprecated	Deprecation
7.3.0-217		Unchanged	

ID	Justification	Status	Change Type
7.3.0-218		Unchanged	
7.3.0-219	Updated name of the functionality.	Updated	Clarification
7.3.0-250	Public PMD was added as a subsystem in phase 2.	Added	Addition
7.3.0-251	Provide the public with access to downloading publicly available data.	Added	Addition
8.1.1-220		Unchanged	

[1]The system design has been further refined upon completion of the system design. Kinetic is not being used due to a lack of availability/readiness. As a result, the system will instead use a proxy server for PED-X functionality, which has also been referred to as SMUG in this document. Refer to SDD Section 4.6.1 for more details.

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