

# Phase 1 User Needs Identification and Requirements Planning (UNIRP)

Atlanta Regional Commission  
ITS4US Deployment Project

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<b>16. Abstract</b> <p>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.</p> <p>The User Needs Identification and Requirements Planning (UNIRP) defines the processes that will be used to generate, coordinate, approve, and support the configuration control of user needs and system requirements. The user needs and requirements development processes are critical processes that must occur early in the project lifecycle, likely before any decisions about design and development processes are made.</p>					
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# 1. Introduction

The Atlanta Regional Commission (ARC) will follow a systems engineering process in delivering the software and data management systems for the Safe Trips in a Connected Transportation Network (ST-CTN) Complete Trip – ITS4US Deployment project. Through our user-centric approach, we will elicit user needs from a variety of stakeholders that will serve as the foundation for the project. These user needs will be captured in the Concept of Operations, ConOps, document. Those user needs will then be reviewed, analyzed, and transformed into verifiable requirements that will define the system’s capabilities. User needs and requirements are the foundation which guides the systems engineering processes that will be applied in delivering Phase 1 of the project.

The User Needs Identification and Requirements Planning (UNIRP) document was prepared to define the processes that will be used to generate, coordinate, approve, and support the configuration control of user needs and system requirements. Developing user needs and requirements is a critical process that must occur early in the project lifecycle before any decisions about design and development processes are made. The UNIRP was developed to define the approach that the project team will use in planning for developing user needs and requirements. The UNIRP document will form the foundation of the Systems Engineering Management Plan (SEMP) that will be delivered later in Phase 1 of the project.

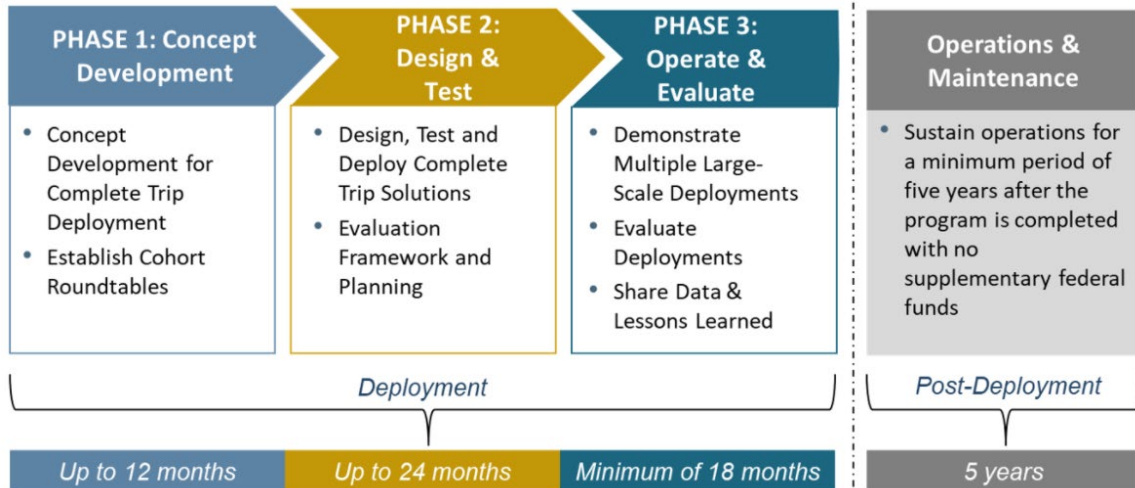
The SEMP will further describe the systems engineering processes ARC will follow during the execution of the project and how the project team plans to manage the specific systems engineering activities performed during the project. The SEMP will incorporate sections of the UNIRP document and other additional information to address the remaining systems engineering processes. Once complete, the SEMP will detail all the systems engineering processes that will be employed by the ST-CTN project team.

## 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 disabilities, older adults, low-income individuals, rural residents, veterans, and limited English proficiency (LEP) travelers.

The program will be executed in three phases as depicted in Figure 1.



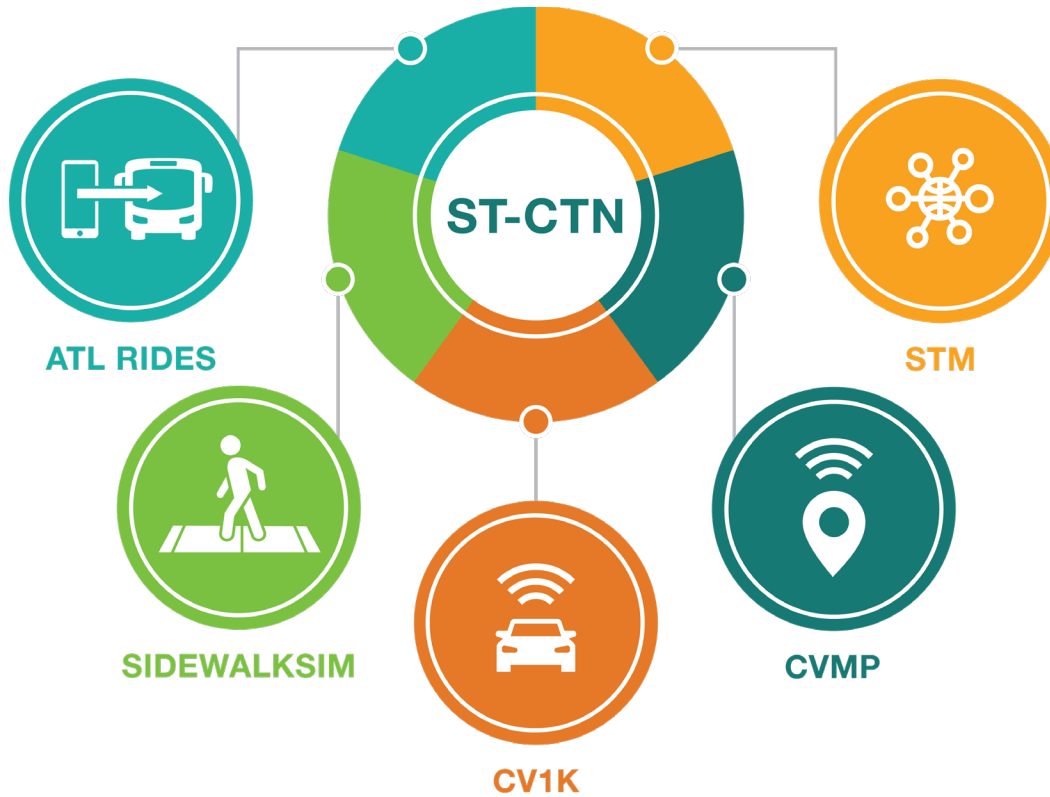


**Figure 1. Phases of the Complete Trip - ITS4US Deployment Program (source: USDOT)**

The U.S. Department of Transportation (U.S. DOT) awarded five sites as Phase 1 recipients to showcase innovative business partnerships, technologies, and practices that promote independent mobility for all travelers regardless of location, income, or disability.

ARC's ST-CTN project was selected as one of the five sites that was awarded funding for Phase 1: Concept Development.

The ST-CTN project will be led by ARC in Gwinnett County, GA. Gwinnett County – a suburban county located directly Northeast of Atlanta. The project team intends to address multiple aspects of the Complete Trip through the development of the ST-CTN concept, which will merge multiple technological innovations. The ST-CTN concept will be founded on five programs currently underway with regional commitments. These projects are pushing the Atlanta region to innovative mobility solutions. ST-CTN will merge these separate initiatives through data fusion and communication 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 vulnerable groups. These initiatives are shown in Figure 2 and defined in more detail below.



**Figure 2. ST-CTN Integrated Initiatives (Source: ARC)**



**ATL RIDES.** Utilizing an FTA Integrated Mobility Innovation (IMI) grant award, the Atlanta-Region Transit Link Authority (ATL) is deploying the Atlanta-Region Rider Information and Data Evaluation System (ATL RIDES). ATL RIDES includes an open source software (OSS) multi-modal trip planning and mobile application, integrated mobile fare payment options, and a connected data platform (CDP) using regional General Transit Feed Specification (GTFS) feeds. The trip planning platform is built on the latest version of Open Trip Planner (OTP) with web and mobile app. The tool supports multi-agency context, multilingual support, and live-tracking capabilities using GTFS feeds. All software and mobile apps developed through the ATL RIDES project will be open source, making them available for use in other communities. The OTP architecture facilitates integration with additional OSS tools including a data analytic engine, call center, and an account management system. Other mobile vendor applications can also be integrated with the OTP engine. New network links representing pedestrian and bike paths, building entrances, indoor walking paths, and elevator locations to be integrated over the next three years will be loaded into Open Street Map (OSM), the transportation network used by OTP.



**SidewalkSim.** Georgia Institute of Technology (GA Tech) developed SidewalkSim as an asset management system and shortest path (lowest impedance) routing tool for pedestrian pathways. The Georgia Tech team has also developed field data collection apps used to inventory features and assess conditions and to analyze pathway suitability for wheelchair and other users. GA Tech has completed pathway networks for more than 2,000 miles of sidewalks in

the City of Atlanta and Clayton County. Site inspections provide more detailed Americans with Disabilities Act (ADA) and inclusive design and condition data for use in pathway accessibility analysis. SidewalkSim identifies the best path between any two points in the pedestrian network, given the set of pathway characteristics and any user-specified needs and route penalties. An application programming interface (API) and public facing app will be deployed to collect crowdsourced data for dynamic conditions, such as sidewalk repairs and elevator outages.



**CV1K.** The Atlanta region is home to one of the largest connected vehicle deployments in the United States – the Regional Connected Vehicle Infrastructure Deployment Program (CV1K). CV1K is deploying interoperable connected vehicle technologies at signalized intersections throughout the Atlanta region using both Dedicated Short-Range Communication (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 connected vehicle infrastructure and applications, including Transit Signal Priority (TSP). Gwinnett County will be one of the largest recipients of the first phase of this deployment.



**CVMP.** The Connected Vehicle Master Plan: Roadmap for Gwinnett (CVMP) 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 connected vehicles (CVs). Among the high priorities is establishing a mobile accessible safety program and alternative strategies for TSP in Gwinnett County.



**STM.** GA Tech developed and deployed the Space Time Memory (STM) platform for the Atlanta region as part of a 2018 Department of Energy ARPA-E TRANSNET project. The STM 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. Outputs are tailored toward different vulnerable user groups and adjusted dynamically based upon their needs using the Commute Advisor API.

These existing tools and regional commitments will enable the project team to efficiently implement ST-CTN, an integrated, innovative system that will use emerging technologies to provide a planning tool for dynamic, safe, and reliable route information for vulnerable road users.

## 1.2. Intended Audience

The intended audience for this UNIRP document is the ST-CTN project team, which includes ARC and its partners, including:

- Gwinnett County
- Atlanta-Region Transit Link Authority (ATL)
- Statewide Independent Living Council of Georgia (SILCGA)
- Kimley-Horn and Associates
- GO Systems and Solutions (GOSystems)
- Georgia Department of Transportation (GDOT)
- Georgia Institute of Technology (GA Tech)
- IBI Group

The UNIRP document is also intended to inform the U.S. DOT on the approach the ST-CTN project team will apply to develop user needs and system requirements. Finally, the document may serve as a reference for other communities across the United States interested in building local partnerships as they develop and deploy integrated and replicable mobility solutions to achieve complete trips for all travelers.

## 1.3. User Needs and Requirements Update Process

The processes defined in the UNIRP document will provide the foundation for how user needs and requirements will be developed. The project team will apply these processes and approaches in the development of the ConOps and Systems Requirements documents. The UNIRP document will serve as the baseline document. As user needs and system requirements are developed, methods for developing, updating, and managing the user needs and requirements baseline may be necessary.

If the project team identifies that changes to the methods and procedures stated in this baseline document require changes or revisions, those changes will be documented in the SEMP. As noted earlier, the UNIRP document will provide the basis for the SEMP. Any updates and changes to the user needs and system requirements development processes will be reflected in the final version of the SEMP (Task 12 deliverable).

## 1.4. Applicable Documents

User needs and requirements are the foundation which will guide the systems engineering processes that will be applied in delivering Phase 1 of the project. The UNIRP document identifies the processes that will be used in the creation of the following Phase 1 documents.

- Concept of Operations (ConOps) for the Safe Trips in a Connected Transportation Environment project
- System Requirements (SyRS) for the Safe Trips in a Connected Transportation Environment project

## 2. User Needs Identification

### 2.1. Introduction to User Needs

The ConOps is the initial step in the systems engineering process whose goal is to lay the groundwork for a successful deployment of the project. Systems engineering focuses on defining user needs and required functionality early in the development cycle, documenting requirements, and then tracing those decisions throughout the implementation process. It is particularly useful for stakeholders entering later in the process to understand the rationale for decisions that were made previously. Thus, the purpose of the ConOps is to capture a clear definition of the users' needs (and constraints) that will support system requirements development.

The ST-CTN project team understands that user needs provide the foundation of all subsequent systems engineering processes and are of critical importance to the success of the overall program. System requirements and design elements will ultimately trace to one or more of the identified user needs.

A user need is an expression of a required capability of the system, expressed in generic (i.e., non-solution oriented) terms. To ensure that user needs are well written, the following criteria shall be 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 a 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.

An example User Need is documented below:

***UN-1 Transferring from subway platform to shared use service boarding location.***  
*Transit users with visual disabilities need to be able to safely and efficiently navigate from the subway platform to the shared services hailing location. A solution that assists users with visual disabilities navigate from the subway platform to the shared services hailing location allows the user to independently traverse the station so that they can change modes and continue their trip.*

By following the above criteria, the ST-CTN project team will establish well defined user needs that will support the successful execution of the systems engineering processes that follow as well as the success of the overall project.

## 2.2. User Needs Identification Processes

The following sections describe the techniques the project team will use to identify user needs for the ST-CTN project.

### 2.2.1. Previously Identified User Needs

When developing the ST-CTN proposal, the project team used existing master plans and outreach reports, combined with a thorough knowledge of the project area and needs of underserved travelers to gain a preliminary understanding of user needs. The high-level needs that were developed for the ST-CTN proposal were broken out into three categories, (i) mobility and accessibility needs, (ii) functional needs, and (iii) system interoperability needs.

#### Mobility and Accessibility Needs:

Underserved travelers need:

- Better access to destinations and transit services – including improved sidewalk connectivity and consistency
- Greater safety and visibility at intersections
- More reliable transit service

#### Functional Needs:

Underserved travelers need:

- Personalized trip information including reliable directions, schedules, messaging, and accommodations before and during the trip
- Multiple alert methods including haptic, auditory, or visual feedback
- Continued app functionality that requires minimal or hands-off interaction from the user
- Solutions that ensure privacy and data security
- Solutions that support multiple languages

#### System Interoperability Needs:

The system and subsystems need:

- Each subsystem in the system of interest needs to interoperate (communicate and interface) with other subsystems
- Each subsystem needs to be developed using an open architecture to in order to “future-proof” the system of interest.

These high-level needs led to the development of the preliminary concept of the ST-CTN system and will provide guidance to the project team throughout the systems engineering process. To develop these high-level user needs into well-written user needs, the ST-CTN project team will conduct stakeholder outreach to underserved communities, owner/operators, and system developers to:

- Gain additional insight into what specifically generated the high-level needs
- Understand which needs are of major importance to the stakeholders

- Ensure that the needs are not currently solved by existing system features
- Understand why the capabilities to address these needs are required in the system

### 2.2.2. Stakeholder Engagement

The ST-CTN Executive Management Team (EMT) and members of the production team held a series of three work sessions to identify a comprehensive list of stakeholders who serve or represent end users, own or operate infrastructure, or are system developers for subsystems within the proposed system deployment area. These stakeholders were then categorized by their area of expertise. The ST-CTN project team will conduct user and system interoperability needs interviews with the following stakeholder groups:

- Underserved Communities – Mobility challenged groups including users with cognitive or physical impairments, aging adults, and LEP groups.
- Infrastructure Owner/Operators (IOOs) – Public or private agencies that will set policy regarding the deployment and maintenance of the deployed infrastructure and services.
- System Developers – Organizations and companies that will develop the software responsible for collecting and distributing the information needed in the final system deployment.

User needs, as in the needs for the end users that will interact with the proposed system, will be collected through interviews with representatives for the underserved communities. System needs, as in the needs that each subsystem will have in order to meet the user needs, will be collected through interviews with IOOs and system developers based on supporting user needs.

The ST-CTN team will conduct focused interviews with stakeholders to gain an understanding of existing challenges and user needs. These inputs will be used to derive the well-formed user needs and desired capabilities of the proposed system(s).

The ST-CTN chose to conduct interviews with small, targeted stakeholder groups to maximize engagement and to ensure that stakeholders are given an opportunity to convey their challenges and needs to the project team. These smaller, more-focused meetings have proven to be effective in engaging stakeholders and giving them an opportunity to be heard. In contrast, larger workshops provide an opportunity to engage all stakeholders in a single meeting, but discussions may be limited to a few more vocal stakeholders. As a result, challenges and needs may not be captured from all stakeholders.

Prior to conducting interviews, the project team will identify the key stakeholders that will be associated with the ST-CTN project. Once identified, the stakeholder will be categorized into one of the three aforementioned stakeholder groups. The intent is to identify like-minded groups of stakeholders together to minimize the number of interviews conducted while maximizing engagement from different stakeholders with different viewpoints.

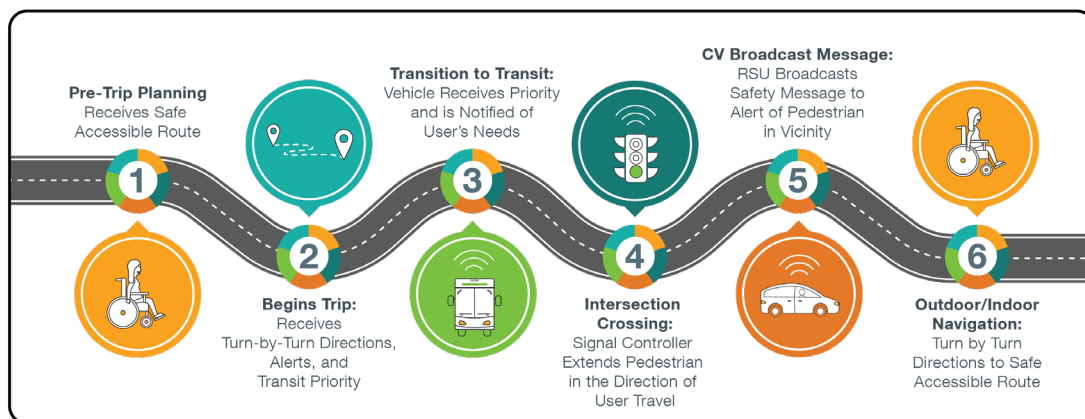
Prior to conducting each interview, the project team will develop interview questions and materials that will be used to elicit input for the interviewees. These materials will be used to guide the conversation to make sure that the appropriate information is captured consistently across all interviews. These materials will also ensure that all topics are covered during the interview.

**Interviews with Underserved Community Advocates.** User needs interviews with advocacy groups focused on serving individuals from underserved communities will be used to understand

the challenges that the communities face while making transit-based trips. Stakeholders will be 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 is discussed, discussions will occur around the distinct segments or steps of a complete trip (as depicted in Figure 3), including:

- Step 1 Pre-trip planning: Receives a safe accessible route
- Step 2 Begins trip: Receives turn by turn directions, alerts, and transit priority
- Step 3 Transition to transit: Transit vehicle receives priority and is notified of users' needs
- Step 4 Intersection crossing: Signal controller extends pedestrian phase in the direction of user travel
- Step 5 CV broadcast message: (roadside unit) RSU broadcasts safety message to alert of pedestrian/bicyclist in vicinity
- Step 6 Outdoor/indoor navigation: Turn by turn directions to safe accessible route

Trip segments will be delineated at all transition points throughout the trip. This will allow the ST-CTN project team to obtain feedback from users and continuously improve our understanding of the needs and key navigation challenges faced by the stakeholders.



**Figure 3: Wendy's Complete and Safe Trip using ST-CTN**

Underserved communities will be represented by members of advocacy groups such as the SILCGA, and the Center for Pan Asian Community Services (CPACS), among others. Interviews are envisioned to be conducted in groups of 3 to 7 people, not counting ST-CTN team members, that will take place over the course of an hour. If follow up meetings are required with the entire group or individual participants, they will be scheduled as needed. Engaging with small groups will allow the ST-CTN team to better understand the challenges that all individuals face and will allow more personal interaction. To focus appropriately on the needs of the end users, the interview sessions will be separated into mobility challenged groups (including cognitive, physical, and aging adults) and LEP groups. It is expected that there will be overlap in stakeholder expertise and both of the groups outlined will also be able to address the challenges of low-income communities. Interview sessions will be 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. Assistive services and technologies will be available during these engagement sessions to help ensure an inclusive experience.

**Interviews with Infrastructure Owners/Operators.** Stakeholder engagement with IOOs will be used to understand the policy, infrastructure, and procurement challenges and needs that will be required to successfully deploy a complex system such as the ST-CTN. Stakeholders from this group will take part in high level discussions with the ST-CTN project team to identify system needs such that the system concept is achievable, expandable, and replicable. These stakeholders include organizations including Gwinnett County, ARC, GDOT, and ATL. Engagement with these stakeholders will take the form of an initial system need interviews. It is expected that multiple follow-up interviews and coordination meetings will be required throughout the project life cycle. The ST-CTN project team will present the Needs Summary (Task 2.2 deliverable) to IOOs in order to develop and formulate system needs for each subsystem represented within the project.

**Interviews with System Developers.** Stakeholder engagement with system developers will be used to understand potential technology challenges and needs that subsystem developers anticipate for a systems integration of this scale. Stakeholders from this group will take part in detailed discussions surrounding the deployment of new technologies and the integration of different software and hardware so the ST-CTN project team can identify challenge areas that must be overcome for a successful deployment. These stakeholders include developers from ATL, the IBI Group, Gwinnett County connected vehicle designers, GA Tech School of Civil and Environmental Engineering, and GA Tech Center for Inclusive Design and Innovation. Engagement with these stakeholders will take the form of an initial system needs interviews. It is expected that multiple follow-up interviews and coordination meetings will be required throughout the project life cycle. The ST-CTN project team will present the Needs Summary (Task 2.2 deliverable) to system developers in order to develop and formulate system needs for each subsystem represented within the project.

Given the COVID-19 pandemic, it is anticipated that all stakeholder interviews will be held virtually utilizing Microsoft Teams platform which can accommodate video conferencing and dial-in options. The ST-CTN project team will reach out to interview participants in advance of the meetings to understand specific stakeholder accommodations that will be provided to ensure all stakeholders can actively participate in the interviews.

Detailed meeting notes will be captured for each interview. Following the interview, notes will be provided to the interviewees to allow them to verify the discussion. These notes will serve as the basis for the ST-CTN project team to develop user needs that will be documented in the Needs Summary and later incorporated into the ConOps. As user needs are developed, the project team may determine that additional information is needed. As such, the project team may follow-up with appropriate stakeholders to clarify their challenges and needs – or to elicit additional inputs.

A stakeholder panel will be formed to review and finalize the well-written user needs which are developed from the ST-CTN project stakeholder engagement process. The panel will be requested to participate based on their interest and participation within the stakeholder user needs interviews; it is envisioned that these stakeholders will be champions for the project and be assets during the life of the project to provide continued direction and accountability. The stakeholder panel will be composed of members from each of the stakeholder groups to ensure that all groups are represented in the final decision-making process. Panel members will be selected based on organizations who represent large constituencies or have a major stake in the system deployment (e.g., such as Gwinnett County Transit and ATL).

### 2.2.3. Use Case Decomposition

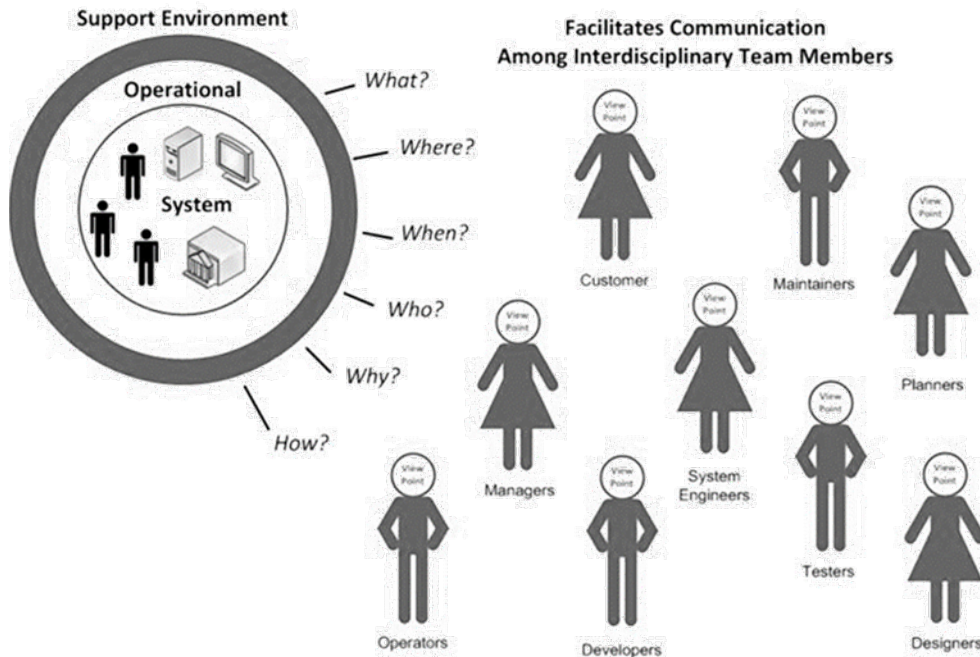
As discussed in Section 2.2.2, the ST-CTN team will develop a set of questions to elicit information on user's "complete trip" challenges and discuss operational scenarios in which potential technologies could be leveraged to overcome barriers and improve travel transitions. Specifically, these operational scenarios will be crafted to address each trip segment of a complete trip including challenges to mode selection, transition between modes, and information and user interface form factors for the end-user. Multimodal trip flows will be created, through description and visualization, to help the team identify challenges, gaps, and obstacles within the complete trip journey. Trip flows will be broken down by trip segment and trip transition and will be shared with stakeholder user groups. This will allow for focused analysis on each segment of the trip as opposed to the trip as a whole. Segments considered include trip planning, outdoor navigation, boarding/using vehicles, transferring between vehicles/modes/payment and using stops/stations, indoor/outdoor transitions, and indoor navigation.

During the interviews and working meetings in which we will review the scenarios, the team will engage the stakeholders to understand their travel challenges and needs. The scenarios will be designed to target the specific stakeholder community interviewed. For example, stakeholder interviews focused on underserved communities will use scenarios that address needs for specific vulnerable communities including people with disabilities, LEP, low income, and zero vehicle households. A directed set of questions will be available for interview and meeting facilitators for use to engage stakeholders about barriers, comfort with a variety of technologies, information needs, and user access methods (presentation). For IOO stakeholders, the operational scenarios will reflect the advanced operational treatments that are needed to implement more accessible, complete trips. These discussions will seek information on existing constraints and institutional coordination needs. The notes from the interviews will be documented and summarized as needs and rationale by the different stakeholder groups. System developer stakeholder operational scenarios will be focused on representing anticipated complex integration challenges that are required to be understood such that system needs can be fully captured.

These operational scenarios will be used to generate use cases to illustrate user needs and highlight information flows between subsystems and components in the ConOps. The needs that emerge from stakeholder interviews and meetings will be documented in the Needs Summary. The Needs Summary document will include well-articulated needs with supporting rationale. This summary will be reviewed with the Stakeholder Panel (a selection of key personnel from each stakeholder group) and incorporated into the ConOps.

## 2.3. Concept of Operations Development

The ConOps will use the template provided by the U.S. DOT that is based on *IEEE 1362-1998 – Guide for Information Technology—System Definition—Concept of Operations (ConOps) Document*. The ConOps is a foundation document that frames the overall system and sets the technical course for the project. Its purpose is to clearly convey a high-level view of the system to be developed in a way that every stakeholder can understand. The ConOps will answer who, what, where, when, why, and how questions about the project from the viewpoint of each stakeholder as shown in Figure 4.



**Figure 4: ConOps Facilitates Communications among Stakeholders about the High Level View of the System**

Per the Institute of Electrical and Electronic Engineers (IEEE) standard, the ConOps document will provide:

- A means of describing a user's needs without becoming bogged down in detailed technical issues.
- A mechanism for documenting a system's characteristics and the user's needs in a manner that can be verified by users without requiring any technical knowledge.
- A place for users to state their desires, visions, and expectations.

The ConOps audience will be key stakeholder groups representing their user needs. The system concept will describe technology-independent solutions except where existing systems are used. As a systems integration effort, the ST-CTN ConOps will focus on mitigating system gaps for underserved users, and integrating data and provisioning information flows between systems, subsystems, and components.

The stakeholder discussion of user challenges and needs during the User Needs Interviews will provide the primary basis of development for the Needs Summary. In addition, existing surveys, literature, and outreach that was conducted during the proposal phase of this project will be incorporated. The User Needs Interviews will also provide an opportunity to identify key stakeholders that would be interested and willing to participate on the Stakeholder and Review Roster. It is envisioned that these stakeholders will be champions throughout the life of the project and support during, not only Phase 1, but also Phases 2 and 3 of this project. The ST-CTN project team will rely on the Stakeholder and Review Roster participants to verify that user needs are achieved. The User Needs Summary will be completed and reviewed by the Stakeholder and Review Roster. The User Needs Summary will guide the development of the Draft ConOps. The

ConOps Walkthrough Briefing Deck will be prepared to guide the review of the ConOps and will be the basis for the ConOps Comment Resolution Report. Upon finalization of the Final ConOps, the ST-CTN project team will present the ConOps in a public webinar.

### 2.3.1. ConOps Development Schedule

The ConOps will be developed in accord with the project Work Breakdown Structure (WBS) documented in the Project Management Plan (PMP) and shown in Table 1. This schedule is consistent with the project schedule as provided by the U.S. DOT. Deliverable due dates will be maintained unless change requests are approved by project Contracting Officer (CO) and Contracting Officer's Representative (COR).

**Table 1. ConOps Development Schedule**

WBS ID	Task Name	Due Date
<b>2</b>	<b>ConOps Development</b>	<b>7/19/2021</b>
<b>2.1</b>	<b>Develop and Maintain Stakeholder Registry and Review Roster</b>	<b>5/3/2021</b>
2.1.1	Develop Draft Stakeholder and Review Roster	4/19/2021
2.1.2	Develop Final Stakeholder and Review Roster	5/3/2021
<b>2.2</b>	<b>Needs Summary</b>	<b>5/3/2021</b>
2.2.1	Develop Draft Needs Summary	4/19/2021
2.2.2	Develop Final Needs Summary	5/3/2021
<b>2.3</b>	<b>ConOps</b>	<b>6/28/2021</b>
2.3.1	Develop Draft ConOps	5/24/2021
2.3.2	Develop Final ConOps	6/28/2021
<b>2.4</b>	<b>ConOps Walkthrough Briefing Deck</b>	<b>5/24/2021</b>
2.4.1	ConOps Walkthrough (June 2, 3, 4)	5/31/2021
<b>2.5</b>	<b>ConOps Comment Resolution Report</b>	<b>6/28/2021</b>
2.5.1	Develop Draft ConOps Comment Resolution Report	6/7/2021
2.5.2	Develop Final ConOps Comment Resolution Report	6/28/2021
<b>2.6</b>	<b>ConOps Webinar (Public)</b>	<b>7/19/2021</b>

### 2.3.2. ConOps Walkthrough

The ST-CTN team will conduct a ConOps Walkthrough with the U.S. DOT and the Stakeholder ConOps Review Panel. Walkthroughs are meetings with developers of the document to go through the document's key elements. The purpose of the ConOps Walkthrough will be to thoroughly review key ConOps sections, including a consolidated list of user needs.

The ST-CTN team will coordinate and schedule ConOps walkthrough with U.S. DOT and the Stakeholder ConOps Review Panel for 3 days. It is anticipated that the ConOps Walkthrough will be held during three half day meetings scheduled on June 2, 3, and 4, 2021. Meetings will be held virtually via Microsoft Teams. Accessible accommodations for panel members will be provided as required.

The ConOps Walkthrough Briefing Deck will be developed and provided to the panel at least 3 to 7 days prior to the walkthrough for their review. Instructions for the walkthrough will be provided with the briefing deck to prepare reviewers for the walkthrough.

The ConOps Walkthrough Briefing Deck will be in MS Word format to enable track changes. The briefing deck template will provide space to record panel agreement or modifications to each ConOps section. The Briefing Deck will also include a table to assess conformance with *Need Criteria* as detailed in Section 2.1.

Each section will be thoroughly reviewed prior to moving on to the next section. The modification and redlined markups and agreement will be documented, and the completed workbook will become the *ConOps Comment Resolution Report*.

An example template of a ConOps Walkthrough Briefing Deck and associated Comment Resolution Report can be found in the *Connected Intersection Committee CI Implementation Guidance ConOps Walkthrough Workbook (WTWB)*, September 15, 2020. (ITE, Connected Intersection Teams site).

## 2.4. Agile Development Considerations

The ST-CTN ConOps development will focus on the systems integration aspect of the ST-CTN project, therefore, there are no Agile development considerations. The ST-CTN project team understands that subsystems within the project will implement Agile development processes to address system needs. The ConOps development will contribute to the Agile development process in that the ConOps system framework will be the starting point for driving the details of subsystem's user story roadmaps. The ConOps needs and system concepts will be expanded and described in more detail during the design phase for each of the subsystems. Any deviations from the ConOps needs and system concept will be maintained under configuration control described in Section 4 Configuration Management. The SEMP will describe specific Agile processes used by the different system subsystems to define the software development lifecycle (SDLC) plan.

# 3. Requirements Planning

## 3.1. Introduction to Requirements Planning

One of the most important attributes of a successful project is a clear statement of requirements that meet the stakeholders' needs. System requirements are the technical statements that define the capabilities that the system must provide or constraints that the system must operate within. The ST-CTN project team understands that, much like user needs, identifying and developing solid system requirements is critical to the success of the overall program. System requirements must also be traceable to one or more user needs. Documenting and tracking this traceability will be an important element to ensuring the system ultimately meets all of the user needs.

Similar to well-written user needs, it is critical that system requirements are well-formed. The following are the criteria (derived from International Council on Systems Engineering (INCOSE) Guide for Requirements Tutorial) of a well-formed system requirement:

- **Necessary:** The requirement is an essential capability, characteristic, or quality factor of the product or process. If removed or deleted, it may cause a deficiency that is unable to be fulfilled by other capabilities of the product or process. Two tests of necessary requirements:
  - Must be traceable to higher level requirement or need
  - If deleted, a major need is not met.
- **Concise:** The requirement simply and clearly references only one need. When a requirement is concise, the statement does not require any explanations, rationale, definitions, or descriptions of system use.
- **Implementation-free:** The requirement does not state how it must be satisfied. The requirement states the desired result in functional and performance terms, not in terms of a solution. Exceptions to this guideline include interface requirements, as specified in Interface Control Documents (ICD). Interface requirements specify what has been previously implemented so that new systems will interface with legacy systems
- **Attainable:** The requirement is achievable at a definable cost. Adequate analysis and trade studies show that the costs are within program cost constraints.
- **Complete:** The stated requirement can stand alone and does not need any further explanation. Each requirement states everything required on the topic and it stands alone when separated from other requirements.
- **Consistent:** The requirement does not contradict or duplicate other requirements. Organizing requirements in accordance with a standard or template facilitates the identification of inconsistencies. It is important to use consistent terminology throughout the requirements document. Therefore, maintaining a glossary of program terms is one effective method for ensuring consistency.
- **Traceable:** Each requirement is traceable to its source (e.g., trade study, ConOps, scenarios, research results, etc.) A requirement also needs to identify related requirements (i.e., parents, children) and requirements that might be impacted by changes to it.
- **Unambiguous:** Each requirement has one interpretation. For a requirement to be unambiguous, the requirement must:
  - Use language that leaves no doubt as to the intended descriptive or numeric value

- Use common or well-defined words and phrases
- Avoid using known ambiguous words and phrase (e.g., “capable of...”)
- **Verifiable:** Each requirement must be verifiable by inspection, analysis, test or demonstration. A requirement must be stated in measurable terms to be verifiable.
- **Allocate-able:** Requirements should be allocated to the appropriate component within the system hierarchy and/or the appropriate organizational entities (e.g., to develop procedures).
- **Style-compliant:** A style-compliant requirement has the following qualities:
  - Content: Simple sentences, correct grammar and punctuation, positive statements, active voice, use of an appropriate directive verb (explains).
  - Format: Paragraph number, paragraph title, subject, relation, value, capitalization, punctuation, and additional explanatory information in a glossary.

Requirements developed for the ST-CTN project will follow a simple grammar as defined below:

- Actor [The System]
- Action [shall do/not do something]
- Target [the object of action]
- Constraint [how, how often, how many, how fast]
- Condition/Localization [if, when, where]

An example requirement is provided below:

***The System [Actor] shall generate [Action] event reports [Target] containing the following information [Constraint] on a scheduled interval [localization].***

While the localization and constraint portions are important, not all requirements will have both. The constraint identifies how you will measure success or failure of the requirement. The localization identifies the circumstances under which the requirement applies.

By following the above criteria, the ST-CTN project team will ensure the success of the systems engineering process that follow the creation of the system requirements as well as the success of the overall project.

## 3.2. Requirement Decomposition

The requirements will be decomposed into several categories that are consistent with categories needed for system integration projects, where unambiguous and concise requirements are needed to augment interface, data, communications, security, overall performance, and component functional requirements that already are defined. The ST-CTN system level requirements will include (i) General; (ii) Performance; (iii) Communications and Security; (iv) Interface and Data; and (v) Component requirement sets. The Component requirements set will cover Function, Infrastructure, and User Interface systems that are not currently deployed.

- **General:** These provisions describe high level requirements that apply to all the components, systems, and subsystems. These typically are not testable but set the logic for the specification decomposition at a more detailed level than the ConOps.
- **Performance:** Performance requirements are those requirements that specify how the system shall perform. This would include things like providing an alert within a specific

- timeframe, specifying a specific data rate, or how accurate the data the component must be. These will be described for extended subsystem/component performance requirements due to the ST-CTN expanded needs, and for effective system integration performance.
- **Communications and Security:** These requirements define the communications protocols (e.g., Open Systems Interconnection (OSI) levels 4 through 7), and security framework for communications between components/systems/subsystems. In particular, the security framework provisions will cover physical security, security for data access while in-transit and at rest for the types of data that is described in the Data Plan.
  - **Interface and Data:** Interface and data requirements describe the integration provisions including data flows between components, interface encoding (e.g., comma-separated value--CSV, JavaScript Object Notation--JSON, Representational state transfer--REST), orchestration, interface specification (e.g., Protocol Requirements List -- PRL), and data concept requirements. The interface specifications may include information on channelization and serialization to the presentation layer (e.g., mobile device, web site, application user interface).
  - **Component Requirements**
    - **Functional:** Although these are usually the most important requirements, as they specify what functions the system must perform, since applications will already be deployed, only extended functionalities of components due to the ST-CTN expanded needs will be specified.
    - **Infrastructure:** Infrastructure requirements are those that specify the computing platform, resiliency, scalability, and reliability of the infrastructure systems and software upon which the component operates. These will be described only for extended subsystem/component infrastructure due to the ST-CTN expanded needs.
    - **User Interface:** User interface requirements describe the presentation modes to the user to meet their accessibility needs. These cover requirements associated with customer facing subsystems and back office dashboard components. The scope of the user interface includes different form factors including haptic, tactical, auditory, graphic and visual for web, mobile, wearable and other channels.

Each component will be fully described in the ConOps including their current operations, functions, and conditions; only extended functionality, infrastructure, and performance requirements, implemented as part of this project, will be addressed in the ST-CTN Systems Requirements document.

### 3.3. System Requirements Traceability

Each requirement will be indexed, thoroughly documented, and traced to the user needs throughout the systems engineering process. A single Excel workbook will document both needs and requirements and their relationship in a Requirements Traceability Matrix (RTM). The fields that will be included within the RTM are shown in Table 2.



Table 2. RTM Fields

RTM Field Name	Description
Requirement ID	A unique identifier for each requirement
Subsystem	The subsystem name for which the requirement is associated. Only include a subsystem name (e.g., ATL RIDES) if this is a unique requirement for the integrated subsystem application. The applicable subsystems at a minimum include: <ul style="list-style-type: none"> <li>• ATL RIDES</li> <li>• Gwinnett CVMP</li> <li>• STM</li> <li>• SidewalkSim</li> <li>• CV1K</li> </ul>
Component	Component of the subsystems will be defined in the ConOps. They will include components for each subsystem. For example, ATL RIDES will include mobile app, OTP engine, call center, account management, etc.
Specification Section	Category as defined in the Requirements Specification – <ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. General Requirements</li> <li>3. Communications and Security Requirements</li> <li>4. Interface and Data Requirements</li> <li>5. Performance Requirements</li> <li>6. Component Requirements <ol style="list-style-type: none"> <li>6(i). Functional</li> <li>6(ii). Infrastructure</li> <li>6(iii). User Interface</li> </ol> </li> <li>7. Appendices</li> </ol>
Requirement Category	The type of requirement. The initial set include: <p>General  Communications and Security  Interface and Data  Performance  Functional (component/subsystem)  Infrastructure (component/subsystem)  User Interface (component/subsystem)</p>
Need ID	The unique identifier that corresponds to the needs defined in the ConOps.
Need Description	The user need description that corresponds to the need defined in the ConOps.
Requirement Title	A title for the requirement.
Requirement Description	A description for the requirement.
Priority	Requirement priority – High [H], Medium [M], Low [L]
Conformance	Describes if the requirement conformance is mandatory [M] or optional [O] or conditional on another requirement [C-#] where # is the requirement it is dependent on.
Verification Test	Describes how the requirement should be verified. The verification categories include: observation, compliance test, or test.

RTM Field Name	Description
Date Inserted	The original date wherein the requirement was inserted into the spreadsheet.
Inserted By	Initials of the person who inserted the original requirement.
Req Source	The source for the requirement, if extracted from another specification or document.

Each component / subsystem may include additional fields based on the SDLC process defined by the system developer or OSS development process.

## 3.4. System Requirements Document Development

The ST-CTN team will develop the system requirements in accordance with IEEE Standard 1233-1998 and the Systems Engineering Body of Knowledge (SEBOK). The ST-CTN team will hold technical work sessions with project stakeholders in order to develop system requirements for system integration and specific subsystems. Technical work sessions will include IOOs and system developer project stakeholders. User needs and system needs from the ConOps document will be used to drive the conversations during these meetings. The ST-CTN team will expand each user need into a set of high level requirements, and each will be classified into a requirement category as listed in the Requirement Decomposition (Section 3.2). The team will then expand the high-level requirements to more detailed requirements which will be assigned to a category. These categories will be reviewed for completeness, verifiability, and feasibility. Once developed, internal reviews of each category and related categories will be conducted by system developers and IOO stakeholders prior to being reviewed by USDOT and the SyRS Review Panel.

### 3.4.1. SyRS Development Schedule

The SyRS will be developed in accord with the project WBS as defined in the PMP and shown in Table 3. This schedule is consistent with the project deliverable deadlines as provided by the USDOT. Deliverable due dates will be maintained unless approved by project CO and COR.

**Table 3. SyRS Development Schedule**

WBS ID	Task Name	Due Date
<b>6</b>	<b>Deployment System Requirements</b>	<b>10/25/2</b>
<b>6.1</b>	<b>Stakeholder SyRS Review Panel Roster</b>	<b>8/30/2021</b>
6.1.1	Develop Draft Stakeholder SyRS Review Panel Roster	8/16/2021
6.1.2	Develop Final Stakeholder SyRS Review Panel Roster	8/30/2021
<b>6.2</b>	<b>SyRS Document</b>	<b>10/25/2021</b>
6.2.1	Develop Draft SyRS Document	9/20/2021
6.2.2	Develop Final SyRS Document	10/25/2021
<b>6.3</b>	<b>SyRS Walkthrough Workbook</b>	<b>9/20/2021</b>
6.3.1	SyRS Walkthrough (specific dates to be scheduled)	9/27/2021
<b>6.4</b>	<b>SyRS Walkthrough Comment Resolution Report</b>	<b>10/25/2021</b>
6.4.1	Develop Draft SyRS Walkthrough Comment Resolution Report	10/4/2021

WBS ID	Task Name	Due Date
6.4.2	Develop Final SyRS Walkthrough Comment Resolution Report	10/25/2021

### 3.4.2. SyRS Walkthrough

The SyRS Walkthrough has two major purposes:

- Review and confirm that each requirement traces to no more than one user need and to ensure that the requirements have been developed to address all user needs.
- Verify and validate that the requirements are well-formed, complete, consistent and prioritized.

The SyRS WTWB will be organized to map requirements to user needs. The facilitator will lead the review and discussion to verify the traceability of user needs to requirements; well-formedness for each requirement, and completeness of requirements to meet augmented component functionality, interface communications, data integration, and other factors that ensure proper operations.

The ST-CTN team will coordinate and schedule the SyRS Walkthrough with USDOT and the Stakeholder SyRS Review Panel for between 2-4 days. It is anticipated that the SyRS Walkthrough will be held the week of September 27, 2021. Meetings will be held virtually via Teams conference call. Accessible accommodations for panel members will be provided as required.

The SyRS WTWB will be developed and provided to the panel at least 3 to 7 days prior to the walkthrough for their review. Instructions for the walkthrough will be provided with the workbook to prepare reviewers for the walkthrough. For example, the types of questions that the facilitator will ask will be included in the instructions. Questions will be asked to determine if the requirement is:

- Well-formed?
- Unambiguous?
- Feasible?
- Complete?
- Verifiable, if so, by which method?
  - Inspection: Examination of the system using one of your five senses
  - Compliance Test: Verification of system using models, specification tests, calculations and testing equipment
  - Test: Verification of system using a controlled and predefined series of inputs across scenarios to ensure specific and predefined outputs are produced
  - Demonstration: Verification of system using a series of inputs to required fields to ensure a report is returned with the data needed
- Logically consistent with the parent need(s)?
- Logically consistent with its parent requirement(s) and sibling requirement(s)?

The SyRS WTWB will be in MS Word format to enable track changes. The workbook template will provide space to record panel agreement or modifications to each user need mapped to a requirement, and for requirement category content.

Each section will be thoroughly reviewed prior to moving on to the next section. The modification and redlined markups and agreement will be documented, and the completed workbook will become the *SyRS Walkthrough Comment Resolution Report*.

Since the SyRS walkthrough will review the mapping between need and requirements, changes may be applied to the user needs. In addition, in reviewing completeness of the requirements, additional needs may be added to the Needs Summary and ConOps. These changes will be updated in the ConOps, following processes laid out in Section 4: Configuration Management, when approved by the Stakeholder SyRS Review Panel. The configuration management process is described in Section 4 below.

### **3.5. Agile Development Considerations**

The subsystem/component level development activities will use an Agile software methodology in their system development lifecycle activities. This methodology will be used since several components of the applications and systems are currently deployed and will primarily require integration into the overall system. Some components will be enhanced with additional capabilities, algorithms for which are dependent on the outcome of ongoing research. To integrate the research path with the development path, an agile software methodology will be the most appropriate approach. The ConOps system framework will be the starting point for driving the details of their user story roadmap, sprints, and epochs. Applying Scrum Methods to ITS Projects (FHWA-JPO-17-508, <https://rosap.ntl.bts.gov/view/dot/32681>) will be used to guide how system requirements will be incorporated into subsystem Agile processes. Although some integration requirements might change slightly due to component or subsystem agile design and operations considerations, the overall integration architecture requirements including designated communications, interface, and data concept requirements will be described by the SyRS and will be shared by all the components and subsystems. The SyRS will identify high level requirements and use cases that show architectural strategies, standard based interface profiles and orchestration to facilitate integration of the overall system. The SEMP will detail the Agile methodologies that each subsystem adopts to implement their processes.

## 4. Configuration Management

Configuration management of user needs and system requirements is critical to reducing the risk of cost and schedule delay. Since all requirements and design trace to user needs, changing a user need without the proper analysis can result in a total rework to sections of the system, which would increase cost and incur delay. The ST-CTN project team will deploy a review process, as described in section 4.1, to ensure that any changes or updates to the user needs are critical to the success of the project and any disruptions caused are necessary to the success of the ST-CTN system.

### 4.1. Configuration Management Processes

The ST-CTN project team will utilize a Microsoft Teams site to store and manage files related to the user needs and system requirements development. Using Microsoft Teams, all members of the ST-CTN project team will have access to the user needs and system requirements when needed. Both user needs and system requirements will be stored in a Microsoft Excel workbook. All changes to user needs and system requirements will be documented in the Microsoft Excel workbook that the user needs and system requirements are stored in, allowing all ST-CTN project team members to review the history of each user need and system requirement.

The ST-CTN project team will deploy two different management processes for user needs and system requirements. One will be deployed during the initial development and one will be deployed for baselined needs and requirements. Both management processes are described below.

#### 4.1.1. Initial User Needs and Requirements Development

User needs and system requirements will be developed and stored in a Microsoft Excel workbook that will be hosted on a Microsoft Teams site. An indexing ID system will be used to easily track user needs, system requirements, and the links between the two. All changes to user needs and system requirements will be documented in the Microsoft Excel workbook. Change log information will include the reason the change was made, the original text or identifier that was changed, which project team member made the change, and the date the change was made.

Since changes to the initial user needs and system requirements are expected to occur frequently, bi-monthly change summaries will be produced for distribution to the ST-CTN project team to ensure that the correct changes have been made. These summary documents will also allow the ST-CTN project team object or approve any changes that have occurred.

When the Final ConOps and SyRS are approved by the U.S. DOT, the Microsoft Excel workbook with the RTM will be versioned into a baseline edition.

### 4.1.2. Baselined User Needs and Requirements

The SEMP will develop a process for managing and setting criteria for updating and changing the user needs, system requirements, and mapping between them. In the SEMP, a set of rules for managing the baselined needs, requirements, and RTM will be defined. For example, after the user needs and system requirements are baselined, the unique identification for each need and requirement will be fixed. If a user need or requirement is removed, the identifier will be retired and no longer used.

The rules will also identify actions driven by the severity of the change impact. Specifically, the criteria will be defined based on impact and risk to the system development. A minor change will be discussed as part of the ST-CTN technical team discussion and approval. The discussion will be documented in meeting notes and updated in RTM that is under version control. If the change impacts cost and schedule, then the Change Control Board (CCB) and change process, described in the PMP will be implemented.

## 4.2. Authoritative Source of User Needs and Requirements

The RTM will be the authoritative source of user needs and requirements (see Table 1). The RTM will be expanded to document changes to the matrix as well as trace to design / user stories / sprints and test procedures. Each user need will be traced to a paragraph in the ConOps and requirements traced to paragraphs in the SyRS. To that end, the final ConOps and SyRS can be updated as needed.

The RTM will be stored and version controlled in the ST-CTN Microsoft Team folders. The document will be linked to appropriate versions of referenced documents including the ConOps and SyRS, appropriate change and meeting notes, and other relevant documents.

The baseline RTM will include fields as shown in Table 4.

**Table 4. Revision Tracking Fields in Baselined**

Name	Description
Requirement or Need ID	Unique identifier for a new user need or system RTM requirement. or repeats the current Need or Requirement ID if unchanged.
Requirement or Need	A flag that identifies if the change was made to the requirement, need or both.
Change type	The type of change made to row. 1—Minor (typo, clarification) 2—Medium (content, addition with no system impact) 3—Major (change to several requirements or design, and impacts cost or schedule) 4—Severe (impacts to selected technology, architecture or multiple components /subsystems) 5—Deprecated (need or requirement is cancelled or eliminated; ID will not be reused)
Revised Description	The description of the updated/new need or requirement.

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Name	Description
Date revised	The date the change was made.
Revised by	The person authorized to make the change.
Reason	The proposal or justification that precipitated the change or update.
Revised notes	Any notes associated with the change.
ConOps Version Updated	The version number of the updated ConOps.
SyRS Version updated	The version number of the updated SyRS.
Attachments	Any links (URL) to a document that is associated with the change.

# Appendix A. Acronyms and Glossary

ADA – Americans with Disability Act

ARC – Atlanta Regional Commission

ATL – Atlanta-Region Transit Link Authority

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

CO – Contracting Officer

ConOps – Concept of Operations

COR – Contracting Officer's Representative

CRM – Comment Resolution Matrix

CV – Connected Vehicle

CV1K – Regional Connected Vehicle Infrastructure Deployment Program

C-V2X – Cellular – Vehicle to Everything

CVMP – Connected Vehicle Master Plan: Roadmap for Gwinnett

DSRC – Dedicated Short-Range Communication

EMT – Executive Management Team

FHWA – Federal Highway Administration

FTA – Federal Transit Administration

GA Tech – Georgia Institute of Technology

GCT – Gwinnett County Transit

GDOT – Georgia Department of Transportation

GOSystems – GO Systems and Solutions

GTFS – General Transit Feed Specification

ICD – Interface Control Document



IEEE – Institute of Electrical and Electronic Engineers

IMI – Integrated Mobility Innovation

INCOSE – International Council on Systems Engineering

IOO – Infrastructure Owner/Operator

ITS – Intelligent Transportation Systems

JPO – Joint Program Office

LEP – Limited English proficiency

MDC – Major Desired Capability

OSI – Open Systems Interconnection

OSM – Open Street Map

OSS – Open Source Software

OST – Office of the Secretary

OTP – Open Trip Planner

PMP – Project Management Plan

PRL – Protocol Requirements List

RSU – Roadside Unit

RTM – Requirements Traceability Matrix

SDLC – Software Development Lifecycle

SEBOK – Systems Engineering Body of Knowledge

SEMP – Systems Engineering Management Plan

SILCGA – Statewide Independent Living Council of Georgia

ST-CTN – Safe Trips in a Connected Transportation Network

STM – Space Time Memory

SyRS – System Requirements Specification

TSP – Transit Signal Priority

USDOT – U.S. Department of Transportation

UNIRP – User Needs Identification and Requirements Planning

WBS – Work Breakdown Structure

WTWB – Walkthrough Workbook

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