Phase 1 System Requirements Specification (SyRS)

ARC ITS4US Deployment Project

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Final Report — October 25, 2021
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COMPLETE TRIP
ITS4US

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16. Abstract

The Atlanta Regional Commission Complete Trip - 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, aging 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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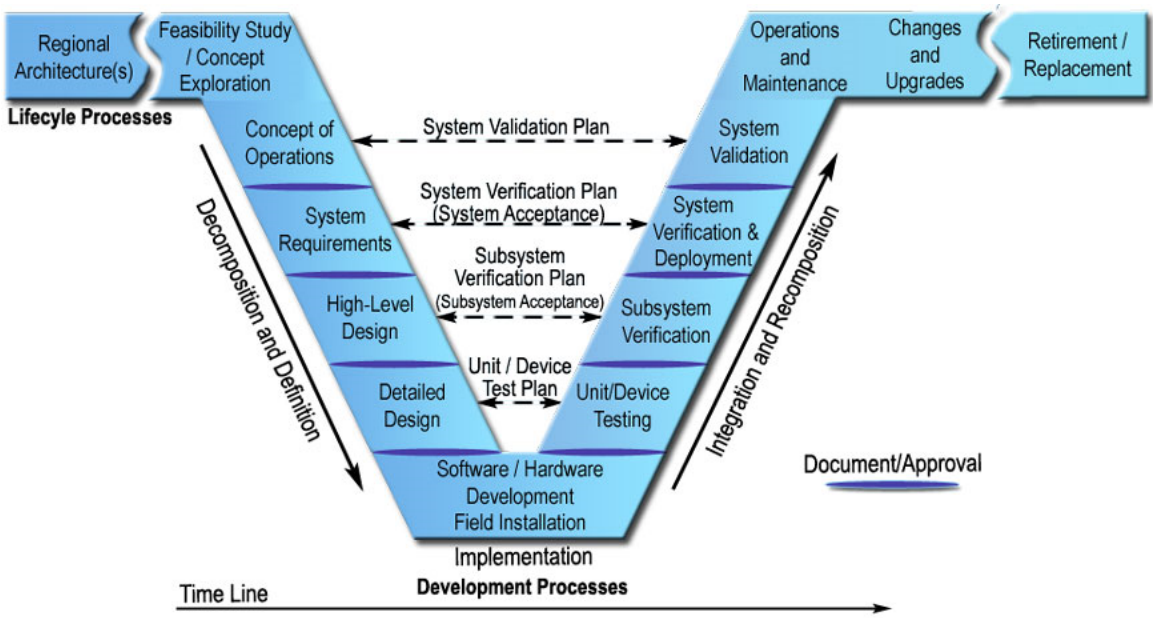
1. Introduction

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 physical or cognitive disabilities, aging 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. A preliminary Agile Roadmap has been identified and can be found in **Appendix B**. It identifies both the Minimum Viable Product (MVP) and subsequent epics and dependencies.

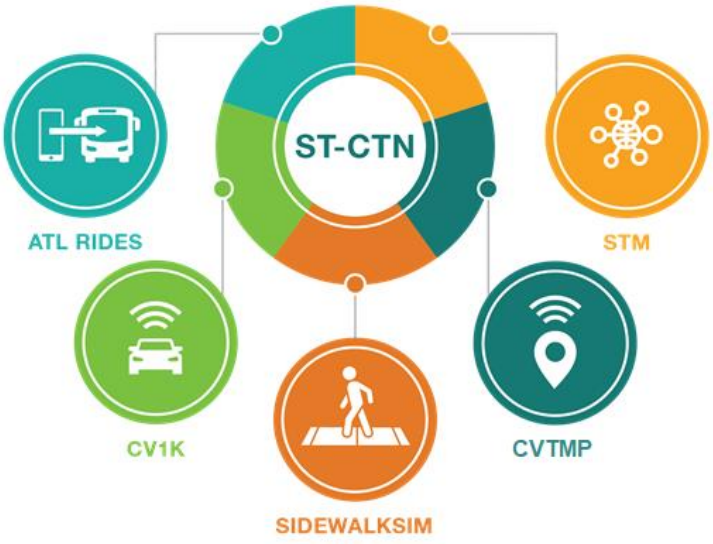
1.1 System Purpose

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 scope of the project is limited to the development of interfaces between existing programs that expand the capabilities of each. The existing initiatives that are being leveraged to support the proposed ST-CTN system are shown in **Figure 2** and defined in more detail below.



Source: ARC, 2020

Figure 2. ST-CTN Integrated Initiatives

ATL RIDES. Atlanta-Region Rider Information and Data Evaluation System (ATL RIDES) developed by the Atlanta-Regional Transit Link Authority (ATL), 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 live-tracking capabilities using GTFS feeds. The Open Trip Planner (OTP) architecture facilitates integration with additional OSS tools including a data analytics engine, call center with interactive voice response (IVR), and account management system.

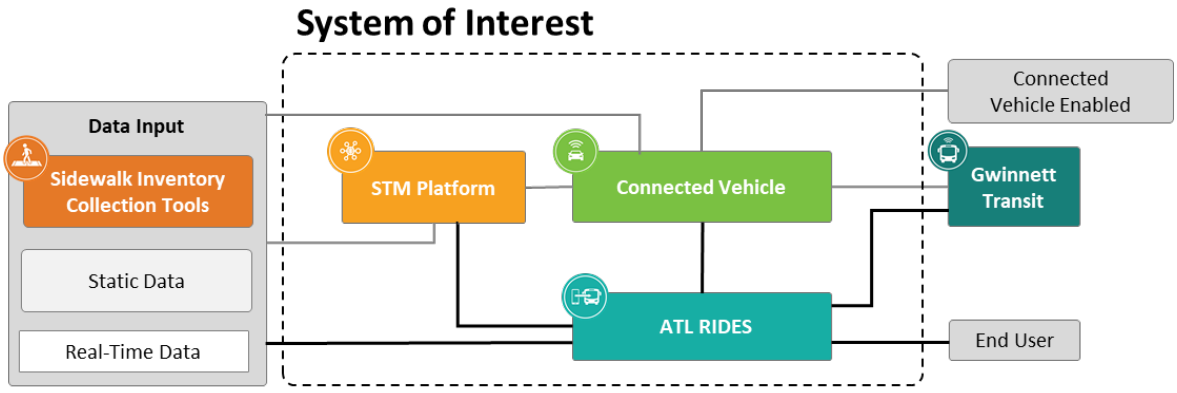
SIDEWALKSIM. SidewalkSim is an asset management system and shortest path (lowest impedance) routing tool for pedestrian pathways. Site inspections provide more detailed Americans with Disabilities Act (ADA) and inclusive design and condition data for use in pathway accessibility analysis. SidewalkSim 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.

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; ATL RIDES is turquoise; and Gwinnett County Transit (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.



ARC: Source, 2021

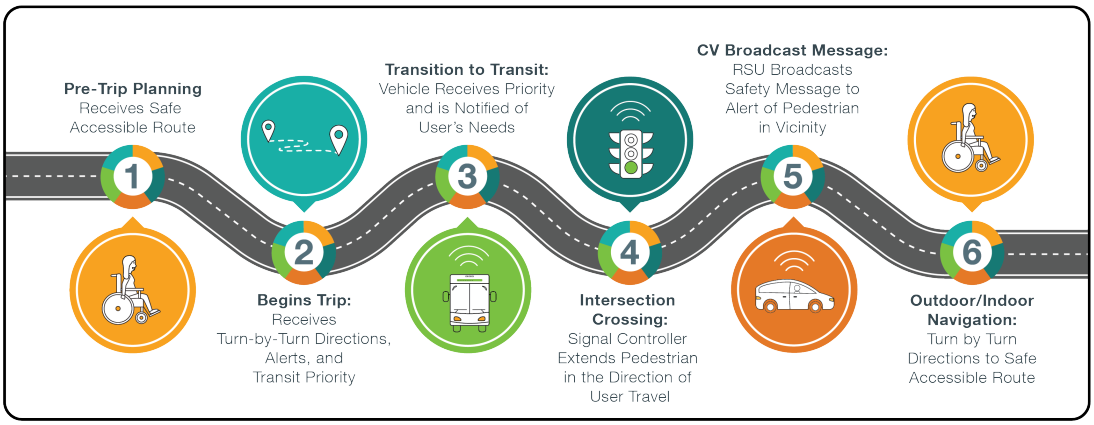
Figure 3. ST-CTN High-Level Context Diagram

1.3 System Overview

The ST-CTN concept will integrate five programs currently existing or underway with regional commitments into a single system. These programs are leading the Atlanta region towards providing all travelers with a suite of innovative mobility solutions, which will be leveraged to support the ST-CTN system. ST-CTN will merge these separate initiatives through data fusion and communications network integration. ARC intends to leverage the successes of the infrastructure, tools, and capabilities of these programs and apply them to support trip planning and wayfinding for all travelers, particularly underserved communities.

*The goal of the ST-CTN system is to leverage existing advanced transportation technology solutions to support **safe, reliable, accessible, complete** trips for all, particularly undeserved communities, including people with disabilities, aging adults, people with LEP, and low-income travelers.*

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 6 segments (as depicted in **Figure 4**) to allow for easier understanding and a greater breakdown of priorities and goals.



Source: ARC, 2020

Figure 4. Traveler's Complete

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 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.

Additionally, user reporting will be available through the application to allow users to provide feedback on infrastructure that is currently out of service (elevators, escalators, etc.) or not accessible due to temporary or permanent obstructions (sidewalks, shared use-paths, etc.). This feature will help users avoid becoming delayed or stranded because of unforeseen outages. Transit providers, city, county, and/or construction crews currently flag outages into the system. New features being proposed as part of the project will allow users to flag infrastructure that has not already been flagged by public agency staff. System development and system integrations completed within the scope of this pilot 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; and use crowdsourced data collection to update infrastructure conditions.

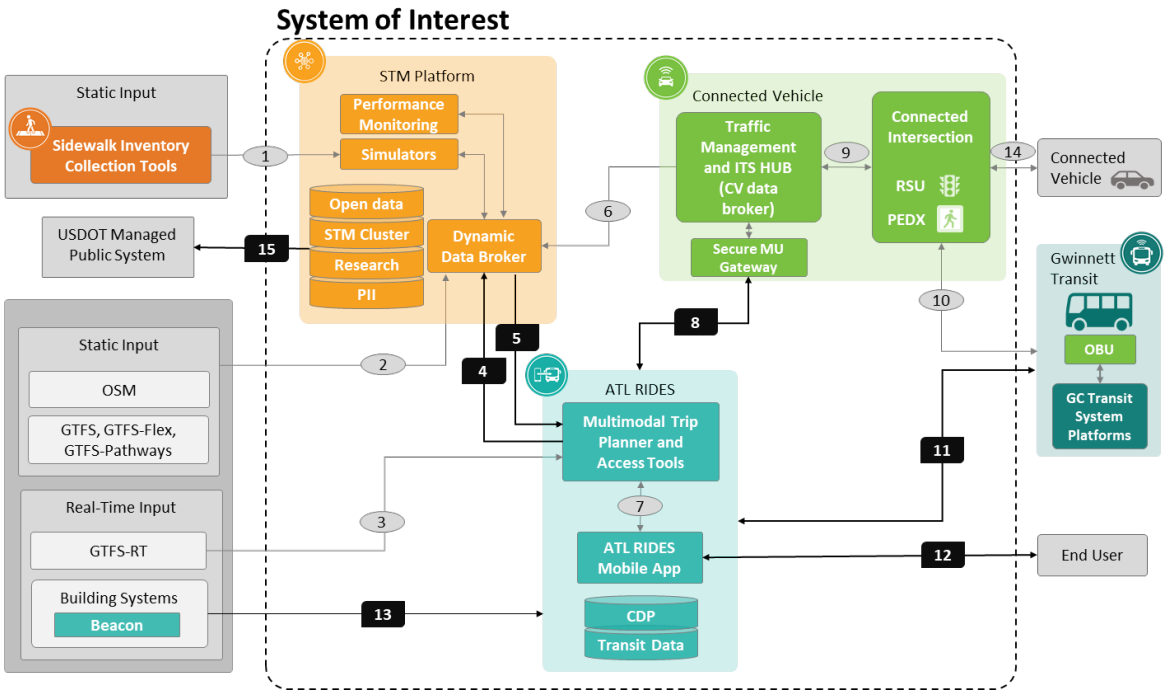
The ST-CTN project will use OSS tools allowing for the results to be replicable across the region and sidewalk inventory innovations will reduce the costs of managing pedestrian assets in any community.

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 5** provides more detail about how the subsystems will interact and be brought together under the ST-CTN system. This figure has been updated from the version in the revised ConOps and PMESP. 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 5. Safe Trip in a Connected Transportation Network Data Exchange Flow Diagram

The Atlanta-Region Ride Information and Data Evaluation System (ATL RIDES) subsystem is contained within the light blue box in the lower-middle of the System of Interest. The ATL RIDES 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 ATL RIDES multimodal trip planner and access tools
4	Mobile App logs, trip feedback and crowdsourced data (introduced in this systems requirement document as the Asset Condition application programming interface (API))
5	STM Network Impedance API
6	CV and Traffic Operations Messages: signal phasing and timing (SPaT), Map Data (MAP), CV Advanced Traveler Information System (ATIS) broadcast data, NaviGAtor intelligent transportation system (ITS), road characteristics, traffic data
7	Open Trip Planner APIs and ATL RIDES APIs
8	Mobile Accessible Pedestrian Signal System (PED-SIG) / Personal Safety Message (PSM)
9	CV messages

Data Exchange ID (EX ID)	Description
10	Transit signal priority and other CV application messages
11	GCT CAD application transactions for transit applications including Transit Connection Protection (replacing CV Transit Stop Request (TSR) and Pedestrian Transit Indication (PTI) as described in ConOps Version 1.0)
12	ATL RIDES and Traveler exchange – profile, trip plan, settings, notifications, feedback, etc.
13	Static and dynamic information from building facilities, including beacons, to ATL RIDES
14	CV Data
15	Project data for USDOT-managed Public System

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 ATL RIDES subsystem. The ATL RIDES subsystem, including the ATL RIDES 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 ATL RIDES subsystem. The ATL RIDES subsystem, including the ATL RIDES 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 ATL RIDES subsystem. The ATL RIDES subsystem, including the ATL RIDES 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 ATL RIDES subsystem or the GCT subsystem. The ATL RIDES subsystem, including the ATL RIDES 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 ATL RIDES 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 ATL RIDES subsystem, including the ATL RIDES 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 ATL RIDES 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 ATL RIDES subsystem, meaning TSP will still be available for buses running behind schedule. The ATL RIDES subsystem, including the ATL RIDES 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 ATL RIDES subsystem including the ATL RIDES 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 ATL RIDES 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 ATL RIDES Multimodal Trip Planner and Access Tools experiences a loss in functionality, the ST-CTN application will not function. Subsystems that push information to ATL RIDES Multimodal Trip Planner and Access Tools may still be able to communicate and provide data without any loss.

2.3 Major System Capabilities

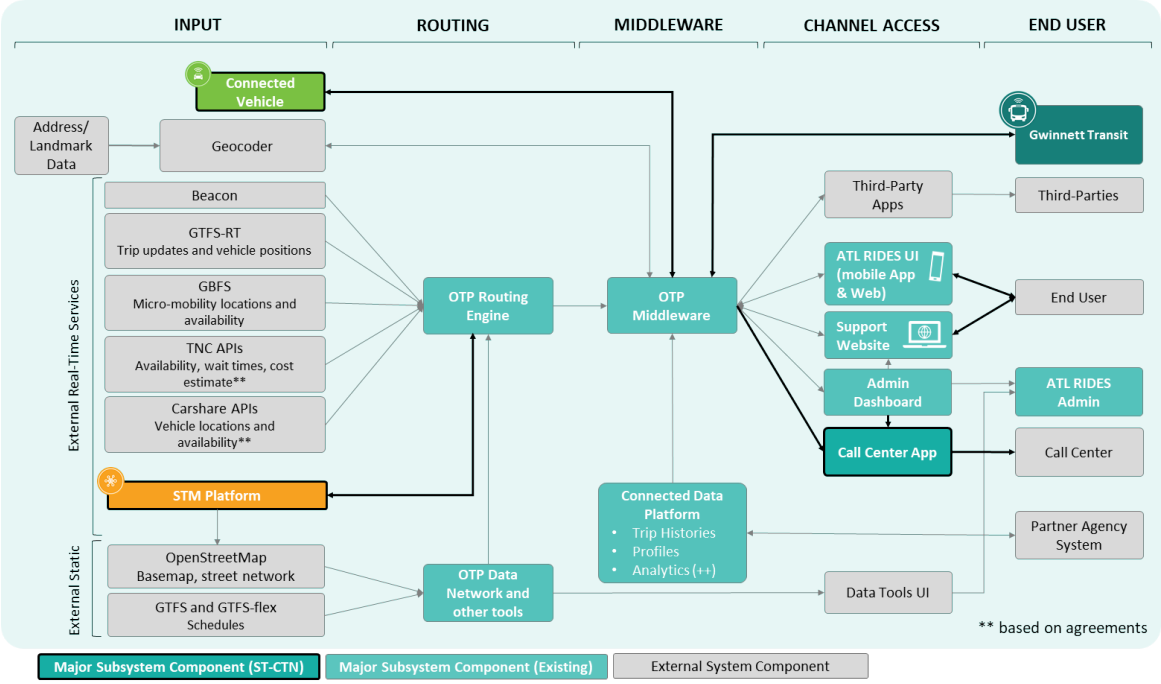
This section highlights the major capabilities of the ST-CTN system and introduces the groupings for the system requirements. This section expands on **Figure 5** and provides in depth descriptions of the subsystems, external interfaces, and data exchanges. All subsystem context diagrams with added functionalities 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 ATL RIDES 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 ATL RIDES 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 6 provides the current ATL RIDES 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 6. Proposed ATL RIDES Subsystem Extension

Channel Access (responsive web application, native mobile app, and IVR/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 an IVR system and call center to handle calls from phones.
- Interface with the STM Platform and STM Network Impedance API for real-time network impedance and provision of Asset Condition API 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 connection protection (aka next bus 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 ATL RIDES subsystem. New interfaces will include (Note: "*" indicates that the interface was identified after developing the ConOps):

- Static Data Input
  - GTFS-Pathways (indoor station graphs).
  - 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 ATL RIDES (Asset Condition API will leverage existing data content of the STM Sidewalk Scout API).

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 ATL RIDES, the infrastructure will be hardened to ensure subsystem reliability, scalability, and availability. The ATL RIDES 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.

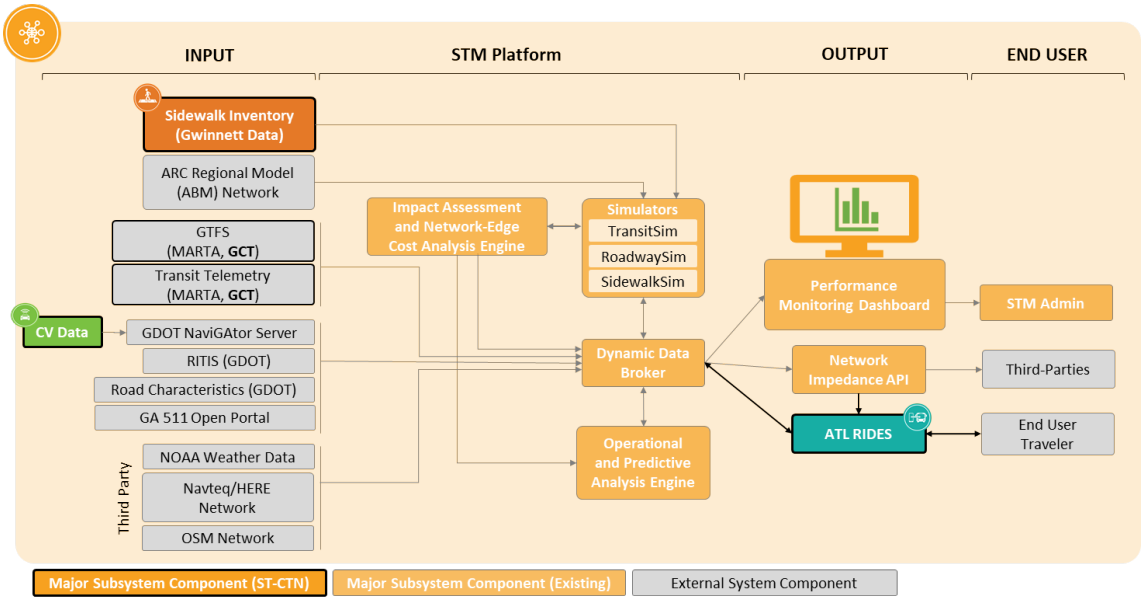
The ATL RIDES mobile app will be available for users to download via the Apple AppStore and Google Play stores. These App Stores also manage upgrade distribution for ATL RIDES to help ensure users are running the most recent version of the app available.

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 ATL RIDES 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 7** provides the proposed STM Platform subsystem context diagram with added functionalities and connectivity presented in bold.



Source: ARC, 2021

Figure 7. 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 ATL RIDES mobile app)
- Feedback from ATL RIDES 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)
- Weather Data: National Oceanic and Atmospheric Administration (NOAA) precipitation forecasts and current precipitation information

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 ATL RIDES 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 using construction permit final inspection reports generated by Gwinnett County, regular Sidewalk MV and Sidewalk Sentry inspections, and agency field inspections and crowdsourced reporting via the ATL RIDES feedback function (based on the Sidewalk Scout app).
- 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 ATL RIDES 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 ATL RIDES 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 5**.

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 ATL RIDES 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 ATL RIDES 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 ATL RIDES app. The API will be developed during the Agile development phase in collaboration with STM and ATL RIDES 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.

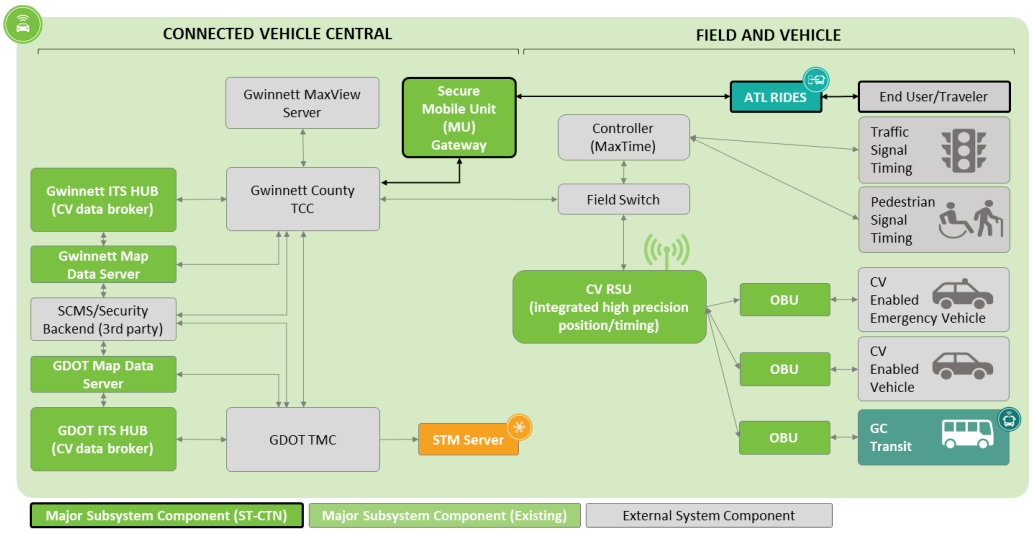
Modes. The STM Platform will include the current modes of operation with additional modes to ensure operations in the broader system. The ST-CTN modes of operation are describe in **Section 2.2** (System Modes and States).

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 ATL RIDES as depicted in **Figure 8.**



Source: ARC, 2021

Figure 8. 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)
- Advanced Transportation Information System (ATIS) broadcast (including emergency / railroad pre-emption warnings)
- Generation and collection of MAP, SPaT and BSM 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 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. In addition, it serves to respond to messages as appropriate. In summary, the SMUG acts as a gatekeeper of non-RSU or non-OBU derived messages into the CV subsystem.

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, ATIS, 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 J2735 and SAE J2945 series messages. Additional message sets will use NTCIP standards including NTCIP 1201, 1202, and 1211.

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 ATL RIDES 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 ATL RIDES 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 5.** 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 Table 3 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 Table 3 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 ATL RIDES multimodal trip planner and access tools
Subsystems Involved	From various existing data sources external to the system (see Table 3 for source details) to ATL RIDES
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 4	Mobile App logs and trip feedback
Subsystems Involved	From ATL RIDES to STM
Exchange Description	New data exchange. ATL 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 ATL Rides

Interface	Description
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 ATL RIDES app. The API will be developed during the Agile development phase in collaboration with STM and ATL RIDES platform developers.
Data Exchange 6	CV and Traffic Operations Messages: SPaT, MAP, CV ATIS broadcast data, 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 MAP and SPaT information, 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. In addition, new ATIS crossing safety messages (railroad crossing and emergency vehicle preemption (EVP)) will be forwarded to the STM Platform. These messages will be developed based on the Gwinnett County CVTMP outside of the ST-CTN project.
Data Exchange 7	OTP APIs and ATL RIDES APIs
Subsystems Involved	Between ATL Rides middleware and UI, internal to the ATL RIDES subsystem
Description	No major change. May be configured differently or add additional user preferences and options.
Data Exchange 8	Mobile Accessible Pedestrian Signal System / Personal Safety Message (PSM)
Subsystems Involved	Between MU (ATL RIDES) and RSU, through the SMUG
Description	New data exchange. These messages will conform to SAE J2735 message sets and J2945 Part 9 for VRUs including the PSM.
Data Exchange 9	CV Messages
Subsystems Involved	Between RSU and TMC/ITS CV back center system, internal to the CV subsystem

Interface	Description
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	CV application transactions including TSR
Subsystems Involved	From ATL RIDES 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	ATL RIDES and Traveler exchange – profile, trip plan, settings, notifications, feedback, etc.
Subsystems Involved	To and from ATL RIDES mobile app to end user, external to the system
Description	Upgraded data exchange. Information exchange from end user to ATL RIDES 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 ATL RIDES 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, transit operator notifications, etc.
Data Exchange 13	Building facility Beacons to ATL RIDES
Subsystems Involved	Facility-deployed beacons to ATL RIDES
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.

Interface	Description
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 information on railroad crossing, EVPs at specific intersections, major incidents, work zones, lane closures and delays.
Data Exchange 15	Project Data for USDOT Managed Public System
Subsystems Involved	From STM Cluster servers (GA Tech processing and data server farm) to USDOT Managed Public System
Description	New data feed. Provides ST-CTN project data to USDOT for independent evaluation, monitoring, and assessment.

2.3.5 External System Interfaces

The system interfaces to be exchanged between external sources and ST-CTN subsystems are identified **i**n 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. The organization that will provide the data and destination of each interface is provided as well. In some cases, the data exchange ID, source, or destination of the interface has not yet been determined and is marked as to be determined (TBD). **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 1)

EX-ID	Input Data	Static / RT	Description	Org	Destination (subsystem)
1	ABM Network	Static	The regional model from ARC.	ARC	STM
3	Address Data	Static	Address directory with addresses in the geographic region.	TBD	ATL RIDES

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.	TBD	STM
2	Facility Conveyance Status	RT	The status of current obstructions and vertical conveyances status (e.g., operating, out of order, under maintenance).	TBD	STM
2, 3	GTFS	Static	General Transit Feed Specification data including accessibility attributes for GCT and Metropolitan Atlanta Regional Transit Authority (MARTA).	GCT MARTA	ATL RIDES, STM
3	GTFS-Flex	Static	General Transit Feed Specification Flex data for Gwinnett paratransit services.	GCT	ATL RIDES
2, 3	GTFS-Pathways	Static	General Transit Feed Specification Pathways data for Doraville MARTA Transit Station.	MARTA	ATL RIDES, 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	ATL RIDES, 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.	TBD	STM, ATL RIDES
2	NavTEQ / HERE Network	Static	Licensed subscription road network data from HERE.	HERE	STM
2, 3	OpenStreetMap	Static	Open Street Map network needed to support ATL RIDES OTP engine and STM simulator component.	OSM ATL	ATL RIDES, STM

EX-ID	Input Data	Static / RT	Description	Org	Destination (subsystem)
1	Sidewalk / Bike Inventory	Static	Sidewalk collected by sidewalk inventory tools. Bike pathways may also be included since they exist in the STM Platform.	TBD	STM
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 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 ATL RIDES preference menu.	ATL ARC GA Tech	STM
2	Weather Data	RT	Open weather information from NOAA.	NOAA	STM

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

Table 4. External System Interfaces – Outputs (source: Data Management Plan Version 1)

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	ATL RIDES	End User

EX-ID	Output Data	Static / RT	Description	Source (subsystem)	Destination
TBD	Performance Data	RT	Performance measurement data collected and aggregated by the ST-CTN system. The details will be described in the PMESP.	STM	TBD

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 **Figure 8**, CV Subsystem. It is anticipated that ATL RIDES 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 physical disability, persons with a cognitive disability, aging 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 mobility limitations (cane, walker, stroller)
- Walking with visual impairments (limited vision, white cane)
- Use of standard manual wheelchairs
- Use of electric wheelchairs (by wheelchair technology level)
- Mobility scooter
- 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 Physical 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 physical 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.

Person with Cognitive Disability

Persons with cognitive disabilities may have trouble understanding specific instructions, word-based prompts or directions; may have trigger words or actions that disrupt them or may have trouble repeating tasks on a day-to-day basis. A cognitive disability is a condition that makes it more difficult for a person to interact or participate in the environment around them. Cognitive disabilities may affect a person's thinking, remembering, learning, communicating, mental health, sensory processing, or social interactions.

Aging Adult

Aging 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). Aging adults are people (typically 60 years of age or older) who have physical or cognitive 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.

Gwinnett County Transit

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 ATL RIDES 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 ATL RIDES subsystem as well as the GCT OBUs. The Gwinnett County TCC will also send and receive messages from traffic signal controllers, broadcasting SPaT data to ATL RIDES and 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 ATL RIDES subsystem. The ATL will be responsible for protecting the security of any data flowing into or out of the ATL RIDES 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 ATL RIDES 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 data collection with the sidewalk inventory tools, Sidewalk Scout, Sidewalk Sentry and Sidewalk MV.

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 ATL RIDES.

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 ATL RIDES 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.

Gwinnett County Transit

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 ATL RIDES subsystem. The information exchanged between the ATL RIDES and GCT subsystems include transit stop request (TSR) 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 ATL RIDES 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.

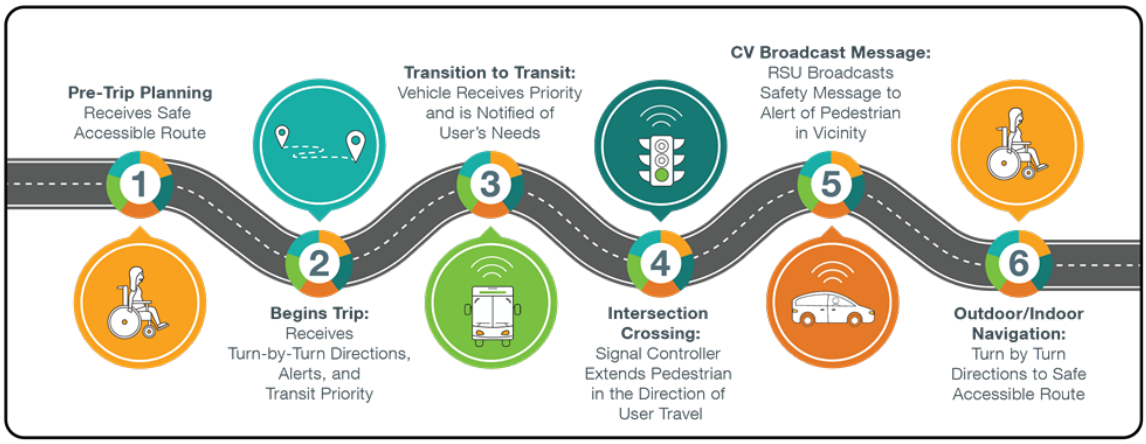
The Georgia Department of Transportation interacts with the ST-CTN system by maintaining communication between the GDOT CV data broker and the STM Platform. This connection allows for information to be sent to the CV and transit operators.

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 9** and the steps are listed below.



Source: ARC, 2020

Figure 9. 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.

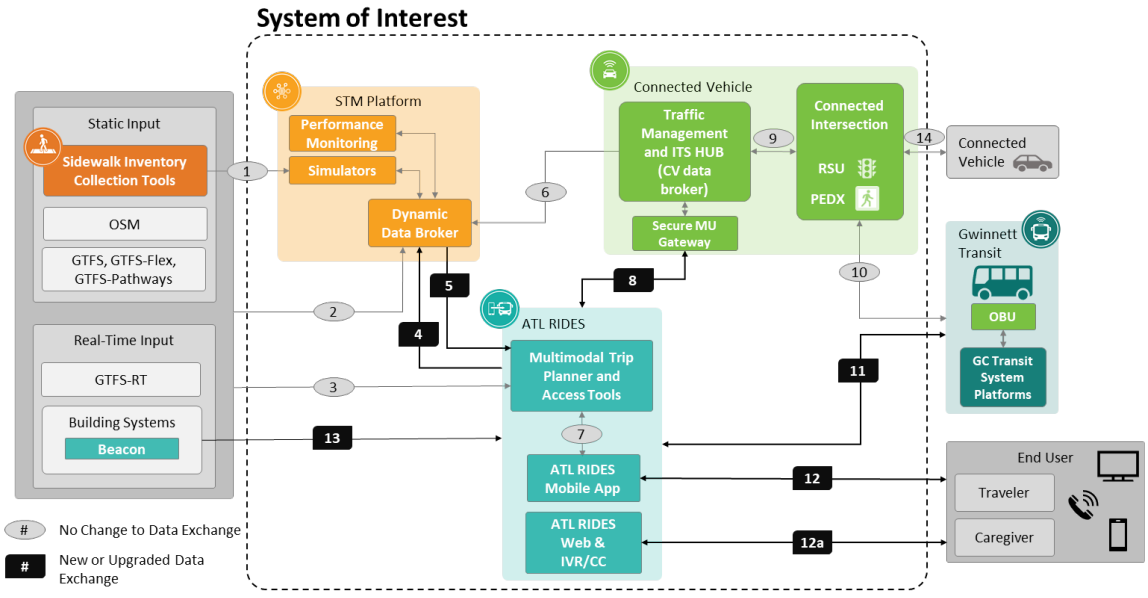
Step 4 **Intersection Crossing.** The traveler interacts with the signal controller which extends pedestrian phase in the direction of user travel.

Step 5 **CV Broadcast Message.** Roadside units broadcast safety message to alert of pedestrian/bicyclist 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 10 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: ARC, 2021

Figure 10. Use Case #1 Information Flow in the ST-CTN System

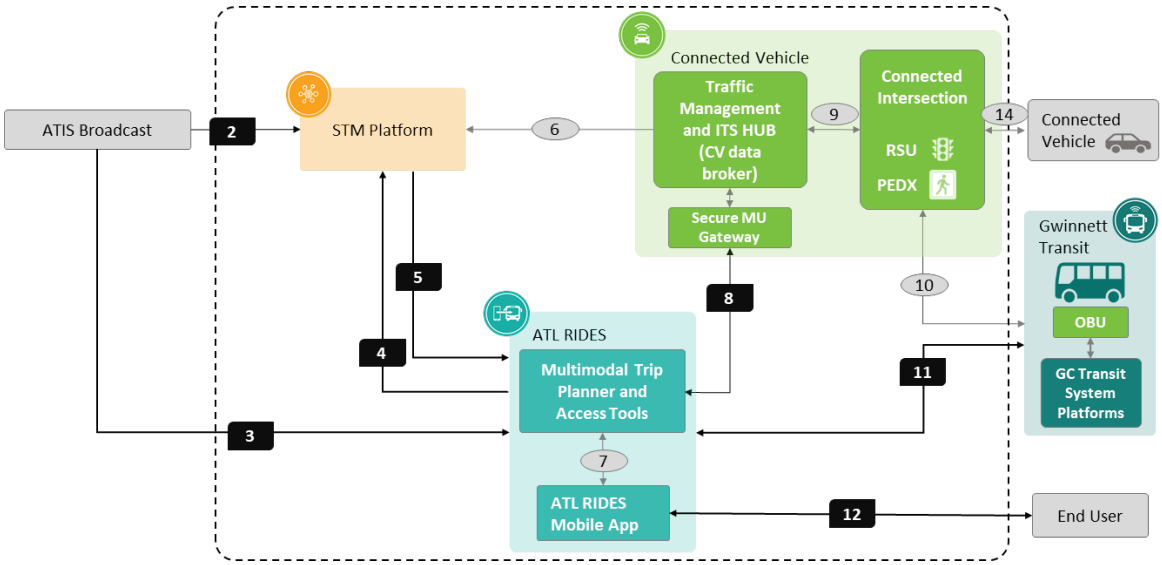
2.6.2 Use Case 2: Connected Vehicle

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 11** illustrates the information flow between the traveler (represented by ATL RIDES mobile app) and the field or vehicles represented by the RSU and OBU equipment. **Table 5** provides the descriptions of the associated data exchanges shown in **Figure 11**. 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
Advanced Traveler Information System (ATIS)	The ATIS application provides for the collection, aggregation, and dissemination of a range of transportation information. The collection of information includes traffic, transit, road weather, work zone, and CV-related data. All the sources of data are aggregated into data environments that can be used to drive data portals, allowing dissemination of the spectrum of transportation information to travelers via mobile devices, in-vehicle displays, web portals, and roadside signage. Note: The broadcasts will include emergency management vehicle preemptions at intersections and railroad crossing alerts transmitted through the GDOT ATMS to both STM and ATL RIDES subsystems.	High
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 – ATL RIDES 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

CV Application	Description	Priority
Transit Stop Request	The TSR 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 be implemented by the GCT Connection Protection application.	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 11. 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	ATIS broadcast Including warnings of EV preemption and railroad crossing to STM
3	ATIS broadcast Including warnings of EV preemption and railroad crossing to ATL RIDES
4	Mobile App logs, and trip feedback and crowdsourced data (introduced in this systems requirement document as the Asset Condition application programming interface (API))
5	STM network impedance API
6	CV operations messages: SPaT, NaviGAtor ITS, road characteristics, traffic data
7	OTP APIs and ATL RIDES APIs
8	PED-SIG / PSM
9	CV messages
10	TSP and other CV application messages
11	TSR (now called the GCT Connected Protection application)
12	ATL RIDES and end user exchange – profile, trip plan, notifications, feedback, etc.
13	Static and dynamic information from building facilities to ATL RIDES
14	CV broadcast messages

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

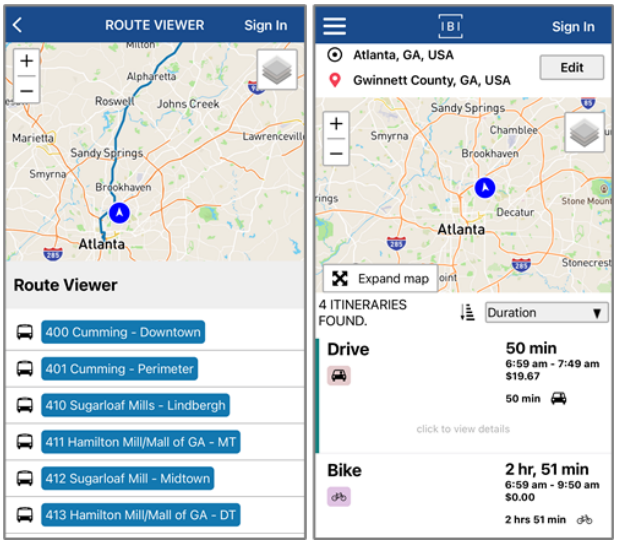
The following sections describe the comprehensive set of system requirements. Sections are organized based on the following logical structure:

- **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 ATL RIDES 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.



Source: The ATL, 2021

Figure 12. 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 ATL RIDES for the ST-CTN system.

The ATL RIDES 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 ATL RIDES subsystem to achieve the following functional system requirements.

Table 7. ATL RIDES Functional Requirements

Requirement ID	Requirement Title	Requirement Statement
1.2.0-018	ATL RIDES Core Functionality	The system shall utilize the OTP and ATL RIDES (IMI grant) functionality, interfaces, architecture and infrastructure as the core ATL RIDES for the ST-CTN. OpenTripPlanner 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.
1.1.0-012	Opt-in to Store and Use PII	ATL RIDES 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 ATL RIDES 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	ATL RIDES 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).

Requirement ID	Requirement Title	Requirement Statement
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.
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	ATL RIDES 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, ATL RIDES 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	ATL RIDES shall allow travelers to update their trip plan notification selections when actuating a saved trip plan.
1.5.0-043	Trip Planning -- Traveler Companion	ATL RIDES 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.

Requirement ID	Requirement Title	Requirement Statement
1.5.0-044	Trip Planning – Group Travel Preference Confirmation	When traveling in a group, ATL RIDES 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, ATL RIDES will ask the traveler to alter their default preferences to align with the preferences for the group travel needs.
1.6.0-045	Trip Planning - Practice Mode	ATL RIDES 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	ATL RIDES 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, crowdsourced obstacles, EVPs, etc.). See Req 2.1.2-076 for related requirement.
2.1.2-076	Network Impedance API Ingestion	ATL RIDES 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	ATL RIDES Mobile and Web Applications	ATL RIDES 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	ATL RIDES 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.

Requirement ID	Requirement Title	Requirement Statement
2.5.0-087	Role Based Access by Trusted Person	ATL RIDES 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	ATL RIDES 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.
2.5.0-089	Help Call Number	ATL RIDES 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	ATL RIDES 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 Connection Protection, PED-SIG, 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	ATL RIDES shall update a 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.
3.2.0-105	Confirm Connection Protection	ATL RIDES shall display a notification to the traveler that the transit vehicle has acknowledged the connection protection request.
6.1.0-174	Subscribe to CV ATIS Message by ATL RIDES	ATL RIDES shall subscribe to the ATIS from the CV Platform.

Requirement ID	Requirement Title	Requirement Statement
6.1.0-175	Ingest CV ATIS Message by ATL RIDES	The ATL RIDES shall ingest (extract, transform, and load) the CV ATIS message as it arrives from the CV Platform.
6.1.0-176	Use CV ATIS Message by ATL RIDES	The ATL RIDES shall use the CV ATIS message as it arrives from the CV Platform. The processing and use of the ATIS message will depend on the content of the message which will be described in the data curation plan as specified by Req 6.1.0-148. The timing from receipt to use will be configurable.
6.2.0-181	Beacons Pairing	ATL RIDES 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	ATL RIDES 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	ATL RIDES 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.
6.2.0-184	Indoor Navigation	ATL RIDES shall provide wayfinding instructions indoors at selected facilities. Wayfinding includes navigation, orientation, and destination finding through notifications to the traveler.
7.1.0-202	View Completed Trips	ATL RIDES shall allow account holders to view completed trips.
7.1.0-203	Print Completed Trips	ATL RIDES shall allow account holders to print completed trips.
7.2.0-206	Traveler Impact Form	ATL RIDES shall provide a traveler feedback form in which travelers can report on impediments of travel. Impediments include obstacles and sidewalk conditions. The form (collecting data for the Asset Condition API) will, at a minimum, implement the STM Sidewalk Scout API content.

Requirement ID	Requirement Title	Requirement Statement
7.2.0-207	Trip Feedback Reports	ATL RIDES 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 ATL RIDES subsystem to achieve the following infrastructure system requirements.

Table 8. ATL RIDES Infrastructure Requirements

Requirement ID	Requirement Title	Requirement Statement
2.3.0-080	Common Communications	ATL RIDES 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 ATL RIDES 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, mobile web, and mobile app).
2.4.0-085	Notification Channels	ATL RIDES 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 ATL RIDES subsystem to achieve the following data system requirements.

Table 9. ATL RIDES Data Requirements

Requirement ID	Requirement Title	Requirement Statement
2.4.0-084	Notification Types	ATL RIDES 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	ATL RIDES - RSU Locations (at signalized intersections)	ATL RIDES 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	ATL RIDES 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.

Requirement ID	Requirement Title	Requirement Statement
7.1.0-200	Store Actual Trip Histories	ATL RIDES 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, Next Bus 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	Traveler Trip Tracking Data	The ATL RIDES 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	ATL RIDES 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 ATL RIDES subsystem to achieve the following operational performance system requirements.

Table 10. ATL RIDES Operational Performance Requirements

Requirement ID	Requirement Title	Requirement Statement
1.4.0-042	Notification Latency	ATL RIDES 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	ATL RIDES Subsystem	ATL RIDES shall monitor ATL RIDES component health and operational status. The specific measures will be identified during Phase 2 of the ST-CTN project.
2.1.1-067	ATL RIDES Subsystem Self Logging	ATL RIDES shall log ATL RIDES component health and operational status. The specific measures will be identified during Phase 2 of the ST-CTN project.
2.1.1-072	ATL RIDES Subsystem Self-Monitoring Transmission	ATL RIDES 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 Beacons

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

Table 11. ATL RIDES – Beacon 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 ATL RIDES.
6.2.0-185	Beacon Asset Inventory Collection	The system shall collect asset information on beacons that are installed in facilities to support indoor navigation.

Requirement ID	Requirement Title	Requirement Statement
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 system shall provide access to the beacon asset inventory to authorized users including ATL RIDES, STM, building owners, and other third parties.
6.2.0-188	Acquire Beacon Asset Inventory	ATL RIDES 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	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 shall include an SDK to interface with iOS and Android to receive and resolve message content.

Requirement ID	Requirement Title	Requirement Statement
6.2.0-197	Beacon Message Configuration	The beacon 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.

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:

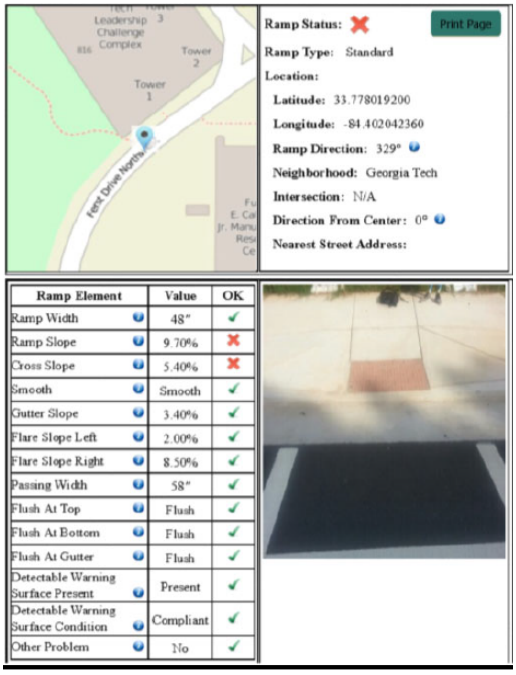
- Georgia NaviGAtor ITS traffic operations data feeds
- Private, licensed data source (data source TBD) for cell phone tracking data
- Private, licensed data source (data source TBD) for fleet data
- GTFS data feeds from GCT (DMP ID 34)
- GTFS data feeds from MARTA (DMP ID 35)
- ARC’s Activity Based Model (ABM) roadway network (DMP ID 3)
- National Oceanic and Atmospheric Administration (NOAA)

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 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 13. 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.

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.

1.3.0-027	Logical VRU Groups	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. An initial set of VRU groups may be modelled by mobility mode type:
		• Person walking (no assistive device)
		• Person walking who has mobility limitations
		  ○ Cane, walker, stroller
		• Person walking who is blind or has vision loss
		  ○ Limited vision, white cane
		• Person using standard manual wheelchair
		• Person using electric wheelchair (by wheelchair technology level)
		• Person using mobility scooter
		• School children (different attention span and potentially different impedance factors to keep them safe)
		The impedance values associated with each VRU group shall be configurable.

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).

Requirement ID	Requirement Title	Requirement Statement
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 crowdsourced, 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 crowdsourced, work zone, 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 VRU group 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.
1.3.0-033	Dynamic Generating Impedance Factors	The STM Platform shall regenerate the impedance values for each VRU group 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 updated dynamic challenges to travel along the Whole Road Network model. At a minimum, the duration between distribution will be at 15 minutes intervals.
6.1.0-171	Subscribe to CV ATIS Message by STM	The STM Platform shall subscribe to the ATIS from the CV Platform.
6.1.0-172	Ingest CV ATIS Message by STM	The STM Platform shall ingest (extract, transform, and load) the CV ATIS message as it arrives from the CV Platform.

Requirement ID	Requirement Title	Requirement Statement
6.1.0-173	Use CV ATIS Message by STM	The STM shall use the CV ATIS message as it arrives from the CV Platform. The processing and use of the ATIS message will depend on the content of the message which will be described in the data curation plan as specified by Req 6.1.0-148. The timing from receipt to use will be configurable.
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.
7.3.0-216	STM Ingestion of GCT Paratransit Ridership	The STM Platform shall ingest GCT paratransit ridership data as available from GCT.
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.

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.

Table 14. STM Platform Data Requirements

Requirement ID	Requirement Title	Requirement Statement
1.3.0-035	Whole Road 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, (bike) public and private generated 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	Whole Road Network and OSM	The Whole Road Network shall use OSM structure as a framework to create the network. 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 ATL RIDES subsystem is based.
1.3.0-038	Import Road Network Data (public / private network)	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).
7.2.0-205	Provision Asset Condition API	The STM Platform shall provide the Asset Condition API (based on the Sidewalk Scout API structure) which ATL RIDES will use to collect and transmit traveler feedback on disruptions and obstacles to their travel. The content of the API parameters will be driven by stakeholder input during the Agile Development Process.

Requirement ID	Requirement Title	Requirement Statement
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
7.3.0-210	Subscribe and Ingest CV Message Logs	The STM subsystem shall ingest message logs from the SMUG 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 ATL RIDES 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.

3.2.4 Operational Performance

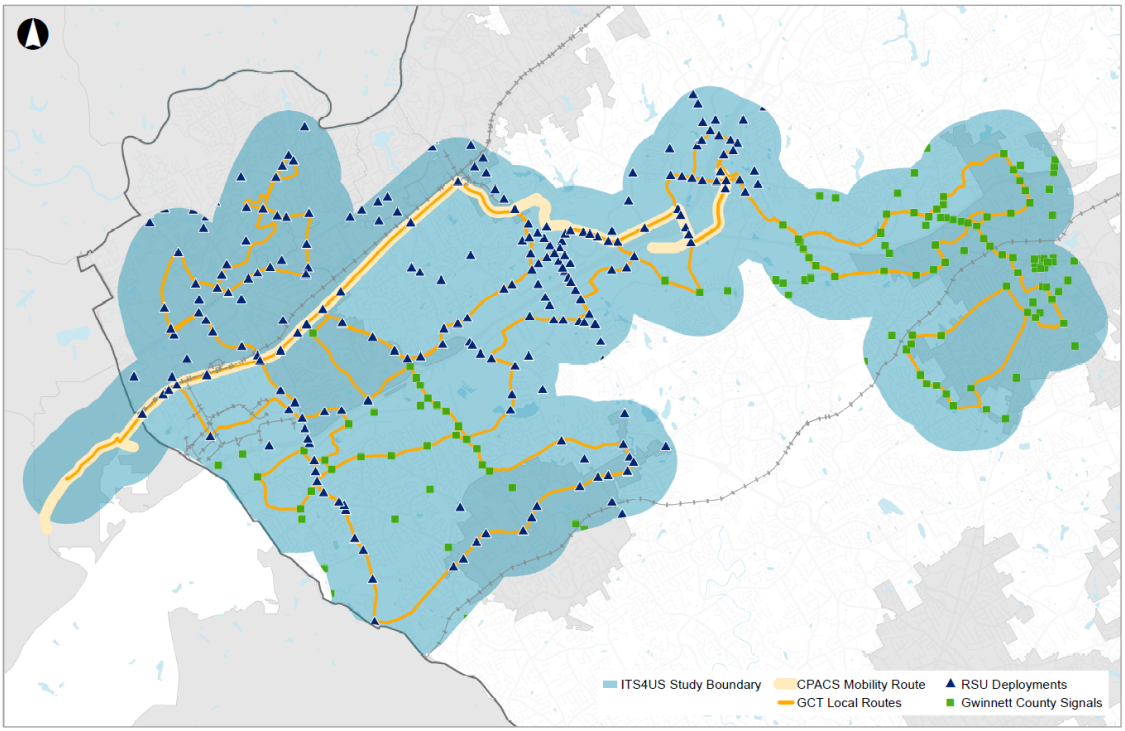
The ST-CTN system will enhance the STM Platform subsystem to achieve the following operational performance system requirements.

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. SPaT (or MaxTime), 2. traffic congestion, 3. ATIS, and 4. real time transit information.
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.
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 14**). 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 14. 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
  - ATIS connectivity

3.3.1 Functional

The ST-CTN system will enhance the CV subsystem to achieve the following functional system requirements.

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 Publish and Subscribe	The CV subsystem shall implement a publish and subscribe service that is available to subsystems (STM and ATL RIDES) to subscribe to published interfaces including: 1. BSM, 2. MAP, 3. SPaT, 4. ATIS message data, and 5. MaxTime (for specific signal controllers).
6.1.0-163	Publish MAP Data	The CV subsystem shall publish the MAP data for access by the STM Platform and ATL RIDES subsystems.
6.1.0-165	Publish SPaT Data	The CV subsystem shall publish the SPaT data for access by the STM Platform and ATL RIDES subsystems.

3.3.2 Infrastructure

The ST-CTN system will enhance the CV subsystem to achieve the following infrastructure system requirements related to SMUG. SMUG will serve as a secure means of exchanging information between a mobile unit (MU) (or proxy such as the ATL RIDES subsystem) and the CV subsystem. The SMUG serves to provide authenticated access, validate messages, and transform and direct the messages to the appropriate destination. In addition, it serves to respond to messages as appropriate. In summary, the Secure MU Gateway acts as a gatekeeper of non-roadside unit (RSU) or non-onboard unit (OBU) derived messages into the CV subsystem.

Table 17. CV Infrastructure Requirements

Requirement ID	Requirement Title	Requirement Statement
5.1.0-138	SMUG Message Process Scalability	The SMUG shall process multiple message transactions simultaneously. The maximum number of simultaneous transactions will be identified during Phase 2 of the ST-CTN project. The quantity used for the pilot may not be the volume required for a fully operational system.

3.3.3 Data

The ST-CTN system will enhance the CV subsystem to achieve the following data system requirements.

Table 18. CV Data Requirements

Requirement ID	Requirement Title	Requirement Statement
5.1.0-139	SMUG Event Recording	SMUG shall include an event recording storage capability which stores ATL RIDES/SMUG transactions, tagged with a time stamp accurate to within a second and synchronized across the system.
5.1.0-140	SMUG Event Log	SMUG shall record every message that flows through SMUG. At a minimum, the log entry will include time received, time transmitted, address of message origin and destination, and message ID.
5.1.0-141	SMUG Event Log Access	The SMUG shall provide access to the log file by the STM performance measure dashboard to download all or subsets of the SMUG log file.

Requirement ID	Requirement Title	Requirement Statement
7.3.0-209	Publish Travel Statistics	ATL RIDES shall publish 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

3.3.4 Operational Performance

The ST-CTN system will enhance the CV subsystem to achieve the following operational performance system requirements.

Table 19. 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.
2.1.1-071	CV Subsystem Self Logging	The CV subsystem shall log 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 Connection Protection. 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
- Transit Stop Request (Connection Protection) | 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 ATL RIDES to the traffic signal to request the pedestrian signal (PED-X) at a specific intersection crossing. The ATL RIDES 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.

Note: The pathway between the ATL RIDES mobile app traverses the ATL RIDES 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.

Table 20. 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 (from MAP data)	ATL RIDES shall generate navigation directions for crossing intersections using the intersection reference, crossing direction, and traveler orientation.
4.1.0-113	Process Signal Controller PED-X Status	ATL RIDES shall process real time MaxTime (signal controller) data to provide status of the walk signal crossing to the traveler. The signal process message shall conform to NTCIP 1202 (and 1201).

Requirement ID	Requirement Title	Requirement Statement
4.1.0-114	Track Traveler Location	ATL RIDES shall track the traveler's approach to an intersection crossing from the trace data collected from their ATL RIDES mobile app.
4.1.0-115	Estimate Time to Send PED-X Request (for intersection crossing)	ATL RIDES shall estimate the time a user will arrive at the intersection based on their VRU category outlined in Section 2.5.1 accounting for system errors and other factors including communications pathways, time, and positional accuracy.
4.1.0-116	Generate PED-X Priority Request Message	ATL RIDES shall generate a PED-X Priority request message (prgPriorityRequestAbsolute) message (as defined in NTCIP 1211 v02) to alert the signal controller to activate the walk signal when a traveler is within walking distance of the next cycle from the crosswalk.
4.1.0-117	Transmit PED-X Priority Request Message	ATL RIDES shall transmit the PED-X Priority Request message with the intersection crossing reference (consistent with the signal controller NTCIP 1202 references) and MaxTime phase. The message will be routed through the SMUG to the referenced intersection.
4.1.0-118	Forward PED-X Priority Messages	The SMUG shall forward PED-X priority messages received from the ATL RIDES to the specified signal controller.
4.1.0-119	Forward PED-X Priority Status Messages	The SMUG shall forward PED-X priority status messages received from traffic signal system to ATL RIDES in response to the PED-X priority messages.
4.1.0-120	Verify and Forward Pre-Defined Messages	The SMUG shall serve as a gateway to exchange messages between ATL RIDES and specific Signal Controllers to authenticate and forward pre-defined message(s) compliant with, at a minimum, SAE J2735 and NTCIP 1211.
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).
4.1.0-122	Generate PED-X Request Update Message	ATL RIDES shall generate a Priority Request Update message (prgPriorityUpdateAbsolute) (as defined in NTCIP 1211) to alert the signal controller to activate the walk signal when a traveler is within walking distance of the next cycle from the crosswalk.

Requirement ID	Requirement Title	Requirement Statement
4.1.0-123	Transmit PED-X Request Update Message	ATL RIDES shall continue to transmit Priority Request Update messages with the crossing reference and signal controller timing phase until ATL RIDES cancels, clears, or times out the request. The cancel or clear message is triggered based on the traveler's travel pattern. The timeout parameter will be specified during Phase 2.
4.1.0-124	Generate PED-X Priority Cancel	ATL RIDES shall generate a PED-X Priority Cancel message (prgPriorityCancel) to the signal controller following a priority request when a traveler deviates from their planned trip based on their trace data. The deviation threshold will be driven by Agile Development Process.
4.1.0-125	Transmit PED-X Priority Cancel	ATL RIDES shall transmit a PED-X Priority Cancel message (prgPriorityCancel) to the signal controller. The transmission time and latency thresholds will be defined during Phase 2.
4.1.0-126	Generate PED-X Priority Clear	ATL RIDES shall generate a PED-X Priority Clear message (prgPriorityClear) to the signal controller following a priority request when ATL RIDES detects that the traveler clears the intersection.
4.1.0-127	Transmit PED-X Priority Clear	ATL RIDES shall transmit a PED-X Priority Clear message (prgPriorityClear) to the signal controller. The transmission time and latency thresholds will be defined during Phase 2.
4.1.0-130	PED-X Priority Request Message	The PED-X Priority Request message shall adapt the prgPriorityRequestAbsolute (from NTCIP 1211) including the desired request information including the identifier of the crosswalk direction and/or crosswalk phase number, the request identifier, time of service requested, the time of estimated departure, and the status of the priority request.
4.1.0-131	PED-X Priority Update Message	The PED-X Priority Update message shall adapt the prgPriorityUpdateAbsolute (from NTCIP 1211) including the desired request information including the identifier of the crosswalk direction and/or crosswalk phase number, the request identifier, time of service requested, the time of estimated departure, and the status of the priority request.
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.

Requirement ID	Requirement Title	Requirement Statement
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 Reciept	Upon receipt of the PED-X Priority Status message, ATL RIDES shall send a notification to traveler that request was received.
4.3.0-136	Walk / Do Not Walk Display to Traveler	ATL RIDES shall manage, transmit and display on the traveler's mobile app the wait or walk state, and approximate time left to cross. The information will be based on MaxTime cycle times. The calculation of the time left to cross will be developed will be developed during the Agile Development Process in Phase 2 to allow a safety buffer to ensure traveler's safety.

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.

Table 21. 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.

Requirement ID	Requirement Title	Requirement Statement
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 Transit Stop Request (Connection Protection)

The TSR or Connection Protection 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 Connection Protection application as the core functionality that ATL RIDES 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 TSR CV application to achieve the following system requirements.

Table 22. TSR Application Requirements

Requirement ID	Requirement Title	Requirement Statement
3.1.0-092	Connection Protection Core Functionality	The ST-CTN system shall leverage the existing GCT CAD Connection Protection 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	Next Bus Request	The GCT CAD shall provide travelers with "connection protection" when requested via their ATL RIDES. 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 (optional); 3. request that the bus wait if the traveler is delayed by less than a few minutes (requires confirmation by operator) The configurations will be developed with stakeholder input during the Agile Development Process.

Requirement ID	Requirement Title	Requirement Statement
3.1.0-095	Connection Protection Trigger	ATL RIDES shall generate a connection protection 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	Connection Protection Acknowledgement	The GCT CAD shall send a notification to ATL RIDES that the transit operator confirmed receipt of the request for next stop pickup.
3.1.0-097	Log Connection Protection Transactions	The GCT CAD shall log connection protection event information including trip identification, time, and location. Other pertinent information will be identified by the GCT and ATL RIDES developers during Phase 2 of the ST-CTN project.
3.1.0-098	Connection Protection Request Performance	ATL RIDES 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 ATL RIDES developer during Phase 2 of the ST-CTN project.
3.1.0-099	Connection Protection Transaction Latency	For the connection protection request transaction, the system shall minimize latency to within 1 minute from ATL RIDES 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. 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.

The ST-CTN system will enhance the TSP CV application to achieve the following system requirements.

Table 23. 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.
3.3.0-108	Smart Corridor TSP Enhancements	The system shall enhance the Transit Signal Priority by identifying additional strategies that involve pedestrian priority requests. Strategies include but are not limited to Next Stop Connection Protection during inclement weather and persons who need longer boarding times.

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 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 24. 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).

Requirement ID	Requirement Title	Requirement Statement
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).
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 to enhance system scalability.

Table 25. 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 be ported to a scalable, cloud infrastructure during Phase 3.
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 to facilitate system performance measurement.

Table 26. 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.
3.1.0-102	GCT Paratransit Ridership	GCT shall provide paratransit 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 dashboard 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).

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 to ensure system security and privacy.

Table 27. 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 ATL RIDES 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.

Requirement ID	Requirement Title	Requirement Statement
1.1.0-014	Account Contact Information	The system shall not use contact information collected for registration for purposes other than ATL RIDES registration. The data will remain in ATL RIDES and will not be shared with the research or PII servers.
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 4.4.
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-ATL RIDES; ATL RIDES-GCT; and RSU-OBU). The design of the network security features will be developed in Phase 2.
5.1.0-142	SMUG Security	The SMUG shall meet agreed upon security procedure, policies and protocols to authenticate, validate and restrict traffic between ATL RIDES and CV (and downstream signal controllers). The security procedures will be developed during Phase 2 of the ST-CTN project.

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.

Table 28. 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.

Requirement ID	Requirement Title	Requirement Statement
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.
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 ATL RIDES subsystem. The ATL RIDES 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 enhance ST-CTN system operations.

Table 29. 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.

Requirement ID	Requirement Title	Requirement Statement
2.1.0-059	Time Synchronization	The system shall keep time synchronized across subsystem or ensure that each subsystem time measurement can be related to a reference time synchronized to within 100ms. For many of the subsystems, cloud infrastructure time, GPS time, or Network Time Protocol (NTP) for traffic operations are the reference time. The process to relate and synchronize time among the subsystems will be developed during 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.
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	ATL RIDES Health and Operational Status Logs	The ATL RIDES 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

Requirement ID	Requirement Title	Requirement Statement
2.1.1-065	CV Health and Operational Status Logs	The CV 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: • SMUG uptime, downtime, recovery, maintenance activity • Operational mode (normal, degraded, failure) status and duration • Number of ST-CTN message requests per day • Number of ST-CTN unique messages per day • Number of ST-CTN connection time-outs • Number of ST-CTN dropped messages
4.1.0-128	Comm Latency Measure	The system shall calculate the end-to-end latency of the message exchange between the Signal Controller and ATL RIDES.

3.8.3 System Maintainability

This section contains requirements regarding maintenance activities and support of the system. The ST-CTN system will achieve the following system requirements to ensure system maintainability.

Table 30. 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.
2.1.0-058	Mobile App Software Updates	The ATL RIDES 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).

Requirement ID	Requirement Title	Requirement Statement
4.1.0-129	Update Comm Latency Measure	The system shall measure the system latency between ATL RIDES and pedestrian signal controller on a periodic basis. The period between analyses will be determined during the design phase.

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 ATL RIDES 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 meet the elaborated policies in Section 5.6 of the ConOps. These policies include organization policies, external regulatory requirements, or constraints of the system's operations.

Table 31. 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

The table below describes the technical system requirements for lifecycle sustainment.

Table 32. 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 Connection Protection Testing Coordination	The ST-CTN project team shall coordinate GCT Connection Protection 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.

Requirement ID	Requirement Title	Requirement Statement
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.
6.1.0-151	Ingest Traveler Feedback Data	The system shall implement the data curation process for crowdsourced data accessed from the ATL RIDES traveler feedback input. Note: The requirement for a curation process for each dataset is described in Section 3.10.1.
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. Note: The requirement for a curation process for each dataset is described in Section 3.10.1.
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.
6.1.0-155	Manage MAP Data	The STM Platform shall subscribe to and implement a data curation process for MAP data from the CV subsystem.
6.1.0-156	Manage SPaT Data	The STM Platform shall subscribe to and implement a data curation process for SPaT data from the CV subsystem on a second-by-second basis.
6.1.0-157	ATL RIDES Manage MaxTime Data	ATL RIDES shall subscribe to and implement a data curation process for MaxTime signal controller data from the CV subsystem on an as needed, second by second basis.
6.1.0-158	STM Manage MaxTime Data	The STM Platform shall subscribe to and implement a data curation process for MaxTime data from the CV subsystem on a second-by-second basis.

Requirement ID	Requirement Title	Requirement Statement
6.1.0-159	ATL RIDES Manage ATIS Data	ATL RIDES shall subscribe to and implement a data curation process for ATIS data from the CV subsystem on an as needed basis.
6.1.0-160	STM Manage ATIS Data	The STM Platform shall subscribe to and implement a data curation process for ATIS data from the CV subsystem on an as needed basis.
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.
6.1.0-166	ST-CTN and CV Publish and Subscribe Testing Coordination - SPaT	The ST-CTN project team shall coordinate CV publish and subscribe testing to verify receipt of existing published CV subsystem SPaT data.
6.1.0-177	ATL RIDES Clean Up ATIS Message	ATL RIDES shall remove from their operational data the ATIS broadcast message when it has expired.
6.1.0-178	STM Clean Up ATIS Message	STM shall remove from their operational data the ATIS broadcast message when it has expired.
6.1.0-179	ST-CTN and CV Publish and Subscribe Testing Coordination - ATIS	The ST-CTN project team shall coordinate CV publish and subscribe testing to verify receipt of existing published CV subsystem ATIS data.
6.1.0-180	ST-CTN and CV Publish and Subscribe Testing Coordination - BSM	The ST-CTN project team shall coordinate CV publish and subscribe testing to verify receipt of existing published CV subsystem BSM 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

The table below describes the non-technical system requirements for lifecycle sustainment.

Table 33. 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 SRT 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 5**, **Figure 6**, **Figure 7**, and **Figure 8**. 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 34** provides system requirement that are necessary in order to support other system requirements and operations. The Requirement IDs listed in **Table 34** are tied to other requirements with similar IDs.

Table 35 provides system requirements that are necessary in order to the ST-CTN system interfaces in general. Requirements for interfaces in **Table 35** are simply required to follow the existing standard as listed.

Table 34. System Specific Interface Requirements

Requirement ID	Requirement Title	Requirement Statement
2.2.0-079	Call Center User Interface	ATL RIDES shall provide UIs (APIs) that support and provide ac6.1.0-131cess 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	Connection Protection APIs	The GCT CAD system shall provide transaction services (APIs) for ATL RIDES to request transit connection protection.
6.1.0-161	MAP Spec	The system developers shall develop an interface control document (ICD) or schema that describes the MAP profile implemented by the CV subsystem.

Requirement ID	Requirement Title	Requirement Statement
6.1.0-162	SPaT Spec	The system developers shall develop an ICD or schema that describes the SPaT profile implemented by the CV subsystem.
6.1.0-168	Signal and RSU Asset Inventory Dataset	The system developers shall develop an ICD or schema that describes the RSU and traffic signal control asset inventory.
6.1.0-169	MaxTime Signal Control Message Set	The system developers shall develop an ICD, Profile Implementation Conformance Statement (PICS) or Management Information Base (MIB) that describes the messages exchanged between the traffic controller and other subsystems. These messages use NTCIP 1202 and 1201 data objects.
6.1.0-170	PED-X Message Spec	The system developers shall develop a PRL or PICS that will be used in the PED-SIG (PED-X) Application that describes adapted NTCIP 1211 message sets. The PRL will describe the data content, message, dialogs and performance requirements for various transactions.

Table 35. 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.
0.0.0-225	Standards Compliance -- NTCIP 1211	See Req 0.0.0-221. NTCIP 1211 v02 – Object Definitions for Signal Control and Prioritization, September 2014, 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.
0.0.0-227	Standards Compliance -- SAE J2735	See Req 0.0.0-221. SAE J2735_202007 – Dedicated Short-Range Communications Message Set Dictionary, July 2020, 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

Requirement ID	Requirement Title	Requirement Statement
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
0.0.0-232	GTFS	See Req 0.0.0-221. GTFS. General Transit Feed Specification Reference. Washington D.C.: GTFS. (2019).
0.0.0-233	GTFS realtime	See Req 0.0.0-221. GTFS Realtime. GTFS Realtime Reference v2. Washington D.C.: GTFS Realtime. (2019)
0.0.0-234	GTFS Flex	See Req 0.0.0-221. GTFS. General Transit Feed Specification Flex Reference. Washington D.C.: GTFS. (2019).
0.0.0-235	GTFS Pathways	See Req 0.0.0-221. GTFS. General Transit Feed Specification Pathway. Washington D.C.: GTFS. (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 36**) 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.

Table 36. Needs-to-Requirements Traceability Matrix

System 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.
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.

System ID/ Requirement ID	System Need/Requirement
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 ATL RIDES 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 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 ATL RIDES for the ST-CTN. OpenTripPlanner 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.
1.1.0-012	ATL RIDES 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 ATL RIDES 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).
1.1.0-014	The system shall not use contact information collected for registration for purposes other than ATL RIDES registration. The data will remain in ATL RIDES 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 4.4.
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-ATL RIDES; ATL RIDES-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 ID/ Requirement ID	System Need/Requirement
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).
1.1.0-013	ATL RIDES 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.
1.2.0-019	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 SRT which will review user stories and drive priority development.
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 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. An initial set of VRU groups may be modelled by mobility mode type:
	• Person walking (no assistive device)
	• Person walking who has mobility limitations
	  ○ Cane, walker, stroller
	• Person walking who is blind or has vision loss
	  ○ Limited vision, white cane
	• Person using standard manual wheelchair
	• Person using electric wheelchair (by wheelchair technology level)
	• Person using mobility scooter
	• School children (different attention span and potentially different impedance factors to keep them safe)
	The impedance values associated with each VRU group shall be configurable.

System ID/ Requirement ID	System Need/Requirement
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 crowdsourced, 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 crowdsourced, work zone, 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 VRU group 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.
1.3.0-033	The STM Platform shall regenerate the impedance values for each VRU group 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, (bike) public and private generated 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.

System ID/ Requirement ID	System Need/Requirement
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. SPaT (or MaxTime), 2. traffic congestion, 3. ATIS, and 4. real time transit information.
1.3.0-037	The Whole Road Network shall use OSM structure as a framework to create the network. 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 ATL RIDES 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.**
1.4.0-039	ATL RIDES 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, ATL RIDES 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	ATL RIDES shall allow travelers to update their trip plan notification selections when actuating a saved trip plan.
1.4.0-042	ATL RIDES 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.

System ID/ Requirement ID	System Need/Requirement
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	ATL RIDES 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, ATL RIDES 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, ATL RIDES 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	ATL RIDES 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.
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 be ported to a scalable, cloud infrastructure during Phase 3.
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).

System ID/ Requirement ID	System Need/Requirement
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.
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.

System ID/ Requirement ID	System Need/Requirement
2.1.0-058	The ATL RIDES 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).
2.1.0-059	The system shall keep time synchronized across subsystem or ensure that each subsystem time measurement can be related to a reference time synchronized to within 100ms. For many of the subsystems, cloud infrastructure time, GPS time, or Network Time Protocol (NTP) for traffic operations are the reference time. The process to relate and synchronize time among the subsystems will be developed during Phase 2 of the ST-CTN project.
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.
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

System ID/ Requirement ID	System Need/Requirement
2.1.1-064	The ATL RIDES 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
2.1.1-065	The CV 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: • SMUG uptime, downtime, recovery, maintenance activity • Operational mode (normal, degraded, failure) status and duration • Number of ST-CTN message requests per day • Number of ST-CTN unique messages per day • Number of ST-CTN connection time-outs • Number of ST-CTN dropped messages
2.1.1-066	ATL RIDES shall monitor ATL RIDES component health and operational status. The specific measures will be identified during Phase 2 of the ST-CTN project.
2.1.1-067	ATL RIDES shall log ATL RIDES component health and operational status. The specific measures will be identified during Phase 2 of the ST-CTN project.

System ID/ Requirement ID	System Need/Requirement
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.
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.
2.1.1-071	The CV subsystem shall log 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	ATL RIDES 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	ATL RIDES 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, crowdsourced obstacles, EVPs, etc.). See Req 2.1.2-076 for related requirement.

System ID/ Requirement ID	System Need/Requirement
2.1.2-076	ATL RIDES 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.**
2.1.3-077	The STM Platform shall publish, at periodic intervals, the Network Impedance API that disseminates updated impedance values based on updated dynamic challenges to travel along the Whole Road Network model. 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	ATL RIDES 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.
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.
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	ATL RIDES 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).

System ID/ Requirement ID	System Need/Requirement
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 ATL RIDES mobile app shall use native SDK and implement the accessibility guidance recommended by the handset and operating system manufacturers.
2.3.0-083	The system shall comply with Web Content Accessibility Guidance (WCAG) 2.1 or higher for all user interfaces (web, mobile 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	ATL RIDES 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	ATL RIDES 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	ATL RIDES 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.

System ID/ Requirement ID	System Need/Requirement
2.5.0-087	ATL RIDES 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	ATL RIDES 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.
2.5.0-089	ATL RIDES 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	ATL RIDES 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 Connection Protection, PED-SIG, 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	ATL RIDES shall update a 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.**

System ID/ Requirement ID	System Need/Requirement
3.1.0-092	The ST-CTN system shall leverage the existing GCT CAD Connection Protection 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 travelers with "connection protection" when requested via their ATL RIDES. 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 (optional); 3. request that the bus wait if the traveler is delayed by less than a few minutes (requires confirmation by operator) The configurations will be developed with stakeholder input during the Agile Development Process.
2.2.0-079	ATL RIDES shall provide UIs (APIs) that support and provide ac6.1.0-131cess 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.
3.1.0-095	ATL RIDES shall generate a connection protection 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 ATL RIDES that the transit operator confirmed receipt of the request for next stop pickup.
3.1.0-097	The GCT CAD shall log connection protection event information including trip identification, time, and location. Other pertinent information will be identified by the GCT and ATL RIDES developers during Phase 2 of the ST-CTN project.

System ID/ Requirement ID	System Need/Requirement
3.1.0-098	ATL RIDES 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 ATL RIDES developer during Phase 2 of the ST-CTN project.
3.1.0-099	For the connection protection request transaction, the system shall minimize latency to within 1 minute from ATL RIDES 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.
3.1.0-102	GCT shall provide paratransit 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.
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.**
3.2.0-105	ATL RIDES shall display a notification to the traveler that the transit vehicle has acknowledged the connection protection request.
3.2.0-106	The ST-CTN project team shall coordinate GCT Connection Protection testing, including elements related to end-to-end timing, security, message processing and management.

System ID/ Requirement ID	System Need/Requirement
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.
3.3.0-108	The system shall enhance the Transit Signal Priority by identifying additional strategies that involve pedestrian priority requests. Strategies include but are not limited to Next Stop Connection Protection during inclement weather and persons who need longer boarding times.
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	ATL RIDES shall generate navigation directions for crossing intersections using the intersection reference, crossing direction, and traveler orientation.
4.1.0-113	ATL RIDES shall process real time MaxTime (signal controller) data to provide status of the walk signal crossing to the traveler. The signal process message shall conform to NTCIP 1202 (and 1201).

System ID/ Requirement ID	System Need/Requirement
4.1.0-114	ATL RIDES shall track the traveler's approach to an intersection crossing from the trace data collected from their ATL RIDES mobile app.
4.1.0-115	ATL RIDES shall estimate the time a user will arrive at the intersection based on their VRU category outlined in Section 2.5.1 accounting for system errors and other factors including communications pathways, time, and positional accuracy.
4.1.0-116	ATL RIDES shall generate a PED-X Priority request message (prgPriorityRequestAbsolute) message (as defined in NTCIP 1211 v02) to alert the signal controller to activate the walk signal when a traveler is within walking distance of the next cycle from the crosswalk.
4.1.0-117	ATL RIDES shall transmit the PED-X Priority Request message with the intersection crossing reference (consistent with the signal controller NTCIP 1202 references) and MaxTime phase. The message will be routed through the SMUG to the referenced intersection.
4.1.0-118	The SMUG shall forward PED-X priority messages received from the ATL RIDES to the specified signal controller.
4.1.0-119	The SMUG shall forward PED-X priority status messages received from traffic signal system to ATL RIDES in response to the PED-X priority messages.
4.1.0-120	The SMUG shall serve as a gateway to exchange messages between ATL RIDES and specific Signal Controllers to authenticate and forward pre-defined message(s) compliant with, at a minimum, SAE J2735 and NTCIP 1211.
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).
4.1.0-122	ATL RIDES shall generate a Priority Request Update message (prgPriorityUpdateAbsolute) (as defined in NTCIP 1211) to alert the signal controller to activate the walk signal when a traveler is within walking distance of the next cycle from the crosswalk.

System ID/ Requirement ID	System Need/Requirement
4.1.0-123	ATL RIDES shall continue to transmit Priority Request Update messages with the crossing reference and signal controller timing phase until ATL RIDES cancels, clears, or times out the request. The cancel or clear message is triggered based on the traveler's travel pattern. The timeout parameter will be specified during Phase 2.
4.1.0-124	ATL RIDES shall generate a PED-X Priority Cancel message (prgPriorityCancel) to the signal controller following a priority request when a traveler deviates from their planned trip based on their trace data. The deviation threshold will be driven by Agile Development Process.
4.1.0-125	ATL RIDES shall transmit a PED-X Priority Cancel message (prgPriorityCancel) to the signal controller. The transmission time and latency thresholds will be defined during Phase 2.
4.1.0-126	ATL RIDES shall generate a PED-X Priority Clear message (prgPriorityClear) to the signal controller following a priority request when ATL RIDES detects that the traveler clears the intersection.
4.1.0-127	ATL RIDES shall transmit a PED-X Priority Clear message (prgPriorityClear) to the signal controller. The transmission time and latency thresholds will be defined during Phase 2.
4.1.0-128	The system shall calculate the end-to-end latency of the message exchange between the Signal Controller and ATL RIDES.
4.1.0-129	The system shall measure the system latency between ATL RIDES and pedestrian signal controller on a periodic basis. The period between analyses will be determined during the design phase.
4.1.0-130	The PED-X Priority Request message shall adapt the prgPriorityRequestAbsolute (from NTCIP 1211) including the desired request information including the identifier of the crosswalk direction and/or crosswalk phase number, the request identifier, time of service requested, the time of estimated departure, and the status of the priority request.
4.1.0-131	The PED-X Priority Update message shall adapt the prgPriorityUpdateAbsolute (from NTCIP 1211) including the desired request information including the identifier of the crosswalk direction and/or crosswalk phase number, the request identifier, time of service requested, the time of estimated departure, and the status of the priority request.

System ID/ Requirement ID	System Need/Requirement
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.
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.**
4.2.0-135	Upon receipt of the PED-X Priority Status message, ATL RIDES 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).**
4.3.0-136	ATL RIDES shall manage, transmit and display on the traveler's mobile app the wait or walk state, and approximate time left to cross. The information will be based on MaxTime cycle times. The calculation of the time left to cross will be developed will be developed during the Agile Development Process in Phase 2 to allow a safety buffer to ensure traveler's safety.
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).
5.1.0-138	The SMUG shall process multiple message transactions simultaneously. The maximum number of simultaneous transactions will be identified during Phase 2 of the ST-CTN project. The quantity used for the pilot may not be the volume required for a fully operational system.

System ID/ Requirement ID	System Need/Requirement
5.1.0-139	SMUG shall include an event recording storage capability which stores ATL RIDES/SMUG transactions, tagged with a time stamp accurate to within a second and synchronized across the system.
5.1.0-140	SMUG shall record every message that flows through SMUG. At a minimum, the log entry will include time received, time transmitted, address of message origin and destination, and message ID.
5.1.0-141	The SMUG shall provide access to the log file by the STM performance measure dashboard to download all or subsets of the SMUG log file.
5.1.0-142	The SMUG shall meet agreed upon security procedure, policies and protocols to authenticate, validate and restrict traffic between ATL RIDES and CV (and downstream signal controllers). The security procedures will be developed during Phase 2 of the ST-CTN project.
CV-SY-5.1.1	**The system needs to identify and communicate traveler presence at 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 has exited the intersection to support pedestrian safety applications.**

System 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 implement a publish and subscribe service that is available to subsystems (STM and ATL RIDES) to subscribe to published interfaces including: 1. BSM, 2. MAP, 3. SPaT, 4. ATIS message data, and 5. MaxTime (for specific signal controllers).

System ID/ Requirement ID	System Need/Requirement
6.1.0-151	The system shall implement the data curation process for crowdsourced data accessed from the ATL RIDES traveler feedback input. Note: The requirement for a curation process for each dataset is described in Section 3.10.1.
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. Note: The requirement for a curation process for each dataset is described in Section 3.10.1.
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.
6.1.0-155	The STM Platform shall subscribe to and implement a data curation process for MAP data from the CV subsystem.
6.1.0-156	The STM Platform shall subscribe to and implement a data curation process for SPaT data from the CV subsystem on a second-by-second basis.
6.1.0-157	ATL RIDES shall subscribe to and implement a data curation process for MaxTime signal controller data from the CV subsystem on an as needed, second by second basis.
6.1.0-158	The STM Platform shall subscribe to and implement a data curation process for MaxTime data from the CV subsystem on a second-by-second basis.
6.1.0-159	ATL RIDES shall subscribe to and implement a data curation process for ATIS data from the CV subsystem on an as needed basis.

System ID/ Requirement ID	System Need/Requirement
6.1.0-160	The STM Platform shall subscribe to and implement a data curation process for ATIS data from the CV subsystem on an as needed basis.
3.1.0-094	The GCT CAD system shall provide transaction services (APIs) for ATL RIDES to request transit connection protection.
6.1.0-161	The system developers shall develop an interface control document (ICD) or schema that describes the MAP profile implemented by the CV subsystem.
6.1.0-163	The CV subsystem shall publish the MAP data for access by the STM Platform and ATL RIDES subsystems.
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.
6.1.0-165	The CV subsystem shall publish the SPaT data for access by the STM Platform and ATL RIDES subsystems.
6.1.0-166	The ST-CTN project team shall coordinate CV publish and subscribe testing to verify receipt of existing published CV subsystem SPaT data.
6.1.0-167	ATL RIDES shall ingest the traffic signal control locations that provide PED-X services into the network used to generate trip itineraries.
6.1.0-162	The system developers shall develop an ICD or schema that describes the SPaT profile implemented by the CV subsystem.
6.1.0-168	The system developers shall develop an ICD or schema that describes the RSU and traffic signal control asset inventory.
6.1.0-169	The system developers shall develop an ICD, Profile Implementation Conformance Statement (PICS) or Management Information Base (MIB) that describes the messages exchanged between the traffic controller and other subsystems. These messages use NTCIP 1202 and 1201 data objects.
6.1.0-171	The STM Platform shall subscribe to the ATIS from the CV Platform.

System ID/ Requirement ID	System Need/Requirement
6.1.0-172	The STM Platform shall ingest (extract, transform, and load) the CV ATIS message as it arrives from the CV Platform.
6.1.0-173	The STM shall use the CV ATIS message as it arrives from the CV Platform. The processing and use of the ATIS message will depend on the content of the message which will be described in the data curation plan as specified by Req 6.1.0-148. The timing from receipt to use will be configurable.
6.1.0-174	ATL RIDES shall subscribe to the ATIS from the CV Platform.
6.1.0-175	The ATL RIDES shall inget (extract, transform, and load) the CV ATIS message as it arrives from the CV Platform.
6.1.0-176	The ATL RIDES shall use the CV ATIS message as it arrives from the CV Platform. The processing and use of the ATIS message will depend on the content of the message which will be described in the data curation plan as specified by Req 6.1.0-148. The timing from receipt to use will be configurable.
6.1.0-177	ATL RIDES shall remove from their operational data the ATIS broadcast message when it has expired.
6.1.0-178	STM shall remove from their operational data the ATIS broadcast message when it has expired.
6.1.0-179	The ST-CTN project team shall coordinate CV publish and subscribe testing to verify receipt of existing published CV subsystem ATIS data.
6.1.0-180	The ST-CTN project team shall coordinate CV publish and subscribe testing to verify receipt of existing published CV subsystem BSM 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	ATL RIDES 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 ID/ Requirement ID	System Need/Requirement
6.2.0-182	ATL RIDES 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	ATL RIDES 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.
6.2.0-184	ATL RIDES 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 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 system shall provide access to the beacon asset inventory to authorized users including ATL RIDES, STM, building owners, and other third parties.
6.2.0-188	ATL RIDES 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 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 shall include an SDK to interface with iOS and Android to receive and resolve message content.
6.2.0-197	The beacon 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.
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	ATL RIDES 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 ID/ Requirement ID	System Need/Requirement
7.1.0-200	ATL RIDES 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, Next Bus 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 ATL RIDES 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.
7.1.0-202	ATL RIDES shall allow account holders to view completed trips.
7.1.0-203	ATL RIDES shall allow account holders to print completed trips.

System ID/ Requirement ID	System Need/Requirement
7.1.0-204	ATL RIDES 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
RP-SY-7.2	**The system needs to collect user input (using crowdsourcing methods) about disruptions and obstructions to their travel during or after their travel.**
7.2.0-205	The STM Platform shall provide the Asset Condition API (based on the Sidewalk Scout API structure) which ATL RIDES will use to collect and transmit traveler feedback on disruptions and obstacles to their travel. The content of the API parameters will be driven by stakeholder input during the Agile Development Process.
7.2.0-206	ATL RIDES shall provide a traveler feedback form in which travelers can report on impediments of travel. Impediments include obstacles and sidewalk conditions. The form (collecting data for the Asset Condition API) will, at a minimum, implement the STM Sidewalk Scout API content.
7.2.0-207	ATL RIDES 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.

System ID/ Requirement ID	System Need/Requirement
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
7.3.0-209	ATL RIDES shall publish 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 ID/ Requirement ID	System Need/Requirement
7.3.0-210	The STM subsystem shall ingest message logs from the SMUG which includes PED-X application transactions on a daily basis at a minimum.
7.3.0-211	The STM Platform shall ingest the ATL RIDES 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.
7.3.0-216	The STM Platform shall ingest GCT paratransit ridership data as available from GCT.
7.3.0-217	The STM Platform shall ingest GCT GTFS data feeds as the updated files are published.
7.3.0-218	The STM Platform shall ingest GCT GTFS-RT data feeds as published.
7.3.0-219	The STM performance measurement dashboard 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).
FT-SY-8.1	**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.**

System ID/ Requirement ID	System Need/Requirement
FT-SY-8.1.1	**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
6.1.0-170	The system developers shall develop a PRL or PICS that will be used in the PED-SIG (PED-X) Application that describes adapted NTCIP 1211 message sets. The PRL will describe the data content, message, dialogs and performance requirements for various transactions.
0.0.0-222	See Req 0.0.0-221. NTCIP 1103 v03 – Transportation Management Protocols, December 2016, AASHTO/ITE/NEMA.
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.
0.0.0-225	See Req 0.0.0-221. NTCIP 1211 v02 – Object Definitions for Signal Control and Prioritization, September 2014, 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.
0.0.0-227	See Req 0.0.0-221. SAE J2735_202007 – Dedicated Short-Range Communications Message Set Dictionary, July 2020, SAE International.

System ID/ Requirement ID	System Need/Requirement
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. (2019).
0.0.0-233	See Req 0.0.0-221. GTFS Realtime. GTFS Realtime Reference v2. Washington D.C.: GTFS Realtime. (2019)
0.0.0-234	See Req 0.0.0-221. GTFS. General Transit Feed Specification Flex Reference. Washington D.C.: GTFS. (2019).
0.0.0-235	See Req 0.0.0-221. GTFS. General Transit Feed Specification Pathway. Washington D.C.: GTFS. (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. Agile Roadmap for ATL RIDES

The system requirements documented in this SyRS will be mapped to the Agile Roadmap. The core requirements for the ATL RIDES will form the minimum viable product (MVP) which will be deployed early in Phase 2. In turn the high-level requirements described in this document will be expanded and prioritized by stakeholder preferences and priorities. A series of epics will follow during Phases 2 and 3 as other data, interfaces, and functions are rolled out and detailed stakeholder input is incorporated. A mapping of the requirements to approximate timing (MVP-, short-, medium-, and long-term epics), and dependencies are listed in **Table 37** below.

The table columns include the following:

Requirement ID – references the requirement identifier

Requirement Title – references the title of the requirement

MVP – check mark indicates that the requirement is included in the MVP

Agile Roadmap Epic – if the function is not in the MVP, then it will be included in an epic that will occur in the:

- short term (6-12 months)
- medium term (12-24 months)
- long term (18-36 months)

Dependencies – identifies any dependent functions, datasets, or interfaces that need to be in place or coordinated with other subsystems or external entities.

This is a preliminary estimate that will be managed during Phases 2 and 3.

Table 37. Agile Roadmap for ATL RIDES

Req ID	Req Title	MVP	Agile Roadmap Epic	Dependencies
1.1.0-012	Opt-in to Store and Use PII		Medium	STM data management systems must have capability in place to store and remove PII

Req ID	Req Title	MVP	Agile Roadmap Epic	Dependencies
1.1.0-013	Opt-out After Opt-in Option		Short	STM data management systems must have capability in place to store and remove PII
1.1.0-014	Account Contact Information	X		
1.2.0-018	ATL RIDES Core Functionality	X		
1.2.0-018	Account Functions	See List Below		
1.2.0-018-01	Account Function (01) Load Mobile App	X		
1.2.0-018-01	Account Function (02) Register Account	X		
1.2.0-018-01	Account Function (03) Contact Information	X		
1.2.0-018-01	Account Function (04) Set Preferences	X		
1.2.0-018-01	Account Function (05) Review Trip Histories	X		
1.2.0-018-01	Account Function (06) Opt-in / Opt-out Tracking		Short	Add dynamic rerouting functionality

Req ID	Req Title	MVP	Agile Roadmap Epic	Dependencies
1.2.0-018-01	Account Function (07) Link to 3rd Party		Medium	
1.2.0-018-01	Account Function (08) Grant Access to Trusted Party		Medium	
1.2.0-018-02	Begins Trip	See List Below		
1.2.0-018-02	Begin Trip (01) Verify Communications			When communications with beacons are integrated
1.2.0-018-02	Begin Trip (02) Load Trip on Mobile App	X		
1.2.0-018-02	Begin Trip (03) Activate Trip	X		
1.2.0-018-02	Begin Trip (04) Receive Updates	X		
1.2.0-018-03	Traveler Trip Planning	See List Below		
1.2.0-018-03	Traveler Trip Planning (01) Select Trip / Preferences	X		
1.2.0-018-03	Traveler Trip Planning (02) Confirm Trip and Preferences	X		

Req ID	Req Title	MVP	Agile Roadmap Epic	Dependencies
1.2.0-018-03	Traveler Trip Planning (03) Simulate Trip and Update Preferences	X		
1.2.0-018-03	Traveler Trip Planning (04) Save Trip	X		
1.2.0-022	Support Service Options		Medium	
1.2.0-023	Trip Planning Communication Channel Options		Short	
1.2.0-024	Trip Execution Communication Channel Options		Short	
1.2.0-025	Service Preferences and Communication Channel Matching		Short	
1.4.0-039	Notification and UI Method		Medium	Add navigation directions and support for voice / haptic/ vibration
1.4.0-040	Selection of Notification by UI Method	X		
1.4.0-041	Update Selection of Notification by UI Method	X		

Req ID	Req Title	MVP	Agile Roadmap Epic	Dependencies
1.5.0-043	Trip Planning - Traveler Companion		Medium	
1.5.0-044	Trip Planning – Group Travel Preference Confirmation		Medium	
1.6.0-045	Trip Planning - Practice Mode		Medium	Dynamic rerouting functionality
2.1.1-066	ATL RIDES Subsystem	X		
2.1.1-067	ATL RIDES Subsystem Self Logging	X		
2.1.1-072	ATL RIDES Subsystem Self-Monitoring Transmission		Short	
2.1.2-075	Continuous Trip Planning		Long	Ability to receive crowdsourced data on obstacles / conditions
2.1.2-076	Network Impedance API Ingestion		Long	Ingest data from STM API / other sources
2.2.0-078	ATL RIDES Mobile and Web Applications	X		
2.2.0-079	Call Center User Interface		Short	
2.3.0-080	Common Communications		Short	

Req ID	Req Title	MVP	Agile Roadmap Epic	Dependencies
2.3.0-082	Native Software Development Kit (SDK)	X		
2.3.0-083	WCAG 2.1 or Higher	X		
2.4.0-084	Notification Types		Medium	
2.4.0-085	Notification Channels		Short	
2.5.0-086	Traveler's Trusted Support		Medium	
2.5.0-087	Role Based Access by Trusted Person		Medium	
2.5.0-088	Track Travelers for Trusted Support		Medium	
2.5.0-089	Help Call Number		Short	
2.6.0-090	Automated Activation Messages		Long	
2.6.0-091	Automated Rerouting		Medium	
3.1.0-095	Connection Protection Trigger		Short	
3.1.0-098	Connection Protection Request Performance		Medium	

Req ID	Req Title	MVP	Agile Roadmap Epic	Dependencies
3.2.0-105	Confirm Connection Protection		Short	
4.1.0-112	Identify Intersection and Crossing		Long	
4.1.0-113	Process Signal Controller PED-X Status		Short	
4.1.0-114	Track Traveler Location		Medium	
4.1.0-115	Estimate Time to Send PED-X Request (for intersection crossing)		Short	
4.1.0-116	Generate PED-X Priority Request Message		Medium	
4.1.0-117	Transmit PED-X Priority Request Message		Medium	
4.1.0-122	Generate PED-X Request Update Message		Medium	
4.1.0-123	Transmit PED-X Request Update Message		Short	
4.1.0-124	Generate PED-X Priority Cancel		Short	

Req ID	Req Title	MVP	Agile Roadmap Epic	Dependencies
4.1.0-125	Transmit PED-X Priority Cancel		Short	
4.1.0-126	Generate PED-X Priority Clear		Short	
4.1.0-127	Transmit PED-X Priority Clear		Short	
4.2.0-135	Traveler Notification of PED-X Request Receipt		Short	
4.3.0-136	Walk / Do Not Walk Display to Traveler		Medium	
5.1.2-145	ST-CTN and CV Applications Testing Coordination - PED-SIG		Medium	
6.1.0-157	ATL RIDES Manage MaxTime Data		Medium	
6.1.0-159	ATL RIDES Manage ATIS Data		Medium	
6.1.0-167	ATL RIDES - RSU Locations (at signalized intersections)		Short	
6.1.0-174	Subscribe to CV ATIS Message by ATL RIDES		Short	

Req ID	Req Title	MVP	Agile Roadmap Epic	Dependencies
6.1.0-175	Ingest CV ATIS Message by ATL RIDES		Short	
6.1.0-176	Use CV ATIS Message by ATL RIDES		Short	
6.1.0-177	ATL RIDES Clean Up ATIS Message		Short	
6.2.0-181	Beacons Pairing		Short	
6.2.0-182	Indoor Navigation Using Beacons		Medium	
6.2.0-183	Indoor Tracking Using Beacons		Medium	
6.2.0-184	Indoor Navigation		Short	
6.2.0-188	Acquire Beacon Asset Inventory		Long	
7.1.0-199	Store Planned Trip Histories		Long	
7.1.0-200	Store Actual Trip Histories		Long	
7.1.0-201	Traveler Trip Tracking Data		Medium	
7.1.0-202	View Completed Trips		Short	
7.1.0-203	Print Completed Trips		Short	

Req ID	Req Title	MVP	Agile Roadmap Epic	Dependencies
7.1.0-204	Generate Travel Statistics		Medium	
7.2.0-206	Traveler Impact Form			Integration into STM
7.2.0-207	Trip Feedback Reports		Short	
7.3.0-209	Publish Travel Statistics		Medium	

Appendix C. 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 D. 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 E. References

Documents referenced during the development of the SyRS are provided below.

Table 38. Referenced Documents

ID	Referenced Documents
[CVTMP]	AECOM. "Gwinnett County Connected Vehicle Technology Master Plan (CVTMP)." Duluth: Gwinnett County Department of Transportation. (2019).
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[NS]	Atlanta Regional Commission. Deliverable Task 2.2 Needs Summary. Atlanta: U.S Department of Transportation. (2021).
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ID	Referenced Documents
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[GTFS]	GTFS. General Transit Feed Specification Reference. Washington D.C.: GTFS. (2019).
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[CI]	ICF, Wyoming Department of Transportation. Connected Intersection - Concept of Operations. Cheyenne: USDOT (2018).
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[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.
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