Phase 1 Safety Management Plan (SMP)

Atlanta Regional Commission: ITS4US Deployment Project

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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 Safety Management Plan for the deployment project. The purpose of this document is to identify the major safety risks associated with the implementation of the ST-CTN Deployment and to lay out a preliminary plan to promote the safety of the participants and surrounding road users. The plan describes the potential safety risk scenarios, assesses the level of risk for each safety scenario, and provides the safety operational concept for the ST-CTN Deployment.

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1. Introduction

The Safety Management Plan (SMP) for the Safe Trips in a Connected Transportation Network (ST-CTN) project is a companion document to the program and project-level systems engineering documents, including the ST-CTN project Concept of Operations (ConOps), Deployment System Requirements (SyRS), Data Management Plan (DMP), Human Use Approval (HUA) Summary, and the Performance Measurement and Evaluation Support Plan (PMESP). It is the key document which outlines how the project ensures the safety of travelers and users of the ST-CTN system.

This document follows the principles of assigning modified Automotive Safety Integrity Level (ASIL) levels for the systems and applications proposed for the ST-CTN project as the International Organization for Standardization (ISO) standard 26262 outlines. The modified-ASIL approach, ST-CTN Safety Integrity Level (SSIL), was developed for the purposes of the ST-CTN project and considers both the severity level of physical and mental harm.

This document describes the underlying safety needs of the ST-CTN project, with respect to traveler safety, to validate the overall safety of the project and to understand the impacts of various scenarios at system and subsystem levels such as power outage, communication failures, unintended or malicious attacks, severe crashes, and adverse weather conditions. It assesses each risk, provides and documents the guidance on designing a safety-critical system that is capable of either eliminating the risks from design, reducing the risks by modifying the design to lower the probability of occurrence of the hazard, or at a minimum, mitigating the impact if the hazard does occur.

The goal of the ST-CTN project is to provide accessible transportation and route safety information in an effective and equitable manner to underserved communities such as aging adults, users with physical or cognitive disabilities, and users with limited English proficiency (LEP). It is important that the SMP guide the development, design, deployment, and operations of the ST-CTN system and subsystems to protect the underserved communities. A well developed and implemented SMP will also allow for easier expansion of the ST-CTN system as the safety of the system will be demonstratable.

1.1. Document Overview

The SMP includes the following sections, which detail the process and strategies employed to address potential risks that may occur during the deployment and operations of the project.

- **Section 2** (Safety Overview and Relationships) identifies the relationships to other project tasks and defines the approach to the safety risk process (SRP).
- **Section 3** (Safety Needs and Scenarios) describes the safety needs of the project and outlines scenarios that illustrate the needs and risks of the concept.

- **Section 4** (Assessment of Safety Risks) provides an assessment of the scenarios described in **Section 3** and provides an SSIL (modified-ASIL) rating for each safety need.
- **Section 5** (Safety Operational Concept) documents how the project will avoid, mitigate, and respond to potential safety impacts.
- **Section 6** (Safety Management Summary) summarizes the content from **Section 2**, **Section 4**, and **Section 5** to help facilitate understanding of overall areas of risk.

1.2. 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 1**, 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.

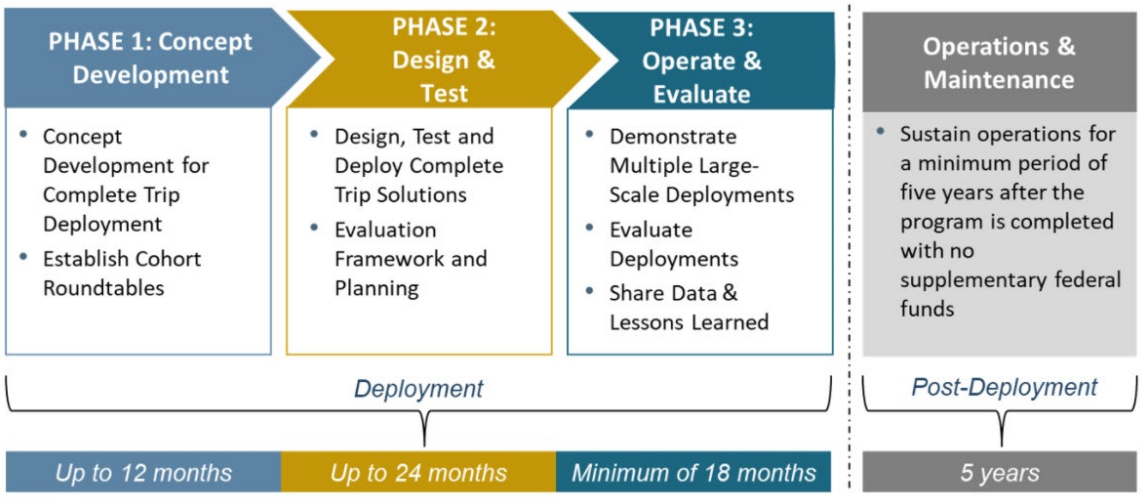

Figure 1. Phases of the Complete Trip – ITS4US Deployment Program (Source: USDOT)

The Atlanta Regional Commission (ARC) was selected by U.S. Department of Transportation (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 connected vehicle (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 all users with the ability to dynamically plan and navigate trips based on their personal needs and preferences. Consistent with the ITS4US Program goals, the ST-CTN project is specifically focused on supporting the following underserved communities:

- **People with Physical Disabilities.** People with physical disabilities are limited in independent, purposeful physical movement of the body or of one or more extremities, and substantially limits one or more major life activities.
- **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 (e.g., crossing a road or boarding a transit vehicle), standing for an extended period of time, or be more sensitive to the elements (e.g., 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.
- **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 culture 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. Which was chosen partially due to its representative nature. It 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 CV planning work recently completed. A map of the project area can be found in **Figure 2**.

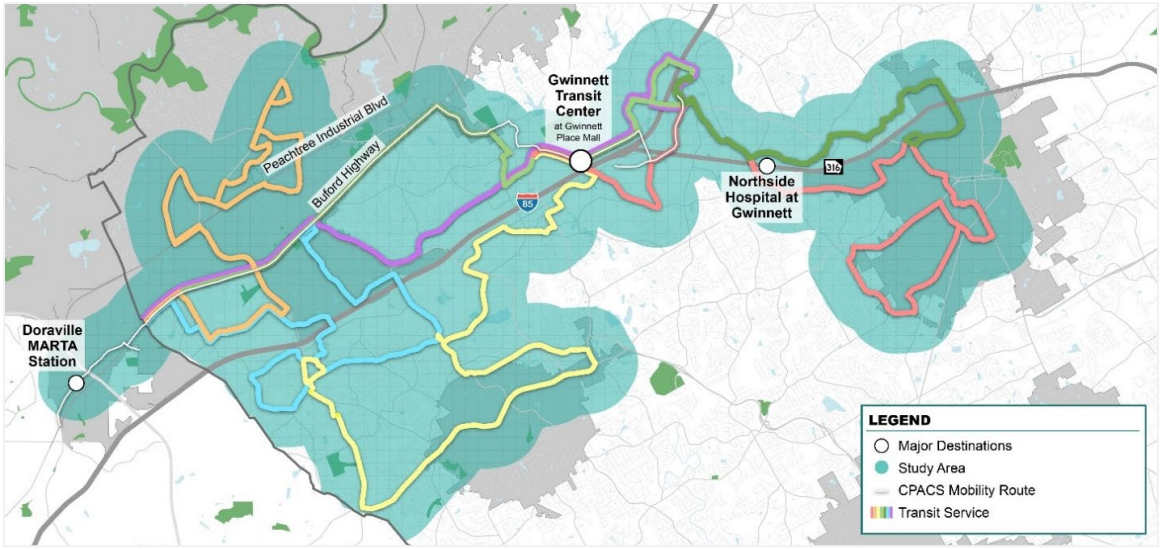

Figure 2. ST-CTN Deployment Site Map (Source: ARC)

1.3. 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 3**) to allow for easier understanding and a greater breakdown of priorities and goals.

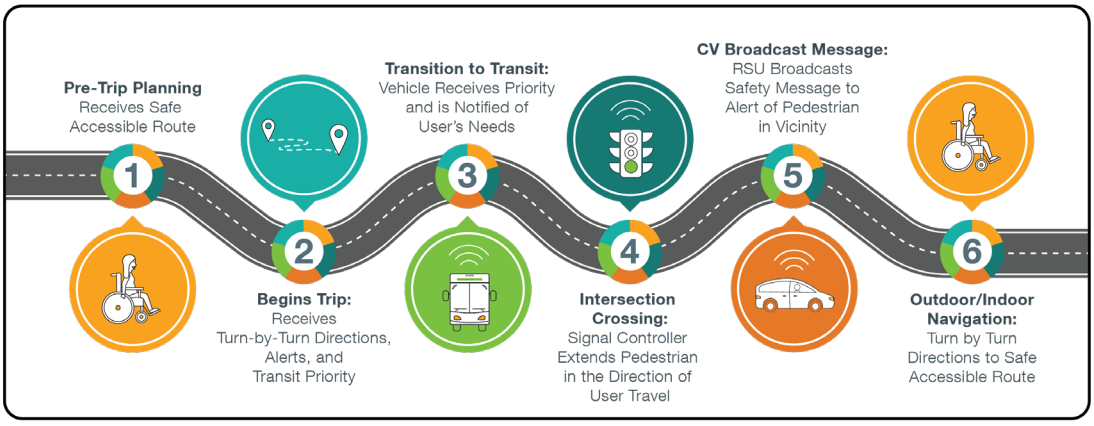

Figure 3. Traveler's Complete Trip (Source: ARC)

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

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

- **Step 2 Begins Trip.** The traveler begins their trip and receives turn by turn directions, alerts, remote pedestrian activation, and can trigger transit signal priority (TSP) if 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 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.
  - Provides users with transit trips that have accommodations that meet user defined preferences.
  - Remotely requests service from transit vehicles while waiting to board or alight.
  - Triggers TSP if the bus is running behind schedule.

- **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 to request pedestrian crossing signal.
  - 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 messages to alert CVs of pedestrians in the vicinity.
  - 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.
  - 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. System development and system integrations completed within the scope of this pilot will enable travelers – specifically those in the underserved community – to plan 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 4** illustrates the concept, including the software, hardware, communications, and services planned for ST-CTN as shown.

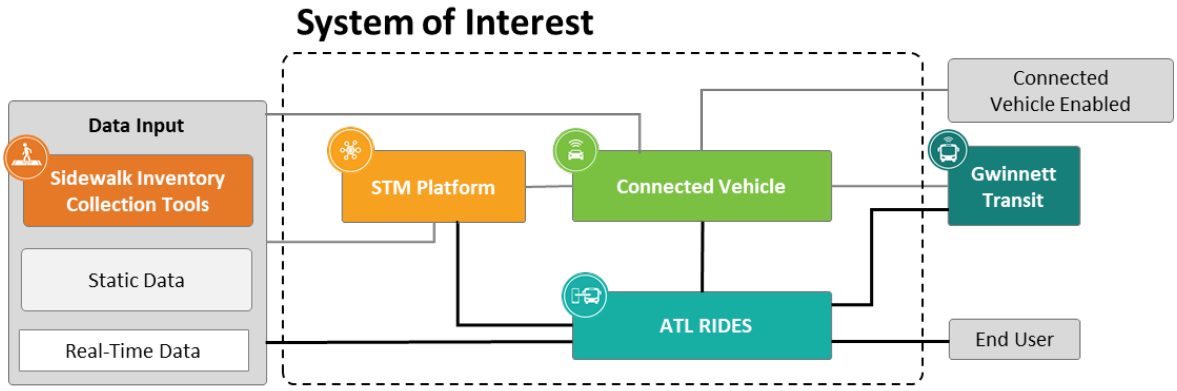

Figure 4. ST-CTN High-Level Context Diagram (Source: ARC)

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 5** 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.

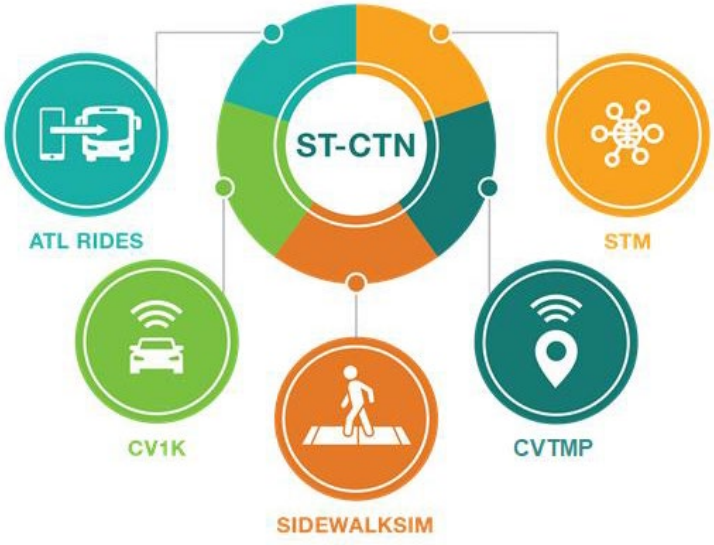

Figure 5. ST-CTN Integrated Initiatives (Source: ARC)

ATL RIDES. The Atlanta-Region Information and Data Evaluation System (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.

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).** 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 SMP 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 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. References

Table 1 lists the supporting documents used in the development of the SMP.

Table 1. References

ID	Referenced Documents
[CVTMP]	AECOM. "Gwinnett County Connected Vehicle Technology Master Plan (CVTMP)." Duluth: Gwinnett County Department of Transportation. (2019).
[ARCRTP]	Atlanta Regional Commission. “The Atlanta Region’s Plan: Regional Transportation Plan” Atlanta: Atlanta Regional Commission. (2021).

ID	Referenced Documents
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[CI]	ICF, Wyoming Department of Transportation. Connected Intersection – Concept of Operations. Cheyenne: USDOT (2018).
[GCTP-1]	Kimley-Horn, Bleakly Advisory Group, Pond, Sycamore, VHB, & Debra Semans. Gwinnett County Destination 2040 - Gwinnett's Comprehensive Transportation Plan - Executive Summary. Atlanta: Gwinnett County. (2017).
[GCTP-2]	Kimley-Horn, Bleakly Advisory Group, Pond, Sycamore, VHB, & Debra Semans. Gwinnett County Destination 2040 - Gwinnett's Comprehensive Transportation Plan - Existing Conditions. Atlanta: Gwinnett County. (2017).
[GCTP-3]	Kimley-Horn, Bleakly Advisory Group, Pond, Sycamore, VHB, & Debra Semans. Gwinnett County Destination 2040 - Gwinnett's Comprehensive Transportation Plan - Needs Assessment. Atlanta: Gwinnett County. (2017).
[GCTP-4]	Kimley-Horn, Bleakly Advisory Group, Pond, Sycamore, VHB, & Debra Semans. Gwinnett County Destination 2040 - Gwinnett's Comprehensive Transportation Plan - Recommendations Report. Atlanta: Gwinnett County. (2017).

ID	Referenced Documents
[ASIL]	International Organization for Standardization. ISO 26262 – Road Vehicles – Functional Safety. Geneva.: International Organization for Standardization (2018).
[GSCVD]	Noblis, Inc. USDOT Guidance Summary for Connected Vehicle Deployments – Safety Management. Washington D.C.: U.S. Department of Transportation. (2017).
[CAV]	Park, Hyungjun; Khattak, Zulqarnain; Smith, Brian. Glossary of Connected and Automated Vehicle Terms *Version 1.0*. Charlottesville.: University of Virginia Center for Transportation Studies. (2018).
[T4T-SMP]	Timpone, Karen. Complete Trip ITS4US – Task 4 Training: Safety Management Plan. Washington D.C.: U.S. Department of Transportation. (2021).
[BAA]	U.S. Department of Transportation, Federal Highway Administration. ITS4US Broad Agency Announcement. Washington D.C.: U.S. Department of Transportation. (2020).

2. Safety Overview and Relationships

This section provides an overview of how the SMP is related to other concept development tasks, those ST-CTN safety stakeholders, and the process by which safety risk will be identified, assessed, and managed throughout the life of the project.

2.1. Related Project Tasks

The ST-CTN system is intended to support safe, complete trips to travelers of all abilities. Safety is a critical component of the project and is reflected in several of the project tasks. **Table 2** provides a summary of the safety-related planning interactions within the planned deployment and key task areas that provide supporting information or will be guided by the SMP.

Table 2. SMP Related Project Tasks

Related Task	Summary
Task 1 – Project Management	Task 1A includes the development of the Project Management Plan (PMP) which defines how the ST-CTN will be managed and the processes that will guide the development of the ST-CTN concept. Safety-related management processes defined within the SMP will guide the management processes within the PMP. In addition, Task 1B, User Needs Identification and Requirements Plan (UNIRP) provides information for the SMP that is used to determine safety needs, develop safety scenarios, and identify safety risks of the project.
Task 2 – Concept of Operations (ConOps)	The ConOps is an input for the SMP and will be used to develop safety needs and scenarios based on the use cases developed in the ConOps.
Task 6 – Deployment System Requirements (SyRS)	The SyRS includes the requirements for systems and subsystems that will be deployed as a part of the ST-CTN project. The safety needs and scenarios will be used to drive safety-related system requirements.
Task 7 – Enabling Technology Readiness Assessment (ETRA)	Critical enabling technologies will be determined based on the safety risks identified and the safety operational concept developed in the SMP as well as the requirements that will be assessed in the SyRS.

Related Task	Summary
Task 8 – Human Use Approval (HUA)	The SMP, which includes safety scenarios and operational concepts, is necessary to prevent or mitigate the risks of personal injury or a data breach which may expose personally identifiable information (PII) of the users. Exposure of PII is considered a safety concern because a ST-CTN system user's personal information, travel patterns, or location could be obtained by a bad actor who is looking to take advantage of them or physically harm them.
Task 9 – Participant Training and Stakeholder Education Plan (PTSEP)	The PTSEP identifies participant roles, activities, responsibilities, and training requirements. The PTSEP will be consistent with the actions described in the SMP to reduce the likelihood and impact of each safety scenario.
Task 13 – Integrated Complete Trip Deployment Plan (ICTDP)	Content from the SMP will be used to summarize challenges that need to be addressed, the deployment approach used to overcome these challenges, and the expected outcomes. The SMP's safety risks and safety operational concept will help to identify some of those challenges.
Task 14 – Deployment Readiness Summary Briefing (DRSB)	Information from the SMP will be used to demonstrate the project's readiness for deployment in order to begin the Design/Build/Test Phase.

Figure 6 provides a visual representation of those tasks that provide input and support to the SMP and those that build on the content developed in the SMP.

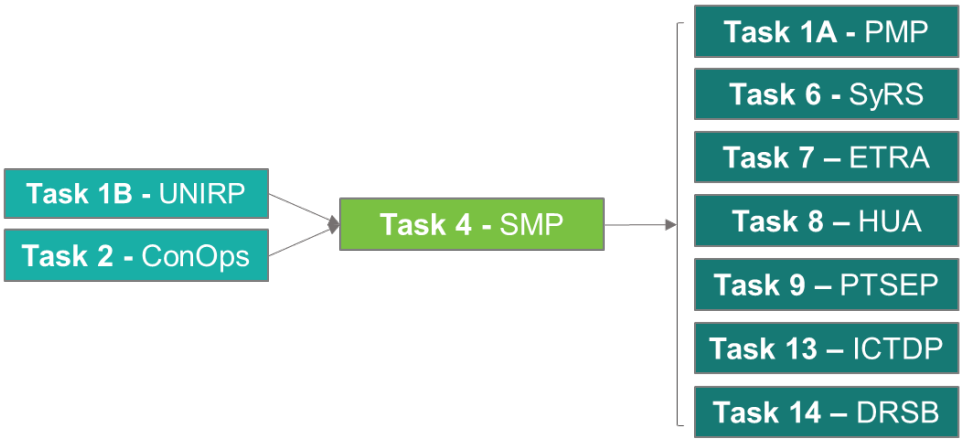

Figure 6. SMP Related Tasks (Source: ARC)

2.2. Safety Stakeholders

The ST-CTN project team is focused on managing and maintaining system users' safety in both physical and virtual environments. Protecting end users from harm in the physical environment includes providing travelers with accessible routes based on their needs and preferences, notifying travelers when there are obstructions along their planned route, etc. Protecting the users' data in the system's virtual environment ensures that travelers' personal information as well as personal travel patterns are not exposed to potential bad actors. Exposure of PII is considered a safety concern because a ST-CTN system user's personal information, travel patterns, or location could be obtained by a bad actor who is looking to take advantage of them or physically harm them. Stakeholders expressed safety concerns related to exposure of personal information during the needs development process which were extrapolated herein and verified by stakeholders.

Due to the disparate nature of these goals – physical and virtual safety – the ST-CTN project has both a Physical Safety Manager and a Virtual Safety Manager, as well as a unique group of stakeholders to manage and prevent safety risks. ARC will serve as the ST-CTN system Safety Manager and will manage interactions across physical and virtual components that affect safety. In addition, the Safety Manager will be responsible for determining who will lead the effort to manage and prevent safety risks that have both physical and virtual components.

The ST-CTN Physical Safety Manager will be Gwinnett County. Considering the location of the physical infrastructure that will be included in the initial ST-CTN deployment is located within and maintained by Gwinnett County, including the transit infrastructure that will be utilized, Gwinnett County is the ideal candidate for managing the safety of the physical system. Stakeholders for the physical infrastructure include GCT, Gwinnett County Traffic and Operations (GCTO), GDOT, and GA Tech.

The Virtual Safety Manager of the ST-CTN system will be ARC. Responsibilities for maintaining the safety and functionality of the virtual components of the ST-CTN system are spread across a group of stakeholders that are more decentralized than the physical component stakeholders. ARC will be able to act as a centralized point for the various stakeholders to report to regarding safety risks that occur during or post deployment of the ST-CTN system. Managing and monitoring virtual safety risks will be the responsibility of each subsystem infrastructure owner/operator (IOO).

Data management will be critical to the management of virtual safety, which is defined as individual's safety and protection in the virtual space of the system from online hazard or risk such as jeopardizing personal information. The DMP defines the methods and processes intended to manage the data throughout the life of the project.

Stakeholders for the virtual infrastructure include GCT, GCTO, the ATL, GDOT, Gwinnett County Information Technology, ARC, and GA Tech.

The safety stakeholders are those user groups and actors focused on the safety of the system who are involved in the usage, management, operation, and maintenance of the proposed system. Stakeholders also include end user and caregivers that will use the ST-CTN applications. 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. **Table 3** elaborates on the roles and responsibilities of the safety stakeholders.

Table 3. Safety Stakeholders List

Organization	Safety Stakeholder	Role	Responsibility
Atlanta Regional Commission (ARC) (Kofi Wakhisi)	Safety Manager and Virtual Safety Manager	• ST-CTN application extension owner and operator • Data owner and steward	• Maintain ST-CTN system functionality • Collect, protect, and maintain data from the ST-CTN system
Atlanta-Region Transit Link Authority (ATL) (Daniel Walls)	Virtual Safety Stakeholder	• ATL RIDES application owner • Data owner and steward	• Maintain ATL RIDES application functionality • Collect, protect, and maintain data from the ATL RIDES application • Protect and maintain GTFS data
End Users (Varies)	System user	• System user	• Setup mobile application including installation of mobile application on personal cell phone or access application on internet • Create profile and input personal accessibility and preference settings • Update application version as required. • Update user profile as needed • Use trip planner for pre-trip and en-route travel • Setup and connect external devices for additional support (i.e., connected cane, wearable device, heading device) • Maintain connection to application through cellular device
Caregivers (Varies)	System user	• System user • End user support	• Assist the end user with their responsibilities • Monitor end user activity to the extent required
Georgia Department of Transportation (GDOT)	Physical and Virtual Stakeholder	• GDOT TMC, statewide advanced traffic management system (ATMS), and	• Ensure all equipment and infrastructure is well maintained and functioning

Organization	Safety Stakeholder	Role	Responsibility
(Alan Davis)		CV subsystem owner and operator • Data owner and steward	• Collect, protect, and maintain any data received from CV systems
Georgia Institute of Technology (GA Tech) (Dr. Randall Guensler)	Physical and Virtual Stakeholder	• STM and sidewalk inventory owner and operator • Data custodian	• Maintain functionality of STM • Ensure the safety of data collectors in the field • Process and protect data received from application and CVs for continual model improvement • Process and provide data to GCDOT and GDOT pertaining to inaccessible pathways
Gwinnett County Transit (GCT) (Karen Winger)	Physical Safety Manager and Virtual Safety Stakeholder	• Bus service operator • Data owner • End user support	• Maintain training and education of staff and vehicle operators on serving underserved communities and ST-CTN system and functions • Maintain physical safety of all transit users • Maintain call center to support all GCT riders and ST-CTN system users • Collect and verify GTFS data • Vehicle operators, call center agents, and mobility trainers provide support as needed to end users
Gwinnett County Traffic and Operations (GCTO) (Alex Hofelich)	Physical Safety Manager and Virtual Safety Stakeholder	• Gwinnett County TCC, traffic signals, and CV subsystem owner and operator • Data owner and steward	• Ensure all equipment and infrastructure is well maintained and functioning • Collect, protect, and maintain any data received from CV systems
Gwinnett County Information Technology (Matthew Puckett)	Virtual Safety Stakeholder	• Information Technology Systems support	• Ensure all IT equipment and infrastructure is well maintained and functioning • Maintain secure connections for data sharing and management
Gwinnett County Fire and Police Departments (Brett West)	Physical and Virtual Stakeholder	• Emergency Responders	• Provide emergency support for end users

2.3. Safety Risk Process and Approach

A five-step process is used to identify and manage safety risks. Initially, safety needs were derived from the user needs and scenarios included in the ConOps. These inputs were then used to determine potential safety risk scenarios. Each scenario was then assessed using a modified-ASIL process that considers physical and mental stress. The modified process for the ST-CTN system is the SSIL. A management strategy was identified for each of the assessed scenarios which will be implemented throughout the life of the project. The safety needs, scenarios, risk assessment, and management strategies are documented. This SMP is intended to be a living document that will iteratively be updated as new or developing safety needs are identified. The full SRP is outlined below and illustrated in **Figure 7**. As a living process, safety needs and scenarios will be monitored throughout the life of the project.

- **SRP1 – Identify.** Identify safety needs based on user needs, IOO needs, and system needs. Determine potential safety scenarios that may occur during the deployment of ST-CTN and assign safety needs to each scenario.

- **SRP2 – Assess.** Assess each safety scenario through the SSIL process. Assign safety manager for each risk.

- **SRP3 – Develop.** Develop safety operational concept.

    - **3A – Avoid.** The SMP will inform and support the development of the system requirements which will guide the design of the ST-CTN system. Potential safety risks will be avoided when requirements are derived to support the design of the system that will eliminate the safety risk.

    - **3B – Mitigate.** Potential safety risks identified within this plan will be mitigated with a safety management plan to control or minimize the level of risk associated with the individual safety scenario. The scenario safety management plan will include safety operational processes and mitigation plans and fail-safes.

      3C – Respond. A planned response and method of reporting to risks that may occur during the project's deployment will be guided by this document.

- **SRP4 – Implement.** Communicate the risk, planned control/countermeasures, and responsible parties to the ST-CTN team. Implement the control/countermeasure for eliminating, preventing, minimizing, or responding to the risk based on the scenario safety management plan.

- **SRP5 – Document.** Document and determine if other steps are needed to minimize other potential forthcoming safety risks that are similar in nature.

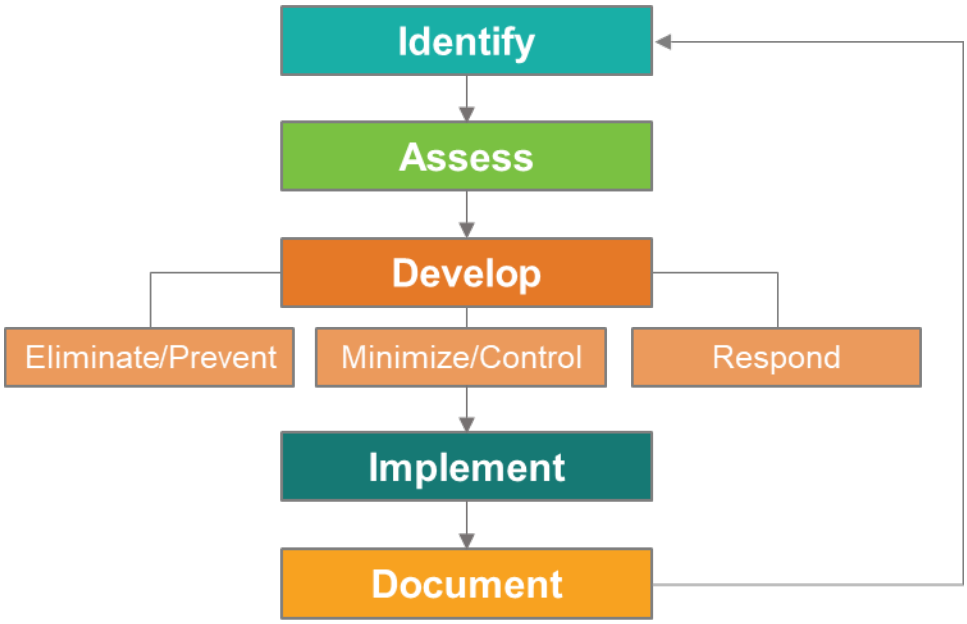

Figure 7. ST-CTN Safety Risk Process

3. Safety Needs and Scenarios

Safety is paramount to the ST-CTN team and stakeholders of the system and is a critical component driving the development of the concept. This section builds upon the needs and use cases that were developed within the ConOps and identifies safety needs and scenarios that will be used to guide the system requirements and future design of the system. In addition, those safety needs and scenarios that are not able to be mitigated through design will be identified and managed throughout the life of the system.

The next sections present the identified safety needs and safety scenarios. Each have been given a unique ID to allow for traceability throughout the project. Each need statement and scenario 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 = Classification
    - EU = End User Need
    - OO = Owner / Operator Need
    - SY = System Need
    - SF = Safety Need
    - SS = Safety Scenario
- 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 safety needs and scenarios documented herein will be used to derive the system requirements and validate the system design after deployment. It is anticipated that safety needs and scenarios will continue to be refined over the life of the concept development phase; the SMP document will be a living document and will be updated to reflect need refinements and additions.

3.1. Safety Needs by Project Component

Safety need statements were developed to clearly define the safety needs of the system, IOOs, and end users. *Safety* in the context of the ST-CTN system is defined as the absence of unreasonable risk due to hazards such as those caused by inadequate or inaccurate information about accessible routing or exposure of travelers' PII. A *safe* route or trip can be considered as one that provides sufficient infrastructure to complete the trip without putting the traveler at risk for injury or unnecessary discomfort.

Table 4 provides a summary of the safety needs and associated system needs. Safety needs were derived by identifying those system needs that have potential safety implications. The system needs were previously driven by the end user and IOO needs. System needs were derived to support the actions of the proposed system that would be required to support the end user and IOO needs. System needs are summarized in Table 12 of the ConOps and are provided within the **Appendix B** of this document for reference.

Additional safety needs were identified during the development of the safety scenarios described in the following section. An iterative process was used to ensure that all relevant safety needs were recognized. This included considering safety needs from the perspective of the end user as well as the system. For example, safety needs were considered in which the end user's safety and ability to complete their trip would be impacted by a system failure. Safety needs were also considered in which the end user would be the primary actor and would incur potential safety impacts due to their own misuse of the system.

The safety needs identified in **Table 4** 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 safety needs will be reflected in this SMP document through the life of the project.

Table 4. Safety Needs

Safety Need ID	Safety Need Statement	Associated Needs
PT-SF-1.1	Travelers need their PII protected and secured to maintain their privacy and safety from bad actors who may take advantage, cause them harm, or create undue stress.	PT-EU-1.1.8 BT-EU-2.1.2 BT-EU-2.2.5 BT-EU-2.2.6 PT-OO-1.2 PT-SY-1.1

Safety Need ID	Safety Need Statement	Associated Needs
PT-SF-1.2	Travelers need the system to provide a safe, accessible route based on their personal preferences and abilities.	PT-EU-1.1.1 PT-EU-1.1.2 PT-EU-1.1.3 PT-EU-1.1.4 PT-EU-1.1.5 PT-EU-1.2.5 PT-EU-1.2.6 PT-EU-1.2.9 BT-EU-2.2.3 PT-SY-1.3
PT-SF-1.3	Travelers need to be able to manage their profile preferences per trip such that the system can provide safe and accessible routes when an End User is traveling with others who have different abilities than their own.	PT-EU-1.1.7 BT-EU-2.1.1 BT-EU-2.1.2 BT-EU-2.1.3 PT-SY-1.5
PT-SF-1.4	Travelers need to be able to practice their turn-by-turn directions before the trip with their preferred notifications, device, or methods to reduce disorientation and discomfort which will increase safety during the trip.	PT-EU-1.2.8 PT-SY-1.6
BT-SF-2.1	Travelers need the system to be reliably accessible so that they can access the information, notifications, and alerts to complete their trips safely and with confidence. Losing access to ST-CTN during a trip could cause anxiety, frustration, loss of way, or inconvenience which may diminish mental health and lead to a traveler safety risk. System downtime and loss functionality will need to be mitigated and fail-safes will need to be designed.	BT-SY-2.1.1 BT-SY-2.1.2
BT-SF-2.2	Travelers need hands-free, turn-by-turn directions based on their preferences and abilities such that they may be adequately informed to complete their trip safely. The ST-CTN system needs to be capable of providing information to travelers in various forms. For example, someone utilizing a wheelchair may require receipt of information in a hands-free format; someone with a hearing impairment may require information provide in haptic format or connected with their hearing device; someone who has a cognitive disability may require information provided in a more graphical format; and someone who with LEP may require information in their preferred language.	PT-EU-1.2.1 PT-EU-1.2.2 PT-EU-1.2.3 PT-EU-1.2.4 PT-EU-1.2.5 BT-EU-2.2.1 BT-EU-2.2.2 BT-EU-2.2.5 PT-OO-1.1 BT-SY-2.2 BT-SY-2.3 BT-SY-2.4
BT-SF-2.3	Travelers who may become disoriented or distressed need the system to provide information on their location to the system call center and designated traveler caregivers so that they can support the traveler during their trip.	BT-EU-2.1.2 BT-EU-2.1.3 BT-SY-2.5

Safety Need ID	Safety Need Statement	Associated Needs
TT-SF-3.1	Travelers need to be able to safely request an approaching transit vehicle to stop and know that the request has been received so that the transit vehicle operator may be aware of their presence even if they are unable to locate themselves directly by the bus stop for safety reasons, i.e. need to stay in the shade, inaccessible stop, etc.	TT-EU-3.1.1 TT-EU-3.1.3 TT-EU-3.1.5 CV-EU-5.1 TT-OO-3.2 CV-OO-5.2 TT-SY-3.1 TT-SY-3.2
IC-SF-4.1	Travelers need to be able to use the system to request activization of a crosswalk signal using a hands-free method and know that the request has been received so that the traveler can safely continue their travel.	IC-IOO-4.1 IC-IOO-4.2 IC-EU-4.1 CV-EU-5.1.1 CV-EU-5.1.2 CV-OO-5.2 IC-SY-4.1 IC-SY-4.2
CV-SF-5.1	Travelers need connected infrastructure to broadcast messages to connected vehicles when the traveler is in the crosswalk.	IC-IOO-4.1 IC-IOO-4.2 CV-IOO-5.1 CV-EU-5.2.1 CV-SY-5.1 CV-SY-5.1.1 CV-SY-5.1.2
CV-SF-5.2	Travelers need connected infrastructure to provide information of the presence of an emergency vehicle or presence of a train at a railroad crossing and the subsequent gate closing so that the traveler is aware the presence of these vehicles and infrastructure.	IC-IOO-4.1 IC-IOO-4.2 CV-IOO-5.1 CV-EU-5.2.1 CV-SY-5.1 CV-SY-5.1.1 CV-SY-5.1.2
NV-SF-6.1	The system needs to ingest static and real-time data about indoor and outdoor assets and conditions to provide travelers a safe, accessible route based on their personal preferences and abilities. Safe, accessible routes will vary based on travelers' abilities. For example, someone utilizing a wheelchair will need a route that does not require traversing stairs, curb, or escalator; someone who is sensitive to weather exposure will need a route that has access to transit stops with bus shelters; and someone utilizing a walker may require minimal escalation.	PT-EU-1.1.3 PT-EU-1.1.4 BT-EU-2.2.3 NV-EU-6.1.1 NV-EU-6.1.2 NV-EU-6.1.3 PT-OO-1.1 NV-OO-6.2 RP-OO-7.1 NV-SY-6.1 NV-SY-6.2

Safety Need ID	Safety Need Statement	Associated Needs
RP-SF-7.1	A traveler and/or guardian need to be able to review their trip histories to understand where the traveler has been and verify the path taken is as expected to ensure the safety of the traveler in terms of being aware of the destination location, updating preferences, or avoiding an unsafe route for future trips.	RP-EU-7.1 RP-OO-7.1 RP-SY-7.1
RP-SF-7.2	Travelers need to be able to provide feedback (using crowdsourcing methods) about disruptions and obstructions to their travel during or after their travel so that it can be used to inform the trip planner in order to ensure other travelers will be traveling a safe and accessible route.	RP-EU-7.1 RP-OO-7.1 RP-SY-7.2

3.2. Safety Scenarios by Project Component

Safety scenarios serve to provide sufficient detail to understand and illustrate safety needs, potential hazards, impacts, and exposure. Safety scenarios were developed based on the safety needs identified above as well as a review of existing literature. Scenarios were refined and expanded based on feedback provided during a work session held with the ST-CTN technical team which included the Executive Management Team (EMT), system developers, and IOOs. Safety scenarios are categorized as either system level or application level as defined below.

- **System Level** – The scenario may be generic or may apply to the entire deployment area or system. The system level safety scenarios include events such as power outages, communication failures, system hacks, severe accidents, or unexpected events related to weather or geographical features.

- **Application Level** – The scenario may apply to a specific application such as a subsystem or a feature that satisfies certain user groups. Examples of application level safety scenarios include features within the application user interface (UI), CV safety message malfunctions, or returns of unsafe routes.

Table 5 provides a summary of safety scenarios, level, and associated safety needs. Any modifications to safety scenarios will be reflected in this SMP document through the life of the project.

Table 5. Safety Scenarios

Scenario ID	Scenario Description	Level	Associated Safety Need ID
Step 1	**Pre-Trip Planning** *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.*		
PT-SS-1.1	The system is breached and traveler profile information is exposed. A bad actor captures the	System	PT-SF-1.1

Scenario ID	Scenario Description	Level	Associated Safety Need ID
	traveler information and seeks out individuals with specific profile characteristics to take advantage of, cause them harm, or create undue stress.		
PT-SS-1.2	The system returns a route that does not meet the traveler's combinations of needs and preferences (as defined in their user profile) and the traveler is unable to safely navigate their route and complete their trip.	System	PT-SF-1.2 NV-SF-6.1 RP-SF-7.2
PT-SS-1.3	A traveler is traveling with another person who has different accessibility needs from their own. The system returns a route that is based on the primary traveler's profile, which is accessible to them, but not to their companion.	Application (ATL RIDES)	PT-SF-1.3
PT-SS-1.4	A traveler is embarking on a trip that is unfamiliar and uncomfortable for them. They become disoriented and distressed and are unable to complete their trip or wander off course and put themselves in an unsafe environment.	Application (ATL RIDES)	PT-SF-1.4
PT-SS-1.5	The system cannot return a route that meets the needs and preferences of the traveler due to non-system related event such as an incident or special event that is blocking accessible routes or there is no route available that meets all the traveler's needs.	System	PT-SF-1.2 NV-SF-6.1 RP-SF-7.2
Step 2 (BT)	**Begin Trip** *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. Selected notifications may be supported through SMS or telephone message.*		
BT-SS-2.1	The system receives a number of simultaneous requests for trip plans and is unable to respond in a timely manner, or crashes the system, leaving users without access to their routes and directions.	System	BT-SF-2.1
BT-SS-2.2	A traveler who relies on an assistive device such as a wheelchair, crutches, hearing aid, cane, etc. may not be able to access their turn-by-turn directions via their mobile device during their travel and becomes disoriented or off course.	Application (ATL RIDES)	BT-SF-2.2
BT-SS-2.3	A traveler defines their user profile and preferences with the expectation that the system will provide information to them in this form. However, the traveler does not have a mobile device that is capable of providing information in the preferred manner and the traveler cannot receive notifications and alerts as expected. The traveler is unaware of the problem and does not realize they are not receiving navigation notifications and alerts. The traveler becomes disoriented and puts themselves in an unsafe environment.	Application (ATL RIDES)	BT-SF-2.1 BT-SF-2.2

Scenario ID	Scenario Description	Level	Associated Safety Need ID
BT-SS-2.4	A traveler defines their user profile and preferences but does not indicate their abilities accurately. The route that is returned is not accessible for the traveler leading to unsafe traveler conditions. For example, a traveler utilizing a wheelchair could be given directions to a bus stop that is inaccessible, and the traveler may have to traverse the shoulder of the roadway to access the area of the bus stop putting themselves at risk to be hit by a car.	Application (ATL RIDES)	PT-SF-1.2
BT-SS-2.5	A traveler becomes disoriented and is distressed. The traveler calls the call center for support but is unable to communicate their location or does not know their location. The traveler becomes more distressed and frustrated and wanders off course in an unsafe environment or is unable to complete their trip.	System	BT-SF-2.3
BT-SS-2.6	A traveler receives turn by turn directions and begins their trip. During the trip, the traveler loses cellular service and cannot access their directions. The traveler becomes distressed and frustrated and wanders off course in an unsafe environment or is unable to complete their trip.	System	BT-SF-2.2
BT-SS-2.7	A traveler is distracted with their phone – focused on directions, settings, notifications, too frequent alerts, etc. – and is not attentive to their surroundings. As a result, the traveler is prone to potential hazards.	System	BT-SF-2.2 TT-SF-3.1 IC-SF-4.1
BT-SS-2.8	A traveler is unable to receive alerts and notifications that meet their needs and preferences, i.e. audible messages may be too quiet or be indistinguishable from other sounds, meaning of the messages are unclear or too complicated, etc. As a result, the traveler becomes disoriented or gets off course.	System	BT-SF-2.2
BT-SS-2.9	A traveler becomes too dependent upon the ST-CTN system and does not maintain awareness of their surroundings and direction. The traveler may not be attentive to traffic hazards while traversing their path, particularly at intersection crossings, or may become disoriented should the system malfunction.	System	BT-SF-2.2 TT-SF-3.1 IC-SF-4.1
BT-SS-2.10	A traveler does not have their geolocation services enabled on their mobile device and therefore cannot receive real-time notifications such as route adjustments due to an elevator or escalator outage, thus creating safety risks along their trip.	System	BT-SF-2.2
Step 3 (TT)	**Transition to Fixed Route Transit** *Traveler journeys to transit, boards, travels on and alights transit vehicle.*		
TT-SS-3.1	A bus stop is not accessible for the traveler and the traveler is unable to locate themselves directly by the bus stop. The transit vehicle operator does not see the traveler at the bus stop and does not stop. The traveler is unable to complete their trip.	System	TT-SF-3.1

Scenario ID	Scenario Description	Level	Associated Safety Need ID
TT-SS-3.2	A traveler who is vulnerable to the elements while waiting for a transit vehicle that is behind schedule. The traveler is unable to access the shelter (or there is not one) and begins to feel unwell.	System	TT-SF-3.1
TT-SS-3.3	The transit vehicle operator is overwhelmed with system messages and becomes distracted with the system thus creating safety risks to themselves, their riders, and other vehicles on the roadway.	System	TT-SF-3.1
Step 4 (IC)	**Intersection Crossing** *Traveler, when approaching and crossing an intersection interacts with the connected intersection to request pedestrian crossing signal and to safety cross the crosswalk.*		
IC-SS-4.1	A traveler approaching an intersection is using the ST-CTN system and expects that an automated pedestrian request in the direction of their travel will be placed. The system malfunctions (i.e. global positioning system (GPS) accuracy is lacking, access to mobile unit (MU) Gateway is not available, etc.) and does not place the request or places the request in the wrong direction. The traveler does not receive a pedestrian walk phase or has to wait an extended period of time because the signal has not been actuated.	System	IC-SF-4.1
IC-SS-4.2	The system misinterprets the pedestrian's intended direction or the traveler does not traverse the intended route. The signal does not provide the Walk indication in the desired direction. The traveler may not receive the additional crossing time that they require and expect.	Application (CV)	IC-SF-4.1
Step 5 (CV)	**Connected Vehicle Broadcast Message** *The CV infrastructure broadcasts messages regarding the presence of system travelers and provides data to the GDOT ATMS (external system) which is then ingested by the ATL RIDES.*		
CV-SS-5.1	The CV subsystem is breached. Unauthorized personnel gain access to the traffic control system or protected data which they could potentially modify CV messages or signal timing and phasing.	Application (CV)	CV-SF-5.1 CV-SF-5.2
CV-SS-5.2	The CV subsystem does not function properly and requests signal phasing and timing (SPaT) changes that are not correct leading to reduced pedestrian crossing time.	System	IC-SF-4.1
CV-SS-5.3	The personal safety message (PSM) broadcast does not function properly, and CV enabled vehicle drivers are not notified of the pedestrian presence or the subsystem sends a message that is inaccurate causing driver confusion and distraction.	Application (CV)	CV-SF-5.1
CV-SS-5.4	The CV subsystem field infrastructure (i.e. RSUs) may malfunction or drop messages, such as	Application (CV)	CV-SF-5.1 CV-SF-5.2

Scenario ID	Scenario Description	Level	Associated Safety Need ID
	pedestrian presence, due to interference from public Wi-Fi and issues with the reduced spectrum.		
Step 6 (NV)	**Outdoor / Indoor Navigation** *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.*		
NV-SS-6.1	A traveler receives inaccurate information about the location of the accessible entrance of their destination which is difficult to find without directions.	System	NV-SF-6.1
NV-SS-6.2	A traveler arrives at their destination. The system does not receive notification that an elevator is out of service and the system does not alert the traveler. The traveler is unaware that the elevator is out of service and is unable to complete their trip safely.	System	NV-SF-6.1 RP-SF-7.2
NV-SS-6.3	A traveler using the system may rely on positional and orientation information, the accuracy of which is dependent on the GPS of their mobile device. The traveler does not have their GPS enabled or it does not provide accurate data to inform the ST-CTN system and the traveler does not receive accurate information. For example, the system may request a pedestrian crossing phase at a signalized intersection too early causing the traveler to have to rush across the street or run out of time to cross.	Application (ATL RIDES)	BT-SF-2.2 TT-SF-3.1 IC-SF-4.1
NV-SS-6.4	A traveler using the ST-CTN system may lose cellular network connectivity, interrupting all incoming real-time information updates. There is an event that impedes the traveler's intended route, but the traveler does not receive notification of route changes and is unable to complete their trip when they arrive at the obstruction and have to turn around.	System	BT-SF-2.2 TT-SF-3.1 IC-SF-4.1
NV-SS-6.5	A traveler depending on the ST-CTN system may run out of battery causing their phone to shut down during their trip. Without power to their phone, the traveler may be unable to complete their trip.	System	BT-SF-2.2 TT-SF-3.1 IC-SF-4.1
Step 7	**Reporting and History** *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.*		
RP-SS-7.1	A traveler with cognitive disabilities arrives at their destination much later than expected. The traveler is distraught, and their caregiver is unable to understand where the traveler has been or what may have happened to them.	Application (ATL RIDES)	RP-SF-7.1

Scenario ID	Scenario Description	Level	Associated Safety Need ID
RP-SS-7.2	A traveler incorrectly reports a routing conflict at the end of their trip. The data provided by the ST-CTN is inaccurate causing unnecessary rerouting for the next traveler or the inability for that traveler to complete their trip. This could cause a traveler to receive an unnecessarily long route leading to exhaustion or other unsafe conditions.	System	NV-SF-6.1 RP-SF-7.2
RP-SS-7.3	The traveler's trip history data is compromised including tracking information on the traveler. A bad actor captures the data and can trace individuals' travel patterns to take advantage of, cause them harm, or create undue stress.	Application (ATL RIDES)	PT-SF-1.1

4. Assessment of Safety Risks

The following sections describe the process that was implemented by the ST-CTN safety stakeholders to assess the safety risks associated with the safety scenarios described in the previous section. The ST-CTN safety stakeholders reviewed scenarios and the safety risk assessment process and analysis findings during the course of weekly work sessions focused on the SMP.

4.1. Safety Risk Assessment

A risk assessment was performed for each identified safety scenario. The risk analysis leverages a modified ASIL approach. The Standard ISO 26262 ASIL focuses on physical injuries as a standard to assess the severity of risk associated with potential safety scenarios. During the interviews with end users, however, it was made clear that mental health, particularly for some of the types of populations being targeted for this deployment, must be a major consideration in the system development. For example, users with Autism Spectrum Disorder (ASD) may exhibit behaviors such as tantrums, aggression, self-injury, property destruction, and ritualistic destruction when stressed. [RCAIT]. Due to this input, a modified approach to assessing safety risk has been applied to this project that assesses severity from a physical and mental health perspective. Focusing on both physical and mental health will allow the safety stakeholders to properly assess the risks associated with the ST-CTN project.

As with the ASIL approach, SSIL is used to express the level of risk reduction required to prevent a specific hazard with level D representing the highest and level A representing the lowest, as shown in **Figure 8**.

Figure 8. SSIL Ratings (Source: National Instruments)

A safety scenario has been assessed as quality management (QM) if the scenario presents a reasonable and manageable risk with a sufficient scenario safety management plan [ASIL].

Similar to the ASIL approach, SSIL performs hazard analysis and risk assessment by measuring severity, exposure, and controllability. These variables have been classified in a similar manner to the ASIL classification but have been modified to accommodate mental health hazards as follows:

- **Severity (S)** – Defined as direct physical or psychological harm to a user within a specific safety scenario. For each safety scenario, an assessment of potential injury or harm was determined and guided the assignment of SSIL severity level. Severity levels can vary greatly within each scenario; preliminary ratings were vetted by safety stakeholders for

reasonableness. The four levels of severity, along with their criteria, are listed below. Additional clarification has been added to describe a range of anxiety producing events that were utilized to guide the assessment of the safety scenarios.

- **S0:** No physical injuries; minor anxiety producing event. An example of a minor anxiety producing event is a user needed to be redirected from a routine route to avoid a temporary obstruction.
- **S1:** Light and moderate injuries; moderate anxiety producing event. An example of a moderate anxiety producing event is a user getting disoriented on an unfamiliar route.
- **S2:** Severe and life-threatening injuries; major or severe anxiety producing event. An example of a major or severe anxiety producing event is a cumulation of change in a routine route, becoming disoriented, in addition to environmental triggers which could include flashing lights and loud noises, such as from an emergency vehicle.
- **S3:** Life-threatening or fatal injuries.

- **Probability of Exposure (E)** – Defined as the probability that a situation associated with a safety scenario will occur during the deployment. For each safety scenario, the probability of exposure to an end user that is vulnerable to the given scenario was determined, based on input from local safety and system development stakeholders, and assigned an SSIL (modified ASIL) level of exposure. The four levels of exposure probability, along with their criteria, are listed below.
  - **E1: very low probability** – Occurs in less than 10% of trips or less than 10% probability of the event occurring during the trip of a traveler who is vulnerable to the given scenario.
  - **E2: low probability** – Occurs in 10-25% of trips or there is a 10-25% probability of the event occurring during the trip of a traveler who is vulnerable to the given scenario.
  - **E3: medium probability** – Occurs in about 25-80% of trips or there is a 25-80% probability of the event occurring during the trip of a traveler who is vulnerable to the given scenario.
  - **E4: high probability** – Occurs during every trip taken or there is 80-100% probability of the event occurring during the trip of a traveler who is vulnerable to the given scenario.

- **Controllability (C)** – Defined as the ability to control a safety scenario once an end user is exposed to the risk. For each safety scenario, the level of control over the outcome was determined based on feedback from the safety and developer stakeholders. There exists the reality of events that are not controllable by the project team, including severe weather, device failures, or erratic driver behavior. These were taken into account, and weighed against situations that are controllable, such as training and mitigation, to develop a final level. The three SSIL levels of controllability, along with their criteria, are listed below.
  - **C1:** simply controllable
  - **C2:** normally controllable
  - **C3:** difficult to control or uncontrollable

Table 6 provides the decomposition of the SSIL rating determined by a scenario's combination of the three SSIL classifications, severity, probability, and controllability, and provides an overall SSIL rating.

Table 6: SSIL Decomposition

Severity Class	Probability Class	Controllability Class 1	Controllability Class 2	Controllability Class 3
S0	E1	QM	QM	QM
S0	E2	QM	QM	QM
S0	E3	QM	QM	QM
S0	E4	QM	QM	A
S1	E1	QM	QM	QM
S1	E2	QM	QM	QM
S1	E3	QM	QM	A
S1	E4	QM	A	B
S2	E1	QM	QM	QM
S2	E2	QM	QM	A
S2	E3	QM	A	B
S2	E4	A	B	C
S3	E1	QM	QM	A
S3	E2	QM	A	B
S3	E3	A	B	C
S3	E4	B	C	D

Table 7 provides the summary of the SSIL safety risk assessment analysis for each scenario identified in **Section 3.2**. The SSIL safety risk process and ST-CTN assessment was vetted and verified by stakeholders. In addition, the safety manager is identified for each scenario based on if the safety risk is anticipated to be physical (Physical Safety Manager is GC) or virtual (Virtual Safety Manager is ARC). In the scenarios that are anticipated to have both physical and virtual risks, both Physical Safety Manager and Virtual Safety Manager are indicated. ARC will act as the lead overall Safety Manager and coordinate internally and externally on all safety concerns.

Table 7. Safety Risk Assessment – SSIL Approach

Scenario ID	S	E	C	SSIL	Safety Manager
PT-SS-1.1	S1	E1	C2	QM	ARC
PT-SS-1.2	S1	E2	C2	QM	ARC
PT-SS-1.3	S1	E2	C2	QM	ARC
PT-SS-1.4	S1	E2	C3	A	GC
PT-SS-1.5	S1	E2	C3	QM	ARC
BT-SS-2.1	S2	E1	C2	QM	ARC
BT-SS-2.2	S2	E2	C2	QM	ARC
BT-SS-2.3	S2	E2	C3	A	ARC
BT-SS-2.4	S2	E2	C3	A	ARC

Scenario ID	S	E	C	SSIL	Safety Manager
BT-SS-2.5	S2	E2	C3	A	ARC
BT-SS-2.6	S2	E2	C3	A	ARC
BT-SS-2.7	S2	E2	C3	A	ARC
BT-SS-2.8	S2	E2	C3	A	ARC
BT-SS-2.9	S2	E2	C3	A	ARC
BT-SS-2.10	S2	E2	C1	QM	ARC
TT-SS-3.1	S2	E2	C2	QM	ARC
TT-SS-3.2	S2	E2	C3	A	GC
TT-SS-3.3	S3	E2	C2	A	ARC
IC-SS-4.1	S3	E2	C2	A	ARC
IC-SS-4.2	S3	E2	C2	A	ARC
CV-SS-5.1	S3	E1	C2	QM	ARC/GC
CV-SS-5.2	S3	E1	C2	QM	ARC/GC
CV-SS-5.3	S1	E1	C2	QM	ARC/GC
CV-SS-5.4	S1	E1	C3	QM	ARC/GC
NV-SS-6.1	S1	E2	C2	QM	ARC/GC
NV-SS-6.2	S2	E2	C2	QM	ARC/GC
NV-SS-6.3	S2	E2	C3	A	ARC/GC
NV-SS-6.4	S2	E2	C3	A	ARC/GC
NV-SS-6.5	S2	E2	C3	A	ARC/GC
RP-SS-7.1	S2	E1	C2	QM	GC
RP-SS-7.2	S1	E1	C3	QM	ARC/GC
RP-SS-7.3	S2	E1	C3	QM	ARC/GC

4.1.1. Physical Safety Risk

The ST-CTN project aims to increase the physical safety of all travelers through the use of technology. While attempting to increase safety, however, certain risks exist in implementing any changes to how people travel that include travelers potentially not being able to complete their trip or causing physically or mental discomfort to users. As the Physical Safety Manager, Gwinnett

County will be responsible for ensuring all partners in the system maintain their infrastructure and are appropriately trained on how the system works. In this section, the types of physical risks that are present in the ST-CTN system will be outlined.

One physical risk to the system user is **their accessibility needs not being met by the system**. There are a number of circumstances that could result in a failure of the user's accessibility needs not being met. For example, there may not be a route that meets the traveler's needs, or the system may be using incorrect data that provides the user a route that is inaccessible. Examples of potential outcomes that could occur due to a traveler using an inaccessible route include, a traveler falling or tripping trying to traverse a curb; a traveler causing harm to themselves trying to traverse a steep hill; a traveler having to access a transit stop by way of the vehicular roadway. Below is a list of scenarios that demonstrate a user's accessibility needs not being met by the system.

- PT-SS-1.5: The system cannot return a route that meets the needs and preferences of the traveler due to non-system related event such as an incident or special event that is blocking accessible routes or there is no route available that meets all the traveler's needs.

- TT-SS-3.2: A traveler who is vulnerable to the elements while waiting for a transit vehicle that is behind schedule. The traveler is unable to access the shelter (or there is not one) and begins to feel unwell.

- NV-SS-6.1: A traveler receives inaccurate information about the location of the accessible entrance of their destination which is difficult to find without directions.

Another physical risk to manage is the potential for the **traveler to lose access system features or support.** There are many ways a user may lose connectivity to the system technologically. There is also a possibility that a user who is highly dependent on remote support would be unable to adequately communicate with their caregiver or a call center representative. Below is a list of potential scenarios in which the traveler may experience service outage or other connection issues.

- BT-SS-2.2: A traveler who relies on an assistive device such as a wheelchair, crutches, hearing aid, cane, etc. may not be able to access their turn-by-turn directions via their mobile device during their travel and becomes disoriented or off course.

- BT-SS-2.3: A traveler defines their user profile and preferences with the expectation that the system will provide information to them in this form. However, the traveler does not have a mobile device that is capable of providing information in the preferred manner and the traveler cannot receive notifications and alerts as expected. The traveler is unaware of the problem and does not realize they are not receiving navigation notifications and alerts. The traveler becomes disoriented and puts themselves in an unsafe environment.

- BT-SS-2.5: A traveler becomes disoriented and is distressed. The traveler calls the call center for support but is unable to communicate their location or does not know their location. The traveler becomes more distressed and frustrated and wanders off course in an unsafe environment or is unable to complete their trip.

- BT-SS-2.6: A traveler receives turn by turn directions and begins their trip. During the trip, the traveler loses cellular service and cannot access their directions. The traveler becomes distressed and frustrated and wanders off course in an unsafe environment or is unable to complete their trip.

- BT-SS-2.8: A traveler is unable to receive alerts and notifications that meet their needs and preferences, i.e. audible messages may be too quiet or be indistinguishable from other sounds, meaning of the messages are unclear or too complicated, etc. As a result, the traveler becomes disoriented or gets off course.

- BT-SS-2.10: A traveler does not have their geolocation services enabled on their mobile device and therefore cannot receive real-time notifications such as route adjustments due to an elevator or escalator outage, thus creating safety risks along their trip.

- NV-SS-6.4: A traveler using the ST-CTN system may lose cellular network connectivity, interrupting all incoming real-time information updates. There is an event that impedes the traveler's intended route, but the traveler does not receive notification of route changes and is unable to complete their trip when they arrive at the obstruction and have to turn around.

- NV-SS-6.5: A traveler depending on the ST-CTN system may run out of battery causing their phone to shut down during their trip. Without power to their phone, the traveler may be unable to complete their trip.

- RP-SS-7.1: A traveler with cognitive disabilities arrives at their destination much later than expected. The traveler is distraught, and their caregiver is unable to understand where the traveler has been or what may have happened to them.

The final category of risks in the physical safety risk management is due to **insufficient training** on the how to use the system or how the system works. Insufficient training is a risk both for user error and the support services that will be in contact with the system such as vehicle operators. These risks will be addressed in the Participant Training and Education Plan and are listed below.

- PT-SS-1.3: A traveler is traveling with another person who has different accessibility needs from their own. The system returns a route that is based on the primary traveler's profile, which is accessible to them, but not to their companion.

- PT-SS-1.4: A traveler is embarking on a trip that is unfamiliar and uncomfortable for them. They become disoriented and distressed and are unable to complete their trip or wander off course and put themselves in an unsafe environment.

- BT-SS-2.3: A traveler defines their user profile and preferences with the expectation that the system will provide information to them in this form. However, the traveler does not have a mobile device that is capable of providing information in the preferred manner and the traveler cannot receive notifications and alerts as expected. The traveler is unaware of the problem and does not realize they are not receiving navigation notifications and alerts. The traveler becomes disoriented and puts themselves in an unsafe environment.

- BT-SS-2.4: A traveler defines their user profile and preferences but does not indicate their abilities accurately. The route that is returned is not accessible for the traveler leading to

unsafe traveler conditions. For example, a traveler utilizing a wheelchair could be given directions to a bus stop that is inaccessible, and the traveler may have to traverse the shoulder of the roadway to access the area of the bus stop putting themselves at risk to be hit by a car.

- BT-SS-2.7: A traveler is distracted with their phone – focused on directions, settings, notifications, too frequent alerts, etc. – and is not attentive to their surroundings. As a result, the traveler is prone to potential hazards.

- BT-SS-2.9: A traveler becomes too dependent upon the ST-CTN system and does not maintain awareness of their surroundings and direction. The traveler may not be attentive to traffic hazards while traversing their path, particularly at intersection crossings, or may become disoriented should the system malfunction.

- BT-SS-2.10: A traveler does not have their geolocation services enabled on their mobile device and therefore cannot receive real-time notifications such as route adjustments due to an elevator or escalator outage, thus creating safety risks along their trip.

- TT-SS-3.1: A bus stop is not ADA accessible and a traveler is unable to locate themselves directly by the bus stop. The transit vehicle operator does not see the traveler at the bus stop and does not stop. The traveler is unable to complete their trip.

- TT-SS-3.3: The transit vehicle operator is overwhelmed with system messages and becomes distracted with the system thus creating safety risks to themselves, their riders, and other vehicles on the roadway.

- NV-SS-6.3: A traveler using the system may rely on positional and orientation information, the accuracy of which is dependent on the GPS of their mobile device. The traveler does not have their GPS enabled or it does not provide accurate data to inform the ST-CTN system and the traveler does not receive accurate information. For example, the system may request a pedestrian crossing phase at a signalized intersection too early causing the traveler to have to rush across the street or run out of time to cross.

4.1.2. Virtual Safety Risk

User's privacy and security in the virtual space of the system is also a safety concern. Data breaches or system malfunctions can lead to psychological or physical harm. For example, a user could become a target for scammers (psychological or physical harm outcomes), the leaking of their assistance needs can lead to unemployment (psychological harm), and any data breach can increase a user's stress and anxiety (psychological harm). Additionally, as a source of information for system users, any inaccurate data could mislead the user and cause them physical harm. As the Virtual Safety Manager, it will be ARC's responsibility to ensure all partners are vigilant in verifying, maintaining, and protecting their data accordingly. In this section, the types of virtual risks inherent to the ST-CTN system will be outlined.

One of the top virtual concerns from a user perspective is **protecting their privacy while maintaining access.** There are many types of data that will need to be secured including users' PII and their tracking data that contains trip histories and routes. The DMP goes into greater detail on how ST-CTN will ensure the protection of all sensitive datasets. However, it is also

important that users or their guardians to be able to access a past data to ensure the physical safety of the user. Listed below are the scenarios relating to users data privacy and access.

- PT-SS-1.1: The system is breached and traveler profile information is exposed. A bad actor captures the traveler information and seeks out individuals with specific profile characteristics to take advantage of, cause them harm, or create undue stress.

- CV-SS-5.1: The CV subsystem is breached. Unauthorized personnel gain access to the traffic control system or protected data which they could potentially modify CV messages or signal timing and phasing.RP-SS-7.1: A traveler with cognitive disabilities arrives at their destination much later than expected. The traveler is distraught, and their caregiver is unable to understand where the traveler has been or what may have happened to them.

Another risk that must be managed for any project in the virtual space is **data integrity.** Inaccurate data in the system would cause a number of issues, including the possibility of greater physical risk to the user. The system will be receiving data from many different sources and each source will need to be verified to ensure the results are accurate for the user. There is more information about data maintenance and quality assurance in the DMP. Listed below are the scenarios relating to the possibility of inaccurate data.

- PT-SS-1.2: The system returns a route that does not meet the traveler's combinations of needs and preferences (as defined in their user profile) and the traveler is unable to safely navigate their route and complete their trip.

- NV-SS-6.1: A traveler receives inaccurate information about the location of the accessible entrance of their destination which is difficult to find without directions.

- NV-SS-6.2: A traveler arrives at their destination. The system does not receive notification that an elevator is out of service and the system does not alert the traveler. The traveler is unaware that the elevator is out of service and is unable to complete their trip safely.

- NV-SS-6.3: A traveler using the system may rely on positional and orientation information, the accuracy of which is dependent on the GPS of their mobile device. The traveler does not have their GPS enabled or it does not provide accurate data to inform the ST-CTN system and the traveler does not receive accurate information. For example, the system may request a pedestrian crossing phase at a signalized intersection too early causing the traveler to have to rush across the street or run out of time to cross.

- RP-SS-7.2: A traveler incorrectly reports a routing conflict at the end of their trip. The data provided by the ST-CTN is inaccurate causing unnecessary rerouting for the next traveler or the inability for that traveler to complete their trip. This could cause a traveler to receive an unnecessarily long route leading to exhaustion or other unsafe conditions.

- RP-SS-7.3: The traveler's trip history data is compromised including tracking information on the traveler. A bad actor captures the data and can trace individuals' travel patterns to take advantage of, cause them harm, or create undue stress.

The final category relating to virtual risk is **system malfunction.** Relying on technology comes with the possibility that it may fail. This could lead to both and increase physical risk to the user as

well as an increased chance of multiple virtual problems. Below is a list of potential scenarios that could occur in the case of any type of system malfunction.

- PT-SS-1.2: The system returns a route that does not meet the traveler's combinations of needs and preferences (as defined in their user profile) and the traveler is unable to safely navigate their route and complete their trip.

- BT-SS-2.1: The system receives a number of simultaneous requests for trip plans and is unable to respond in a timely manner, or crashes the system, leaving users without access to their routes and directions.

- IC-SS-4.1: A traveler approaching an intersection is using the ST-CTN system and expects that an automated pedestrian request in the direction of their travel will be placed. The system malfunctions (i.e. global positioning system (GPS) accuracy is lacking, access to mobile unit (MU) Gateway is not available, etc.) and does not place the request or places the request in the wrong direction. The traveler does not receive a pedestrian walk phase or has to wait an extended period of time because the signal has not been actuated.

- IC-SS-4.2: The system misinterprets the pedestrian’s intended direction or the traveler does not traverse the intended route. The signal does not provide the Walk indication in the desired direction. The traveler may not receive the additional crossing time that they require and expect.

- CV-SS-5.1: The CV subsystem is breached. Unauthorized personnel gain access to the traffic control system or protected data which they could potentially modify CV messages or signal timing and phasing.

- CV-SS-5.2: The CV subsystem does not function properly and requests signal phasing and timing (SPaT) changes that are not correct leading to reduced pedestrian crossing time.

- CV-SS-5.3: The personal safety message (PSM) broadcast does not function properly, and CV enabled vehicle drivers are not notified of the pedestrian presence or the subsystem sends a message that is inaccurate causing driver confusion and distraction.

- CV-SS-5.4: The CV subsystem field infrastructure (i.e. RSUs) may malfunction or drop messages, such as pedestrian presence, due to interference from public Wi-Fi and issues with the reduced spectrum.

5. Safety Operational Concept

Identifying safety needs and scenarios, assessing risk, and developing strategies to avoid, mitigate, and respond to safety impacts is critical to the safe and successful deployment, operations, and management of the ST-CTN system. This section provides an overview of the design, operational, mitigation and fail-safes, and response strategies that will be used to manage safety risks and potential impacts related to the ST-CTN system.

5.1. Safety Design

Safety will be of critical focus during the design of the ST-CTN system. The safety needs and scenarios presented in **Section 3** will drive the development of the system requirements which will guide the design, deployment, and verification of the ST-CTN system. The design of the ST-CTN system will be the primary method by which potential safety impacts will be avoided and mitigated. Examples of potential safety design elements that will be incorporated into the ST-CTN system are presented below in **Table 8**. For additional safety design elements within the context of the ST-CTN project, **Table 11**, provides a summary of safety managements strategies as they pertain to each safety scenario.

Table 8. Safety Design Elements

ST-CTN Subsystem	Safety Design Elements
ATL RIDES	• Designed to ensure secure data routing, processing, and storage processes. • Designed to ensure secure access to PII shared by travelers and to prevent unauthorized or malicious users. • Designed to provide notifications/alerts to travelers for mobile device malfunctions. • Designed to support offline, downloadable turn-by-turn directions. • Designed to integrate with common assistive devices. • Designed to allow traveler to share their location with the ST-CTN call center. • Designed to allow travelers to customize their method and frequency of alerts and notifications. • Designed to alert travelers of system and/or personal device malfunctions.
STM Platform	• Designed to be scalable such that the system can handle simultaneous requests, routing, notifications, etc. • Designed to balance processing of simultaneous routing and re-routing requests with real-time, dynamic input.

ST-CTN Subsystem	Safety Design Elements
CV	• Equipment designed and procured to support current standard safety specifications. • Designed to log communication losses or failures. • Designed to leverage SCMS capabilities to enable security and identification of bad actors. • Designed and configured to provide consistent method of broadcasting standard CV messages. • Designed to account for variability within traveler and subsystem device positional accuracy. • Designed to protect PII of system users.

These safety design elements are not intended to be exhaustive, and it is expected that system requirements development will define and guide the comprehensive set of design elements required to avoid, mitigate, and minimize potential safety risks associated with the ST-CTN project. For additional safety design elements within the context of the ST-CTN project, **Table 11**, provides a summary of safety managements strategies as they pertain to each safety scenario.

5.2. Safety Operational Processes

Operational processes will be developed and executed to support the safe and reliable operations of the ST-CTN system. Examples of key safety operational processes that will guide the operations of the ST-CTN system are presented below in **Table 9**.

Table 9. Safety Operational Processes

ST-CTN Subsystem	Safety Operational Process
ATL RIDES	• Processes to monitor subsystem and system performance and function. • Access to the ST-CTN call center will be provided if the system malfunctions or if the traveler needs additional support. • ST-CTN call center operators will have access to traveler profiles, if allowed by the traveler, and their position information. • Training will be provided to support proper application setup and system use. • Travelers will have the option to practice their route virtually prior to beginning their trip. • Subsystem will be monitored consistently to ensure proper function and security.
STM Platform	• Data will be reviewed regularly to ensure quality and consistency. • Crowdsourced data will be monitored and reviewed regularly to ensure quality. • Subsystem will be monitored consistently to ensure proper function and security.

CV	• Subsystem will be monitored consistently to ensure proper function and security. • Subsystem operators will be trained to manage and operate system components prior to deployment.

These safety operational processes are not intended to be exhaustive, and it is expected that system requirements development will define and guide the comprehensive set of operational processes required to avoid, mitigate, and minimize potential safety risks associated with the ST-CTN project. For additional safety operational processes within the context of the ST-CTN project, **Table 11**, provides a summary of safety managements strategies as they pertain to each safety scenario.

5.3. Mitigations and Fail-Safes

System requirements will guide the development of mitigation measures and fail-safe strategies to control the severity of impacts if safety impacts occur. Examples of mitigation and fail-safe strategies that will be employed during the deployment and operations of the ST-CTN system are presented below in **Table 10**.

Table 10. Mitigation and Fail-Safe Strategies

ST-CTN Subsystem	Mitigation and Fail-Safe Strategies
ATL RIDES	• System will provide travelers flexibility to select routes that may not meet their needs but are more desirable due to distance or other circumstance. • System will provide travelers with offline access to their pre-planned route if they lose connectivity. • System will alert travelers if their device is not functioning properly or may run out of charge. • System will direct travelers to an alternative method of travel if their needs are not able to be accommodated by the system.
STM Platform	• Subsystem will rely on historical data if real-time data connectivity is lost.
CV	• Subsystem hardware will utilize standard fail-safe methods to monitor conflicts and ensure safe traffic signal operations. • If the system is to fail, standard signal timing and pedestrian crossing phasing will be provided.

These mitigation and fail-safe strategies are not intended to be exhaustive, and it is expected that system requirements development will define and guide the comprehensive set of mitigation measures required to mitigate, minimize, and control severity of potential safety risks associated with the ST-CTN project.

5.4. Safety Responses

Safety is paramount to the successful development, design, deployment, and operations of the ST-CTN system. In the event that a safety incident occurs, a swift, coordinated response to mitigate and minimize the impact to safety and future events will be critical. It is anticipated that typical Gwinnett County emergency response procedures will be implemented in the event of imminent danger. The following process will be used to respond to a safety event.

- Identify and understand the safety incident
- Notify Safety Manager
- Manage safety response
- Assess the impact
- Mitigate future safety risks
- Report and document safety incident and response

It is possible that an event will occur in which safety has not been impacted but that potential safety risks are discovered. The Safety Manager will initiate a safety response to these events consistent with those events in which safety has been impacted.

5.5. Safety Reporting

All potential safety incidents will be tracked and reported throughout the life of the project. The purpose for tracking and reporting safety incidents is to ensure every effort is made to minimize and mitigate current and future potential safety incidents. The Physical Safety Manager and Virtual Safety Manager will be responsible for leading and ensuring the quality of safety reporting on the ST-CTN project. The following process will be used to guide the documentation and reporting of all safety incidents.

- Each safety incident is required to be tracked and reported.

- The Safety Manager will be responsible working with the appropriate ST-CTN team members to complete the ST-CTN Incident Report Form, provided in **Appendix C**.

- Incidents of significance, as determined by the Safety Manager, will require an after-action meeting. The Safety Manager will coordinate and notify the USDOT of these incidents. It is expected that USDOT will participate in the after-action meeting as they deem fit.

- The Safety Manager will be responsible for communicating with the ST-CTN team to provide information about all safety incidents and responses. ST-CTN team members will have access to the SMP throughout the life of the project.

- The Safety Manager will be responsible for communicating with USDOT to provide information about all safety incidents and responses.

- The Safety Risk Summary (**Section 6.1**) will be updated should an incident occur that is not reflected.

- SMP will be assessed and updated if an incident occurs of severity 2 or greater as defined by the process presented in **Section 4.1**.

- SMP will be assessed and updated, as necessary, on an annual basis and provided to USDOT for review and approval.

6. Safety Management Summary

Having an easily understandable summary is important to streamline the iterative SRP. This chapter includes the final table of the ARC team's safety risks for the ST-CTN project and how they will continue to be addressed moving forward.

6.1. Safety Risk Summary

Table 11 provides a summary of the potential safety scenarios, risk assessments, and management strategies, that were identified through the SRP. It also includes which safety manager, ARC or Gwinnett County (GC), will be the lead on implementing each strategy. The overall status of each scenario will continue to be updated as the management strategies are implemented.

Table 11. Safety Risk Management Summary

Scenario	Scenario ID	S	E	C	SSIL	Safety Manager	Safety Management Strategies	Factors to Monitor	Overall Status
The system is breached and traveler profile information is exposed. A bad actor captures the traveler information and seeks out individuals with specific profile characteristics to take advantage of, cause them harm, or create undue stress.	PT-SS-1.1	S1	E1	C2	QM	ARC	Design - The system is designed to prevent access to unauthorized or malicious actors. More information on the security of the system can be found in the DMP. Operations - Support services will monitor access to the system and make sure the system is functioning properly.	Monitor access to the system and log intrusive events.	Prevention /Management
The system returns a route that does not meet the traveler's combinations of needs and preferences (as defined in their	PT-SS-1.2	S1	E2	C2	QM	ARC	Operations - If the system malfunctions or uses inaccurate data and returns a route that is inaccessible for the user, the user	Verify accuracy of all data be used in the system and iteratively improve routing engine	Prevention

user profile) and the traveler is unable to safely navigate their route and complete their trip.							will be able to get support through a call center or guardian to ensure their safety.	based on user feedback	
A traveler is traveling with another person who has different accessibility needs from their own. The system returns a route that is based on the primary traveler's profile, which is accessible to them, but not to their companion.	PT-SS-1.3	S1	E2	C2	QM	ARC	Design - The system will be designed in a way to accommodate companion accessibility, but training will be necessary to ensure users are aware of this feature.	The user interface must be designed such that it is easy to find where to add companion accessibility needs	Prevention
A traveler is embarking on a trip that is unfamiliar and uncomfortable for them. They become disoriented and distressed and are unable to complete their trip or wander off course and put themselves in an unsafe environment.	PT-SS-1.4	S1	E2	C3	A	ARC	Design - Several features will need to be available in the system to increase the comfort of users during new trips including streetview photo walkthroughs before the user leaves for their trip.	User feedback and support feedback to iterate the design of app features.	Prevention
The system cannot return a route that meets the needs and preferences of the traveler due to non-system related event such as an incident or special event that is blocking accessible routes or there is no route available that meets all the traveler's needs.	PT-SS-1.5	S1	E2	C3	QM	ARC	Mitigation - There may be circumstances where a user's needs cannot be accommodated to their chosen destination either due to temporary or permanent infrastructure limitations. In these cases, the application will need to give the user different accommodation options such as paratransit, microtransit, or ride hailing services.	The data regarding inaccessible trips will be distributed to Gwinnett County to help them prioritize future infrastructure projects and better plan temporary obstructions.	Management
The system receives a number of simultaneous requests for trip plans and is unable to	BT-SS-2.1	S2	E1	C2	QM	ARC	Design - The system will be designed to handle a large number	Monitor the number of requests that are being	Prevention

respond in a timely manner, or crashes the system, leaving users without access to their routes and directions.							of simultaneous requests for trip plans.	generated in a given period.	
A traveler who relies on an assistive device such as a wheelchair, crutches, hearing aid, cane, etc. may not be able to access their turn-by-turn directions via their mobile device during their travel and becomes disoriented or off course.	BT-SS-2.2	S2	E2	C2	QM	ARC	Design - Integration with common assistive devices is necessary for an optimal functioning system including smart canes, etc.	User feedback on their primary devices will guide the continued integration of more devices of the life of the project	Prevention
A traveler defines their user profile and preferences with the expectation that the system will provide information to them in this form. However, the traveler does not have a mobile device that is capable of providing information in the preferred manner and the traveler cannot receive notifications and alerts as expected. The traveler is unaware of the problem and does not realize they are not receiving navigation notifications and alerts. The traveler becomes disoriented and puts themselves in an unsafe environment.	BT-SS-2.3	S2	E2	C3	A	ARC	Design- The ATL-RIDES application will be able to alert the user that some functions are unable to operate due to their mobile device settings. Operations - A list of required device features will be created and included in all training materials.	User feedback will be used to enhance training techniques and materials as necessary	Prevention

A traveler defines their user profile and preferences but does not indicate their abilities accurately. The route that is returned is not accessible for the traveler leading to unsafe traveler conditions. For example, a traveler utilizing a wheelchair could be given directions to a bus stop that is inaccessible, and the traveler may have to traverse the shoulder of the roadway to access the area of the bus stop putting themselves at risk to be hit by a car.	BT-SS-2.4	S2	E2	C3	A	ARC	Operations - Users will require training before they are able to use the app.	User feedback will be used to update app UI and ensure it is easy to use	Prevention
A traveler becomes disoriented and is distressed. The traveler calls the call center for support but is unable to communicate their location or does not know their location. The traveler becomes more distressed and frustrated and wanders off course in an unsafe environment or is unable to complete their trip.	BT-SS-2.5	S2	E2	C3	A	GC	Design - The system will need to allow the option for a traveler to automatically share their location with call center support.	Call center data for the number of times they need location information	Management
A traveler receives turn by turn directions and begins their trip. During the trip, the traveler loses cellular service and cannot access their directions. The traveler becomes	BT-SS-2.6	S2	E2	C3	A	ARC	Design - An option to download directions to be used without network data will be implemented. Operations - Users will be trained on what to do if cellular service is lost during their trip and access to	User feedback about training using features available with and without data	Prevention

distressed and frustrated and wanders off course in an unsafe environment or is unable to complete their trip.							directions and even support services such as the call center or 911 is not available.		
A traveler is distracted with their phone – focused on directions, settings, notifications, too frequent alerts, etc. – and is not attentive to their surroundings. As a result, the traveler is prone to potential hazards.	BT-SS-2.7	S2	E2	C3	A	ARC	Design - During training users will need to get hands on experience with the app notifications during a trip. Operations - The app will also be designed to give reminders to users to pay attention to their surroundings.	User feedback on ways to customize notifications and training with the system	Prevention
A traveler is unable to receive alerts and notifications that meet their needs and preferences, i.e. audible messages may be too quiet or be indistinguishable from other sounds, meaning of the messages are unclear or too complicated, etc. As a result, the traveler becomes disoriented or gets off course.	BT-SS-2.8	S2	E2	C3	A	ARC	Design - The app must be designed for users to be able to fully customize all notifications and the system will alert the user when they are off course or heading the wrong direction and recalculate their path to get them back on track.	User feedback on notifications will prioritize necessary updates	Prevention
A traveler becomes too dependent upon the ST-CTN system and does not maintain awareness of their surroundings and direction. The traveler may not be attentive to traffic hazards while traversing their path, particularly at intersection crossings, or may become disoriented should the system malfunction.	BT-SS-2.9	S2	E2	C3	A	ARC	Design - The app will be designed to give reminders to users to pay attention to their surroundings. The app will also be designed to alert the user to any loss of function as appropriate.	System malfunctions, user feedback on their experience	Management

A traveler does not have their geolocation services enabled on their mobile device and therefore cannot receive real-time notifications such as route adjustments due to an elevator or escalator outage, thus creating safety risks along their trip.	BT-SS-2.10	S2	E2	C1	QM	ARC	Design - The app will alert users that their location is disabled when starting a trip. Operations - Training materials will include all system requirements for full system functionality.	Number of trips being made without location tracking enabled	Prevention
A bus stop is not ADA accessible and a traveler is unable to locate themselves directly by the bus stop. The transit vehicle operator does not see the traveler at the bus stop and does not stop. The traveler is unable to complete their trip.	TT-SS-3.1	S2	E2	C2	QM	GC	Design - The system will be designed to communicate with the bus driver to request a stop automatically.	Connected vehicle up time, vehicle operator and user feedback	Prevention
A traveler who is vulnerable to the elements while waiting for a transit vehicle that is behind schedule. The traveler is unable to access the shelter (or there is not one) and begins to feel unwell.	TT-SS-3.2	S2	E2	C3	A	GC	Design - The system will enable the user to require a shelter on their trip or alert them that there is not shelter before making the trip. Additionally, the user's profile will automatically trigger Transit Signal Priority to get the bus back on schedule faster.	Connected vehicle uptime, User feedback, Transit infrastructure data accuracy	Prevention
The transit vehicle operator is overwhelmed with system messages and becomes distracted with the system thus creating safety risks to themselves, their riders, and other vehicles on the roadway.	TT-SS-3.3	S3	E2	C2	A	GC	Design - The system will limit alerts when vehicle is in motion to only stop requests that will be integrated into the current stop request system.	Connected vehicle up time, vehicle operator and user feedback	Prevention

A traveler approaching an intersection is using the ST-CTN system and expects that an automated pedestrian request in the direction of their travel will be placed. The system malfunctions (i.e. global positioning system (GPS) accuracy is lacking, access to mobile unit (MU) Gateway is not available, etc.) and does not place the request or places the request in the wrong direction. The traveler does not receive a pedestrian walk phase or has to wait an extended period of time because the signal has not been actuated.	IC-SS-4.1	S3	E2	C2	A	ARC/GC	Design - The system will be designed to alert the user about any malfunctions.	Connected vehicle up time, user feedback	Management
The system misinterprets the pedestrian's intended direction or the traveler does not traverse the intended route. The signal does not provide the Walk indication in the desired direction. The traveler may not receive the additional crossing time that they require and expect.	IC-SS-4.2	S3	E2	C2	A	ARC/GC	Design - The system will alert the user when they are off course or heading the wrong direction and recalculate their path to get them back on track. It will also periodically give the user reminders to be aware of their surroundings.	Tracking data on rerouting, incomplete trips and near misses if available	Prevention
The CV subsystem is breached. Unauthorized personnel gain access to the traffic control system or	CV-SS-5.1	S3	E1	C2	QM	ARC/GC	Design - The system is designed to prevent access to unauthorized or malicious actors. More information on the security of the	Monitor access to the system and log intrusive events.	Prevention /Management

protected data which they could potentially modify CV messages or signal timing and phasing.							system can be found in the DMP. Operations - Support services will monitor access to the system and make sure the CV system is functioning properly.		
The CV subsystem does not function properly and requests signal phasing and timing (SPaT) changes that are not correct leading to reduced pedestrian crossing time.	CV-SS-5.2	S3	E1	C2	QM	ARC/GC	Design - The system will be designed to send National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) approved messages and commands to traffic signal controllers, thereby preventing malfunctions.	Monitor and log command failures to address.	Prevention
The personal safety message (PSM) broadcast does not function properly, and CV enabled vehicle drivers are not notified of the pedestrian presence or the subsystem sends a message that is inaccurate causing driver confusion and distraction.	CV-SS-5.3	S1	E1	C2	QM	ARC/GC	Design - The system will be designed to only send approved messages to connected vehicles indicating that pedestrians are in the vicinity, drivers are still expected to maintain awareness of their surroundings at all times.	Monitor messages and log any that fall outside specific operating parameters	Prevention
The Security Credential Management System (SCMS) associated with the CV subsystem does not function properly and a bad actor is able to access the system and access the agency's network.	CV-SS-5.4	S1	E1	C3		ARC/GC	Design - The system is designed to prevent access to unauthorized or malicious actors. Operational - Support services will monitor access to the system and make sure the SCMS is functioning properly.	Monitor access to the system and log intrusive events.	Prevention /Management
The CV subsystem field infrastructure (i.e. RSUs) may malfunction or drop messages,	CV-SS-5.4	S1	E1	C3	QM	ARC/GC	Design - The system will be designed to log communication losses and device failures in order	Monitor communication losses and device	Management

such as pedestrian presence, due to interference from public Wi-Fi and issues with the reduced spectrum.							to allow better management of in-field equipment.	failures to generate maintenance tickets	
A traveler receives inaccurate information about the location of the accessible entrance of their destination which is difficult to find without directions.	NV-SS-6.1	S1	E2	C2	QM	ARC/GC	Design - The system will be designed to provide accurate routing data through accessible spaces. Operations - Call center operators will be able to support users if they require additional information about their destination or route including other accessibility accommodations.	Accessibility information including location and function should be reviewed periodically for accuracy. Routing errors should be logged and reviewed to understand the cause.	Management
A traveler arrives at their destination. The system does not receive notification that an elevator is out of service and the system does not alert the traveler. The traveler is unaware that the elevator is out of service and is unable to complete their trip safely.	NV-SS-6.2	S2	E2	C2	QM	ARC/GC	Design - The system will be designed to incorporate crowdsourced data into route creation, thereby allowing other users to report an outage if it is not reported through other channels. Operations - Call center operators will be able to support users if they require additional information about their destination or route including other accessibility accommodations.	Data regarding outages should be tracked in order to understand how it is being reported and if additional data collection methods are needed	Prevention /Management
A traveler using the system may rely on positional and orientation information, the accuracy of which is dependent on the GPS of their mobile device. The traveler does not have their GPS enabled or it	NV-SS-6.3	S2	E2	C3	A	ARC	Design - The system will be designed to notify users that they have not enabled their GPS functionality. The system will be designed to accommodate for mobile device GPS accuracy and not require GPS information to be	Report generation focusing on trips that were cut short due to device power loss/failure/malfunction.	Prevention

does not provide accurate data to inform the ST-CTN system and the traveler does not receive accurate information. For example, the system may request a pedestrian crossing phase at a signalized intersection too early causing the traveler to have to rush across the street or run out of time to cross.							accurate beyond the accuracy of existing systems.		
A traveler using the ST-CTN system may lose cellular network connectivity, interrupting all incoming real-time information updates. There is an event that impedes the traveler's intended route, but the traveler does not receive notification of route changes and is unable to complete their trip when they arrive at the obstruction and have to turn around.	NV-SS-6.4	S2	E2	C3	A	ARC	Design - The system will be designed to notify users of connection interruptions and allow them to continue in offline mode if desired.	Report generation focusing on trips that were cut short due to device power loss/failure/malfunction.	Prevention
A traveler depending on the ST-CTN system may run out of battery causing their phone to shut down during their trip. Without power to their phone, the traveler may be unable to complete their trip.	NV-SS-6.5	S2	E2	C3	A	ARC	Design - The system will be designed to notify users of low battery at the beginning of their trip as well as during the impending disconnection.	Report generation focusing on trips that were cut short due to device power loss/failure/malfunction.	Prevention
A traveler with cognitive disabilities arrives at their	RP-SS-7.1	S2	E1	C2	QM	ARC	Design - The system will be designed to provide access to trip	Active trip timelines should be monitored	Management

destination much later than expected. The traveler is distraught, and their caregiver is unable to understand where the traveler has been or what may have happened to them.							history and location data to caregivers, allowing them to review the route that was generated, and the route taken. Operations - Call center personnel will be able to field calls and questions both from users and caregivers to assist them in completing or understanding their trip.	through a watchdog system that indicates if a trip has extended well past its estimated time.	
A traveler incorrectly reports a routing conflict at the end of their trip. The data provided by the ST-CTN is inaccurate causing unnecessary rerouting for the next traveler or the inability for that traveler to complete their trip. This could cause a traveler to receive an unnecessarily long route leading to exhaustion or other unsafe conditions.	RP-SS-7.2	S1	E1	C3	QM	ARC	Design - The system will be designed to assign weights to crowdsourced data based on the number of entries of the same information. Operations - When critical infrastructure is reported as out/malfunctioning/non-compliant, action will be taken to determine the accuracy of the report.	The data that is being submitted through crowdsourced methods should be periodically reviewed for accuracy.	Prevention /Management
The traveler's trip history data is compromised including tracking information on the traveler. A bad actor captures the data and can trace individuals' travel patterns to take advantage of, cause them harm, or create undue stress.	RP-SS-7.3	S2	E1	C3	QM	ARC	Design - The system will be designed in a way to prevent access to PII to users outside of controlled environments. Operations - Users will be directed to sign in to their account only from trusted devices.	PII data that needs to be stored on a central server shall be anonymized upon entry to the system to prevent unauthorized use.	Prevention

6.2. Continuing Safety Planning

Safety is a primary focus of the development, design, and operations of the ST-CTN system. It is expected that safety needs, scenarios, and risks will be identified throughout the life of the project. The SMP provides the process by which these safety risks will be assessed and managed. The ST-CTN Physical Safety Manager and Virtual Safety Manager will be responsible for leading the continued safety planning and management of the ST-CTN project.

The safety risk summary, **Table 11**, will be used to guide those safety risks that have been identified thus far. The Physical Safety Manager and Virtual Safety Manager will be responsible for ensuring that the requirements, design, and operational strategies are implemented and verified consistent with the direction of this plan.

It is anticipated that additional safety risks will be identified during system design, deployment, and operations; the Safety Risk Summary will be updated to reflect these risks and associated management strategies throughout the life of the project.

All safety incidents will be tracked and reported on throughout the life of the project as described in **Section 5.5**. The purpose for tracking and reporting safety incidents is to ensure every effort is made to minimize and mitigate current and future potential safety incidents.

It is expected that in addition to newly identified safety risks, the assessment of existing risks may change as more is learned throughout the project. In addition, safety stakeholders will change, and responsibilities may need to be reassessed. The circumstances leading to an update of each document is outlined below.

The Safety Risk Summary will be updated:

- Monthly as part of project management
- When a safety risk occurs that is not currently reflected in the table
- When a new safety risk is identified

The SMP will be updated:

- Annually
- When an incident of SSIL Severity 2 or greater occurs

Appendix A. Acronyms and Glossary

Acronyms

ADA – Americans with Disability Act

ARC – Atlanta Regional Commission

ASIL – Automotive Safety Integrity Level

ATL – Atlanta-Region Transit Link Authority

ATL RIDES – Atlanta-Region Information and Data Evaluation System

ATMS – advanced traffic management system

CDP – connected data platform

ConOps – Concept of Operations

CV – connected vehicle

CV1K – Regional Connected Vehicle Infrastructure Deployment Program

C-V2X – Cellular Vehicle to Everything

CVTMP – Connected Vehicle Technology Master Plan

DMP – Data Management Plan

DRSB – Deployment Readiness Summary Briefing

DSRC – Dedicated Short-Range Communications

EMT – Executive Management Team

ETRA – Enabling Technology Readiness Assessment

FHWA – Federal Highway Administration

FTA – Federal Transit Administration

GA Tech – Georgia Institute of Technology

GCDOT – Gwinnett County Department of Transportation

GCT – Gwinnett County Transit

GCTO – Gwinnett County Traffic and Operations

GDOT – Georgia Department of Transportation

GOSystems – GO Systems and Solutions

GPS – global positioning system

GTFS – General Transit Feed Specification

HUA – Human Use Approval

ICTDP – Integrated Complete Trip Deployment Plan

IOO – infrastructure owner/operator

ISO – International Organization for Standardization

ITS – Intelligent Transportation Systems

IVR – integrated voice response

JPO – Joint Program Office

KHA - Kimley-Horn and Associates, Inc.

LEP – limited English proficiency

MU – mobile unit

OSS – open-source software

OST – Office of the Secretary

OTP – Open Trip Planner

PII – personally identifiable information

PMESP – Performance Measurement and Evaluation Support Plan

PMP – Project Management Plan

PSM – personal safety message

PTSEP – Participant Training and Stakeholder Education Plan

QM – quality management

RSU – roadside unit

SCMS – Security Credential Management System

SILCGA – Statewide Independent Living Council of Georgia

SMP – Safety Management Plan

SPaT – signal phasing and timing

SRP – safety risk process

SSIL – ST-CTN Safety Integrity Level

ST-CTN – Safe Trips in a Connected Transportation Network

STM – Space Time Memory

SyRS – Deployment System Requirements

TSP – transit signal priority

UI – user interface

UNIRP – User Needs Identification and Requirements Plan

USDOT – U.S. Department of Transportation

Glossary

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

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]

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

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

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

Roadside Unit (RSU) – A DSRC transceiver that is alongside a roadway. It broadcasts or exchanges data with on-board units. [CAV]

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

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. [CAV]

Appendix B. System Needs

The following table is referenced from the ST-CTN Phase 1 Concept of Operations, Table 12. System needs.

Table B1. ST-CTN System Needs

Need ID	System Need Statement	Priority	Associated End User and IOO Need
Pre-Trip Planning (PT) 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 BT-EU-2.1.2 BT-EU-2.2.5 BT-EU-2.2.6 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 BT-EU-2.2.1 BT-EU-2.2.5 BT-EU-2.2.6 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 PT-EU-1.1.2 PT-EU-1.1.3 PT-EU-1.1.4 PT-EU-1.1.5 PT-EU-1.2.5 PT-EU-1.2.6 PT-EU-1.2.9 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 PT-EU-1.2.2 PT-EU-1.2.3 PT-EU-1.2.4 PT-EU-1.2.5 BT-EU-2.2.1 PT-OO-1.1
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 BT-EU-2.1.1 BT-EU-2.1.2 BT-EU-2.1.3

Need ID	System Need Statement	Priority	Associated End User and IOO Need
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) 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 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 PT-EU-1.2.2 PT-EU-1.2.3 PT-EU-1.2.4 PT-EU-1.2.5
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 PT-EU-1.2.2 PT-EU-1.2.3 PT-EU-1.2.4 PT-EU-1.2.5 BT-EU-2.2.1 BT-EU-2.2.2

Need ID	System Need Statement	Priority	Associated End User and IOO Need
			BT-EU-2.2.5 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 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 PT-EU-1.1.2 PT-EU-1.1.3 PT-EU-1.1.4 PT-EU-1.1.5 BT-EU-2.1.3 BT-EU-2.1.4 BT-EU-2.2.1 BT-EU-2.2.2 BT-EU-2.2.3 BT-EU-2.2.4 BT-EU-2.2.5 BT-EU-2.2.6 TT-EU-3.1.1 TT-EU-3.1.2 TT-EU-3.1.3 TT-EU-3.1.4 TT-EU-3.1.5 TT-EU-3.1.6 TT-EU-3.1.7 CV-EU-5.1.1 CV-EU-5.1.2 NV-EU-6.1.1 NV-EU-6.1.2 NV-EU-6.1.3 PT-OO-1.1
Transition to Transit (TT) 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 TT-EU-3.1.3 TT-EU-3.1.5 CV-EU-5.1 TT-OO-3.2 CV-OO-5.2
TT-SY-3.2	The system needs to confirm receipt and status of the request for a transit stop request so that the	E	-

Need ID	System Need Statement	Priority	Associated End User and IOO Need
	traveler knows that their request has been received by the system.		
Intersection Crossing (IC) 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 IC-EU-4.1 CV-EU-5.1.1 CV-EU-5.1.2 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) CV-SY-5.1	The system needs to connect travelers to the connected infrastructure to increase safety.	E	IC-IOO-4.1 IC-IOO-4.2 CV-IOO-5.1
CV-SY-5.1.1	The system needs to identify and communicate traveler presence at intersections to nearby CVs for the safety of the traveler(s).	E	CV-EU-5.2.1 IC-IOO-4.1 IC-IOO-4.2 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 IC-IOO-4.1 IC-IOO-4.2 CV-IOO-5.1
Indoor/Outdoor Navigation (NV) 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 PT-EU-1.1.4 BT-EU-2.2.3 NV-EU-6.1.1 NV-EU-6.1.2 NV-EU-6.1.3 PT-OO-1.1 NV-OO-6.2 RP-OO-7.1
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 PT-EU-1.1.4 NV-EU-6.1.2 NV-EU-6.1.3

Need ID	System Need Statement	Priority	Associated End User and IOO Need
Reporting (RP) 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 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 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 RP-OO-7.1
Future Development (FT) 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 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 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 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 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 FT-OO-8.2
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, ridehaling, microtransit services or others.	O	FT-OO-8.1 FT-OO-8.2

Appendix C. ST- CTN Incident Report Form

ST-CTN Incident Report Form

Part 1: (Safety Manager to complete with User)

Information about the person who was involved in the incident:

Name: _____ **Traveler / Team Member / Transit Operator / Contractor** *(please circle one)*

Users' Mode of Travel *(Personal Vehicle/Bus/Pedestrian/Cyclist):* _____

Contract Primary Telephone: _____ **Home / Cell / Work** *(please circle one)*

What type of incident was it? *(please circle one)*

Near Miss Collision Device Failure Routing Failure Infrastructure Conditions Property Loss

When did the incident happen?	**Where did the incident happen?**
Date: **Time:**	**Location:**

What segment of the trip is the incident related to? *(please circle one)*

Pre-Trip Planning Begin Trip Transition to Transit Intersection Crossing CV Broadcast Message Outdoor/Indoor Navigation

What Happened?

Description: *(include details of any device involved, other vehicles involved, property lost of damaged)*

Was a known safety risk involved? *(please circle one)* **YES** **NO**

If **YES** - what was the safety risk?

Names and contact information of any witnesses:

What injury or injuries were sustained, and to whom?	**Was law enforcement notified?**
Is this a serious harm injury *(please circle one)* **YES** **NO**	**Name of agency:**
Was first aid or emergency care provided? *(please describe)*	**Contact for agency:**

Declaration: The above report provides a true, accurate and complete account of the accident / incident / near miss / malfunction

_____ _____ _____

User's Name *(please print)* Signature Date

ST-CTN Incident Report Form

Part 2: (Safety Manager to complete with User)				
What were the contributing factors to this incident *(if any)* **?**		**Safety Risk Identification** Is this a new safety risk? **YES** **NO** Is this a significant safety risk? **YES** **NO** If **YES**, identify the safety management process to be done (refer to SMP/Risk Register and add to recommended actions below)		
Recommended Actions				
Has the Risk Management Process been completed for this safety scenario? **YES** **NO** (please circle)	What has been done?	Safety Manager Responsible:	Due Date:	Completed On:
Is a review of the Safety Management Plan required? **YES** **NO** (please circle)	Which Part?	Safety Manager Responsible:	Due Date:	Completed On:
Other Recommended Actions				
Specific actions to prevent recurrence:		Safety Manager Responsible:	Due Date:	Completed On:
Specific actions to prevent recurrence:		Safety Manager Responsible:	Due Date:	Completed On:
Communications				
All relevant team members and users have received information regarding the incident, changes of operations, and/or changes of procedures.		Safety Manager Responsible:	Due Date:	Completed On:
Was the incident related to a malfunction of the device of system? (please circle) **YES** **NO** If yes, describe the malfunction: Was the incident related to an issue with the device's installation? (please circle) **YES** **NO** If yes, describe the installation issue:		Other comments:		
Safety Managers Name *(please print)*		Signature		Date

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