# Phase 1 Concept of Operations (ConOps)

## Atlanta Regional Commission ITS4US Deployment Project

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COMPLETE TRIP
ITS4US

U.S. Department of Transportation

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## Notice

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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 Concept of Operations (ConOps) for the deployment project. This ConOps is the initial step in the systems engineering process whose goal is to lay the groundwork for a successful deployment of the ST-CTN project. The ConOps helps build consensus among stakeholders regarding project components, roles and responsibilities, and operations. The ConOps provides a foundation for more detailed analyses that will follow.


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# 1. Scope

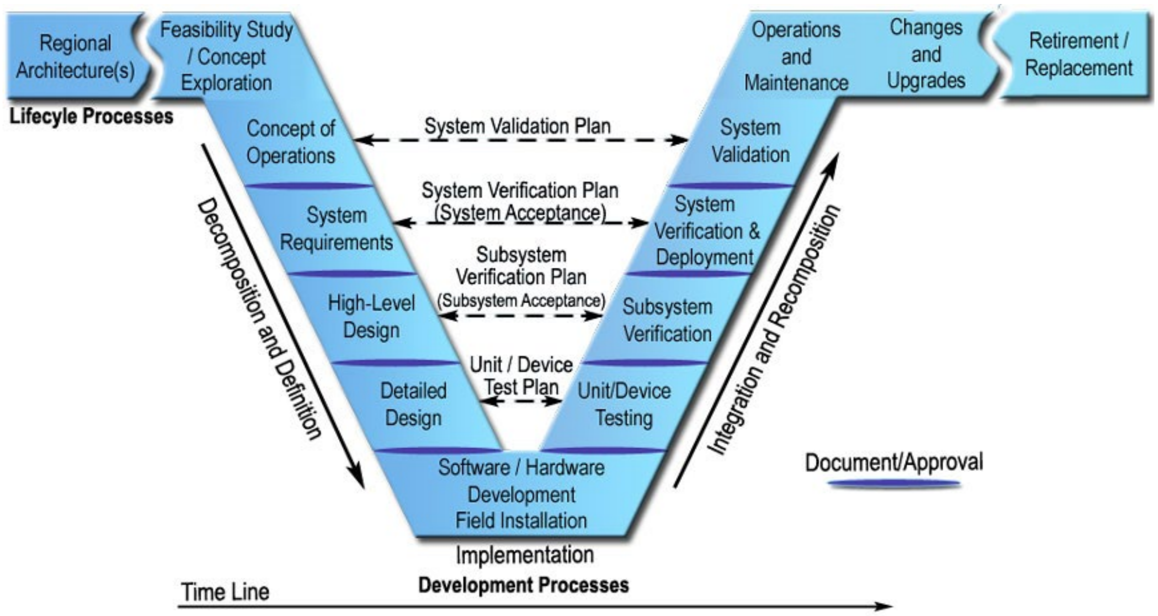
This document serves as the Concept of Operations (ConOps) for the Safe Trips in a Connected Transportation Network (ST-CTN) project led by Atlanta Regional Commission (ARC) in Gwinnett County, Georgia as part of U.S. Department of Transportation's (USDOT's) Complete Trip – ITS4US Deployment Program. 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.

This ConOps is the initial step in the systems engineering process whose goal is to lay the groundwork for a successful deployment of the ST-CTN project. The ConOps helps build consensus among stakeholders regarding project components, roles and responsibilities, and operations. This helps minimize risks of conflict or change later in the project development process. The ConOps provides a foundation for more detailed analyses that will follow. Key objectives of the ConOps include:

- Identification of user needs and system capabilities in terms that all project stakeholders can understand
- Stakeholder agreement on interrelationships and roles and responsibilities for the system
- Shared understanding by system owners, operators, maintainers, and developers of how the system will operate under different scenarios
- Agreement on key performance measures and a basic plan for how the system will be validated at the end of project development

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.

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 this ConOps will serve as the basis for requirements and design later in the process. Other components of the ST-CTN project will follow an agile development process where requirements and solutions evolve through collaboration between self-organizing cross-functional teams. For agile projects, needs and desired capabilities developed in the ConOps will ultimately drive subsystem's user story roadmaps for developers implementing an agile development process.




*Source: FHWA*

**Figure 1. The "Vee" Systems Engineering Process**

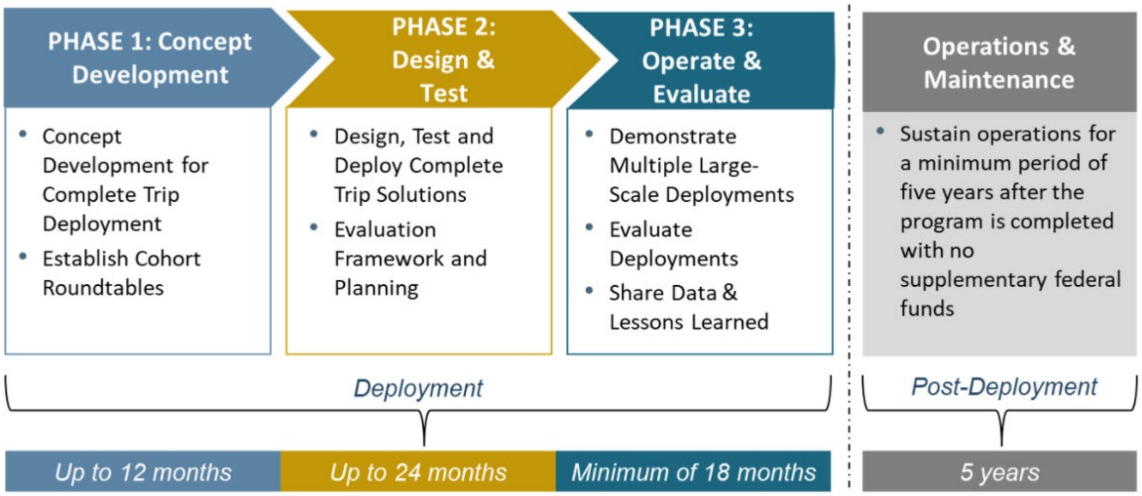
## 1.1 Project Background

The Complete Trip - ITS4US Deployment Program is a multimodal effort – led by the Intelligent Transportation Systems (ITS) Joint Program Office (JPO) – and supported by the Office of the Secretary (OST), Federal Highway Administration (FHWA), and Federal Transit Administration (FTA) – to identify ways to provide more efficient, affordable, and accessible transportation options for underserved communities that often face greater challenges in accessing essential services. The program aims to solve mobility challenges for all travelers with a specific focus on underserved communities, including people with physical or cognitive disabilities, older adults, low-income individuals, and LEP travelers. This program seeks to enable communities to build local partnerships, develop and deploy integrated and replicable mobility solutions to achieve complete trips for all travelers.

The Complete Trip – ITS4US Deployment Program will be executed in three phases. As depicted in **Figure 2**, deployment sites are expected to go through three phases:

- **Phase 1.** Concept Development
- **Phase 2.** Design and Testing
- **Phase 3.** Operations and Evaluation

Post deployment, sites are expected to sustain operations for a minimum period of five years without supplementary federal funds.




*Source: USDOT*

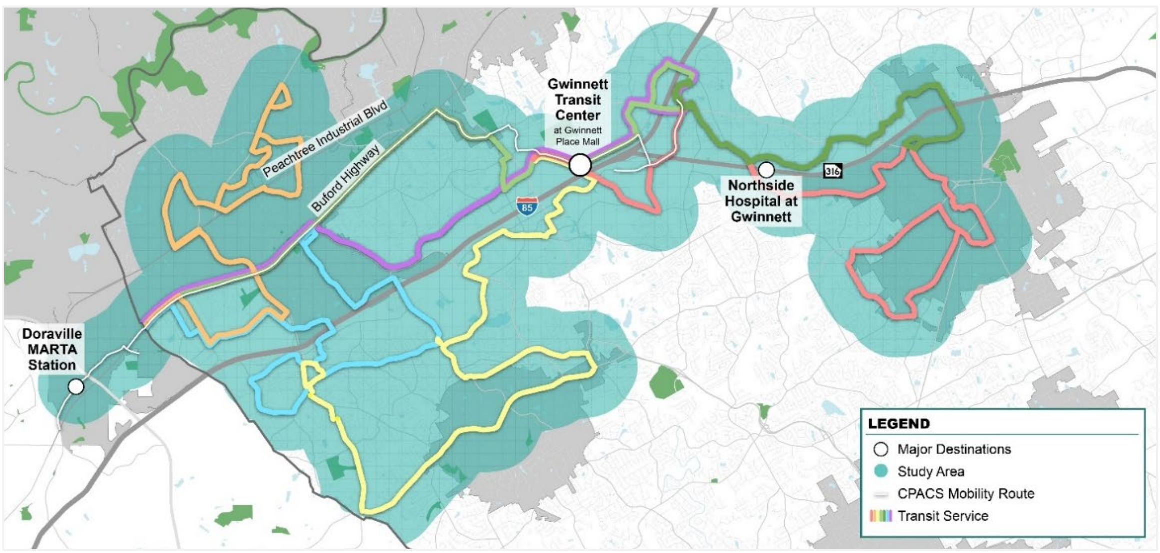
**Figure 2. Phases of the Complete Trip – ITS4US Deployment Program**

ARC was selected by USDOT as one of the Phase 1 projects to showcase innovative business partnerships, technologies, and practices that promote independent mobility for all travelers regardless of location, income, or disability. The project team intends to address multiple aspects of the Complete Trip by integrating multiple technological innovations. The ST-CTN system will integrate CV data with an open-sourced web-based and mobile application. The application will provide users with the ability to create a personalized trip plan with information regarding the navigation of physical infrastructure, the ability to resolve unexpected obstacles, and ensure users visibility throughout the trip. The proposed deployment will provide targeted users with the ability to dynamically plan and navigate trips. Underserved communities of interest include:

- **People with Physical Disabilities.** People with physical disabilities are limited in independent, purposeful physical movement of the body, or one or more extremities, and are substantially limited in one or more major life activity.
- **People with Cognitive Disabilities.** People with cognitive disabilities have a condition that makes it more difficult 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 Adults.** Aging adults may have trouble performing specific tasks within a set time period (e.g., crossing a road or boarding a transit vehicle), standing for an extended period of time, or may be more sensitive to weather conditions. 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.
- **Limited English Proficiency (LEP) Communities.** A person with LEP refers to a person who is not fluent in the English language. Users who have LEP may have trouble understanding directions and alerts when delivered in their non-native language, may have different cultural norms that make it difficult to follow directions others would feel are standard, or may have difficulty understanding wayfinding signs.
- **Low Income Communities.** Users 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 (e.g., 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.

The ST-CTN project will be implemented in Gwinnett County. The project area is home to a significant portion of the underserved communities that reside in Gwinnett County. Over 50% of the disabled population, LEP population, and zero vehicle household population in Gwinnett County is located within the project area. Approximately 50% of the low-income population and approximately 25% of the older adult population in Gwinnett County is located within the project area. It also faces many of the same challenges as much of Metro Atlanta, including suburban land-uses; wide, high-speed roadways; and inconsistent pedestrian infrastructure. This area also was chosen to leverage its implementation readiness and the planning work recently completed at the County level on CVs, as well as transit needs and expansion. A map of the project area can be found in **Figure 3**.




*Source: ARC*

**Figure 3. ST-CTN Deployment Site Map**

## 1.2 Acronyms and Glossary

A list of acronyms can be found in **Appendix A** and the glossary of terms is provided in **Appendix B**.

## 1.3 Document Overview

This ConOps document is based on the ConOps template provided by the USDOT for the ITS4US-Complete Trip program and adapted from the Institute of Electrical and Electronic Engineers (IEEE) Guide for information Technology – System Definition – Concept of Operations (ConOps Document, IEEE Standard 1362, 1998). The remainder of this document consists of the following sections and content:

- **Section 2** (Referenced Documents) identifies external documents referenced throughout the ConOps document.
- **Section 3** (Current System and Situation) describes the existing system from the standpoint of the project stakeholders.
- **Section 4** (Justification for and Nature of Changes) describes the shortcomings of the current system from the standpoint of the project stakeholders. It also provides the user needs – or desired capabilities – for the proposed system.
- **Section 5** (Concepts for the Proposed System) describes the proposed system and subsystem functionality required to meet the user needs identified in **Section 4**. This section also describes the key features, the users, and their interaction with the system.
- **Section 6** (Operational Scenarios) documents the user-oriented use cases for how the proposed system should operate.
- **Section 7** (Summary of Impacts) describes the operational and organizational impacts of the new system on the users, developers, maintainers, and other agencies or organization involved with the ST-CTN system.
- **Section 8** (Analysis of the Proposed Systems) provides an analysis of the benefits, limitations, advantages, disadvantages, and alternatives considered for the proposed system.

## 1.4 Sponsors, Project Team, and Intended Audience

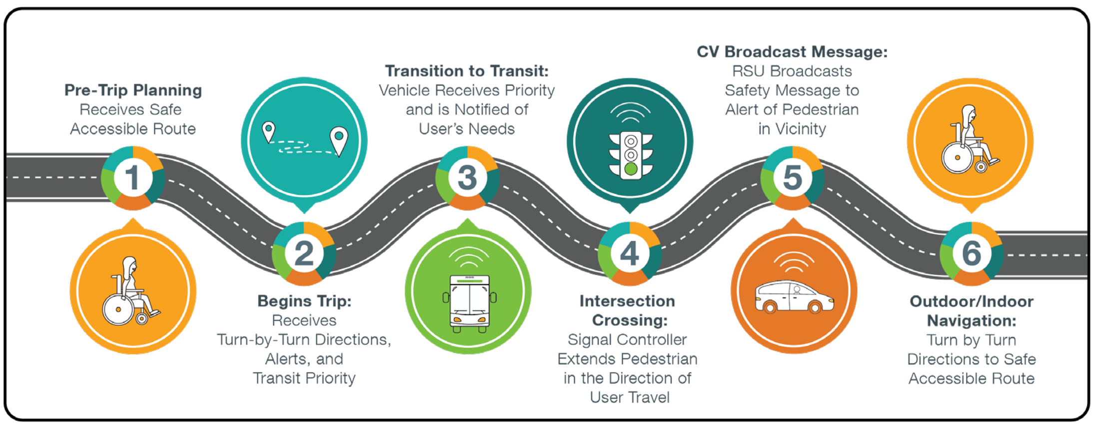
The ST-CTN project is being led by ARC in Gwinnett County, GA. The project team intends to address multiple aspects of the Complete Trip through the development of the ST-CTN concept. The ST-CTN project team includes the following partners and their respective roles on the project:

- **ARC.** Project management, concept development, and concept collaboration lead
- **Gwinnett County Department of Transportation (GCDOT).** System development and local agency deployment lead
- **Gwinnett County Transit (GCT).** System development and local agency deployment lead
- **Atlanta-Region Transit Link Authority (ATL).** Atlanta-Region Rider Information and Data Evaluation System (ATL RIDES) integration lead
- **Statewide Independent Living Council of Georgia (SILCGA).** Community coordinator lead
- **Georgia Department of Transportation (GDOT).** CV integration lead
- **Georgia Institute of Technology (GA Tech).** Technical innovation lead
- **GO Systems and Solutions (GOSystems).** System development lead
- **IBI Group.** ATL RIDES system and mobility app development lead
- **Kimley-Horn and Associates, Inc. (KHA).** Concept development and production management leads

The intended audience of this ConOps includes the stakeholders who will use, develop, and manage the software and infrastructure that will be deployed as a part of the ST-CTN system. These stakeholders include: underserved communities within the program limits, GCDOT personnel involved with transportation systems management and operations and CV systems, GCT personnel involved with fleet management and operations, GDOT personnel involved with transportation systems management and operations and CV systems, and the ATL personnel involved with the ATL RIDES system. Additionally, USDOT personnel and future deployment teams will find this document useful for developing assessment documents and understanding the context of the ST-CTN system.

## 1.5 System Overview

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*

**Figure 4. Traveler's Complete Trip**

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

- **Step 1 Pre-Trip Planning.** The traveler plans for and receives a safe accessible route.
  - The ability to customize trip preferences based on the user's abilities.

- **Step 2 Begins Trip.** The traveler begins their trip and receives turn by turn directions, alerts, remote pedestrian activation, and can trigger TSP if the user requires additional time boarding or alighting a transit vehicle, is unable to stand for long periods, or is sensitive to weather conditions.
  - Turn by turn, shortest path, directions along pathways that meet user defined preferences.

    - Provides support services for users if they become disoriented or have issues accessing defined paths.
    - Activates TSP for buses if the user requires additional time boarding or alighting a transit vehicle, is unable to stand for long periods, or is sensitive to weather conditions.

- **Step 3 Transition to Transit.** The traveler transitions to transit and the transit vehicle receives priority and is notified of users' needs. TSP can be triggered if the bus is running behind schedule due to a longer boarding time needed by a user.
    - Provides users with transit trips that have accommodations that meet user defined preferences.
    - Sends alerts to transit vehicles when users need additional time to board, navigate internally, or alight the transit vehicle.
    - Remotely requests service from transit vehicles while waiting to board or alight.
    - Triggers TSP if the bus is running behind schedule due to a user needing additional time to board or alight.

- **Step 4 Intersection Crossing.** When crossing a signalized intersection, the traveler interacts with the signal controller 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 connected vehicles 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.

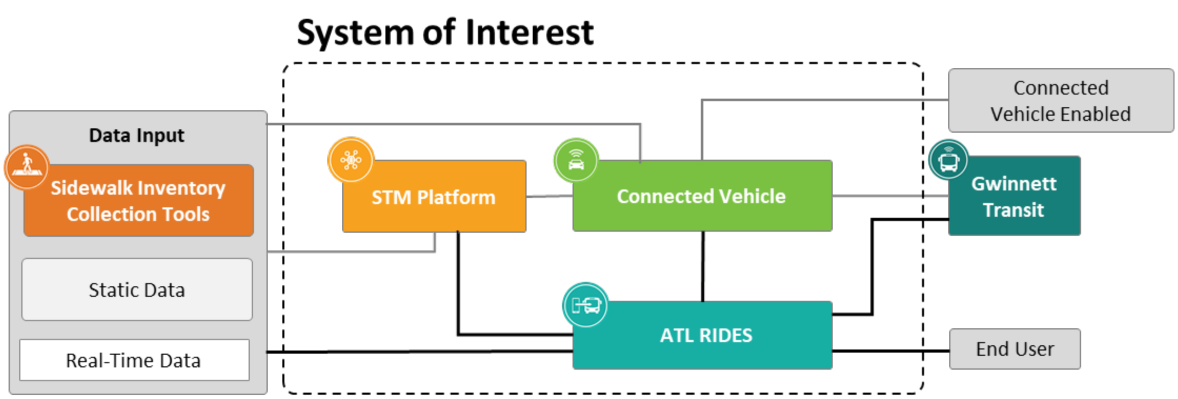
- **Step 6 Outdoor/Indoor Navigation.** The traveler is provided with turn-by-turn directions to a safe accessible route.
    - Hands-free navigation via mobile apps and/or wearables and accessible channels (haptic, voice, text).
    - Alerts and dynamic rerouting in response to changes in path conditions.
    - 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 open source software (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.

The conceptual diagram presented in **Figure 5** illustrates the concept, including the software, hardware, communications, and services planned for ST-CTN as shown.

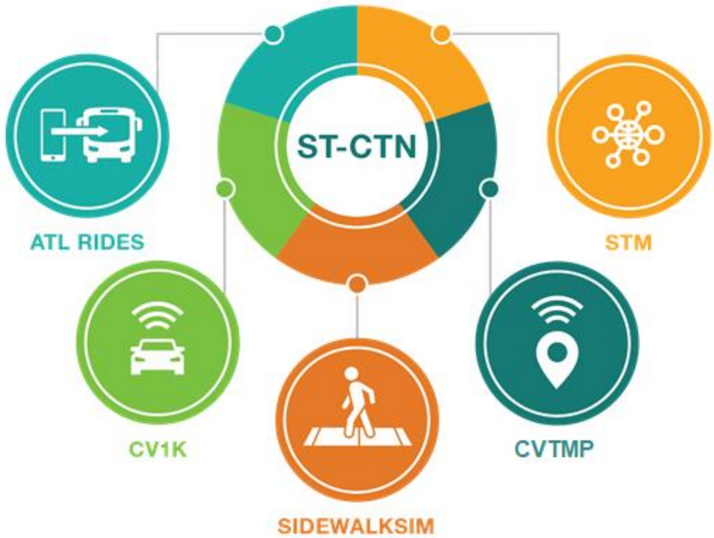



*Source: ARC*

**Figure 5. ST-CTN High-Level Context Diagram**

The scope of the project is limited to development of interfaces between existing programs that expand the capabilities of these programs. The existing initiatives that are being leveraged to support the proposed ST-CTN system are shown in **Figure 6** and defined in more detail below.

These icons and colors are used throughout the ConOps document to clearly identify the critical components of ST-CTN.




*Source: ARC*

**Figure 6. ST-CTN Integrated Initiatives**

**ATL RIDES.** ATL RIDES includes an 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 integrated 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 Disability 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 TSP in Gwinnett County.

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

In some cases, partner agencies are upgrading the services within their current systems to create a more robust data set or toolset for the ST-CTN program; details on these upgrades and changes are discussed further in **Section 5**.

# 2. Referenced Documents

**Table 1** lists the documents that were used to support the development of the ST-CTN ConOps document. References to these documents are identified with the acronym provided in brackets.

**Table 1. Referenced Documents**

| ID | Referenced Documents |
| --- | --- |
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*Source: ARC*

# 3. Current System and Situation

This section describes the multimodal transportation network within the project study area as it currently exists and highlights the problems and challenges that motivated the development of the proposed system. It defines how the region currently operates regarding transportation for underserved communities and the stakeholders, systems, and other components that are currently in place.

## 3.1 Background and Scope

Access to a robust multimodal transportation system is crucial to providing equitable access for all communities within the Metro Atlanta region and around the United States. Housing, employment, education, and healthcare choices are all dictated by access to a transportation system that allows users to make complete trips [ICS]. A complete trip is defined by an individual's ability to go from origin to destination reliably, spontaneously, confidently, independently, safely, and efficiently without gaps in the travel chain regardless of location, income, or disability [BAA]. Stakeholders, particularly those within underserved communities, need more traveler information and support to complete their trips safely, reliably, and efficiently.

### 3.1.1 Project Study Area

The project study area is an example of a transportation network that needs to provide complete trips for its population. Even though the project study area only contains 30% of Gwinnett County's total population, it contains over 50% of the population of people with disabilities, over 50% of LEP households, over 50% of zero-vehicle households, and nearly 50% of households that classify as low income [ACS].

The population in Gwinnett County has grown by over 16% between 2010 and 2019 estimates, outpacing surrounding counties including DeKalb County and Fulton County which had a growth rate over the same period of 9.7% and 15.6% respectively [QF]. According to the Gwinnett County's Destination 2040 Comprehensive Transportation Plan (CTP), the majority of the population growth is occurring within the ST-CTN project study area [GCTP-2].

The mean travel time to work for Gwinnett County between the years of 2015 and 2019 is 34.1 minutes. This is higher compared to its neighboring counties where the mean travel time to work in DeKalb and Fulton Counties are 32.3 minutes and 28.8 minutes, respectively. Several major roadways cut through the project area, including Buford Highway, Peachtree Industrial Boulevard, and Interstate 85 (I-85). Buford Highway is a well-known destination in the region for having the city's largest collection of authentic ethnic restaurants, a source of pride in its community. However, Buford Highway is notoriously dangerous for pedestrians [DW]. Peachtree Industrial Boulevard is also a major roadway through the project area, handling significant amounts of commuter travel and freight traffic volumes. I-85 bisects the project area, creating a boundary that interrupts accessibility between communities. As of this submittal Gwinnett County has not completed an ADA Transition Plan. Inventory of sidewalks within the project limits is not published.

A robust transit system exists in the project study area including GCT fixed route and on-demand paratransit service and Center for Pan Asian Community Services (CPACS) mobility on-demand service. Major destinations connected to the area's bus service include, Northside Hospital at Gwinnett, Sugarloaf Mills Shopping Center, the Gwinnett Place Mall, the Gwinnett Justice and Administration Center, the Gwinnett Civic Center and Arena, and HomeFirst Gwinnett Initiative, a nonprofit addressing homelessness in Gwinnett County. There are several important transit connections and transfer points within the project area. Metropolitan Atlanta Regional Transit Authority's (MARTA) Doraville Station provides a crucial connection between GCT and MARTA rail destinations, which includes direct service to the airport and downtown Atlanta. Gwinnett County Transit Center also is a major transfer point between GCT transit lines and CPACS mobility on-demand transit services.

The project study area is based on the GCT on-demand paratransit service area which is provided within ¾ mile on either side of the existing fixed route system. This encompasses seven fixed route lines with connections to MARTA heavy rail. CPACS-Mobility is an on-demand bus service that operates within Gwinnett County and offers expanded transportation services to immigrant and refugee LEP seniors above 65 years old, disabled persons 19 and older, and transportation disadvantaged users [CPACS]. The goal of CPACS-Mobility is to increase access to transportation for refugees, immigrant seniors, and disabled persons providing quality of life trips such as shopping, recreation, religious, civic, and for social purposes. CPACS-Mobility buses also provide late-night, weekend, shuttle, demand-responsive van, and ridesharing/carpool/vanpool services.

### 3.1.2 Objectives

One of the main goals for ARC and the region, as stated in The Atlanta Region's Plan Policy Framework, is to ensure a comprehensive transportation network, incorporating regional transit and 21st century technology. ARC has identified many means to achieve this goal including promoting an accessible and equitable transportation system and fostering the application of advanced technologies to the transportation system. Many areas in the Atlanta region have infrastructure and land use challenges that make getting to transit difficult and reduce access to jobs and services. It is vital to maintain and expand the comprehensive transportation system to ensure equal access for everyone. Technology has already changed the way residents live and travel in the Atlanta region. New technologies can provide travelers with real-time data to inform decisions and will continue to shape the way residents and goods move in the future. The Atlanta Region supports the development and further application of existing technologies, such as user friendly, accessible smart phone apps, to improve the travel experience.

Many agencies and advocates are already working toward these goals in ways that ST-CTN will be able to leverage. The Atlanta region is home to one of the largest CV deployments in the United States – CV1K. CV1K program's aim is to increase safety by deploying interoperable CV technologies at signalized intersections throughout the Atlanta region. The program provides support to configure, operate, and maintain CV infrastructure and applications, including TSP. Gwinnett County is the largest recipient of the first phase of CV1K in keeping with the priorities stated in the CVTMP [CVTMP]. The CVTMP's goals are 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 set the standard for implementing CVs.

Among the high priorities identified is establishing a mobile accessible safety program and alternative strategies for TSP in Gwinnett County.

ATL is currently in development of ATL RIDES. The system is a multi-modal trip planner and mobile application with integrated mobile fare payment options and a Connected Data Platform (CDP) using regional GTFS feeds. The goal of this project is to give all travelers easier access to consolidated transit information, making it easier to use transit. The tool supports multi-agency context, multilingual support, and live-tracking capabilities using GTFS feeds. The OTP architecture facilitates integration with additional OSS tools including a data analytics engine, call center/IVR, and account management system.

GA Tech researchers have created an asset management system and shortest path routing tool for pedestrian pathways, SidewalkSim. Site inspections provide more detailed 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 any user-specified needs. Also, part of GA Tech's research is a python platform, STM, which 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. The STM output allows routing decisions to incorporate travel time, safety, and other impedance values into path selection. Both of these tools have been created to give all travelers better access to accurate data when they plan their trip.

### 3.1.3 Scope

The current systems relevant to the ST-CTN project regarding transportation for underserved communities are comprised of disparate systems, projects, and initiatives, including ATL RIDES, STM Platform, Sidewalk Inventory Collection Tools, GC and GDOT CV Program, and GCT. These systems each serve their current stakeholders within the scope of their respective systems.

- **ATL RIDES.** This effort supports multimodal trip planning for regional travelers, but has limited features to support the underserved communities that are the focus of the ST-CTN project.

- **STM Platform.** This research-grade model is used to predict trajectories through the regional network 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.

- **Sidewalk Inventory Collection Tools.** These tools are used to inventory pedestrian facilities and the current asset characteristics, including accessibility and obstruction features. Gwinnett County data does not currently exist.

- **GC and GDOT CV Program.** This initiative provides CV infrastructure to support the future development and testing of CV applications, original equipment manufacturers (OEM), and third parties. Gwinnett County existing applications under development include emergency vehicle preemption (EVP) and TSP.

- **GCT.** GCT currently provides commuter, local, and on-demand transit service to all, including the underserved community, within the GCT service area.

## 3.2 Description of the Current System and Situation

The following sections provide an overview of the current systems relevant to the ST-CTN project and their respective current operational environments; capabilities, functions, and features; major system components; inputs, outputs, and data flows; performance characteristics; and system schedules.

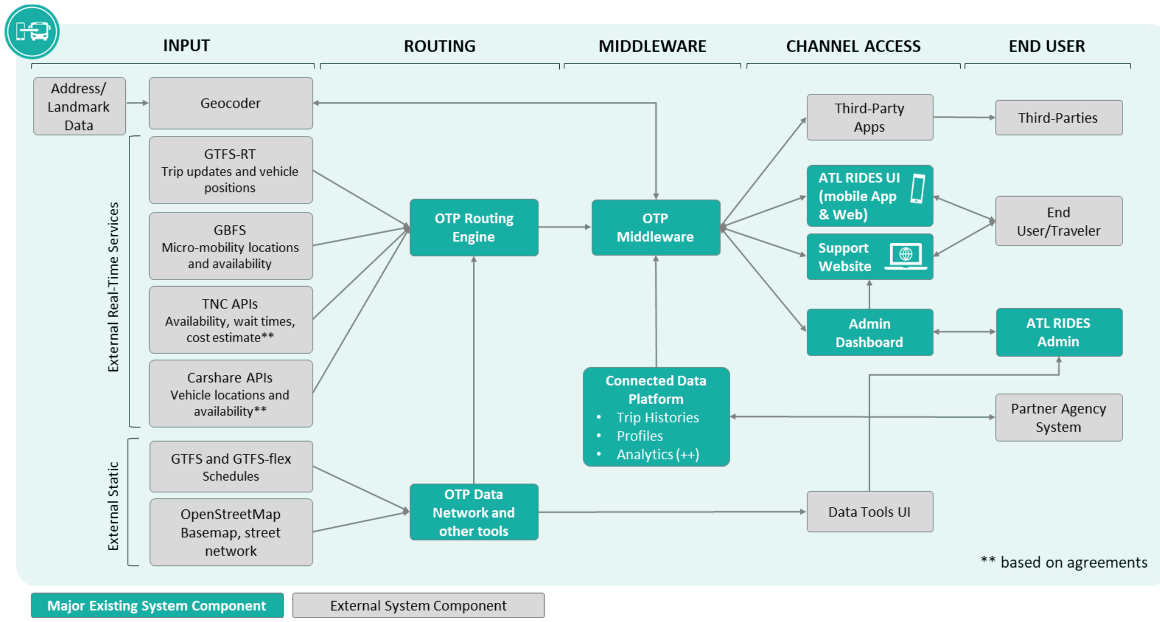
### 3.2.1 ATL RIDES Multimodal Trip Planner

The ATL was awarded funding through FTA's Integrated Mobility Innovation (IMI) Demonstration program in March 2020 to create ATL RIDES. It is a journey planning application using a connected data environment to improve the experience of multi-modal trip planning, increase transit ridership, provide coordinated information across the region's multiple transit operators, and demonstrate using a connected data environment to support transportation decision making. ATL RIDES is being created to provide more reliable and easier to access transit data to all travelers making it easier for them to utilize the region's transit services.

**Operational Environment.** ATL RIDES platform is an OSS multimodal trip planning and mobile application, integrated mobile fare payment options, and a CDP using regional GTFS feeds. The trip planning platform is built on the latest version of OTP with a web application and mobile app.

**Capabilities, Functions, and Features.** The tool supports multi-agency context, multilingual support, and live-tracking capabilities. The responsive web application and native mobile apps provide the tools and functions for making trip search requests, updating preferences and settings, viewing map-based and itinerary views of trip results and managing a user's account, including saved preferences, favorite locations, and stored trips for monitoring.

**Major System Components**. ATL RIDES consists of four primary modules: (i) the core OTP routing engine, (ii) OTP-middleware, (iii) responsive web app user interface (UI), and native mobile apps for iOS and Android smartphones. **Figure 7** provides the current ATL RIDES system context diagram.




*Source: ARC*

**Figure 7. Current ATL RIDES Context Diagram**

**Inputs, Outputs, and Data Flow.** The ATL RIDES system currently interfaces with a number of real-time data services and static data sets. The core OTP routing engine receives data from a range of real-time and static sources, including:

- **Real-Time Services**
  - Transit real-time updates for service alerts, vehicle positions, and arrival/departure predictions – General Transit Feed Specification-Real Time (GTFS-RT)
  - Micro-mobility (bikeshare and e-scooter) locations and availability – General Bikeshare Feed Specification (GBFS)
  - Transportation Network Company (TNC) availability, wait time, and cost estimates via provider APIs
  - Carshare vehicle locations and availability via provider APIs
- **Static Data Sets**
  - Transit schedule information (GTFS for fixed route and GTFS-Flex for demand responsive and flexible schedules)
  - Road and sidewalk network – OpenStreetMap (OSM)

When a trip search request is passed from the middleware to the routing engine, the routing engine returns a range of multimodal trip options based on the origin, destination, time preferences and mode preferences that were made in the user's trip search request. These trip itinerary options are passed back to the web app or mobile app where the user made the search and displayed in the app for the user to filter, sort, and compare in order to select their preferred trip option.

The ATL RIDES system relies on the external Geocode.earth geocoding API service when a user makes a trip request to translate addresses and placenames into latitude/longitude values that can be understood by the routing engine. That request is then passed on to the OTP-middleware.

The OTP-middleware coordinates between the system modules, passing the request on to the core routing engine, but also is responsible for storing user account data and monitoring saved trips for service alerts, delays, or other disruptions that would trigger a notification to the user. The OTP-middleware also includes the CDP, which allows anonymized trip plan requests, trip itineraries and other data generated by the ATL RIDES system to be available for analysis and/or partner agency use.

**Performance Characteristics.** Performance of the ATL RIDES platform consists of availability to customers, speed of trip plan response, and quality/reliability of information. The system's routing engine is cloud hosted behind a load balancer, allowing the system to be scaled to meet demand. This also provides redundancy in the event there is an issue with the routing engine server. Regular performance testing of trip plan response time ensures adequate compute resources are dedicated at any given time. In addition, regular audits of input data quality, and spot checking of trip plan results help ensure high quality, reliable trip plan information.

For system security, ATL RIDES relies on the Auth0 user authentication service for username/ password and system permissions management. To protect user privacy, trip plan request and results data are only archived for analysis if the user has opted-in to trip plan logging, and their logged data is only made available for analysis in an anonymized format. In addition, if a user later chooses to opt-out of data logging, all of their records are purged from the system.

**System Schedule.** The ATL RIDES system is currently being developed by the ATL through the FTA's IMI Program. The project is committed to be completed in May of 2022 with the following milestones scheduled for completion as shown below in **Table 2**.

**Table 2. ATL RIDES Milestone Schedule**

| Project Item | Completion Date |
|---|---|
| Regional Data Assessment Support and Policy Recommendations | Completed Spring 2021 |
| Conceptual and Detailed Design | Completed Spring 2021 |
| Modifications to the OTP Routing Engine and React-User Interface | September 2021 |
| CDP and OTP Middleware Development | September 2021 |
| Mobile Application Development and Mobile Ticketing Integration | September 2021 |
| User Testing and Evaluation | September 2022 |
| Data Analysis from the CDP | September 2022 |
| Customer Education and Outreach | September 2022 |

*Source: ARC*

### 3.2.2 Space Time Memory (STM) Platform

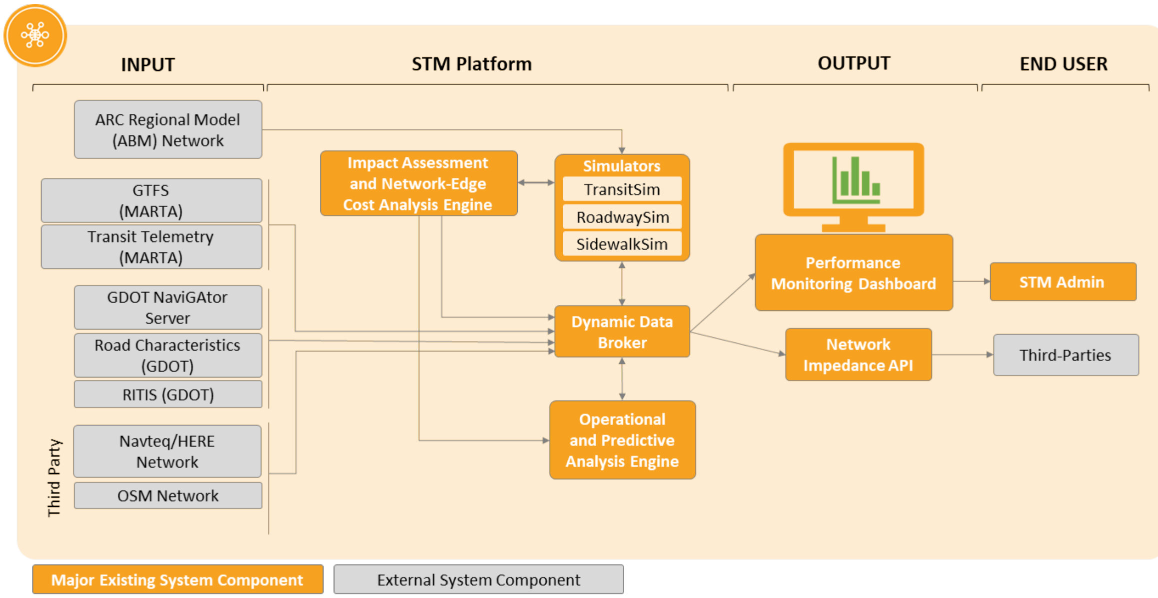
The regional STM, as currently deployed, is a research-grade model developed by GA Tech from 2016-2018 for the Department of Energy (DOE) Advanced Research Projects Agency-Energy (ARPA-E) Traveler Response Architecture using Novel Signaling for Network Efficient in Transportation (TRANSNET) Atlanta project. The current regional STM is being used by GA Tech in shortest path modeling for research and data analysis and outputs. The STM stores historic traffic condition data for every link in the modeled transportation system at 5-minute temporal resolution, along with more than 100 infrastructure parameters, for use in deep learning applications. The system can use current traffic conditions to predict the shortest path from any origin to destination on the network using traditional Dijkstra processes, and is designed to predict shortest paths based upon congestion formation and dissipation projected over the short term (within one hour) using machine learning processes. The system finds the shortest paths by moving vehicles through space-time trajectories, where the link speeds encountered by the vehicle along each path is the projected speed at the time the vehicle arrives at each link. The goal of this system is to predict trajectories through the network 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.

**Operational Environment.** The STM platform is an OSS application that 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. It is currently comprised of a dynamic data broker which manages the operational and predictive analysis engine.

**Capabilities, Functions, and Features.** The STM platform is designed to ingest data from a wide variety of sources, including GDOT NaviGAtor data feeds, GTFS data feeds from GCT and MARTA, ARC's planning network, National Oceanic and Atmospheric Administration (NOAA), and any third-party system capable of providing real-time feeds for roadway traffic conditions, as shown in **Figure 8**. The STM attaches data to the network as link attributes in five-minute time bins through a process of data transformation and data fusion. The data transformation includes steps for data verification, validity checking, imputation of missing data, and network conflation.

The STM platform projects trip trajectories through the transportation network, as network conditions change in space and time. The Python system can currently project through a roadway and transit network once the data is provided. That projection is used to find the shortest path, allowing routing decisions to incorporate travel time, safety, and other impedance values into path selection. Outputs are provided through the use of a Commute Advisor Application Programming Interface (API).

**Major System Components.** The STM system consists of a wide range of data inputs, the STM data broker, system simulators, operational and performance analysis engine, network-edge cost computing engine, performance monitoring dashboard, and commute advisor API and UI. **Figure 8** provides the STM system context diagram.




*Source: ARC*

**Figure 8. Current STM Context Diagram**

The system simulators are part of the Python-based modeling suite which calculates the preferred route based on network information and Dijkstra's shortest path (lowest impedance value) algorithms where users can optimize path selection to minimize travel distance, travel time, energy use, or any specified user impedance function. For example, impedance penalties can be applied for wheelchair travel when ramps are absent or do not meet ADA slope or cross-slope standards.

- *RoadwaySim* – uses a 203,000-link roadway network from multiple static and dynamic resources which is updated every 5-minutes. The roadway network is independent from the other networks but is connected.
- *TransitSim* – currently includes all MARTA fixed rail routes, 90 MARTA bus routes, and Georgia Regional Transit 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.
- *SidewalkSim* – uses a pedestrian pathway network that is independent from, but connected to, the surrounding roadway and transit networks. SidewalkSim network links represent sidewalks, pathways, roadway crossings, and grade-separated pedestrian pathways in the pedestrian network. Connection nodes represent the locations where pedestrians transition from link to link and enter/egress roadway, rail, and other crossings. The system also tracks relevant sidewalk and pathway elements that affect mobility (e.g., curb ramps, curb cuts, signal heads, push button controls, etc.). This allows GA Tech to track mobility-relevant features associated with each element.

  Sidewalk networks have been inventoried throughout the region for the GA Tech campus, Midtown area, City of Atlanta, East Point, Sandy Springs, Cobb County, and Clayton County. Sidewalk networks have been inventoried outside of the region in Yarmouth (ME) and Northampton (MA).

**Inputs, Outputs, and Data Flow.** The STM system ingests data from a range of sources, uses the data to model and identify optimum routes, and then provides this information to users.

The STM system and data broker receive and manage the following data input:

- *Roadway Networks* – ARC's Activity-based Model (ABM) and HERE's (formerly, Navteq) network are confirmed and utilized as the primary roadway network. Given the higher accuracy levels of the ABM and accuracy and completeness of the HERE network, the system simulator networks used by the STM start with reconciling these two network data sources, eliminating unnecessary nodes, and adding nodes as needed to complete minor road pathways.
- *Open Street Map Network* – The team regularly updates the OSM network to reflect changes in static network elements identified with the sidewalk inventory tools described in **Section 3.2.3** (Sidewalk machine vision (Sidewalk MV), Sidewalk Sentry, Sidewalk Scout, etc.) and as machine-learning processes identify network refinements that can increase route efficiency.
- *Transit Data* – GTFS data feeds and transit telemetry from MARTA and others as available are pulled into the STM and leveraged by the system simulators to identify routing for transit.
- *Roadway Characteristics* – GDOT's NaviGAtor advanced transportation management system (ATMS) software, GDOT roadway information, and GDOT's access to Regional Integrated Transportation Information System (RITIS) data is used to define the existing conditions of the roadway within the STM system.
    - The NaviGAtor system monitors and archives data for monitored freeway and arterial links at 20-second, lane-by-lane resolution. In addition, this connectivity also gives the STM platform access to the GDOT CV Program described in **Section 3.2.4**. The STM currently processes NaviGAtor data feeds to system simulators at 5-minute resolution.
    - The STM is capable of carrying real-time network data from any external data source, provided that the source can deliver link-level data at 5-minute temporal resolution. The STM retains all attributes provided by every data source.
    - The STM currently carries more than 100 roadway-related parameters from the various data sources for use in its deep learning processes. A significant number of these parameters are design-related and considered static in nature, such as facility class, link length, number of lanes, lane width, engineering capacity, design speed, posted speed limit, surface type, etc.
    - A road grade dataset from 2019 has been prepared by the team at high resolution for the entire metro area and can be applied at any spatial scale.
    - Lighting conditions by time of day are also used to support safe, efficient routing.

The STM dynamic data broker receives the data and disseminates appropriate data sets to the system simulators, operational and predictive analysis engine, and the impact assessment and network-edge cost analysis engine. The network-edge cost engine calculates the impedance value or level of inconvenience of a route to a traveler taking into consideration multiple parameters including time, monetary cost, and comfort. The data is analyzed and assessed and sent back to the data broker to be distributed to the appropriate output channel. In the ARPA-E research project, the STM system provided the following output within the production environment:

- *Commute Advisor API Version 1.0* – The commute advisor API provides STM near-real-time updates to transportation network impedances compatible with OSM network data feeds.

**Performance Characteristics.** The STM dynamic data broker currently receives network performance data and disseminates appropriate data sets to the system simulators, operational and predictive analysis engine, and the impact assessment and network-edge cost analysis engine at a five-minute temporal resolution. Stress testing performed in the ARPA-E project established that a single-server solution is capable of considering origin-destinations within a regional area from more than 20,000 users simultaneously.

Currently data and impedances are reviewed manually to ensure quality and integrity of the data. In the event of communication outages within the system, the default mode is to use the OTP with no impedances updated.

The STM system is currently in a research environment and does not contain any encryption features that would be implemented within a production environment. However, structure to support a production environment is built and able to be migrated with additional enhancements.

**System Schedule.** The research-grade STM system currently exists. The system will be expanded and enhanced to a production grade system in Phase 2. The Northwest Region Project is a parallel effort developing tools to be used across the entire region but will not include any local roads.

**Table 3. STM Platform Milestones Schedule**

| Project | Milestone | Completion Date |
|---|---|---|
| Northwest Region Project | Network Reconciliation (OSM and ABM) Tool Development | October 2021 |

*Source: ARC*

### 3.2.3 Sidewalk Inventory Collection Tools

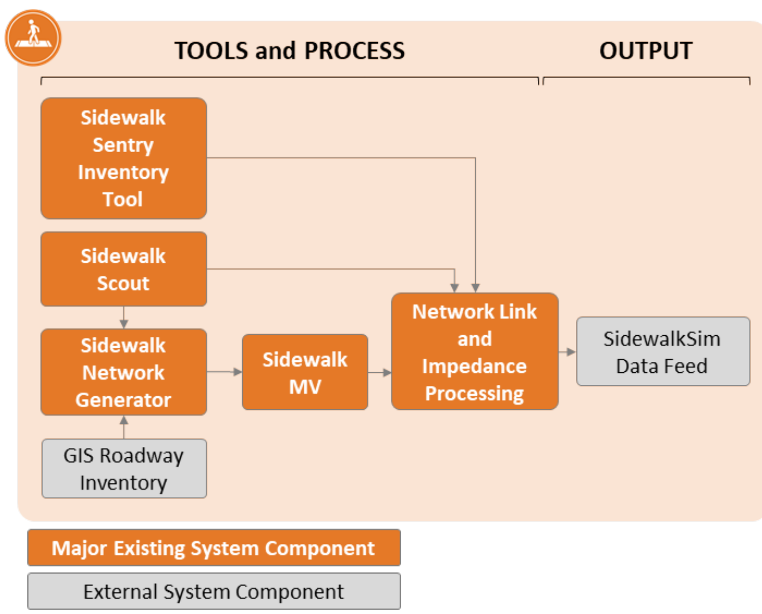
The sidewalk inventory collection tools provide enhanced pedestrian infrastructure data that is currently integrated within the SidewalkSim simulators referenced above in the STM system. SidewalkSim will be an integral element of the production grade STM, providing the pedestrian pathway network that is independent from, but connected to, the surrounding roadway and transit networks used in multi-modal path processing. The SidewalkSim network links represent sidewalks, pathways, roadway crossings, and grade-separated pedestrian pathways in the pedestrian network. The system also tracks relevant sidewalk and pathway elements that affect mobility (e.g., curb ramps, curb cuts, signal heads, push button controls, etc.). This allows GA Tech to track mobility-relevant features associated with each element. GA Tech has already developed a number of systems to inventory and collect sidewalk asset condition and ADA design compliance data. The purpose and goal of the development of these inventory collection tools is to be able to efficiently and accurately inventory pedestrian pathways and initial conformance with

ADA design standards such that the data may be leveraged to support better traveler information and safety applications.

**Operational Environment.** The Sidewalk Scout, Sidewalk Sentry, and Sidewalk MV tools together create an enhanced sidewalk inventory system that collects and records sidewalk infrastructure, conditions, and obstructions. Enhanced sidewalk data collection and accessibility inventory using these systems has been completed in several areas around the region including Midtown Atlanta, East Point, Sandy Springs, Cobb County, and Clayton County, as well as other locations nationally.

**Capabilities, Functions, and Features.** Taken together, these three systems are used to inventory pedestrian pathway assets (sidewalks, crossings, pedestrian curb ramps, driveway curb cuts, etc.) and to assess element conditions for use in asset management tracking, to guide investment prioritization, and/or to inform travelers about path conditions.

**Major System Components.** The sidewalk inventory system is comprised of the Sidewalk Scout, Sidewalk Sentry, and Sidewalk MV data collection tools. **Figure 9** provides the sidewalk inventory system context diagram.




*Source: ARC*

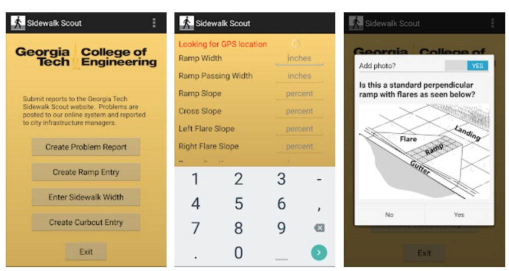
**Figure 9. Current Sidewalk Inventory Collection Tools**

Sidewalk Sentry is a tablet-based Android application used to collect sidewalk roughness data and a video inventory of sidewalks, crossings, ramps, and curb cuts. As shown in **Figure 10**, the tablet is attached to a non-motorized wheelchair and the data collector walks through the network at 2-3 mph collecting rolling ground level video, geographic position system (GPS) data, and accelerometer/gyroscope data from internal sensors. The GPS data is made more accurate by pre-processing location data before collecting field data – data used to support a non-safety critical application. The system uses the GPS and video data to create Geographic Information System (GIS) based sidewalk inventories. A web-based application is used by inspectors to playback video and record deviations from ADA design standards and condition defects (e.g., presence of potholes, obstructions, pavement disjoints, width narrowing, debris, ponded water, etc.).

*Source: GA Tech*

**Figure 10: Sidewalk Sentry Wheelchair**

Sidewalk Scout™ is an Android app as shown in **Figure 11**, that allows registered users to record photos of individual sidewalk elements and report specific defects in sidewalk conditions or pedestrian amenities, including sidewalk obstruction, inadequate sidewalk width, improper slope and cross-slope, pavement discontinuities, broken walk signal heads, etc. The Sidewalk Scout™ app feeds data directly into the GA Tech sidewalk inventory system, with proper user training, Sidewalk Sentry can be used as a crowdsourced data collection app.




*Source: GA Tech*

**Figure 11: Sidewalk Scout User Interface**

The team at GA Tech has been developing Sidewalk MV tools designed to process video and automatically identify the presence and position of sidewalk assets from the inventory videos and identify defects from the inspection videos. Enhanced machine vision processes are expected to improve sidewalk data granularity and accuracy at lower labor costs.

**Inputs, Outputs, and Data Flow.** Sidewalk inventories are developed through a series of processes that ingest data, processes the data and output a network that is compatible with SidewalkSim shortest path calculator.

The sidewalk inventory system receives and manages the following data input:

- Parcel-level land use data and roadway centerline data are used to create pedestrian pathways. The resulting pedestrian network represents all sidewalks, pathways, roadway crossings, and grade-separated pedestrian pathways as links.
- Sidewalk Sentry video data are used to verify asset spatial placement and to video-inspect sidewalk elements for deviations from ADA design standards and condition defects that are likely to increase route impedance.
- Sidewalk Scout inspection data are used during field inspections of sidewalk assets to identify deviations from ADA design standards and condition defects that are likely to increase route impedance.

**Performance Characteristics.** The sidewalk inventory network accuracy is assessed during the spatial reconciliation process. Networks are tested through origin-destination path analysis in which broken links are discovered and reconciled. Shortest path performance is tested and is a function of network density (links involved in path calculations).

**Schedule.** Minor system updates and refinements are completed during use of the sidewalk inventory tools. The Sidewalk MV tool is currently being developed by the GA Tech team as a research investment for use in future research and will be employed in support of ST-CTN to the extent that the tools have been field-demonstrated to provide efficiency and accuracy benefits. This tool is not required for ST-CTN implementation.

**Table 4. Sidewalk Inventory Milestones Schedule**

| Milestone | Completion Date |
|---|---|
| Sidewalk MV Tool | Continued Development |

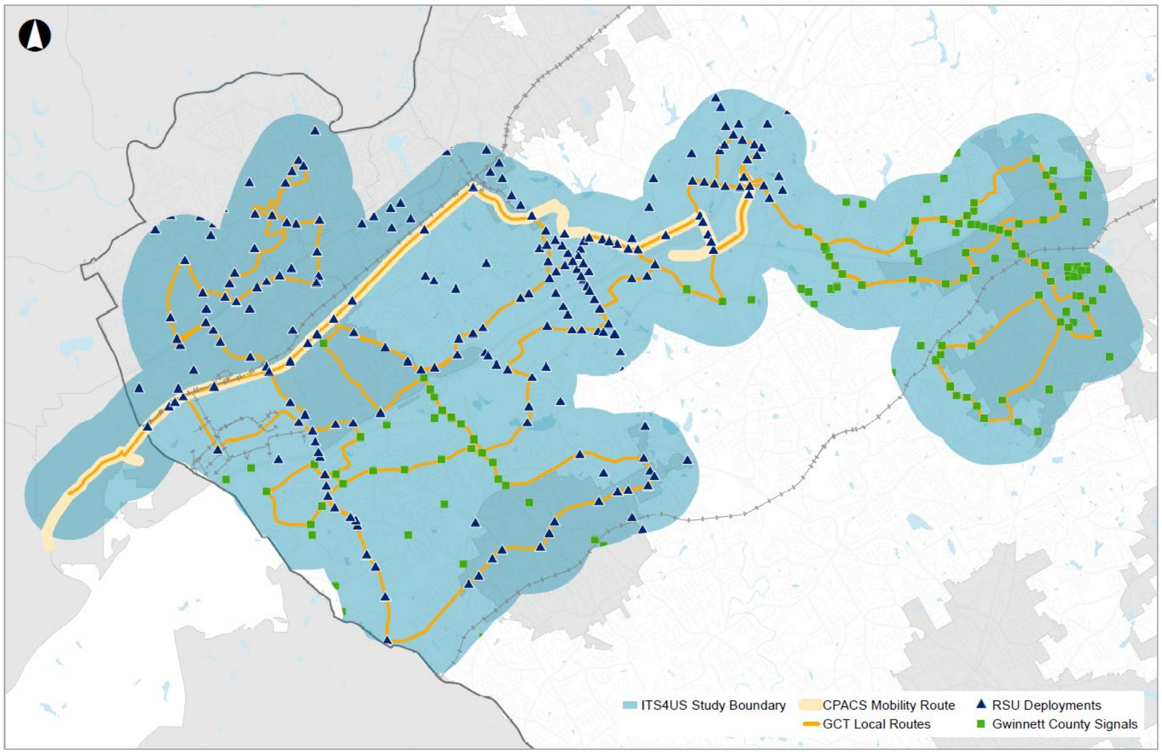
*Source: ARC*

### 3.2.4 Gwinnett County and GDOT Connected Vehicle

Gwinnett County operates and maintains 745 traffic signals, 328 closed circuit television (CCTV) cameras, and 244 miles of fiber throughout the county with a robust advanced traffic signal system. Gwinnett County works closely with GDOT who is responsible for traffic signals along state-owned roadways within the county. The CV system will rely on and work with the established traffic signal system.

Gwinnett County is a leader in deployment of CV infrastructure having approximately 100 existing RSUs deployed along key corridors and currently participating in the GDOT CV1K deployment program. Gwinnett County is currently deploying interoperable CV technologies at signalized intersections throughout the Atlanta region  to deliver safety and mobility-based applications. The program provides support to configure, operate, and maintain CV infrastructure and applications, including TSP. The goal of the program is to provide CV infrastructure to support the future development and testing of CV applications by agencies, original equipment manufacturers (OEM), and third parties.

**Operational Environment.** 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 12**). In addition, Gwinnett County is in the process of selecting a vendor to supply onboard units (OBUs) for county vehicles and support application development. Gwinnett County's CV operational environment relies on infrastructure and support from GDOT.

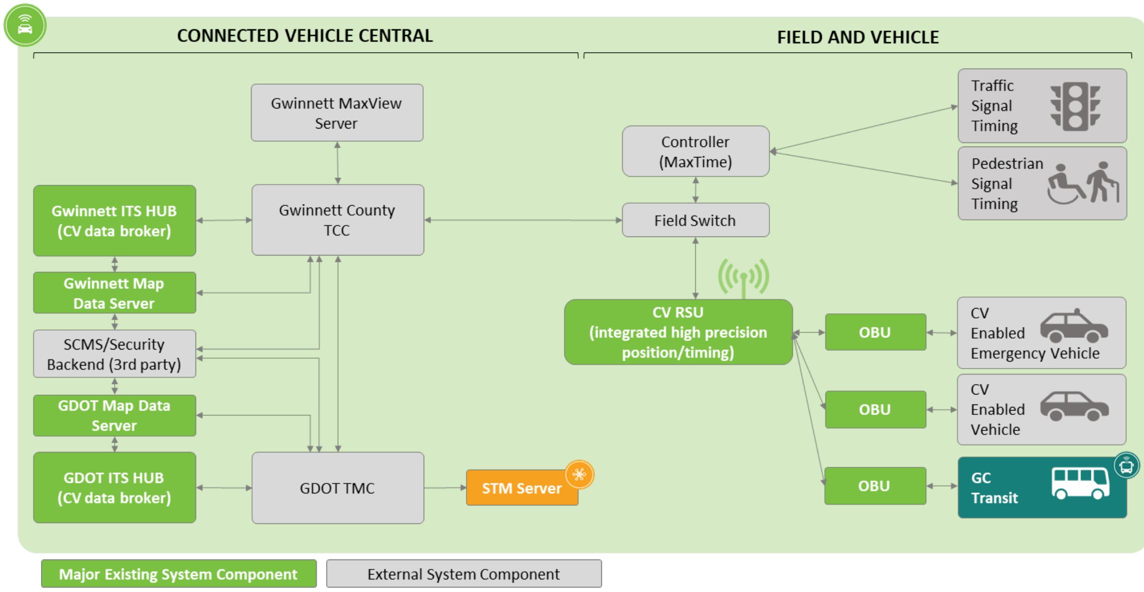



*Source: Gwinnett County*

**Figure 12. Gwinnett County CV Program RSU Deployment Locations**

**Capabilities, Functions, and Features.** Gwinnett County is currently broadcasting signal, phasing and timing (SPaT) and Map Data (MAP) from signalized intersections along key corridors throughout the county. The county is working towards 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. Transit signal priority hardware components will be purchased, deployed, and configured through the Smart Corridor project.

**Major System Components.** The CV program is comprised of field and central CV equipment and supporting infrastructure. **Figure 13** provides the Gwinnett County CV program context diagram.




*Source: ARC*

**Figure 13. Gwinnett County and GDOT CV Program Context Diagram**

The central components of the CV program consist of the ITS Hub or CV data broker, and ATMS servers (NaviGAtor and MaxView). The ITS Hub is responsible for receiving data from the field, processing the information, developing messaging, and monitoring CV infrastructure. The ATMS servers manage, operate, and monitor the traffic signal equipment and interface with the traffic management center (TMC). The central ITS Hub is replicated from the GDOT TMC to the Gwinnett County traffic control center (TCC) for resiliency and data preservation. The MAP Server stores and provides information on road configuration using the MAP standards (in the SAE J2735 standard). The MAP data server, with the security credentialing service, provides signed MAP messages that are sent to the RSUs. RSUs are configured with a high precision positioning and timing source that synchronizes RSU and OBU equipment.

The field components of the CV program primarily consist of RSUs which broadcast SPaT and MAP messages. County vehicles equipped with OBUs and connected consumer vehicles can receive and broadcast basic safety messages (BSM) and receive MAP and SPaT data from the RSUs.

**Inputs, Outputs, and Data Flow.** The CV system receives input from traffic signals, including signal phasing and timing data. The data flows as described below.

- GDOT-Owned Signals
  - Data is communicated from the field controller through the field hardened Ethernet switch, to the GDOT NaviGAtor server located in Gwinnett.
  - Data is replicated and sent to the Gwinnett ITS hub.
  - Data is sent from the GDOT NaviGAtor server located in Gwinnett to the GDOT NaviGAtor server located at GDOT.
  - The GDOT NaviGAtor server located at GDOT sends the data to the GDOT ITS hub for processing.

  - The GDOT ITS hub data is sent back through the communication path to the field hardened ethernet switch, to the RSU and broadcasted to be received by CV enabled devices. Data can also be sent from the GDOT ITS hub to modify timing and phasing in the traffic signal controller.
- Gwinnett-Owned Signals
  - Data is communicated from the field controller through the field hardened Ethernet switch, to the GDOT NaviGAtor server located in Gwinnett.
  - Data is sent to the Gwinnett ITS hub for processing.
  - The Gwinnett ITS hub data is sent back through the communication path to the field hardened ethernet switch, to the RSU and broadcasted to be received by CV enabled devices. Data can also be sent from the Gwinnett ITS hub to modify timing and phasing in the traffic signal controller.

**Performance Characteristics.** Performance characteristics, including quality and security, are being defined by the Smart Corridor project. The existing GDOT infrastructure includes a Security Credential Management System (SCMS) which is a third-party system that provides and manages security certificates to support trust for components that interface with the CV system. The SCMS being used is IEEE 1609.2 conforming and will be implemented with TSP requests during configuration and deployment.

**System Schedule. Table 5** provides a brief overview of the CV milestones for the CV1K and Smart Corridor projects that will both be leveraged for the implementation of the ST-CTN system.

**Table 5. CV Milestone Schedule**

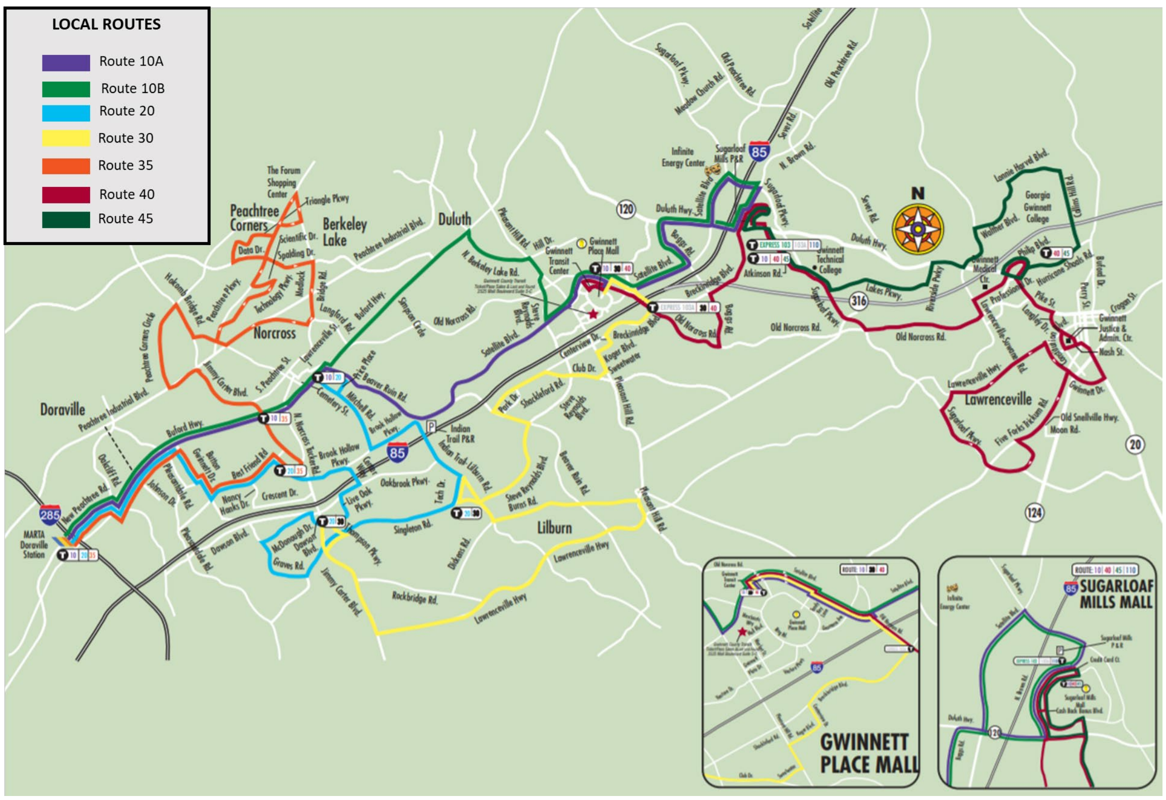
| Project | Milestone | Completion Date |
|---|---|---|
| CV1K | 400 RSUs ordered | June 2021 |
| Smart Corridor | Vendor/Consultant selection | May 2021 |
| Smart Corridor | OBUs for Transit Buses ordered | January 2022 |
| CV1K | RSU deployment | February 2022 |
| Smart Corridor | OBU installation | May 2022 |
| Smart Corridor | TSP deployment | Summer 2022 |

*Source: ARC*

### 3.2.5 Gwinnett County Transit

The Gwinnett County transit system currently provides commuter, local, and on-demand (paratransit) services throughout Gwinnett County, Georgia.

**Operational Environment.** Local, fixed-route service is the primary focus for the ST-CTN project and is operated with a fleet of 38 transit vehicles within the County. GCT currently operates seven local service bus lines. These bus lines reach the communities of Doraville, Norcross, Lawrenceville, Lilburn, Peachtree Corners, and Duluth. Route 10A, 10B, 20, and 35 all provide access to the Doraville MARTA Station. A map of GCT's Local Service Routes is provided in **Figure 14**. Outside of the Gwinnett County Transit Center at the Gwinnett Place Mall, access to these bus lines is provided through roadside bus stops at fixed locations. The infrastructure at the bus stops varies from no infrastructure to sheltered locations with seating. Transit vehicles utilize automatic vehicle location (AVL) and a central computer-aided dispatch (CAD) system for service operations and management. In addition, transit vehicles are outfitted with cellular routers that provide free Wi-Fi to riders.




*Source: Gwinnett County*

**Figure 14. Gwinnett County Transit Local Route Service Map**

Transit speeds from the CTP Needs Assessment (2018) are included in **Table 6**. Route 45 is not included in the table as that route was added after the CTP was published. As noted in the CTP Needs Assessment, 25% of riders transfer twice on their one-way trip.

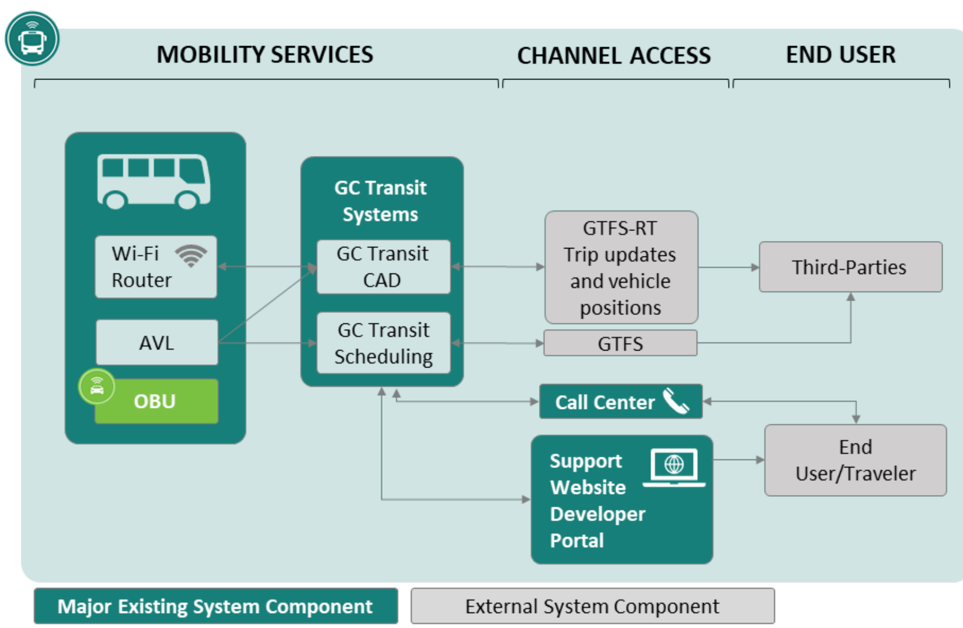
**Table 6. CTP Needs Assessment Transit Speeds (Average Travel Speed by GCT Route)**

| Direction | 10A | 10B | 20 | 30 | 35 | 40 |
|---|---|---|---|---|---|---|
| **Inbound** | 12.5 mph | 14.9 mph | 16.7 mph | 18.1 mph | 15.9 mph | 19.9 mph |
| **Outbound** | 13.7 mph | 15.1 mph | 15.6 mph | 18.8 mph | 15.2 mph | 16.9 mph |

*Source: Gwinnett County*

**Capabilities, Functions, and Features.** The GCT system is capable of sharing transit schedule information, both in static and real-time. The system currently provides real-time ridership, route information, and service alerts information, which is available to travelers through a third-party app, myStop Mobile. Transit vehicles have onboard passenger counters (not specific by seat type, i.e., there are no sensors that track if wheelchair tie-downs are utilized), dynamic signs, operator mobile displays, and free passenger Wi-Fi. The GCT system will operate TSP with completion of the Smart Corridor project.

**Major System Components.** The GCT system is comprised of central system platforms, call center, and support website and developer portal. **Figure 15** provides the GCT system context diagram.




*Source: ARC*

**Figure 15. Gwinnett County Transit Current Bus and Operational Technology**

Central system platforms manage the GCT CAD and scheduling applications. These applications process static and real-time information including, transit vehicle locations, scheduling, routes, and ridership. The processed information is available to support a call center, support website developer portal, and GTFS feeds.

The GCT call center and support website developer portal provides information and direct support to customers. Customer service is available through the call center Monday through Friday from

6:00am to 8:00pm and Saturday from 7:00am to 8:00pm. Customers can access the website anytime and view routes, track vehicle status, plan trips, set alerts, and view messages.

**Inputs, Outputs, and Data Flow.** The GCT system receives input from transit vehicle onboard AVL devices and routers. This data is processed by the GCT system platforms which provide GTFS-RT and GTFS data feeds as well as operational and performance data. The GTFS-RT and GTFS data feeds are provided for third-party use and application. The operational and performance data is utilized by the call center and website which is then provided for customer consumption.

**Performance Characteristics.** The GCT system components have the following performance characteristics, including quality and security:

- Onboard Wi-Fi routers offer free access to all riders within the GCT system. These will be upgraded in Fall of 2021 to Sierra Wireless MG90 Gigabit Wi-Fi routers.
- Automated vehicle location devices currently provide vehicle location and availability data approximately every 30 seconds. The current system has noticeable float but provides the quality and accuracy that is required to meet the needs of the GCT system.
- Security upgrades are being completed to support the upgraded Wi-Fi routers to include virtual local area networks (VLAN) which will partition the network and allow for added security and quality.
- Deployed OBUs will get security certificates from the SCMS through the RSUs.

**System Schedule.** The GCT schedule of milestones that are pertinent to the ST-CTN proposed concept are shown below in **Table 7**.

**Table 7. Gwinnett County Transit Milestones Schedule**

| Milestone | Completion Date |
|---|---|
| Router Upgrades | Q1 2022 |
| System Platform Consolidation | Q1 2022 |
| ATL RIDES Data Integration and Verification | Q2 2022 |
| TSP Implementation | Q3 2022 |

*Source: ARC*

## 3.3 Current System Stakeholders and User Groups

The current system stakeholders are those user groups and actors involved in the usage, management, operation, and maintenance of the current system. User groups and actors are distinguished by the way in which the user groups interact with the system. In this context, a user is anyone who interacts with the system including end users, operational users, subsystem developers and operators, and system maintainers.

User groups have been identified within three user classifications based on the general nature in which they interact with the current system. It is anticipated that the current system stakeholders will be maintained and migrate to the proposed system once available.

- **End Users (EU).** These users directly interact with the front end of the system. This user classification includes the user groups that represent the underserved populations that are the primary focus of the ST-CTN project.
- **Infrastructure Owner Operators (IOO).** These users represent infrastructure owners and operators within the project area. This includes transit infrastructure, communications infrastructure, CV infrastructure, signal infrastructure, and information technology infrastructure.
- **System Developers (SD).** These users represent system and subsystem developers who develop, update, and maintain the subsystems that support the ST-CTN project.

**Table 8** provides a brief description of current system stakeholders by user groups and their current roles and responsibilities.

**Table 8. Current System Stakeholders and User Groups**

| User Group | Abbreviation | Description |
|---|---|---|
| ***End User Classification*** | | |
| Physical Disability | EU-PD | End users 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.<br><br>**Role:** End user of the system.<br><br>**Responsibility:** Interact with the system through the provided UI; provides preferences and abilities; provides feedback and input to enhance the functionality and accuracy of the system. |

| User Group | Abbreviation | Description |
|---|---|---|
| Cognitive Disability | EU-CD | End users 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.<br><br>**Role:** End user of the system.<br><br>**Responsibility:** Interact with the system through the provided UI; provides preferences and abilities; provides feedback and input to enhance the functionality and accuracy of the system. |
| Aging Adult | EU-AA | End users who are 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.<br><br>**Role:** End user of the system.<br><br>**Responsibility:** Interact with the system through the provided UI; provides preferences and abilities; provides feedback and input to enhance the functionality and accuracy of the system. |
| Limited English Proficiency | EU-LEP | End users 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.<br><br>**Role:** End user of the system.<br><br>**Responsibility:** Interact with the system through the provided UI; provides preferences and abilities; provides feedback and input to enhance the functionality and accuracy of the system. |

| User Group | Abbreviation | Description |
|---|---|---|
| Low Income | EU-LI | End users 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.<br><br>**Role:** End user of the system.<br><br>**Responsibility:** Interact with the system through the provided UI; provides preferences and abilities; provides feedback and input to enhance the functionality and accuracy of the system. |
| ***Infrastructure Owner Operator Classification*** | | |
| Gwinnett County Transit | IOO-GCT | The Gwinnett County Transit user group includes the administrative staff, maintenance staff, drivers, and operators that work with the Gwinnett County Transit organization.<br><br>**Role:** Owner / operator of the current Gwinnett County Transit system.<br><br>**Responsibility:** Operates routes; monitors and maintains schedule; facilities planning and operations. Bus operations and maintenance. Provides transit data generation (GTFS, GTFS-RT). |

| User Group | Abbreviation | Description |
|---|---|---|
| Gwinnett County Traffic and Operations | IOO-GCTO | 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.<br><br>**Role:** Owner / operator of the current Gwinnett County traffic operations, including Gwinnett County TCC, traffic signal and CV infrastructure.<br><br>**Responsibility:** Manages and operates infrastructure to support efficient traffic operations, including TCC; traffic signal system (Maxtime and Maxview); field traffic signal equipment; CV infrastructure – RSUs; GDOT NaviGAtor server located at Gwinnett County. |
| The Atlanta-Region Transit Link Authority (The ATL) | IOO-ATL | The ATL user group includes administrative staff, engineering staff, operators, and support personnel who work with the ATL organization.<br><br>**Role:** Owner / operator of the current ATL RIDES application.<br><br>**Responsibility:** Manages and operates ATL RIDES application and supporting infrastructure. |
| Georgia Department of Transportation (GDOT) | IOO-GDOT | The GDOT user group includes administrative staff, engineering staff, Traffic Management Center (TMC) operators, and technicians who work with the GDOT organization.<br><br>**Role:** Owner / operator of the GDOT TMC, statewide ATMS (NaviGAtor), existing CV infrastructure.<br><br>**Responsibility:** Collaborates with Gwinnett County to manage and operate infrastructure to support efficient traffic operations including, traffic signal system (Maxtime and Maxview); field traffic signal equipment; CV infrastructure – RSUs; GDOT NaviGAtor server located at GDOT TMC; ITS Hub. |

| User Group | Abbreviation | Description |
|---|---|---|
| Gwinnett County Information Technology | IOO-GCIT | 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.<br><br>**Role:** Owner / operator of the current Gwinnett County Information Technology Department.<br><br>**Responsibility:** Manages and operates the Gwinnett County communications, security, data management and all server systems. |
| Atlanta Regional Commission (ARC) | IOO-ARC | The ARC user group includes administrative staff, engineering staff, operators, and support personnel who work with the ARC organization.<br><br>**Role:** Owner / operator of the current Atlanta Regional Commission.<br><br>**Responsibility:** Responsible for encouraging and coordinating regional expansion of the ST-CTN concept and potentially owning and operating subsystem component infrastructure. |
| ***System Developer Classification*** | | |
| Georgia Institute of Technology | SD-GAT | The Georgia Institute of Technology user group includes engineering staff, IT support staff, and operators from the Georgia Institute of Technology.<br><br>**Role:** System developer at the Georgia Institute of Technology for the STM and sidewalk inventory tools.<br><br>**Responsibility:** Responsible for the STM processing, operations, and maintenance. Responsible for the operations, processing of data collection with the sidewalk inventory tools, Sidewalk Scout, Sidewalk Sentry, and Sidewalk MV. |

| User Group | Abbreviation | Description |
|---|---|---|
| Gwinnett County Information Technology | SD-GCIT | The Gwinnett County Information Technology user group includes administrative staff, engineering staff, and IT staff who work with the Gwinnett County Information Technology organization.<br><br>**Role:** Systems developer for Gwinnett County Information Technology.<br><br>**Responsibility:** Responsible for the Gwinnett County Information Technology network operations, maintenance, uptime, and security. |
| Gwinnett County Connected Vehicles | SD-GCCV | The Gwinnett County Connected Vehicles user group includes administrative staff and engineering staff who work with the Gwinnett County Department of Transportation.<br><br>**Role:** Systems developer for Gwinnett County Connected Vehicles.<br><br>**Responsibility:** Responsible for the Gwinnett County Connected Vehicle functions and technologies. |
| Gwinnett County Transit | SD-GCT | The Gwinnett County Transit user group includes the administrative staff, maintenance staff, drivers, and operators that work with the Gwinnett County Transit organization.<br><br>**Role:** Systems developer for Gwinnett County Transit.<br><br>**Responsibility:** Responsible for the Gwinnett County Transit elements. |
| ATL RIDES | SD-ATLR | The ATL RIDES user group includes administrative staff, engineering staff, operators, developers, and support personnel who work with the ATL organization.<br><br>**Role:** Systems developer, operator, and maintenance for ATL RIDES.<br><br>**Responsibility:** Responsible for data management, application function and processing, application, and mobile app for the ATL RIDES subsystem. |

| User Group | Abbreviation | Description |
|---|---|---|
| Georgia Department of Transportation | SD-GDOT | The GDOT user group includes administrative staff, engineering staff, TMC operators, and technicians who work with the GDOT organization. They will be responsible for the GDOT CV elements.<br><br>**Role:** Systems developer, operator, and maintenance for GDOT CV system and GDOT traffic signal system.<br><br>**Responsibility:** Responsible for the GDOT CV elements, including ITS Hub, signal RSUs at GDOT maintained intersections, ATMS software (NaviGAtor), and MaxView. |

*Source: ARC*

## 3.4 Support Environment

The existing systems that will be leveraged to develop the ST-CTN system rely on critical components that will support the future system as well. The current system is supported by the following systems, infrastructure, and capabilities that are relevant to the proposed ST-CTN system:

- **Communications Network Infrastructure.** This infrastructure supports communication to the traffic signals, detection systems, traffic cameras, and field CV equipment. This allows system operators to monitor and actively manage signal timing, monitor field conditions and incidents, and monitor and manage CV messaging.
- **Centralized Traffic Signal System.** The system supports the efficient movement of vehicular and pedestrian traffic throughout Gwinnett County. The traffic signal system is integrated with the current CV system to broadcast SPaT and receive BSM messages at connected intersections.
- **Gwinnett County TCC.** The management and operation of Gwinnett County advanced transportation systems are accomplished from the Gwinnett County TCC which is the central location for housing system applications and servers, as well as operators. Relevant systems managed and operated from the Gwinnett County TCC include MaxView/MaxTime traffic signal system, digital video system, and CV system.
- **GDOT TMC.** The management and operation of the GDOT advanced transportation systems are accomplished from the GDOT TMC which is the central location for housing system applications and servers, as well as operators. Relevant systems managed and operated from the GDOT TMC include MaxView/MaxTime traffic signal system, digital video system, 511 Open Portal, and CV system.
- **CV Supporting Infrastructure.** This infrastructure includes the field Ethernet switch, traffic signal controller, and SCMS / security backend support. These external system components are referenced in **Figure 13** and support the Gwinnett County and GDOT CV Program deployments.
- **Data.** Real-time and static data is critical to the current systems. Data inputs include GTFS-RT, GBFS, GTFS-Flex, GTFS-Pathways, OpenStreetMap base map, GA 511 Open Portal, etc.

- **Traveler App or Application Device.** These devices are required to facilitate the connectivity between the ATL RIDES application and the end user / traveler.

## 3.5 Modes of Operation for Current System

This section describes the normal operation, degraded, and failure modes of operation for the current systems described above.

**Normal Operation.** During normal operations, the respective systems, as described in **Section 3.2**, are 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, the systems are not functioning as intended. Several degraded modes are explained below.

- If the **ATL RIDES** front end interface experiences a loss in functionality, the end user may not be able to access their user profile, plan a trip, or navigate a trip. If the ATL RIDES backend interfaces lose connectivity or functionality, data will not update and static data and conditions will apply until functionality may be reestablished.
- If the **STM Platform** experiences a loss of functionality, the current research environment will potentially lose data and the ability to process multimodal trip plans. This currently has minimal consequence because the STM Platform is not in production mode.
- If communication between the **Sidewalk Inventory** and the STM Platform is interrupted, accurate, real-time, travel impedances will not be processed within the STM simulators. This currently has minimal consequence because the STM Platform is not in production mode.
- If the Gwinnett County and GDOT CV system experiences a loss in functionality, the RSUs will be unable to broadcast or receive messages. Therefore, TSP requests and pedestrian signal requests will not be received or responded to. In addition, if a communication failure is present within the network, local messages will be able to be broadcasted (SPaT), however, TSP will not be functional and connectivity with pedestrians will not be possible.
- If the GCT System Platforms experience a loss in functionally, GTFS data, scheduling, and real-time bus status will not be accessible by other dependent systems.

**Failure Mode.** In failure mode, the current systems are not available to provide outputs or serve end users.

## 3.6 Operational Policies and Constraints

Currently each system described follows the guidelines set by its lead agency. The IT policies for each system are based on similar standards that serve to protect the integrity and security of their networks. No system is currently using proprietary data or information that would impact this project. Additionally, all agencies have budgeted funding for maintenance of the current systems as described including staffing. This does not include GA Tech's STM and Sidewalk Inventory systems, which is addressed in further detail in **Section 7.2.5**.

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# 4. Justification for and Nature of Changes

Access to affordable and reliable multimodal transportation affords people with disabilities, and people in underserved communities flexibility to successfully complete trips. This access is critical to reaching essential services like healthcare, but also expands everyone's opportunities in education, employment, housing, and community life. This section describes the shortcomings of the current system and sheds light on the motivation for the modification of the existing system to integrate solutions that allow all users to successfully make complete trips.

## 4.1 Justification of Changes

Providing the underserved community with tools that allow them to successfully plan and complete multimodal transportation trips increases their mobility, thereby increasing their economic, housing, and social integration potential. Without the ability to complete trips in an accessible network, underserved users may have limited alternative options or not be able to complete the trip at all. These options can be costly and sometimes unreliable for underserved communities and can place them at a disadvantage when engaging in economic or social relationships. Additionally, information on whether a trip is completable given a user's abilities and preferences is not available from any singular source. Without confidence in their ability to complete a trip, it is likely they will choose not to make a trip at all.

The ST-CTN project study area is made up of many underserved communities including people with disabilities, older adults, people with limited English proficiency, and low-income individuals. It also encompasses the entirety of the GCT local fixed route transit network. With the technology advances being made through the Gwinnett County CV and CV1K initiatives, ST-CTN is seizing the opportunity to better accommodate accessibility needs through technology.

### 4.1.1 Transit

The current transit system within Gwinnett County provides accommodations to underserved communities in the form of accessible transit vehicles, reduced fare options, and transit on-demand services. However, it does not offer full accessibility information to travelers such as bus stop accommodations and does not connect transit operators with information about a traveler's needs such as the need for additional boarding time. Buses may also not always effectively announce their arrival at bus stops, which greatly affects individuals with visual and cognitive disabilities. It is also difficult for some travelers to request a stop once on the bus or to know when to request their stop.

Travelers using transit can also have much longer trip times, not only from the necessity of an indirect route, but also from poor reliability of buses in mixed traffic. According to Connect Gwinnett Transit Plan, GCT's on-time performance is below 80% for local bus routes [CGCT].

The current transit system also has a high percentage of riders transferring between transit services.

Many of these challenges will be solved through ST-CTN. Travelers will have much more information about their trip in much greater detail. They will be able to program the system to alert them when the bus arriving, that their stop is next, and will be able to request service to board or alight a bus automatically, based on their programmed trip plan, or remotely, through their mobile device. ST-CTN can also connect the traveler to the transit operator to deliver information about their disability or needs. TSP technologies will help ensure on-time arrivals for those travelers who need additional time boarding or alighting the transit vehicle, are unable to stand for long periods, or are sensitive to adverse weather conditions, increasing the on-time performance of the system. Additionally, TSP could be activated post boarding to catch up to the schedule if the user requires additional time to board or alight the transit vehicle. An increase in on-time performance through the use of TSP, would also ensure that users who require a transfer are able to arrive at their designated transfer point on-time. Remote service requests would be able to inform drivers that a passenger is planning on completing a transfer if their current service is running behind schedule.

### 4.1.2 Trip Planning

The ATL RIDES application supports enhanced multimodal mobility for regional travelers. ATL RIDES allows users to create personal profiles and store general preferences, such as mode choice, traveled facility type, preferred route, and notification types. The development of ATL RIDES provides an opportunity for disseminating more transit travel information regionally. However, the application does not currently provide travelers with full accessibility features for alerts and hands-free use. It is also not integrated with the necessary data sets to provide users routing information based on their abilities and does not have the ability to communicate with connected vehicle infrastructure.

The underserved communities that ST-CTN is seeking to support have identified a range of travel needs to create a fully accessible application. These needs include connection to a call center, sharing user location with a care giver, audio alerts, haptic feedback alerts, personalized landmark navigation, personalized verbal cues, and more. Currently, ATL RIDES does not have as robust of a personalization platform necessary to accommodate the needs of people with disabilities, older adults, and LEP communities outside of Spanish, Chinese, Korean and Vietnamese speakers. These features must be created to help underserved communities gain independence and access throughout the deployment area.

The ATL RIDES application needs to integrate with more data sets in order to provide detailed trip accessibility information and routing. ST-CTN will integrate these data sets through GA Tech’s STM and SidewalkSim platforms. Additionally, ST-CTN will integrate ATL-RIDES with connected vehicle infrastructure to enable the traveler to access the safety and reliability benefits of that technology including holding pedestrian signals at crosswalks, triggering TSP for better transit reliability, and sending and receiving personal safety messages to and from nearby connected vehicles.

### 4.1.3 CV Infrastructure

In the Atlanta region 69% of crashes occur on roadway with less than 4 lanes [ARCRTP]. These are the same streets that are more likely to be used by pedestrians. In fact, bicycle and pedestrian fatalities, as a percent of all fatalities, grew to 20% in 2018, without a significant increase in mode share [ARCRTP]. While this is both a regional and national issue, in the ST-CTN project study area there are many intersections with twice the regional average of crashes. The installation of CV applications is one way to increase safety as more auto manufacturers include CV devices in their vehicles. However, to ensure all travelers have the ability to benefit from this technology, applications must be created. ST-CTN will enable all travelers regardless of their vulnerable road user class, to take advantage of Gwinnett County's investment in connected infrastructure and increase their safety. It will also support transit riders by enabling TSP and increasing transit reliability.

One of the ways the ST-CTN system will enhance the Gwinnett County CV infrastructure is the inclusion of remote (hands free) pedestrian signal actuation. This is currently not included in the Gwinnett County CVTMP due to several constraints including the inability to discern intent when a user is approaching an intersection. Since the ST-CTN application is providing routing guidance to the user, the intent to cross a road at a signalize crossing is established, making this feature possible. Additionally, the ST-CTN application will understand the user's ability to cross a road within the given timeframe and be able to request an extension for the user if needed.

The ST-CTN system will use the ATL RIDES app to broadcast personal safety messages to connected vehicles and connected intersections. The Gwinnett County CVTMP identifies safety messages that will be broadcast when a pedestrian phase is active to nearby vehicles. The ST-CTN application will also be able to receive messages if a connected transit vehicle is approaching the user. These features will improve on the current system and provide a safer environment for vulnerable road users.

### 4.1.4 Data

One of the most consistent issues faced by travelers, especially those with disabilities, is a lack of information on the accessibility of their trip. ST-CTN will give travelers much more data about their trip to make the best decision for them. GA Tech's STM and SidewalkSim will be critical in this area. Detailed information about sidewalk conditions is not readily available over much of the region and at all in the project area. Creating a system for collecting this data efficiently will enable all areas in the region to have a more complete sidewalk and asset data set.

The data collected through ST-CTN is critical for the success of the project. Particularly for people with disabilities and aging adults, information regarding the infrastructure along a trip route can give travelers a higher level of confidence that they will be able to complete their trip. Without this information travelers may encounter an obstacle that forces them to take a long detour or force them to return home. Providing as much information to the traveler is the crux of the ST-CTN system and key to a flexible transportation system that serves all.

### 4.1.5 Expectations of the Proposed Concept

The proposed system offers an opportunity to better support underserved communities with increased mobility, safety, and information about their trips; expand the existing infrastructure asset management system that is available to Gwinnett County through crowdsourced data collection options; and increase the reliability of transit service within the project study area. By having additional information about their trip options, the underserved community will be able to increase their safety and mobility, thereby increasing their economic and social opportunities. By crowdsourcing data collection, Gwinnett County will be able to better manage their infrastructure assets within the project study area. By increasing the deployed technology within GCT's network, an increase in on-time performance and service is expected.

**Table 9** provides a summary of the expected benefits for the systems users.

**Table 9. System Users' Expected Benefits**

| User Classification | Expected Benefits of Proposed Concept |
|---|---|
| End User | • Improved trip planning capability.<br>• Turn by turn directions that consider user's preferences and abilities.<br>• Real-time information on transit vehicle status.<br>• Accessibility features within application including haptic feedback, hands free mode, and sensory adjustments.<br>• TSP activation if a bus is running behind while a person with a disability or older adult is waiting for service.<br>• TSP activation to catch up to schedule if an end user needs additional time to board or alight a bus.<br>• Adequate time provided when boarding and alighting transit vehicles.<br>• Pedestrian phase time extension at signal crossings.<br>• Increased visibility near roadways through CV technology.<br>• Ability to automatically request transit service, based on the programmed trip plan, to board or alight a bus.<br>• Ability to remotely request transit service, through a mobile device, to board or alight a bus.<br>• Indoor space navigation information. |
| Gwinnett County Department of Transportation | • Enhanced asset management of pedestrian infrastructure from initial mapping and crowdsourced data collection. |
| Gwinnett County Transit | • TSP activation if a bus is running behind while a person with a disability or older adult is waiting for service.<br>• TSP activation to catch up to schedule if an end user needs additional time to board or alight a bus. Enhanced asset management of transit infrastructure through crowdsourced data collection.<br>• Transit operators have enhanced situational awareness in case of emergency by knowing if a transit user requires additional support. |

*Source: ARC*

## 4.2 Description of Desired Changes

Identifying user needs is one of the first steps taken when beginning the systems engineering process. Well written user needs provide a foundation for all subsequent systems engineering processes and are of critical importance to the success of the ST-CTN project. System needs, system requirements, and design elements are traced to identified user needs, so developing a thorough list of user needs at the onset of the project allows all subsequent processes to flow smoothly. User needs also provide future stakeholders, IOOs, and SDs with the rationale for decisions that were made previously in the systems engineering process.

IEEE 1362-1998 Guide for Information Technology – System Definition – Concept of Operations Document defines a user need as: "a user requirement for a system that a user believes would solve a problem experienced by the user," noting that the use of word "requirement" here does not imply system requirements. A user need is an expression of a required capability of the system, expressed in general (i.e., non-solution oriented) terms. To ensure that user needs are well written, the following criteria is applied to each user need:

- **Uniquely Identifiable.** Each need must be uniquely identified (i.e., each need shall be assigned a unique number and title).
- **Major Desired Capability (MDC).** Each need shall express an MDC in the system, regardless of whether the capability exists in the current system or situation or if there is a gap.
- **Solution Free.** Each need shall be solution free, thus giving designers flexibility and latitude to produce the best feasible solution.
- **Capture Rationale.** Each need shall capture the rationale or intent as to why the capability is needed in the system.

The ST-CTN project team conducted stakeholder engagement in the form of user needs interviews with advocacy groups and representatives from underserved communities to:

- Gain insight and an understanding of mobility and technology challenges and needs that are experienced during travel
- Understand the priorities and greatest obstacles facing stakeholders related to travel
- Learn about existing solutions and activities that individuals use to address their challenges and needs today

Through the process of identifying user needs, the ST-CTN team identified what project stakeholders, specifically those from the underserved community, need from the proposed system. 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. To ensure that the entire trip was discussed, discussions occurred around the distinct segments or steps of a complete trip, including:

**Step 1** **Pre-Trip Planning.** The traveler will interact with the trip plan and receive turn by turn directions based on their user profile. The route can avoid obstacles such as rough sidewalks, curbs without adequate ramps, and inadequate drop-off/pickup points.

**Step 2** **Begins Trip.** The traveler will begin their trip and follow turn by turn directions along their safe and accessible route.

**Step 3** **Transition to Transit.** The traveler’s transit vehicle and driver will be notified of the travel request and given priority along the route if conditions require, such as inclement weather or in the case of a traveler needing additional time to board the bus. The traveler will be alerted to estimated wait times and any trip modifications.

**Step 4** **Intersection Crossing.** When a traveler is required to cross an intersection, a message will be placed to the signal controller to extend the pedestrian phase in the direction of travel.

**Step 5** **CV Broadcast Message.** The traveler will be recognized by the CV infrastructure located at signalized intersections and the RSU will broadcast BSMs to alert of pedestrian/bicyclist in vicinity.

**Step 6** **Outdoor/Indoor Navigation.** The traveler will be provided with turn by turn directions along a safe and accessible route. This includes navigating the closest, accessible paths for outdoor navigation. Accessible building entrances and indoor navigation information such as building entrances, elevators, escalators, and connecting paths will be provided for key facilities within the ST-CTN project area.

Underserved communities were represented by members of advocacy groups such as the SILCGA, ARC’s Aging and Independence Service Group, CPACS, and others. Hour long user needs interviews were conducted with groups of 3 to 7 stakeholders (not counting ST-CTN team members). To focus appropriately on the needs of the end users, the interview sessions were separated into mobility challenged groups (including cognitive disability, physical disability, and aging adults) and LEP groups. The challenges and needs of low-income communities were discussed during all user needs interviews, understanding that these underserved populations sometimes overlap in nature and that the stakeholders were able to provide insight related to low-income communities as well. Interviews were led by trained, local facilitators who have experience engaging underserved communities and have an ongoing relationship with regional and national advocacy groups that represent them.

The user needs interviews and a review of the literature were used to outline existing challenges and needs. This information was captured and categorized within the anticipated relevant trip segment that was described. Based on inputs, needs statements were defined. As needs were reviewed and consolidated, the project team identified that there was a relationship between many of the needs. To help organize the user needs, a parent child relationship was identified in which child needs have a hierarchal relationship to parent needs. Each need statement has been given a unique identifier with the following nomenclature:

AB-CD-E.F.G, where:

- AB = Need Area / Trip Segment
    - PT = Pre-Trip Planning

  - BT =Begin Trip
  - TT = Transition to Transit
  - IC = Intersection Crossing
  - CV = Connected Vehicle Broadcast Message
  - NV = Indoor/Outdoor Navigation
  - RP = Reporting
  - FT = Future Development
- CD = User Classification
  - EU = End User
  - OO = Owner / Operator
  - SY = System
- E = Need Area Number
- F = Need Statement Number
- G = Child Statement Number (if applicable)

Child statement numbers were applied to needs that were similar in nature to one another and were grouped under a need statement number. An example of this is the need statement "Travelers need personalized trip information that accommodates their preferences and abilities." Child needs include the need for information that considers the dimensions of the infrastructure, the need for information that considers temporary or permanent obstructions of the infrastructure, and the need for information that considers the dimensions of infrastructure within buildings. The child needs help define the scope of each need statement they are applied to.

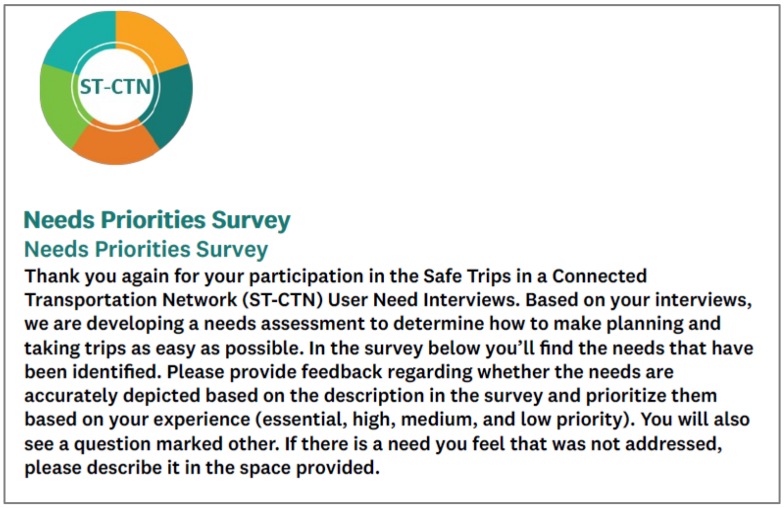
The next sections present the identified user needs – end user needs, IOO needs, and system needs. All user needs have been given a unique ID to allow for traceability throughout the project. The user needs will dictate the proposed concepts discussed in this ConOps document. The user needs documented herein will be used to drive the system requirements and validate the system design after deployment. It is anticipated that user needs will continue to be refined over the life of the concept development phase; the ConOps document will be a living document and will be updated to reflect need refinements and additions.

### 4.2.1 Priorities Among Changes

End User, IOO, and System needs have been classified as essential, desirable, or optional in their respective tables in **Section 4.2.2, Section, 4.2.3** and **Section 4.2.4**. The essential, desirable, and optional priorities are defined as such:

- **Essential Needs.** Needs that shall be provided by the new system.
- **Desirable Needs.** Needs that should be provided by the new system.
- **Optional Needs.** Needs that might be provided by the new system.

User needs interviews with end users and advocacy groups who represent underserved communities were conducted to gain insight on mobility and technology needs and challenges experienced throughout a persons' complete trip. After the completion of the user needs interviews and development of the end user need statements, the participants of the user needs interviews were asked to review the end user need statements in the form of a survey. Survey participants were asked to provide feedback regarding whether the needs were accurately depicted and to prioritize them based on their experience.




**Needs Priorities Survey**

**Needs Priorities Survey**

**Thank you again for your participation in the Safe Trips in a Connected Transportation Network (ST-CTN) User Need Interviews. Based on your interviews, we are developing a needs assessment to determine how to make planning and taking trips as easy as possible. In the survey below you'll find the needs that have been identified. Please provide feedback regarding whether the needs are accurately depicted based on the description in the survey and prioritize them based on your experience (essential, high, medium, and low priority). You will also see a question marked other. If there is a need you feel that was not addressed, please describe it in the space provided.**

*Source: ARC*

**Figure 16. Needs Priority Survey Introduction**

Upon receiving the results of the survey, a meeting was held with the ST-CTN technical team which included the EMT, system developers, and IOOs to discuss the survey results and finalize the end user need statements and need priorities. The end user need priorities guided the priorities of the IOO and system needs.

Needs that were classified as essential were deemed critical to the operation of the application or safety of the end user by the stakeholders and technical team. If these needs are not accounted for in the final system, the possibility of application failure increases and the level of safety of the end user decreases.

Needs that were classified as desirable were deemed as quality of life improvements or marginal increases to the safety of end users by the stakeholders. In some cases, these needs are outside of the scope of the project or will be included in future updates. If these needs are not accounted for in the final system, the application will run as intended and the level of safety of the end user will not decrease.

Only a single need was classified as optional, the need for the application to consider current weather conditions along the planned route. This need does not apply to the project area where ST-CTN is being deployed but could be considered valuable to future project areas that suffer from winter weather conditions that may produce hazardous conditions.

## 4.2.2 End User Needs

The following table provides a summary of the end user needs, associated justification for those needs, and priority (essential, desired, and optional). More information regarding the prioritization process is provided in **Section 4.2.1**. These needs are based on the literature review and a series of user needs interviews with end users and advocacy groups who represent underserved communities. Any modifications to end user needs will be reflected in this ConOps document through the life of the project.

**Table 10. End User Needs**

| Need ID | End User Need Statement | Priority |
|---|---|---|
| Pre-Trip Planning (PT)<br>PT-EU-1.1 | Travelers need personalized trip information that accommodates their preferences and abilities. | E |
| PT-EU-1.1.1 | Travelers need personal trip information that considers the dimensions, conditions, and status of outdoor facilities and physical infrastructure. Travelers using public right of ways such as shared use paths and sidewalks need to ensure that the planned trip considers the dimensions, safe intersections (curb cuts, traffic and pedestrian signals, etc.), conditions, and status to ensure that the traveler can complete the trip based on their preferences and abilities. | E |
| PT-EU-1.1.2 | Travelers need personal trip information that considers temporary and permanent obstructions (e.g., cafes, store signs) along their planned trip that limit their access along public right of ways. Travelers using public right of ways such as shared use paths and sidewalks need to ensure that the planned trip considers permanent obstructions such as protrusions from the surface, side of buildings or above, broken and undulating paths, and temporary detours and pop-up obstructions to ensure that the traveler can complete the trip based on their preferences and abilities. | E |
| PT-EU-1.1.3 | Travelers need personal trip information that considers the dimensions, conditions, and status of facilities and physical infrastructure within buildings and public spaces along their planned trip. Travelers accessing public buildings and spaces need to ensure that the planned trip considers the dimensions, conditions, and status of facilities within buildings and public spaces to ensure that the traveler can complete the trip based on their preferences and abilities. | D |
| PT-EU-1.1.4 | Travelers need personal trip information that considers the Americans with Disabilities Act (ADA) compliance of building entrances along their planned trip. Travelers accessing public buildings need to ensure that the planned trip considers the ADA compliance of building entrances to ensure that the traveler is rerouted to an accessible entrance or that the traveler is able to complete the trip based on their preferences and abilities. | E |

| Need ID | End User Need Statement | Priority |
|---|---|---|
| PT-EU-1.1.5 | Travelers need personal trip information that considers the current weather conditions along their planned trip. Travelers need to ensure that the planned trip considers the current weather conditions to ensure that the traveler can complete the trip based on their preferences and abilities. | O |
| PT-EU-1.1.6 | Travelers need personalized trip information to consider the accessibility features (i.e. chair lift, ramp, internal widths) that transit vehicles have which will accommodate their needs/preferences. For example, Travelers with mobility disabilities and older adults using assistive devices, such as wheelchairs, walkers, etc. or travelers with support attendants (including service animals) need to ensure that vehicles can accommodate their preferences. | E |
| PT-EU-1.1.7 | Travelers traveling in a group need the ability to set preferences to group travel. Travelers who are traveling with a group of people that have different abilities and preferences need to be able to temporarily augment their own abilities and preferences to ensure that the group of travelers can complete the trip based on the group preferences and abilities. Temporary needs would remain active until the user disables them. | D |
| PT-EU-1.1.8 | Travelers need their personally identifiable information (PII) to be secure and private. | E |
| PT-EU-1.1.9 | Travelers need, when traveling on fixed route or transit on-demand services separate from Gwinnett County Transit, personalized trip information to consider the accessibility features (i.e. chair lift, ramp, internal widths) that vehicles have that accommodate their needs/preferences. For example, travelers with mobility disabilities and older adults using assistive devices (e.g., wheelchairs, walkers, etc. or travelers with support attendants including service animals) need to ensure that vehicles can accommodate their needs. | O |
| PT-EU-1.2 | Travelers need the ability to customize their App accessibility features to accommodate their abilities. | E |
| PT-EU-1.2.1 | Travelers with vision loss need the ability to customize their App accessibility features to accommodate their abilities. Travelers need the App to be able to provide audio, audio-described graphics, and haptic feedback or audio alerts to assist them in navigating a complete trip. | E |
| PT-EU-1.2.2 | Travelers with hearing loss need the ability to customize their App accessibility features to accommodate their abilities. Travelers need the App to be able to provide text based or haptic feedback alerts to assist them in navigating a complete trip. | E |
| PT-EU-1.2.3 | Travelers need the ability to receive alerts from the App on their preferred device or tool including wearable devices, hearing device, connected canes, etc. This allows travelers to access information from the App using devices and/or tools that the traveler is familiar using when navigating the trip. | E |

| Need ID | End User Need Statement | Priority |
| --- | --- | --- |
| PT-EU-1.2.4 | Travelers with sensory sensitivity, including sensitivity to vibration, sounds, or lights need the ability to customize their App accessibility features to accommodate their preferences. This allows travelers with sensory sensitivity to access the App in a way that accommodates their preferences and abilities to assist them in navigating a complete trip. | E |
| PT-EU-1.2.5 | Travelers need the ability to access the app in a hands-free mode if they are unable to hold or manipulate the cell phone during the entire trip. This allows travelers to update their trip configuration or preferences using hands free features in a way that accommodates their preferences and abilities to assist them in navigating a complete trip. | E |
| PT-EU-1.2.6 | Travelers with low reading levels need to be able to customize their App accessibility features to accommodate their abilities. Travelers need to be able to receive information from the App that does not require a high reading level. Potential means for conveying this information might include image-based instructions and routing descriptions, pictures of landmarks to guide their routing decisions, or visualizations of boarding or alighting locations in a way that accommodates their preferences and abilities to assist them in navigating a complete trip. | E |
| PT-EU-1.2.7 | Travelers need the ability to pay for transit trips through the App. Travelers with physical or cognitive disabilities may have difficulties paying the fare when boarding the bus and the ability to pay the fare using the App or through proximity sensors allows the traveler to be accommodated based on their preferences and abilities. | D |
| PT-EU-1.2.8 | Travelers need the ability to preview route choices, location information, all entrances to their destination building, and potentially practice routing choices or entire trip segments in order to be able to make new and unfamiliar trips. | E |
| PT-EU-1.2.9 | Travelers with LEP need information regarding the route provided through visualizations or landmarks, mapping, or turn by turn directions. Travelers need to be able to receive information from the App that does not require a high level of proficiency with the English language such that they can understand the directions and navigate their complete trip. Potential means for conveying this information might include image-based instructions and routing descriptions, pictures of landmarks to guide their routing decisions, or visualizations of boarding or alighting locations. | E |
| Begin Trip (BT)<br>BT-EU-2.1 | Travelers need support services during trip planning and traveling based on their preferences and abilities. | E |
| BT-EU-2.1.1 | Travelers need the ability to talk or interact with support personnel during their trip to help them if they have difficulties processing information, are unfamiliar with the App, or get easily disoriented during routing. | E |

| Need ID | End User Need Statement | Priority |
|---|---|---|
| BT-EU-2.1.2 | Travelers need to be able to share their location with support personnel or caregivers during their trip who can help them if they become disoriented or require assistance while completing their planned trip. | E |
| BT-EU-2.1.3 | Some travelers with cognitive or physical disabilities, need to have the transit vehicle operator know about their conditions in case of an incident. Travelers may be nonverbal, have triggers, or be unable to move quickly. The transit vehicle operator will be able to assist the traveler better by having this information available to them through onboard device or through a dispatcher. | E |
| BT-EU-2.1.4 | Travelers need to have additional information including stop announcements, provided to them through the use of the App, particularly if they have difficulty or are unable to engage with transit operators due to auditory or cognitive disabilities. | E |
| BT-EU-2.2 | Travelers need to receive personalized information and alerts during their trip in a way that is accessible to them. | E |
| BT-EU-2.2.1 | Travelers need the App to be able to provide real-time, turn-by-turn updates to trip progress and routing choices. Some travelers required specific feedback about their trip progress and path and require additional time to understand routing changes. These alerts need to be personalized for each traveler and will ensure that travelers are safely able to navigate their trip. | E |
| BT-EU-2.2.2 | Travelers need to be able to receive alerts while executing their trip that alerts them to situations where they are off their route, alerts them when they are getting close to a landmark, or alerts them if they are going the wrong way. These alerts need to be personalized for each traveler and will ensure that travelers are safely able to navigate their trip. | E |
| BT-EU-2.2.3 | Travelers need the App to be able to provide real-time updates on route conditions that may prevent the traveler from completing their trip. Sidewalk, path, transit service, and indoor infrastructure (e.g., out-of-order elevators or escalators) can change during the course of travel; the App needs to be able to provide this information, when available, to travelers who are currently navigating their trip based on their personalized information to ensure they are able to successfully complete it. | D |
| BT-EU-2.2.4 | Travelers need to receive information from the App based on their personalized information prior to boarding or alighting a transit vehicle that conveys information about the transit vehicle and informs the travelers that they are getting on the right transit vehicle or alighting at the right stop. Some travelers may have difficulty or be unable to recognize the correct transit vehicle or the correct departure point without additional information being provided by the App, ensuring that they are able to complete their trip successfully. | E |

| Need ID | End User Need Statement | Priority |
|---|---|---|
| BT-EU-2.2.5 | Travelers need personalization options for notifications and alerts that are sent to the traveler. Some travelers associate different meanings to words or phrases based on cognitive disabilities or language barriers. Allowing the travelers to personalize the messages they receive will ensure that they are able to successfully navigate their trip. | D |
| BT-EU-2.2.6 | Travelers need the ability to opt-in to functions on the app such as preferred mobile device or method of communications, alerts, automated requests, tracking, off-line navigation, notifications to third-parties, support types, etc. so that they may manage and receive information in a manner that is safe and comfortable for them during their travel. | E |
| Transition to Transit (TT)<br>TT-EU-3.1 | Travelers need the ability to communicate with transit infrastructure and transit vehicle operators to ensure adequate time to board or alight a transit vehicle based on their abilities. | E |
| TT-EU-3.1.1 | Travelers need to communicate with transit infrastructure, including transit vehicle operators, if they require additional time to board or alight a transit vehicle based on their abilities. | E |
| TT-EU-3.1.2 | Travelers need to communicate with transit infrastructure, including transit vehicle operators, if they require assistance to board or alight a transit vehicle (e.g., transit ramp or lift) based on their abilities. | E |
| TT-EU-3.1.3 | Travelers need to communicate with transit infrastructure, including transit vehicle operators, if they require additional time to pay for transit vehicle services after boarding a vehicle. | D |
| TT-EU-3.1.4 | Travelers need to communicate with transit infrastructure, including transit vehicle operators, if they require priority access to designated areas of seating within the bus such as areas with wheelchair tie downs or priority seating at the front of the bus. | E |
| TT-EU-3.1.5 | Travelers need to communicate with transit infrastructure, including transit vehicle operators, if they require additional time to navigate the interior of the transit vehicle to get to a seat or alight the vehicle. | D |
| TT-EU-3.1.6 | Travelers need to communicate with transit infrastructure, including transit vehicle operators, if they have difficulty operating mobility assistance devices on the transit vehicle and need support and assistance from the transit vehicle operator. | D |
| TT-EU-3.1.7 | Travelers need the ability to remotely request service from a transit vehicle while waiting to alight. Some travelers may have difficulty operating transit vehicle equipment, such as a stop request cord or button, to notify the operator that a stop is required, and therefore need the ability to do so through the App. | D |
| Intersection Crossing (IC)<br>IC-EU-4.1 | Travelers need the ability to communicate with infrastructure and CVs at signalized crosswalks beyond the currently existing push buttons. | D |

| Need ID | End User Need Statement | Priority |
|---|---|---|
| IC-EU-4.1.1 | Travelers need the ability to communicate with connected intersections at signalized crosswalks when they require additional time to cross the road. | D |
| IC-EU-4.1.2 | Travelers need the ability to communicate with connected intersections at signalized intersections to receive additional information about the crossing time and other characteristics of the signalized crossing. | D |
| IC-EU-4.1.3 | Travelers need the ability to communicate “hands-free” with signalized crosswalk infrastructure requesting the appropriate crossing signal if they are not able to reach or press a crosswalk push button. | D |
| Connected Vehicle Broadcast Message (CV)<br>CV-EU-5.1 | Travelers need the ability to remotely request transit service while waiting or traveling to a transit stop. | D |
| CV-EU-5.1.1 | Travelers need the ability to remotely request service from a transit vehicle while waiting at a stop. Some travelers may have difficulty indicating to an approaching transit vehicle that they require service, and therefore need to be able to submit a request through the App. | D |
| CV-EU-5.1.2 | Travelers need the ability to remotely request service from a bus while traveling to a stop internally in a transit hub. Some travelers may need additional time transferring between modes or transit services in a given amount of time and the ability to request service in route and would ensure that travelers are able to complete their trip. | D |
| CV-EU-5.2 | Travelers need the ability to alert CVs to their presence at marked crossings and transit stops. | D |
| CV-EU-5.2.1 | Travelers need the ability to communicate their presence when crossing the road, at marked or unmarked crosswalks, to CVs. Some travelers may not be visible to CVs while crossing the road. | D |
| CV-EU-5.2.2 | Travelers need the ability to be notified of approaching vehicles while navigating through their complete trip. Some travelers may have difficulties seeing and identifying oncoming vehicles and need additional feedback from the App when one is approaching. | D |
| Indoor/Outdoor Navigation (NV)<br>NV-EU-6.1 | Travelers need accurate information to successfully navigate indoor spaces. | D |
| NV-EU-6.1.1 | Travelers with physical disabilities need information about accessible building entrances in order to successfully navigate new spaces. | D |
| NV-EU-6.1.2 | Travelers need assistance navigating through indoor spaces they are unfamiliar with or that may be under changing conditions such as construction or service outages, and therefore need accurate information to successfully navigate indoor spaces. | D |

| Need ID | End User Need Statement | Priority |
|---|---|---|
| NV-EU-6.1.3 | Travelers need to know when buildings are open to the public, so they are able to determine if an accessible path, sometimes with access to elevators or escalators, is available, and therefore need accurate information to successfully navigate indoor spaces. | D |
| Reporting (RP) RP-EU-7.1 | Travelers need the ability to provide feedback on infrastructure and services. | D |
| RP-EU-7.1.1 | Travelers need to have the ability to provide feedback on infrastructure and services if they notice an elevator or escalator service outage that is not currently identified through the App. | D |
| RP-EU-7.1.2 | Travelers need to have the ability to provide feedback on infrastructure and services if they notice inaccessible sidewalks due to construction, grades, vegetation, or other obstructions that are not currently identified through the App. | D |
| RP-EU-7.1.3 | Travelers need to have the ability to provide feedback on infrastructure and services if they notice transit service outages that are not currently identified through the App. | D |
| RP-EU-7.1.4 | Travelers need to have the ability to provide feedback on infrastructure and services if they notice issues with the App that have not been previously identified and addressed. | D |

*Source: ARC*

### 4.2.3 Infrastructure Owner / Operator Needs

The following table provides a summary of the IOO needs, associated justification for those needs, and priority (essential, desired, and optional). More information regarding the prioritization process is provided in **Section 4.2.1**. These needs are primarily driven by existing county and regional plans as well as identified end user needs. IOO interviews were held to discuss existing infrastructure and systems; during this time, key end user needs were shared and IOO needs were identified. Any modifications to IOO needs will be reflected in this ConOps document through the life of the project.

**Table 11. IOO Needs**

| Need ID | IOO Need Statement | Priority |
|---|---|---|
| Pre-Trip Planning (PT) PT-OO-1.1 | Gwinnett County Department of Transportation (GCDOT) and Gwinnett County Transit (GCT) need to provide all travelers real-time, secure, and reliable travel information to support safe, complete trip planning and navigation, especially for underserved communities. [GCTP-4] | E |
| PT-OO-1.2 | Infrastructure Owner Operators need to protect travelers' personal information by ensuring that any PII data is safe, secure, and private. | E |

| Need ID | IOO Need Statement | Priority |
|---|---|---|
| Transition to Transit (TT)<br><br>TT-OO-3.1 | Transit operators need more information about their riders' preferences and abilities to better serve them; particularly people with disabilities and people with limited English proficiency (LEP). | D |
| TT-OO-3.2 | To support the use of transit, GCT needs to improve travel time reliability, including bus speeds and reliability for several transit routes. [CVTMP] | D |
| TT-OO-3.3 | To improve pedestrian safety hailing an approaching transit vehicle, or boarding or alighting a transit vehicle, a connected vehicle (CV) application needs to notify the connected bus and infrastructure about a person with a disability currently boarding or alighting the vehicle. [CVTMP] (related CV applications include: Transit Vehicle at Station/Stop Warnings, Transit Stop Request, Transit Pedestrian Indication) | D |
| Intersection Crossing (IC)<br><br>IC-OO-4.1 | Connected intersections need to improve safety and mobility of vulnerable road users as they approach and cross the intersection. The Gwinnett County CVTMP (CVTMP) describes near-term application deployments to achieve this near-term need including: Mobile Accessible Pedestrian Signal System (PED-SIG) as well as long-term applications such as Pedestrian Mobility, and Pedestrian in Signalized Crosswalk Warning. | E |
| IC-OO-4.2 | To improve pedestrian safety at crosswalks, a CV application needs to create a more detailed alert to communicate the presence of pedestrian activities at crosswalks including information such as crosswalk occupancy, direction of travel, speed, and whether the crosswalk is clear of pedestrians. [CVTMP, p., 35] (related CV applications include: PED-SIG, Pedestrian in Signalized Crosswalk Warning, and Pedestrian Mobility) | E |
| CV-OO-5.1 | To communicate the location of intersections that support the connected vehicle safety strategies for pedestrians and transit, the County needs to inventory and disseminate the locations of intersections that support Multimodal Intelligent Traffic Signal System (MMITSS) applications including PED-SIG, Transit Signal Priority (TSP), and other related CV applications. | E |
| Connected Vehicle Broadcast Message (CV)<br><br>CV-OO-5.2 | An optimized signal system needs to accommodate signal priority for transit movement through a signalized intersection based on conditional criteria such as vehicle loads or schedule adherence in order to improve operating performance of the transit vehicles. Related CV applications include Intelligent Traffic Signal System (I -SIG), MMITSS and TSP. [CVTMP] | D |

| Need ID | IOO Need Statement | Priority |
|---|---|---|
| Indoor/Outdoor Navigation (NV)<br><br>NV-OO-6.2 | To generate personalized and accessible indoor and outdoor trip plans and event notifications, Gwinnett County needs to manage static and dynamic information on pathway assets, conditions and states that include accessible entrance, indoor navigable routes, elevator and escalator status, and signalized intersections with pedestrian crossing signals. | E |
| Reporting (RP)<br><br>RP-OO-7.1 | Gwinnett County needs to collect current bus stop accessibility and shelter conditions and make that information accessible to travelers. | E |
| RP-OO-7.1.1 | Gwinnett County needs to collect inventory on bus stops/shelter assets' condition including accessibility for boarding and alighting transit vehicles at stop locations and accessible approaches to bus stop and station / hub locations and share with travelers who need updated information on the condition of transit stops in order to make a complete trip based on their preferences and abilities. | E |
| RP-OO-7.1.2 | Gwinnett County needs to disseminate information on bus stops and shelter assets and condition including accessibility for boarding and alighting transit vehicles at stop locations such that travelers may use updated information on the condition of transit stops in order to make a complete trip based on their preferences and abilities. | E |
| RP-OO-7.1.3 | Gwinnett County needs to disseminate information to inform travelers about accessible approaches to bus stop and station / hub locations such that travelers may use updated information on the condition of transit stops in order to make a complete trip based on their preferences and abilities. | E |
| RP-OO-7.1.4 | Gwinnett County needs to complete the Gwinnett County ADA Transition Plan and replace, repair, upgrade inadequate transit infrastructure (i.e., sidewalks, county building entrances, bus stops and shelters) as outlined in their plan so that all travelers may complete trips safely throughout the county.7 | D |
| Future Development (FT)<br><br>FT-OO-8.1 | Gwinnett County and GDOT CV infrastructure needs to establish guidelines for deploying new and evolving technology to support leveraging advances in technology while balancing scalability and use of existing and future applications. | D |
| FT-OO-8.2 | Gwinnett County and GDOT CV infrastructure and strategy implementation must be compatible with one another and set a standard approach for replicating similar applications by local agencies across the state. The purpose of the ST-CTN project is to be replicable throughout the region and the implementation of conflicting strategies or technologies would degrade its ability to be replicable. | D |

*Source: ARC*

### 4.2.4 System Needs

The following table provides a summary of the system needs, justification for those needs, priority (essential, desired, and optional), and associated end user and IOO needs. More information regarding the prioritization process is provided in **Section 4.2.1**. The end user needs, along with the IOO needs drive the system needs. System needs were developed through an iterative process in which a technical team of ST-CTN executive management team (EMT) and system developers considered end user needs, IOO needs, and actions of the proposed system that would be required to support the end user and IOO needs. System needs were derived to support these actions, end user, and IOO needs. Some system needs are not mapped directly to a user need or IOO need; rational has been included for these system needs to explain the process behind their development. System needs are summarized in **Table 12**.

The system needs identified below will drive the development of the system requirements. Traceability of system requirements will be ensured during the concept development, design, and deployment phases of the ST-CTN project. Any modifications to system needs will be reflected in this ConOps document through the life of the project.

**Table 12. System Needs**

| Need ID | System Need Statement | Priority | Associated End User and IOO Need |
|---|---|---|---|
| Pre-Trip Planning (PT)<br><br>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. | E | PT-EU-1.1.8<br>BT-EU-2.1.2<br>BT-EU-2.2.5<br>BT-EU-2.2.6<br>PT-OO-1.2 |
| 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. | E | BT-EU-2.1.2<br>BT-EU-2.2.1<br>BT-EU-2.2.5<br>BT-EU-2.2.6<br>PT-OO-1.1 |
| 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). | E | PT-EU-1.1.1<br>PT-EU-1.1.2<br>PT-EU-1.1.3<br>PT-EU-1.1.4<br>PT-EU-1.1.5<br>PT-EU-1.2.5<br>PT-EU-1.2.6<br>PT-EU-1.2.9<br>BT-EU-2.2.3 |
| PT-SY-1.4 | The system needs to allow travelers to customize the UI of the application based on their abilities or preferences. | E | PT-EU-1.2.1<br>PT-EU-1.2.2<br>PT-EU-1.2.3<br>PT-EU-1.2.4<br>PT-EU-1.2.5<br>BT-EU-2.2.1<br>PT-OO-1.1 |

| Need ID | System Need Statement | Priority | Associated End User and IOO Need |
|---|---|---|---|
| PT-SY-1.5 | The system needs to have an option of adding additional travelers and their accessibility needs when planning a trip. | D | PT-EU-1.1.7<br>BT-EU-2.1.1<br>BT-EU-2.1.2<br>BT-EU-2.1.3 |
| 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. | D | PT-EU-1.2.8 |
| Begin Trip (BT)<br><br>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. | E | - |
| 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. | E | - |
| 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. | E | - |
| 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. | E | - |
| 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. | E | BT-EU-2.2.1<br>BT-EU-2.2.2 |
| BT-SY-2.3 | The system needs to be compatible with open standards that are embedded or used in devices including mobile phones and connected assistive devices. | D | PT-EU-1.2.1<br>PT-EU-1.2.2<br>PT-EU-1.2.3<br>PT-EU-1.2.4<br>PT-EU-1.2.5 |

| Need ID | System Need Statement | Priority | Associated End User and IOO Need |
|---|---|---|---|
| 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. | E | PT-EU-1.2.1<br>PT-EU-1.2.2<br>PT-EU-1.2.3<br>PT-EU-1.2.4<br>PT-EU-1.2.5<br>BT-EU-2.2.1<br>BT-EU-2.2.2<br>BT-EU-2.2.5<br>PT-OO-1.1 |
| 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. | E | BT-EU-2.1.2<br>BT-EU-2.1.3 |
| 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. | E | PT-EU-1.1.1<br>PT-EU-1.1.2<br>PT-EU-1.1.3<br>PT-EU-1.1.4<br>PT-EU-1.1.5<br>BT-EU-2.1.3<br>BT-EU-2.1.4<br>BT-EU-2.2.1<br>BT-EU-2.2.2<br>BT-EU-2.2.3<br>BT-EU-2.2.4<br>BT-EU-2.2.5<br>BT-EU-2.2.6<br>TT-EU-3.1.1<br>TT-EU-3.1.2<br>TT-EU-3.1.3<br>TT-EU-3.1.4<br>TT-EU-3.1.5<br>TT-EU-3.1.6<br>TT-EU-3.1.7<br>CV-EU-5.1.1<br>CV-EU-5.1.2<br>NV-EU-6.1.1<br>NV-EU-6.1.2<br>NV-EU-6.1.3<br>PT-OO-1.1 |
| Transition to Transit (TT)<br><br>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. | E | TT-EU-3.1.1<br>TT-EU-3.1.3<br>TT-EU-3.1.5<br>CV-EU-5.1<br>TT-OO-3.2<br>CV-OO-5.2 |

| Need ID | System Need Statement | Priority | Associated End User and IOO Need |
|---|---|---|---|
| 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. | E | - |
| Intersection Crossing (IC)<br><br>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. | E | IC-IOO-4.2<br>IC-EU-4.1<br>CV-EU-5.1.1<br>CV-EU-5.1.2<br>CV-OO-5.2 |
| 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. | E | IC-IOO-4.1 |
| Connected Vehicle Broadcast Message (CV)<br><br>CV-SY-5.1 | The system needs to connect travelers to the connected infrastructure to increase safety. | E | IC-IOO-4.1<br>IC-IOO-4.2<br>CV-IOO-5.1 |
| 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). | E | CV-EU-5.2.1<br>IC-IOO-4.1<br>IC-IOO-4.2<br>CV-IOO-5.1 |
| CV-SY-5.1.2 | The system needs to detect that a traveler has exited the intersection to support pedestrian safety applications. | E | CV-EU-5.2.1<br>IC-IOO-4.1<br>IC-IOO-4.2<br>CV-IOO-5.1 |
| Indoor/Outdoor Navigation (NV)<br><br>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. | E | PT-EU-1.1.3<br>PT-EU-1.1.4<br>BT-EU-2.2.3<br>NV-EU-6.1.1<br>NV-EU-6.1.2<br>NV-EU-6.1.3<br>PT-OO-1.1<br>NV-OO-6.2<br>RP-OO-7.1 |

| Need ID | System Need Statement | Priority | Associated End User and IOO Need |
|---|---|---|---|
| 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. | D | PT-EU-1.1.3<br>PT-EU-1.1.4<br>NV-EU-6.1.2<br>NV-EU-6.1.3 |
| Reporting (RP)<br><br>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. | D | RP-EU-7.1<br>RP-OO-7.1 |
| 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. | D | RP-EU-7.1<br>RP-OO-7.1 |
| 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. | E | RP-EU-7.1<br>RP-OO-7.1 |
| Future Development (FT)<br><br>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. | D | FT-OO-8.1<br>FT-OO-8.2 |
| 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. | D | FT-OO-8.1<br>FT-OO-8.2 |
| FT-SY-8.1.2 | The system needs to be scalable such that other geographic areas may be included in the future. | D | FT-OO-8.1<br>FT-OO-8.2 |
| FT-SY-8.1.3 | The system needs to be scalable such that transit or other mobility on demand services may be integrated in the future – this includes the ability to book transit/mobility on demand trips less than 24 hours in advance. | D | FT-OO-8.1<br>FT-OO-8.2 |
| FT-SY-8.1.4 | The system needs to be scalable such that it can support future functionalities such as subsidized trip costs across multiple mobility options. | D | FT-OO-8.1<br>FT-OO-8.2 |

| Need ID | System Need Statement | Priority | Associated End User and IOO Need |
|---|---|---|---|
| FT-SY-8.1.5 | The system needs to be scalable to accommodate future growth, modifications, or integration with multiple services, including those that may be mobility service access rights from private sector agencies such as bikeshare, ridehailing, microtransit services or others. | O | FT-OO-8.1<br>FT-OO-8.2 |

*Source: ARC*

## 4.3 Changes Considered but Not Included

The majority of the desired changes identified by stakeholders were included in the user needs. In some cases, desired changes identified by stakeholders were outside the scope of the project or were not related to the proposed system. System developer and IOO needs were generated from the end user needs that were included in the Needs Summary Document, therefore, there are no desired changes identified by the IOO or System Developers that were not included.

**Table 13** provides a summary of changes that were considered based on end user feedback but were excluded from the proposed system.

**Table 13. Considered Changes Not Included**

| Need Area / Trip Segment | Need Statement | Reason for Omission |
|---|---|---|
| Pre-Trip Planning | Travelers with hearing loss need the ability to generate messages using graphical sign language. | The production team determined that it would be too difficult to generate all application outputs in this format. Additionally, it was determined that this feature would be underutilized, and that text could be used instead. |
| Pre-Trip Planning | Travelers need an expanded schedule of transit service hours. | It is outside of the scope of this project to expand the service hours or route configuration of existing fixed route and on-demand transit services. |
| Pre-Trip Planning | Travelers need the ability to customize application and maps based on their comfort level using mobile applications and maps. | The ATL RIDES application uses base mapping from OSMs. Although some features are customizable, the effort required to provide additional and on-demand customization is outside the scope of work for this program. Application customization features such as haptic feedback and alternative languages are covered in other needs. |

| Need Area / Trip Segment | Need Statement | Reason for Omission |
|---|---|---|
| Begin Trip | Travelers need better street lighting to complete their trip safely. | It is outside of the scope of this project to install or modify street lighting. |
| Transition to Transit | Transit vehicle operators need more training on the use of accessibility features and how to recognize and respond to users with mobility challenges. | It is outside of the scope of this project to provide training on accessibility features installed on transit vehicles or to provide training on how to recognize and respond to user specific mobility challenges. |
| Transition to Transit | CPACS microtransit vehicles need to have OBUs installed to allow for TSP or CV applications. | It is outside of the scope of this project to install OBUs on CPACS microtransit vehicles. |
| Transition to Transit | Providing information to operators on customers with disabilities (e.g., how to interact with travelers with cognitive disabilities) | It is outside of the scope of this project to provide training to bus drivers on how to recognize and respond to user specific mobility challenges. |
| Intersection Crossing | Travelers need safe intersections and interchanges constructed within the project area. | It is outside of the scope of this project to modify the entirety of an intersection. This project will identify areas of concern such as missing curb cuts or ramps. |
| Indoor/Outdoor Navigation | Travelers need doorway thresholds reduced and non-automatic door pressure to be reduced. | It is outside of the scope of this project to modify building entries. This project will identify areas of concern such as those listed. |
| Indoor Navigation | The addition of “talking signs” inside facilities to help travelers navigate. | It is outside the scope of this project to modify or install infrastructure within public or private indoor spaces. |
| Future Development | Transit stations need to be expanded to provide additional shelter and restrooms. | It is outside of the scope of this project to expand existing transit facilities. |
| Future Development | The application should include public amenities and partner with private companies to provide discounts or benefits for using the application. | It is outside of the scope of this project to provide these additional services. |

*Source: ARC*

## 4.4 Assumptions and Constraints

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 project progress as planned and on-schedule with all the capabilities needed to support the ST-CTN project.
- All connected vehicle infrastructure and applications will adhere to GDOT's Security Credential Management System (SCMS) which is compliant with IEEE 1609.
- 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 Federal Communication Commission (FCCs) rules for the use of the Safety Band.

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# 5. Concepts for the Proposed System

The proposed ST-CTN system is being developed to address the needs and challenges that have been expressed by end users, particularly those representing underserved communities. The new system is a result of end user, IOO, and system needs and desired capabilities as described in **Section 4**.

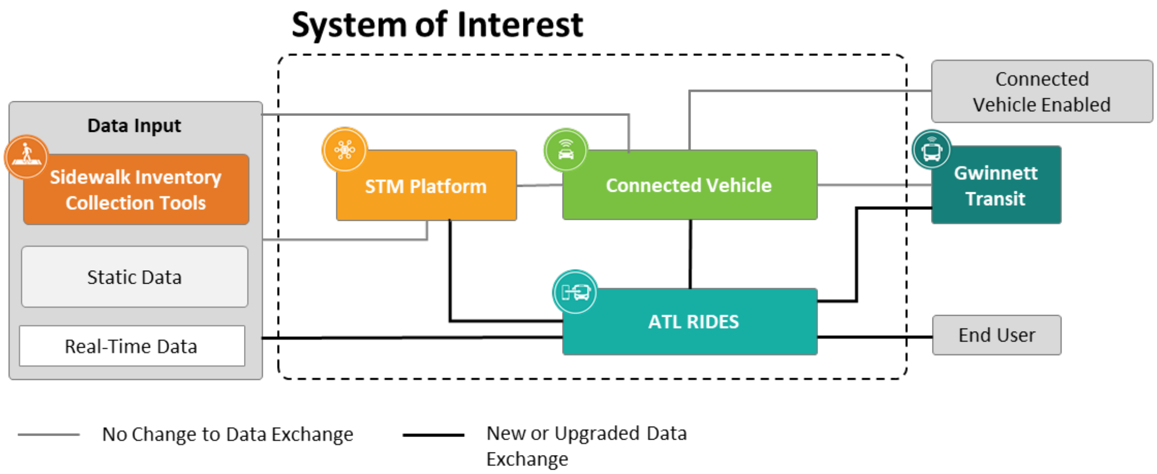
## 5.1 Background and Scope

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 limited English proficiency, and low-income travelers.*

ST-CTN system 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.

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 17** 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 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 Gwinnett County Transit existing independent systems will serve to support the proposed ST-CTN system. Data exchanges between subsystems are denoted by a gray or black line. A gray line indicates an existing and unchanged data exchange between subsystems. A black line indicates a new or upgraded data exchange between subsystems.

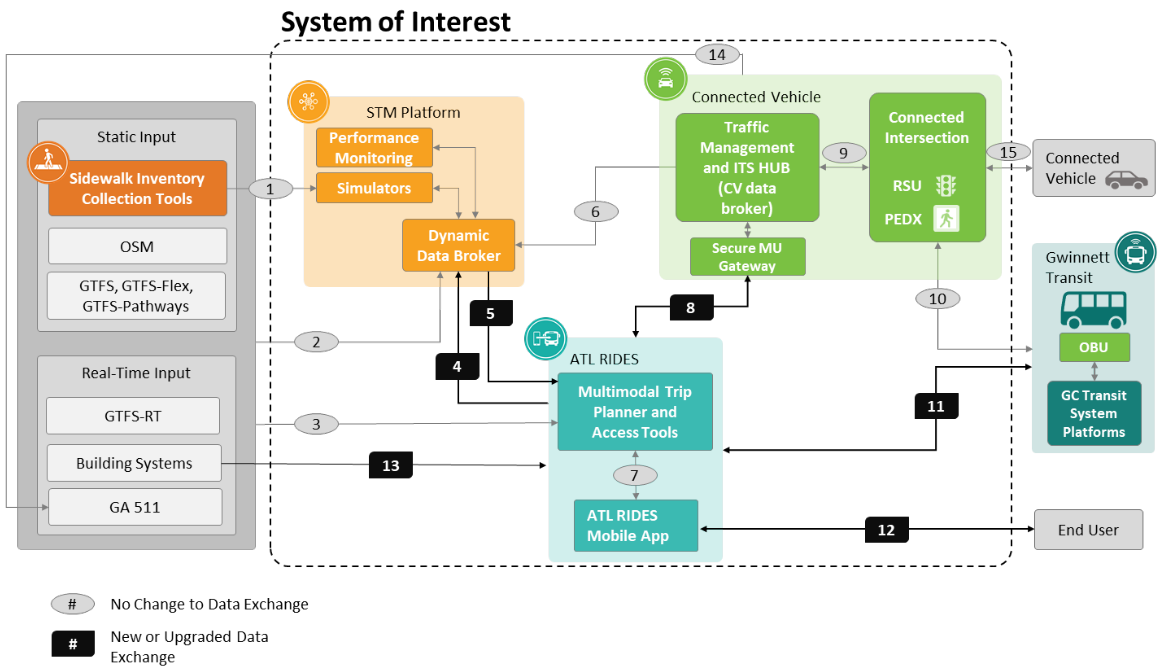



*Source: ARC*

**Figure 17. Safe Trip in a Connected Transportation Network Simplified Context Diagram**

## 5.2 Description of the Proposed System

The following section provides an overview of all the major aspects of the new system, focusing on those subsystems that will require expanded functionality and additional connectivity – ATL RIDES, STM Platform, and CV Program. In addition, system interfaces and interoperability as well as external system interfaces are described. Critical ST-CTN data exchanges are identified by number and color in the context diagram and correspond to the exchanges described in **Table 14**. These descriptions are focused only on the scope of work required to implement the new system and information that is necessary to provide context to that work. As described in **Section 3**, there are a number of existing and on-going efforts that are being performed outside the scope of this project that are critical to the success of ST-CTN. **Figure 18** provides the ST-CTN context diagram in more detail.




*Source: ARC*

**Figure 18. Safe Trip in a Connected Transportation Network Data Exchange Flow Diagram**

Critical ST-CTN data exchanges are identified by number in the context diagram above and described in **Table 14**. 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 14. Critical ST-CTN Connection Descriptions**

| Data Exchange 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 and trip feedback |
| 5 | STM Network Impedance API |
| 6 | CV and Traffic Operations Messages: SPaT, NaviGAtor ITS, road characteristics, traffic data |
| 7 | OTP APIs and ATL RIDES APIs |
| 8 | Mobile Accessible Pedestrian Signal System (PED-SIG) / Pedestrian Safety Message (PSM) |
| 9 | CV messages |

| Data Exchange ID | Description |
|---|---|
| 10 | TSP and other CV application messages |
| 11 | CV application transactions for transit applications including Transit Stop Request (TSR) |
| 12 | ATL RIDES and Traveler exchange – profile, trip plan, settings, notifications, feedback, etc. |
| 13 | Static and dynamic information from building facilities to the ATL RIDES |
| 14 | CV broadcast messages for open data portal (via GA 511) |
| 15 | CV broadcast messages |

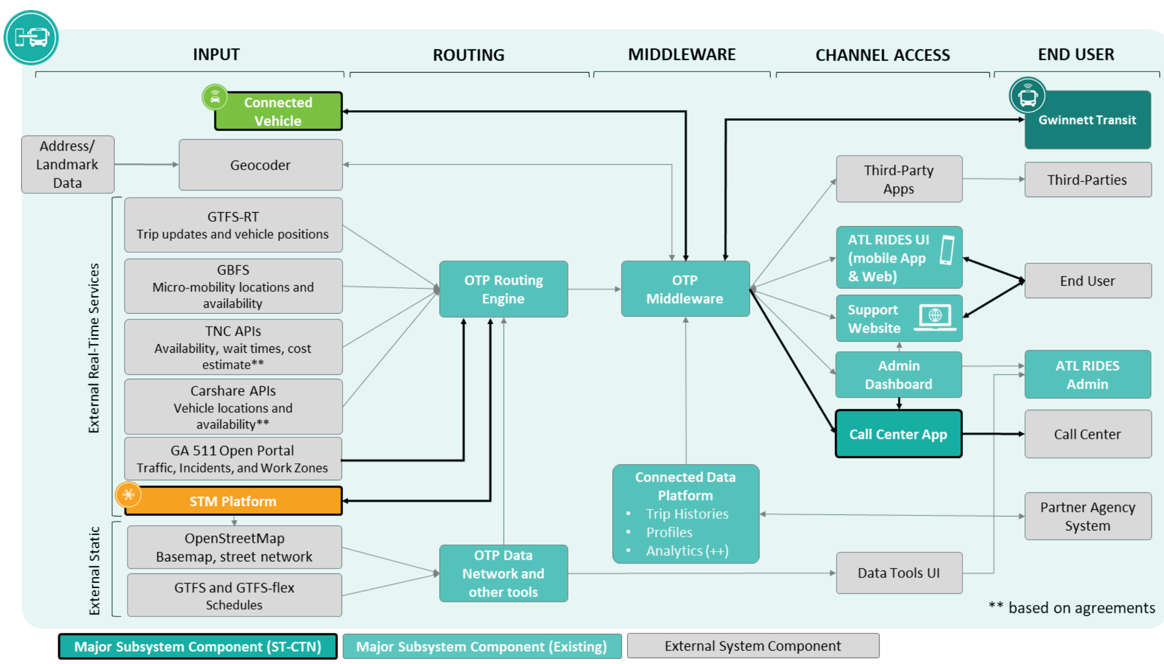
*Source: ARC*

Expansions and enhancements required to support the ST-CTN system within the ATL RIDES, STM Platform, and CV Program subsystems are described in the following sections.

### 5.2.1 ATL RIDES Multimodal Trip Planner Subsystem

ATL RIDES is being developed with the support of FTA's 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 utilizes the region's transit services.

**Description.** As described in **Section 3.2.1**, 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 PII-free and performance measures to the STM for evaluation purposes.




*Source: ARC*

**Figure 19. Proposed ATL RIDES Subsystem Extension**

**Functions. Figure 19** 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 **Section 4.2.4**. 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.

*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:

- 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 condition information on user trip itineraries.

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

- Incorporate OSM graph for sidewalks and roadways using updates from STM network (update frequencies to be defined in Phase 2). 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:

- Static Data Input
  - GTFS-Pathways (indoor station graphs)
- 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 (Mobile Unit) and other CV applications including the PED-SIG application

Description of these interfaces are included in **Section 5.2.4** System Interfaces and Interoperability and **Section 5.2.5** External System Interfaces.

**Operating Environment.** Given the production needs of the 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.

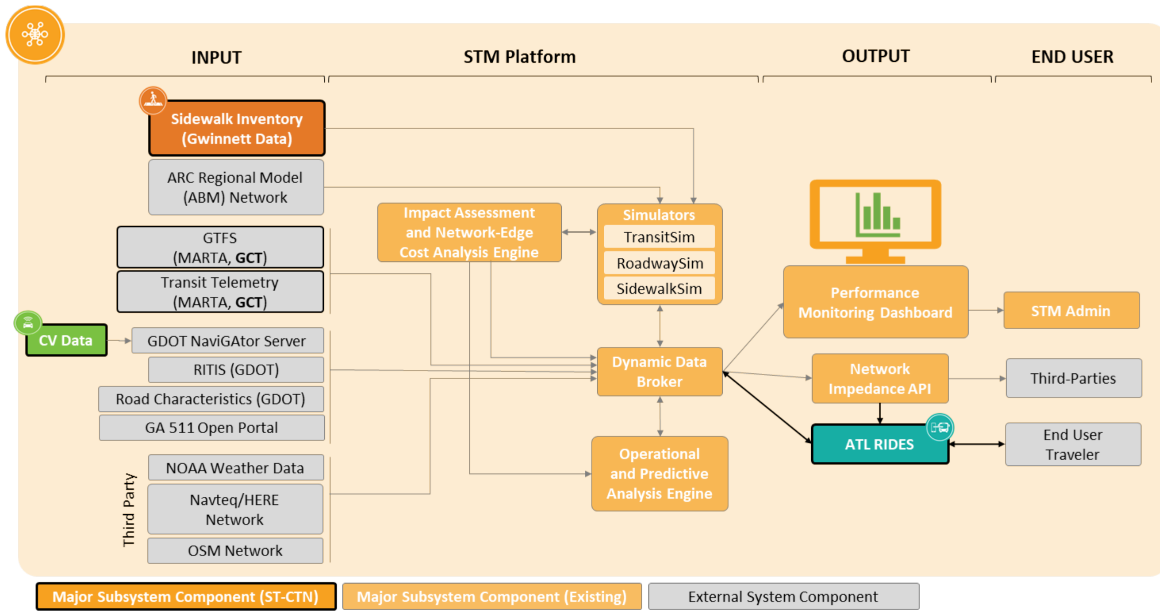
The ATL RIDES mobile app will be available for users to download via the Apple AppStore and Google Play stores. These App Stores also manage upgrade distribution for ATL RIDES to help ensure users are running the most recent version of the app available.

**Modes.** The modes of operation will not change from the current system and are further described in **Section 5.5** (Modes of Operations for Proposed System).

### 5.2.2 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 **Section 3.2.2** System Schedule). 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 20** provides the proposed STM Platform subsystem context diagram with added functionalities and connectivity presented in bold.




*Source: ARC*

**Figure 20. 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 GTFS-RT data from GCT
- CV data from the GDOT CV ITS Hub
- Augmented static sidewalk data from the sidewalk inventory tools
- Augmented dynamic sidewalk 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: 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 **Section 3.2.3** (Sidewalk Sentry, Sidewalk Scout, Sidewalk MV, etc.) 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 VM and Sidewalk Sentry inspections, and agency field inspections and crowdsourced reporting via 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 Sidewalk Scout app.

*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.

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 5.2.1** Channel function). T 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. 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 Plan.

*Commute Advisor Mobile App* – The Commute Advisor Mobile app which is deployed in the current research platform will not be used for the ST-CTN project. Instead, the ATL RIDES Multimodal Trip Planner Subsystem will consume the maps through two methods. These are described in the Interfaces section.

**Interfaces.** The STM Platform will add or upgrade two interfaces, represented by Data Exchange ID 4 and 5 in **Figure 18**.

*OSM updates (new)* – The STM 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.

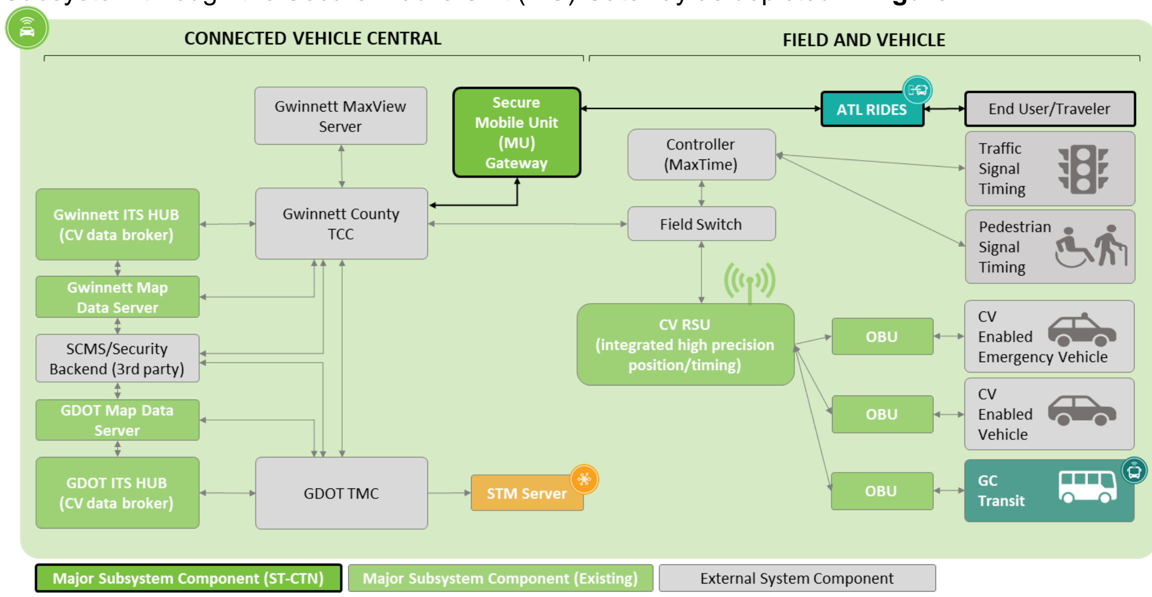
**Operating Environment.** Given the production needs of the STM platform, the infrastructure will be hardened to ensure subsystem reliability, scalability and availability. The system requires a dedicated server environment in a cloud-based infrastructure. This will ensure scalability and redundancy 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 5.5**.

### 5.2.3 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 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 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 TMC and Gwinnett County TCC – Navigator TMC, MaxTime/View signal operations, 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. Specifically, the equipment will consist of OBUs installed on GCT vehicles to support TSP and communications channels between the traveler mobile unit and the signal system to support PED-SIG and other applications supporting pedestrian safety. To achieve the goals of this project, that is, more effectively integrating the mobile units (MUs) (pedestrian and other vulnerable road users) into the CV environment, this project will deploy a direct connection between MUs (represented by the ATL RIDES subsystem) and the CV Vehicle Subsystem through the Secure Mobile Unit (MU) Gateway as depicted in **Figure 21.**




*Source: ARC*

**Figure 21. Proposed CV Subsystem Extension**

**Functions.** The functions will be driven by the applications that are deployed by the CV Smart Corridor project (as detailed in **Table 5**). An additional component, the Secure MU Gateway will be deployed in the proposed system to enable communications between the MU and OBU/RSU equipment.

*Secure Mobile Unit (MU) Gateway* – The MU Gateway will serve 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. In addition, it serves to respond to messages as appropriate. In summary, the Secure MU Gateway 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, Advanced Traveler Information System, PED-SIG, and Pedestrian in Signalized Crosswalk Warning. These applications along with the medium and low priority applications are described further in **Table 23** (located in **Section 6**).

**Interfaces.** Interfaces used to exchange information between the CV components (RSU, OBU and MU) will be based on SAE J2735 and SAE J2945 series messages. Additional message sets may be adapted from other standards including NTCIP.

The interfaces will occur between the following CV components:

- RSU and OBU on Gwinnett Transit bus (for TSP)
- RSU (signal system) and MU (for pedestrian safety applications)

- RSU and OBU on vehicles (for pedestrian safety applications)
- MU and RSU (for PED-SIG and other pedestrian awareness 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.

**Operating Environment.** The CV subsystem support environment consists of communications network infrastructure, OBUs, MUs, 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 (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 CAD.

*MU* – The mobile units may be supported by several communications technologies including Bluetooth, WiFi and cellular, and navigational sensors such as GPS and accelerometers which support location positioning.

*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 leverage 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 5.5**.

### 5.2.4 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 14** and **Figure 18.** These system interfaces are described more comprehensively below in **Table 15**. Several of these interfaces are already developed and implemented. During the design phase, they may be updated to accommodate additional functionality.

**Table 15. ST-CTN System Interfaces and Interoperability**

| Interface | Description |
| --- | --- |
| **Data Exchange 1** | **Sidewalk inventory data, including accessibility features to the STM Platform simulators** |

| Interface | Description |
|---|---|
| Subsystems Involved | From Sidewalk Inventory Collection Tools external to the system (see Table 16 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 16 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 16 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 / 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 Operations messages**<br><br>**(CV and Traffic Operations Messages: SPaT, 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.<br><br>In addition, new ATIS crossing safety messages (railroad crossing and EVP) will be forwarded to the STM. 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 (PED-SIG) / Pedestrian Safety Message (PSM)** |
| Subsystems Involved | Between MU (ATL RIDES) and RSU, through the Secure MU Gateway |
| Description | New data exchange. These messages will conform to SAE J2735 message sets and J2945 Part 9 for Vulnerable Road Users including the Personal Safety Message (PSM). |
| **Data Exchange 9** | **CV Messages** |

| Interface | Description |
|---|---|
| Subsystems Involved | Between RSU and TMC/ITS CV back center system, internal to the CV subsystem |
| Description | No change to existing message sets. |
| **Data Exchange 10** | **TSP and other CV application messages** |
| Subsystems Involved | Between RSU and OBU on transit bus |
| Description | No major change. Messages that request priority service for transit vehicles. |
| **Data Exchange 11** | **CV application transactions including Transit Stop Request (TSR)** |
| Subsystems Involved | From ATL RIDES mobile app to bus operator display in the external Gwinnett County Transit subsystem |
| Description | New data exchange. Information on traveler 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.<br><br>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** | **Static and dynamic information from building facilities to the ATL RIDES** |
| Subsystems Involved | From Building Systems (facilities) to ATL RIDES |

| Interface | Description |
|---|---|
| Description | New data feed. Provides static information on pathways and destinations in the facility, and near real time information on conditions and status of pathways including elevator/escalator operations. |
| **Data Exchange 14** | **CV broadcast messages for open data portal (via GA 511)** |
| Subsystems Involved | From CV subsystem via broadcast messages, provisioned to GA 511 open data portal and interactive map. |
| Description | No change to existing message sets. (part of GDOT CV program). Provides information on railroad crossing, emergency vehicle preemptions at specific intersections, major incidents, work zones, lane closures and delays. |
| **Data Exchange 15** | **CV broadcast messages** |
| Subsystems Involved | Between enabled connected vehicles external to the system (see Table 17 for destination details) and RSUs within the CV subsystem |
| Description | No change to existing message sets. |

*Source: ARC*

### 5.2.5 External System Interfaces

The system interfaces to be exchanged between external sources and ST-CTN subsystems are identified in each of the detailed subsystem context diagrams in **Section 5.2.1** to **Section 5.2.3**.

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 at to be determined (TBD). **Table 16** summarizes the external system interfaces that input to specific ST-CTN subsystems.

**Table 16. External System Interfaces – Inputs**

| EX-ID | Input Data | Static / RT | Description | Organization | Destination (subsystem) |
|---|---|---|---|---|---|
| 1 | ABM Network | Static | The regional model from ARC. | ARC | STM |

| EX-ID | Input Data | Static / RT | Description | Organization | Destination (subsystem) |
|---|---|---|---|---|---|
| 3 | Address Data | Static | Address directory with addresses in the geographic region. | TBD | ATL RIDES |
| 13 | Facility Assets | Static | The location of wayfinding signs and announcements in facilities including transit hubs and stations. | TBD | STM |
| 13 | 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 | GA 511 | Static and RT | Alerts about traffic, incidents, and work zones including feeds sent from the CV subsystem warnings about emergency vehicles preemptions at specific intersections and railroad crossing gate closing. | GDOT | STM,<br>ATL RIDES |
| 2, 3 | GTFS | Static | General Transit Feed Specification data including accessibility attributes for Gwinnett County Transit and MARTA. | GCT<br><br>MARTA | ATL RIDES, STM |
| 2, 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 |

| EX-ID | Input Data | Static / RT | Description | Organization | Destination (subsystem) |
|---|---|---|---|---|---|
| 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<br><br>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 current obstructions. | TBD | STM,<br>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<br><br>ATL | ATL RIDES, STM |
| 1 | Sidewalk / Bike Inventory | Static | Sidewalk collected by sidewalk inventory tools. Bike pathways may also be included since they exist in the STM. | 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. | Crowdsourced dataGAData | 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 |

| EX-ID | Input Data | Static / RT | Description | Organization | Destination (subsystem) |
|---|---|---|---|---|---|
| 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<br>ARC<br>GA Tech | STM |
| 2 | Weather Data | RT | Open weather information from NOAA. | NOAA | STM |

*Source: ARC*

**Table 17** identifies the output interfaces that are offered by subsystem.

**Table 17. External System Interfaces – Outputs**

| 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) | Connected Vehicle | Connected Vehicles<br><br>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 |
| TBD | Performance Data | RT | Performance measurement data collected and aggregated by the CT-STN system. The details will be described in the Performance Measurement and Evaluation Plan. | STM | TBD |

*Source: ARC*

## 5.3 Stakeholders and Actors of the Proposed System

The following sections describe the stakeholders, other involved personnel, and actors in the proposed system.

### 5.3.1 Stakeholder Roles

The following table provides the ST-CTN stakeholders, along with their roles, in the proposed system:

**Table 18. Stakeholders and Roles in the ST-CTN System**

| User Group | Roles |
|---|---|
| ***End User Classification*** | |
| Person with Physical Disability | **Role:** Traveler (End user of the system). |
| Person with Cognitive Disability | **Role:** Traveler (End user of the system). |
| Aging Adult | **Role:** Traveler (End user of the system). |
| Person with Limited English Proficiency | **Role:** Traveler (End user of the system). |
| Person considered to have Low Income | **Role:** Traveler (End user of the system). |
| ***Infrastructure Owner Operator Classification*** | |
| Gwinnett County DOT - Transit | **Role:** Owner / operator / maintainer of the Gwinnett County Transit system including bus fleet, stop, station, signage and service information. |
| Gwinnett County DOT - Traffic and Operations | **Role:** Owner / operator / maintainer of the Gwinnett County traffic operations, including Gwinnett County TCC, traffic signal and CV infrastructure and applications. Owner / operator of the Gwinnett County communications network including communications to traffic signals and ATMS devices and maintaining server infrastructure within the Gwinnett County TCC. |
| Gwinnett County Department of Transportation | **Role:** Owner / operator / maintainer of sidewalks and ramps in Gwinnett County |
| The Atlanta-Region Transit Link Authority (The ATL) | **Role:** Owner / operator of the ATL RIDES application. |
| Georgia Department of Transportation (GDOT) | **Role:** Owner / operator / maintainer of the GDOT Traffic Management Center (TMC), statewide ATMS (NaviGAtor), and CV infrastructure. |
| Gwinnett County Information Technology | **Role:** Owner / operator of the Gwinnett County network security components within the county. |
| Atlanta Regional Commission (ARC) | **Role:** Owner/operator of ST-CTN application extension and Metropolitan Planning Organization (MPO) for the Atlanta Region responsible for funding development and oversight. |

*Source: ARC*

ST-CTN stakeholder roles and responsibilities by subsystem are provided in **Section 5.3.3**.

### 5.3.2 Other Involved Personnel

Stakeholders who are involved with the proposed system in a passive or supportive role include:

- **USDOT.** Sponsoring agency.
- **SILCGA.** Outreach coordinator and major system testing sponsor.
- **disABIILITY Link.** Provides outreach and system testing.
- **CPACS.** Provides outreach and system testing. Provides demand-responsive service for Gwinnett County travelers.
- **Georgia Department of Education (DOEd).** Provides outreach and system testing.
- **Georgia Department of Behavioral Health and Developmental Disabilities (DBHDD).** Provides outreach and system testing.
- **GA Tech Tools for Life.** Provides outreach and system testing.
- **Third Party Application Developers.** Developers interested in using open data created by the proposed system.

### 5.3.3 Roles and Responsibilities

Stakeholder roles and responsibilities by subsystems are described in **Table 19**, **Table 20**, and **Table 21** below. The tables present subsystem roles, the primary stakeholder, and their primary responsibilities. Responsibilities are inclusive of tasks needed to ensure the proper operations of this proposed system.

Roles and responsibilities for the ATL RIDES subsystem are provided in **Table 19**.

**Table 19. Roles and Responsibilities for the ATL RIDES Subsystem**

| Role | Stakeholder | Responsibilities |
|---|---|---|
| Call Center Operators | GCT | • Provide en route guidance for end users.<br>• Aid traveler / account holder with profile setup.<br>• Aid traveler / account holder with accessibility settings in application.<br>• Address customer service requests and commendation. |
| Data Custodians | GCT<br>ATL | • Maintain accurate transit route data through generation and verification of GTFS data. (GCT)<br>• Continually improve the quality of the data generated by the system. (ATL) |

| Role | Stakeholder | Responsibilities |
|---|---|---|
| Maintenance | ATL<br>ARC<br>IBI Group | • Perform preventative maintenance on the proposed subsystem.<br>• Perform corrective maintenance on the proposed subsystem.<br>• Provide technical support for end users.<br>• Upgrade and test software including infrastructure software, UIs, and web systems.<br>• Maintain external input format of data that are consumed by the proposed system.<br>• Update web system and interface based on currently accepted standards.<br>• Update mobile application based on currently accepted standards. |
| Outreach | ATL | • Inform partner agencies of application roll out.<br>• Inform partner agencies of application updates that will impact end user operations. |
| Subsystem Operators | ATL<br>ARC<br>IBI Group | • Operate parallel applications of ATL RIDES (ATL) and ST-CTN expansion (ARC).<br>• Continuously monitor operations, communications network, and interface flows.<br>• Monitor security system for potential intrusions.<br>• Protect the PII of end users.<br>• Preserve data streams for verification and backup purposes in accordance to the PII policies. |
| Subsystem Owners | ATL<br>ARC | • Financial responsibilities for maintaining the current ATL RIDES system (ATL) and ST-CTN expansion (ARC) with updated roles and responsibilities. |
| Trainers | ATL<br>SILCGA<br>disABILITY Link<br>CPACS<br>Georgia DOEd<br>Georgia DBHDD<br>Georgia Tech Tools for Life | • Train traveler / caregiver with who are accessing and using the application.<br>• Train call center dispatch and operators on the application features and functions to provide assistance to end users. |

| Role | Stakeholder | Responsibilities |
|---|---|---|
| Travelers | End User including but not limited to:<br>Person with Physical Disability<br>Person with Cognitive Disability<br>Aging Adult<br>Limited English Proficiency<br>Low Income | • Setup mobile application including installation of mobile application on personal cell phone.<br>• Create profile and input personal accessibility settings.<br>• Update application as required.<br>• Use trip planner for pre-trip and en-route travel. |

*Source: ARC*

Roles and responsibilities for the STM subsystem are provided in **Table 20**.

**Table 20. Roles and Responsibilities for the STM Subsystem**

| Role | Stakeholder | Responsibilities |
|---|---|---|
| Data Collectors | GA Tech<br>GCDOT | • Collect and catalog sidewalk data within the project study area.<br>• Respond to requests for data collection based on end user feedback if a path is deemed not accessible but programed as such.<br>• Complete and upload construction permit final inspection reports to network when sidewalk improvements are completed. |
| Data Custodians | GA Tech<br>ATL / ARC | • Generate simulations of road and sidewalk networks.<br>• Maintain repository of transit route data for transitSIM.<br>• Maintain database of accessible paths.<br>• Continually improve the quality of the data generated by the system. |
| Maintenance | GA Tech | • Perform preventative maintenance on the proposed subsystem.<br>• Perform corrective maintenance on the proposed subsystem.<br>• Upgrade and test software including infrastructure software, UIs, and web systems.<br>• Maintain external inputs to proposed system.<br>• Complete performance monitoring goals and objectives as defined for the subsystem in the Performance Measurement and Evaluation Plan. |

| Role | Stakeholder | Responsibilities |
|---|---|---|
| Subsystem Operators | GA Tech | • Continuously monitor operations, communications network, and interface flows.<br>• Monitor security system for potential intrusions.<br>• Maintain and operate the SidewalkSim simulator to ensure current data is included in route mapping.<br>• Maintain Network-Edge Cost Computing Engine to ensure that current data is being accounted for in the algorithm.<br>• Update system parameters and algorithms based on feedback from ATL Rides and end users. |
| Subsystem Owners | GA Tech<br>ARC | • Financial responsibilities for maintaining the proposed system. |
| Trainers | GA Tech | • Train system operators and maintainers to ensure that established connections and data streams are maintained. |

*Source: ARC*

Roles and responsibilities for the CV subsystem are provided in **Table 21**.

**Table 21. Roles and Responsibilities for the CV Subsystem**

| Role | Stakeholder | Responsibilities |
|---|---|---|
| Data Custodians | GDOT<br>GCDOT | • Collect and store data in ITS Hub.<br>• Ensure PII security of collected data and remove PII for third party access.<br>• Continually improve the quality of the data generated by the system. |
| Maintenance | GDOT<br>GCDOT | • Maintain infrastructure equipment.<br>• Complete performance monitoring goals and objectives as defined for the subsystem in the Performance Measurement Plan. |

| Role | Stakeholder | Responsibilities |
|---|---|---|
| Subsystem Operations | GDOT<br>GCDOT | • Operate and monitor CV equipment (RSU)<br>• Ensure interfaces and communication networks operate properly and connect with current traffic control systems.<br>• Collect operations data for performance measurement review. |
| Subsystem Owners | GCDOT | • Financial responsibilities for maintaining the proposed system |

*Source: ARC*

### 5.3.4 Interactions Among System Stakeholders

Many interactions between stakeholders remain unchanged as described in **Section 3**. A greater degree of coordination will need to occur among ARC, GCDOT, GCT, and the ATL. The status of accessibly infrastructure is of critical importance to the travelers benefiting from this system. Prompt programming of construction activities resulting in temporary closures, verification of and maintenance actions on inaccessible paths, and programming of equipment outages on transit vehicles will be a high priority during the life cycle of the application. Additionally, temporary or permanent transit route changes will need to be communicated between all parties early to address any deficiencies in the network. Finally, interaction between travelers and IOOs will increase significantly as there will be crowdsourced data collection of inaccessible paths or infrastructure that may require follow up conversations and engagement.

## 5.4 Support Environment

The support environment described in **Section 3.4** will remain mostly unchanged. GDOT and GCDOT ATMS systems will provide real-time information on signal operations within the project limits, allowing for and informing stakeholders of any TSP or remote pedestrian activations. The system will be supported by the fiber and 4G communications network deployed by GCDOT and GDOT. ITS infrastructure that supports CV and connected infrastructure operations will be deployed through the CVTMP related applications and will be maintained by GCDOT.

Communication uptime is of critical importance to the overall functionality of the proposed system. The failure of a single subsystem through a communication loss will degrade the functionality of the entire system. The GCDOT ATMS system will monitor and report on the communication status of signals, ITS equipment, and other field devices. The communication status of OBUs, including AVL equipment and TSP responders, along with the GTFS feed will be managed by GCT.

The initial deployment of ST-CTN will require the support of the Sidewalk Inventory Collection Tools described in **Section 3.2.3**. Upon completion of the deployment phase of ST-CTN, sidewalk and pedestrian pathways infrastructure characteristics will be maintained through GCDOT updates and crowdsourced data.

The status of sidewalk improvements, temporary sidewalk closures due to construction or other activities, and temporary signal closures will be managed by Gwinnett County. This will include pushing updates to the proposed system so routing decisions can be completed in real-time. Additionally, when sidewalk improvements are completed, GCDOT will be responsible for publishing construction permit final inspection reports to the network to be ingested by SidewalkSim.

## 5.5 Modes of Operations for Proposed System

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

**Normal Operation:** During normal operations, the full system, as described in **Section 5.2**, 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 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 and travel requests for service 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 and travel requests for service 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 Platforms experiences a loss in functionally, 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, 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.

**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.

## 5.6 Operational Policies and Constraints

It is anticipated that the ST-CTN project will need to work within the partner agency operational policies and constraints. Specifically, the funding mechanisms, resources, and network communications will be critical aspects to understand and define such that long-term deployment, management, operations, and maintenance may be put in place to support the ST-CTN system.

### 5.6.1 Funding and Resources

All agencies involved in ST-CTN have separate funding sources, each of which comes with different requirements and constraints. ARC, as the project lead primarily has access to federal funding. While there are several different federal funding sources that could apply to various types of transportation projects, ARC has the sole authority to program funding from the following FHWA programs: (1) Surface Transportation Block Grant Program (STBGP) – Urbanized Area Apportionment, (2) Congestion Mitigation and Air Quality Program (CMAQ), and (3) Transportation Alternatives Program (TAP), which is a sub-program within STBGP [FAST]. The total funding availability from these three programs is approximately $120 million (based on FAST Act authorization levels). STBGP and CMAQ are best suited for ITS programs and projects, though both have a 20% match requirement for local funding.

In addition to the FHWA programs, there are three FTA, formula-based funding programs that are annually apportioned to Atlanta Urbanized Area (totaling $140 million per year, based on the current FAST Act funding levels): Section 5307/5340 - Urbanized Area Formula Program; Section 5337 - State of Good Repair Grants Program; and Section 5339 - Bus and Bus Facilities Program. ARC has a direct annual suballocation of 5307 (approximately $175,000 per year), which can be used for any ITS-related activity. Gwinnett County is also entitled to an annual suballocation for all three FTA programs (about $7 million per year).

ARC's transportation planning program is summarized annually in the Unified Planning Work Program (UPWP), which documents proposed expenditures of metropolitan planning funds (a.k.a. "PL" and "5303" funds) that are apportioned to FHWA and FTA. ARC receives approximately $9 million per year in planning funds, which are eligible for planning support, concept development, and most activity associated with systems engineering.

GDOT is able to use federal funding, but also has state funds available, which have fewer restrictions and does not require a local match. As part of the CV1K program, GDOT has also locked in pricing for connected vehicle RSUs, ensuring there are no price jumps in case future purchases of that equipment are necessary. Gwinnett County has access to local funds including their Special Purpose Local Option Sales Tax (SPLOST).

It is not anticipated that any agency will be required to make staffing changes for this project. Additionally, GDOT Operations has a full staff with expertise in connected vehicle infrastructure and applications who will be able to support the project. Likewise, ARC has a staffed transportation technologist position that requires experience with software and data integration, which will be supporting the project.

### 5.6.2 Information Technology and Communications

Each agency involved in ST-CTN likewise 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 in this ConOps through the use of a Secure MU Gateway in the connected vehicle diagram as seen in **Section 5.2.3**, Connected Vehicle Subsystem. It is anticipated that ATL RIDES will continue to be hosted via Amazon Web Services with 24/7 hours of operation.

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# 6. Operational Scenarios

The following operational scenarios (also referred to as use cases) provide a description of the proposed system operational flow. The purpose of these operational scenarios is to provide a step by step description of how the proposed system should operate. Two use cases are described in this section: *Use Case 1: Traveler's Complete Trip with ST-CTN* depicts interactions between the end user (referred to as the traveler) and the ST-CTN system, and *Use Case 2: Connected Vehicle* depicts interactions between subsystems (also referred to as system actors). The scenarios cover major capabilities and user classes but are not exhaustive of every detail of the system.

The actions within each use case verify the specific user needs (end user, IOO and system needs) as listed in **Section 4**. The following use case scenarios have been developed to demonstrate how the system will operate and how the end users and system actors interact with the system. Travelers will use the ST-CTN system to plan and navigate their complete trip using the ATL RIDES subsystem (with the augmented functionality described in **Section 5.2.1**). The end user needs, along with the IOO needs drive the system needs; together, the end user, IOO, and system needs form the consolidated needs list in **Section 4.2.2**, **Section 4.2.3**, and **Section 4.2.4**.

## 6.1 Use Case Structure

The ST-CTN project is focused on integration and enhancements to multiple existing subsystems to provide a complete trip solution which will support underserved communities. As such, the traveler is the primary focus of the system. Use Case 1 describes the traveler's experience with the proposed system and the actions that will be required by the system to support that experience. Use Case 1 considers the traveler's complete trip and is comprehensive in nature, thus, operational flows of the ST-CTN subsystems are identified throughout Use Case 1. This approach provides context to how the various ST-CTN subsystems relate to each other and work together to support the complete system. Use Case 1 is broken into several sections:

- **Description.** High level description of the complete trip and the steps (segments and transitions) taken by a traveler illustrated in **Figure 22.**
- **Purpose.** The goal of the use case.
- **Constraints.** The constraints and limitations for which travelers will face.
- **Actors.** The people and systems that interaction in the use case.
- **Preconditions.** The actions that are needed or assumed prior to the start of the use case.
- **Needs.** A reference to how the needs drive the actions described in the operational flow.
- **Operational Flows.** A set of actions, categorized by each step in the complete trip description. These actions are driven by end user needs, and drive the system needs.

These are shown in the columns of **Table 22** that describe the action and the corresponding end user, IOO, and system needs listed in the appropriate column.

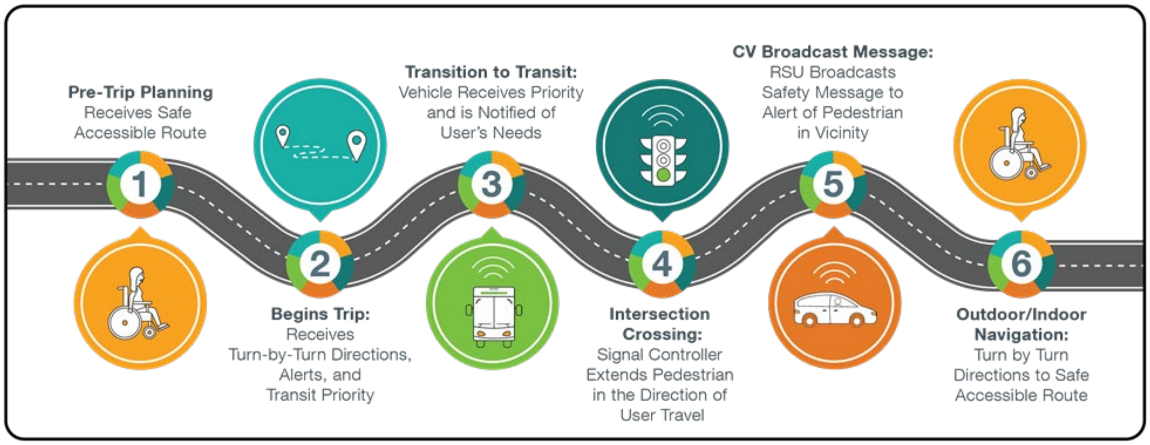
Use Case 2 is focused on the CV subsystem and the interfaces that are necessary to support the CV applications. Use Case 2 may be considered a family of applications wherein the field equipment (RSU), vehicles – particularly Gwinnett bus (OBU), and travelers (MU) interact with system in the following ways: (1) the traveler and connected intersection pedestrian infrastructure, (2) traveler and adjacent CVs, and (3) the traveler and connected transit vehicle. Each of these interactions are described by one or more CV applications within the operational flow. The interaction with a traveler may be a passive detection of the person as a *vulnerable road user*, or as an active participant in the connected infrastructure using a MU. The Use Case includes the following sections:

- **Description.** Because the CV subsystem is composed of applications already considered for deployment by the Gwinnett County Smart Corridor project, the application descriptions, detailed in **Table 23**, are extracted from the CVTMP (2019). The illustration presents information flows among the actors included in the set of applications.
- **Constraints.** The constraints and limitations of the CV equipment including integration of the MU with the CV subsystem.
- **Actors.** The travelers, systems, and equipment that interact in the use case.
- **Preconditions.** The actions that are needed or assumed prior to the start of the use case.
- **Needs.** Specific IOO and System needs associated with all the CV applications.
- **Operational Flows.** The operational flows for each application are listed in **Table 25**. An entry for each application includes the general purpose and any preconditions related to the application.

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

The traveler will use the ATL RIDES subsystem to interact with the ST-CTN system. This Use Case describes the complete trip experience for the primary actor, the traveler.

**Description.** 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, as shown in **Figure 22**. The trip segments include the trip planning through completion using the extended multimodal complete trip ATL RIDES platform. The traveler will interact with the system through one or more of the ATL RIDES UI channels – mobile app, web site, or call center/IVR. The technology method for accessing the system is seamless and synchronized so that the method of access provides similar functionality. It should be noted that the technology solutions will be identified in a later phase of the project. In this asynchronous operational flow, the traveler uses the ATL RIDES subsystem functionality to plan, execute travel, and complete a trip. The user is able to do is by personalizing, selecting, and activating information on directions, conditions, and status along their trip. The traveler will leverage their device to communicated with CV infrastructure to experience a safer trip. The six steps of the complete trip are shown in **Figure 22** and the steps are listed below.




*Source: ARC*

**Figure 22. 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.** RSUs 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.

**Purpose.** The purpose of this use case is to illustrate how a traveler will interact with the ST-CTN system through the ATL RIDES app to navigate their complete trip; integrating wayfinding across multiple trip segments and receiving directions, conditions, and status on the links between legs based on their preferences and abilities.

**Constraints.** A significant constraint for all underserved populations is the need for the solution to be integrated across each trip segment in a seamless manner. There are also constraints that are specific to underserved populations. For example, individuals with visual loss may need information provided audibly or may need additional assistance navigating. Individuals with loss of mobility, may need accessible routes based on their preferences and abilities.

Additional constraints related to the ATL RIDES multimodal complete trip subsystem include the following:

- The ability to integrate and notify travelers of real-time information is dependent on external data collection methods.
- The addition of multiple preferences will limit the number of travel options available to users. Note: During the Agile development phase, stakeholders will contribute to the

types of preferences incorporated into the application to verify that the system is not overly constrained such that a traveler cannot receive a trip plan.

- Off-line usage of trip plan will be limited to download of an existing trip plan and map. Many of the navigation and provision of notifications depend on the mobile app user opting-in to tracking services.
- Interaction between the ATL RIDES mobile app and Gwinnett Transit bus will depend on communication upgrades and augmentation of bus onboard systems. These are still in development as discussed in **Section 3**.

**Actors.** The following actors will participate in this use case:

- End User (Traveler and Caregiver / service animal)
- ATL RIDES UI devices (Web, Mobile App, Call Center/IVR connection)
- Gwinnett County Transit Vehicles
- Connected Intersection
- Facility Navigation Assets

**Preconditions.** It is assumed that the traveler has access to the ATL RIDES UI such as the web application or mobile app. Full system functionality also requires that the traveler creates a secure profile and defines their personal preferences and abilities. In addition, connected vehicle equipment (OBU and RSU) are required for a traveler to communicate with connected intersections and Gwinnett Transit vehicles. Finally, the call center must be staffed with knowledgeable agents.

**Needs.** The needs associated with this use case consist of all the end user needs as identified in **Section 4**. End user needs are associated with actions in the Operational Flow Table (see **Table 22**), column entitled “End User ID.” The end user needs (see **Section 4.2.2**) 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.

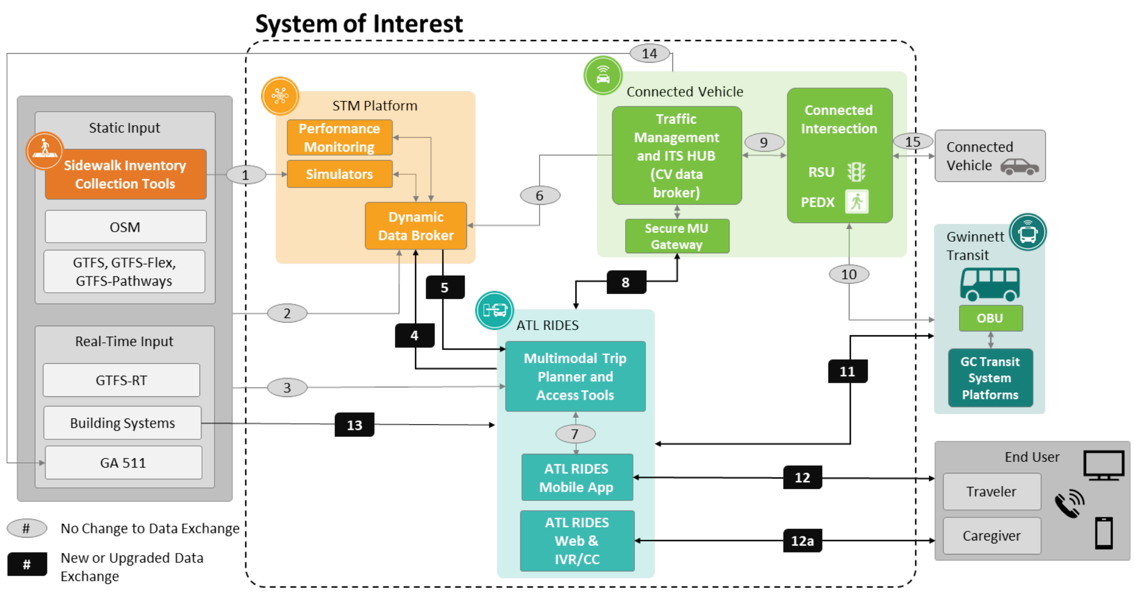
Most actions in **Table 22** reference needs that are consistent with their trip segments as denoted by the naming conventions used in the need identifier. For example, needs associated with *Transition to Transit (TT)* are assigned to actions in *Step 3 Transition to Fixed Route Transit*. Some needs from other steps, primarily Begin Trip (BT), are associated with pre-trip preference selection (Step 1). For example, BT-EU-2.2.5 – which describes what and how notifications are received while traveling is associated with Step 1 Action 1.1.6 *Traveler selects Opt-in preferences (tracking, off-line navigation, notifications to 3rd parties, link to other accounts, support types).* The Begin Trip (BT) needs drive actions that require the traveler to select their trip preferences prior to beginning their trip. Hence, the actions are derived from the needs solicited from other segments.

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. As such the system needs were derived from the user interaction (scenarios) with the ATL RIDES UIs. These system needs are associated with the end user needs and each action in **Table 22**.

**Information Needs.** References for the Information Exchange IDs are shown in **Figure 23**. It is assumed that the current network conditions (static and real-time) for transit, road (intersection), sidewalk, and indoor pathways are current and ingested by the ATL RIDES (Exchange ID 3). Facility pathways, destinations, and current conveyance status are ingested by the ATL RIDES (Exchange ID 13). Simulation network models that contain impedance values personalized for end user preferences will be provided by the STM to the ATL RIDES for trip planning and for regeneration while en-route (Exchange ID 5). The updated networks incorporate crowdsourced information on network conditions (Exchange ID 12 to Exchange ID 4).

Data exchanged between the end users (travelers and caregivers) and the ATL RIDES trip planner occur using a thin client exchange (Exchange ID 7), and then are distributed through two communication channels (Exchange ID 12 and 12a). Exchange ID 12 has a full set of static and real time exchanges that occur during all of use case 1 actions. Exchange ID 12a is a subset of the same interfaces that support trip planning and a few notifications. Crowdsourced data input by end users in the actions in Step 7 – Reporting and History, are collected and sent by the ATL RIDES UIs and directed to the STM using Exchange ID 4.

Information exchanged between the Traveler and Connected Vehicle and Intersection are described in Use Case 2.




*Source: ARC*

**Figure 23. Use Case #1 Information Flow in the ST-CTN System**

**Operational Flow.** The operational flow between the traveler interactions with the ST-CTN system, manifested by their interaction with the ATL RIDES UIs, are listed in **Table 22**. The first column provides the step ID that corresponds to the six-step complete trip shown in **Figure 22**. The second column lists the corresponding step name followed by the action category and specific actions. The column entitled End User Need ID associates the End User Need ID and IOO Need ID (referenced in **Section 4.2.2** and **Section 4.2.3**) to the action and provides a method to verify that the system will address all of the end user needs. Finally, the System Need ID column encapsulates the End User Needs into a consolidated System Need as referenced in **Section 4.2.4**.

**Table 22. Use Case 1: End User's Complete Trip with ST-CTN Operational Flow**

| Action ID | Use Case Action | End User/ IOO Need ID | SN ID |
|---|---|---|---|
| **Step 1** | **Pre-Trip Planning**<br><br>*Traveler registers, completes preferred trip preferences including what information and when it should be delivered, and when ready to set up trip, generates trip plan. These processes are conducted by the traveler* via their phone *(call center agent), web browser or mobile app* (**Exchange ID #12, 12a, and 7**). | | |
| PT-UC1-1.1 | Preferences. Traveler completes their Trip Preferences. The preferences contribute to generate the network impedances. The networks (transit, road, and sidewalk) are used to optimize the personalized alternative itineraries, and to identify obstacles to travel when traveler is en-route. Preferences include the following: | | |
| 1.1.1 | Traveler selects preferences by ability (i.e., types of assistive devices, language, etc.). | PT-EU-1.1.6<br>PT-EU-1.2.1<br>PT-EU-1.2.2<br>PT-EU-1.2.3<br>PT-EU-1.2.4<br>PT-EU-1.2.5<br>PT-EU-1.2.6<br>PT-EU-1.2.9 | PT-SY-1.3 |
| 1.1.2 | Traveler selects preferences for route options (i.e., max distance, roughness, gradient, indoor, crosswalk types, etc.). | PT-EU-1.1.1<br>PT-EU-1.1.2<br>PT-EU-1.1.3<br>PT-EU-1.1.4<br>PT-EU-1.1.5 | PT-SY-1.3 |
| 1.1.3 | Traveler selects preferences for mobility service/mode, shortest route, fewest transfers, cheapest fare, etc. Note: these settings exist already in the ATL RIDES application. | PT-EU-1.1.1<br>PT-EU-1.1.2<br>PT-EU-1.1.3 | PT-SY-1.3 |
| 1.1.4 | Traveler selects user interface notification preference on mobile app (voice, text, haptic), SMS, or other. | PT-EU-1.2.1<br>PT-EU-1.2.2<br>PT-EU-1.2.3<br>PT-EU-1.2.4<br>PT-EU-1.2.5<br>BT-EU-2.2.5 | BT-SY-2.4 |

| Action ID | Use Case Action | End User/ IOO Need ID | SN ID |
|---|---|---|---|
| 1.1.5 | Traveler selects preferences for trip support service:<br><br>• Accompanied by service animal or caregiver<br>• Link to call for support and help (caregiver, call center) | BT-EU-2.1.1<br>BT-EU-2.1.2<br>BT-EU-2.1.3 | PT-SY-1.5 |
| 1.1.6 | Traveler opts-in to specific services:<br><br>• Link their account ATL RIDE account with other mobility services (link to other accounts, support types)<br>• Opt-in to tracking (or prefer off-line navigation features only)<br>• Opt-in to notify third parties (e.g., caregiver, guardian) about their navigation status | BT-EU-2.2.5 | PT-SY-1.1 |
| 1.1.7 | Traveler selects options for automated services:<br><br>• Reroute when trip plan has obstruction<br>• Request for PedX (CV)<br>• Communication with indoor navigation aids<br>• Couple with assistive device<br>• Communicate with transit operator about needs<br>• Notifications for request for stop or request for service | BT-EU-2.2.5 | BT-SY-2.6 |
| 1.1.8 | Traveler assigns customized preferences for specified trip types. | PT-EU-1.1.7 | PT-SY-1.5 |
| PT-UC1-1.2 | Notification Types. Traveler completes their preferences for the types of notification they require. The selections are used by the ATL RIDES to push notifications to their preference UI channel (including telephone, mobile app, or caregiver). | | |
| 1.2.1 | Traveler selects type of turn by turn directions desired. Alternatives include turn by turn directions by landmarks, transition points, or by frequency (time or distance). | BT-EU-2.2.1<br>BT-EU-2.2.2 | BT-SY-2.2<br>BT-SY-2.6 |
| 1.2.2 | Traveler selects notification on their orientation when transitioning to new trip segment (e.g., alighting vehicle, exit/enter facility). | BT-EU-2.2.2<br>BT-EU-2.2.3<br>BT-EU-2.2.4 | BT-SY-2.6 |
| 1.2.3 | Traveler selects notification on ETA for transit. | BT-EU-2.2.4 | BT-SY-2.6 |

| Action ID | Use Case Action | End User/ IOO Need ID | SN ID |
|---|---|---|---|
| 1.2.4 | Traveler selects notification on transit schedule delay. | BT-EU-2.2.3 | BT-SY-2.6 |
| 1.2.5 | Traveler selects notification on disruption in trip plan (transit, walking, elevator/escalator, obstacle in pathway, work zone). | PT-EU-1.1.2<br>BT-EU-2.2.2<br>BT-EU-2.2.3 | BT-SY-2.6 |
| 1.2.6 | Traveler selects notification with detour or re-routing instructions (if deviated from trip plan or encounter disruption). | PT-EU-1.1.2<br>BT-EU-2.2.2<br>BT-EU-2.2.3 | BT-SY-2.6 |
| 1.2.7 | Traveler selects status notification sent to third party such as guardian / caregiver. | BT-EU-2.1.2<br>BT-EU-2.1.3 | BT-SY-2.5 |
| PT-UC1-1.3 | Trip Plan. Traveler generates trip plan. | | |
| 1.3.1 | Traveler sets origin / destination and timing. | PT-EU-1.2.1<br>PT-EU-1.2.2 | PT-SY-1.4 |
| 1.3.2 | Traveler reviews and if desired, updates their preferences and notifications for this trip (including notifications and other preferences). | PT-EU-1.2.1<br>PT-EU-1.2.2 | PT-SY-1.4 |
| 1.3.3 | Traveler reviews and if desired, updates navigation alerts for trip including identifying additional landmarks or events. | BT-EU-2.2.1<br>BT-EU-2.2.2<br>BT-EU-2.2.5 | BT-SY-2.4 |
| 1.3.4 | Traveler generates trip (and if not satisfied, return to Action 1.3.1 to repeat). | PT-EU-1.2.1<br>PT-EU-1.2.2 | PT-SY-1.4 |
| 1.3.5 | Traveler plays trip plan using preferred user interface channels (e.g., for user practice). | PT-EU-1.2.8 | PT-SY-1.6 |
| 1.3.6 | Traveler plans indoor route to their destination (if data is available for facility). | PT-EU-1.1.3<br>PT-EU-1.1.4 | NV-SY-6.1<br>NV-SY-6.2 |
| 1.3.7 | Travelers can opt-in or opt-out of tracking. Note: When the app monitors their trip; this request will not work when off-line functionality is requested. | PT-EU-1.1.8<br>BT-EU-2.1.2<br>BT-EU-2.2.5<br>BT-EU-2.2.6 | PT-SY-1.1<br>PT-SY-1.2 |

| Action ID | Use Case Action | End User/ IOO Need ID | SN ID |
|---|---|---|---|
| **Step 2 (BT)** | **Begin Trip**<br><br>*Traveler begins their trip using their mobile app to navigate based on their selected trip plan. These processes are conducted by the traveler* via *mobile app* (**Exchange ID #12 and 7**). *Selected notifications may be supported through SMS or telephone message.* | | |
| BT-UC1-2.1 | Begin Trip. Traveler begins their trip using the ATL RIDES Mobile app; when tracking is on, the app will track the traveler's location (geofence), and appropriate navigation alerts and notifications will be triggered. During the trip, the ATL RIDES platform will continuously monitor the traveler's location and trigger alerts, identify obstacles and re-route based on traveler's preferences. | | |
| 2.1.1 | Traveler opens their trip plan in their mobile app (or sync with assistive device – e.g., cane, cochlear implant, wearable). | PT-EU-1.2.1<br>PT-EU-1.2.2<br>PT-EU-1.2.3<br>PT-EU-1.2.4<br>PT-EU-1.2.5 | BT-SY-2.3 |
| 2.1.2 | Alternatively, Traveler initiates trip plan using IVR or phone call to activate notification requests on pre-planned route. | BT-EU-2.2 | PT-SY-1.2 |
| 2.1.3 | Traveler journeys to first trip segment (station, stop) receiving selected navigation alerts and notifications. | PT-EU-1.1.1<br>PT-EU-1.1.2<br>PT-EU-1.1.3<br>PT-EU-1.1.4<br>PT-EU-1.1.5 | BT-SY-2.6 |
| **Step 3 (TT)** | **Transition to Fixed Route Transit**<br><br>*Traveler journeys to transit, boards, travels on and alights transit vehicle. These actions occur between the ATL RIDES and Transit Vehicle. The path may flow from the Transit Operations to ATL RIDES back office (to the traveler) or directly between the Transit Vehicle and Traveler (***Exchange #11***). The CV applications flow through the CV platform and follow the flows designated by appropriate Use Case 2 descriptions. Most flows follow the path to / from the ATL RIDES and Secure MU Gateway (**Exchange ID #8**).* | | |

| Action ID | Use Case Action | End User/ IOO Need ID | SN ID |
|---|---|---|---|
| TT-UC1-3.1 | Boarding. Traveler boards transit vehicle. | | |
| 3.1.1 | As traveler waits at transit stop, they request transit service. If they opt-in to communicate with the transit operator about their "preferences by ability" (see Use Case 2: Transit Pedestrian Indication Application) and under certain weather conditions, a request for transit priority may trigger TSP (see Use Case 2 TSP). | TT-EU-3.1.1<br>TT-EU-3.1.3<br>TT-EU-3.1.5<br>CV-EU-5.1.1<br>CV-EU-5.1.2 | TT-SY-3.1 |
| 3.1.2 | Travelers will be sent notification of incoming bus to a station or stop when the notification is selected. | BT-EU-2.2.4 | BT-SY-2.6 |
| 3.1.3 | Travelers will be sent notification of location and estimated time of arrival of transit vehicle when the notification is selected. | BT-EU-2.2.4 | BT-SY-2.6 |
| 3.1.4 | As traveler boards vehicle, the traveler app will inform driver of passenger profile when traveler opts-in. For example, if the traveler has difficulty with their vision and needs assistance in finding a seat and identifying their stop, information may be sent to the driver of the traveler's stop request. | BT-EU-2.1.3<br>TT-EU-3.1.1<br>TT-EU-3.1.2<br>TT-EU-3.1.3<br>TT-EU-3.1.4<br>TT-EU-3.1.5<br>TT-EU-3.1.6 | BT-SY-2.6 |
| TT-UC1-3.2 | Traveling in Vehicle. Traveler riding in the transit vehicle. | | |
| 3.2.1 | Traveler requests next stop using the hands-free function on the mobile app which triggers the vehicle's next stop indicator. The stop request is based on their trip selection. | TT-EU-3.1.7<br>CV-EU-5.1.1<br>CV-EU-5.1.2 | FUTURE |
| 3.2.2 | Travelers receives next stop information (using their mobile app to connect directly to their assistive device such as a hearing aid). | BT-EU-2.1.4<br>BT-EU-2.2.4 | FUTURE |
| **Step 4 (IC)** | **Intersection Crossing**<br><br>*Traveler, when approaching and crossing an intersection interacts with the connected intersection to request pedestrian crossing signal and to safety cross the crosswalk.* | | |

| Action ID | Use Case Action | End User/ IOO Need ID | SN ID |
|---|---|---|---|
| IC-UC1-4.1 | Crosswalk. Traveler requests pedestrian crossing and traverses crosswalk. | | |
| 4.1.1 | Traveler receives alert about sidewalk path they are currently on or along their path that has an obstacle. Upon receipt, the traveler may request support through their assistive services (custodian, call center) or request a reroute using their trip planner. These alternatives may be automatically generated if their preferences included Action 1.1.7. | PT-EU-1.1.2<br>BT-EU-2.2.3 | BT-SY-2.6 |
| 4.1.2 | As traveler approaches a crosswalk, they transmit a request via the ATL RIDES app for the pedestrian crossing. This request is triggered by their ATL RIDES trip plan which incorporate the crossing street, signal phasing cycle and preference for hands-off and automated notification of the pedestrian signal request (see Use Case 2: PED-SIG Application).<br><br>Alternatively, traveler may manually request PED-SIG from their mobile app, but they will need to identify the crossing direction. | IC-EU-4.1.1<br>IC-EU-4.1.2<br>IC-EU-4.1.3 | TT-SY-3.1 |
| 4.1.3 | If automatically or manually requested PED-SIG, they will receive a confirmation that PED-SIG was received by signal system (see Use Case 2: PED-SIG Application). | IC-IOO-4.1 | TT-SY-3.2 |
| 4.1.4 | As pedestrian enters the intersection, the CV Subsystem sends alert to nearby connected equipped vehicles that traveler is in the intersection (see Use Case 2: Pedestrian in Signalized Crosswalk Warning (Transit) and PED-SIG Applications).Note: depending on the SAE levels of driving automation, vehicles may be prevent the vehicle from entering the intersection while pedestrian is present in the crosswalk. | CV-EU-5.2.2 | CV-SY-5.1.1 |
| 4.1.5 | While tracking traveler, the ATL RIDES app sends message to CV subsystem that traveler is in or completed crossing intersection and the alert ceases. | CV-EU-5.2.1 | CV-SY-5.1.2 |
| **Step 5 (CV)** | **Connected Vehicle Broadcast Message**<br><br>*The data flow path begins from the CV Platform to the GDOT ATMS (external system) to the GA 511 system (external system) which is then ingested by the ATL RIDES* (**Exchange ID 3**) *and STM Platforms* (**Exchange ID 2**). | | |

| Action ID | Use Case Action | End User/ IOO Need ID | SN ID |
|---|---|---|---|
| CV-UC1-5.1 | Traveling. Traveler navigates near connected intersection (see Use Case 2). | | |
| 5.1.1 | Traveler receives broadcast alerts from ATL RIDES of disruptions on road including emergency vehicles at intersections or trains crossings (see Use Case 2: ATIS Application). These alerts are sent to traveler only if they are in the vicinity of railroad or intersection with emergency preemption. | IC-IOO-4.1 | BT-SY-2.6 |
| **Step 6 (NV)** | **Outdoor / Indoor Navigation**<br><br>*Traveler navigates trip through outdoor and indoor paths. The data exchange occurs between the traveler and their access method (web, mobile app, call center alert) and ATL RIDES (***Exchange 12***) for outdoor navigation. For indoor navigation, the main flow is between the ATL RIDES and the building facility (***Exchange 13***).* | | |
| NV-UC1-6.1 | Orienteering to trip segment. Traveler orients their navigation when they transition between segments or modes. | | |
| 6.1.1 | As traveler begins next trip segment, they receive a notification that they are traveling in correct (or incorrect) direction. The traveler specifies how they want to receive the notification (e.g., text message, haptic sensor) and when they receive the information (going in the correct or incorrect direction). | BT-EU-2.2.2 | BT-SY-2.6 |
| 6.1.2 | Traveler is directed to the most accessible path to their bus stop or pick up location (or alternatively from their alighting or drop off location). Note: The system provides the traveler with navigation alerts to the most accessible path to their next trip segment. This might be the bus pickup location or accessible entrance to a facility. | PT-EU-1.1.1<br>PT-EU-1.1.2<br>PT-EU-1.1.3<br>PT-EU-1.1.4<br>PT-EU-1.1.5 | BT-SY-2.6 |
| NV-UC1-6.2 | Transition Outdoor/ Indoor Navigation. Traveler transitions between outdoor and indoor locations. | | |
| 6.2.1 | Traveler receives alert about facility accessibility or disruptions to access (elevator/escalator outages). | BT-EU-2.2.3<br>NV-EU-6.1.1<br>NV-EU-6.1.2<br>NV-EU-6.1.3 | BT-SY-2.6 |

| Action ID | Use Case Action | End User/ IOO Need ID | SN ID |
|---|---|---|---|
| 6.2.2 | Traveler receives turn by turn directions (based on their preferences) about how best to access indoor facility (accessible entrance/exit). | BT-EU-2.2.3<br>NV-EU-6.1.1<br>NV-EU-6.1.2<br>NV-EU-6.1.3 | BT-SY-2.6 |
| 6.2.3 | Traveler receives alert about weather conditions outdoors including pavement conditions as reported by other users. Note: This information may be sent as a notification that there is an obstacle to travel. | PT-EU-1.1.5 | BT-SY-2.6 |
| NV-UC1-6.3 | Indoor Navigation (including at Transit Hub / Station). Traveler travels to indoor facilities and connects to wayfinding assets for facility information. | | |
| 6.3.1 | Traveler receives notification that app has synced with indoor navigation assets. | NV-EU-6.1.2<br>NV-EU-6.1.3 | NV-SY-6.2 |
| 6.3.2 | Traveler receives wayfinding information from indoor wayfinding assets via their preferred UI (e.g., "You are here" notification). | NV-EU-6.1.2<br>NV-EU-6.1.3 | NV-SY-6.1 |
| 6.3.3 | Traveler receives directions to elevator (or alternative elevator bank if out of service). | PT-EU-1.1.3<br>PT-EU-1.1.4<br>BT-EU-2.2.3<br>NV-EU-6.1.1<br>NV-EU-6.1.2<br>NV-EU-6.1.3 | NV-SY-6.1 |
| **Step 7** | **Reporting and History**<br><br>*Travelers may report problems about their journeys, obstacles to travel and review trip histories. The data exchange is between the ATL RIDES application and traveler (***Exchange ID #12***). The stored data is ingested by the STM evaluation module (***Exchange #4***).* | | |
| RP-UC1-7.1 | Reporting and Performance Monitoring. Traveler reports a problem or obstacle to traveler (crowd-sourced information) or reviews their trip feedback history. | | |

| Action ID | Use Case Action | End User/ IOO Need ID | SN ID |
|---|---|---|---|
| 7.1.1 | Traveler reports problem about challenges during travel (obstacles and issues) including transit or shared use paths.<br>• Traveler pulls down report form that includes fields to describe issue such as: type of problem (trip plan, infrastructure, transit, etc), the location, location feature type, problem details, and more.<br>• Submits form to ATL RIDES<br>• Receives confirmation of receipt of problem report.<br><br>Note: ATL RIDES uses this crowd sourced reporting for traveler alerts and notifications and sends information to STM Subsystem to be integrated into the routing networks. | RP-EU-7.1.1<br>RP-EU-7.1.2<br>RP-EU-7.1.3<br>RP-EU-7.1.4 | RP-SY-7.2 |
| 7.1.2 | Traveler or traveler's guardian reviews their trip histories for verification and safety purposes. | RP-EU-7.1.1<br>RP-EU-7.1.2<br>RP-EU-7.1.3<br>RP-EU-7.1.4 | RP-SY-7.1<br>RP-SY-7.3 |

*Source: ARC*

## 6.3 Use Case 2: Connected Vehicle

The ST-CTN proposed system leverages the Gwinnett County and GDOT 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.

**Description.** CV applications will be implemented as part of the Gwinnett County and GDOT CV Program (see **Section 3.2.4**). The ST-CTN system will connect the traveler with the connected intersections and connected platform based on several applications currently being deployed in the aforementioned program. The traveler will receive alerts and trigger safety messages and requests through the ATL RIDES platform (i.e., mobile app). Since the CV field and center systems are fully networked, the path by which the transmission occurs will be determined during the design phase. The Gwinnett County CVTMP identified several applications that will incorporate communication notifications directly to the traveler through their MU (ATL RIDES mobile app). In all these applications, the interaction between the traveler and intersection, or traveler and bus will conform to the security policies and message exchanges of CV equipment. The applications and associated priority (column 3) that will be implemented are listed in **Table 23**.

**Table 23. CV Application Descriptions**

| CV Application | Description | Priority |
|---|---|---|
| Advanced Traveler Information System (ATIS) | The Advanced Traveler Information System 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, 511 systems, and roadside signage.<br><br>Note: Initially the broadcasts will include emergency management vehicle preemptions at intersections and railroad crossing alerts transmitted through the GA 511 Open Portal. | High |
| Transit Pedestrian Indication | The Transit Pedestrian Indication application provides vehicle-to-device communications to inform pedestrians at a station or stop about the presence of a transit vehicle. In addition, this application informs the transit vehicle operator about the presence of pedestrians nearby and those waiting for the bus. It helps prevent collisions between transit vehicles and pedestrians. | Low (Optional) |

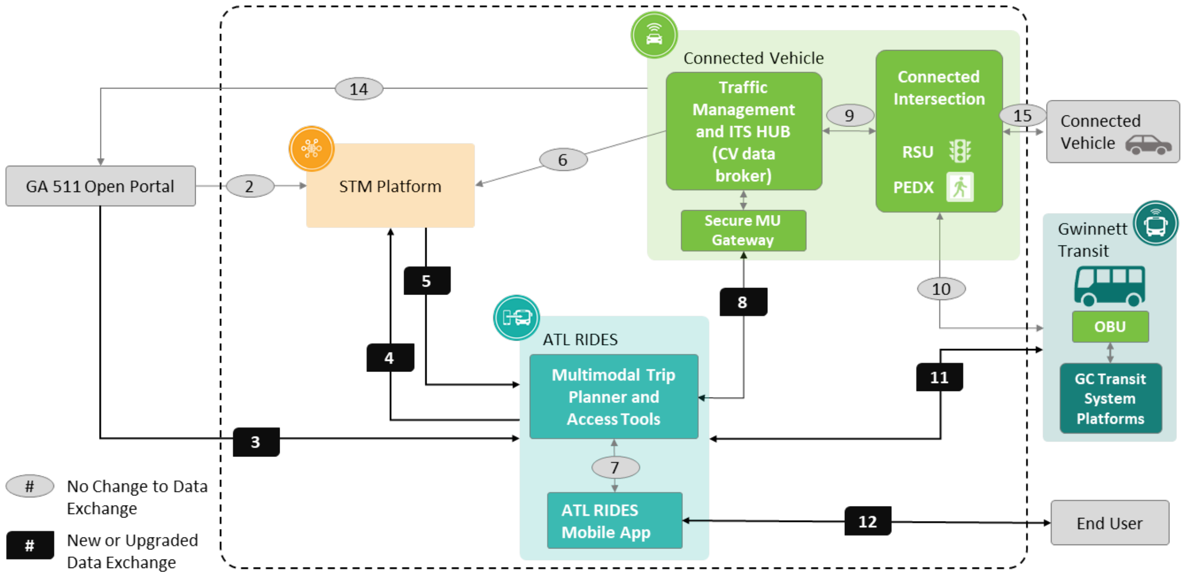
| CV Application | Description | Priority |
|---|---|---|
| Mobile Accessible Pedestrian Signal System (PED-SIG) | An application that allows for an automated call via the Secure MU Gateway from the smart phone of [any authorized] pedestrian [using the MU – ATL RIDES app] to the traffic signal, as well as audio cues to safely navigate the crosswalk.<br><br>Note: The pathway between the MU to RSU must go through the Secure MU Gateway as described in **Section 5.2.3**. | 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. | High |
| Transit Stop Request | The Transit Stop Request application allows a transit passenger to send a stop request to an approaching transit vehicle. This application allows a transit vehicle to know that a passenger has requested a transit stop from an infrastructure device. | Medium |
| Transit Signal Priority | An application that provides signal priority to transit vehicles at intersections and along arterial corridors. The TSP application uses V2I communications to allow a transit vehicle to request a priority at one or a series of intersections. The application includes feedback to the transit driver indicating whether the signal priority was granted or not. This application can contribute to improved operating performance of the transit vehicles by reducing the time spent stopped at a red light. | High |

*Source: ARC*

The exchange of information between the traveler (represented by ATL RIDES mobile app) and the field or vehicles represented by the RSU and OBU equipment are shown in **Figure 24**. More specific information relevant to Use Case 2 is provided herein, however data exchanges are represented consistent with the ST-CTN context diagram shown in **Figure 18** and described in **Table 24**.

The public portal is implemented through the GDOT ATMS and data ingested by the GA 511 system. To that end, the ATIS broadcasts that are available to the public portal will be accessed by the ATL RIDES and transmitted to the mobile app. To interface with the CV applications that require security credentials, the ATL RIDES platform will work with the GDOT/Gwinnett Smart Corridor project to implement the most practical solution including registering and receiving valid certificates from the SCMS.

Use Case 2 is organized as a traditional use case, highlighting the system interactions (**Figure 24**), application descriptions adapted from the GDOT/Gwinnett stakeholder needs (**Table 23**), constraints, actors, preconditions, related system needs, main flows (**Table 25**), and information needs.




*Source: ARC*

**Figure 24. Use Case 2 Connected Vehicle Applications Information Flow in the ST-CTN System**

The following table provides the descriptions of the associated data exchanges shown in **Figure 24**. These connections are consistent with the ST-CTN system context diagram but provide more specific information related to Use Case 2 where appropriate.

**Table 24. Critical ST-CTN Use Case 2 CV Connection Descriptions**

| Data Exchange 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 |
| 5 | STM Network Impedance API |
| 6 | CV Operations Messages: SPaT, NaviGAtor ITS, Road Characteristics, Traffic Data |
| 7 | OTP APIs and ATL RIDES APIs |
| 8 | Mobile Accessible Pedestrian Signal Request [PED-SIG] / Pedestrian Safety Message (PSM) |
| 9 | CV Messages |
| 10 | TSP and Other CV Application Messages using existing CV standards such as SAE J2735 and J2945/x |
| 11 | CV Application Transactions including Transit Stop Request (TSR) |

| Data Exchange ID | Description |
|---|---|
| 12 | ATL RIDES and End User Exchange – Profile, Trip Plan, notifications, feedback, etc. |
| 13 | Not relevant for Use Case 2 |
| 14 | CV ATIS Message Including Warnings of EV Preemption and Railroad Crossing |
| 15 | CV Broadcast Messages |

*Source: ARC*

**Constraints.** All the use cases with the MU as a key actor are constrained by the smartphone capabilities. These include the following:

- Smartphone battery life. The location accuracy and communications drain the power from the smartphone to the extent that the mobile unit power may not be available throughout the complete trip.
- Location accuracy. The location quality generated by the smartphone may not be sufficient for precisely locating and tracking the pedestrian in and around an intersection particularly in an urban canyon, multipath including tree canopy, and indoor navigation.
- Latency of the MU in transmitting its PSM in person to infrastructure (P2I) or person to a transit vehicle (P2V), receiving safety critical messages from the infrastructure (I2P) or other vehicles (V2P).

In addition, if the MU or by extension the ATL RIDES platform is sending a request to a CV component (RSU or central system), then it must follow security guidelines and acquire authorization. The use case diagram, shown in **Figure 24**, includes a conceptual processor to verify proper credentialing of the requesting actor.

Note: There are several initiatives that are exploring mitigation of these constraints, in addition, solutions may be implemented that reduce the impact of the constraints.

**Actors.** The main actors in the CV applications include the following:

- MU – represented by the ATL Rides Platform (may be the mobile app or a trigger issued by the ATL Rides back office).
- RSU – Represented by the connected intersection or through the connection to the CV Data Broker.
- Gwinnett Transit Bus OBU – represented by the GCT bus in revenue service.
- STM Platform – represents a supporting service to allocate the impedance value of the safety alert to the traveler through the Commute Advisor API.
- GA 511 Open Portal.
- Secure MU Gateway – the communication channel that manages transactions between authorized MU and RSU.

**Precondition**. The following preconditions are required by the system to enable CV subsystem functionality.

- The account holder will opt-in to a notification from the ATL RIDES prior to the ATL RIDES triggering a request from the CV and sending a notification on its behalf.
- Prior to a request from the CV, all connected devices will be enrolled in the SCMS and have valid security certificates or equivalent (as described in the Secure MU Gateway in **Section 5.2.3**. Authorized MU devices will be validated through the ATL RIDES and CV subsystems.
- RSU is broadcasting a compliant SAE J2735 MAP message and OBUs are broadcasting a compliant Basic Safety Message (BSM)

**Related Needs.**

- End User Needs. The CV applications and associated actions express the end user needs identified within the trip segment steps 3 (transition to transit), 4 (intersection crossing), and 5 (connected vehicle) and as described in **Section 4.2.2**.
    - TT-EU-3.1
    - IC-EU-4.1
    - CV-EU-5.1
    - CV-EU-5.2
- IOO Needs. The CV applications and associated actions express the IOO needs by GDOT and Gwinnett County and as described in **Section 4.2.3**.
    - PT-OO-1.1
    - TT-OO-3.1
    - TT-OO-3.2
    - TT-OO-3.3
    - IC-OO-4.1
    - IC-OO-4.2
    - CV-OO-5.1
    - CV-OO-5.2
    - FT-OO-8.1
    - FT-OO-8.2
- System Needs. The CV applications and associated actions express the following system needs and as described in **Section 4.2.4**.
    - TT-SY-3.1
    - TT-SY-3.2
    - IC-SY-4.1
    - CV-SY-5.1
    - CV-SY-5.1.1
    - CV-SY-5.1.2
    - RP-SY-7.3
    - FT-SY-8.1.2

**Operational Flow.** The CV use case operational flows are described in **Table 25** for each CV application.

**Table 25. Use Case 2: Connected Vehicle Application Operational Flows**

<table>
<tr><th>CV Application</th><th>Scenarios – Main Flow</th></tr>
<tr><td>Advanced Traveler Information System</td><td>The Advanced Traveler Information System (ATIS) scenario, shown in Figure 24, provides situational awareness information to the public about safety related events. Among the events that impact pedestrians are warning about emergency vehicle preemption and railroad crossing. These messages are distributed and published on the GA 511 site as open data event messages. This use case describes how the information will be delivered to travelers using the ATL Rides app who are in the vicinity of the event. The actions will flow as follows:
<ol>
<li>ATL RIDES subsystem subscribes to the ATIS data broadcasts (Exchange ID 3) that are pushed to GA 511 Open Portal from the CV subsystem (Exchange ID 14). This enables the ATL RIDES subsystem to collect key ATIS messages that affect travelers who plan and execute trips using the mobile app.</li>
<li>When an event occurs, the CV ATIS application will send notifications to the GA 511 Open Portal (Exchange ID 14).</li>
<li>Because of the subscription, the GA 511 will push CV ATIS messages to the ATL RIDES (Exchange ID 3) and the STM Platform (Exchange ID 2).</li>
<li>ATL RIDES will identify travelers (who opt in to tracking) and determine if any of them selected ATIS messages about crossing emergency vehicle or railroad crossing warnings.</li>
<li>If selected, the ATL RIDES will forward the message to travelers who opt-in and who are in the vicinity of the alert (Exchange ID 12).</li>
</ol></td></tr>
<tr><td>Transit Pedestrian Indication</td><td>The Transit Pedestrian Indication scenario actions will flow as follows:
<ol>
<li>The use case begins when a pedestrian with a trip plan opts in to be tracked and the trip plan identifies their location at or near a transit stop on their itinerary. The pedestrian may request that information about their needs and accommodations be sent to the transit vehicle operator.
<ol type="a"><li>Alternatively, a traveler may request information about the next bus (by route/route direction) at a stop. The traveler opts in for alerts on the status of the bus. (See Use Case 1 for actions).</li></ol></li>
<li>The CV will broadcast information (communication path may be implemented as a center to center flow e.g., Exchange IDs 12, 8, 9, to 10 or direct flow – Exchange ID 11) about the next transit service expected to arrive at the stop to travelers at the stop using MU devices that have opted-in for the alert.</li>
</ol></td></tr>
</table>

| CV Application | Scenarios – Main Flow |
|---|---|
| Transit Pedestrian Indication (cont.) | 3. When the bus arrives and the doors open, the pedestrian indication message will be triggered to alert the traveler via the MU (see flow description in Action 2 above)).<br>a. Optionally, the MU may respond to the Transit Pedestrian Indication message with a response about any special needs required by the traveler waiting at the stop. This may include information such as requires extra time to board, need for wheelchair securement, need for bike rack slot.<br>4. Alternatively,<br>a. The ATL RIDES may subscribe to information about the bus at a designated stop from the CV subsystem (Exchange ID 8).<br>b. When the bus arrives, the CV subsystem will send an alert to the ATL RIDES (Exchange ID 8),<br>c. Which will forward the notification to the ATL RIDES mobile app (Exchange ID 7).<br>Note: The message set for this application has not yet been determined. |
| Transit Signal Priority | The TSP will use a typical flow of operations traditionally applied to the priority request generator (PRG)- priority request server (PRS) and coordinator (CO) model described in *NTCIP 1211 Signal Control and Prioritization Message Set*. The PRG, PRS and CO are constructs that represent the functions associated with generating, serving and coordinating priority requests. The NTCIP 1211 includes six different architectures in which the three functional units are hosted by either a transit control center, traffic operations system, traffic signal controller (or cabinet) or transit vehicle. For that reason, no specific flows are identified, only the flows among the three functional components.<br>Preconditions include:<br>• The logic for generating a priority request is loaded into the PRG.<br>• The logic for granting priority request is loaded in the PRS.<br>• The CO monitors the signal timing. |

| CV Application | Scenarios – Main Flow |
|---|---|
| Transit Signal Priority (cont.) | The actions will flow occurs using Exchange ID 10 as follows:<br><br>Main Flow<br><br>1. The use case begins when the PRG determines a priority request is desired.<br>2. The PRG generates a TSP signal request message (SRM) to the PRS. The TSP request message contains the identifier of the vehicle that desires priority, the identifier of the route for the vehicle, a request identifier, the priority strategy requested, time of service requested, and the time of estimated departure.<br>3. The PRG generates a TSP request message and transmits it to the PRS at a configurable service threshold value (e.g., 30 seconds before the bus arrives at the intersection).<br>4. The Controller logs the time the TSP request message is transmitted to PRS.<br>5. The PRS receives and logs all transactions to and from the PRG and Controller (between the PRS and these entities as well as from these entities from external sources).<br>6. The PRG receives the TSP signal status message (SSM). A TSP request status message contains the identifier of the vehicle that desires priority, the identifier of the route for the vehicle, the request identifier, the priority strategy requested, time of service requested, and the time of estimated departure, and the status of the priority request.<br>7. The PRS receives and logs all transactions to and from the PRG and Controller (between the PRS and these entities as well as from these entities from external sources).<br>8. The flow repeats with Action 2 continuously as the PRG continues transmitting a TSP request message; the PRS continually tracks the bus and calculates time to service. Update messages, to inform the PRS and Controller of changes to the bus's anticipated arrival, are generated and transmitted to the PRG on an as-needed basis.<br>9. The signal controller services TSP at the appropriate time, as the bus is approaching the intersection.<br>10. The PRG output and TSP request messages continue until the vehicle(s) have cleared the intersection (e.g., time to service = 0) or the PRG cancels the priority request. The PRG will transmit the TSP request message at a rate agreed to by signal operations and no more than once every 5 seconds.<br>11. At the end of the day, information will be sent to the STM Performance Measure Dashboard (Exchange ID 6). |

| CV Application | Scenarios – Main Flow |
|---|---|
| Transit Signal Priority (cont.) | Alternate Flows<br>• Action 2) The PRG generates a TSP SSM to the PRS. The TSP SSM contains the same fields as the TSP SRM requested priority strategy.<br>• Action 2) The PRG generates a TSP request clear message to the PRS. The TSP request clear message contains similar fields as the TSP request message is used to indicate that the requesting vehicle has cleared the intersection and priority is no longer needed.<br>• Action 2) The PRG generates a TSP request cancel message to the PRS. The TSP request cancel message contains similar fields as the TSP request message is used to indicate that the priority is no longer needed.<br>• Action 2 through 11) If an EVP request is received, the PRS will automatically override any existing TSP requests, and will not service any new TSP requests. These instances will be logged on the PRS log files. |
| Mobile Accessible Pedestrian Signal System (PED-SIG) | The PED-SIG scenario enables a traveler using a MU to request pedestrian signal actuation and exchange a message transaction set encapsulated by Flow 8. A traveler device would require authentication and security credentials to signal a hands-free request through a Secure MU Gateway (Exchange ID 8). The request would include information from MAP data (SAE J2735) to identify the desired crosswalk path.<br><br>Note: This scenario can be implemented using an active mode where the pedestrian issues messages about their approach, walk strategy (walking path), SRM, clearance time, SSM, and cancellation. Or the application may be implemented in the passive mode, where the traveler issues a PSM when it nears an intersection and then continues to broadcast until they cross the intersection. The alternative approach, using the PSM, may not provide sufficient information for a signal system to detect the direction of travel and activate the appropriate walk signal. To this end, the scenario described below is similar to one implemented for TSP. It is based on the NTCIP functional components, the PRG, PRS and CO.<br><br>Preconditions<br>• The logic for generating a PED-SIG request is loaded into a PED-SIG request generator.<br>• The logic for granting PED-SIG request is loaded in the PED-SIG Request Server.<br>• The Coordinator (CO) monitors the signal timing and determines when the request can be submitted for actuation. |

| CV Application | Scenarios – Main Flow |
|---|---|
| Mobile Accessible Pedestrian Signal System (PED-SIG)<br><br>(cont.) | The actions will flow (using Exchange ID 8) as follows:<br><br>Main Flow<br><br>1. When generating a trip which requires intersection crossing at an RSU enabled signalized intersection, the ATL RIDES subsystem will request MAP data from the CV subsystem to pre-generate a PED-SIG request with the designated crossing path (Exchange ID 8). This path will be inserted into the strategy requested of PRG.<br>2. When the traveler nears the intersection, the ATL RIDES (MU or backend) will send a request for PED-SIG with estimated request time to the PRG at the specified intersection (Exchange ID 8 to PED-SIG).<br>3. The PRG generates a PED-SIG message to the PRS. The PED-SIG message contains the identifier of the type of traveler that desires the signal, a request identifier, the strategy or path requested, time of service desired requested (TSD), and the time of estimated departure.<br>4. The PRG generates a PED-SIG message and transmits it to the PRS at a configurable TSD threshold value (e.g., 30 seconds before the person arrives at the intersection).<br>5. The Controller logs the time the PED-SIG message is transmitted to PRS.<br>6. The PRS receives and logs all transactions to and from the PRG and CO (between the PRS and these entities as well as from these entities from external sources).<br>7. The PRG receives the PED-SIG status message. A PED-SIG request status message contains the identifier traveler that desires service, the request identifier, the service strategy requested, time of service desired request, and the time of estimated departure, and the status of the request.<br>8. The PRS receives and logs all transactions to and from the PRG and Controller (between the PRS and these entities as well as from these entities from external sources).<br>9. The flow repeats with Action 2 continuously as the PRG continues transmitting a PED-SIG message; the PRS continually tracks the traveler and calculates estimated time to service. Update messages, to inform the PRS and CO of changes to the traveler's anticipated arrival, are generated and transmitted to the PRG on an as-needed basis.<br>10. The signal controller services the traveler with a walk signal at the appropriate time, as the traveler is approaching the intersection. |

| CV Application | Scenarios – Main Flow |
|---|---|
| Mobile Accessible Pedestrian Signal System (PED-SIG)<br><br>(cont.) | 11. The PRG output and PED-SIG message continue until the traveler(s) have cleared the intersection (e.g., TSD = 0) or the PRG cancels the priority request. The PRG will transmit the PED-SIG request message at a rate agreed to by signal operations and no more than once every 5 seconds.<br><br>12. At the end of the day, information will be sent to the STM Performance Measure Dashboard (Flow 6). |
| Pedestrian in Signalized Crosswalk Warning (Transit) | In this scenario the RSU broadcasts a message that are received by OBUs on transit vehicles to notify transit bus operators when pedestrians are within the crosswalk of a signalized intersection that is in the intended path of the bus. The actions will flow as follows:<br><br>1. When the pedestrian crossing signal is on, a pedestrian in crosswalk warning is broadcast (Exchange ID 10 and 15) to all vehicles (OBUs) in the vicinity including transit buses.<br>2. The second-by-second traffic information near the pedestrian crossing and the MU locations (collected by ATL RIDES) will be processed by the STM Performance Measure Dashboard through the Exchange ID 6. |
| Transit Stop Request | The Transit Stop Request scenario allows a transit passenger to send a stop request to an approaching transit vehicle. The actions will flow as follows:<br><br>1. The MU will request that a transit vehicle stop at a specific stop (Exchange ID 6 or Flow 9). There are several pathways by which the request may be channeled including a similar device to the Secure MU Gateway at the intersection with a message that is specifically targeted to the next bus.<br>2. The Transit vehicle will receive a message (via Exchange ID 11) on their mobile data terminal with the information on the traveler and pickup/stop location. |

*Source: ARC*

**Information Needs.** The flows and information needs will conform to messages described in SAE J2735 and the family of SAE J2945 series, as well as the ongoing ITE Connected Intersections systems engineering and NTCIP 1211 as appropriate.

Security protocols and transactions follow the IEEE 1609.2-2016 Standard for Wireless Access in Vehicular Environments (WAVE) – Security Services for Applications and Management Messages.

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# 7. Summary of Impacts

This section describes the operational impacts of the new ST-CTN system on the users and other agencies and organizations involved with the system. It also explains how any transition periods will impact system stakeholders and users moving from the current set of independent systems to the new ST-CTN system. This information is intended to be used for stakeholders to plan for these impacts during the development of and transition to the new system.

## 7.1 Operational Impacts

The ST-CTN proposed system will have a direct impact on the operational nature of GCT, GCDOT, GDOT, ATL Rides, and travelers using the ATL RIDES application from the underserved community. The following sections describe potential impacts for each user group within the ST-CTN system.

### 7.1.1 Gwinnett County Transit Operational Impacts

The operational changes for the GCT user group include:

- Changes to the onboard equipment on transit vehicles and practices that support the maintenance of the onboard equipment. The existing onboard operator communications equipment will be used to provide the driver feedback about a boarding passenger if they require additional boarding/alighting time or need assistance from the driver to operate mobility assistive devices.
- Changes to the ways that GCT transit vehicles receive stop requests which will allow passengers to request a stop through the application. This will not impact existing bus stop locations or routing.
- Additional information including whether a traveler has specific needs to board/alight the vehicle will be sent to bus drivers. Reviewing the information while operating a vehicle may be against Standard Operating Procedures.
- Changes to stop facilities management and maintenance practices that support the need for accessible bus stops and shelters, and accessible pathways to bus stops and shelters. Gwinnett County Transit will need to monitor the condition and accessibility of bus stop assets, prepare for and complete repairs, disseminate accessibility information to the proposed system, and accept user submitted inventory updates.
- Changes to operations may be made based on aggregated data received from the ST-CTN expansion. GCT may decide to prioritize future transit expansion or projects based on the type of users interacting with the system and their mobility needs.
- Changes to the method that TSP is activated, potentially resulting in situations where a bus arrives prior to its scheduled time. TSP will be activated automatically based on programmed trip plans and traveler preferences, resulting in more frequent activations of

TSP then before deployment of the ST-CTN. This increased frequency could alter the bus travel patterns, causing them to have to wait at a stop until a scheduled departure time is met.

### 7.1.2 GCDOT Operational Impacts

The operational changes for the GCDOT user group include:

- Changes to asset management and field maintenance practices that support the need for accessible sidewalks and shared-use paths. GCDOT will have access to more ways to monitor the condition and accessibility of shared use right of way assets through crowdsourced data. This data can be used to prioritize repairs. Staff resources will be required to maintain accessibility information in a way that will enable it to feed back into the proposed system.
- Potential change to deploy a Secure MU Gateway in the traffic signal cabinets or central system which would allow connected vehicle and connected infrastructure inputs and outputs to communicate with mobile devices.
- Changes to connected vehicle and connected infrastructure inputs and outputs to allow for TSP and pedestrian safety applications as described in the proposed system.

### 7.1.3 GDOT Operational Impacts

The operational changes for the GDOT user group include:

- Changes to connected vehicle and connected infrastructure inputs and outputs to allow for communication needs through Secure MU Gateway of the proposed system.
- Changes to connected vehicle and connected infrastructure inputs and outputs to allow for TSP and more active role of MU (pedestrians using smartphones) as described in the proposed system.

### 7.1.4 ATL RIDES Operational Impacts

The ATL RIDES user group will consist of both ATL and ARC. Operational changes include:

- Changes to UI to allow users from the underserved community access the application including from a phone, computer, or with assistive technologies.
- Changes to the system that allows for greater scalability without losing connections with end users.
- Changes to application to allow for hands-free, turn by turn directions.
- Long-term technical support assistance will be needed for the web and mobile versions of the ST-CTN application. These will include addressing bugs in the system or software disruptions. Technical support personal will have additional tasks added to their responsibilities with the new application and workflow processes may have to be adjusted.

- An agreement between Georgia Tech and ARC will be made for maintenance and operational support for STM for the duration of the project.

### 7.1.5 Transit Users Operational Impacts

The operational changes for the Transit Users user group include:

- Addition of a new tool a transit rider can use to plan their trip and access transit schedule information.
- Additional information needed from users to determine the most accessible route according to their needs.
- Additional application to connect to user's existing wearable technologies such as a smart cane.
- Operational risk in relying on application's location accuracy for users who those who require precise location details including people with visual or cognitive disabilities.

## 7.2 Organizational Impacts

The ST-CTN proposed system will have a direct impact on the organizational nature of GCT, GCDOT, GDOT, ATL, and ARC. Impacts are broken out per user group below.

### 7.2.1 Gwinnett County Transit Organizational Impacts

The organizational impact for the GCT user group include:

- Changes to policies and operating procedures regarding how vehicle operators receive information from riders to include automatic ST-CTN messages.
- Training for GCT operators and administrators is expected to be included in the development phase to give them a better understanding of the application and the impacts to their position.
- Long-term impacts include updating training materials for drivers and will not require additional staffing or budget.

### 7.2.2 GCDOT Organizational Impacts

The organizational impact for the GCDOT user group include:

- Technology infrastructure maintenance responsibilities will be minimal for the ST-CTN system and fall under current maintenance practices. Long-term impacts of maintenance are already budgeted and planned for in existing CV plans.

- Enhanced sidewalk facility data will enable GCDOT to more efficiently maintain assets but could create more work to incorporate data into current system.

- GCDOT staff and support consultants need to develop capabilities to understand and operate CV systems.

### 7.2.3 GDOT Organizational Impacts

The organizational impact for the GDOT user group include:

- ITS staff and support consultants need to develop capabilities to understand and operate CV systems.
- Long-term impacts are minimal as GDOT already has these work tasks covered by their current staff and work plans.

### 7.2.4 ATL Organizational Impacts

The organizational impact for the ATL user group include:

- Long-term maintenance and development in future iterations of the ATL RIDES application already covered by current staffing and budget. An agreement between ATL and ARC will outline that ATL will maintain the full regional ATL RIDES app and ARC will be responsible for the maintenance of the additional functionality provided by the ST-CTN system.
- Long-term call center support services will be needed for the ST-CTN application. The call center will need to be staffed by operators who are well versed in the application including the setup process in order to properly assist end users. Additionally, operators who speak multiple languages or are familiar with the Text Telephone (TTY) system in order to properly assist all end users. The call center may need to expand as the ST-CTN application is deployed outside of the project area. An agreement between ARC and ATL will need to be made to designate ownership of Call Center operations.

### 7.2.5 ARC Organizational Impacts

The organizational impact for the ARC user group include:

- ARC will facilitate a group of all the project partners to collaborate to manage the system integration during the 8 years of development and operations.
- Long-term maintenance of the ST-CTN ATL RIDES app add-on. An agreement between ATL and ARC will outline that ATL will maintain the full regional ATL RIDES app and ARC will be responsible for the maintenance of the additional functionality provided by the ST-CTN system, including the maintenance of, and functionality provided by, the STM Platform and Sidewalk Inventory Connection Tools subsystems. This task will be managed by the existing position of Transportation Technologist. If necessary, ARC may need to hire a consultant to help maintain the app. This will be budgeted in the annual UPWP.
- Expansion of the ST-CTN system. Expanding the system will require coordination among the local jurisdictions, as well as software developers. This task will be led by the regional planning team at ARC and the regional TSMO planner will work with the transportation technologist to decide how and where to expand the system. If necessary, ARC may

need to hire a consultant to help update and adjust the app for multiple jurisdictions. This will be budgeted in the annual UPWP.

- Long-term call center support services will be needed for the ST-CTN application. The call center will need to be staffed by operators who are well versed in the application including the setup process in order to properly assist end users. Additionally, operators who speak multiple languages or are familiar with the Text Telephone (TTY) system in order to properly assist all end users. The call center may need to expand as the ST-CTN application is deployed outside of the project area. An agreement between ARC and ATL will need to be made to designate ownership of Call Center operations.

### 7.2.6 SILCGA Organizational Impacts

The organizational impact for the SILCGA user group include:

- Long-term training and promotion of the user app. While ARC will be promoting the expansion of the system regionally, SILCGA will work with their partners including DisAbility Link and GA Tech's Tools 4 Life Program to continue to engage and train potential users. This task is currently in line with their mission and work program so no staff or budget changes will need to be made.

## 7.3 Impacts During Development

The development phase for the proposed system involves system design, testing, and verification. During this phase IOO and system developer stakeholder engagement will continue to support the development of the application. End user stakeholder engagement will continue in the form of reviews and demonstrations of the application. It is expected that the proposed system will operate in parallel to the existing system, with a portion of the underserved community being given access to the proposed system for testing purposes.

ATL RIDES is currently being developed by ATL. The application will be completed and fully deployed by September 2022. The ST-CTN application is being developed as a parallel system to the ATL RIDES system. Delays experiences during the ATL RIDES development will impact the development and roll-out of the ST-CTN application. The schedule for the ATL RIDES development is discussed in detail in **Section 3.2.1**.

The STM platform has one upgrade listed that will take place during the development phase of the ST-CTN application, which is the development of a tool and processes used to perform network reconciliation for the ABM, HERE, and OSM networks. The STM platform uses the ABM as its base network for roadway links and will need to add bicycle pathways from OSM and local roads from HERE. The Sidewalk Inventory Collection tools will also be going through continuous improvements prior to and during the development phase. Should any of these upgrades not take place prior to the development phase, the real-time routing and impedance value analysis functionality of the ST-CTN application will be diminished. The schedules for these deployments is discussed in more detail in **Section 3.2.2** and **Section 3.2.3**.

The development phase will overlap several infrastructure improvement projects that are planned within the project limits including the Gwinnett County CVTMP and the CV1K project which will deploy CV infrastructure to signals and transit vehicles. If these project timelines are delayed or the deployment area is altered, there will be impacts to the development of the ST-CTN application with sub-systems that relate to CVs. The schedule for these deployments is discussed in detail in **Section 3.2.4**. These other improvement projects may include resurfacing, widening, or other projects that may cause temporary transit rerouting or communication interruptions.

Gwinnett County Transit is planning on implementing route adjustments during the development phase of the project. These route adjustments will need to be considered while completing system development and coordination will be needed to ensure that the new routes are active in the application once they are active for GCT. Additionally, GCT has several system development milestones occurring during the deployment phase including router upgrades, TSP implementation and ATL RIDES integration. The schedule for these upgrades is discussed in **Section 3.2.5**. Any impact to these schedules could delay deployment of the entirety of, or specific portions of the ST-CTN project. In addition, service changes that impact route operations may be implemented, such as micro or flex routing. These require additional services including hailing functionality.

The ST-CTN application will run in parallel with the ATL RIDES application. There are not expected to be any impacts to either application during the system testing processes.

# 8. Analysis of the Proposed Systems

This section will focus on the expected benefits of the proposed system from a quantitative and qualitative perspective. The analysis approach will be summarized, and the expected benefits, limitations, disadvantages, and trade-offs considered will be provided. The Performance Measurement Plan (Task 5) will expand on the information provided below and offer a more detailed description of the quantitative and qualitative assessments.

## 8.1 Analysis of the Proposed System

The analysis of the proposed system will include the benefits, limitations, and disadvantages of the proposed system as described in **Section 5**. In general, it is the goal of the proposed system to increase reliability of access to the transit system, increase the safety of transit users throughout their trip, and increase mobility of the underserved community.

### 8.1.1 Expected Benefits

The expected benefits of the proposed system are included below. Expected benefits are categorized by trip segment, as discussed in **Section 4.2**. The expected benefits are tied to the user needs discussed in **Section 4.2.1.** Each need was assigned a priority of Essential (E), Desirable (D), or Optional (O). The priority of the needs tied to the benefit are included in **Table 26**.

**Table 26. Proposed System Expected Benefits**

| Trip Segment | Proposed Improvement | Expected Benefit | Benefited Stakeholder | Priority |
|---|---|---|---|---|
| Pre-Trip Planning | Provide travelers with real-time, secure, and reliable traveler information regarding their planned trip. | -Increased Reliability<br><br>-Increased Mobility | Traveler<br><br>GCDOT<br><br>Gwinnett County Transit | E |
| Pre-Trip Planning | Provide travelers with trip personalization tools that allow them to program and complete trips that match their ability levels. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler | E |

| Trip Segment | Proposed Improvement | Expected Benefit | Benefited Stakeholder | Priority |
|---|---|---|---|---|
| Pre-Trip Planning | Provide travelers with the option to set trip preferences to group travel, which will base the trip routing choices on the ability level of a group of travelers as opposed to a single traveler. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler | D |
| Pre-Trip Planning | Provide travelers with the ability to set notification preferences, such as haptic feedback, voice, text, or image alerts. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler | E |
| Pre-Trip Planning | Provide travelers with the ability to preview trips prior to departure to ensure that the traveler understands the extent of their trip. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler | E |
| Begin Trip | Providing a call center line through the application will allow travelers who get disoriented or need assistance to complete their trip. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler | E |
| Begin Trip | Provide travelers with alerts that they have departed the designated route, or that they are getting on the wrong transit vehicle. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler | E |

| Trip Segment | Proposed Improvement | Expected Benefit | Benefited Stakeholder | Priority |
|---|---|---|---|---|
| Transition to Transit | Provide some high-level information to transit vehicle operators which will ensure that all travelers have enough time to board or alight a transit vehicle, are provided the assistance they require when operating mobility assistance devices or need additional time to pay the fare. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler<br><br>Gwinnett County Transit | E |
| Transition to Transit | Provide travelers with the ability to remotely request service to alight a vehicle, the application will ensure that all travelers are able to reach their destination. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler<br><br>Gwinnett County Transit | D |
| Intersection Crossing | By allowing the travelers to request pedestrian service, extend crossing times, and by providing the traveler with information about the crossing. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler<br><br>Gwinnett County DOT | D |
| Connected Vehicles | Connected vehicle applications will allow travelers to remotely request service from transit vehicles, without having to stand for long periods of time, flag down a vehicle, or rush to make an internal connection. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler<br><br>Gwinnett County Transit | D |
| Connected Vehicles | Travelers will be alerted about, as well as alert, passing CVs, making both parties aware of the other. | -Increased Safety | Traveler | D |

| Trip Segment | Proposed Improvement | Expected Benefit | Benefited Stakeholder | Priority |
|---|---|---|---|---|
| Connected Vehicles | Implementing TSP will improve transit schedule reliability and on time performance. | -Increased Reliability<br><br>-Increased Mobility | Traveler<br><br>Gwinnett County Transit | E |
| Indoor Navigation | Travelers will be provided with information on indoor navigation at select locations including accessible access points and service outages. | -Increased Reliability<br><br>-Increased Mobility | Traveler | D |
| Reporting | Travelers will have the ability to report on infrastructure, including elevators, escalators, or sidewalks that are not accessible. | -Increased Safety<br><br>-Increased Reliability<br><br>-Increased Mobility | Traveler<br><br>Gwinnett County DOT | D |

*Source: ARC*

Key performance measures and targets are difficult to establish in transportation studies, specifically when focusing on the perception of safety and mobility from the end users' point of view. The goals of the proposed system include:

- Increased Trip Reliability – Providing travelers in the underserved community with the ability to program and complete a trip reliably, from origin to destination, and all the transitions between trip segments, based on their abilities is the ultimate goal of the project. This can be measured in several ways, including:
  - Qualitative: Solicit feedback from the travelers on their ability to program and complete trips while using the ST-CTN application.
  - Quantitative: Collect and analyze non identifiable data about trip completion percentage through the application.
  - Quantitative: Collect and analyze data about network and application uptime and number of users.
  - Quantitative: Collect and analyze data about transit service on-time performance and speed.
  - Quantitative: Collect and analyze non identifiable data about remote service calls for transit or pedestrian services.
- Increased Trip Safety – Providing travelers in the underserved community with the ability to program and complete a trip safely, from origin to destination, based on their abilities is the major goal of the project. This can be measured in several ways, including:

  - Qualitative: Solicit feedback from the travelers on their perception of safety while using the ST-CTN application.
  - Quantitative: Collect and analyze non identifiable data about the number and type of CV broadcasts to determine if near-miss situations are occurring.
  - Quantitative: Collect and analyze non identifiable data on pedestrian extension requests.
  - Quantitative: Track crashes in the project area to note any decrease in occurrences.
- Increased Mobility and Accessibility – Providing travelers in the underserved community increased mobility and accessibility is a major goal of the project. This can be measured in several ways, including:
  - Qualitative: Solicit feedback from travelers on their mobility options and the accessibility of transportation choices with access to the ST-CTN application.
  - Quantitative: Collect and analyze non identifiable data about existing travel patterns through the deployment of a control version of the application during the development and testing phase. Compare this data to travel patterns after the full system is deployed.
  - Quantitative: Collect and analyze key performance data produced by third parties including employment data, travel time data, and quality of life data before and after the deployment of the application.

These performance measures will be expanded on during the development of the Performance Measurement Plan (Task 5).

### 8.1.2 Limitations and Disadvantages

The following limitations and disadvantages of the proposed system are acknowledged below. The ST-CTN project team will determine if there are ways to measure the impact during the development of the Performance Measurement Plan (Task 5).

- Outreach – Recruiting and keeping volunteer users engaged throughout the development process presents a challenge to the deployment of the proposed system. As users relocate, change travel patterns due to job changes, or become disengaged, the accuracy of the data produced will be impacted. The engagement rate of the application will be measured during the development phases to ensure that a reliable data set is maintained.
- Technology Access – Access to the mobile application will require the use of a smart phone with a data plan. The application will be available through a web browser, but enhanced features, such as CV applications or real-time route guidance will not be available. The method of access will be monitored throughout the development phase.
- Location Data – Mobile devices and CV have limitations to the accuracy of data they are able to broadcast. The ability to accurately determine orientation or low latency direction

of travel presents a challenge for both end users and CVs. The application will have to predict end user movement based on planned trip routing when activating pedestrian service requests. Similarly, CV broadcasts will have to be based on near term direction of travel information and may not always accurately portray the true nature of a vehicle. Qualitative data can be collected during the development and deployment stage to understand the impact of inaccurate location data, such as questionnaires issued post trip.

- Service Mode – The ST-CTN application focuses on transit-based trips. Third-party integration of ride hailing/booking service or flex/micro transit services can be integrated at a future time but will not be available during the development phase. This could impact the way users interact with the app during the development phase, causing a reduction of reliable data. Qualitative data can be collected to understand this impact through user surveys.
- Information Overload – The ST-CTN application will be simple to use but highly customizable. Some users may experience information overload when customizing the application preferences and their abilities into the application. Outreach services and reset functions can be included to minimize these challenges. Qualitative data can be collected to understand the ease of which the user can customize the application.
- Customization Lock Out – The ST-CTN application is highly customizable with many preferences impacting route generation. It is possible that a specific preference or set of preferences could be selected which would return a trip plan that far exceeds an ideal trip travel time or does not return a trip plan at all. This could be avoided by generating several trip plans for each trip with indicators of the different characteristics of each plan, allowing the user to select the route that best suits their needs at the time. Quantitative data can be collected to understand what preferences are linked to trips with higher travel times and how often trips with characteristics that do not match the traveler's selected preferences.
- Limited Indoor Environments – The initial deployment of the application will only feature a single indoor navigable environment, the Doraville MARTA Station. This limitation could cause some confusion when travelers are attempting to navigate other indoor environments with the application. These features are expected to expand as the application is developed further and additional data sources are incorporated. Qualitative data can be collected in the form of trip surveys to understand how often users are accessing indoor spaces as a part of their trip.
- Limited Geographic Area – The ST-CTN application will be developed and deployed in the project area identified in **Section 5**. This limitation will impact the traveler's ability to make a complete trip if they are starting or ending their trip outside of the project limits. The base ATL RIDES application will be able support the traveler's transit and routing needs outside of the project area, but the generated routes will not account for all their preferences. Quantitative data can be collected to understand how many trips are starting or ending outside of the project area. This data can be used to support further expansion of the ST-CTN application.

## 8.2 Alternatives and Trade-Offs Considered

The proposed concept, as described in **Section 5**, meets the goals of the ST-CTN project by providing an application that allows users to complete trips, from origin to destination, safely, while accounting for their preferences and abilities. There were needs discussed during the stakeholder engagement that fell outside of the scope of the project or did not contribute to the goal of the projects. Changes considered but not included in the proposed concept are discussed in **Section 4.3** and expanded on below.

Expansion of Transit Service – Alternative that include the expansion of transit service, through the addition of new routes, extended operating hours, or purchasing of OBUs for microtransit vehicles are outside of the scope of this project and not considered as a part of this ConOps. The proposed system will be using the existing infrastructure that is deployed or will be deployed through upcoming infrastructure projects. Likewise, the transit system that is currently operational or that will be operational during the deployment phase, is a fixed route system, and altering the service area or schedule would have detrimental impacts on the system.

Construction of Additional Infrastructure – Alternatives that include adding street lighting, modifying building features including entry points and signage, modifying intersections, or expanding transit stops are outside of the scope of this project and not considered as a part of this ConOps. The proposed system and project are not capable of building new infrastructure within the project limits.

Additional Training for Transit Operators – Alternatives that include additional training for transit vehicle operators including training on how to recognize and respond to traveler specific mobility challenges or training on how to better operate mobility assistive devices on the bus are outside of the scope of this project and not considered as a part of this ConOps. Information will be provided to the drivers on passengers who need additional time to board or alight the bus, pay for a fare, or require priority seating. The proposed system and project are not capable of providing training to transit vehicle operators.

On-Demand Application Customization – Alternatives that include application customization to match the traveler’s ability, such as map customization, or application simplification (i.e., the removal of options from menus) are not considered as a part of this ConOps. The effort required to provide additional customization to base map features, or the simplification of the application are not aligned with the goals of the proposed system. Support through outreach programs and call centers is included in the proposed system to assist users with understanding how to use the application.

The ST-CTN team and system developers considered trade-offs between Agile and Waterfall software development methodologies. Ultimately, the system developers were able to choose their preference for software development that is included in the proposed system. Many of the subsystems are fully developed with modifications being applied to operate in or interface with the proposed system and it would have been disruptive to the individual development cycles to require the developers to shift to a new methodology. Agile development will also be able to keep pace with the feedback that is received during the development phase.

Mobile App Limitations. Issues such as latency, positional accuracy, battery life limit the ability for the mobile app to actively participate in the connected vehicle environment as an active participant. Research and demonstration projects are currently underway that may mitigate the impacts of the limits. For example, the NavCog project is addressing improved locational accuracy, additional Bluetooth and Wi-Fi sensors using triangulation are improving locational precision, mobile handsets are extending the life of batteries, including additional capabilities that improve location accuracy and ranging such as machine vision and ultrawide band sensors. In addition, there are also potential solutions using the batteries on electric wheelchairs to support travel execution for people using wheelchairs.

# Appendix A. Acronyms

ABM - Activity-based Model

ACS – American Community Survey

ADA – Americans with Disability Act

API – Application Programming Interface

ARC – Atlanta Regional Commission

ATL – Atlanta-Region Transit Link Authority

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

ATMS – Advanced Transportation Management System

AVL – Automatic Vehicle Location

BSM – Basic Safety Message

CAD – Computer-Aided Dispatch

CCTV – Closed Circuit Television

CDP – Connected Data Platform

CMAQ – Congestion Mitigation and Air Quality Program

CO – Coordinator

ConOps – Concept of Operations

CPACS – Center for Pan Asian Community Services

CTP – Comprehensive Transportation Plan

CV – Connected Vehicle

CV1K – Regional Connected Vehicle Infrastructure Deployment Program

C-V2X – Cellular – Vehicle to Everything

CVTMP – Connected Vehicle Technology Master Plan

DBHDD – Georgia Department of Behavioral Health and Developmental Disabilities

DOE – Department of Energy

DOEd – Department of Education

DSRC – Dedicated Short-Range Communication

EMT – Executive Management Team

EVP – Emergency Vehicle Preemption

FCC – Federal Communication Commission

FHWA – Federal Highway Administration

FTA – Federal Transit Administration

GA Tech – Georgia Institute of Technology

GBFS – General Bikeshare Feed Specification

GCCV – Gwinnett County Connected Vehicles

GCDOT – Gwinnett County Department of Transportation

GCIT – Gwinnett County Information Technology

GCT – Gwinnett County Transit

GCTO – Gwinnett County Traffic and Operations

GDOT – Georgia Department of Transportation

GIS – Geographic Information System

GOSystems – GO Systems and Solutions

GPS – Geographic Positioning System

GRTA – Georgia Regional Transit Authority

GTFS – General Transit Feed Specification

I2P – infrastructure to person

IEEE – Institute of Electrical and Electronic Engineers

IMI – Integrated Mobility Innovation

IOO – Infrastructure Owner/Operator

I-SIG – Intelligent Traffic Signal System

IT – information technology

ITS – Intelligent Transportation Systems

IVR – Interactive Voice Response

JPO – Joint Program Office

KHA – Kimley-Horn and Associates, Inc.

LEP – Limited English proficiency

MAP – Map Data

MARTA – Metropolitan Atlanta Regional Transit Authority

MDC – Major Desired Capability

MMITSS – Multimodal Intelligent Traffic Signal System

MPO – Metropolitan Planning Organization

MU – Mobile Unit

NFC – Near-Field Communication

NIST – National Institute of Standards and Technology

NOAA – National Oceanic and Atmospheric Administration

OBU – Onboard Unit

OSM – Open Street Map

OSS – Open Source Software

OST – Office of the Secretary

OTP – Open Trip Planner

P2I – Person to Infrastructure

P2V – Person to Vehicle

PED-SIG – Mobile Accessible Pedestrian Signal System

PII – Personally Identifiable Information

PRG – Priority Request Generator

PRS – Priority Request Service

PSM – Personal Safety Message

RITIS – Regional Integrated Transportation Information System

RSU – Roadside Unit

RTP – Regional Transportation Plan

SCMS – Security Credential Management System

Sidewalk MV – Sidewalk Machine Vision

SILCGA – Statewide Independent Living Council of Georgia

SLA – Service Level Agreement

SPaT – Signal, Phasing, and Timing

SRM – Signal Request Message

SSM – Signal Status Message

SRTA – State Road and Tollway Authority

STBGP – Surface Transportation Block Grant Program

ST-CTN – Safe Trips in a Connected Transportation Network

STM – Space Time Memory

TAP – Transportation Alternatives Program

TBD – To Be Determined

TCC – Traffic Control Center

TIP – Transportation Improvement Program

TMC – Traffic Management Center

TNC – Transportation Network Company

TSP – Transit Signal Priority

TTY – Text Telephone system

UI – User Interface

UPWP – Unified Planning Work Program

USDOT – U.S. Department of Transportation

V2P – Vehicle to Person

VLAN – Virtual Local Area Network

# Appendix B. Glossary

**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].

**Artificial Intelligence –** Intelligence that is learned, displayed, and carried out by machines. An "intelligent" machine perceives its environment and then takes actions that maximize its chance of success at some goal. Examples that we know include human speech recognition, which turns spoken words into the contents of a text document or email, and autonomous driving, where the vehicle has a learning element to recognize its environment including other vehicles, pedestrians and the infrastructure. Intelligence and decision-making that come from a machine and an autonomous vehicle is known as artificial intelligence. Deep learning and machine learning are mainly included in AI. [CVPFS]

**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). [CVPFS]

**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 [CVTMP].

**Cellular V2X – Cellular V2X (C-V2X)** 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.

**Connected Vehicle (C) –** 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. [CVPFS]

**Dedicated Short-Range Communication (DSRC) –** A protocol for communication between vehicles and between moving vehicles and fixed roadside access points. The protocol addresses safety critical issues associating with sending and receiving data. The protocol provides low-latency data-only V2V and V2I communications. [CVPFS]

**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].

**High Precision Positioning/Timing Source --** Source data service which could be a base station or a satellite allowing the system to calculate positioning and UTC for system processes or provide position corrections. An example of a High Precision Positioning/Timing Source is a GNSS receiver. [CI]

**Intelligent Traffic Signal System (I-SIG)** – A traffic signal system that controls signals and maximizes flows in real time by collecting data from vehicles through V2V, V2P, and V2I communications. [CVPFS]

**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 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]

**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]

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

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

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

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

**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. [CVPFS]

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

**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. [CVPFS]

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