Phase 2 Integrated Complete Trip Deployment Plan (ICTDP)

Georgia Department of Transportation ITS4US Deployment Project

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16. Abstract

The Georgia Department of Transportation 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, and reliability. 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 efficient and cost-effective transportation options for all.

This document serves as the Integrated Complete Trip Deployment Plan (ICTDP) for the deployment project. The ICTDP describes the refinements to the deployment concept developed in Phase 1, the project's approach to tasks within Phases 2 and 3, deployment schedule and costs, and a detailed list of technical, institutional, and financial risks.

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1 Refined Phase 1 Deployment Concept

This section provides a summary of the refined Safe Trips in a Connected Transportation Network (ST-CTN) deployment concept developed in Phase 1.

1.1 Introduction

The Georgia Department of Transportation (GDOT) and Atlanta Regional Commission's (ARC) ST-CTN project was selected by the U.S. Department of Transportation (USDOT) as a part of the ITS4US Deployment Program. The project seeks to enhance the traveler's complete trip travel experience by enhancing mobility, reliability, and safety for system users. This is done by leveraging innovative solutions, existing deployments and team collaboration such as integrating connected vehicle (CV) data with an open-source software-based trip planner that is used to provision web-based and mobile application user access. The trip planner 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 users with the ability to dynamically plan and navigate trips.

1.1.1 Document Purpose

The objective of the Integrated Complete Trip Deployment Plan (ICTDP) is to reflect refinements to the deployment concept made in Phase 1, any potential changes in the planned Phase 2 and 3 deployment schedule and costs, and a more detailed examination of technical, institutional, and financial risks. It is intended to serve as Volume 1, Part I of the Complete Trip - ITS4US Deployment Program Phases 2 & 3 Notice of Funding Opportunity (NOFO) Technical Application.

1.1.2 Organization of this Document

The ICTDP includes the following sections, which will guide the ST-CTN project team through Phases 2 and 3 of the project which includes system design, deployment, operations, and evaluation.

- **Section 2** (Phase 2 and Phase 3 Technical Approach) provides a high-level overview of the technical approach that the ST-CTN team will take to successfully deliver each task required within Phases 2 and 3 of the ITS4US Deployment Program.
- **Section 3** (Phase 2 and 3 Deployment Schedule) provides a high-level deployment schedule of the capability of incorporating key elements into the proposed system.
- **Section 4** (Phase 2 and 3 Deployment Cost Estimate) summarizes the projected cost estimates in order to provide guidance for other deployers.

1.2 Deployment Concept

In the ITS4US Deployment Program, the USDOT envisions a physical environment and information provisions to enable a seamless journey for all travelers, “regardless of location, income, or disability.” The project team intends to integrate multiple technological innovations. The ST-CTN system will integrate CV data with an open-sourced web-based and mobile application. The application will provide users with the ability to create a personalized trip plan with information regarding the navigation of physical infrastructure, the ability to resolve unexpected obstacles, and ensure users visibility throughout the trip. The proposed deployment will provide users with the ability to dynamically plan and navigate trips. Anticipated users are expected to include:

- **People with Disabilities.** People with disabilities experience a broad range of travel limitations and associated needs. Four functional ability groups are discussed below. Each group has different transportation needs and barriers that may also vary within the group. Some individuals have multiple disabilities. The four groups are mobility, vision, and hearing.
    - **Mobility.** Functional physical ability is a large category that covers any physical movement of the body and can include use of hands, arms, legs, feet, neck and back. This group includes wheelchair users and others.
    - **Vision.** There is a broad spectrum of functional visual ability, from needing reading glasses to total blindness. Vision impairments result from conditions that range from the presence of some usable vision, low vision, to the absence of any vision, total blindness. Some people with visual impairments have some vision sufficient to read large print, navigate around obstacles, or distinguish between light and shadow.
    - **Hearing.** Hearing impairments affect the frequency and/or intensity of one’s hearing. According to the CDC, "deaf" individuals do not hear well enough to rely on their hearing to process speech and language. Individuals with mild to moderate hearing impairments may be “hard of hearing," but are not "deaf." These individuals differ from deaf individuals in that they use their hearing to assist in communication with others. Aids can assist with some types of hearing loss. American Sign Language (ASL), lip-reading and the exchange of written notes are sometimes helpful in communication, but not everyone will have the ability to use these techniques.
- **Older Adults.** Older adults form a substantial demographic of US residents. There are currently approximately 50 million US residents above the age of 65. As individuals age, many develop mobility, vision, and hearing disabilities making it difficult to travel on their own and may experience a growing need for reliable transportation services in order to maintain their independence and mobility. Approximately 35 percent of older adults have some type of disability, while two out of three have some form of chronic medical condition. Many older adults choose not to drive or are unable to drive. Accordingly, they are often in particular need of flexible, reliable, and affordable transportation to access medical appointments, shopping, or other necessary services.
- **Limited English Proficiency Communities.** A person with limited English proficiency (LEP) refers to a person who is not fluent in the English language. Users who have LEP may have trouble understanding directions and alerts when delivered in their non-native language, may have different cultural norms that make it difficult to follow directions, or may have difficulty understanding wayfinding signs.
- **Low-Income Populations** Low-income Americans, defined by the USDOT as persons whose household income is at or below the Department of Health and Human Services poverty guidelines, 6 are a demographic that require reliable and affordable

transportation. They are less likely to own private vehicles, thus increasing the importance of having access to public 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.

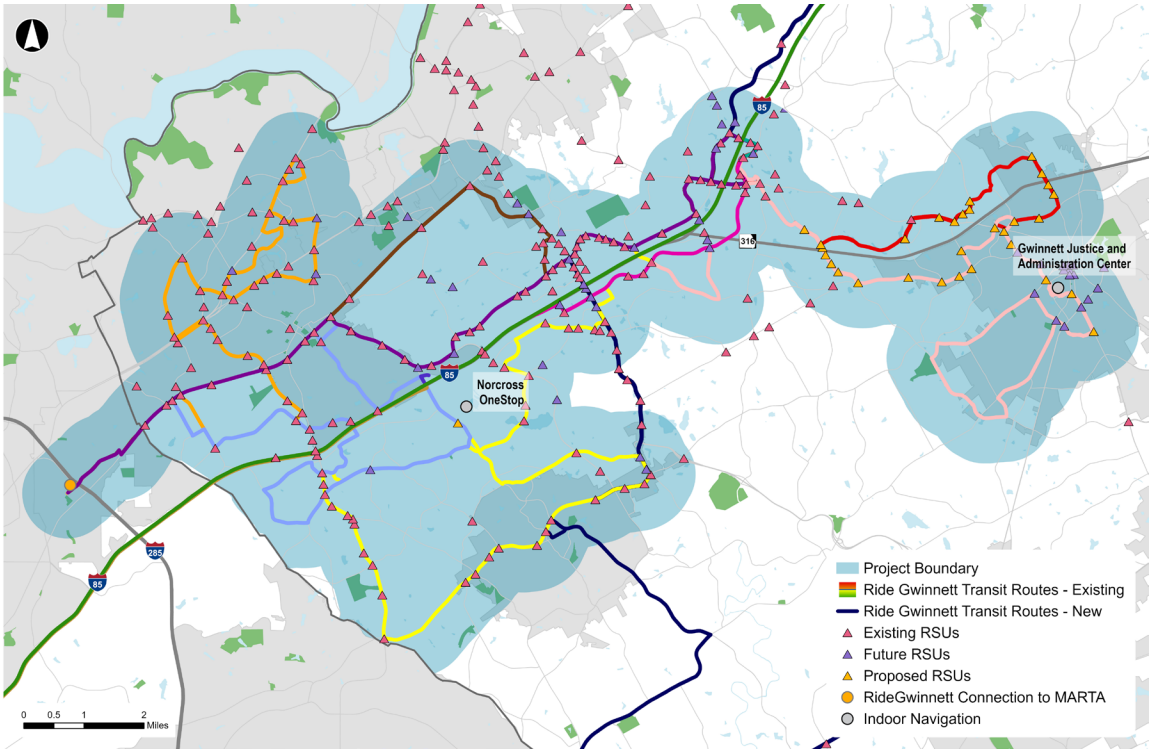
1.2.1 Project Area and Challenges

The ST-CTN project will be implemented in Gwinnett County. The project area is home to a significant portion of the communities referenced above that reside in Gwinnett County. Over 50% of people with disabilities, people with LEP, and zero vehicle household population in Gwinnett County are located within the project area. Approximately 50% of the low-income population and approximately 25% of the older adult population in Gwinnett County are located within the project area. A map of the project area can be found in **Figure 1**.

The ST-CTN project area has a primarily suburban land use and transportation pattern. As such, there are several major infrastructure and accessibility issues facing older adults and individuals with disabilities. Many of the roadways are composed of multiple lanes in each direction, with long blocks and high vehicle speeds. These types of roads can be unsafe for all pedestrians, but especially for people with disabilities and those with mobility impairments. Long blocks and low street connectivity also make navigating around an unexpected obstruction, such as a discontinued sidewalk, difficult to traverse. This area also contains pedestrian infrastructure that does not provide pathway connectivity and includes sections that often do not meet Americans with Disability Act (ADA) specifications. These issues can be problematic in an area with a heavy reliance on transit.

Buford Highway and Peachtree Industrial Boulevard are well known as dangerous roads for pedestrians in the region, given their size and speed. The intersections at these roadways generally span six lanes with no pedestrian crossing islands. This can be a significant challenge for mobility impaired pedestrians as they may need more time on average to cross that distance. Buford Highway is also a major business corridor with frequent driveways that increase pedestrian conflict points with vehicles.

Interstates cause a different set of challenges for people with disabilities and pedestrians who are mobility challenged. Because roadway connections over the interstate are limited, an obstacle along an access point may double or triple the expected travel time and distance for these vulnerable populations. Having advance knowledge of insufficient infrastructure and other physical obstacles will improve route selection and help ensure the safety of all pedestrians.



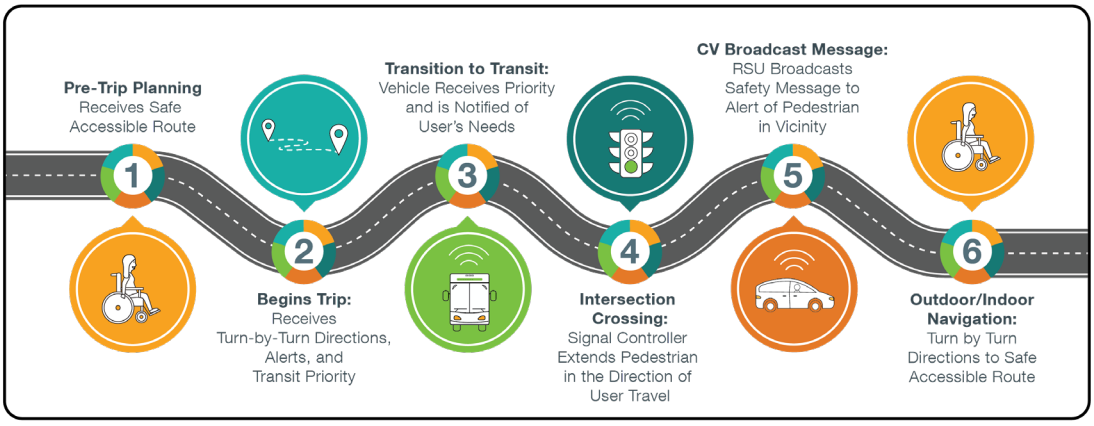
Source: GDOT, 2024

Figure 1. ST-CTN Deployment Site Map

1.2.2 Project Concept Overview

The ST-CTN project aims to upgrade and integrate existing technologies and services to assist all travelers with completing their trip successfully, safely, and reliably. The vision of the project is to provide users complete trip functionality with directions, conditions, and status on the links between trip legs that are personalized based on the user's profile, while connecting the user to CV infrastructure to provide safer trips and more transportation network awareness. Transit based

trips were delineated into six segments (as depicted in **Figure 2**) to allow for easier understanding and a greater breakdown of priorities and goals.



Source: ARC, 2020

Figure 2. Traveler's Complete Trip

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

- **Step 1 Pre-Trip Planning.** The traveler plans for and receives a safe accessible route.
  - The ability to customize trip preferences based on the user's needs.
- **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).
  - 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 if the user's trip includes fixed route transit service that is behind schedule.
- **Step 3 Transition to Transit.** The traveler transitions to transit and the transit vehicle receives priority and is notified of users' needs. TSP can be triggered if the bus is running behind schedule due to a longer boarding time needed by a user.
  - Provides users with transit trips that meet user defined preferences.
  - Sends alerts to transit vehicles when users need additional time to board, navigate internally, or alight the transit vehicle.
  - Remotely requests service from transit vehicles while waiting to board or alight.
  - Triggers TSP if the bus is running behind schedule greater than one minute.
- **Step 4 Intersection Crossing.** When crossing a signalized intersection, the traveler interacts with the signal controller which extends the pedestrian phase in the direction of user travel.
  - Allows the user to communicate with connected intersections if they are unable to reach or press the crosswalk button.

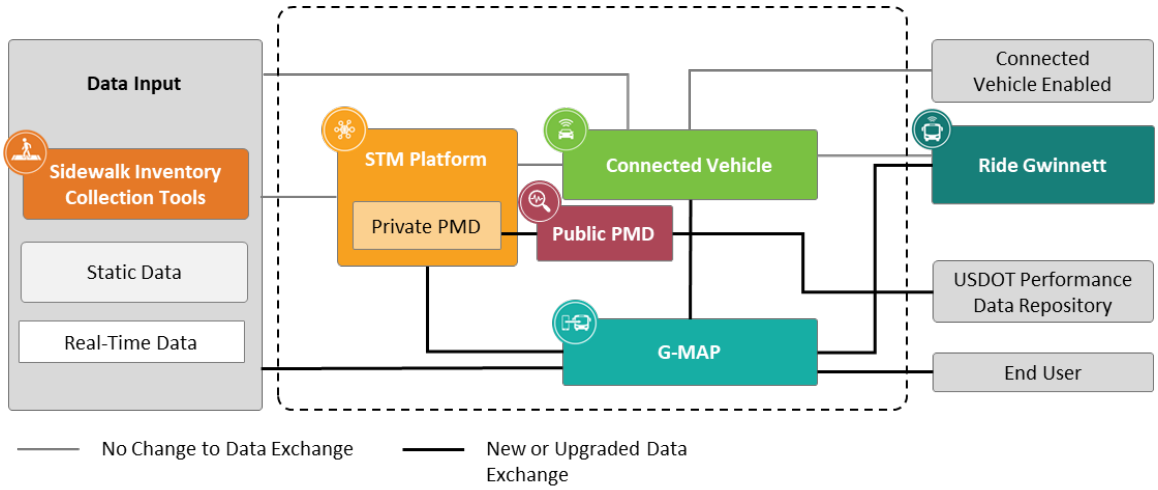
  - Provides the user with information about the intersection crossing and adds time to the crossing if needed.

- **Step 5 CV Broadcast Message.** Roadside units (RSUs) broadcast safety message to alert CVs of pedestrians/bicyclists in the vicinity.
  - Provides communications to enabled CVs from pedestrian crossing signal systems (via RSUs) to make them aware of pedestrians crossing a roadway.
- **Step 6 Outdoor/Indoor Navigation.** The traveler is provided with turn by turn directions to a safe accessible route.
  - Hands-free navigation via mobile apps and/or wearables and multiple channels (haptic, voice, text).
  - Alerts and dynamic rerouting in response to changes in path conditions.
  - Provides the user with efficient routes into and through two facilities within the project area.
  - Provides users with updates on the operating status of indoor infrastructure such as elevators and escalators.

There is an additional **Step 7** that is not part of the traveler's complete trip but is part of the ST-CTN system: **Reporting**. This step provides summaries of the data collected during the Complete Trip process.

System development and system integrations completed within the scope of this project will enable travelers to program and safely complete single mode or multimodal trips that are based on their needs; improve the transition between modes by providing additional details to users and transit service operators; suggest dynamic routing changes based on infrastructure condition and calculated delay.

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



Source: GDOT, 2023

Figure 3. ST-CTN High-Level Context Diagram

The existing initiatives that are being leveraged to support the proposed ST-CTN system are defined in more detail below as well as those components that will be developed specifically to support ST-CTN project evaluation. The icons and colors depicted below are used throughout the document to clearly identify the critical components of ST-CTN. In some cases, partner agencies are upgrading the services within their current systems to create a more robust data set or toolset for the ST-CTN program.

OTP for G-MAP. Atlanta Rider 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 mobile app turn-by-turn directions. The Open Trip Planner (OTP) architecture facilitates integration with additional OSS tools including a data analytics engine, call center module with application programming interfaces (APIs), and account management system. The existing ATL RIDES application will be modified and enhanced based on ST-CTN project needs and leveraged to create a new, independent application which will be differentiated as the *OTP for G-MAP* subsystem (hereafter referred to as G-MAP).

SIDEWALKSIM. SidewalkSim is an asset management system and shortest path (lowest impedance) routing tool for pedestrian pathways. Site inspections provide more detailed design and condition data for use in pathway efficiency 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 safety program and alternative strategies for TSP in Gwinnett County.



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

In addition, the ST-CTN system will include the development of a Performance Measurement Dashboard (PMD) that is not currently in use.



PMD. The PMD is a data storage and distribution tool that archives operational, survey and performance metrics of the system. The PMD intends to ingest, quality check, and curate all types of data – static and dynamic, structured and unstructured, open and private datasets. The PMD will store the datasets so that they can be viewed and accessed based on user roles. The PMD will include a public PMD for the public to access open data presented on an interactive dashboard to the public.

1.2.3 Project Benefits

The proposed system offers an opportunity to better support communities with increased mobility, safety, and information about their trips; expand infrastructure asset management to Gwinnett County through enhanced pedestrian data collection; and increase the reliability of transit service within the study area. By having additional information about their trip options, the traveler will be able to increase their safety and mobility, thereby increasing their economic and social opportunities. By collecting enhanced pedestrian data, Gwinnett County will be able to better manage their infrastructure assets within the project study area. By increasing the deployed technology within Gwinnett County Transit's (GCT) network, an increase in on-time performance and service is expected. **Table 1** provides a summary of the expected benefits for the systems users.

Table 1. System Users' Expected Benefits

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

1.2.4 Identified Needs

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

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

- AB = Need Area / Trip Segment
  - PT = Pre-Trip Planning
  - BT = Begin Trip
  - TT = Transition to Transit
  - IC = Intersection Crossing

    - CV = Connected Vehicle Broadcast Message
    - NV = Indoor/Outdoor Navigation
    - AM = Asset Management
    - FT = Future Development
- CD = User Classification
    - EU = End User
    - OO = Owner / Operator
    - SY = System
- E = Need Area
- F = Need Statement Number
- G = Child Statement Number (if applicable)

The end user needs are outlined below. More detailed information and a full list of needs is available in the Phase 1 ConOps. It should be noted that item 11, FT-EU-8.1 has been identified since the completion of the Phase 1 ConOps. The Phase 1 ConOps will be updated during Phase 2 (end of year 1) to reflect any changes during concept development and high-level design.

1. **PT-EU-1.1** Travelers need personalized trip information that accommodates their preferences and abilities.
2. **PT-EU-1.2** Travelers need the ability to customize their App accessibility features to accommodate their abilities.
3. **BT-EU-2.1** Travelers need support services during trip planning and traveling based on their preferences and abilities.
4. **BT-EU-2.2** Travelers need to receive personalized information and alerts during their trip in a way that is accessible to them.
5. **TT-EU-3.1** Travelers need the ability to communicate with transit infrastructure and transit vehicle operators to ensure adequate time to board or alight a transit vehicle based on their abilities.
6. **IC-EU-4.1** Travelers need the ability to communicate with infrastructure and CVs at signalized crosswalks beyond the currently existing push buttons.
7. **CV-EU-5.1** Travelers need the ability to remotely request transit service while waiting or traveling to a transit stop.
8. **NV-EU-6.1** Travelers need accurate information to successfully navigate indoor spaces.
9. **RP-EU-7.1** Travelers need the ability to provide feedback on infrastructure and services.

1.2.5 Goals and Objectives

Goals and associated objectives for the ST-CTN project were defined based on the user needs identified during the development of the ConOps. These user needs include end user needs, IOO needs, and system needs. The goals and objectives clearly establish the intent of the project such that project performance may be measured and evaluated. The success of the project will be determined based on the ability of the deployment to achieve the stated goals and objectives. Goals and associated objectives are presented in **Table 2** and are published in the Phase 1 ICTDP.

Table 2. ST-CTN Goals and Objectives

Goal / Objective ID	Goal and Objectives
Goal 1	**Enhance the traveler's multimodal complete trip experience with the ST-CTN system functions and features, particularly for underserved communities.**
Objective 1.1	Enhance traveler's multimodal complete trip experience with safe and accessible ST-CTN system functions and features.
Objective 1.2	Enhance en-route traveler support to increase traveler confidence and independence.
Objective 1.3	Enhance the ability for travelers to seamlessly transfer between modes throughout their complete trip – while considering changes in routes due to unplanned events.
Goal 2	**Enhance safety for ST-CTN system users, particularly for underserved communities.**
Objective 2.1	Improve perception of transportation-related safety along pedestrian routes within the study area.
Objective 2.2	Increase driver awareness of pedestrians crossing a signalized intersection.
Objective 2.3	Reduce transportation-related incidents at signalized intersections within the study area.
Goal 3	**Improve reliability for system users, particularly for underserved communities.**
Objective 3.1	Enhance and maintain transit reliability by implementing enhanced TSP configurations for ST-CTN system users.
Objective 3.2	Reduce traveler transit wait times at bus stops.
Objective 3.3	Increase transportation system reliability by providing timely traveler information and routing for system users.
Goal 4	**Improve mobility and accessibility for system users, particularly for underserved communities.**
Objective 4.1	Improve transit travel times with enhanced TSP operations for ST-CTN system users.
Objective 4.2	Increase traveler knowledge of accessible routes within the study area based on their individual needs and preferences.
Objective 4.3	Increase accessibility by implementing automated actuation of walk phase requests at signalized intersections within the study area.
Objective 4.4	Increase mobility and accessibility by implementing Ride Requests through travelers' mobile device or automated Ride Requests based on a traveler's planned route within the application.
Objective 4.5	Increase accessibility in locations where travelers identify existing barriers with infrastructure enhancements.

1.2.6 Performance Measurement

The successful delivery of the ST-CTN project concept will be evaluated based on performance measures and goals described in **Table 3**. Performance measures, metrics, and associated targets (described in the Section 3.1 of the Performance Measurement and Evaluation Support Plan (PMESP)) were developed through an iterative process in which a core team of researchers and engineers created and vetted measures, metrics, and targets with the ST-CTN technical team.

Table 3. ST-CTN Performance Measures

Performance Measure ID	Performance Measure Name	Goal
CT-PM-1	Enhance Traveler Experience	Goal 1 – Enhance Traveler Experience
CT-PM-2	Improve Accessibility	Goal 1 – Enhance Traveler Experience Goal 4 – Improve Mobility and Accessibility
CT-PM-3	Enhance Complete Trip Pedestrian Safety	Goal 2 – Enhance Safety
CT-PM-4	Enhance Fixed-Route Transit	Goal 1 – Enhance Traveler Experience Goal 3 – Improve Reliability Goal 4 – Improve Mobility and Accessibility
CV-PM-1	Enhance Safety and Awareness with CVs	Goal 2 – Enhance Safety
CV-PM-2	Improve Transit Reliability	Goal 3 – Improve Reliability Goal 4 – Improve Mobility and Accessibility

There are many facets to the analysis of complex systems like ST-CTN. The methods used to analyze the system include surveys and time-based assessments.

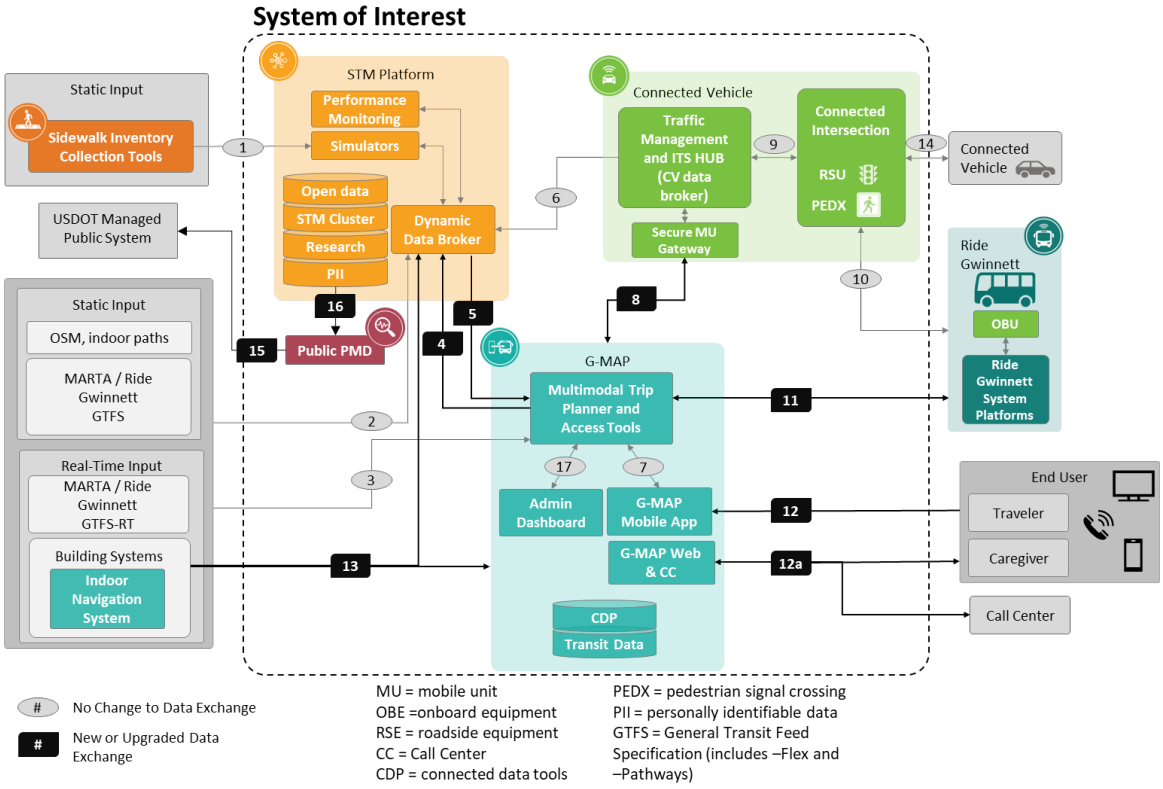
Survey research is often used to gauge differences in system use and the factors affecting decision making between the users and non-users of specific systems (e.g., transit users vs. non-transit users). For ST-CTN the team will be undertaking traditional commuter and customer service surveys that are designed to assess differences in local user and non-user travel performance over time, as well as real-time, app-based trip-level surveys to gauge customer satisfaction with the system. There will be two types of surveys: short form and long form. Short form surveys will be given at the end of some of the trips made using the system. These sporadic surveys will only consist of a few questions about that trip specifically if a traveler deviates from the G-MAP generated route. Long form surveys will be given to all participants on a quarterly basis and at the end of Phase 3. System implementation questions will include questions related to frequency of use, reasons for using the system, satisfaction with specific system elements, and willingness to recommend the system.

Time based studies focus on identifying whether a specific set of modified system conditions or policies have led to a system response in a set of dependent variables. Changes in network design and accessibility can lead to significant changes in travel behavior. Behavioral responses are complex, depending upon such factors as trip purpose, trip cost, user demographics, viable travel alternatives, etc. Assessing causality in before-and-after studies can be complex. The influence of exogenous variables on behavior must also be controlled in these analyses. It is critical that before-and-after studies integrate and control for the most important factors likely to influence changes in travel behavior. In this project, the entire metro area is assessed via annual household surveys and annual commuter surveys. By assessing the statistical significance of regional trends compared to this study's performance measure, the ST-CTN project team will ensure that it was actually the treatment that led to the change in observed system response.

1.2.7 Data

The ST-CTN deployment can be thought of as a *system of systems.* The scope of work required to develop, design, and deploy ST-CTN is focused on the expansion or enhancement of current

systems and added connectivity between those systems. **Figure 4** provides a Data Exchange Flow Diagram of the proposed system – indicating the system of interest and added subsystem connectivity. The STM Platform, Public PMD, G-MAP, and CV subsystems will each require expanded capability and added connectivity to support the proposed ST-CTN system. The Sidewalk Inventory Collection Tools and GCT existing independent systems will serve to support the proposed ST-CTN system. Data exchanges between subsystems are denoted by a gray or black line. A gray line indicates an existing and unchanged data exchange between subsystems. A black line indicates a new or upgraded data exchange between subsystems.



Source: ARC, 2021

Figure 4. ST-CTN Data Exchange Flow Diagram with Data Storage Systems

Critical ST-CTN data exchanges are identified by number in the context diagram above and described in **Table 4**. The grey oval labels indicate existing data exchanges that will be utilized with no change to the current data exchange. Black rectangular labels indicate data exchanges that will be new or upgraded to support the ST-CTN system.

Table 4. Critical ST-CTN Connection Descriptions (related to Context Diagram with Data Storage Systems)

Data Exchange ID (EX ID)	Description	Status
1	Sidewalk inventory data, including accessibility features to the STM Platform simulators	Updated content (not format)
2	Static and dynamic data from various existing sources to the STM Platform dynamic data broker	Updated content (not format)
3	Static and dynamic data from various existing sources to the G-MAP multimodal trip planner	No change
4	G-MAP Mobile App logs and trip feedback	New
5	STM Network Impedance application programming interface (API)	New
6	CV and Traffic Operations Messages: NaviGAtor intelligent transportation system (ITS), road characteristics, traffic data	Updated
7	OTP APIs and G-MAP APIs	No change
8	Mobile Accessible Pedestrian Signal System (PED-SIG)	New
9	CV messages	No change
10	TSP and other CV application messages	No change
11	Ride Request messages	New
12	G-MAP Mobile App APIs and Traveler exchange – profile, trip plan, settings, notifications, feedback, etc. Note: Data Exchange ID 12a includes similar flows with restrictions on viewing and changing certain data.	Updated content (not format)
13	Dynamic information from building facilities (including beacons to the G-MAP mobile app) and INS vendor cloud SDK	New
14	CV Data	No change
15	Project data for USDOT-managed Public System	New
16	Public facing data and visualizations for reporting on system operations and performance	New
17	G-MAP Web Services and Traveler exchange – profile, trip plan, settings, notifications, feedback, etc. Access to functions and information depends on user role. Interface available to traveler (registered person), trusted companion, or call taker in call center.	No change

Data Collection

The ST-CTN system will be generating several types of data to be used in measuring the system's performance and also for planning purposes. **Table 5** below outlines the types of data that will be collected by the system including the Dataset Name, the Data Management Plan (DMP) Data ID, the data owner, and the update frequency. All of the datasets listed below will continue to be collected post pilot and shared between project stakeholders as necessary.

Table 5. Baseline Datasets by Performance Metric

Dataset Name	DMP Data ID	Collection Lead (Data Owner)	Update Frequency
GTFS-Realtime Ride Gwinnett	36	GCT	Continuous
GCT Complaint Log	65	GCT	As Needed
Fixed-Route Transit Ridership	64	GCT	As Needed

1.2.8 Safety

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.

1.3 At-Scale Deployment Summary

This section summarizes the estimated number of service area, transit service, roadside and indoor navigation infrastructure, and participants expected as part of a fully deployed ST-CTN system. The deployment elements include any asset or service that is quantifiable. The quantities are expected to be maintained, if not increased, during the 5-year period following Phase 3.

The project study area (see **Figure 1**) is based on the GCT on-demand paratransit service area which is provided within ¾ mile on either side of the existing fixed route system. This includes seven fixed route lines with connections to Metropolitan Atlanta Regional Transit Authority's (MARTA) heavy rail at the Doraville Station. The MARTA Doraville Station provides a crucial connection between GCT and MARTA rail destinations including direct service to the airport and downtown Atlanta. The GCT plans to change their service structure over the next few years which will change several of the summary quantities including project study area, vehicles, and routes.

Table 6 outlines the elements that will be in utilization when the project is fully deployed. These elements, their software controls and system integration will be installed, tested, and operational by the end of Phase 2. They will reach a 100% operational milestone at the beginning of Phase 3.

Table 6. Deployment Elements

Deployment Elements	Quantity
Signalized Intersections	Centrally controlled signalized intersections: 356 RSU equipped signalized intersections: 215 Signalized intersections along transit routes: 209 RSU equipped signalized intersections along transit routes: 132
GCT Vehicles / Routes	Fixed Routes: 7 routes Fixed Route Transit Vehicles: 38 Vehicles equipped with On-board Units (OBUs) for TSP: 38 Vehicles supporting Connection Protection: 38
Facilities with Indoor Navigation Support (Beacons)	Number of facilities: 2 (Gwinnett Justice Administration Center and Gwinnett County OneStop Norcross)
Inventory of Sidewalk	Sidewalk (linear miles): approximately 2,000
Project Study Area (sq miles)	90 sq miles

The ST-CTN project team has a goal of recruiting approximately 1,000 end users for the evaluation in Phase 3. Minimum targets for each end user subgroup are provided in **Table 7**. It should be noted that one end user may identify with one or more subgroup below. For example, if an end user is an older adult who also uses a mobility device, the end user would be counted within two subgroups. Participants will be measured by the number of customer accounts in the G-MAP trip planning platform. Finally, as the scale and functionality are extended post-pilot, the ST-CTN project team, counties, and other key stakeholders will continue outreach, recruitment, and training to increase usage throughout the region.

Table 7. Group 3 – G-MAP End User Targets

End User Participant Subgroup	Participant Minimum Target
End User Trainers	25
End Users with Mobility, Vision, and/or Hearing Disability	100
End Users with Trusted Companions	25
Older Adults	100
End Users with LEP	100
End Users with Low Income	100
General End Users	100

1.4 Team Organizational Structure

This section summarizes team organization, key personnel, changes in staff from Phase 1 and organizational/governance processes.

1.4.1 Team Organization

The ST-CTN project team, with the support of stakeholders, has successfully developed the ST-CTN concept during Phase 1 of the Complete Trip – ITS4US Deployment Program. The team organization is expected to largely be maintained during Phases 2 and 3 of the project with

additional support from strategic partners and with GDOT replacing ARC as the project lead. The following sections describe the team organization for Phases 2 and 3 of the ST-CTN project.

1.4.1.1 Project Team Partners

The ST-CTN project team is composed of the following organizations:



Source: ARC, 2022

Figure 5. Project Partner Logos

- **Georgia Department of Transportation (GDOT) – Project Management / Financial Administration.** The GDOT is the department responsible for the state of Georgia's roads. GDOT will be the lead agency for Phases 2 and 3, ultimately responsible for the success of the ST-CTN design, deployment, operations, and evaluation. GDOT will serve as the financial administrator and will rely on ARC to provide management for the project.
- **Atlanta Regional Commission (ARC) – Project Management / Product Owner.** ARC is the federally designated Metropolitan Planning Organization (MPO). ARC will support GDOT by continuing to provide management of the project but will rely on GDOT for financial administration.
- **Gwinnett County – Local Deployment.** 30 miles northeast of Atlanta, Gwinnett County has been one of the fastest growing counties in the country with a current (2019) population of 936,250. GCDOT operates local bus and paratransit service in the county with regional connections. Gwinnett County will serve as the Local Deployment Lead (LDL) and will manage the local deployment and integration of the project.
- **Atlanta-Region Transit Link Authority (The ATL) – ATL RIDES Owner / Regional Expansion Strategy.** The ATL is charged with developing a regional transit plan for the 13-county Metropolitan Atlanta area. The ATL will serve as a project stakeholder and provide strategic direction to ensure that the project is scalable throughout the region.
- **Statewide Independent Living Council of Georgia (SILCGA) – Community Advocacy Liaison / Outreach and Training Coordination.** SILCGA is a nonprofit governed by people with all types of disabilities. SILCGA identifies societal barriers to independent living and collaborates to remove those barriers and to increase the support needed to create independent living opportunities. SILCGA will support the coordination and delivery of outreach and training activities, serving as a liaison to advocacy groups and other key stakeholders that support the underserved communities.

- **Georgia Institute of Technology (GA Tech) – STM Platform Development.** GA Tech is a leading research university. GA Tech will be responsible for capturing the enhanced sidewalk inventory data and design and development of the STM Platform subsystem.
- **Kimley-Horn and Associates, Inc. (KHA) – Quality Assurance / Configuration Management.** KHA is a consulting firm specializing in the planning, design, and implementation of state-of-the-art transportation systems. KHA will manage the configuration of Phase 1 documentation, ensuring that any changes that impact previously completed work is updated to be consistent. KHA will continue to serve as production quality assurance. In addition, KHA will serve as local outreach support.
- **GO Systems and Solutions LLC (GOSystems) – Systems Engineering.** GOSystems is a small, women-owned business providing systems engineering, solution architecture, system development, and testing services. GOSystems will be leading the systems development for this project, focusing on systems engineering and integration, standards, and data management. GOSystems will also lead the systems engineering process and ensure that all needs and requirements are met by the system.
- **IBI Group/Arcadis (IBI) – G-MAP Development.** IBI/Arcadis is a team of industry leading architects, engineers, planners, designers, and technology professionals. They are currently working with ATL. IBI will be responsible for the design and development of the enhancements and integration to the G-MAP subsystem.

Phases 2 and 3 will include a new project partner:

- **ICF International, Inc. (ICF) – Deployment Management.** ICF is an advisory and digital services provider that helps clients solve their most complex challenges, navigate change and shape the future. ICF will manage the design, deployment, and testing of the ST-CTN system. In addition, ICF will lead the project outreach.

Phases 2 and 3 will also include the following deployment subcontractors:

- **Georgia Tech Research Institute (GTRI)** is the nonprofit, applied research division of GA Tech. GTRI will support the migration of the STM Platform subsystem to a production environment, including migrating the system to a cloud environment.
- **Avail Technologies (Avail)** is a developer delivering comprehensive solutions for transit operators. Avail will lead the integration of the Ride Request application.
- **HNTB Corporation (HNTB)** is an employee-owned infrastructure solutions firm. HNTB will support GDOT with financial and project administration. In addition, HNTB will develop and administer the procurement of the beacons to support indoor navigation.
- **360 Network Solutions, LLC (360ns)** is an intelligent transportation and mobility solution provider. 360ns will manage the deployment and integration of CV applications currently being deployed within Gwinnett County.

1.4.1.2 Team Structure

The team structure is comprised of the following key elements. **Figure 6** provides the organizational graphic of the team structure.

- Agreement Sponsors –USDOT personnel responsible for the successful delivery of the Complete Trip – ITS4US Deployment Program. Agreement Sponsors will provide the ST-CTN team financial support, programmatic expectations and direction, and technical expertise.

- Executive Management Team (EMT) – comprised of the key personnel responsible for the successful delivery of the ST-CTN project, including collaborating with USDOT Agreement Officer (AO) and Agreement Officer Representative (AOR); actively managing the project; leading coordination and engagement with Stakeholders, including end users; ensuring the safe, efficient, quality development, deployment, and implementation of the ST-CTN project. The EMT will report to the Agreement Sponsors.
- Co-Project Management Lead (CPML) – responsible for the quality and timely provision of required project management artifacts and for tracking project progress against target performance throughout the project lifecycle. The CPMLs are responsible for risk tracking and risk mitigation. Alan Davis will serve as the lead CPML, responsible for the financial administration of the contract. The CPMLs will report to the Agreement Sponsors.
- Quality Assurance Engineer (QAE) – responsible for reviewing documents for quality and accuracy. The QAE will report to the CPMLs.
- Co-System Deployment Lead (CDL) – responsible for managing, scheduling, controlling and monitoring the system development team. The DL will work with the EMT to coordinate all activities including training, outreach, performance measurement and marketing with the efforts undertaken by the System Development organization. The CDLs will report to the CPMLs.
- Systems Engineering Lead (SEL) – provides technical support and guidance to systems engineering and software development teams on processes, integration, and technology design, development, integration, and deployment strategy. The SEL will report to CPMLs.
- Product Owner – responsible for working with the development team to define User Stories and prioritize the Backlog to streamline the execution of program priorities while maintaining the conceptual and technical integrity of the features or components for the team. The Product Owner is accountable for maximizing the value of the product resulting from the work of the Development Teams.
- Community Coordinator Lead (CCL) – responsible for engaging community groups and individuals. The LDL will report to the CDLs.
- Local Deployment Lead (LDL) – responsible for managing local deployment activities. The LDL will coordinate on-site activities such as testing and demonstrations. The LDL will report to the CDLs.
- Project Support Team – responsible for implementing the systems engineering and Agile process to design, develop, integrate, and deploy the ST-CTN system. The Project Support Team will report to the EMT. The Development Teams within the Project Support Team will report to the SEL. Deployment subcontractors include those partners that will be added to the team to perform distinct activities, including travel training partners who will assist in training end users on system functionality.



Source: GDOT, 2024

Figure 6. Phase 2-3 ST-CTN Team Structure

1.4.2 Key Personnel

The ST-CTN Team is comprised of national experts with local knowledge and extensive experience successfully collaborating to implement innovative projects. We are pleased to present Alan Davis, PE, PTOE and Kofi Wakhisi, Esq, AICP as our CPMLs, Joseph Hacker and

Natalie Smusz-Mengelkoch, PE as CDLs, and Polly Okunieff as SEL. Both Alan Davis and Joseph Hacker will be Points of Contact (POCs) for the project. In addition, Joseph Hacker will serve as Product Owner. **Table 8** lists key personnel with their role, capabilities, and credentials for the ST-CTN project. Key personnel as designated in the NOFO are given an asterisk (*) by their role.

Table 8. Key Personnel and EMT Staffing Matrix

Name Organization	Role	Capabilities & Credentials
Alan Davis, PE, PTOE GDOT	Co-Project Management Lead* Point of Contact	Davis is the State Signal Engineer for the Office of Traffic Operations at GDOT where he oversees programs for crash analysis, traffic studies, traffic engineering and access management. He also oversees design services for traffic signals and implementation of ITS.
Kofi Wakhisi, Esq, AICP ARC	Co-Project Management Lead*	Wakhisi works in the Transportation Access and Mobility Group at ARC, supervising the Regional Planning and External Coordination team. This team is responsible for carrying out the federal planning process for active modes, transit capacity expansion, freight and logistics, transportation systems management and operations (TSMO), livability, and transportation equity.
Joseph Hacker, PhD, AICP ARC	Co-Deployment Lead* Point of Contact Product Owner	Hacker is a former professor and experienced Transportation Planner, with a focus on Intelligent Transportation Systems (ITS) and TSMO. He started his career at the Philadelphia MPO as a manager of transit, bicycle, and pedestrian planning, combining results-driven projects with his personal emphases on innovation and effective project management. He then spent 12 years as a professor of planning and economic development in the Andrew Young School of Policy Studies at Georgia State University.
Natalie Smusz-Mengelkoch, PE, PSPO I ICF	Co-Deployment Lead*	Smusz-Mengelkoch has 20 years of experience in ITS engineering and planning–having led projects in all implementation phases from programming, planning, and preliminary engineering to design, integration, and operations. Natalie's broad background within TSMO allows her to bring a unique and well-rounded perspective.
Polly Okunieff GOSystems	Systems Engineering Lead*	Okunieff has over 36 years of experience as a systems, business, and data analyst with 27 of those years developing integrated systems and enterprise architectures, strategic plans, operational concepts, technical designs, and specifications to deploy multimodal and accessible transportation systems. Over 30 years developing systems using systems engineering management approach.

Name Organization	Role	Capabilities & Credentials
Jordan Hall SILCGA	Community Coordinator Lead	Hall is the Mobility Coordinator of the SILCGA, for over two years. She has been working with CIL and other statewide and local entities across Georgia to address the Mobility needs within the Aging and Disability communities.
Danny Tongson Gwinnett County	Local Development Lead	Tongson has provided information technology services for more than 20 years as a public employee and as a private contractor. He joined Gwinnett County three years ago as the Information Technology Project Coordinator.
Matt Smith KHA	Quality Assurance Engineer	Smith has 30 years of experience in the transportation technology and mobility industry. His experience in the public and private sectors has focused on the safety of our transportation system users, while enabling technology-based solutions that will improve transportation safety, mobility, and access.

1.4.3 Changes in Organizational Form from Phase 1

The ST-CTN project team will be restructured for Phases 2 and 3. GDOT will be the Phase 2/3 applicant and prospective Phases 2 and 3 recipient. GDOT will serve as the lead CPML and a POC. GDOT and ARC will execute an Inter-governmental Agreement. ARC will subcontract with ST-CTN project team partners. The reasons for restructuring the partnership are to alleviate the financial and administrative responsibilities and shift them to a more resilient agency. GDOT's administrative competencies and financial resources are why the partnership has chosen for it to become the lead agency, especially in light of the upcoming Phase 2/3 activities (technology design, testing, deployment, and maintenance). In addition, GDOT's hands-on engagement and fiscal management during Phases 2 and 3 will maximize the potential for scaling the ST-CTN deployment to other jurisdictions within metro Atlanta and throughout the State of Georgia.

Changes from Phase 1 team structure include the addition of the role of Quality Assurance Engineer (QAE) which has been added to the EMT. Personnel changes from Phase 1 are outlined in **Section 1.4.3**.

Changes from Phase 1 team structure include GDOT replacing ARC as the project lead, the addition of the QAE role within the EMT, the addition of ICF as the deployment lead, and the addition of deployment subcontractors. Within deployment subcontractors, travel training partners are included and will assist in training end users on system functionality.

The following lists the changes in organizational form from Phase 1:

- **Alan Davis** will become a Co-Project Management Lead and GDOT POC as GDOT replaces ARC as the project lead
- **Kofi Wakhisi** will change from Project Management Lead to Co-Project Management Lead

- **Joseph Hacker** will replace Maria Roell and his role will change from Concept Development Lead to Co-Development Lead and will remain the ARC POC
- **Natalie Smusz-Mengelkoch** will change from Deputy Project Manager to Co-Development Lead
- **Paula Okunieff** will change from System Development Lead to Systems Engineering Lead
- The new role of Quality Assurance Engineer, filled by **Matt Smith**, will be added to the EMT
- **Danny Tongson** will replace Daniel Piotrowski as the Local Development Lead
- **Jordan Hall** will remain the Community Coordinator Lead
- Five new project partners will be added: **GTRI**, **ICF**, **Avail**, **360ns**, and **HNTB**.

1.4.4 Summary of Financial and Organizational Models for Sustained Operations

The ST-CTN system sustained operations will be maintained for a minimum period of five years after the program is completed with no supplementary federal funds. As the owner/operator of the ST-CTN navigation application and as the region's MPO, ARC will lead and convene the governance partners and hire supporting services for sustained operations and maintenance of the ST-CTN system.

The governance partners will include ARC, GDOT, the ATL, and Gwinnett County. Each of the governance partners will maintain and operate any of the infrastructure, data, or systems of which they have ownership. This will be accomplished through the use of service level agreements (SLAs) and existing organization models. **Table 9** provides a summary of those SLAs that will be pursued to sustain operations post pilot deployment.

Table 9. Institutional Partner Technical Agreements Post Pilot

Prime	Sub	Sub to ARC	Description & Scope of Agreement
GDOT	ARC	-	SLA specifications/parameters on CV data to be determined at the end of Phase 2; operations, technology and data maintenance, and training and outreach
GDOT	ARC	GCT	SLA specifications/parameters on operations to be determined at the end of Phase 2; operations, technology and data maintenance, and training and outreach
GDOT	ARC	GCDOT	SLA specifications/parameters on CV data feeds to be determined at the end of Phase 2; operations, technology and data maintenance, and training and outreach
GDOT	ARC	ATL	SLA specifications/parameters on transit data feeds to be determined at the end of Phase 2; operations, technology and data maintenance, and training and outreach

For any system wide decisions and changes, ARC will convene the Governance Partners to make decisions. In the future, local jurisdictions will be added as Governance Partners as they join and expand the system.

Currently, ARC anticipates that the only support services required to maintain and operate the system will be for the navigation application itself. This will be competitively procured by ARC after the completion of Phase 3. All other owner operators have already planned and committed to maintaining their respective subsystem responsibilities through other projects. Additionally, ARC will be able to aid owner operator maintenance activities through the Transportation Improvement Program (TIP), if necessary.

1.4.5 Organizational Risks

This section describes the most critical assumptions and organizational risks anticipated for the ST-CTN deployment during Phases 2, 3, and post-deployment. The risks and mitigation strategies are described in **Table 10**. Risks will be tracked within the Risk Management Registry (developed during Phase 1 and submitted to USDOT monthly) throughout Phases 2 and 3 to ensure that any organizational related risks impacting the successful delivery of the ST-CTN project are avoided or mitigated efficiently.

Table 10. Organizational Risks

Risk Title	Description	Mitigation
Resource Allocation	Staffing allocation have the potential to impact the outcome of the ST-CTN project by limiting the time available to properly carry out one's project responsibilities.	The ST-CTN project team is implementing the following to mitigate resource limitations • Clearly define system requirements with partner concurrence. • Clearly define Phase 2 and Phase 3 partner roles and responsibilities. • Develop Phase 2 and Phase 3 schedules and budgets with partner concurrence.
Staffing Changes	It is possible that over the four plus years of the project deployment, staffing changes or other commitments will hinder the successes of the ST-CTN project.	To mitigate staffing change issues, the team will • Follow project processes as defined in the Project Management Plan (PMP). • Maintain documentation of project processes and key decisions. • Consistently share information across ST-CTN project team members.
Organizational Changes Impact to Data Sharing	The ST-CTN system depends on data from many sources as described in the DMP. It will be critical that data be shared effectively to ensure proper operations of the ST-CTN is maintained. Organizational changes have the risk of impacting data sharing.	To mitigate potential data sharing issues, the team will • Ensure data owners have a role in defining and governing data sharing agreements. • Clearly define the data sets needed during Phase 2 and Phase 3 activities. • Define activities that are outside of standard data sharing agreements to protect the integrity of the data set.

Risk Title	Description	Mitigation
Organizational Support of ST-CTN Dependent Subsystems	It is possible that over the course of the project, partners will stop supporting specific aspects that the system is reliant on. This lack of support could cause impacts to the outcomes of the ST-CTN project.	The ST-CTN project team choose well supported system elements to mitigate the risk that they would be discontinued. When possible, open-source elements were used to decrease the likelihood of this outcome even further. The ST-CTN project team will monitor system dependent subsystem support and identify backup data flows or data sources if discontinuation of original sources or processes has been identified.

2 Phase 2 and Phase 3 Technical Approach

Safe Trip in a Connected Transportation Network (ST-CTN) provides a unique opportunity to build a fully integrated, standards-based, OSS that is replicable anywhere nationwide. This high-impact system will provide complete trip planning, journeying, and reporting for all travelers and be tailored to each traveler's accessibility needs—regardless of language, income, or disability. The project focuses on the transfers between trip segments with OSS and hardware development kits for other organizations to collect, verify, and load indoor and shared use path information onto open-source maps. The project lessons learned will provide strategies, applications, and model institutional partnerships to help ensure convenient, safe, and reliable access by the variety of communities in the deployment area.

2.1 Introduction

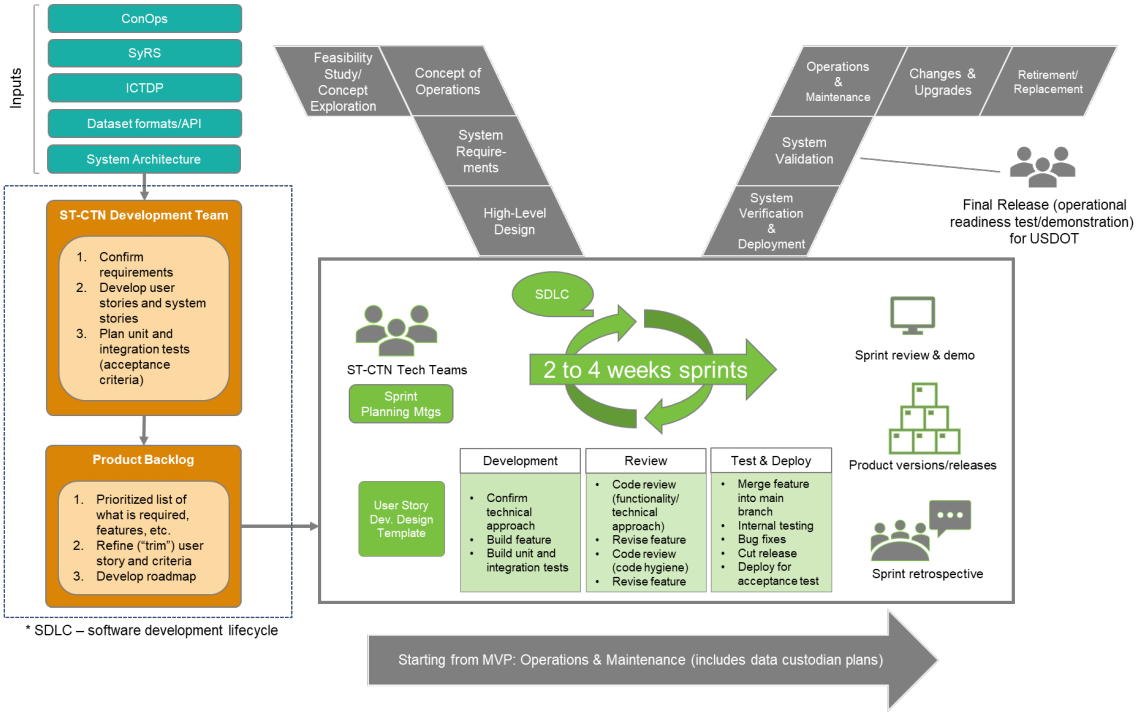
The ST-CTN project team is comprised of national experts with local knowledge and extensive experience successfully collaborating to implement innovative projects. The team takes pride in making things happen; and we have a strong commitment to serving all travelers. We are passionate about developing innovative solutions to solve challenges. Whether we are preparing for a ConOps workshop, developing the DMP, or pulling everything together within the Deployment Readiness Summary Briefing, we will be thinking through how to progress the project to the next phase, implementation, and eventual standard operations. Understanding the aggressive schedule requirements, number of partners, and the challenges that come with concept development, integration, and deployment of this scale, the team has been structured to address technical, institutional, and financial risks associated with the three-phase effort. We have implemented this strategy to successfully to complete Phase 1 and intend to continue to largely maintain our current structure and approach during Phase 2 and 3. The following sections describe how the ST-CTN project team will achieve the technical requirements of Phases 2 and 3.

2.2 Phase 2 Technical Approach

The following sections provide a high-level overview of the technical approach that the ST-CTN project team will take to successfully deliver each task required within Phase 2 of the ITS4US Deployment Program. Specific anticipated challenges and efficiencies are addressed.

Delivery of the ST-CTN project will follow an Agile/Vee Hybrid methodology where Agile (Scrum) will be combined with a traditional systems engineering process (Vee-Process). The approach, depicted in **Figure 7,** establishes user needs, requirements, architecture, and conceptual design early in the process consistent with the Vee-Process and then pivots to an Agile process. The traditional stages of the Vee-Process will be followed until the system requirements and Systems Architecture Document (SAD) are completed. These foundational components trace the needs

and requirements to aid in the system deployment, while setting the stage for the Scrum process that allows for iterative and incremental development during the design and implementation stage. User needs and requirements will serve as inputs to epics and user stories in the Product Backlog. The Product Backlog will define the epics and user stories and establish the minimum viable product (MVP).



Source: ARC, 2021

Figure 7. The ST-CTN Agile/Vee Hybrid Methodology

Development of STN-CTN project will then be incrementally delivered and tested during 2-to-4-week Sprints. Released Scrum software products will go through multiple Sprint cycles, with each Sprint cycle delivering a portion of the product until the complete product (or planned increment release) is ready for integration with other parts of the system. When Scrum is complete, the process then reenters the Vee-Process for the system verification and validation (V&V) activities (in this case after merging into main branch and integration testing).

2.2.1 Task 2-A: Project Management

Deployment of the ST-CTN requires a structured and disciplined approach to manage the execution of the work and make sure the team responsible for deployment delivers the highest quality products on time and within budget. Our approach is based on best practices from the Project Management Institute's (PMI's) Body of Knowledge (PMBOK Guide Seventh Edition). Our project management approach focuses on communication and coordination. The size and schedule of this project comes with risks, but the project team has ample experience in proactively mitigating risks in complex projects. The project management task will provide management and control of the project, including managing schedule; technical processes and budget; communicating with the project team, USDOT, and other stakeholders as we design, deploy, and test the system.

A PMP will be developed that describes the activities required to perform the work. The PMP will define the roles and responsibilities of all key individuals within the program/project team and will contain the following information:

- Scope Management. The scope, goals, and objectives—along with a matrix of all deliverables and their planned delivery dates—will be included. A baseline scope will be developed. The deliverables will be consistent with the deliverables defined in the NOFO and documented in this report. To manage the scope, we will work with the AOR to define the deliverables and timeline. In developing deliverables, we will adhere to USDOT templates and industry standards. We will work with USDOT to reach consensus on the scope and content; and any desired scope changes will be made through scope change procedures. Any changes to scope will be approved by the AOR and AO. If there is an approved change to the scope, we will update the scope, schedule, and costs.

- Schedule Management. A baseline schedule will be developed from the deliverables identified in the NOFO and this report. A work breakdown structure (WBS) will be developed that will clearly define the work activity, start and end dates, name of the individual or entity primarily responsible for accomplishing the work, and dependencies with other work activities. The schedule will be developed in Microsoft Project and will be updated monthly capturing the percent work completed.

- Cost Management. A baseline budget will be developed and processes will be defined for planning and controlling the budget for the deployment. Costs will be monitored and reported on a monthly basis. Our process will ensure that any issues with costs will be identified and controlled quickly before cost overruns can occur.

- Quality Management. The Quality Management Plan will define the procedures the team will follow to ensure both quality assurance (QA) and quality control (QC). The plan will document and define processes for how we will ensure quality for traditional vee-process deliverables as well as Agile products and deliverables.

- Configuration Management. This plan will discuss the processes for configuration control. It will define processes and roles and responsibilities of team members. Several development and configuration management tools will be incorporated into the Phase 2 and Phase 3 processes to manage design, development, test and accept activities during the project. Development tools will include Agile development process tool (e.g., Jira and GitLab), Agile road mapping/scheduling tools (e.g., GitLab and Monday.com), and document management tools (e.g., Teams and SharePoint). Critical to configuration management is the need for a Configuration Control Board (CCB) to determine when and how proposed changes should be implemented. A Configuration Manager will also participate, tracking and reporting any changes to user needs and requirements – and their impacts.

- Risk Management. This plan will describe the approach to risk management and mitigation. A risk log will be developed for the project in accordance with USDOT's Risk Management Template. Risks will be assessed based on their probability and potential impact. Items identified as high risks will be assessed in greater detail and a risk mitigation approach will be developed. We will discuss risks and their mitigation approaches with AOR and document them in our progress reports. Both internal and external risks will be identified and tracked, including external blockers preventing Agile

user stories and documentation from being completed. Risks will be discussed accordingly as part of Agile meetings.

A Draft PMP will be delivered to the USDOT. After receiving and resolving USDOT comments, a revised version of the PMP will be delivered. During the course of the deployment, if updates are required, the project team will update the PMP accordingly. Any such modifications shall go through the cycle of draft submission, USDOT review and comment, comment resolution, and submission of a revised version.

Kick-off Meeting. We will work with the AOR to schedule and arrange the location and agenda for the kick-off meeting. The ST-CTN team will have all key personnel or their designees, plus one additional representative, attend the kick-off meeting. The meeting will be used to discuss the contractual requirements and approach to the work.

Monthly Progress Reporting. The ST-CTN project team will provide monthly reporting in accordance with the Phase 2 Template provided by USDOT at the Kick-off Meeting. The monthly report will document the technical progress, status summary, detailed financial summary, and current risk register.

Lessons Learned Logbook (LLL). The ST-CTN project team will capture lessons learned iteratively throughout the project so that insights can be shared with peers actively deploying similar initiatives. Team members will be actively encouraged to provide inputs to the logbook. Sprint Retrospective Meetings will include a specific action for teams to provide inputs. The logbook will include, at a minimum, as succinct title, task ID, summary of the issue identified, the realized/potential impacts, mitigation action(s) taken, and results identified. The logbook will be updated monthly and new entries will be included in the monthly progress report.

Regular Communications. The ST-CTN will conduct regular communications with the USDOT and other ITS4US Deployment Program Phase 2 and 3 teams. The ST-CTN POCs will serve as the focal points of communication with the AOR and AO. Participation in regular meetings includes:

- Bi-Weekly Deployment Teleconferences. The ST-CTN team will organize and participate in site-specific deployment coordination teleconferences with the AOR and federal team members. These meetings will be used to review work in progress, identify issues and risks, and coordinate technical assistance.

- Monthly All-Sites Coordination Teleconferences. The ST-CTN team will participate in monthly calls to support coordination across ITS4US Deployment Program Phase 2 and 3 sites. A minimum of one representative will participate in the meetings to provide updates and share lessons learned to encourage collaborations among the deployment sites.

- Roundtable Participation. The ST-CTN team will have a minimum of one representative participate in up to five periodic roundtable meetings per year including Technical, Outreach, Performance Measures & Human Use Approval (HUA), and up to two other roundtables. For planning purposes, we assume each of these roundtables will convene bi-monthly.

Task 2-A Deliverables

- Phase 2 Kick-off Meeting
- Draft PMP
- Revised PMP (as required)
- Monthly Progress Report Part I: Technical Progress and Status Summary
- Monthly Progress Report Part II: Detailed Financial Summary
- Participation in site-specific bi-weekly coordination teleconferences
- Participation monthly all-site coordination teleconferences
- Participation in periodic roundtable teleconferences

2.2.2 Task 2-B: System Architecture and Design

Systems Architecture Document (SAD). Using the Phase 1 ConOps, Systems Requirements Specification (SyRS), System Engineering Management Plan (SEMP), and this document as inputs, a well-structured architecture for the site deployment concept will be developed based on the Institute of Electrical and Electronic Engineers (IEEE) Standard 42010-2011 (IEEE Recommended Practice for Software Architecture Descriptions). The architecture will include the following views/architectures:

- **Enterprise Architecture.** This architecture will describe the relationships between organizations required to support the overall architecture. The organizations establish the roles and responsibilities for operating, maintaining, and sustaining the system. Specifically, the enterprise architecture will trace to system lifecycle sustainability requirements, as well as the roles and responsibilities, constraints, and impacts described in the ConOps. The enterprise architecture will address the following questions (extracted from the National ITS Reference Architecture (ARC-IT) Version 9.0):

    - Who is responsible for providing transportation-related user services?
    - Who is responsible for installation, operations and maintenance (O&M) of ITS services, applications and devices?
    - What relationships need to exist between transportation operators to facilitate services between and within jurisdictions?
    - What relationships need to exist between the providers of services and the consumers of services?

- **Data Architecture (Data Layer):** This architecture will describe the data layer. The data layer is defined in the DMP. The Phase 1 DMP included dataset types that correspond to the data categories detailed in the data layer. Data schema, specifications, definitions, and standards are associated with the datasets included in the data layer. In addition, the protected nature of the datasets is also included in the DMP and will inform the related functional and physical architecture entities. The layer will link to the specific datasets in the most current DMP. The data layer will be updated when the Phase 2 DMP and Updated DMP (Phase 3) documents are reissued.

- **Function and Interfaces Architecture (Function and Service Layer):** This architecture will describe abstract functional elements (processes) and their logical interactions (data flows) that satisfy the system requirements. The context diagram included in the Phase 1 ConOps identified subsystem modules and information flows (including APIs, specific datasets, their type, and related standards). The Function and Interface Architecture will

be refined to reflect details and updates to the functions and services in the ST-CTN system. The architecture functional entities will identify the high-level user stories that are derived from the SyRS for each subsystem. The Design Processes will link the detailed user stories in the Product Backlog to the functions in this layer.

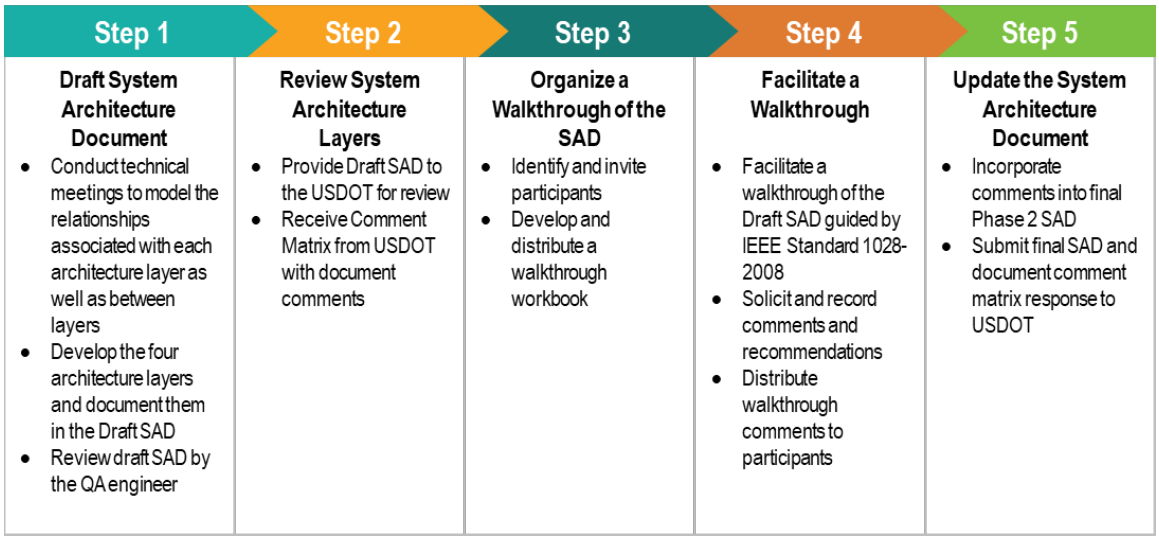
- **Physical Architecture (Technology and Communication Layer):** This architecture will describe physical objects (systems and devices) and their application objects as well as the high-level interfaces between those physical objects. The physical architecture will use the ARC-IT Version 9 physical entities to describe the assets used to implement the ST-CTN system. The physical architecture answers these questions (extracted from the National ITS Reference Architecture (ARC-IT) Version 9.0):

    - What physical entities are involved in the delivery of a given service?
    - What interfaces are required between different physical elements?
    - What functionality is allocated to physical entities?
    - What are the security considerations for information exchanged between physical elements?
    - What are the security considerations for physical devices?

    Summary diagrams of the Service Packages that correspond to the functions will be included in the physical architecture. Several ARC-IT Version 9 service packages include gaps in related Multimodal and Accessible Travel service packages. The ST-CTN project team will work with the USDOT to propose additional classes, actors, and information flows to complete the services provided by the ST-CTN project.

- Communications Architecture. This architecture will describe the communications protocols between application objects. The Communications Architecture is a subset of the Technology and Communication Layer.

The SAD development processes are depicted in **Figure 8** below.



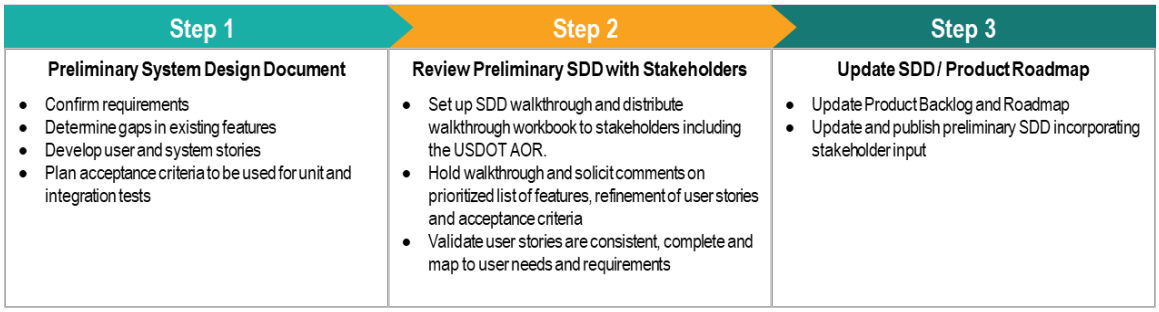
Source: ARC, 2022

Figure 8. SAD Development Process

The SAD will also include an associated Standards Plan and Interface Control Document (ICD) that identifies the nature of required interfaces to other systems, which should be defined to utilize existing networking or other standards when available. The ST-CTN project team will identify information exchange needs and/or use cases in the ICD. To the extent that such exchanges are supported by standards, applicable standards will be used. Where new standards are needed, these needs will be fully documented in the Standards Plan. To provide information required to refine ITS architecture and standards in support of nationwide deployment, the ST-CTN team will also document their experiences and cooperate with architecture and standards developers to improve the quality of these products based on lessons learned in deployment (see Task 2-L).

System Design Document (SDD). Based on the SyRS and the SAD, the system design will be created describing the full scope of the system. The system design will consist of an initial Product Backlog and schedule for the G-MAP and STM Platform (including performance measurement dashboard components) subsystems and the systems that integrate with it, including the CV subsystem elements and beacons. The system design will be presented as a high-level design document (i.e., a preliminary design, hereafter referred as the SDD) which includes a preliminary set of user and system stories, database, process workflow, user interface (UI), and dependencies (including interfaces).

The Working Draft SDD will be created to guide the Agile Development process. Requirements will be allocated to the user stories, system components, and interfaces will be specified. The project team will develop the Working Draft SDD at the onset of Phase 2. Design will continue throughout the Scrum Process and a Draft (as-built) SDD will then be delivered at the end of the Phase 2. IEEE 1016-2009: Recommended Practice for Software Design Descriptions will be used as a guideline for format and content to develop the SDD. The high-level design will be presented to stakeholders through a walkthrough to identify these user stories, priorities, and dependencies. The preliminary Working Draft SDD development process is depicted in **Figure 9** below.



Source: ARC, 2022

Figure 9. Preliminary Working Draft SDD Development Process

During the Agile Process, design will be conducted as part of Sprints. All design artifacts will be documented and stored on MS Teams and mapped back to user stories, requirements, and user needs in the RTM. This will ensure traceability between user needs, system requirements, and system design. Rather than taking a traditional systems engineering approach and developing a detailed design document at the on-set of the design phase, the Draft and Final SDD documents will be iteratively developed. The Agile Development Process will be leveraged to facilitate the iterative design, review, deploy, test, and documentation of system components. The artifacts created during the Agile Process will be packaged at the end of the development process to

create a Draft and Final (As-Built) SDD. This draft will be submitted as the formal SDD deliverable.

USDOT will review the Working Draft SDD prior to the start of the Agile process. The Working Draft SDD will provide the framework for artifacts that will be developed during the Agile process. It is expected that USDOT will provide any feedback on content and artifacts to be developed through the Agile process at this time, prior to the start of the Agile process because the ST-CTN project team will be unable to retroactively produce artifacts outside of the process. The design will be completed iteratively throughout the process and the artifacts will be available for review by USDOT at their request. At the end of the process, the project team will submit the Draft to the USDOT for a formal review. The USDOT will review the Draft SDD and provide comments to the ST-CTN team. The ST-CTN project team will address USDOT's comments prior to submitting the Final SDD.

Once the Working Draft SDD is completed, Phase 1 deliverables – including the ConOps, SyRS, and ICTDP – will be updated/revised to reflect the most up-to-date information.

Task 2-B Deliverables

- Draft SAD
- Systems Architecture Walkthrough and Workbook (assumed to be held virtually)
- Revised SAD with Comment Resolution Report
- Final SAD
- Working Draft SDD
- Systems Design Walkthrough and Workbook (held at deployment site)
- Revised SDD with Comment Resolution Report
- Draft SDD
- Final SDD
- Updated Phase 1 Deliverables, at a minimum:
    - Revised ConOps
    - Revised Systems Requirements
    - Revised ICTDP

2.2.3 Task 2-C: Data Management Planning

Large amounts of varying types of data will be generated during Phase 2 and 3 activities. This task includes the development of a Data Privacy Plan (DPP), a Privacy Management Plan, and a Phase 2 DMP. Together, these plans will document how data will be collected, integrated, managed, and disseminated during Phase 2 and 3. All plans will consider the USDOT's Privacy Policy and Public Access Plan to ensure consistency and compliance with USDOT requirements [DPP] [PAP].

Data Privacy Plan (DPP). To provide a complete trip for users, the ST-CTN team will need to collect and process certain categories of PII. The project team is committed to good stewardship of this personal data, providing notice and consent for collecting personal information, collecting the minimum amount of personal information necessary to achieve its specified purposes, protecting it securely, and handling it with respect for individual privacy. The ST-CTN team will follow the USDOT guidelines in designing a system structured with Privacy by Design. With this philosophy, individuals will not be tracked or identified. At a minimum, the DPP will be consistent

with the DMP, HUA and in accordance with approved IRB human subject agreement provisions. The DPP will include the following information:

- Introduction – purpose and content of document
- Approach – proposed methods to manage data and maintain privacy where needed
- Controls – technical, policy, standards, and physical controls that will be used
- Compliance – documented assurances that all team members and project participants will comply with the Privacy Management Plan
- Resources – proposed sufficient resources to ensure compliance

Before the DPP is finalized, the Privacy Management Plan will be completed, and the ST-CTN team will submit to USDOT a one-page Notice of Privacy. The DPP will be initially submitted in draft form to USDOT and will be revised based on comments from USDOT into a final version for review and approval.

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***Privacy Management Plan*.** Although not part of this contract, a Privacy Management Plan will be developed by the ST-CTN team, in accordance with Georgia and any local laws. The project team will work closely with the State of Georgia on emerging guidance and policy on privacy. These state guidelines, if ready, will inform the privacy plan.

***Data Management Plan (DMP)*.** A Phase 2 DMP will be prepared that builds on the Phase 1 plan. The DMP will include processes for managing data collectively as a strategic asset and, subject to applicable privacy, security, and other safeguards, making data available to enable transparent system performance measurement, support independent evaluation, and fuel entrepreneurship, innovation, and economic development. The Phase 2 DMP will document the datasets and their flow from generation through their use to applications in the deployment, including, but not limited to:

- Data sources and destinations,
- Volume of data flow,
- Contents of data flow,
- Communications medium involved, and
- Long term storage plans.

The plan will describe all data collection activities and incorporate data curation plans developed for critical datasets specified in the SyRS. Further, it will assess the variety, volume, and velocity (frequency of collection) of deployment-related data that can be accommodated, in order to ensure the end-to-end delivery of data to all identified recipients/users/systems. The plan will also establish consistent and systematic QC procedures.



Source: ARC, 2022

Figure 10. Data Management Plan Components

The DMP will also discuss the data sharing framework which applies specialized rules for sharing information across the data components -- overview, stewardship, and standards depicted in **Figure 10**. The framework consists of appropriately prepared system control, performance, and evaluation data, stripped of PII, that will be made available to the USDOT and posted in timely fashion on public-facing resources, freely available to the public and research community. The DMP will discuss processes for making these data available to the USDOT.

The ST-CTN shall deliver a draft DMP to USDOT for review. A revised DMP in response to USDOT comments with an accompanying Comment Resolution Report will be submitted to the USDOT. Based on DOT review of the revised DMP, the ST-CTN team will deliver a final DMP.

Task 2-C Deliverables

- Draft DPP
- Revised DPP with Comment Resolution Report
- Final DPP
- Notice of Privacy Management Consistency
- Draft Phase 2 DMP
- Revised Phase 2 DMP with Comment Resolution Report
- Final Phase 2 DMP

2.2.4 Task 2-D: Acquisition and Installation Planning

This task covers the acquisitions, configuration, and installations of all equipment, software, and supporting capabilities required for the ST-CTN system. The ST-CTN project is primarily a software project and will require minimal equipment and software to be procured. The ST-CTN project will procure supplemental location services for indoor navigation including beacons and software/services to support indoor wayfinding. These beacons will need to be procured by the project team. The GDOT, supported by HNTB, will issue a Request for Proposal (RFP) or Qualifications (RFQ) to procure and oversee installation of the requested services. Additional equipment and/or software may be identified as the ST-CTN project team completes the initial design of the system.

Equipment for the CV component of the project will be largely procured outside of the project by GDOT. The equipment includes RSUs and transit vehicle OBUs. All fixed-route transit vehicles will be equipped with OBUs outside of the ST-CTN project. For those locations that will require

RSUs in excess of what is currently being provided, the ST-CTN project team will procure and install equipment through GDOT's existing qualified products list (QPL) and service contract.

Comprehensive Acquisition Plan (CAP). The ST-CTN team will develop a CAP. The plan will identify the type and number of devices, equipment, and software-based capabilities to be acquired. The CAP will provide an overview of the proposed acquisition approach that includes an assessment of time-to-procure relative to the overall deployment schedule. The plan will also include a strategy to equitably engage and inform prospective vendors over time in case of changes to requirements, quantities, and delivery timelines.

For each identified type of equipment and services, the CAP will include, at a minimum:

- A description of the item
- Reference(s) to relevant requirements and specifications derived from SyRS and SMP, and documented in the SDD
- Note any/all certification and environmental condition requirements
- Describe the method of acquisition
- Potential vendors/suppliers

The CAP for the indoor navigation vendor will identify critical functions and services that will be able to be scaled, reduces not only the project costs, but the total cost of ownership including maintenance costs over the post-project 5-year period. The project team anticipates that the CAP will be issued, and procurement staged to enable the integration development team to schedule the services and install the equipment prior to the system test execution and operational readiness activities.

Comprehensive Installation Plan (CIP). A CIP will be developed that further identifies the types and number of equipment required to be configured and installed. Installation of infrastructure related elements will adhere and be consistent with state and local standards and installation approval procedures, or when the equipment is installed indoors (e.g., beacons), they adhere to facility policies and regulations. The CIP will provide an overview of the supplier base and procurement method(s), a high-level plan for inventory and configuration management, a high-level initial installation schedule, and one or more high-level installation plan(s). For each identified type of equipment and installation environment (e.g., fleet type, signal system type, beacon), the CIP will identify:

- Supplier(s),
- Inventory control method(s),
- Required configuration or pre-installation modifications,
- Pre- and post-installation inspection procedures,
- Installation location(s)
- Detailed installation procedures,
- QA/QC and maintenance processes (with identified responsible parties),
- A preliminary, high-level installation schedule,
- Hardware/software configuration control processes, and
- Spare parts/warranty contingency plans.

For both the CAP and CIP, a draft document will be delivered to the USDOT for review. Revised plans will be delivered in response to USDOT comments with an accompanying Comment

Resolution Report. Based on USDOT review of the revised documents, the ST-CTN team will deliver final CAP and CIP documents.

Task 2-D Deliverables

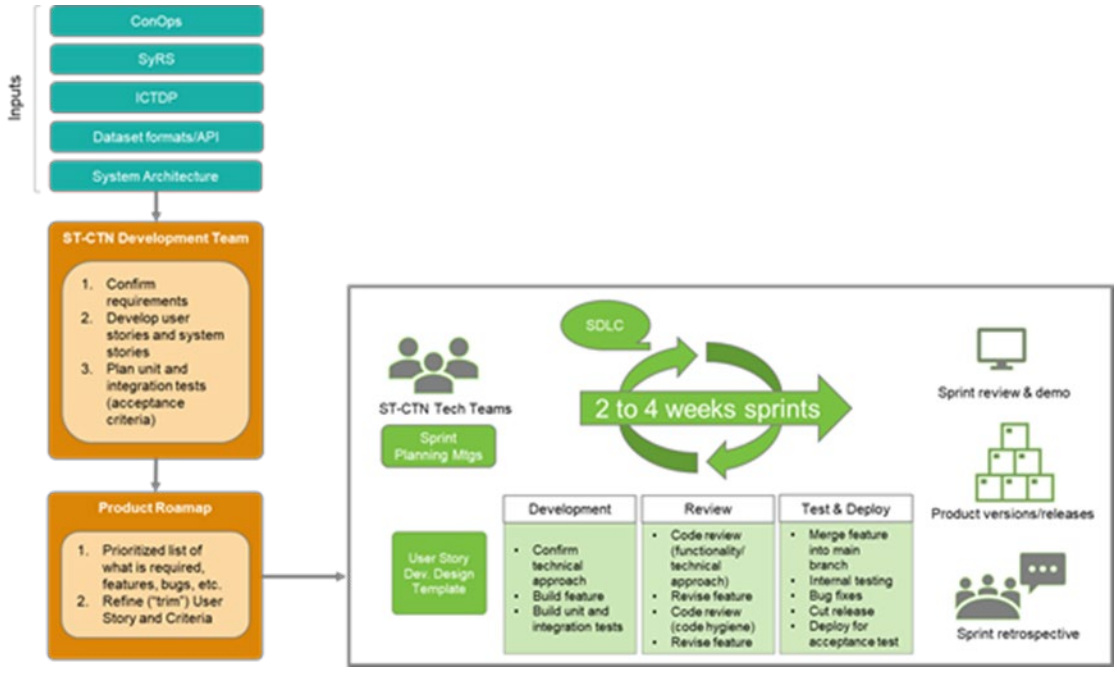
- Draft CAP
- Revised CAP with Comment Resolution Report
- Final CAP
- Draft CIP
- Revised CIP with Comment Resolution Report
- Final CIP

2.2.5 Task 2-E: Software Development and Integration

The ST-CTN team will apply an Agile approach as defined in the SEMP. This process calls for short iterations of development and allows requirements to be flexible during development. This will also enable USDOT to see the software progress and allow them to evaluate it early in the development process enabling changes to be made more efficiently. The development processes consist of building the feature, unit testing, and feature branch integration testing. The feature is integrated into a branch code set to perform the unit and integration tests. These are conducted prior to and following peer review processes. An overview of the Agile Process is depicted in **Figure 11** and defined by the following steps.

Step 1: Software Product and Release Planning. Content from the Vee-Process deliverables will serve as inputs to the Agile Process. Using these documents as inputs, the ST-CTN Development Teams will work with ST-CTN Stakeholder Groups to perform Software Release Planning. During Software Release Planning, user needs and requirements will be broken down into Epics and Agile User Stories. Once the SDD is created, the team will review the user and system stories and acceptance criteria in the SDD to develop a Product Roadmap and Software Development Schedule (SDS), which is essentially a phased deployment schedule that can be shared with the project stakeholders. Content included in the SDS includes, but is not limited to the following software capabilities:

- The development/enhancement of individual applications or modules to meet deployment-specific needs
- The integration of applications, services, and technologies in a synergistic collection (e.g., “Epics”)
- The management of data, safety, performance measurement, or other requirements
- Planning for user testing and engagement
- Interfacing (as required) with security and credential/user authentication systems
- Testing at sub-system or system levels
- Interfacing with existing legacy systems
- The development of software environments and architectures
- The adaptation and application processes to generate software releases and system deployment
- Optimization of code and refactoring
- Development of documentation and adherence to system requirements tracking



Source: ARC, 2022

Figure 11. Agile (Scrum) Process

The Product Roadmap will include a high-level plan that shows when in the future new products are expected to be developed or introduced by the team. The Product Roadmap will define and present major releases of the ST-CTN system. The Product Roadmap will capture the schedule for releases including the MVP. The Product Roadmap will also identify times when all software products and hardware will be integrated together. The Product Roadmap will guide the ST-CTN project team in Sprint Planning to ensure that key milestones are met. The Roadmap will be reviewed and updated periodically (i.e., quarterly) with the Product Owner, Development Teams, and Stakeholder Groups.

Step 2: Sprint Planning. Sprint Planning consists of processes related to planning and estimating tasks for an upcoming Sprint. Prior to beginning a Sprint, user stories and their related acceptance criteria will be created and incorporated into the Prioritized Product Roadmap. The Product Owner, with support from the Scrum Master and the rest of the development team will be responsible for prioritization of the Roadmap. The Product Owner will have the final word on the prioritization. Acceptance criteria include the product characteristics, specified by the Product Owner, that need to be satisfied before they are accepted by the user, customer, or other authorized entities. These are used to measure and compare the characteristics of the final product with specified characteristics.

Once all stories are ready, a Sprint Planning meeting will be held with the team to create a Sprint Backlog containing all tasks to be completed in the Sprint. The team will consist of the Product Owner, Scrum Master, and Development Team, and other team members relevant to the Sprint. The purpose of Sprint Planning is to reach agreement with the team members that they have time to complete the tasks assigned to them for the Sprint. The Scrum Master and ST-CTN Development Team estimates the effort required to develop the functionality described in each

user story, and the ST-CTN Development Team will commit to delivering the tasks during the Sprint period.

Step 3: Implementation. Implementation includes the execution of the tasks and activities in a Sprint to iteratively create the ST-CTN product. In this step, the ST-CTN Development Teams will work on the tasks in the Sprint Backlog to create deliverables, features, or products. The ST-CTN Agile Development Process Tool, such as Jira, will be used to track the work and activities being carried out. Everyday a highly focused, time-boxed meeting (or Daily Standup) will be conducted. These meetings will serve as the forum for the team to update each other on their progress and any impediments they may be facing. Key activities included in this step include:

- **Development.** Development includes confirmation of the technical approach, building features, and/or conducting unit and/or integration tests. The Development Team will work to deliver an MVP in accordance with the Product Backlog. The team will then incrementally develop additional features to deliver the full product.

- **Code Review.** Review includes conducting two types of code review (functional and technical) and code hygiene (style and documentation).

- **Documentation.** Documentation includes developing appropriate documentation and uploading materials within the appropriate Agile development tools.

- **Test and Deploy.** This activity includes conducting internal testing, identifying and fixing bugs (if required), merging features back into the main branch, and conducting acceptance testing. Acceptance tests will be used to check the requested and implemented feature and determine whether these deliverables, features, or products meet the requirements. Rather than taking a big-bang approach to testing, testing will occur incrementally as part of the Agile Process. All user stories will be mapped to user needs and requirements – and will include acceptance criteria and test cases. Details of the testing activities, facilities, tools, and other artifacts are discussed in **Section 2.2.7**.

Step 4: Review and Retrospective. This step includes reviewing the deliverables, features, and products and the work that has been done and determining ways to improve the practices and methods used to do project work.

OSS and Supporting Documentation. All OSS and supporting documentation to be provided will be identified as deliverables/milestones within the SDS. The ST-CTN team is committed to open-source development for new interfaces and enhancements. As such, all new interfaces and enhances will be open source and made available on GitHub and submitted to the USDOT as open source.

Task 2-E Deliverables

- Initial SDS
- SDS Update with Progress/Risk Summary
    - Element of Monthly Progress Report Part I: Technical Progress and Status Summary, per Section F.3 Monthly Progress Reporting
- OSS and Supporting Documentation (per the SDS)

2.2.6 Task 2-F: Participant and Staff Training

Relevant participants, operators, installers, maintenance staff, and other personnel will be trained to install, interact with, operate, maintain, and/or repair the various components of the ST-CTN system. During Phase 1, a Participant Training and Stakeholder Education Plan (PTSEP) was developed. The PTSEP provides a foundational guide for developing and delivering training efforts to participants and caregivers of the system's deployment. The document identified participants, determined eligibility, defined the recruitment and selection process, developed a retention plan, and discussed a training methodology and assessment.

Phase 2 and Phase 3 trainings will be focused on providing the necessary support and information to system developers, IOOs, system administrators, researchers, operations staff (e.g., call center) and end users. The training plan identifies the facilities, methods, learning objectives, duration, and other pertinent details that are needed to develop training materials, train the trainer, deliver end user training not only during the initial rollout but throughout the program deployment (in Phase 3 and beyond). Phase 3 training will primarily focus on providing end users with an introduction to the ST-CTN system and the skills necessary to leverage the system to complete their trips. The end user training will be conducted by community organizations whose role and expertise are consistent with training volunteers recruited to participate in the project.

Training for the various groups depend on when the subsystem is made available for controlled testing (alpha or beta testing) and Operational Readiness. For example, the G-MAP website and mobile app might be available during Phase 2 for controlled testing. **Table 11** provides a high-level schedule of the anticipated trainings that will occur during phases 2 and 3 of the ST-CTN project.

Table 11. High-Level Training Summary and Schedule (from PTSEP)

Training Course	Subgroup	Training Time Frame (Dependency)	Phase	Frequency
Course 1: Sidewalk Data Collection	Researchers (Data Collection Team)	Phase 2 notice-to-proceed (NTP)	Early Phase 2	As Needed
Course 2: STM System Administration	System Administrators	Phase 2 Completion	Early Phase 3	As Needed
Course 3: G-MAP System Administration	System Administrators	Phase 2 Completion	Early Phase 3	As Needed
Course 4: IRB Training for Research Data	Researchers, ST-CTN Project Team	Prior to collecting, processing, or viewing PII	Phase 2	Continuous and Maintained
Course 5: Performance Measurement Dashboard (PMD) Management	Researchers, ST-CTN Project Team	Phase 2 Completion	Early Phase 3	As Needed
Course 6: High-Level Overview for IOOs	ST-CTN IOOs	G-MAP Minimal Viable Product	Early Phase 3	As Needed
Course 7: Call Center Operations on G-MAP	Ride Gwinnett Call Center Operators	Phase 2 Completion	End of Phase 2	Coordination with Existing
Course 8: Transit Driver Operations	Ride Gwinnett Vehicle Operators	Phase 2 Completion	End of Phase 2	Coordination with Existing
Course 9: G-MAP Website	End Users	G-MAP Minimal Viable Product	Early Phase 3	As Needed
Course 10: G-MAP Mobile App	End Users	G-MAP Minimal Viable Product	Early Phase 3	As Needed
Course 11: Call Center Trip Planning	End Users	G-MAP Minimal Viable Product	Early Phase 3	As Needed

In Phase 2, a WBS of activities required to implement the PTSEP will be created and documented in a Training Implementation Schedule (TIS) including subsystem dependencies. The ST-CTN team will deliver an initial draft TIS to the AOR for review and approval. Progress will be reported (at a minimum) monthly. The updated TIS will include a concise summary of activities underway, progress made since the last update, and any technical issues/risks with mitigation actions taken since the last update.

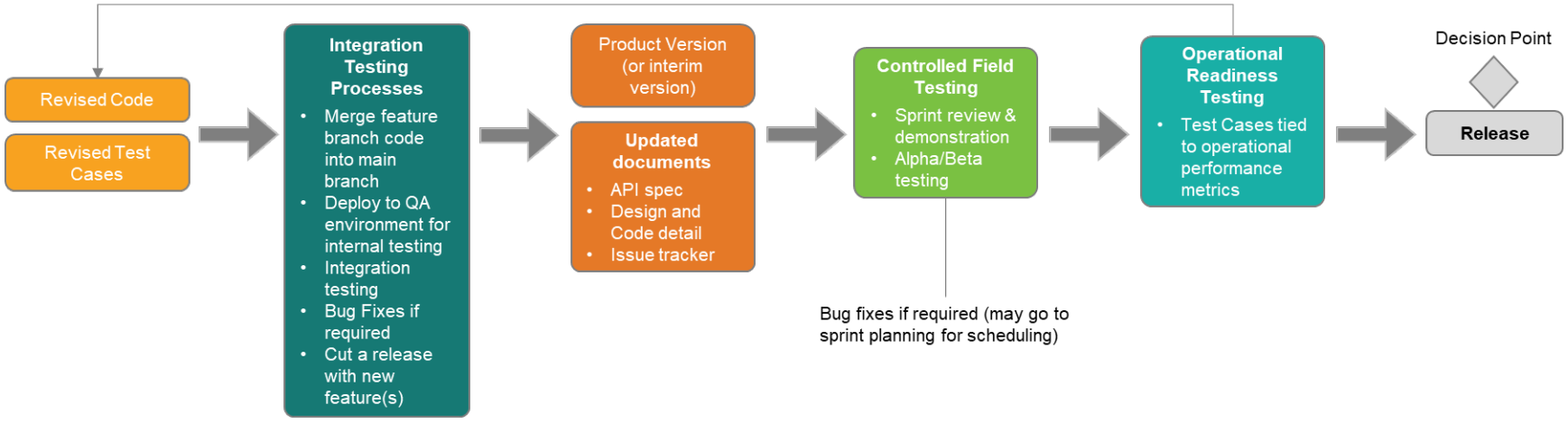
The ST-CTN team will develop training materials and develop trainings consistent with the PTSEP. In delivering trainings, the team will adhere to all HUA processes and deliver appropriate materials.

Task 2-F Deliverables

- Initial TIS
- TIS Update with Progress/Risk Summary
    - Element of Monthly Progress Report Part I: Technical Progress and Status Summary, see Section F.3 Monthly Progress Reporting
- Training Materials (Initial and Updates, as specified in the PTSEP and TIS)
- HUA Confirmation Materials (per the Human Use Approval Summary (HUAS))

2.2.7 Task 2-G: System Test Planning

The Integration and Testing Processes will begin after development, review, module (unit) testing, and feature integration testing is conducted during the Development and Implementation processes. During the Development and Implementation Processes, the unit and integration tests procedures are built. These test procedures include development and sequence of test cases, testing criteria, testing methods, and test data to be conducted during the tests. Integration testing for the main branch code will include not only the new integration test cases, but a subset of all the test cases generated for the existing code base to ensure that the additional features and functions did not impact other parts of the code. These tests will be documented, reviewed, and signed-off by the systems engineering team and the Product Owner. In addition, all graphical User Interfaces for web and mobile sites will be tested for functionality (through automated scripts) and accessibility by useability experts.



Source: ARC, 2021

Figure 12. Testing Process

A test environment will be set up to test main branch merging and testing. The environment will include test data generators and simulators for external system and interface exchange. As multiple subsystems are deployed, test environments set up to test stand-alone features will be integrated into a more complete ST-CTN test environment. The test environment may include bench testing of integrated software and hardware components such as the signal controllers for the PED-SIG or indoor beacons for the indoor navigation functions that are integrated with the G-MAP mobile app.

All test plans including test procedures related test cases, test data, and links to their code base versions will be stored in a GitHub site. The repository contains tests that address all the features, functions, and performance of the subsystems for the legacy and new components developed for this system. The collection will be used for regression testing during the merge process to verify that the system continues to work safely, correctly and without defect.

Test planning will begin as soon as a feature is included in the Sprint Backlog for development. Test planning for each software feature begins with specifying the inputs, testing cases, and expected results using scenarios for how the feature handles a variety of operations or conditions. The test plan will include information on the feature to be tested, test documentation, test verification methods, pass/fail criteria, testing roles and responsibilities (including review, test, certify), test deliverables, and schedule. Test data will be developed to test how the feature reacts to varying input conditions.

A test procedure is defined as a set of test cases comprised of step-by-step instructions used to exercise each flow and process implemented in a function. The test procedure may be documented for manual execution or written as an automated script. Test procedures are defined by specifying test cases, trigger events, and expected results with pass / fail criteria included for each test case. Automated scripts can run through multiple test data and generate exception reports which detail anomalies from expected outcomes. Test procedures and their related test cases will be reviewed by Sprint Team members prior to execution to ensure they meet requirements and acceptance criteria reviewed by the stakeholders during the Agile Planning / Review meetings. The test procedure will run multiple times with different test data to exercise the feature over varying conditions.

Following execution of the test procedures, the results will be reviewed by the System Engineering Team to verify that the tests are complete, validated against the requirements, and verified to run correctly. The validation review will be included in the Requirement Traceability Matrix, mapping each test case to one or more requirements. In addition, the System Engineering Team will verify that the documentation is updated and published to the test plan repository. Prior to release, the collection of test cases associated with the subsystem extensions will be published in a System Test Plan (STP) compliant with ISO/IEC/IEEE 29119™ Software and systems engineering – Software testing (standard series). The STP test cases and results will be used to show evidence of comprehensive testing in the Operational Readiness Test Plan (ORTP). The ORTP will incorporate (at a minimum) the following STP elements for each test:

- **Test Descriptions.** Written descriptions of the individual test and its trace to requirements as part of the V&V processes.

- **Test Cases.** A set of test inputs, execution conditions, and expected results developed for a particular objective, such as to exercise a particular path within a system or a software application or to verify compliance with a specific requirement or set of requirements.

- **Test Procedures.** Detailed procedures on how one verifies and validates that the component of the system examined actually functions as intended and as desired.

- **Test Data.** Scripts used to execute software operations, data that must be entered by someone as part of the process of V&V of the system and its component integration, or a description of what system-generated data will flow through different components of the system to accomplish a system function

- **Test Results.** Documents that describe the results of each test conducted.

- **Test Failure Remediation.** The actions to be taken in the event of a failed test.

- **Schedule.** The schedule for conducting the operational readiness tests (ORT) and any interdependencies between the different test cases

An Operational Readiness Demonstration Plan (ORDP) will also be developed to demonstrate safe, secure, and effective operations of the ST-CTN. The plan will be based on Sprint Reviews

and Demonstrations. This plan will incorporate (at a minimum) the following elements (adapted for the aspect of deployment readiness tested) for each demonstration:

- **Demonstration Descriptions.** The descriptions identify the objective, general location, participants, equipment, and actions to be taken within the demonstration to illustrate the successful deployment of key use cases.

- **Demonstration Procedures.** Procedures describe the sequence of events expected to be demonstrated and observable validation criteria associated with the overall purpose of the demonstration.

- **Demonstration Data.** Demonstration data will be collected before, during, or after the demonstration to support the observable demonstration validation criteria related to demonstration success (e.g., pass or fail).

- **Demonstration Results.** Documents that capture the results of each demonstration conducted. The ORDP will also describe how demonstration results will be summarized and documented across all demonstrations and delivered to USDOT.

A comprehensive Operational Readiness Plan (ORP) that combines the ORTP and ORDP will be developed. The ORP will highlight specific demonstrations that exhibit a set of selected integrated, end-to-end system capabilities central to the deployment ConOps (e.g., key use cases). Select demonstrations may be conducted as a live, real-time activity for the AOR and federal team wherein success and failure of the demonstration are directly observable.

After the delivery of the draft ORP, an ORP Walkthrough will be conducted in the Washington, DC metro area to demonstrate the completeness and technical soundness of the plan (including preparing a Walkthrough Workbook to structure and expedite the Walkthrough process). A virtual meeting may replace the in-person meeting, subject to USDOT approval. In response to USDOT comments (both written comments provided prior to the Walkthrough and verbal comments provided during the Walkthrough), the ST-CTN team will submit a revised ORP and an accompanying comment resolution report. Based on USDOT review of the revised ORP, a final ORP will be delivered.

Prior to developing the ORP, the ST-CTN team will develop an Operational Readiness Concept Briefing outlining the aspects of the deployment to be considered in the assessment of operational readiness and later documented in the ORP. This briefing will include comprehensive systems engineering considerations (i.e., unit, subsystem, integration, and system acceptance testing identified in the STP) as well as assessments of whether the deployment can operate safely and securely, whether staff and participants are suitably trained, human use approval has been obtained for all deployment participants, institutional and financial arrangements have been finalized, and whether the impact of the deployment can be discerned, measured, and reported. The briefing will be held in the Washington, DC metro area (also available for remote participants through a web conferencing capability). A (completely) virtual briefing may replace the in-person briefing, subject to DOT approval. The briefing shall include a preliminary list of proposed demonstrations. The briefing will cover, at a minimum:

- Key use cases illustrating the capability of the system to perform in accordance with the Phase 1 ConOps
- Safety-focused demonstration elements

- Privacy-focused demonstration elements
- Performance measurement and evaluation support demonstration elements
- Institutional coordination and successful execution of governance frameworks, management processes, and financial arrangements
- Maintenance-oriented demonstration elements

Task 2-G Deliverables

- Draft STP
- Revised STP with Comment Resolution Report
- Final STP
- Operational Readiness Concept Briefing
- Draft ORP
- ORP Walkthrough and Workbook
- Revised ORP with Comment Resolution Report
- Final ORP

2.2.8 Task 2-H: Installation and Operational Readiness Testing

The ST-CTN project team will install equipment according to the CIP and establish readiness based on the ORP in Task 2-G. As mentioned in the Task 2-G, software components with hardware elements like the PED-SIG, indoor navigation, and ride request will be integrated into the Agile software development process. Once integrated with the G-MAP software, the STP will include bench testing, controlled field testing and then open field testing to ensure the software elements work seamlessly with the hardware components. This approach also ensures the safety of all testing staff during operational readiness testing. We anticipate that in some instances, tuning and readjustment of the hardware components may be required (particularly for indoor beacons). The CIP will identify the initial plans for the hardware installation process, but the STP will capture additional information to improve and tune the system to effectively integrate the hardware and software components.

An Installation and Operational Readiness Schedule (IORS) will be created and documented in an initial IORS. The initial draft IORS shall be submitted to the AOR for review and approval. Progress will be reported monthly that will include a concise summary of activities underway, progress made since the last update, and any/all technical issues/risks with any/all mitigation actions taken since the last update. As a part of the monthly IORS update, the ST-CTN team will shall include an appendix or within the schedule tab that reports relevant countable deployment elements.

Connected vehicle roadside equipment will be confirmed ready and operational through the centralized CV infrastructure. The ST-CTN project team will work with GDOT / GCDOT staff to test the health and readiness of equipment located in the project area. GCT has internal monitoring equipment to ensure that the OBUs installed in their buses are operational. The logs will be reviewed during the integration, testing, and readiness stages to ensure that they are operating correctly and as expected.

Prior to start of Operational Readiness Testing, a System Test Results Summary (STRS) will be developed. The STRS will provide the summary of test results from the testing outlined in the STP, which should include the pass/fail status of the tests conducted in each phase (Unit,

Subsystem, Integration, and System Acceptance), number of defects found, and number of defects resolved. The STRS will also note any open defects, the severity/impact of those defects on the system, and the timeframe for when they will be resolved.

After completion of the ORTs, the test results will be documented and reported according to the processes identified in the ORP. Demonstrations will be scheduled in conjunction with the AOR and key federal staff. Demonstrations will be conducted and documented per the processes identified in the ORP.

Task 2-H Deliverables

- IORS
- IORS Updated with Progress/Risk Summary
    - Element of Monthly Progress Report Part I: Technical Progress and Status Summary, per Section F.3 Monthly Progress Reporting
- STRS (per the System Test Schedule (STS))
- Test Results Summary Documentation (per the ORP)
- Operational Readiness Demonstrations (per the ORP)

2.2.9 Task 2-I: Maintenance and Operations Planning

The O&M processes will be guided by the development of the Comprehensive Maintenance and Operations Plan (CMOP) and implemented in accordance with the System Operations and Maintenance Schedule (SOMS). The CMOP will deal specifically
with managing the technologies of the system and cover the following areas:

The O&M Management section will cover the following areas:

- System components and software configurable items
- Software classification –
  this will drive the software maintenance levels and procedures described in the maintenance section.
- Roles and responsibilities for system and subsystem maintenance and operations
- Service Desk and Emergency Communications
- Asset Management including:
    - Application and data portfolio
    - Document configuration management
    - Beacon inventory / asset management
    - Change Management Process

The Operations section will address the following areas:

- Tools and activities to monitor the system and subsystems including normal operations, communications, security, and safety
    - Activities to manage impacts to the system, both planned and unplanned. These include:
        - identifying anomalies and recovery methods
        - Initiating defect and discrepancy management process

  - Tools and activities to backup data
  - Activities to manage the system configuration
  - Tools and activities to report on SLA criteria
  - Periodic training for O&M staff

The Maintenance section will address the following areas:

- Software maintenance levels including preventative, corrective, and software enhancement
- Data maintenance plan describing staffing, schedule, tools, storage, and other resources needed to conduct data maintenance
- Data curation plans by data custodians: reviewed by the data governance committee
- Beacon maintenance plan including plan for preventive maintenance and replacement
- Software maintenance plan including the following processes and activities:
  - Defect management process
  - Preventive maintenance activities (patches and version updates)
  - Corrective maintenance activities (version updates)
  - System enhancement activities
  - Format, approval and distribution of Software Maintenance Notes to users

The CMOP will leverage existing IOO staff (GCDOT, GCT, GDOT) to implement the O&M processes and tools (e.g., asset management, information technology). Training is a critical element to ensure readiness and is included in the plan for all related roles, the details to be determined during the draft of the plan. The CMOP will drive Phase 3 O&M activities. A schedule for implementing O&M institutions, processes, and activities will be identified in the ORP and demonstrated and documented during the ORDP. The processes will be exercised and refined prior to transition to Phase 3. As Phase 3 unfolds and lessons are learned, the plan will be refined and updated as needed.

A draft CMOP will be delivered USDOT for review. A revised CMOP in response to USDOT comments with an accompanying Comment Resolution Report will be prepared. Based on USDOT review of the revised CMOP, the team will deliver a final CMOP.

Task 2-I Deliverables

- Draft CMOP
- Revised CMOP with Comment Resolution Report
- Final CMOP

2.2.10 Task 2-J: Stakeholder Outreach

The ST-CTN team will revise the Phase 1 Outreach Plan and develop a Phase 2 Outreach Plan. All stakeholder outreach activity in Phase 2 (and Phase 3) will be guided by the Phase 2 Outreach Plan. This includes, for example, the development and/or acquisition of awareness campaigns, web/social media content, trade show and conference materials, and other supporting materials intended to inform and engage stakeholders and the general public. The ST-CTN project team has two main communication objectives that will be delivered through outreach: awareness and recruitment.

Awareness. Raising awareness for the project involves disseminating information about the innovative transportation technologies used within the system and how this project supports the complete trip travel experience for all, particularly for the communities of focus for this project. Communication focused on building project awareness will include outreach to the local and regional community, stakeholders, and industry partners. Awareness may include local awareness as well as knowledge and technology transfer (KTT) to other agencies interested in advancing similar solutions.

Recruitment. The ST-CTN system benefits those who actively use the system. Communication focused on recruiting system end users will be critical to the continued success of the project. Participation will be encouraged by discussing the advantages of utilizing the system. Increased participation will build a more effective system and ensure that a variety of people from underserved communities benefit from the project.

Based on the revised/updated Phase 2 Outreach Plan, the ST-CTN team will also create and document in an Outreach Implementation Schedule (OIS) that includes all activities required to implement the Phase 2 Outreach Plan. Monthly updates to the OIS will be prepared and delivered that document progress against plan, and track risks/issues. The updated OIS will include a concise summary of activities underway, progress made since the last update, and technical issues/risks with mitigation actions taken since the last update. Monthly schedule and risk updates will be delivered from the time that this task is initiated until the end of Phase 2.

The ST-CTN team will deliver all outreach materials and products consistent with the approved Phase 2 Outreach Plan. **Table 12** provides a summary of the development and/or acquisition of all planned outreach materials that will be produced and released.

Table 12. Planned Outreach Materials

Communication Platform	Development / Delivery Method	Outreach Materials	Delivery Accommodations
Deployment Website	• Esri ArcGIS Hub Site (Electronic)	• Project description including goals and objectives • Information on how to get involved • Promotional video • Training videos • Information on the research performance measures • Factsheets • Links to new releases and publications	• Web Content Accessibility Guide (WCAG) 2.0 Compliant • Written/Recorded English, Spanish, Korean, Vietnamese, and Chinese [Simplified] • ASL for video content • Closed Caption

Communication Platform	Development / Delivery Method	Outreach Materials	Delivery Accommodations
Public Meetings and Conferences	• Written Content (Physical) • Written Content (Electronic) • Live Content (In-Person) • Live Content (Virtual)	• Presentation slides • Factsheets/Brochures • Posters • Other collateral/content, as identified	• 508 compliant electronic documentation • Written English, Spanish, Korean, Vietnamese, and Chinese [Simplified] • ASL • Closed Caption • Braille or Large Print if needed/feasible
Social Media	• Written Content (Electronic)	• Posts • Campaigns	• 508 compliant electronic documentation • English, Spanish, Korean, Vietnamese, and Chinese [Simplified]
On-Site Events	• Written Content (Physical) • Written Content (Electronic) • Live Content (In-Person) • Live Content (Virtual)	• Presentation slides • Factsheets/ Brochures • Other collateral/content, as identified	• 508 compliant electronic documentation • English, Spanish, Korean, Vietnamese, and Chinese [Simplified] • ASL • Closed Caption • Braille or Large Print if needed/feasible
Local Community Outreach	• Written Content (Physical) • Written Content (Electronic) • Live Content (In-Person) • Live Content (Virtual)	• Presentation slides • Factsheets/Brochures • Other collateral/content, as identified	• 508 compliant electronic documentation • English, Spanish, Korean, Vietnamese, and Chinese [Simplified] • ASL • Closed Caption • Braille or Large Print, if needed/feasible
Webinars	• Written Content (Electronic) • Live Content (Virtual)	• Presentation slides	• 508 compliant electronic documentation • English, Spanish, Korean, Vietnamese, and Chinese [Simplified] • ASL • Closed Caption
Industry Journal	• Written Content (Physical) • Written Content (Electronic)	• Project-specific article	• 508 compliant electronic documentation • Journal specific accessibility standards

The ST-CTN team will participate in workshops, conferences, and tradeshows as well as attend and/or host events and webinars to highlight the project.

Task 2-J Deliverables

- Draft Phase 2 Outreach Plan
- Revised Phase 2 Outreach Plan with Comment Resolution Report
- Final Phase 2 Outreach Plan
- Initial OIS
- OIS Updated with Progress/Risk Summary
    - Element of Monthly Progress Report Part I: Technical Progress and Status Summary, see Section F.3 Monthly Progress Reporting
- Outreach Materials (as specified in the Phase 2 Outreach Plan and OIS)

2.2.11 Task 2-K: Performance Measurement and Independent Evaluation Support

The ST-CTN team will collect, process, and distribute data and performance reports according to the Phase 1 PMESP and to support the Independent Evaluation effort. The Final Phase 2 PMESP identified the following goals and objectives.

Table 13. ST-CTN Goals and Objectives

Goal / Objective ID	Goal and Objectives
Goal 1	**Enhance the traveler's multimodal complete trip experience with the ST-CTN system functions and features, particularly for underserved communities.**
Objective 1.1	Enhance traveler's multimodal complete trip experience with safe and accessible ST-CTN system functions and features.
Objective 1.2	Enhance enroute traveler support to increase traveler confidence and independence.
Objective 1.3	Enhance the ability for travelers to seamlessly transfer between modes throughout their complete trip – while considering changes in routes due to unplanned events.
Goal 2	**Enhance safety for ST-CTN system users, particularly for underserved communities.**
Objective 2.1	Reduce transportation-related incidents and injuries along pedestrian routes within the study area.
Objective 2.2	Increase driver awareness of pedestrians crossing a signalized intersection.
Objective 2.3	Reduce transportation related incidents at signalized intersections within the study area.
Goal 3	**Improve reliability for system users, particularly for underserved communities.**
Objective 3.1	Enhance and maintain transit reliability by implementing enhanced TSP configurations for ST-CTN system users.
Objective 3.2	Reduce traveler transit wait times at bus stops.
Objective 3.3	Increase transportation system reliability by providing timely traveler information and routing for system users.

Goal / Objective ID	Goal and Objectives
Goal 4	**Improve mobility and accessibility for system users, particularly for underserved communities.**
Objective 4.1	Improve transit travel times with enhanced TSP operations for ST-CTN system users.
Objective 4.2	Increase traveler knowledge of accessible routes within the study area based on their individual needs and preferences.
Objective 4.3	Increase accessibility by implementing automated actuation of walk phase requests at signalized intersections within the study area.
Objective 4.4	Increase mobility and accessibility by implementing Ride Requests through travelers' mobile device or automated Ride Requests based on a traveler's planned route within the application.
Objective 4.5	Increase accessibility in locations where travelers identify existing barriers with infrastructure enhancements.

Performance measures and targets were established using these goals and objectives and are documented in the PMESP.

Working end-to-end data collection and processing capabilities will be established. Prior to operations, the collection and processing of baseline (“BEFORE”) data to support performance measurement activities will also be established. As appropriate and directed by USDOT, the ST-CTN team shall coordinate with the Independent Evaluator and facilitate independent evaluator access to ST-CTN data in accordance with the DMP.

To best support the Independent Evaluator, the ST-CTN team will ensure standard data sharing and access to private data. All performance measures and their documented methodologies will be directly accessible to the IE via an online interface. All open-source data that are processed to populate dashboards will be made available to the research team in accordance with the DMP. Protected data will only be made available to those physically present in the Secure Data Lab at GA Tech. The project team will provide the IE team with metadata and dummy data, so that the IE team can create any scripts that may need to be run for their evaluation purposes in advance of any visit to the Secure Data Center. Access to protected data by third-party users may also be granted through the implementation of an NDA and approval of an IRB human subjects protocol amendment. The ST-CTN team has also outlined key stakeholders who will be available to work with the IE as necessary.

The STN-CTN team will also execute the activities as outlined in the PMESP, including, but not limited to, identifying:

- Methods and records used to track the state of active applications and services in the operational phase, including operational status, geographic coverage, application versions active (or deactivated), and other contextual information and operational condition descriptions relevant to system performance and participant outcomes
- Performance measure calculation procedures

- Data related to the mitigation of confounding factors, including factors tracked, sources of available information utilized to track these factors, and mitigation approaches (if any) utilized by the ST-CTN project.

A Performance Measurement and Evaluation Support Schedule (PMESS) will be prepared that includes a WBS of activities (and dependencies) required to implement the PMESP (and DMP) for the specific purposes of the performance measurement and evaluation support. The PMESS will identify milestones, performance summary reports, and pre-deployment ("BEFORE") data for coordination with USDOT. Monthly updates to the PMESS will be prepared in response to USDOT comments on format and content, as well as to document progress against plan and track risks/issues. The updated PMESS will include a concise summary of activities underway, progress made since the last update, and data impact log to record any changes that impact data needed for performance measurement effort. Monthly schedule and risk updates will be delivered from the time that this task is initiated until the end of Phase 2.

The ST-CTN team will periodically (but no less than once) update the PMESP in Phase 2. Any/all analytical models and algorithmic methodologies utilized in performance measure calculation will be updated in the PMESP. In addition, the ST-CTN team will update the HUAS, as needed, according to the PMESP update and with IRB approval of changes.

The ST-CTN team will deliver the products (e.g., Pre-Deployment Performance Data and System Performance Reports) identified in the PMESP and other supporting information on or before delivery dates identified in the PMESS.

Task 2-K Deliverables

- Initial PMESS
- PMESS Updated with Progress/Risk Summary (monthly)
    - Element of Monthly Progress Report Part I: Technical Progress and Status Summary, per Section F.3 Monthly Progress Reporting
- Updated PMESP (minimum one update)
- Revised HUAS (updated as necessary with IRB approval)
- Performance Measurement Materials identified in the PMESP and PMESS (e.g., Pre-Deployment Performance Data, System Performance Reports) and other supporting information

2.2.12 Task 2-L: Participation in Standards Development

The purpose of participating in standards development activities is to help bring real-world experience related to assumptions, constraints and conditions, requirements and operational performance into standards development and compliance provisions. The ST-CTN team will assist the USDOT in improving and expanding ITS architecture and standards to support ITS deployments based on experiences and lessons learned as a part of the deployment activity.

Under this task, the ST-CTN team will participate in relevant standards development activities including select Standards Development Organization (SDO) working group/committee meetings, providing input to the SDO working group in the form of technical information.

As directed by the AOR, the ST-CTN team will provide appropriate input to expand, correct or otherwise improve ITS architecture(s) based on experiences in this effort. In a case where the AOR determines that the significance of the content in relevant Technical Memoranda is essential to expedite replicability, the ST-CTN team will make available an appropriate subject matter expert (SME) available to participate in SDO working group and/or technical committee meetings and provide/edit content of applicable standards. The SME will participate in technical discussions and provide program needs, use cases, and requirements to the appropriate SDOs. The ST-CTN team is also committed to reviewing/editing standards documentation relevant to the deployment program as it is developed and balloted within the SDO process.

Task 2-L Deliverables

- SDO-specific Technical Memoranda (as defined in the Standards Plan within the SAD)
- Participation in SDO working group or committee meetings/activities (as required)

2.3 Phase 3 Technical Approach

The following sections provide a high-level overview of the technical approach that the ST-CTN project team will take to successfully deliver each task required within Phase 3 of the Complete Trip – ITS4US Deployment. Specific anticipated challenges and efficiencies are addressed.

2.3.1 Task 3-A: Project Management

This task is a continuation of the Phase 2 Program Management activity, with the same objectives, activities, and scope. Continuing from Phase 2, the project management team will update the PMP and project schedule. The team will continue to deliver monthly progress reports that include: Project Milestone Schedule, Updated Task Schedules, Project and Task Detailed Risk Register, and LLL. Detailed financial summaries will also be delivered along with the monthly progress report.

The ST-CTN team will have key personnel attend a Phase 3 kick-off meeting in Washington, D.C. The ST-CTN team will also continue to participate in site-specific bi-weekly coordination teleconferences as well as in monthly all-site coordination teleconferences.

Task 3-A Deliverables

- Phase 3 Kick-off Meeting
- PMP
- Revised PMP (as required)
- Monthly Progress Report Part I: Technical Progress and Status Summary
    - Includes: Project Milestone Schedule, Updated Task Schedules, Project and Task Detailed Risk Register, and LLL
- Monthly Progress Report Part II: Detailed Financial Summary
- Participation in site-specific bi-weekly coordination teleconferences
- Participation in monthly all-site coordination teleconferences
- Participation in periodic roundtable teleconferences

2.3.2 Task 3-B: System Operations and Maintenance

The ST-CTN team will operate and maintain the system according to the CMOP. System installation and operational status are documented by the Recipient in a SOMS. Any/all activations or implementations of plans identified in the Phase 1 SMP shall be included and highlighted in the SOMS. An initial SOMS will be delivered to the AOR for review and approval. Progress shall be provided by the ST-CTN team as a monthly update to the SOMS. Monthly updates to the SOMS will be provided and include a concise summary of activities underway, progress made since the last update, and any/all technical issues/risks/incidents with any/all mitigation actions taken since the last update.

As a part of the monthly SOMS update, an appendix will be included that reports the number of participants, mobile devices, service area dimensions, roadside/wayside infrastructure elements, and other relevant countable deployment elements envisioned as a part of *at-scale* deployment. Monthly schedule and risk updates will be delivered from the time that this task is initiated until the end of Phase 3.

Task 3-B Deliverables

- Initial SOMS
- Updated SOMS with Progress/Risk Summary (monthly)
    - Element of Monthly Progress Report Part I: Technical Progress and Status Summary, per Section F.3 Monthly Progress Reporting

2.3.3 Task 3-C: Stakeholder Outreach

The ST-CTN team will perform outreach activities as defined in the Phase 2 Outreach Plan. This includes the development and/or acquisition of outreach materials, web/social media content, trade show and conference materials, and other supporting materials intended to inform and engage stakeholders and the general public.

An Operational Capability Showcase will be conducted no later than the first 12 months of Phase 3. This event is not intended to be a structured demonstration rather a media event to show the capabilities, intent, and value of the deployment. Preliminary ideas for the event include a presentation and celebration hosted at the Gwinnett Justice and Administration Center (GJAC) where indoor navigation will be available to participants through the ST-CTN system.

The team will continue to update the Outreach Plan as needed throughout the phase. The ST-CTN team will develop an OIS that includes a word breakdown structure of activities required to implement the Phase 2 Outreach Plan in Phase 3. As in Phase 2, activity in this task includes collaboration with domestic and international sites planning for or deploying similar technologies. ST-CTN team will deliver an initial draft OIS to the AOR for review and approval. Progress will be reported monthly and will include a concise summary of activities underway, progress made since the last update, and any/all technical issues/risks with any/all mitigation actions taken since the last update.

The ST-CTN team will also develop an Operational Capability Showcase Plan (OCSP) and conduct the Operational Capability Showcase in coordination with the AOR and federal outreach activity. The showcase will be documented by the ST-CTN team with a draft Operational Capability Showcase Summary (OCSS) indicating how the results/products of the showcase were

integrated into site outreach materials and interactions in workshops, conferences, and trade shows. A revised OCSS will be prepared in response to USDOT comments with an accompanying Comment Resolution Report. Based on USDOT review of the revised OCSS, a final OCSS will be delivered.

Task 3-C Deliverables

- Initial OIS
- Outreach Materials (as specified in the Outreach Plan and OIS)
- Updated OIS with Progress/Risk Summary (monthly)
    - Element of Monthly Progress Report Part I: Technical Progress and Status Summary, per Section F.3 Monthly Progress Reporting
- Draft OCSP
- Revised OCSP with Comment Resolution Report
- Final OCSP
- Operational Capability Showcase
- Draft OCSS
- Revised OCSS with Comment Resolution Report
- Final OCSS

2.3.4 Task 3-D: Performance Measurement and Independent Evaluation Support

During Phase 3 activities, the ST-CTN will be demonstrated in a real-world environment and the performance documented. The updated PMESP prepared during the Phase 2 activities will guide the performance measurement efforts. The focus of this task is to define how the PMESP will be executed, report to USDOT the data and performance measurement results, and coordinate efforts with the Independent Evaluator. Specifically, the team will:

- Provide monthly updates to the PMESS
- Deliver post-deployment performance materials and reports
- Update the PMESP and corresponding DMP
- Support Independent Evaluator Activities

PMESS. During Phase 2, the PMESS will have been established and updates provided monthly. During Phase 3, this process will continue. The schedule will focus on Phase 3 activities, with more detail included and an expanded WBS to guide the measurement and evaluation of the ST-CTN components and overall system throughout the demonstration. The schedule will include:

- Major PMESP activities (Phase 3) and their timeframe
- Key milestones and dates to implement the PMESP successfully
- PMESP deliverables with dates (including performance-related data and results)
- Technical issues and risks affecting the execution of the PMESP (as a supplement)

Monthly updates of the PMESS will be provided to USDOT documenting the PMESP progress, including percentage completion estimates for all major milestones and deliverables. The PMESS will be updated as necessary during the course of Phase 3 and updates shown in the monthly progress reports. Also included with the monthly updates will be a narrative describing activities

underway, progress made since the last update, any technical issues/risks that have arisen, and mitigation actions taken.

PMESP and DMP. The ST-CTN team plans to update the PMESP as necessary. These updates will include any revisions to the PMs or evaluation designs and the performance measurement results to date. Specifically, the Plan revisions will include, but not be limited to:

- Updates to the performance measures or evaluation designs, analytical models, and algorithmic methodologies to reflect, most accurately, the systems deployed
- Updates to the performance confounding factors and mitigation approaches that reflect the most current understanding and approaches
- Results to date of the performance-measurement Phase 3 activities, including data collected and analyses conducted

The DMP also will be updated as will the PMESP. This document will include the data collected and other supporting information to support the PMESP activities and the management approaches employed to secure, store and share the appropriate data. A review draft and final versions of the PMESP and DMP will be provided to USDOT.

Independent Evaluator Activities. The ST-CTN team will continue to work collaboratively to ensure a comprehensive and successful evaluation is completed and documented to benefit the Atlanta region, other interested areas, and others. During Phase 3, the ST-CTN team will continue to work closely with the IE to provide assistance, data, access to stakeholders, and general support to help the IE achieve their goals and objectives (defined in their Evaluation Plan). Additionally, the ST-CTN team will provide the analysis procedures, analytical tools, and models used during Phase 3 evaluation efforts in support of the IE's evaluation activities.

Task 3-D Deliverables

- Updated PMESS, (monthly):
  - Element of Monthly Progress Report Part I: Technical Progress and Status Summary, per Section F.3 Monthly Progress Reporting
- Updated PMESP (minimum one update)
- Updated DMP (minimum one update)
- Performance Measurement Materials identified in the PMESP and PMESS (e.g., Post-Deployment Performance Data, System Performance Reports, Performance Measurement Results) and other supporting information
- Site Performance Measurement Dashboard
- Public-facing Data (Regular updates as documented in the DMP and PMESS)

2.3.5 Task 3-E: Post-Deployment Transition Planning

This task area covers planning for the transition of the system from operations under the aegis of the ITS4US Deployment Program and into routine operational practice. The ST-CTN team will develop a Comprehensive Transition Plan (CTP) that identifies the concepts, applications, governance framework, agreements, key documents, and equipment to be maintained as elements of routine operational practice after the completion of Phase 3. The CTP will have one

section for concepts and applications found to be successful and included in continuing operations, and one section for concepts and applications found to be unsuccessful and to be removed from continuing operations. The CTP will provide rationale for each successful and unsuccessful element.

The CTP will also describe what organizational responsibilities will be taken in the post-deployment period compared to organizational responsibilities in Phase 3. It will also include documentation of the financial resources and agreements required to ensure financial sustainability in the post-deployment period for all continuing elements. Public and private sources of funds will be identified and if one or more new businesses are proposed to be a source of funds, a business plan containing standard elements shall be part of the documentation. Any dependencies on external organizations will be documented. The CTP will explicitly identify contingency plans with respect to identified uncertainties and other potential post-deployment issues posing a risk to successful post-deployment operations.

The ST-CTN team will deliver a draft CTP to USDOT for review. A revised CTP will be prepared in response to USDOT comments with an accompanying Comment Resolution Report. Based on USDOT review of the revised CTP, the ST-CTN team will deliver a final CTP.

Task 3-E Deliverables

- Draft CTP
- Revised CTP with Comment Resolution Report
- Final CTP

2.3.6 Task 3-F: Participation in Standards Development

Similar to Task 2-L, the task objective is to communicate lessons learned about using and adapting standards in an operational environment. Lessons learned from applying standards associated with ST-CTN SAD, SDD, testing, and operations will be documented with issues, constraints, conditions, updated use cases and requirements that impact existing standards, gaps in standards, and ITS architecture service packages. As directed by the USDOT AOR, the SEL and team will develop a technical memoranda that addresses issues relative to the family of data, processing, testing and compliance standards, and their implementation, testing and compliance tools. The draft technical memoranda will be provided to the AOR for review and update prior their delivery to specific SDO and grassroot specification development organizations. The ST-CTN SEL or designated team expert will participate in standard meetings and activities per USDOT direction.

Task 3-F Deliverables

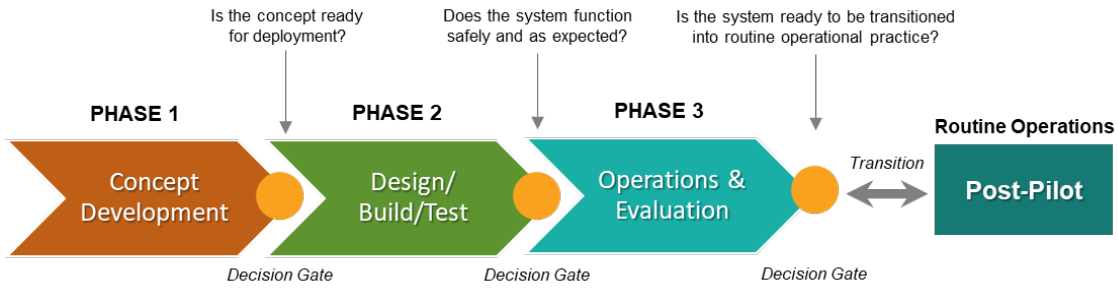
- SDO-specific Technical Memoranda (as defined in the Standards Plan within the SAD)
- Participation in SDO working group or committee meetings/activities (as required)

3 Phase 2 and 3 Deployment Schedule

This section provides a summary of the ST-CTN project schedules, including an overview of the ITS4US Deployment Program schedule, Phase 2 and 3 deployment schedules, and a discussion of anticipated schedule risks.

3.1 ITS4US Complete Trip Program Phases

This section includes discussion of the activities encompassing Phases 1, 2, and 3 of the ST-CTN initiative and how the project transitions between phases. The ST-CTN project is being delivered as part of the USDOT's ITS4US Deployment Program which is being executed in three phases – Phase 1: Concept Development; Phase 2: Design, Build, and Testing; and Phase 3: Operations and Evaluation. **Figure 13** depicts the phases and decision gates for the initiative.



Source: ARC, 2021

Figure 13. ITS4US Program Phases and Decision Gates

Phase 1: Concept Development includes concept development for the ST-CTN project. In this phase, the preliminary proposed idea is developed into a structured concept that is suitable for further design, development, testing, and operation. Through stakeholder engagement activities, a set of documents are created to plan for and develop the concept for the project. These foundational documents guide the remainder of the initiative. Phase 1 culminates with this document (the ICTDP) which serves as a decision gate for going into Phase 2. The ICTDP is intended to serve two purposes: first, to summarize the refined deployment concept developed in Phase 1 activity and second, to set forth a high-level Phase 2 (Design/Build/Test) and Phase 3 (Operations and Evaluation) schedule. A refinement of the original Phase 1 proposal's high-level cost estimate for Phase 2 and Phase 3 is identified reflecting the refined deployment concept, the deployment schedule, and the more detailed examination of risks and requirements associated with at-scale deployment (technical, institutional, and financial) revealed during Phase 1 activity.

Phase 2: Design, Build, and Test includes activities to design, build, test, and deploy the ST-CTN project. This phase includes activities to design, build/implement, and test the ST-CTN system prior to the system becoming operational. During Phase 2, development will be

conducted, and unit and system testing will occur to ensure that the system developed meets the needs and requirements established in Phase 1. An Agile Process will be used to incrementally develop the ST-CTN solution. Design, implementation, and testing will occur as part of the Sprint process. Testing will be done incrementally and summarized in the STP that will articulate how all of the requirements defined in the SyRS are met. Phase 2 culminates with ORTs and Demonstration to assess that the system functions as required. Operational readiness is established with a comprehensive set of tests and supporting demonstrations to be designed and conducted by the ST-CTN project team. The ST-CTN project team will conduct a set of relevant tests to verify that the system performs according to the documented System Requirements. Demonstrations will also be conducted (at a higher level) and show that the system performs as expected in key use cases/scenarios. Relevant testing defined in the STP will be conducted *prior* to conducting the ORT and Operational Readiness Demonstration. At the end of Phase 2, all data collection, system development, test and deployment, O&M processes and institutions will be complete and ready for full (100%) use. Elements of the Performance Management Dashboard may require adjustment as new data are collected during Phase 3.

Phase 3: Operations and Evaluation includes activities related to the operations and evaluation of the system. The system will *Go Live* at the beginning of Phase 3. All systems and subsystems will be at 100% deployment and fully operational for a minimum duration of 18 months. We anticipate that the Performance Measurement Dashboard (PMD) will require some adjustment and tweaking to support the evaluation reporting during the first two months after Go Live. During Phase 3, the ST-CTN project team will operate and maintain the system.

After the three phases of the effort are complete, successful elements of the integrated complete trip deployment are expected to transition to become elements of routine operational practice. The region will be responsible for the funding of continued operations of successful elements of the deployments for a minimum of 5 years beyond the period of performance of the federal ITS4US Deployment Program. As part of Phase 1, the ST-CTN team prepared an Institutional, Partnership and Financial Plan (IPFP) intended to codify and provide definitive documentation of stakeholder agreement on concept, objectives, institutional and financial arrangements necessary for the successful implementation and operation of the deployment.

3.2 Phase 2 and 3 Deployment Schedule

The Phase 2 and 3 deployment schedule is provided in **Table 14**. The schedule is based on the requirements from the NOFO and considers a NTP date of June 15, 2022 for Phase 2 and June 15, 2024 for Phase 3. Dates may change based on the actual NTP. A more detailed scheduled will be developed at the beginning of each phase and include in a detailed WBS with dependencies identified between tasks.

Table 14. Phase 2 and 3 Schedule Summary

Phase	Task	Deliverable	Dependencies	Proposed Due Date
2	A	Phase 2 Kick-off Meeting		6/21/2022
2	A	Revised PMP		As Needed
2	A	Monthly Progress Report Part I, II, LLL, Project Milestone Schedule, Updated Task Schedules, Project and Task Detailed Risk Register		Monthly

Phase	Task	Deliverable	Dependencies	Proposed Due Date
2	A	Bi-Weekly Coordination Teleconference Participation		Bi-weekly
2	A	Participation in Monthly All-Site Coordination Teleconferences		Monthly
2	A	Participation in Roundtable Teleconferences		As Needed
2	B	Systems Architecture Walkthrough and Workbook		10/12/2022
2	B	Revised SAD with Comment Resolution Report	Draft SAD	2/16/2023
2	B	Final SAD	Revised SAD	6/19/2023
2	B	Working Draft SDD	Final SAD	10/30/2023
2	B	Systems Design Walkthrough and Workbook	Prelim SDD	10/30/2023
2	B	Draft SDD	Complete Agile Development	9/9/2024
2	B	Revised SDD with Comment Resolution Report	Draft SDD	10/14/2024
2	B	Final Systems Design Document	Revised SDD	11/4/2024
2	B	Updated Phase 1 Deliverables (including, but not limited to: Revised ConOps, Revised Systems Requirements, and Revised ICTDP)		8/30/2024
2	C	Final DPP	Revised DPP	8/29/2023
2	C	Notice of Privacy Management Consistency		11/6/2023
2	C	Final Phase 2 Data Management Plan	Revised DMP	8/18/2023
2	D	Final CAP	Revised CAP	6/30/2023
2	D	Final CIP	Revised CIP	12/1/2023
2	E	Initial SDS	Project Milestone Schedule	7/14/2023
2	E	SDS Update with Progress/Risk Summary	Previous month SDS	Monthly*
2	E	Agile Process: Planning, Review and Demonstration Meetings, Sprints, Integration Testing, etc.	Working Draft SDD	Sprint Roadmap per the SDS
2	E	OSS and Supporting Documentation	Agile Process	per the SDS
2	F	Initial TIS		4/29/2024
2	F	TIS Update with Progress/Risk Summary	Previous month TIS	monthly*
2	F	Training Materials		1/31/2025
2	F	HUA Confirmation Materials		per the HUAS
2	G	Final STP	Revised STP	9/19/2023
2	G	Operational Readiness Concept Briefing		9/6/2023
2	G	ORP Walkthrough and Workbook	Draft ORP	10/9/2024
2	G	Final ORP	Revised ORP	11/11/2024
2	H	Initial IORS		9/23/2024
2	H	IORS Updated with Progress/Risk Summary	Previous month	Monthly*
2	H	STRS		10/14/2024

Phase	Task	Deliverable	Dependencies	Proposed Due Date
2	H	Test Results Summary Documentation	Final STP and IORS	10/14/2024
2	H	Operational Readiness Demonstrations	Final STP, IORS, ORP	11/22/2024
2	I	Final CMOP	Revised CMOP	11/18/2024
2	J	Revised Phase 2 Outreach Plan with Comment Resolution Report	Draft Outreach	9/30/2022
2	J	Final Phase 2 Outreach Plan	Revised Outreach	9/16/2022
2	J	Initial OIS		9/30/2022
2	J	OIS Updated with Progress/Risk Summary	Previous month OIS	Monthly*
2	J	Outreach Materials		12/31/2024
2	K	Initial PMESS		10/16/2023
2	K	PMESS Updated with Progress/Risk Summary	Previous month PMESS	monthly*
2	K	Updated PMESP		minimum one update
2	K	Revised HUAS		11/25/2024
2	K	Performance Measurement Materials identified in the PMESP and PMESS (e.g., Pre-Deployment Performance Data, System Performance Reports) and other supporting information		12/31/2024
2	L	SDO-specific Technical Memoranda		10/21/2024
2	L	Participation in SDO Meetings/Activities		12/2/2024

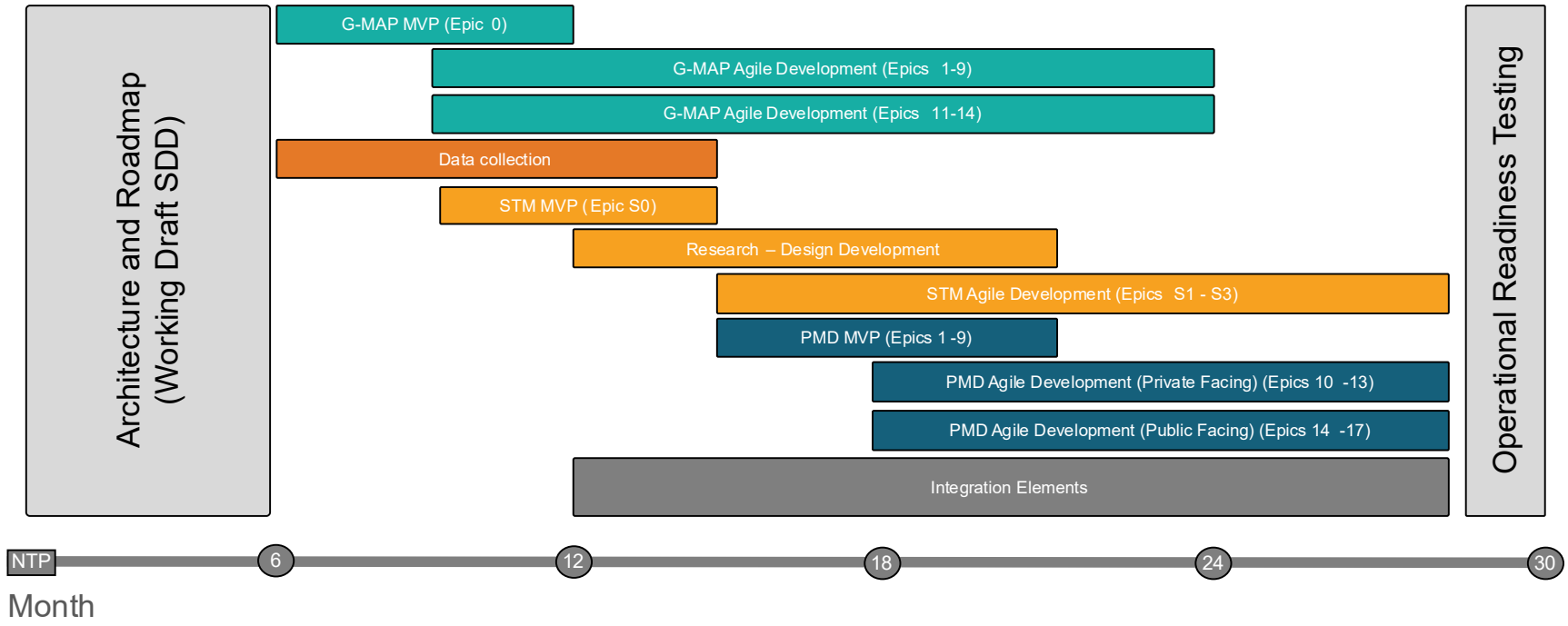
Phase	Task	Deliverable	Dependencies	Proposed Due Date
3		Milestone #1 • 100% subsystem functionality supporting ATL RIDES customer account management. • 25% customer accounts of target (250 users recruited prior to Phase 3) • 100% ATL RIDES and STM impedance values for trip routing and execution. • 100% functionality and equipment installed in in GCT vehicles to support TSP and connection protection. • 100 % of sidewalk data collected in the project boundaries. • 80% of 2 facilities outfitted with sensors for indoor navigation • 100% Operations and Maintenance process readiness including software update processes • 80% PMD data ingestion, curation and analytical processes except full verification of operational data collection and analysis processes • Begin pilot 12 month countdown from GO LIVE date		Phase 3 NTP GO LIVE
3		Milestone #2 • 100% of 2 facilities outfitted with sensors for indoor navigation • 100% PMD with verification of operational data collection and analysis processes • 50% customer accounts of target (500)		Phase 3 NTP + 60 days
3		Milestone #3 • 100% customer accounts of target (1,000)		Phase 3 NTP +180 days
3	A	Phase 3 Kick-off Meeting		1/13/2025
3	A	Revised PMP		As Required
3	A	Monthly Progress Report Part I, II, LLL, Project Milestone Schedule, Updated Task Schedules, Project and Task Detailed Risk Register		Monthly
3	A	Participation in Site-Specific Bi-Weekly Coordination Teleconferences		Bi-weekly
3	A	Participation in Monthly All-Site Coordination Teleconferences		Monthly
3	A	Participation in Periodic Roundtable Teleconferences		As Needed
3	B	Initial SOMS		1/13/2025
3	B	Updated SOMS with Progress/Risk Summary	Initial SOMS	Monthly*
3	C	Initial OIS		1/13/2025

Phase	Task	Deliverable	Dependencies	Proposed Due Date
3	C	Outreach Materials		per the Phase 2 Outreach Plan and OIS
3	C	Updated OIS with Progress/Risk Summary	Initial OIS	Monthly*
3	C	Revised OCSP with Comment Resolution Report	Draft OCSP	2/17/2025
3	C	Final OCSP	Revised OCSP	3/10/2025
3	C	Operational Capability Showcase		11/17/2025
3	C	Revised OCSS with Comment Resolution Report	Draft OCSS	1/12/2026
3	C	Final OCSS	Revised OCSS	1/19/2026
3	D	Updated PMESS with Progress/Risk Summary	PMESS	Monthly*
3	D	Performance Measurement Materials identified in the PMESP and PMESS (e.g., Pre-Deployment Performance Data, System Performance Reports, Performance Measurement Results) and other supporting information		per the PMESS
3	D	Site Performance Measurement Dashboard		per the PMESS
3	D	Updated PMESP	PMESP	as needed, minimum one update
3	D	Updated DMP	DMP	As needed, minimum one update
3	D	Public-facing Data		per the DMP and PMESS
3	E	Revised CTP with Comment Resolution Report	Draft CTP	12/15/2025
3	E	Final CTP	Revised CTP	1/12/2026
3	F	SDO-specific Technical Memoranda		per Standards Plan within the SAD
3	F	Participation in SDO meetings/activities		as required

As defined in the SEMP, an Agile/Vee Hybrid methodology will be utilized by the ST-CTN project team where Agile (Scrum) will be combined with a traditional systems engineering process (Vee-Process). Each subsystem – STM Platform, CV, and G-MAP – will follow an Agile approach to develop and test the software products. An Agile approach will also be followed in developing performance measurement activities.

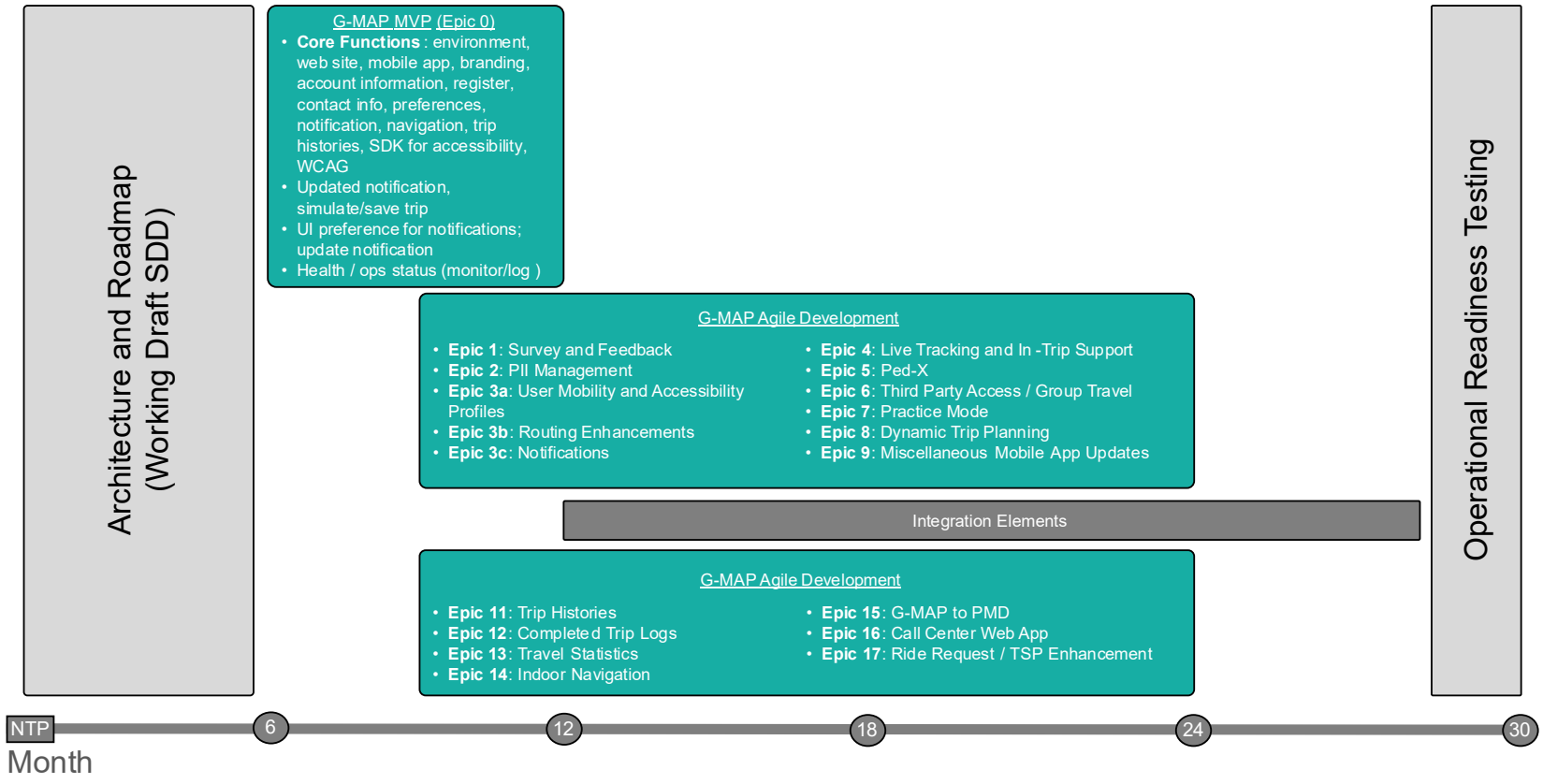
During Phase 1, the ST-CTN project team developed initial Agile Development Roadmaps for the various subsystems / components. **Figure 14** depicts a high-level Agile Development Roadmap including integration of external systems (e.g., Ped-SIG and indoor navigation) for Phase 2 of the ST-CTN project. The Roadmap summarizes the timelines to develop the MVP and timelines for completion of the other Epics. Agile Development Roadmaps specific for the development of G-MAP, the STM Platform, Integration Activities, and the PMD are depicted in **Figure 15**, **Figure 16**, **Figure 17**, and **Figure 18**.

Each Product Backlog was developed based on requirements from the SyRS to define features for the MVP and associated Epics. The Product Backlog will serve as the foundation for the Agile process and integration of external system activities and will be refined in Phase 2 during the system architecture and design task. The SDD will include the schedule for interim releases based on dependent Epics, integration (and regression) testing, and demonstration that all acceptance criteria that a software product must satisfy are met and ready to be accepted by the Product Owner, Stakeholders and USDOT.



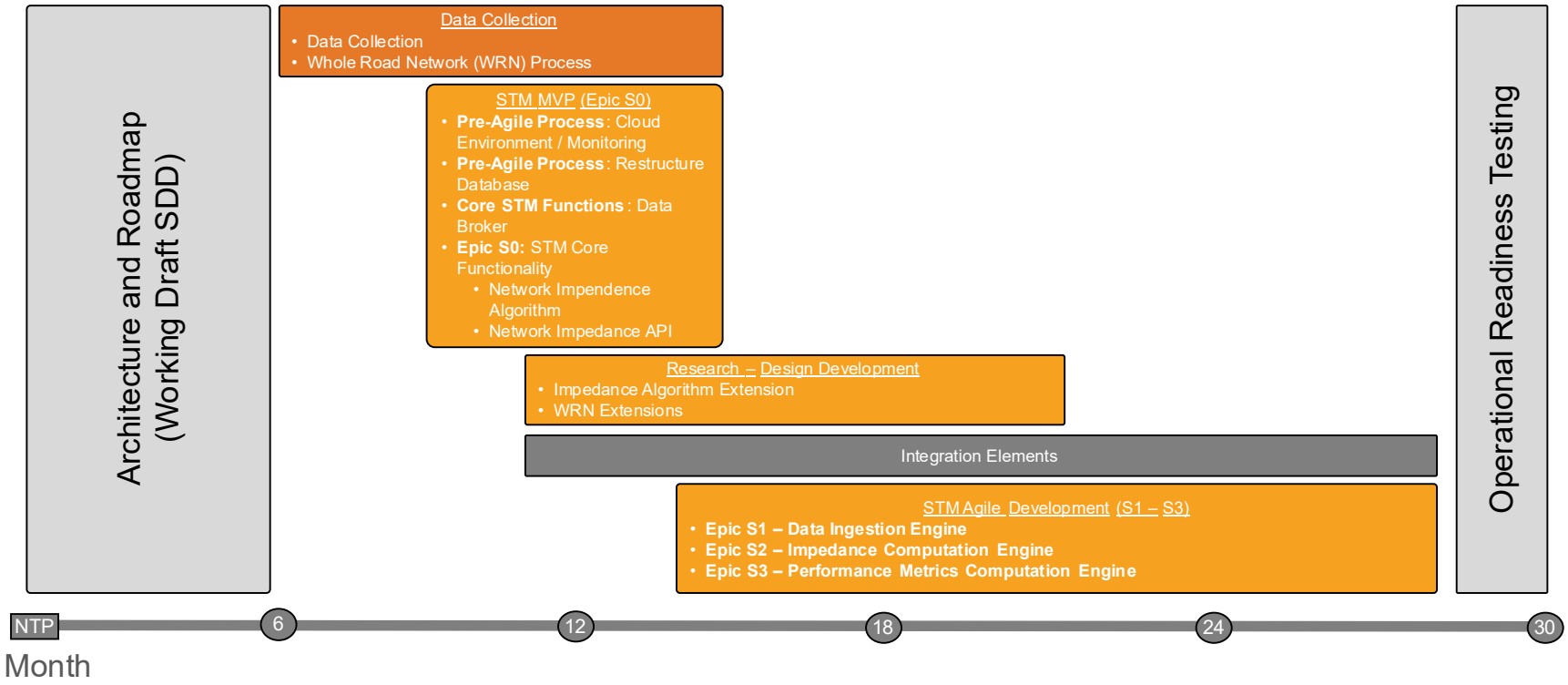
Source: GDOT, 2024

Figure 14. ST-CTN Phase 2 Agile Development Roadmap



Source: GDOT, 2024

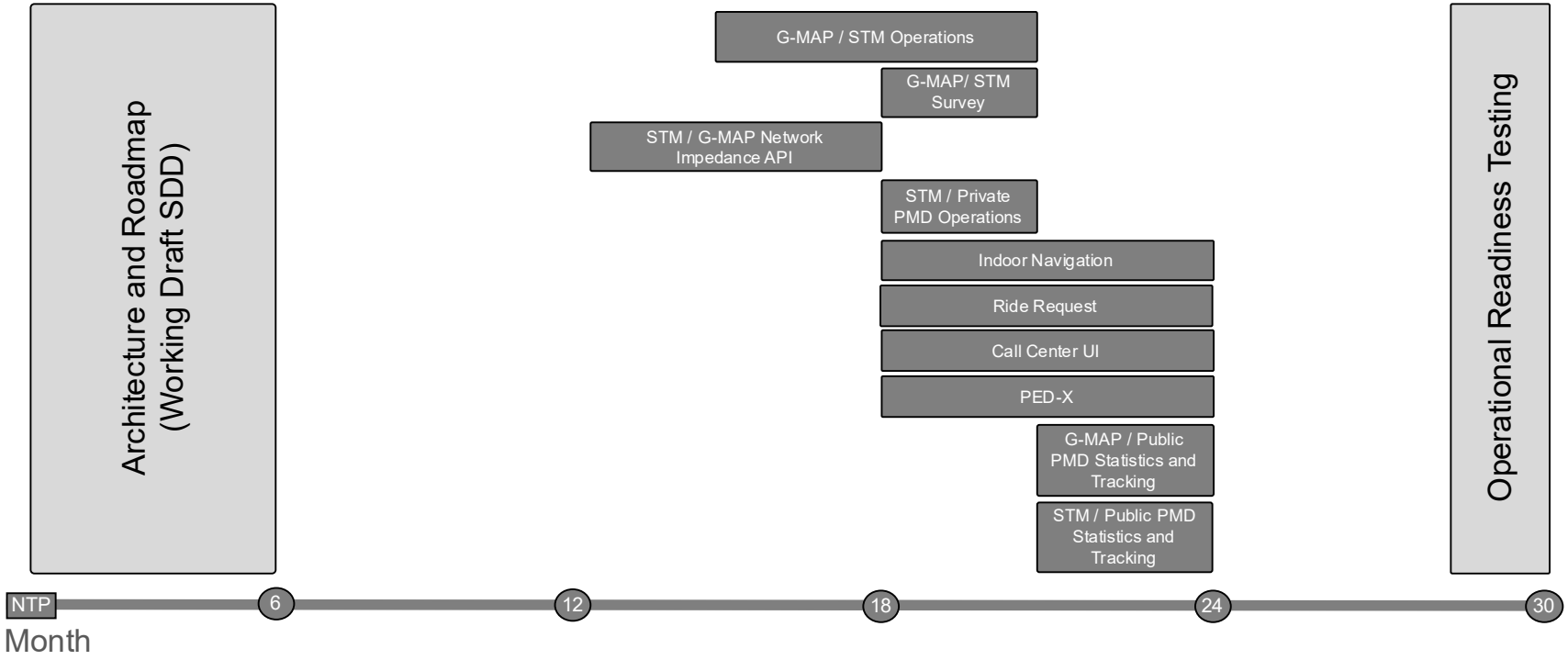
Figure 15. ST-CTN Phase 2 – G-MAP Agile Development Roadmap



Source: GDOT, 2024

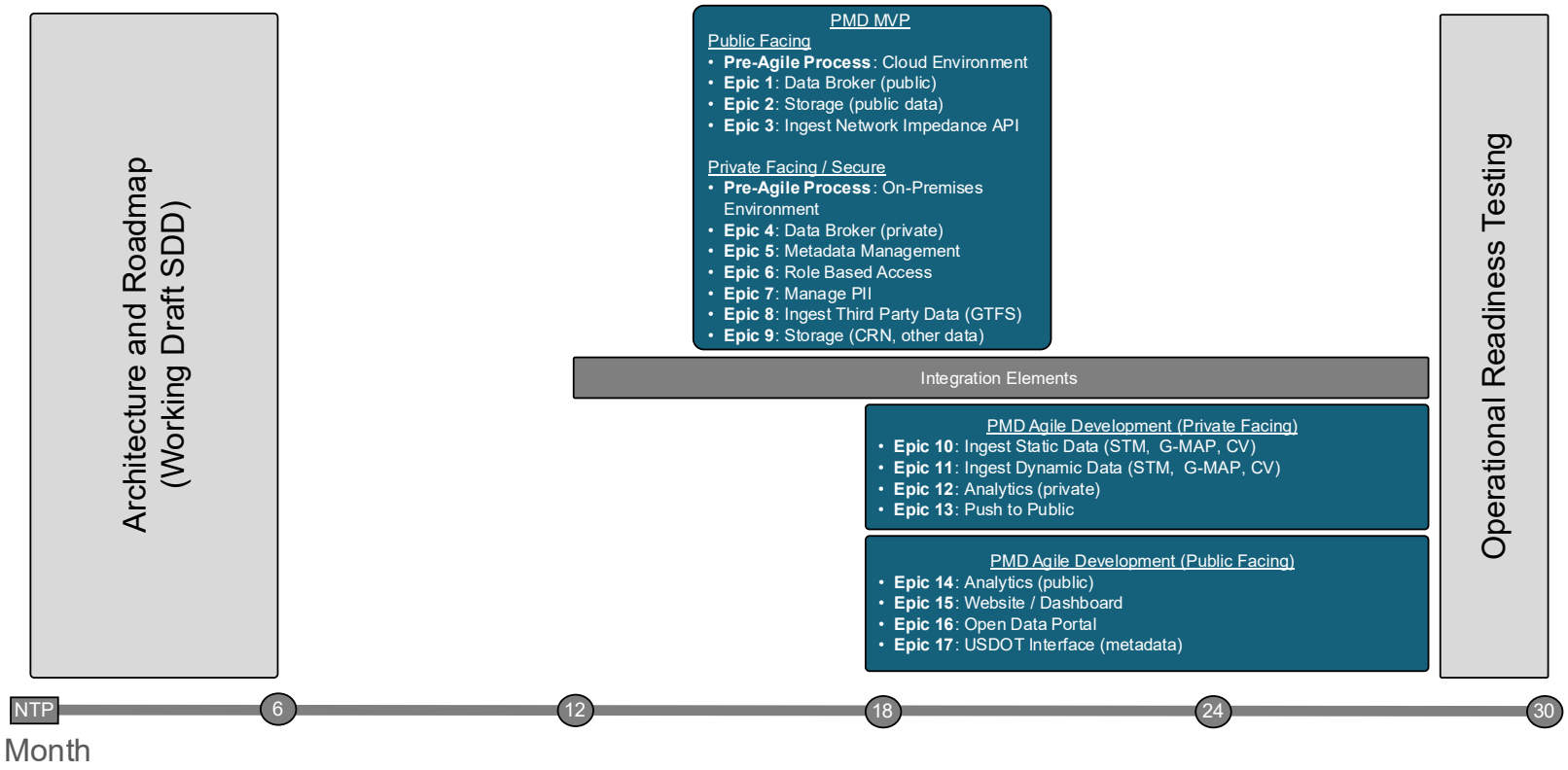
Figure 16. ST-CTN Phase 2 – STM Platform Agile Development Roadmap

Key integration elements that will require development are identified in **Figure 17**. It is expected that integration testing will continue to take place throughout Phase 2, however, the development required to support system integration (design, coding and testing of subsystems and external components) will take place during the schedule shown below.



Source: GDOT, 2024

Figure 17. ST-CTN Phase 2 – ST-CTN Agile Development Integration Roadmap



Source: GDOT, 2024

Figure 18. ST-CTN Phase 2 – Performance Measure Dashboard Agile Development Roadmap

3.3 Schedule Risks

This section describes the anticipated risks and mitigation strategies for proposed Phase 2 and Phase 3 schedules. The risks and mitigation strategies are described in **Table 15**. Identified risks will be tracked within the Risk Management Registry (developed during Phase 1 and submitted to USDOT monthly) throughout the remainder of the project to ensure that any schedule risks impacting the ST-CTN project are avoided or mitigated efficiently.

Table 15. Schedule Related Risks and Mitigation Strategies

Risk Title	Description	Mitigation
COVID 19 Pandemic Procurement Delay **Closed**	The ongoing COVID 19 pandemic could have a major impact on the ST-CTN deployment schedule due to equipment delays or other related delays.	The pandemic has now been ongoing for the past two years. With proper planning and a well-defined acquisition plan, the ST-CTN team is confident that the risk can be mitigated.
Task Dependency Interruptions	Each subsystem within the ST-CTN project has to be designed, built, and tested prior to deployment. This process relies on a series of dependent tasks that must be completed before the next task. Should one of these tasks fall behind schedule, the successful deployment of the system in the 24-month timeframe is at risk.	The ST-CTN project team has engaged the system developers and IOOs to ensure that staffing and production capacity are available within the 24-month Phase 2 timeframe. Regularly occurring internal project team meetings will continue through Phase 2 and Phase 3 to ensure that the scheduled deployment remains achievable. The EMT, in parallel will monitor the project budget and allocation as needed.
Staff Turnover	Throughout the course of the ST-CTN project, it is possible that key team members or support personal will change positions within partner agencies or companies. New team members may not have the institutional knowledge or experience to move forward with the ST-CTN projects, impacting the deployment schedule.	**Section 1.4.2** describes the anticipated contingency plan to mitigate key personnel changes. The ST-CTN project team has been diligent in its documentation and engagement, creating clear action plans for deployment to be used by all partners should personnel change.
Communication Technology	Current communication methods for the connected vehicle subsystem rely on 5.9 Ghz, C-V2X methods. With the potential migration to 5G communication, our system could become dated quickly.	GDOT does not anticipate migrating existing 5.9 Ghz C-V2X connected vehicle infrastructure during Phase 2 or Phase 3 of the ST-CTN project. If GDOT determines to migrate in the future, the transit signal priority (TSP) functionality and logic is expected to remain the same with minimal impact to the ST-CTN system.

Risk Title	Description	Mitigation
Study Area Impact due to Bus Route Changes **Closed**	Gwinnett County Transit is currently making changes to one of its bus routes that will change the shape of the study area.	Bus routing changes will be made periodically during this deployment. There will be no impacts to the project unless changes occur where CV infrastructure is not planned. Given the extent of the CV deployment this is unlikely. We will maintain coordination with local staff to ensure early knowledge of any changes.
Federal Communications Commission (FCC) Rulings/ Spectrum Reallocation	The FCC has ruled to shorten the safety spectrum that the connected vehicle signals will be using to communicate with the infrastructure.	System testing will need to be done during Phase II to ensure the system works properly within the allotted spectrum.
Call Center Responsibilities Expansion	It is currently uncertain how the anticipated call center responsibilities will be accommodated should ST-CTN expand beyond Gwinnett County.	The ST-CTN project team plans to continue discussions to try to identify how a regional call center may be established which could support the future growth of the ST-CTN.
Internal Contract Language Concerns **Closed**	The ST-CTN project team is actively working to reconcile internal contract language concerns and have not been able to reach agreement with all project partners at this time.	Discussions between legal teams are on-going and making progress. Project schedule has been reviewed and modified to prevent any major delays. Continued contract delays will impact the current schedule if not resolved by mid-September.
Contract Delays Impacting Schedule **Closed**	The ST-CTN project team contracts have been delayed. Currently project team subcontractors do not have executed contracts which is beginning to impact the Phase 2 schedule.	Several ST-CTN project team members have continued to work at-risk to mitigate the impact of contract delays on the overall Phase 2 schedule. In addition, the schedule has been modified to mitigate overall schedule delays. However, the team can no longer move forward without access to the full technical team. Therefore, we anticipate that any further delay may begin to impact the final deliverables schedule and extend past Phase 2 timeline if contracts are not put in-place immediately.
Contract Delays Impacting Schedule **Closed**	The ST-CTN project team contracts have been delayed. Project team subcontracts were sent on 12/8 and are expected to be fully executed by the end of the year. This delay will impact the Phase 2 schedule.	The ST-CTN project team will work to understand the implications to the Phase 2 schedule once we are able to have access to our full team. We will look for ways to expedite schedule such that we can hold to the Phase 2 schedule expectations. We will communicate any concerns with USDOT and, if absolutely necessary, will request an extension.

Risk Title	Description	Mitigation
Contract Delays Impacting Schedule **Closed**	The ST-CTN project team contracts have been delayed and this delay will impact the Phase 2 schedule.	The ST-CTN project team is working to understand the implications to the Phase 2 schedule once we are able to have access to our full team. We will look for ways to expedite schedule such that we can hold to the Phase 2 schedule expectations. We will communicate any concerns with USDOT and, if absolutely necessary, will request an extension.
Experimental Device Licensing Risk **Closed**	We are leveraging the existing Gwinnett County/GDOT CV deployments which are C-V2X (there was originally discussion to use DSRC, but C-V2X has been selected since the ConOps). The devices are licensed as experimental and do run the risk of termination/revocation. We would expect that by the time we get to operation of ST-CTN we will have resolution on at least our waivers. We have added this as a risk within our registry but do not have control. A potential mitigation strategy would be to reinstall DSRC and accomplish operations that way.	This is not something within our control and there is limited risk to overall project functionality. We will stay abreast of any changes, and pivot accordingly.
GA Tech Contract Delays **Closed**	The GA Tech contract continues to be delayed. This delay is expected to impact the Phase 2 schedule.	The ST-CTN project team is waiting for a contract to be executed between GDOT and GA Tech. The work scheduled to be completed by GA Tech has not been started and the project team is unable to complete the documentation and deliverables without access to GA Tech. The project team has been told that an executed contract is forthcoming, however, it is not understood at this time when a contract can be expected such that the schedule can be updated. As a mitigation strategy, the ST-CTN project team has coordinated with existing contracting partners to develop a potential alternative solution which will personalize travel to meet stakeholder needs.

Risk Title	Description	Mitigation
Student Hiring Challenges **Closed**	Students will be collecting sidewalk inventory but may be difficult to hire due to the contracting delay.	Georgia Tech will use summer semester students to perform initial collection of sidewalk inventory.
Vendor Delays in Platform Migration **Closed**	The PED-X application relies on a modified API within the Qfree Kinetic platform. GDOT is migrating MAXView/MAXTime platform to the centralized Kinetic platform. The migration is behind due to vendor delays.	The ST-CTN will facilitate an alternate path that gives a direct call to the controller in the event that Kinetic is not available. It will remove some functionality, but will achieve the needed outcome of placing a ped call if Kinetic is not available. The alternative architecture will provide remote ped actuation to up to 10 intersections and will be developed such that it is easily migrated to the central system for scalability during Phase 3 when Kinetic is online.
Indoor Navigation at Doraville MARTA Station **Closed**	The ST-CTN team is currently in conversation with MARTA to discuss involving the Doraville MARTA station in the project.	The ST-CTN team is working with MARTA to determine if installation of indoor navigation beacons at Doraville MARTA station is possible.
Project Development Delays **Closed**	The ST-CTN project development is delayed. This delay is impacting the Phase 2 schedule.	The ST-CTN project team is working to understand the implications to the Phase 2 schedule because of project development delays. We will look for ways to expedite schedule such that we can hold to the Phase 2 schedule expectations. We will continue to communicate concerns with USDOT and, if absolutely necessary, will request an extension. An extension has been requested.
Coordination with Gwinnett County IT	Due to PED-X architecture changes, a direct connection will likely be needed with Gwinnett County's central signal system. Coordination with Gwinnett County IT may take longer than anticipated.	The ST-CTN project team is coordinating with Gwinnett County IT to provide all information needed as soon as possible. Gwinnett County IT is working on getting the form processed for the server to be implemented.
MOU with MARTA **Closed**	The Memorandum of Understanding (MOU) with MARTA has not been signed.	The ST-CTN project team will continue to follow up with MARTA to encourage their management's review of the MOU. The ST-CTN project team has also asked USDOT to contact MARTA and share the importance of this project. Upon still not receiving response from MARTA, USDOT has followed up with management. MARTA will no longer be participating in indoor navigation.

Risk Title	Description	Mitigation
Ride Gwinnett TSP Configuration Issues **Closed**	Ride Gwinnett transit signal priority (TSP) current configuration is potentially different than the project team initially understood such that it may not be possible to 'enhance' the functionality. The intent was to reduce the threshold at which TSP is granted. However, the current threshold may be much shorter making it imperceptible (due to latency in the current system) to reduce the threshold.	The ST-CTN project team is seeking to understand the current TSP configurations more fully. Enhanced TSP will be possible, however, the current configuration is set to a 1-minute threshold. Therefore, it is unlikely that the G-MAP triggered TSP will provide significant schedule benefit.
INS SDK Feature Gaps **Closed**	The INS SDK is missing some of the expected customer facing features that are available in the outdoor navigation, i.e. audio notification, re-routing, recognition of user (blue dot). This will require additional work that is not currently identified in existing scopes. Additional work may cause slight delay.	The ST-CTN project team is working to understand the specific gaps to share with stakeholders and seek their feedback and direction. Arcadis has agreed to develop SDK gaps for G-MAP.
Georgia Tech Contract Extension **Closed**	Georgia Tech's contract with GDOT is currently set to end on July 31, 2024. Georgia Tech and GDOT are currently coordinating to extend the contract.	Georgia Tech and GDOT are working towards extending the contract. Contract is in process and routing for execution.
Second Location for Indoor Navigation **Closed**	The ST-CTN project team needs to identify a second location for indoor navigation following MARTA's decision to not be involved in the indoor navigation element of this project.	The ST-CTN project team is assessing a number of locations for indoor navigation installation. GDOT submitted a list of potential alternative locations for indoor navigation. GDOT is working with USDOT to identify the best candidate. GDOT has worked with USDOT to identify Norcross OneStop as the second location for indoor navigation.
Dynamic Impedances Ingestion Approach Misunderstanding	The software development team had an internal misunderstanding about the approach to the ingestion of dynamic impedances. This issue presents a potential schedule risk.	The ST-CTN project team is working on developing a schedule and identifying risks for this work.

Risk Title	Description	Mitigation
G-MAP Application Bugs	The software development team and testing team have identified several bugs in the G-MAP application during release 1 and release 2 testing. These bugs are preventing the testing of other features.	The ST-CTN project team is working to document these bugs and have them addressed quickly to continue testing.
Translation Errors in STM Development	The STM development team has identified translation errors between the Neptune database and pedestrian data.	The STM development team is working to resolve the translation errors.

4 Phase 2 and 3 Deployment Cost Estimate

The following sections provide a high-level summary of costs for Phases 2 and 3 of the project.

4.1 Cost Summary

The cost summary is meant to provide guidance for other deployers, detailed cost elements are not included. **Table 16** is a summary of high-level cost estimates for Phases 2 and 3. Tasks 2A and 3A reflect costs for program management activities. Additional program management costs are included within each task. For example, Task 2E includes Sprint kickoff and close-out meeting time for the Product Owner to manage and ensure the safe, efficient, timely delivery of the project. The ST-CTN team will be able to better manage and identify budget risks by having the costs associated with task-related program management within each task.

Table 16. Summary of High-Level Cost Estimates

Task	Estimated Cost
Phase 2 - Design, Build, and Test	
2A - Program Management	$ 609,916
2B - System Architecture and Design	$ 547,432
2C - Data Management Planning	$ 196,212
2D - Acquisition and Installation Planning	$ 770,982
2E - Software Development and Integration	$ 4,112,787
2F - Participant and Staff Training	$ 188,853
2G - System Test Planning	$ 315,320
2H - Installation and Operational Readiness Testing	$ 234,283
2I - Maintenance and Operations Planning	$ 66,825
2J - Stakeholder Outreach	$ 406,642
2K - Performance Measurement and Independent Evaluation Support	$ 118,439
2L - Participation in Standards Development	$ 65,513
Phase 2 Budget	**$ 7,633,202**
Phase 3 - Operate, Maintain, and Evaluate	
3A - Program Management	$ 489,338
3B - System Operations and Maintenance	$ 131,034
3C - Stakeholder Outreach	$ 738,945
3D - Performance Measurement and Independent Evaluation Support	$ 253,051
3E - Post-Deployment Transition Planning	$ 751,219
3F - Participation in Standards Development	$ 67,212
Phase 3 Budget	**$ 2,430,798**
Total Phase 2 and 3 Budget	**$ 10,064,000**

Table 17 provides a summary of Phase 2 and 3 estimated cost by area of expenditure. Major areas of expenditure for this project include:

- Labor – ST-CTN project partner's direct labor estimated to be required to successfully deliver the requirements within Phases 2 and 3.
- Travel – expected expenditures to support ST-CTN project partners' travel to conduct outreach, attend on-site meetings or testing for the project.
- Materials / Equipment – includes anticipated hardware and subscription costs for application hosting. In addition, this area of expenditure also includes outreach and training materials.
- Vendor Procurement – will be utilized to support the deployment of indoor navigation through the use of beacons which will increase the location accuracy of a traveler while they are inside of a building.
- Reimbursements – ST-CTN research partners will require tuition reimbursements to be able to utilize student support on the project. In addition, training reimbursements will be paid to those training partners who integrate ST-CTN system training into their existing travel trainings. These training partners are anticipated to be local advocacy groups as described in the PTSEP.
- Subcontracts – will be utilized in some cases where existing contracts can be leveraged or amended to support work required for this project.

Table 17. Estimated Costs by Area of Expenditure

Major Area of Expenditure	Estimated Cost
Phase 2 - Design, Build, and Test	
Direct Labor	$ 5,679,620
Travel	$ 42,517
Materials / Equipment	$ 413,955
Vendor Procurement	$ 250,000
Reimbursements	$ 98,749
Subcontracts	$ 1,148,361
Phase 2 Budget	**$ 7,633,202**
Phase 3 - Operate, Maintain, and Evaluate	
Direct Labor	$ 1,728,177
Travel	$ 23,838
Materials / Equipment	$ 90,271
Vendor Procurement	$ -
Reimbursements	$ 44,688
Subcontracts	$ 543,824
Phase 3 Budget	**$ 2,430,798**
Total Phase 2 and 3 Budget	**$ 10,064,000**

4.2 Cost Risks

Managing costs risks will be critical to the successful deployment of the ST-CTN project. This section summarizes the most critical cost-related risks and mitigation strategies for Phase 2 and Phase 3 of the ST-CTN project. The risks and mitigation strategies are described in **Table 18**. Identified risks will be tracked within the Risk Management Registry (developed during Phase 1 and submitted to USDOT monthly) throughout the remainder of the project to ensure that any cost risks impacting the ST-CTN project are avoided or mitigated efficiently.

Table 18. Cost Related Risks and Mitigation Strategies

Risk Title	Description	Mitigation
Cost Share	The ST-CTN project team is confident that the required cost share for the project can be secured. However, due to budgeting schedules, Phase 2 is currently in the process of being allocated and will be required to progress through project selection and prioritization.	All partners are committed to securing cost share funds through their respective funding processes as well as non-federal grant and private philanthropic partnership opportunities. Coordination is underway between GDOT, Gwinnett County, and ARC to identify the exact amount of contribution for Phases 2/3. There will multiple opportunities to secure match funding before and after the contract for Phase 2 begins. More detailed descriptions of these are provided in Vol 2 Part II.
Beacon Procurement Costs	A vendor procurement will be issued to deploy a beacon subsystem which will support indoor navigation. It is possible that vendor proposals are higher than anticipated.	Beacon procurement estimates have been developed to be conservative based on industry knowledge and experience. With proper planning and a well-defined acquisition plan, the ST-CTN team is confident that the risk can be mitigated.
Software Development and Integration Costs	Software development costs are known to be challenging to estimate. Unforeseen obstacles or delays could cause cost overruns.	The ST-CTN team held a series of work sessions on each software development element – G-MAP, STM Platform, PMD, and integration – to focus on the anticipated effort that will be needed to meet the requirements stated within the SyRS. Estimated costs were vetted by all ST-CTN project team members to ensure accuracy and consensus. The risk of software and integration cost overruns are expected to be avoided due to the thorough investment of planning. Costs will be monitored throughout Phases 2 and 3 to ensure mitigation is not required.

4.3 Estimated Phase 2-3 Costs

Section 4.1 provides a summary of the high-level estimated costs anticipated for Phases 2 and 3 of the ST-CTN project. This section provides further detail regarding those costs. **Table 19** provides the cost breakdown for each planned task during Phases 2 and 3, the cost share budget, federal share budget, and total budget. Estimated costs include direct labor, travel, materials and equipment, vendor procurements, reimbursements, and subcontracts.

Table 19. Estimated Phase 2-3 Costs

Task	Cost Share Budget	Federal Share Budget	Total Budget
Phase 2 - Design, Build, and Test			
2A - Program Management	$ 121,983	$ 487,932	$ 609,916
2B - System Architecture and Design	$ 109,486	$ 437,945	$ 547,432
2C - Data Management Planning	$ 39,242	$ 156,969	$ 196,212
2D - Acquisition and Installation Planning	$ 154,196	$ 616,786	$ 770,982
2E - Software Development and Integration	$ 822,557	$ 3,290,230	$ 4,112,787
2F - Participant and Staff Training	$ 37,771	$ 151,082	$ 188,853
2G - System Test Planning	$ 63,064	$ 252,256	$ 315,320
2H - Installation and Operational Readiness Testing	$ 46,857	$ 187,427	$ 234,283
2I - Maintenance and Operations Planning	$ 13,365	$ 53,460	$ 66,825
2J - Stakeholder Outreach	$ 81,328	$ 325,314	$ 406,642
2K - Performance Measurement and Independent Evaluation Support	$ 23,688	$ 94,751	$ 118,439
2L - Participation in Standards Development	$ 13,103	$ 52,410	$ 65,513
Phase 2 Budget	**$ 1,526,640**	**$ 6,106,562**	**$ 7,633,202**
Phase 3 - Operate, Maintain, and Evaluate			
3A - Project Management	$ 97,868	$ 391,470	$ 489,338
3B - System Operations and Maintenance	$ 26,207	$ 104,827	$ 131,034
3C - Stakeholder Outreach	$ 147,789	$ 591,156	$ 738,945
3D - Performance Measurement and Independent Evaluation Support	$ 50,610	$ 202,441	$ 253,051
3E - Post-Deployment Transition Planning	$ 150,244	$ 600,975	$ 751,219
3F - Participation in Standards Development	$ 13,442	$ 53,769	$ 67,212
Phase 3 Budget	**$ 486,160**	**$ 1,944,639**	**$ 2,430,798**
Total Phase 2 and 3 Budget	**$ 2,012,800**	**$ 8,051,200**	**$ 10,064,000**

Appendix A. Acronyms and Glossary

Table 20 below provides a list of acronyms and associated meanings.

Table 20. Acronyms

Acronym	Meaning
360ns	360 Network Solutions, LLC
ADA	Americans with Disability Act
AO	Agreement Officer
AOR	Agreement Officer Representative
API	Application programming interface
ARC	Atlanta Regional Commission
ARC-IT	National ITS Reference Architecture
ASL	American sign language
ATL RIDES	Atlanta Rider Information and Data Evaluation System
ATIS	Advanced traveler information system
Avail	Avail Technologies
CAP	Comprehensive Acquisition Plan
CCB	Configuration Control Board
CCL	Community Coordinator Lead
CDC	Centers for Disease Control and Prevention
CDL	Co-System Deployment Lead
CDP	Connected data platform
CIL	Centers for Independent Living
CIP	Comprehensive Installation Plan
CMOP	Comprehensive Maintenance and Operations Plan
ConOps	Concept of Operations
CPML	Co-Project Management Lead
CTP	Comprehensive Transition Plan
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
DPP	Data Privacy Plan
DSRC	Dedicated Short-Range Communications
EMT	Executive Management Team
FCC	Federal Communications Commission
GA Tech	Georgia Institute of Technology
GCDOT	Gwinnett County Department of Transportation
GCT	Gwinnett County Transit
GDOT	Georgia Department of Transportation
GJAC	Gwinnett Justice and Administration Center

Acronym	Meaning
G-MAP	Georgia Mobility and Accessibility Planner
GOSystems	GO Systems and Solutions LLC
GTFS	General Transit Feed Specification
HNTB	HNTB Corporation
HUA	Human Use Approval
HUAS	Human Use Approval Summary
IBI	IBI Group
ICD	Interface Control Document
ICF	ICF International, Inc.
ICTDP	Integrated Complete Trip Deployment Plan
IEEE	Institute of Electrical and Electronic Engineers
IOO	Infrastructure owner/operator
IORS	Installation and Operational Readiness Schedule
IPFP	Institutional, Partnership, and Financial Plan
IRB	Institutional Review Board
ITS	Intelligent transportation system
KHA	Kimley-Horn and Associates, Inc.
KTT	Knowledge and technology transfer
LDL	Local Deployment Lead
LEP	Limited English proficiency
LLL	Lessons Learned Logbook
MARTA	Metropolitan Atlanta Regional Transit Authority
MVP	Minimum viable product
NDA	Nondisclosure agreement
NOFO	Notice of Funding Opportunity
NTP	Notice-to-proceed
O&M	Operations and maintenance
OBU	On-board unit
OCSP	Operational Capability Showcase Plan
OCSS	Operational Capability Showcase Schedule
OIS	Outreach Implementation Schedule
ORDP	Operational Readiness Demonstration Plan
ORP	Operational Readiness Plan
ORT	Operational Readiness Test
ORTP	Operational Readiness Test Plan
OSS	Open-source software
OTP	Open Trip Planner
PED-SIG	Mobile Accessible Pedestrian Signal System
PII	Personally identifiable information
PMBOK	PMI Body of Knowledge
PMD	Performance Measurement Dashboard
PMESP	Performance Measurement and Evaluation Support Plan
PMESS	Performance Measurement and Evaluation Support Schedule
PMI	Project Management Institute
PMP	Project Management Plan
POC	Point of Contact

Acronym	Meaning
PTSEP	Participant Training and Stakeholder Education Plan
QA	Quality assurance
QAE	Quality Assurance Engineer
QC	Quality control
QPL	Qualified products list
RFP	Request for Proposal
RFQ	Request for Qualifications
RSU	Roadside unit
SAD	Systems Architecture Document
SDD	System Design Document
SDO	Standards Development Organization
SDS	Software Development Schedule
SEL	Systems Engineering Lead
SEMP	System Engineering Management Plan
SILCGA	Statewide Independent Living Council of Georgia
SLA	Service level agreement
SME	Subject matter expert
SOMS	System Operations and Maintenance Schedule
ST-CTN	Safe Trips in a Connected Transportation Network
STM	Space time memory
STP	System Test Plan
STRS	System Test Results Summary
STS	System Test Schedule
SyRS	Systems Requirements Specification
The ATL	Atlanta-Regional Transit Link Authority
TIS	Training Implementation Schedule
TSMO	Transportation systems management and operations
TSP	Transit signal priority
UI	User interface
USDOT	U.S. Department of Transportation
V&V	Verification and validation
WBS	Work breakdown structure
WCAG	Web Content Accessibility Guide

Table 21 below provides a list of commonly used terms throughout this document and associated definitions.

Table 21. Glossary

Term	Definition
Advanced Traveler Information System (ATIS)	a system that collects, aggregates and disseminates transportation information, such as traffic, transit, weather, and connected vehicle data. This data is aggregate into data environments allowing for the dissemination of this information to travelers via mobile devices. [ATIS]
Americans with Disability Act (ADA)	An act to “provide a clear and comprehensive national mandate for the elimination of discrimination against individuals with disabilities.” The act provides enforceable standards to address discrimination against individuals with disabilities and requires public facilities to be readily accessible and usable by individuals with disabilities [ADA].
Application Programming Interface (API)	Enables companies to make available the data of their products and services to external developers and business partners. This allows multiple services and products from different companies to communicate and leverage each other’s data for improved collaboration, innovation, and added security [API].
Cellular – Vehicle to Everything (C-V2X)	A connected vehicle platform that works over the cellular network to provide vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-pedestrian communication. It is similar to DSRC but uses the cellular network instead of a short-range spectrum. It is a 3GPP standard describing a technology to achieve the V2X requirements. C-V2X is an alternative to 802.11p, the IEEE specified standard for V2V and other forms of V2X communications. [CVTMP]
Connected Vehicle (CV)	A vehicle (car, truck, bus, etc.) that is equipped with a wireless communication device (1). A CV uses any of the available wireless communication technologies to communicate with other cars on the road (vehicle-to-vehicle [V2V]), roadside infrastructure (vehicle-to-infrastructure [V2I]), and other travelers and the cloud. [CAV]
Connected Vehicle Technology Master Plan (CVTMP)	a plan that 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. [ConOps]

Term	Definition
Dedicated Short-Range Communication (DSRC)	A protocol for communication between vehicles and between moving vehicles and fixed roadside access points. The protocol addresses safety critical issues associating with sending and receiving data. The protocol provides low-latency data-only V2V and V2I communications. [CAV]
General Transit Feed Specification (GTFS)	A data specification that allows public transit agencies to publish their data to be consumed by a variety of transit-related applications. This data includes schedule, fare, and vehicle position which can be used to predict arrival times and display real-time information [GTFS].
Mobile Accessible Pedestrian Signal System (PED-SIG)	A mobile application system that exchanges information between roadside or intersection sensors and mobile devices carried by a pedestrian. The system is used to inform impaired pedestrians when to begin traversing a crosswalk and how to remain within the crosswalk. [CAV]
Onboard Unit (OBU)	An ITS related hardware that performs the data exchange between the infrastructure and a vehicle and installed in a vehicle (includes an after-market device). An OBU may contain applications that process the data received from the infrastructure and other sources such as another OBU. [CI]
Personally Identifiable Information (PII)	Information on an individual's identity such as name, address, identifying number, telephone number, email address, etc.
Personal Safety Message (PSM)	A data broadcast by a vulnerable road user (such as pedestrians) to announce their presence to approaching vehicles. [CAV]
Regional Connected Vehicle Infrastructure Deployment Program (CV1K)	the program deploying interoperable CV technologies at signalized intersection through the Atlanta region using Dedicated Short-Range Communications (DSRC) and C-V2X technologies to deliver safety and mobility-based applications. [ConOps]
Roadside Unit (RSU)	A transportation field device that performs the data exchange between OBUs, MUs, and other infrastructure elements. [CI]
Signal Phase and Timing (SPaT)	The signal state of the intersection and how long this state will persist for each approach and lane that is active, according to the SPaT Benefits Report. The SPaT message sends the current state of each phase, with all-red intervals not transmitted. Movements are given to specific lanes and approaches by use of the lane numbers present in the message. In a connected vehicle environment, the message is sent from the roadway infrastructure to approaching vehicles. [CAV]

Term	Definition
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. References

This section includes a list of documents referenced during the plan, including URLs and USDOT Publication Numbers, where possible.

Table 22. References

ID	Referenced Documents
[CVTMP]	AECOM. "Gwinnett County Connected Vehicle Technology Master Plan (CVTMP)." Duluth: Gwinnett County Department of Transportation. (2019).
[PMP]	Atlanta Regional Commission. Deliverable Task 1A Project Management Plan. Atlanta: U.S. Department of Transportation. (2021).
[UNIRP]	Atlanta Regional Commission. Deliverable Task 1B User Needs Identification and Requirements Planning (FHWA-JPO-21-852). Atlanta: U.S. Department of Transportation. (2021).
[ConOps]	Atlanta Regional Commission. Deliverable Task 2 Concept of Operations (FHWA-JPO-21-857). Atlanta: U.S Department of Transportation. (2021).
[DMP]	Atlanta Regional Commission. Deliverable Task 3 Data Management Plan (FHWA-JPO-21-865). Atlanta: U.S Department of Transportation. (2021).
[SMP]	Atlanta Regional Commission. Deliverable Task 4 Safety Management Plan (FHWA-JPO-21-870). Atlanta: U.S Department of Transportation. (2021).
[PMESP]	Atlanta Regional Commission. Deliverable Task 5 Performance Measurement and Evaluation Support Plan (FHWA-JPO-21-875). Atlanta: U.S Department of Transportation. (2021).
[SyRS]	Atlanta Regional Commission. Deliverable Task 6 System Requirements Specifications (FHWA-JPO-21-880). Atlanta: U.S Department of Transportation. (2021).
[ETRA]	Atlanta Regional Commission. Deliverable Task 7 Enabling Technology Readiness Assessment (FHWA-JPO-21-885). Atlanta: U.S Department of Transportation. (2021).
[HUAS]	Atlanta Regional Commission. Deliverable Task 8 Human Use Approval Summary (FHWA-JPO-21-895). Atlanta: U.S Department of Transportation. (2021).

ID	Referenced Documents
[PTSEP]	Atlanta Regional Commission. Deliverable Task 9 Participant Training and Stakeholder Education Plan (FHWA-JPO-21-900). Atlanta: U.S Department of Transportation. (2021).
[IPFP]	Atlanta Regional Commission. Deliverable Task 10 Institutional, Partnership, and Financial Plan (FHWA-JPO-21-905). Atlanta: U.S Department of Transportation. (2022).
[OP]	Atlanta Regional Commission. Deliverable Task 11 Outreach Plan (FHWA-JPO-21-910). Atlanta: U.S Department of Transportation. (2022).
[SEMP]	Atlanta Regional Commission. Deliverable Task 12 Systems Engineering Management Plan (FHWA-JPO-21-915). Atlanta: U.S Department of Transportation. (2022).
[ATIS]	Connected Vehicle Reference Implementation Architecture (CVRIA). Advanced Traveler Information System. Santa Ana: Iteris. (2016).
[CV1K]	Georgia Department of Transportation. "The Regional Connected Vehicle Program Scope of Work." Atlanta: Georgia Department of Transportation. (2018).
[GTFS]	GTFS. General Transit Feed Specification Reference. Washington D.C.: GTFS. (2019).
[API]	IBM Cloud Education. Application Programming Interface (API). Armonk: IBM. (2020).
[CI]	ICF, Wyoming Department of Transportation. Connected Intersection - Concept of Operations. Cheyenne: USDOT (2018).
[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).
[ADA]	United States Department of Justice, Civil Rights Division. Americans with Disabilities Act of 1990. Washington D.C.: United States Government. (2009)
[DPP]	U.S. Department of Transportation. DOT Privacy Policy. Washington D.C.: U.S. Department of Transportation. (2016).
[BAA]	U.S. Department of Transportation, Federal Highway Administration. ITS4US Broad Agency Announcement. Washington D.C.: U.S. Department of Transportation. (2020)
[PAP]	U.S. Department of Transportation. Plan to Increase Public Access to the Results of Federally-Funded Scientific Research Results. Washington D.C.: U.S. Department of Transportation. (2015).

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