Phase 1 Integrated Complete Trip Deployment Plan

ICF-Buffalo ITS4US Deployment Project

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Final — March 11, 2022
FHWA-JPO-22-947

COMPLETE TRIP
ITS4US

U.S. Department of Transportation

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16. Abstract

The Buffalo NY ITS4US Deployment Project seeks to improve mobility to, from and within the Buffalo Niagara Medical Campus by deploying new and advanced technologies with a focus on addressing existing mobility and accessibility challenges. Examples of the technologies to be deployed are electric and self-driving shuttles, a trip planning app that is customized for accessible travel, intersections that use tactile and mobile technologies to enable travelers with disabilities navigate intersections, and Smart Infrastructure to support outdoor and indoor wayfinding. The deployment geography includes the 120-acre Medical Campus and surrounding neighborhoods with a focus on three nearby neighborhoods (Fruit Belt, Masten Park and Allentown) with underserved populations (low income, vision impaired, deaf or hard of hearing, wheeled mobility device users, limited English proficiency and older adults).

This document describes the deployment plan for Phase 2 and Phase 3. This plan compiles the activities in Phase 1 to provide an overview of the deployment at scale and the plan to deliver Phase 2 and Phase 3.

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ICF	March 11, 2022	0.2	Revised draft based on comments from USDOT

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1 Introduction

1.1 Introduction

Buffalo, New York (NY) is one of five sites selected for United States (U.S.) Department of Transportation (USDOT) Complete Trip - Intelligent Transportation Systems for Underserved Communities (ITS4US) Deployment Program, which seeks to integrate innovative technologies to improve mobility and accessibility. The Buffalo, NY project plans to deploy an integrated set of travel support services and systems within neighborhoods surrounding Buffalo Niagara Medical Campus (BNMC).

This document, which serves as both the Phase 1 Integrated Complete Trip Deployment Plan (ICTDP) and the Response to NOFO 693JJ322NF00001, details the refinements to the deployment concept made throughout Phase 1 and provides insight into the deployment approach for Phases 2 and 3.

1.2 Project Background

Buffalo is striving toward a sustainable future at all levels of society, incorporating actions in the community, government, and private entities in the area. Enabling community mobility and access to jobs, healthcare, and services to traditionally underserved populations is the primary motivation for all the regional partners involved in this deployment.

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

As one of the selected sites, the Buffalo, NY ITS4US deployment concept addresses:

1. **Providing transit access to healthcare and jobs** to underserved residents including persons with disabilities and allowing them to share in the economic development in downtown Buffalo.
2. **Leveraging technology to work in support for accessible transportation**, integrating accessible transportation technology, transit, and connected automation to solve a transportation need.
3. **Developing a scalable model** for considering accessibility and universal design in transportation technology projects.

The Buffalo, NY ITS4US project will be completed in three phases: Phase 1- Concept Development, Phase 2- Design and Test and Phase 3- Operation and Evaluation.

1.3 Document Purpose

The deployment process of the NFTA ITS4US Pilot will happen in Phase 2, with a duration of up to 24 months, followed by an 18-month demonstration period – Phase 3.

The purpose of this document is two-fold:

1. Summarize the Phase 1 activities in a way that presents a cohesive and comprehensive Phases 2 and 3 approach – what is proposed and how it will be accomplished. The ICTDP, a required deliverable under Task 13, serves as a capstone document that brings together the iterative, stakeholder-driven process used in Phase 1 to conceptualize the system.

2. Describe how the NFTA ITS4US Pilot team will successfully deliver on the requirements defined in the Notice of Funding Opportunity (NOFO). This document serves as our application for the NOFO and meets the requirement for Volume I–Part I identified in the NOFO. Through the ICTDP, NFTA seeks to articulate our ability to deliver on the plans in Phase 1 by identifying and demonstrating that the partnership, the systems engineering, and the development approaches are apt for the task.

1.4 Organization of this Document

The remainder of this document is organized as follow:

- Section 2 provides a summary of the deployment concept.
- Section 3 describes the Phase 2 and Phase 3 technical approach.
- Section 4 details the deployment schedule for Phase 2 and Phase 3, presenting information ranging from the program management plan of the project to the maintenance and operation plan.
- ~~Section 5 details the deployment cost estimate for Phase 2 and Phase 3.~~ Removed from this document.
- Appendix A provides the acronyms used and a glossary for reference.
- Appendix B lists the references used in this document.

2 Summary of Deployment Concept

The Greater Buffalo-Niagara Regional Transportation Council (GBNRTC) established its vision of the region for 2050 in its "Moving Forward 2050 – A Regional Transportation Plan for Buffalo Niagara" (GBNRTC; University at Buffalo Regional Institute, The SUNY at Buffalo School of Architecture and Planning; Cambridge Systematics; TyLin International, 2018). The plan seeks to guide transportation investments to:

1. Raise the region's standard of living.
2. Support efficient freight movement.
3. Maximize infrastructure resiliency.
4. Support focused growth in communities (urban, suburban, and rural).
5. Ensure access to opportunities and services.
6. Support healthy and safe communities through targeted transportation investment.
7. Strengthen the fiscal health of local governments.
8. Preserve and protect a healthy environment and accessible open spaces and waterways.
9. Create a fully integrated and seamless transportation environment.

The Buffalo ITS4US project goals directly align with GBNRTC's goals 1, 4, 5, 6, and 9 by providing innovative tools and services to better enable travelers to make complete trips in and around the BNMC. Furthermore, the proposed system focuses on providing transit access to healthcare and jobs to underserved citizens and allow them to share in the economic development in downtown Buffalo.

To achieve these goals, the proposed system of interest is made of four major subsystems and a variety of data interfaces between them. The four major subsystems include:

- **Complete Trip Platform** – The complete trip platform (CTP) is the integrated trip planning function for travelers. It includes various modules that allow users to personalize their trip planning, execution, and navigation experience. Specific modules in this subsystem include:

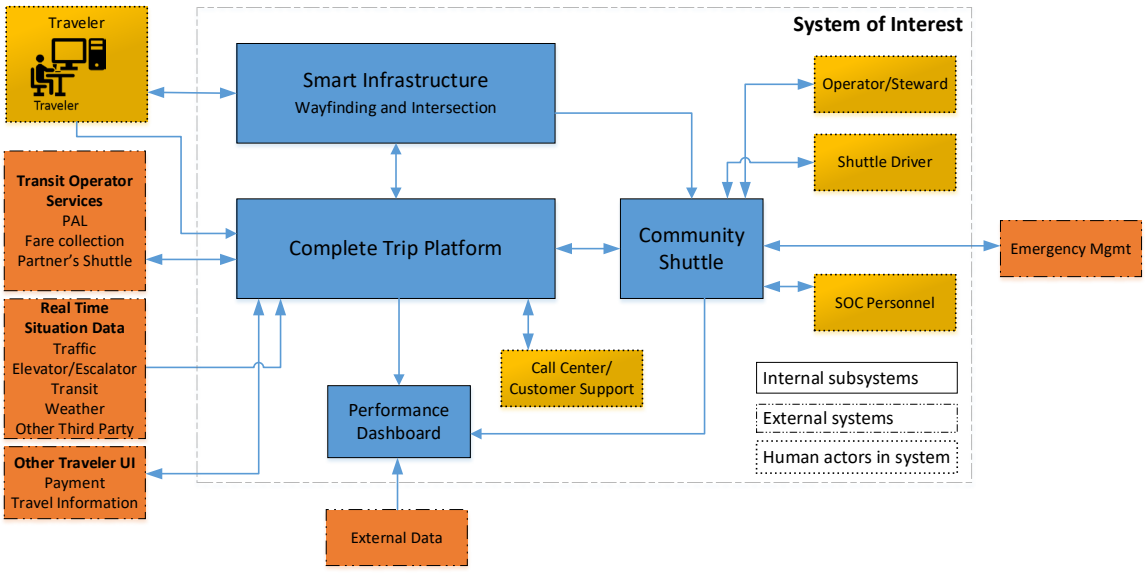
User Profiles	Real-time situation monitoring
Trip Booking	Performance metrics
Trip Planning	Trip history/ledger
Trip Monitoring and Notifications	User Interface (UI): Mobile application

Geolocation and Mapping
Navigation

UI: Web and Interactive voice response

- **Community Shuttle Subsystem** – The Community Shuttle subsystem provides demand-responsive transit services within a specified zone of operations, using a mix of vehicles, including both human-driven (HDS) and self-driving shuttles (SDS). The SDS will operate on a predefined route(s), consisting of a set of streets within the zone and pick-up and drop-off locations, but will be responsive to travelers' demand (e.g., it can skip certain pick-up/drop-off locations if there is no demand). The HDS vehicles will provide door-to-door on demand service within the zone of operation. Modules within this subsystem include both types of vehicles, as well as a Shuttle Operations Center (SOC).
- **Smart Infrastructure Subsystem** – The smart infrastructure subsystem includes wayfinding and orientation for indoor and outdoor, provision of navigation and destination finding through information kiosks (Transportation Information Hub), augmented communications technologies (Smart Signs that serves as aiding sensor for wayfinding and navigation), and intersection treatment (PED-X) for hands-free, pedestrian signal requests.
- **Performance Dashboard Subsystem** – This subsystem measures and presents the performance of the system to the agency operating the system.

Figure 1 provides a high-level context diagram for the system. The reader is referred to the Phase 1 Concept of Operations (FHWA-JPO-21-860) for more details on the system's components and functions.



Source: Buffalo, NY ITS4US

Figure 1. High level context diagram for the Buffalo, NY ITS4US System.

2.1 Site Stakeholders

Enabling community mobility and access to jobs, healthcare, and services to traditionally underserved populations is the primary motivation for all the regional partners involved in this deployment. As such, this deployment seeks to serve the specific transportation needs of BNMC visitors, employees, and residents of the focus neighborhoods that identify with the following groups:

- People with disabilities, including mobility/wheelchair users, visually impaired individuals, and individuals who are deaf or hard of hearing .
- Low-income individuals.
- Older adults.
- Limited- or non- English proficient persons.
- Caregivers for persons fitting in the above groups.
- People who work at the BNMC and who visit to receive medical services.
- People who live in the Fruit Belt, Masten Park and Allentown neighborhoods who travel to/from the BNMC or travel to/from the NFTA light rail station.

2.2 Deployment Objectives

Within and around the BNMC, there are accessibility-and pedestrian-related transportation and mobility challenges that hinder the BNMC and local/regional transportation agencies from providing safe and accessible transportation to residents and visitors. These challenges include traffic safety issues at street crossings, lack of accessible infrastructure in street rights of way, and lack of efficient and reliable circulation paths between facilities on the campus and in surrounding neighborhoods. These problems affect pedestrian activity for individuals with disabilities, older adults, and travelers with temporary mobility challenges (such as people carrying groceries or with double strollers).

Street crossings are challenging to people with disabilities and older adults. Common problems include the collection of water, ice, and snow at the bottom of curb ramps due to poor drainage; counter slopes at the bottom of curb ramps that make walking difficult and cause wheelchair users to bottom out; broken and irregular pavement in the crossing area; the use of brick and cobbles that makes wheelchair use very uncomfortable; deterioration of tactile warning signals; and poor contrast of crosswalks with the street surface. These issues and problems have a direct impact on people's ability to reach BNMC's facilities and get to their appointments on time, or even make the trip/appointment at all—this issue was highlighted during several interviews with stakeholders, as noted in the Concept of Operations document (FHWA-JPO-21-860). In Buffalo, emerging mobility services (e.g., bike share, e-scooter, ride share) may not be a viable option for the target population mentioned in Section 2.1. For those who cannot drive a personal vehicle, public transit continues to be the primary mode of choice.

The user needs assessment identified the following as desired changes in mobility and transportation opportunities.

- **Consistent, continuous trips to, from, and within the BNMC area**: Ensuring that there is an accessible and convenient path of travel to and from all origins/destinations.

- **Online and offline ways to receive real time information on services, and infrastructure usability and accessibility**: Enabling a comprehensive array of alternatives that includes online and offline visual, audio, and haptic notifications, or a combination thereof, would allow travelers to understand the current condition of their trip and how to best react to deviations from their original plans spontaneously.

- **Trip paths that are safe, accessible, and compatible with user-defined preferences and capabilities**: Guiding travelers to pathways that are reasonably leveled, slip resistant, and smooth, especially during mild-to-mid weather conditions.

- **Integrated, flexible, demand-responsive, end-to-end transit options for the community:** Ensuring integrated, complete, and comprehensive end-to-end services to travelers, including travelers with disabilities.

2.3 Applications and Services Provided

The proposed Buffalo Complete Trip-ITS4US concept brings together inclusive design, integrated trip planning, and micro transit elements to provide complete trip support to travelers who use the system, especially travelers with disabilities, and who are older, lower income, or limited in their English proficiency. Travelers using the complete trip system gain the following benefits from the system elements:

- A door-to-door travel planning app, or complete trip platform (CTP), that allows travelers to make safe, efficient and effective transit trips to and from the deployment area, including during inclement weather.

- Supporting indoor and outdoor wayfinding guidance near the BNMC.

- For paratransit access line (PAL) eligible travelers, an alternative way to access PAL services, as well as providing more flexibility and support for trips that are not supported by PAL.

- Increased safety and improved capability to cross specific intersections and use specific prioritized pathways for accessing BNMC campus entities.

- Access to a new community shuttle (CS) service with human-driven shuttle (HDS) and self-driving shuttle (SDS) that connects nearby neighborhoods to destinations and services within the deployment area.

- Enabling caretakers to manage and monitor trips for the travelers who are in their care.

2.4 Use Cases and Performance Measures

Performance measures (PMs) assess whether the short-term outcomes of the deployment (e.g., more efficient trips) have occurred as well as progress towards achievement of the desired longer-term impacts. To prioritize and guide the development of PMs, use cases were identified that describe the *functions for which* the deployment technologies (i.e., CTP, SDS and HDS shuttle service, smart infrastructure) are expected to have the greatest benefits for underserved groups.

Complete Trips Platform Use Cases

1) **Register Profile and Preferences** - This use case describes the processes and interactions with travelers to set up a CTP user account. The function enables the account holder to select their travel preferences for types of navigation triggers, wayfinding notifications and alert communications. The functions also enable users to identify their preferences for mode, accessibility needs, and link other accounts (such as a PAL account) with their CTP account.

2) **Generate Trip Plan and Book a Trip -** This use case consists of functions for a traveler to plan a trip by inserting their origin and destination. They may customize this trip by selecting general preferences (e.g., modes, maximum walking distance, shortest trip, fewest transfers), or if they log in to their account use an existing trip plan or set of preferences for travel and notification. The traveler can also adjust their trip preferences and save the updated trip plan. In addition, as an account holder authorized to use registered mobility services such as PAL or Shuttle, the traveler can generate a complete trip plan with a trip leg that includes reservations and confirmation with the mobility service (PAL Direct or Shuttle).

3) **Public Transport Services -** This use case describes the information provisions associated with accessing public transit mode options. These include NFTA bus, light rail, and PAL Direct, as well as Shuttle options that are included in these services. The services consist of hailing, boarding, traveling in and alighting these public transport vehicles.

4) **Navigation -** This use case describes wayfinding and navigation on pathways to complete a trip. This use case consists of the use of the CTP when traveling including crossing intersections, traversing sidewalks, wayfinding to and through indoor facilities.

5) **Reporting and History -** This use case describes information provided to the traveler on the CTP that is available for account holders about trips they completed. In addition, the traveler can submit trip obstacles and improvements made during their journey. This provides a crowd-source approach to collecting information on accessibility status, like elevator outages, paths in the trip plan, etc.

Human-Driven and Self-Driving Community Shuttle Service Use Cases

6) **Shuttle Service Reservation and Dispatch -** This use case describes several of the processes and functions of the Shuttle Operation Center (SOC), and especially those that will be applied and activated when receiving a traveler request for service by the shuttle system.

7) **Passenger Pick-up, Securement, and Drop-off via the SDS -** This use case describes several of the processes and functions of the Shuttle Subsystem which will be applied and activated when a traveler boards a SDS, secures themselves onboard the vehicle, travels on the SDS, and finally gets off the SDS at their final or intermediate destination.

8) **Passenger Pick-up, Securement, and Drop-off via the HDS -** This use case describes several of the processes and functions of the Shuttle Subsystem, which will be applied and activated when a traveler boards an HDS, has his/her mobility aid mechanism secured, travels on the shuttle, and finally gets off at their final destination.

9) **Manage Incidents -** This use case describes the processes and functions that will be activated by the shuttle subsystem to manage shuttle-related incidents. The incidents may involve the environment around the shuttle (e.g., inclement weather), the vehicle itself (a malfunction) or travelers onboard the shuttle.

Smart Infrastructure Use Case

10) **Intersection Pedestrian Crossing (PedX) Request -** This use case describes the transmission of a PedX request message from the CTP to the traffic signal controller. This use case supports the intersection crossing system.

The performance measures listed below were developed based on the above use cases and the data that will be available. Note that each measure has a set of metrics and targets that allows the research team to assess each measure.

- Improved ability of the CTP users to make satisfactory Complete Trips in the study area or help others to do so in the case of caregivers. This measure looks into how accessible, safe and integrated are the door-to-door trip plans/services and how useful is the information provided.

- Usefulness of the CTP Registration and Trip Preferences Processes. This measure assesses how easy it is to register and provide trip preferences.

- Usefulness of the CTP Trip Planning and Booking Processes. This measure analyzes the perceived ease of using the route planning and booking option, the satisfaction with the paths offered by the CTP, and the number of trip plans that are executed using the app. This measure also looks into the how users report incidents through the CTP platform.

- Improved ability to find destinations efficiently using the CTP wayfinding functionality. This measure assesses the percentage of CTP users who elect to receive the wayfinding notifications during their trips, frequency of active use of the wayfinding information, and perceived usefulness of the wayfinding information.

- Improved ability to cross specific intersections safely using CTP smart signal functionality. This measure looks into the use of the CTP intersection crossing function, its perceived ease of use, responsiveness and safety.

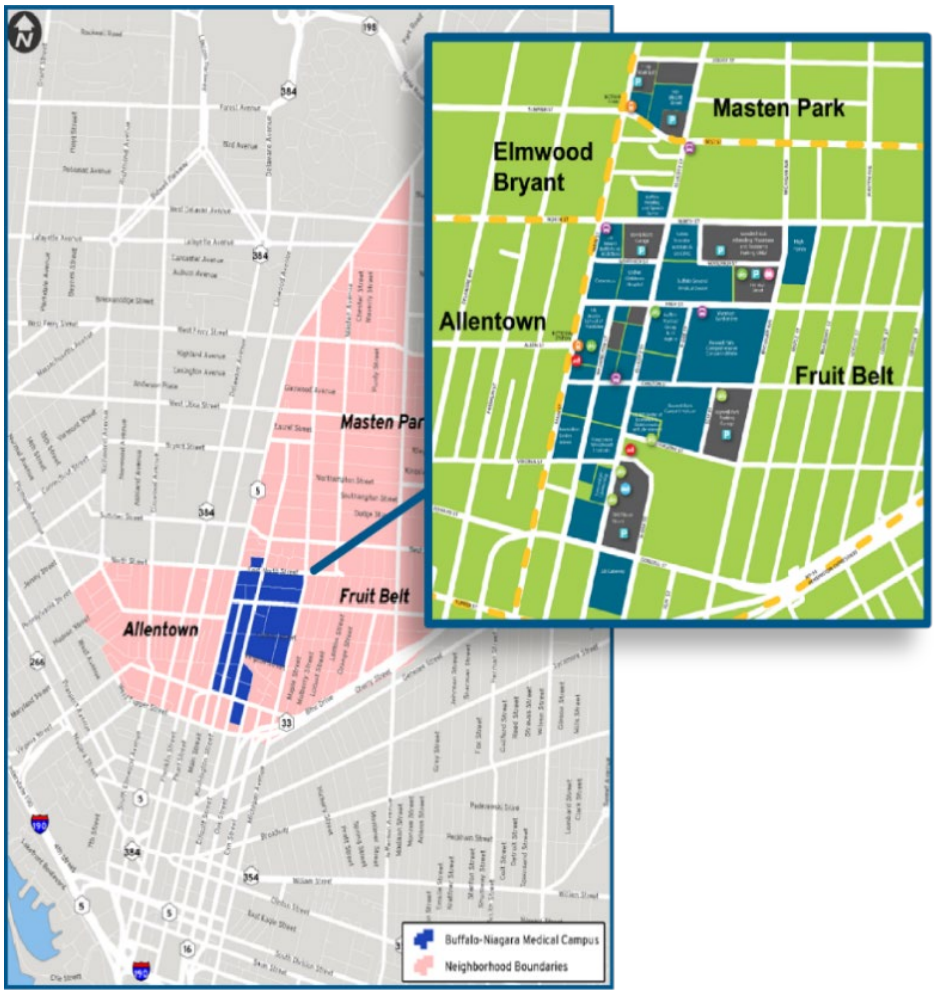
- Provision of an efficient, reliable, and safe new on-demand transit shuttle system. This measure assesses the community shuttle's reliability (perceived and measured on-time

performance), frequency of use and additional factors such as convenience and affordability.

2.5 Deployment Map

The deployment location for this project is the downtown Buffalo area, with a focus on the travel to and from the Buffalo Niagara Medical Campus (BNMC). This deployment includes the 120-acre Medical Campus and surrounding neighborhoods, with a target of three neighborhoods: Fruit belt, Masten Park, and Allentown—see Figure 2. The Buffalo Niagara Medical Campus include nearly 9 million square feet of clinical, research, office, and development space. More than 16,000 people work or study at the BNMC and more than 1.5 million people visit each year for healthcare and other services, generating a significant transportation demand for the area.

Note that the specific location of fixed components and routes for the Community Shuttle will be determined in Phase 2 once we have baseline data to determine the optimal location for each.



Source: ITS4US Buffalo, NY

Figure 2. Deployment Location.

2.6 Data Generated

Various types of data will be generated by the system. The type contains information on whether the data is structured, semi-structured or unstructured, and its velocity (static or dynamic), or unknown. Specific data types include:

- **Structured data** – Data formatted with schema defining data entries, their syntax, and semantics. Data types including in the dataset may include txt, csv, png, mpeg, and others. Dataset types include:
    - Application Programming Interface (API) – transaction set or data exchange services between two systems.
    - Geographic/attribute file – geographic data (features and attributes).
- **Semi-Structured data** – formatted data where the data entries may be ordered differently, or content may change. Dataset types include:
    - Log file – semi structured data set that includes a line (row) for each entry. Typically, entries include a date and time entered.
    - Web forms – semi-structured data.
- **Unstructured data** – unformatted data where data is unknown when delivered. Crowdsource input and surveys are examples of unstructured data.
- **Dynamic Velocity** – datasets that are streamed or require real time data acquisition methods. Dataset types include:
    - Real time data feed – real time data may be streamed, pushed, or pulled from a source.
- **Static Velocity –** datasets that are typically pulled from a source. They may change on a daily, monthly, or other frequency. Dataset types include:
    - Static data feed – static data that is typically pulled from a source. This data does not change very often.

Once data is gathered in the system, there are four different access levels to control the information. The access levels combine levels of privacy and license restrictions (e.g., limited copying or redistribution). There is one open access and three private access types, as listed below:

- **Open** – Data that can be used by the public with no or limited licensing restrictions. This data is available to the public without needing to request permissions and will be provided to the USDOT-managed Public System. These may be anonymized or aggregated version of private datasets to protect Personally Identifiable Information (PII).
- **Private - Research** – This data will be available for research, but in order to access the data, the users must meet IRB requirements. Research data may contain PII. Examples

of research data are Shuttle Booking Summary and Details, PAL Direct Reservations Summary and Details, CTP Usage Log Files, SOC Dispatch Log Files, Trip Planning Data, and Customer Comment Forms. There is also data that is categorized as research and open, which is stored anonymously.

- **Private - Operational (Proprietary)** – This data can only be accessed by data stewards and operational personnel for operations uses only. Third party datasets and protected data are included in this. Any access to third party or commercial business interest data is determined by usage agreements between parties. Examples of operational data include NITTEC Traffic Information, Intersection Crossing Assets, and Fare App APIs.

- **Private - Protected (PII)** – Data that has PII will be restricted to protect the PII. This data should have some operational purpose to justify its storage. An example of protected data is the CS Service Vehicle Manifest because it contains PII and HIPAA related information.

The overall data collection and management processes, e.g., storage systems, security provisions, quality control, and curation processes, will be governed by the Data Management Plan, to be updated in Phases 2 and 3 (as discussed in Section 3.1.3). The physical entities storing each type of dataset will be identified in the System Architecture Document.

2.7 Assessing Performance Measures

The performance measures will be assessed using the data generated from the Complete Trips Platform app, data from user surveys, shuttle reservations management data, shuttle trip operations data, and additional data on weather conditions, road construction and closures, and operating status of BNMC equipment and facilities. This assessment will take place during four key periods of time:

1. **Pre-Deployment (baseline)** – after participant recruitment and before using the Complete Trips Platform, namely late Phase 2 / early Phase 3.

2. **Initial Deployment** – at the end of the initial ramp-up period (first and/or second quarter of Phase 3).

3. **Mid-Term Post-Deployment** – halfway between the end of the ramp-up period and the end of Phase 3

4. **Final Post-Deployment –** at the end of Phase 3.

Each of the categories of performance has between two and eight metrics with associated data sources and targets—see Section 3.1.11 for a complete list of metrics. Ideally, by the end of Phase 3, all the components of the system would rate better (on average) across all measures of performance—further confirmation is needed through the Phase 2 Alpha and Beta testing that will occur as part of the agile development process. Persons involved in the Alpha and Beta testing will be “outside” of the recruited study participants so as not to bias their baseline data results. In Phase 2, data from these types of questions can be used in a diagnostic and exploratory manner, to (1) provide a preliminary assessment of the performance of various aspects of the CTP and

other system components as they are developed and introduced, and (2) to set realistic targets for what levels can be achieved in Phase 3.

2.8 Participant Safety

To ensure safety of all participants, a three-step approach of identifying the safety needs and hazards, assessing the safety risks, and a safety operational concept will be developed.

- **Safety Needs and Hazard Identification** - Use case scenarios have been developed to identify the hazards as a result of traveler or operator interactions with different parts of the system, including travel during severe weather and proper response to emergencies.

- **Safety Risk Assessment** - A number is assigned to dimensions of severity, exposure, and controllability. The numbers vary from 0-4 with 4 being the worst-case scenario. Severity refers to the worst possible consequences of each scenario described. Exposure refers to the probability of the system having to operate in the given scenario. An example of exposure level four would be the probability of each participant of getting off the bus. Given that every participant who gets on must get off, this will happen all the time and is highly probably. The final level, controllability refers to the ability to avoid a given hazard through actions of the person operating the system or the system's control.

- **Safety Operational Concept** – Once performing the two steps of hazard identification and the safety risk assessment, the goal with the Safety Operational Concept is to avoid, mitigate and respond to all the potential safety impacts identified in the previous sections. There are four approaches to the Safety Operational Concept for this project: including safety design elements; establishing policies and operating rules (e.g., regular maintenance of the community shuttle vehicles, and appropriate training and education programs); adding pre-deployment conditions or fail-safe modes for when a component fails; and implementing emergency response plans.

In addition to the three-step process of identifying safety needs and hazards, assessing risks, and developing a safety operational concept, key stakeholders will form a committee to inform the safety of those traveling to and from BNMC; persons with disabilities (PWDs) using the Buffalo ITS4US system; the Community Shuttle; and the SDS. The committee is designed to meet on a regular basis to identify any hazards and how to mitigate them. A Committee Charter will be developed during Phase 2 to describe the roles and responsibilities as applied to each use case scenarios. The use cases will describe the range of safety hazards and mitigation actions, from daily to emergency situations. The Charter will also describe the frequency of training and the types of tabletop exercises and in-field training each of the stakeholders associated with ensuring passenger safety will need to undergo.

2.9 System Security

To ensure system security, especially when considering data exchange, there are several considerations and steps put in place. The system requirements include a multilayered security policy. Physical devices are specified to be tamper proof and will be secured and surveyed in facilities and vehicles. Network security will be implemented through firewalls and enforcing security policies and rules to prevent infiltration through the network. Endpoint security by

restricting data exchange only with authorized entities. Application security by implementing user/role-based access to applications. And finally, data security by enforcing security provisions to data at-rest (in data stores) and in-transit (exchanged between entities).

As noted in the Systems Engineering Management Plan (SEMP) (FHWA-JPO-21-918), procedures for security monitoring will be included in a System Operations and Maintenance Standard Operating Procedures (SOP). The SOP will include all communications, tools, and practices to manage traveler and operator safety and security, as well as security oversight of PII. Consistent security monitoring, including audits and system updates, will also be included in the SOP, to ensure comprehensive system security.

The security of less mature systems is outlined in the Enabling Technology Readiness Assessment. For example, for the ET-2 Paratransit Access Line (PAL) and HDS Trip Booking interface, it is explicitly expressed that there will be security provisions and policies in place to ensure that the data exchange does not include any medical or personal information that could be traced back to a specific user.

2.10 Open-Source Software

The software generated for this project will be published as open source software (OSS) and provided to the USDOT OSS system with the proper documentation that details how to install, test and run the applications

The Complete Trip Platform (CTP) application leverages the Open Trip Plan software, an existing, publicly available open-source software, interfaces, features, and application modules. As identified in the SEMP's Appendix B, a plan to manage all OSS is available. The plan includes how we will manage the OSS code related to both the CTP and the Performance Measurement Dashboard. All OSS code will be published and managed through a GitHub site, which is open to third party developers. The code will include build and compilation routines, testing procedures and other architecture design documentation generated from the development and deployment effort.

In addition, interface specifications and control documents, conformance and testing procedures or tools will be included in the OSS with information on how they should be used with the project code bases.

2.11 At-Scale Deployment Summary

Table 1 provides a summary of the at-scale deployment numbers as expected to be during Phases 2 and 3. The numbers achieved during Phase 3 are intended to be maintained as a part of a sustained deployment for a minimum of five years beyond the completion of the Pilot (end of Phase 3).

Table 1. The Deployment in Numbers

Deployment Element	Estimated Number
Participants	100 participants during Phase 2 to support development and testing of the system and its components. 300-500 participants total in Phase 3 (including Phase 2 participants). Final number will be dependent on the number of people interested in participating. Outreach and recruitment efforts will focus on obtaining the highest and most diverse number of participants possible.
Beacons/Smart Signs	Under 100 devices. The final number is unknown at the time and will be determined once the facilities are measured.
Touch Models	1 model as part of this pilot (location to be determined in Phase 2). Note that pilot will leverage the efforts of an external study that is placing another model at the Innovation Center on the BNMC.
TIH	2 hubs, with location to be determined in Phase 2.
PED-X Intersections	2 intersections, Main St. & Best St. and Ellicott St. & High St. 2 National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) Supported MioVision platform to serve as a communications broker / gateway (one per intersection, total number: 2).
Vehicles	A maximum of 4 shuttles , a combination of SDS and HDS. Phase 2 will start with 2 shuttles for testing and integration efforts, and 2 additional shuttles will be added in Phase 3. SDS Vehicles: 1-2 (note: the number will depend on the procurement) HDS Vehicles: 2-3 depending on the service plan.
Online/Offline Platforms	1 CTP website and mobile application. 1 Performance Dashboard.

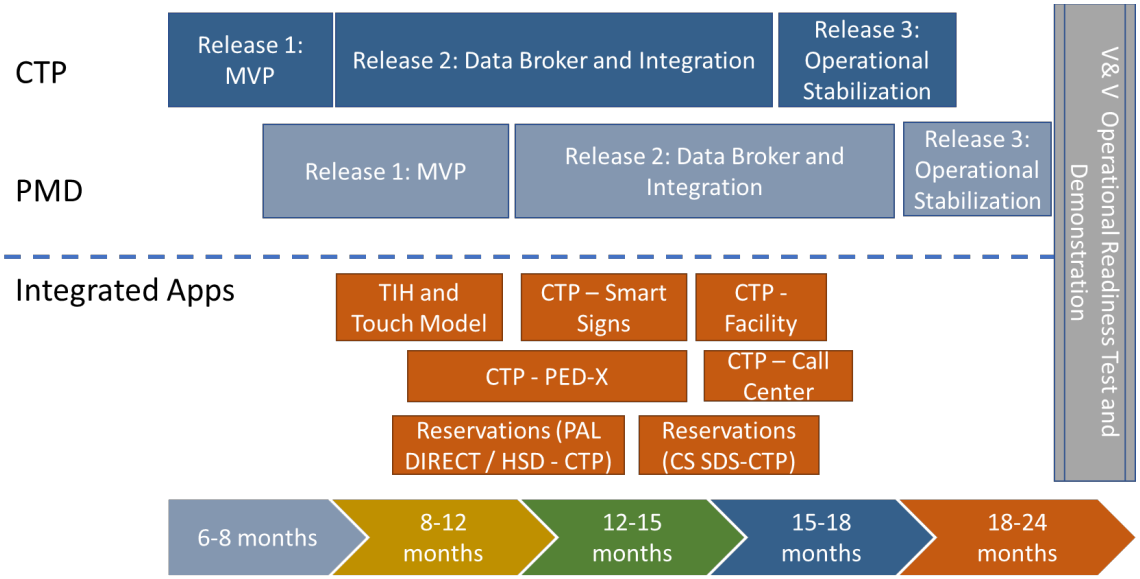
Figure 3 presents the Agile process release plan for the different component throughout Phase 2 of the pilot. Based on this release schedule, it is expected that:

- The Performance Dashboard will be ready for testing and stabilization by month 18 of Phase 2. Release 3 will consist of populating the system with outputs from other subsystems, fixing bugs and preparing data analytics and reporting functions.

- The CTP platform will be developed through three releases, with the final product ready for testing, stabilization, and integration towards the end of the third quarter of Phase 2.

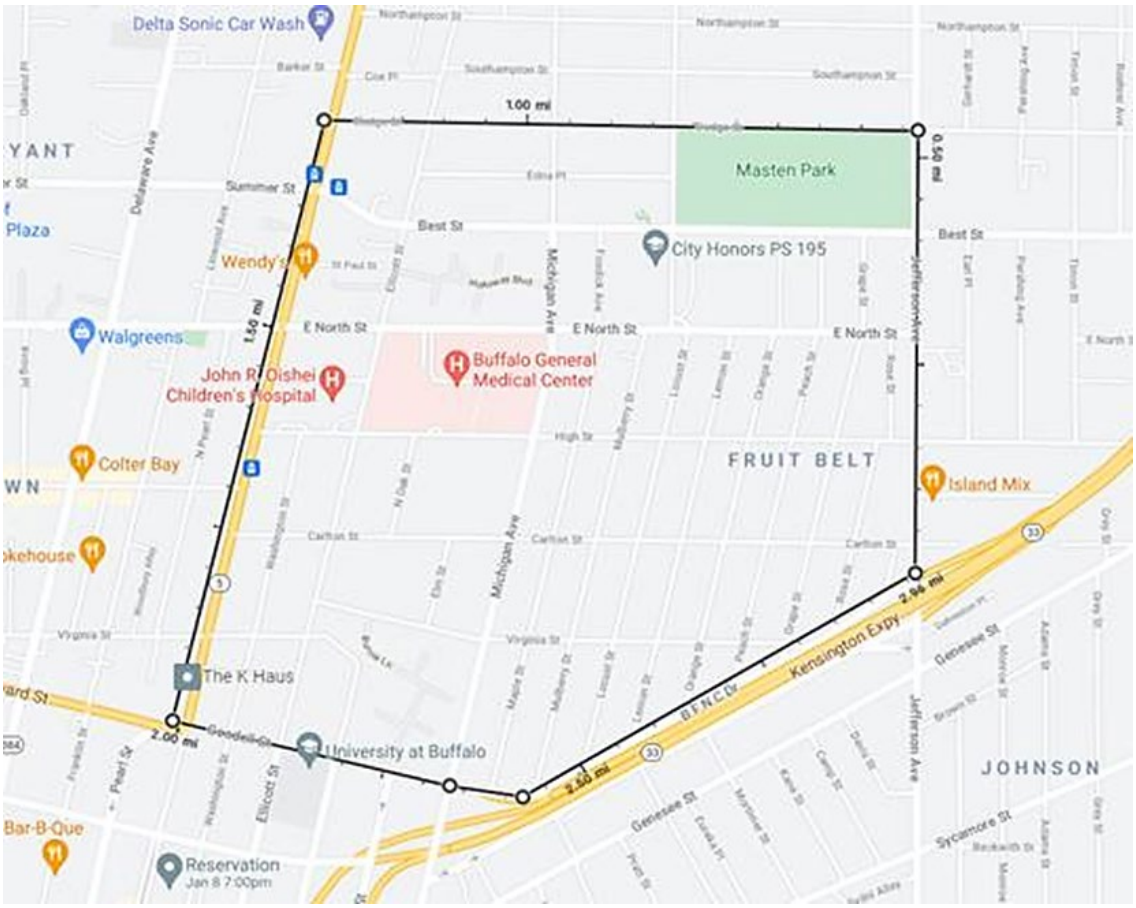
- The first shuttles will be available for tests and integration during the last six months of Phase 2. Figure 4 shows the proposed area of operations for the Community Shuttle—final area and routes will be determined in Phase 2.

- In addition to the testing of each Agile sprint, release, and integration element, testing and integration of most applications and services will take place during the last 6 months of Phase 2, alongside with a system wide operational readiness test and demonstration. The overall approach to testing is discussed in Section 3.1.7.



Source: Buffalo, NY ITS4US

Figure 3. Phase 2 Release Planning for Agile Processes.

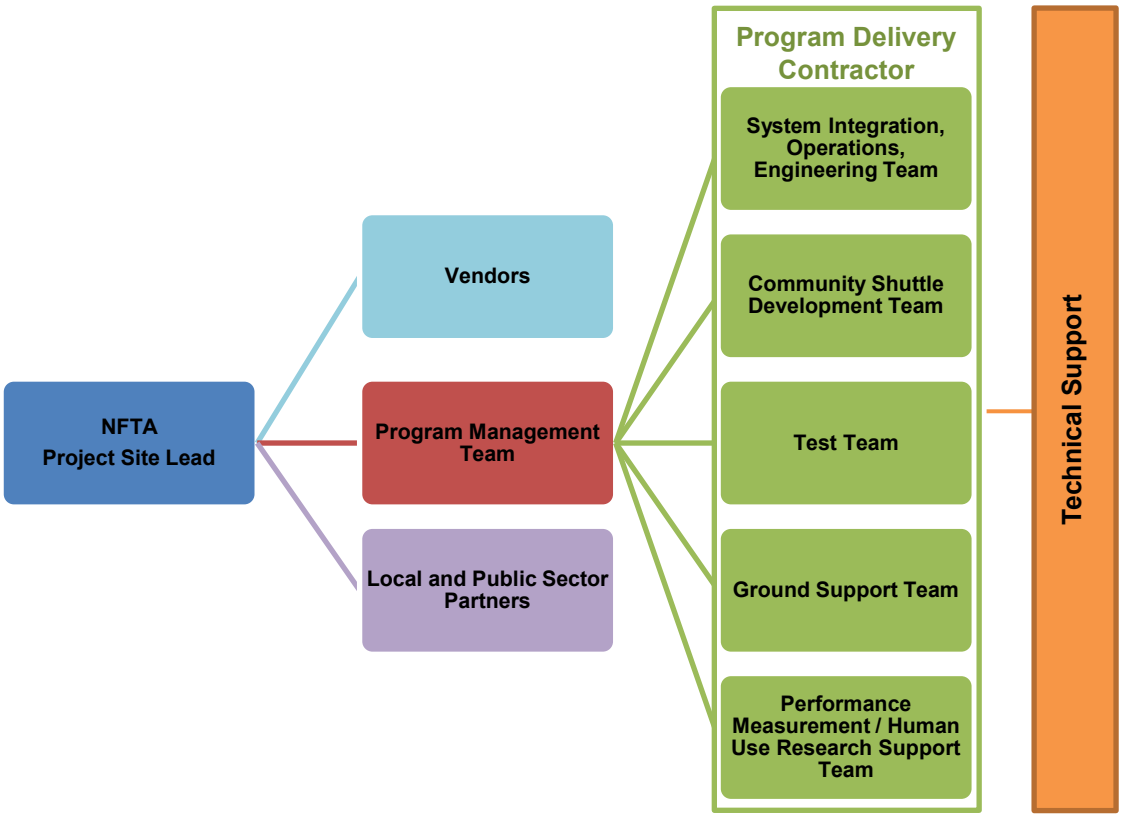


Source: Buffalo, NY ITS4US & Google Maps.

Figure 4. Proposed Service Area for the Community Shuttle

2.12 Team Organizational Structure

The Niagara Frontier Transportation Authority (NFTA), as the grant recipient for the pilot, is the overall lead and responsible for the governance of Phases 2 and 3 of the pilot. NFTA will be supported by a program delivery contractor team and partners to deliver the scope of work identified in the grant award—see Figure 5 for a high-level governance structure of the Phase 2-3 Project Team. The names and firms associated with the program delivery contractor team will be identified through a competitive Request for Qualifications (RFQ) process conducted by NFTA.



Source: Buffalo, NY ITS4US

Figure 5. Team Governance Structure for Phases 2-3.

NFTA envisions a comprehensive delivery team that includes all the necessary roles to delivery Phase 2 and Phase 3. In anticipation of the RFQ, the teams and supporting key personnel have already been identified and are described in Table 2.

Table 2. Key Support Personnel for Phases 2-3.

Personnel	Role
Program Management Team	
NFTA Project Mgmt. Lead	• Manages the project and leads the management team, including the Systems Engineering Lead (SEL), Deployment Lead, and procurement processes. • Manages budget and schedule.
NFTA Deployment Lead	• Manages the day to day operations of the project including organizing and leading deployment team meetings, coordination, agreements and partnerships. • Monitors team performance and implements management best practices throughout the project. • Ensures that the system is built in accordance with the approved concept and that provides a smooth

Personnel	Role
	transition from pilot to continuous operations through NFTA.
Program Delivery Manager	• Oversees the day-to-day activities of the project.
Program Delivery Support	• Supports the Program Delivery Manager.
QA Engineer	• Reviews technical materials for accuracy, consistency, and clarity. • Reviews deliverables for clarity, editorial quality, completeness, and conformance to deliverable templates
Procurement Lead	• Manages procurement process for externally acquired services. These may include SDS vehicle and system operations center, application programming interface (API) and integration activities with third party vendors, and component installation.
System Integration, Operations, Engineering Team	
System Engineering Lead (SEL)	• Manages systems engineering processes including traceability from needs to system verification/validation. • Oversees verification and validation support to development teams through the Configuration Manager and Lead Test Manager. • Oversees system development approach including procurement and agile schedule and coordination. • Attends, represents and participates in project management meetings. • Coordinates, develops and reviews all technical solutions to ensure they are developed to meet scalability, reliability and quality provisions. • Leads technology team including Scrum masters and procured systems technical lead to ensure seamless integration and deployment.
Deputy SEL	• Support the SEL and co-manage the system engineering process.
Configuration Manager	• Verifies new systems engineering documents are consistent with existing systems engineering needs and requirements. • Ensures traceability to previous systems engineering documents. This person also manages updates and changes to systems engineering documents to ensure consistency and integrity of needs and requirements traceability throughout process. • Reports on impacts to needs and requirements to the Configuration Control Board (CCB).
Master Scrum Master	• Coordinates efforts with each team scrum masters who are using an Agile Development Method, as well

Personnel	Role
	as with external systems (e.g., signal systems) and community shuttle system integration activities. • Manages overall and integration processes, product backlog, sprint roadmap (schedule), stakeholder input. • Coordinates software development lifecycle efforts among agile and non-agile development teams including internal reviews, software merges, testing and defect management, change management, and alpha and beta testing participants. • Establishes liaison between stakeholders and developers. • Schedules integration teams based on user and product backlog dependencies. • Works with SEL and team scrum masters to manage implementation and deployment. • Works with System Engineering staff to ensure traceability to needs and requirements through integration and acceptance testing.
CTP Scrum Master	• Leads the Agile development process for the CTP. • Coordinates efforts with the Master Scrum Master. • Leads CTP sprint planning, review, and demonstrations. • Measures and reports on sprint statistics. • Interacts and solicit inputs from stakeholders to identify updates to the sprint outcomes. • Assigns backlog and determines with the Product Owner, when Sprints are Ready and when development is Done.
CTP Developer Team (database /application /user experience / test manager)	• CTP developers who work together to design, code, integrate and test the CTP platform. • Attend CTP sprint planning, review and demonstration meetings. • Participate in Agile integration teams as needed.
PMD Developer Team	• PMD developers who work together to design, code, integrate and test the PMD subsystem. • Attend PMD sprint planning, review, and demonstration meetings • Participate in Agile integration teams as needed including developing public portal, supporting performance metrics and supporting metadata management.
Ped-X Integrator	• Serves as the lead engineer / solution architect for the Ped-X equipment and services. • Coordinates with third parties to incorporate Ped-X equipment and services into the ITS4US services.

Personnel	Role
Indoor Navigation and TIH Integrator	• Serves as the lead engineer / solution architect for the indoor navigation and TIH / touch model equipment and services. • Coordinates with third parties to incorporate indoor navigation and TIH/ touch model equipment and services into the ITS4US services.
Community Shuttle Development Team	
CS Integration Lead	• Coordinates integration of NFTA's Paratransit Access Line (PAL) services, including the dispatch, into the Community Shuttle (as the HDS). This person will also facilitate the integration of the SDS into the CS. • Coordinates integration of the different types of vehicles/services making up the CS Subsystem. • Coordinates integration of the SDS passenger onboard services with the SDS vehicle. • Coordinates integration of the commercial-off-the-shelf (COTS) within the SDS SOC. • Designs testing procedures for the CS Subsystem. • Supports CS-related Operational Readiness Test Plan criteria, verification, and validation.
HDS Passenger (Pax) Onboard	• Oversees the procurement of the hardware (HW) and software (SW) (HW/SW) for the HDS passenger onboard services. • Oversees and manages the integration of the different COTS procured for the HDS passenger onboard services. • Designs testing procedures for the HDS passenger onboard services to ensure the satisfaction of the requirements. • Supports the HDS passenger onboard services Operational Readiness Test Plan criteria, verification, and validation.
SDS Pax Onboard	• Leads the integration of the SDS passenger onboard services with the SDS vehicle.
SDS Veh/SOC COTS Lead	• Leads the integration of the commercial-off-the-shelf (COTS) within the SDS SOC.
SDS Testing	• Supports the testing of all SDS components and services. • Supports CS-related Operational Readiness Test Plan criteria, verification, and validation
Test Team	
Test Lead	• Establishes a consistent approach for performing integration testing for both the Agile developed subsystems and procured systems.

Personnel	Role
	• Establishes testing and integration schedule with technical teams. • Reviews test case, scenarios and pass/fail criteria to ensure that they address requirements and user needs. • Reviews test for pass and ranks test failure severity and debug schedules. • Supports Operational Readiness briefing checklist • Supports ORP testing criteria, verification, and validation. • Coordinates with the SEL, deputy SEL, and configuration manager, verifies / validates that the ORP testing meets end-to-end user needs.
Ground Support Team	
Outreach Lead	• Coordinates and oversees all stakeholder outreach activities for the pilot.
Outreach Team	• Supports stakeholder outreach activities.
Recruitment Lead	• Coordinates and oversees all stakeholder engagement activities for the pilot.
Field Support	• Supports all stakeholder engagement and field data collection for the activities for the pilot.
Training Lead	• Coordinates and oversees all participant training activities for the pilot.
Performance Measurement / Human Use Research Support Team	
Human Use Research and Approval Lead	• Coordinates and oversees all efforts needed to maintain IRB compliance for the duration of the pilot.
Performance Measurement Lead	• Coordinates and oversees all performance measurement and evaluation activity for the pilot.
Performance Measurement Team	• Support the performance measurement and evaluation activities for the pilot.

2.12.1 Changes in Organizational Form from Phase 1

Phase 1 of the ITS4US deployment was led by ICF. NFTA will be the lead for Phase 2 and Phase 3 and identify a delivery contractor team that will accomplish the scope in these phases. The selected team will deliver the program per the plans developed in Phase 1 and identified in technical approach in Section 3.

2.12.2 Summary of Financial and Organizational Models for Sustained Operations

Sustained operations beyond Phase 3 are expected to be based on the successes and lessons learned demonstrated in Phase 2 and Phase 3 but will vary based on each component.

- Complete Trip Platform – Once operational, the use of the app may expand through participation of the 511NY Rideshare program for travelers in Buffalo[1] and potentially other regions within the State. Additional development and integration efforts will occur as part of a statewide mobility management strategy.

- Community Shuttle – Based on the demand and reception by the traveling public, BNMC Inc, NFTA and other community partners would need to identify a sustainable model of operational funds for the shuttle operations. This could be from other public and private grant funding, partner contribution. It is likely that the SDS technology and business models at the end of Phase 3 be significantly different than what was used in this demonstration. As such, future financial and organization models will consider the prevailing SDS capabilities and business models at that time. Aspects of the human driving shuttle operations and CTP technology may also be integrated as part of regular NFTA operations. The transition plan developed in Phase 3 will identify an organizational and financial model for the shuttles, summarizing lessons learned and the results from quantitative analysis on operational cost and return of investment.

- Indoor and outdoor navigation infrastructure – Largely, these would be low-cost equipment that would likely be maintained through BNMC Inc and partner activities.

- Ped-X Infrastructure – Different parts of NYS are exploring upgrades to traffic signals using technology providers that will be part of this pilot. Overall, if the Ped-X application shows value, overtime, greater and greater proportions of signals that upgrade their intersection hardware can support this feature. At this time, it is expected that the two intersections equipped as part of this deployment will be maintained and operated by the City of Buffalo as part of their regular operation structure. Maintenance responsibilities and ownership of this will be revised in Phases 2 and 3.

2.12.3 Organizational Risks

The robust stakeholder-driven systems engineering process followed in Phase 1 allowed the team to identify and mitigate several organizational risks around the scope of the deployment. In transitioning from Phase 1 to Phase 2 and during Phase 2 and Phase 3, the three critical organizational risks that remain include the following:

1. **Successful selection of the program delivery contractor.** NFTA issued an RFQ on March 8, 2022, expected to close on March 30, 2022, to begin the process of selecting the contractor. NFTA will select the contractor based on their demonstrated ability and approach to successfully deliver the contract.

[1] 511NY Rideshare is sponsored by the New York State Department of Transportation to work with large and small employers, public and private agencies, property managers, and commuters throughout New York State to reduce traffic congestion, improve air quality, and empower New Yorkers to make smart transportation choices. Information for the Greater Niagara Region can be found HERE (https://511nyrideshare.org/web/go-buffalo-niagara/).

2. **Procurement of the SDS vendor.** Given the market uncertainties, and rapidly changing landscape of low-speed shuttle operations, this remains a high organizational risk. The ability of the private sector to successfully support an SDS demonstration may change rapidly. For example, a SDS company that was active with University of Buffalo recently ceased operations. Other companies are rapidly pivoting in terms of software, vehicle models and business arrangements. NFTA will work early in Phase 2 to begin procurement for this aspect of the pilot.

3. **Staff and participants turnover.** Recruitment and retention of the required staff and target populations is always a risk in deployment projects, especially when considering changing travel patterns and conditions. Building from our human-use plan and the IRB application, the team would need to recruit users early in Phase 2 to help support the development of the CTP. Maintaining the user group for an extended period of time is an ongoing risk that needs to be managed. For staff retention, the deployment project will leverage its internal retention policies as well as those of selected vendors and team members.

3 Phase 2 and Phase 3 Technical Approach

The following sections present our approach to the design and development of the ITS4US Deployment Pilot. Our approach mirrors the task order and requirements specified in the NOFO.

3.1 Phase 2 Technical Approach

3.1.1 Task 2-A: Program Management

Managing a multidisciplinary team of partners, engaging the broader list of stakeholders effectively, communicating, and reporting on progress with the Federal Highway Administration (FHWA), and maintaining the integrity and quality of the deployed pilot concept while adhering to scope, schedule, and cost are the primary requirements for NFTA throughout Phases 2 and 3.

As the grant awardee, NFTA will be responsible for successful oversight and program management throughout this task. NFTA will be supported by the expertise from the deployment team—as stated in Section 2.12, the program delivery contractor team will be identified through a competitive RFQ process conducted by NFTA.

Following Project Management Body of Knowledge guidance, the team will create a Program Management Plan (PMP) for Phase 2 using the template developed in Phase 1. This version will describe, in each section, the sub-plans—Scope Management, Schedule Management, Communications Management, Cost Management, Quality Management, Configuration Management, and Risk Management—and the roles and responsibilities of all key individuals of the project team for Phase 2. The plan will include:

- **Managing Scope** – As the project evolves, NFTA and the project management lead will identify any impacts to scope early. The scope is controlled by the information presented in the grant award document. Modification of the scope of services can be authorized only by the USDOT Grant Officer. This authorization will be the only basis upon which scope and budget modifications are made, change orders are issued, and (if applicable) additional compensation claimed. All deliverable submissions will be sent to the ITS Projects mailbox (ITSProjects@dot.gov) in addition to the Grant Officer's Representative. As the project progresses, USDOT will verify project deliverables against the Work Breakdown Structure (WBS) and deliverables list. USDOT will issue a written acceptance of the deliverable once they have verified that the deliverable meets the requirements defined in the project plan. All deliverables will be submitted as draft documents and reviewed by USDOT. Changes to drafts and comments will be provided in writing to the ICF Project Manager. NFTA will revise the documents and provide a comment disposition matrix along with the final deliverable.

- **Managing Schedules** – The baseline schedule is included in this application. Schedule management activities include monitoring, analyzing, documenting, prioritizing, approving or rejecting, and publishing all schedule-related changes. NFTA will create the baseline project schedule using Microsoft Project, noting the estimated durations of activities and relationships among them. The resulting schedule is subject to control, requiring that any proposed major change be submitted for formal review and approval.
- **Managing Workload and Resources** –Staff requirements will be identified for each element in the WBS. By combining the hours listed in each project for staff members, utilization levels are tracked monthly.
- **Managing Quality** – During quality planning, NFTA identified a Quality Assurance / Quality Control (QA/QC) Lead for the project. With assistance from members of the Project Leadership team, the QA/QC Lead will identify relevant quality standards for the project and determine how to satisfy them. For this phase of the project, the quality planning standards that will be considered include, but are not restricted to, the following:
    - Documentation standards – Meeting ITS-JPO's documentation and publication guidelines including 508
    - Acceptance Standards – Meeting USDOT's acceptance criteria for all required deliverables
    - Schedule Standards – Ensuring on-time delivery of all project deliverables
    - Quality assurance review standards – Ensuring technical quality of deliverables
    - Testing standards
- **Managing Cost** – An Earned Value Management System (EVMS) will be used to monitor cost performance. The following four Earned Value metrics will be used to measure project cost performance consistent with Project Management Body of Knowledge guidelines:
    - Schedule Variance (SV)
    - Cost Variance
    - Schedule Performance Index (SPI)
    - Cost Performance Index (CPI)
- **Managing Configuration Control** – NFTA strongly believes in ensuring configuration control of all deliverables and activities produced under this task. Not only will all documents be configuration controlled through our online document sharing portals, but a Configuration Control Board (CCB) will be established to manage document updates. The **Configuration Manager** will report to the CCB on a periodic basis to report on the justification and outreach to stakeholders that precipitated changes to needs, requirements, and constraints encountered during the development, deployment or operations. The Configuration Manager will identify the documents that need to be changed, discuss the impacts of these changes, and maintain working deliverable documents where the changes are maintained, including selected past deliverables. Minutes of the CCB meetings will be kept and stored with discussion and consensus of the proposed changes.
- **Managing Risk** – Effective risk planning involves a clear process for identifying risks, analyzing the impacts, and developing a response plan to mitigate the impact of the risk—with all actions being recorded in a risk log. NFTA will follow the risk cycle rigorously throughout the project and proactively identify, analyze, plan, and monitor risks.

The draft PMP shall be delivered to DOT for review within 4 weeks of the award. Upon review, NFTA will resolve DOT's comments. The PMP will be a living document that will be updated quarterly throughout Phase 2, or sooner if needed.

The PMP shall be accompanied by a detailed deployment Project Schedule. The Project Schedule shall list all activities required to bring all required work to a successful completion and shall contain – at a minimum – three levels of the Work Breakdown Structure (WBS). The Project Schedule should be submitted in Microsoft Project (2007 or later) format. The Project Schedule shall be updated monthly and shall describe the following:

- Name of the work activity;
- Expected start and end dates;
- Name of the individual with the primary responsibility for accomplishing the work;
- Dependencies with other work activities in the Project Schedule;
- All deliverables, procurements, or milestones resulting from the work activity; and
- Percent Work Completed.

NFTA will maintain a high degree of communication throughout the project both internally with the project team and externally with USDOT. The team will create a coordination site where all project documents will be available at different levels of access to the entire team and FHWA. Monthly progress reports will be submitted to FHWA that include all deliverables and deliverable status, narrative of month's accomplishments by task, project activities in the next quarterly period, an updated work breakdown structure, and narratives for schedule risk, technical risk, partnership risk, retrospective cost and project cost-to-complete.

Below are highlighted efforts that NFTA will take to communicate with FHWA**.**

- **Kick-Off Meeting** – To kick off the Phase 2 activities, the team's key personnel will attend a kick-off meeting in Washington, DC within four weeks of the award effective date, organized by the Agreement Officer's Representative (AOR). The kickoff meeting is planned as an in-person meeting, however, may be replaced by a virtual meeting subject to DOT approval and local guidelines/policies regarding in-person meeting restrictions.
- **Monthly Progress Reports** – NFTA will provide Monthly Progress Reports following the DOT-approved template provided by the DOT at the Phase 2 kick-off meeting. This monthly report is composed of two documents, the Technical Progress and Status Summary, and the Detailed Financial Summary.
- **Lessons Learned Logbook (LLL)** – To meet overall program goals, deployment sites are expected to share insights and lessons learned with peers considering or actively deploying similar capabilities. This includes the accommodation of site visits and other activity/products conducted in Task 2-J Outreach. In addition, in this task NFTA shall maintain a Lessons Learned Logbook (LLL) that captures for each lesson: a succinct title, relevant agreement task (e.g., Task 2-D), a summary of the issue identified, the realized/potential impacts, mitigating action(s) taken, and results identified (to date). The

LLL shall be updated monthly, and a summary of new or updated entries incorporated into the Part I: Technical Progress and Status Summary in accordance with Monthly Progress Report Section. The LLL will be used for several purposes including developing Technical Memoranda for Standard Development Organizations.

- **Bi-Weekly Deployment Teleconferences** – Bi-weekly progress calls with USDOT will supplement the progress reports required as part of the contract. The project management lead will attend monthly all-site coordination teleconferences as part of the contract to support coordination and collaboration among the three deployment sites.

- **Monthly All Sites Coordination Teleconferences** - To assist in coordination across sites and encourage collaboration among deployment sites, the NFTA shall have a minimum of one representative participate in a *monthly all-site coordination teleconference* to be conducted with all Phase 2 and Phase 3 Recipients.

- **Periodic Roundtable Teleconferences –** NFTA will have at least one representative participating in the up to five roundtable meetings involving other site representatives and federal staff. These meeting will be a continuation from the roundtables held in Phase 1.

3.1.2 Task 2-B: System Architecture and Design

In this task, the NFTA Team will develop detailed descriptions of the systems to be deployed during the remainder of the program, guided by *IEEE/ISO/IEC 42010-2011 - ISO/IEC/IEEE Systems and software engineering -- Architecture description* and *IEEE 1016-2009 - IEEE Standard for Information Technology--Systems Design--Software Design Descriptions*.

As a first step in the System Architecture and Design process, the team will revisit the core deliverables developed in Phase 1 and update them based on the current scope and processes adopted in the Phase 1 Systems Engineering Management Plan (SEMP) and other documents generated during second half of Phase 1. These updates will follow the configuration management process and include the following:

- Updated system description and proposed solutions.
- Consistency in terms, acronyms, and references.
- Updated references to standards.

Although not expected to be an extensive or resource-intensive subtask, this important step ensures consistency in documentation before moving forward with significant design and development efforts.

During this task, NFTA will develop and maintain a Systems Architecture Document (SAD) with a Standards Plan and a System Design Document (SDD) per the scope defined in the NOFO. All documents will be under configuration control throughout the development, deployment and pilot stages.

SAD

As described by the Phase 2 deliverables, the SAD includes an appendix with the interface control documents (ICD) and standards plan. Due to the delivery timeframe of the commercial of the shelf (COTS) and adopted Agile development processes, the Buffalo team does not expect

the ICD, data profiles, specifications, or schema to be available to publish until designs are completed.

The NFTA team will follow the Architecture including the following steps:

- Step 1: Develop and submit draft System Architectures for review by key stakeholders.
- Step 2: Identify stakeholder to invite to a SAD walkthrough to review System Architectures including USDOT's Agreement Officer Representative (AOR) and Federal members.
- Step 3: Prepare and distribute a SAD walkthrough workbook to invited participants. The walkthrough will follow the guidance of IEEE Standard 1028-2008.
- Step 4: Conduct and solicit input from walkthrough participants from in-person and remote/virtual participants.
- Step 5: Update and submit final SAD and comment resolution response.

Based on USDOT review of the revised document, NFTA will deliver a final System Architecture document. The final, as-built, SAD will be published following system readiness test plan acceptance.

SDD

In general, the development processes consist of developing a design document for each hardware and software component procured for the system as specified by the SyRS. The design processes detail function and information flow, properties, and characteristics of the system.

The SDD will include detailed design descriptions of major system components including:

- **Community Shuttle (CS)** including functions, vehicles, dispatch and operations center.
- **Complete Trip Platform (CTP)** including the interfaces to end-user devices, and integration with reservation systems, pedestrian crossing, smart signs, and call center.
- **Performance Measurement Dashboard (PMD)** including open data and private data stores, access and analytical functions.
- **Smart Infrastructure (SI)** including support devices to aid indoor wayfinding and destination finding, kiosks and touchpoint technology. In addition, the SI subsystem includes the pedestrian crossing (Ped-X) components as well.

SDD and the Agile Design Process

The subsystems that depend exclusively on software or support open architecture / open standards will use an Agile Development Process. These include the CTP and PMD. The preliminary SDD will be developed early in Phase 2. This preliminary design will consist of a Product Backlog derived and traced to the system requirements. The Product Backlog will include the user story, acceptance criteria and dependencies on databases, input, other user stories and user interface elements. Priority and dependent stories will be identified, and applications

(including smart infrastructure, CS functions, and other components) needing integration will be staged and identified in the design document. The dependencies will drive the Product Roadmap for the subsystems using the Agile process. In addition, if based on existing open source software, interfaces, or design documents, references to those artifacts will be included in the Preliminary SDD. Each user story will be mapped to requirements in the Needs to Requirement Traceability Matrix (NRTM) to ensure traceability to the requirements.

A Preliminary SDD walkthrough will be conducted to review the Product Backlog and priorities. Walkthrough will include the Project Sponsor (USDOT), Product Owner and Stakeholder Team, as described in the Project Team Organization (Figure 5) and depicted in the Systems Engineering – Agile Integration (Figure 3). The walkthrough will follow the guidance of IEEE Standard 1028-2008.

The SDD will be updated during the Agile process at Sprint Planning Meetings where the product backlog and schedule will be updated based on stakeholder priorities. The product backlog will be posted to the Daily Development tool to track and plan sprint backlog activities. During the Sprint Planning Meetings, the stakeholder team will review the process workflow and logic, user interface mockups, data schema, interface specifications and data dictionaries. The updated designs will be posted on the Daily Development site for transparency.

Passage from design to develop will be subject to a design review of the stakeholder team. The design team member will update their design and the Configuration Manager will validate that the requirement is properly assigned, and test verification method is assigned. If a defect, bug report or code refactoring results in a change of logic or other artifact, the developer will update the document, and the Configuration Manager validate the change was traced to the NRTM.

A final System Design Document will be generated from the reviewed user stories after Phase 2 system readiness test acceptance.

COTS Turnkey Procurement

The COTS turnkey systems which include the self-driving shuttle and control software will not generate any design documents. The systems are proprietary. The Comprehensive Acquisition Plan (CAP), described in Task 2-D, will detail COTS technology capabilities, incorporating the requirements specified in the SyRS. If the system provides open interfaces, the documents detailing the interfaces will be promulgated for examination. Note that the COTS Turnkey procurement will be applied to the SDS vehicle and control modules. Vendors may offer specially manufactured vehicles and systems, or vehicles that are outfitted with after-market equipment. Both configurations are included under the label of turnkey procurement since the vendor will be responsible for all the development, integration, testing, deployment, (operations), and maintenance.

COTS Aftermarket Procurement Requiring Integration and Installation

Design documents will be developed for COTS aftermarket hardware and software items. The aftermarket equipment are typical of passenger information components installed in transit vehicles or as transit dispatch software. They include vehicle passenger securement, vehicle passenger information systems, smart signs / beacons, and reservations and dispatching software and hardware. The COTS portions of the assets will be procured, and the CAP will detail technical and functional requirements as detailed in the SyRS. The design documents will be

developed to identify the open architecture elements and configuration parameters of each product and how it will be set up and configured to meet the needs of the system when integrated into the vehicle. Among the elements that may be included in a design document include:

- Elements related to wiring, mounting, and physical interconnection drawings and description which will be integrated into a Comprehensive Installation Plan (CIP).
- System configuration parameters and their settings for this project.
- Profiles[2] and guidance on how the interfaces are applied.

As a COTS product, we assume that changes to the design of the open architecture elements will not be feasible, rather integration will depend on adapting the interfaces and configuration parameters to connect with the system component.

COTS Aftermarket design processes will include the following steps:

- Step 1: Develop and submit draft SDD and CIP for review by key stakeholders.
- Step 2: Identify stakeholder to invite to a SDD and CIP walkthrough to review SDD including AOR and Federal members.
- Step 3: Prepare and distribute a SDD and CIP walkthrough workbook to invited participants.
- Step 4: Conduct and solicit input from walkthrough.
- Step 5: Update and submit final SDD and CIP and comment resolution response.

Integration of interfaces with the CTP or PMD subsystems will be subject to the Agile Development Processes.

When the SDD is complete, the Recipient will deliver updated versions of Phase 1 deliverable, as needed. At a minimum, these updates will include: ConOps, SyRS, and ICTDP.

3.1.3 Task 2-C: Data Management Planning

NFTA will develop a Data Privacy Plan (DPP), a Privacy Management Plan, and a Phase 2 Data Management Plan (DMP).

[2] A profile according to ISO/IEC TR 10000-1:1998 is “a set of one or more base standards and/or ISPs [International Standardized Profile], and where applicable, the identification of chosen classes, conforming subsets, options and parameters of those base standards, or ISPs necessary to accomplish a particular function.

Data Privacy Plan

The DPP will be consistent with the Phase 1 Concept of Operations, the Phase 1 Human Use Approval Summary, and the Phase 1 Data Management Plan. Any variances from these documents will be identified and highlighted for DOT review. If DOT approves the variances, they shall be incorporated into Phase 1 documentation. NFTA shall deliver the draft DPP to DOT for review with a Comment Resolution Report. The DPP will also be reviewed and approved by the IRB.

The DPP will contain the following sections:

- 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.

The DPP will inform the Privacy Management Plan. Although the Privacy Management Plan is not a deliverable, NFTA is responsible to submit a Notice of Privacy Management Consistency to DOT stating that a Privacy Management Plan has been completed prior to finalizing the DPP.

Data Management Plan

NFTA will update the Phase 1 Data Management Plan (DMP). This updated plan will further identify any additional datasets (as detailed in Section 2.6), data collection procedures, privacy, update frequency, and standard reference. The DMP is a living document that is expected to be updated frequently in Phase 2 as the design is refined, standards and standard formats are implemented and tests, and data is collected into appropriate data stores. The DMP will include a data sharing framework that will be implemented to share public-designated data with the public, USDOT and the Independent Evaluator, and other interested parties. Procedures to ensure the proper handling of protected intellectual property rights and personal privacy also will be implemented during Phase 2. As described in the SyRS, data curation plans are required for managing datasets. These will be incorporated by reference into the DMP to support management of datasets and their metadata that will be report as part of the data sharing framework.

Additional data to be shared with USDOT and the Independent Evaluator (and documented in the framework) will focus on system performance and evaluation activities. The content, frequency, dissemination methods, and destination of the data will be defined in the framework and documented in the DMP. USDOT is currently working to define the database destination options and enhance the capabilities of those databases with the goal of efficient, timely, and cost-effective ITS4US Pilot project collection and sharing. The NFTA will design this data-sharing framework in Phase 2 in accordance with the most current methods available from USDOT. Special care with Personally Identifiable Information (PII) will be taken to ensure personal security is safeguarded in accordance with Phase 1 planning documents approved by USDOT.

The Draft Phase 2 DMP will be drafted and delivered to the AOR for review and comment. Based on these comments, the DMP will be updated and delivered as the Final Phase 2 DMP.

3.1.4 Task 2-D: Acquisition and Installation Planning

The acquisition and installation planning task will be driven by the Comprehensive Acquisition Plan (CAP) and the Comprehensive Installation Plan (CIP) documents that will be developed by the team under NFTA's supervision and, if needed, in collaboration with vendors. These documents will incorporate the needs and requirements documented in the SyRS related to the COT software and equipment needed to support the Buffalo ITS4US concept.

NFTA will be responsible for procuring all the equipment and software necessary for the ITS4US Deployment Pilot.

The CAP and CIP will be reviewed by the procurement team members to understand the goals and expectations of the ITS4US Pilot. Using the CAP and CIP as guidance, the team will work directly with the vendors to acquire equipment and track the inventory. The tracking of the equipment will be key in understanding warranties and available maintenance for the purchased equipment. The team will create an inventory tracking system that will capture this information and be able to report this to the NFTA. Part of the team's responsibility will be to revisit the cost and negotiate the best possible cost for purchase and ongoing maintenance of the equipment.

These documents will be developed in tandem based on the selection and evaluation of hardware and software vendors. Vendor evaluation was started during Phase 1 and will be completed prior to the design and development of the CAP and CIP documents. This task will cover the acquisition, configuration, and installation of all devices, equipment, and software-based capabilities. The CAP will identify the type and number of each item acquired during the development of the designed system. In detail, the CAP will include sections for:

- Vehicles and In-Vehicle Equipment (e.g., securement, passenger information)
- Roadside Equipment (that serve as a gateway to the signal systems)
- Smart Signs / Beacons (for indoor wayfinding and destination finding)
- Reservations and dispatch software (these may be available from existing NFTA software)
- Other Equipment and Supporting Capabilities.

The acquisition of the equipment will be handled by NFTA. The procurement of equipment will be guided by CAP and the deployment schedule and will comply with NFTA's procurement policies and guidelines (version April 26, 2018 by Resolution of the Board of Commissioners). Procurement of the equipment will be handled by a Procurement Lead within the team, who will be responsible for following the procurement process laid out within the CAP. The procurement process will follow these steps:

1. Evaluation of the purchase request by the team including any sole source justifications if necessary.
2. Submittal of a purchase order to the vendor based on the agreed-upon purchase price of the equipment and quantities required.
3. Tracking of the order confirmation and delivery schedule provided by the vendor.
4. Receipt and inventory of the delivery to compare the purchase order and equipment received.

The NFTA Procurement Lead will be responsible for tracking and reporting on the equipment budget to the management team. The CAP will be submitted in draft form for review and

comments by the team. A revised CAP will be delivered after receipt of comments from USDOT along with a comment resolution report. The final CAP will be delivered for acceptance.

The CIP will provide direction for the team to install and deploy the devices, equipment, and software-based capabilities that were acquired under the CAP. The CIP will be developed based on the equipment and software specifications provided by the potential vendors and compliant with the SyRS of the ITS4US Pilot. The CIP will contain an overview of the supplier best practices defined during vendor evaluations. The team will provide a plan for inventory and configuration management describing the procedures for tracking inventory and the configuration process, which will be followed during the deployment of inventory. The installation schedule will be developed within the CIP based on the overall project schedule. An assessment of the procurement timeframe with each potential vendor will help the team meet the installation schedule deadlines. Installation plans will be developed to cover each specific system within the CIP.

For equipment interfacing, the architecture document describes the general information flows and interfaces and traces the requirements to each information flow. The requirements associated with these flows will trace from the architecture diagrams to the design documents and then to the integration processes. The integration will be driven by design artifacts developed during the design processes or by specifications provided as part of the vendor procurement.

Physical integration processes will involve developing technical teams that review and implement the integration plans. The integration will occur in two parts – system configuration of the equipment and interface integration with the CTP or PMD modules. Integration with the CTP or PMD modules will be delegated to the Agile Software Development Process (see Section 3.1.5 for more details). System configuration will be conducted to *bench test* the integrated subsystems followed by controlled field testing.

Separate integration testing will be developed for each fleet type and/or infrastructure asset. For example, integration of the Ped-X equipment will be conducted as a bench test with the CTP mobile app prior to installation at each proposed intersection; the reservations and dispatch system(s) will be tested with each CS fleet type (SDS vs. HDS).

The CIP will be submitted in draft form for review and comment by the USDOT team. A revised CIP will be delivered after receipt of comments from USDOT along with a comment resolution report. The final CIP will be delivered for acceptance.

3.1.5 Task 2-E: Software Development and Integration

As described in the SEMP, the majority of the software development and integration activities will use an Agile Methodology. The COTS related software integration and system configuration will be integrated into the Agile roadmap (initially built in the preliminary SDD) to coordinate subsystem testing with integration development, testing, and tuning. The software will be subject to combined systems engineering (SE) activities, Agile process, and established software development lifecycle (SDLC) procedures as shown in Figure 6.

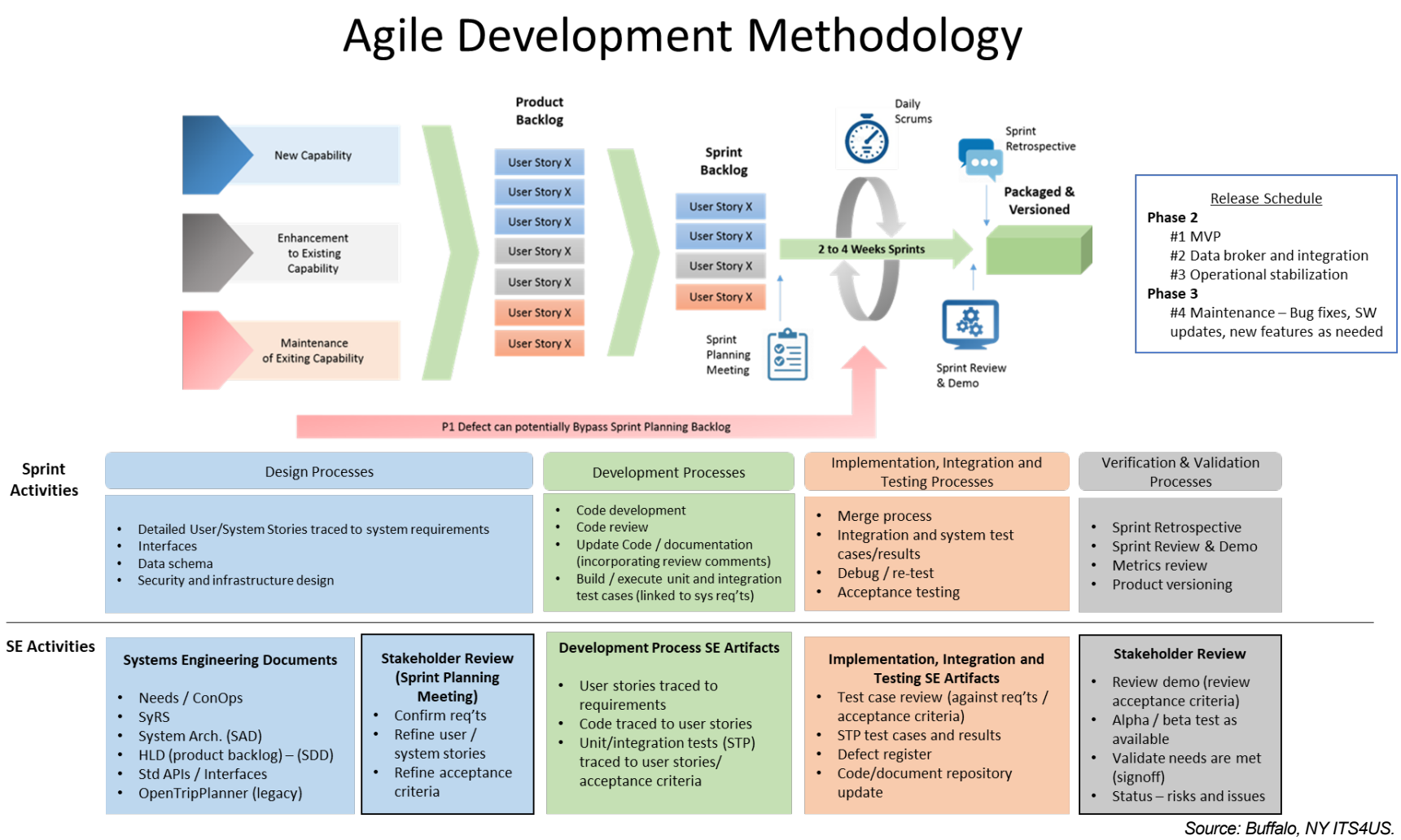
During the Agile process, each software development process (Design, Code, Integrate, Test, Deploy) is integrated into the sprint activities. The Agile process includes individual sprints for design, coding, integration and testing. Prior to initiating a sprint, during the Agile Planning meetings participants (developers, product owner, scrum master, and configuration manager) will

review design, code, test case/criteria and script, and integration element readiness. Staff assigned to review the artifacts will report on the conditions, risks and readiness of the element to graduate to the next stage. The Scrum Master will add the ready elements to the sprint backlog for that period or schedule the artifact for future sprints. During the meeting the product roadmap will be refined and updated.

During the Agile Review meetings and demonstrations, the participants (developers, scrum master, product owner, and other key stakeholders, and other communities of interest as needed) will review the sprints to confirm priority, acceptance criteria, and verify component implementation.

Readiness is reviewed by the product owner and appointed reviewers (e.g., peer-developers, System Engineering staff) who review the design, code or test artifacts. “Done” is reviewed by Test Lead and Product Owner at the Sprint Review meeting and to ensure that the test criteria for the given scenarios and datasets passed and that appropriate regression testing was conducted to verify that the product and integrated elements still performs as expected after the change.

Design, coding and testing formats and standards will be established to ensure consistency throughout the various teams developing subsystems.



Source: Buffalo, NY ITS4US.

Figure 6. Software Development and Integration

3.1.6 Task 2-F: Participant and Staff Training

A Participant Training and Stakeholder Education Plan (PTSEP) was developed during Phase 1. The plan identifies all stakeholders of the ITS4US Pilot project that will need to be trained and educated to ensure proper deployment, operation, and maintenance of the system. The main stakeholder groups identified for training and education are:

1. Users of the System and Services
    a. Persons with Disabilities
    b. Low Income
    c. Older Adult
    d. Limited English Proficiency (LEP)
    e. Neighborhood Residents
    f. BNMC Employees, Visitors and Patients
    g. Caregivers
2. Operators
    a. HDS Dispatch
    b. HDS Drivers
    c. SDS Dispatch (SOC)
    d. SDS Stewards
    e. SDS Maintenance
    f. Maintenance Smart Infrastructure
    g. Customer Service and Call Center
    h. Data Analyst
    i. System Administrators
3. Trainers
4. Additional Actors
    a. Internal Team Member
    b. External Actors

The PTSEP (and the overall project) follows Federal regulations and the Institutional Review Board (IRB) application and approval processes to protect human participants in the pilot. A Human Use Summary (HUAS) was developed to document and explain the IRB application, obtaining participants' consent, review process, and how the NFTA addressed the IRB comments and secured the IRB approval for Phases 2 and 3.

Training Modules

Specific training modules will be developed in different accessible formats to educate stakeholders on aspects of the pilot, guided by each stakeholder training needs and objectives. The modules will be updated as needed throughout the deployment and demonstration phases of the pilot.

- General Module

- Complete Trip Platform Module
- Community Shuttle Module
- Smart Infrastructure Module
- Call Center Module
- Installation and Maintenance Module
- Train the Trainer Module
- Additional Actors Module
- Data Governance and System Administration Module

Depending on their roles, participant may need to take multiple modules to achieve their training objectives. The project team understand that this is an evolving list of modules and content. As such, more may need to be added and the information provided on each module may need to be refined as Phase 2 progresses. Detailed scope and content on each module will also be better defined in Phase 2. Table 3 through Table 6 link the training modules to each user group and subgroup.

Table 3. Training Modules for User Group 1 – Users of the System and Services.

(Sub)Group	General	CTP	Shuttle	Smart Infra.	Call Center	Install & Maint.	Train the Trainer	Add. Actors	Data and Admin.
Persons with Disabilities	X	X	X	X					
Low Income	X	X	X	X					
Older Adult	X	X	X	X					
Limited English Proficiency	X	X	X	X					
Neighborhood Residents	X	X	X	X					
BNMC Employees, Visitors and Patients	X	X	X	X					
Caregivers	X	X	X	X					

Table 4. Training Modules for User Group 2 – Operators.

(Sub)Group	General	CTP	Shuttle	Smart Infra.	Call Center	Install & Maint.	Train the Trainer	Add. Actors	Data and Admin.
PAL Dispatch	X		X						
PAL Driver	X		X						

(Sub)Group	General	CTP	Shuttle	Smart Infra.	Call Center	Install & Maint.	Train the Trainer	Add. Actors	Data and Admin.
SDS Dispatch (SOC)	X		X						
SDS Steward	X	X	X						
SDS Maintenance	X					X			
Maint. Smart Infrastructure	X					X			
Customer Service and Call Center	X	X			X				
Data Analyst	X								X
System Administrators	X								X

Table 5. Training Modules for User Group 3 – Trainers.

(Sub)Group	General	CTP	Shuttle	Smart Infra.	Call Center	Install & Maint.	Train the Trainer	Add. Actors	Data and Admin.
Trainers	X						X		

Table 6. Training Modules for User Group 4 – Additional Actors.

(Sub)Group	General	CTP	Shuttle	Smart Infra.	Call Center	Install & Maint.	Train the Trainer	Add. Actors	Data and Admin.
External Actors	X							X	
Internal Team Members	X							X	X

Training Approaches

Three key training approaches are envisioned for this project: real time e-training, field demonstration / in person workshops, and online / offline training. To the extent possible, all training (content and approach) will be incorporated into existing training, such as training already provided by NFTA to PAL users or as part of professional development training for NFTA or BNMC staff.

- Real Time E-Training – These will be scheduled training to be taken in real time through an online platform. This approach will be available to all groups and most likely limited to a certain number of occurrences. They may be recorded and made available to all groups through the pilot's website as part of the online/offline trainings. This approach will have several versions, tailored to each subgroup to address their training needs and objectives, detailed in previous sections. However, all participants will be trained on the pilot project, its goals and basic system components, and their role within the pilot.

- Field Demonstration / In-Person Workshops – These will be hands on approaches to training, allowing participants to interact with the system while accompanied by a designated trainer. Field demonstrations and test drives in a controlled environment at the UB-BNMC facility(ies) could be used to provide training to drivers on the various system components, namely the SDS and the smart infrastructure (including intersections). In-Person Workshops could be used to complement field demonstrations when needed, mainly for more complex trainings. During these, participants will receive hands-on training on how to interact with the system and its components, including how to install and troubleshoot malfunctioning systems as well as updating the hardware and software if needed.

- Online/Offline Training – This approach will provide general understanding of the system and how to use it. This will include information available on the CTP App and downloadable/printable training content, which may include simple PowerPoints, frequently asked questions, and user guides. The project team will have printed user guides to provide to users available for free upon request. In some cases, this module will also server to provide refreshers and support more complex trainings—such as installation guides.

The PTSEP indicates training assessment strategies, including obtaining feedback from trainees, and provides an initial Training Implementation Schedule (TIS). Overall, training, and the development of training materials, will be performed in coordination with the release plan for the system's Agile development processes. The TIS will be updated again in Phase 2 to provide more details of the training, based on the more detailed Agile development process, and then monthly to provide information on the status of the development of materials, training efforts and risks—this will be submitted in parallel to or as part of the Monthly Progress Report, per guidance from the AOR. It is expected that most materials will be completed by the end of Phase 2; however, some materials may need to be updated in Phase 3 to account for system updates pushed during the demonstration phase.

3.1.7 Task 2-G: System Test Planning

The objective of this task is to verify and validate that stakeholder driven needs and requirements have been fulfilled. Additionally, it establishes the Operational Readiness Plan (ORP) to verify and demonstrate to USDOT and other stakeholders that the NFTA ITS4US Pilot Deployment meets performance requirements, is operational, and will be reliable, available, maintainable, and safe.

As described by ISO/IEC/IEEE 15288:2015 V&V process trace the needs to requirements and through the SE processes to provide *objective evidence* that that need fulfills the stakeholders' intended use.

System Test Plan

System Test Planning will be overseen by the System Engineering Team (SE Team) composed of the System Engineering Lead (SEL), Configuration Manager, and Test Lead. These three roles ensure that at each stage the needs are traced to requirements, requirements to design (user story), design to test case, and test cases and scenarios to meet the acceptance criteria that will eventually be documented in the Operational Readiness Test Plan (ORTP) and demonstrated in the Operational Readiness Demonstration Plan (ORDP). The system testing cases, plans, and procedures will be developed incrementally and executed for each sprint as the Agile process progresses. Selected test procedures, scripts and cases will be applied regressively throughout

the development process to retest existing components. That is, testing for each sprint and epic will rerun functional and non-functional tests to ensure that previously developed and tested software still performs as expected after a change. The Agile Demonstrations also serve as system validation testing.

System test planning include the development and implementation of test plans. The system test planning will include coordinating system integration testing of the Agile development subsystems with the CS subsystem. The CTP, PMD, and related components will be developed and integrated during the sprint cycles. For the CTP, the components include the Smart Infrastructure, call center and PAL Direct components as shown in Figure 3. For the PMD, integration components will include data feeds and analytic functions from individual subsystems. The HDS and SDS elements will be inspected, testing and field testing prior to being ready for full system integration. System integration will occur concurrent with the PMD Release 3 period to ensure integration of all data and analytic functions prior to the Operational Readiness Testing and Demonstration.

Test plans include test environments, test stages, test resources (including tools and storage), test case development, test conduct, results, and defect processes. Specifically,

- Testing will be conducted in different environments depending on the test stage.
- Test cases and procedures will be tracked throughout the test process and configuration controlled.
- Test development consists of documenting information of the features to be tested including their related requirements and needs, test techniques, testing environments, testing roles and responsibilities (including review, test, certify), test deliverables and schedule. The test techniques consist of test procedures that target key functions implemented by the system, scenarios (with a variety of input data), acceptance criteria, and procedures for hardware and software developed and integrated into the Buffalo system. The testing artifacts, whether for the Agile or COTS integration verification, will be subject to the same test documentation.
- Tests will be subject to objective test pass / fail criteria for each step in the test process.
- Test Conduct and Results will be reviewed by the Test lead. Failed tests will be diagnosed and detailed in a defective list subject to the defect process. Failures will be ranked based on the type of requirement or need they are traced to. For example, if the test failed and was traced to a safety issue or stopped further testing, then it will be ranked as a high priority. If a test failed because it did not display an error message, then its' ranking will be assigned a lower priority.

The System Test Plan (STP) will document the following test stages:

- **Bench Testing**: Applied to COTS Turnkey subsystems, bench testing is constrained to pre-installation review of physical installation and interconnections installation and testing plans.
- **Unit Testing**: the unit tests will only be conducted for the Agile developed code developers.

- **Subsystem Integration (Subsystem verification)**: system integration tests will be conducted during the Agile development process for PMD and CTP subsystems and their external / subsystem integration.

- **Integration Testing (System Verification Testing):** The verification processes will use the test procedures to confirm, through objective evidence that the specified system requirements have been fulfilled (verification). The purpose of the verification processes is to identify anomalies (errors, defects, or faults) with the system using comprehensive tests that are tied to the requirements. Each test case is tied to one or more requirements to ensure that the system performs as expected. Verification testing is typically referred to as structure-based testing or "white box testing" where the internal structure of the code is known to the tester. The COTS interfaces will be subject to verification testing. At a minimum, transition from verification to validation requires the system to comply with safety provisions specified by the requirements. In addition, accessibility testing will be conducted for end-user tools and utilities (including user interfaces) to ensure all end-users can use the services.

- **Field Testing (Validation Testing):** The validation processes will use the test procedures to confirm, *through objective evidence*, that the stakeholder needs for a specific intended use have been fulfilled (validation). The Validation processes use similar test plans but are tied to stakeholder needs. The field testing will provision stakeholders with applications to validate that the system meets their needs and requirements within a controlled environment. Validation testing is typically referred to as specification-based testing or black box testing where the functions are tested against stakeholder needs and expectations. The CS (SDS and HDS) subsystem will utilize the UB Proving Grounds to test that the SDS and HDS can meet the requirements included in the SyRS prior to deploying the equipment to local right of ways. Field testing will include application alpha and beta testing of CTP releases and autonomous vehicle learning processes to discover designated paths through the BNMC neighborhoods. For example, the CTP field testing will include all functions and integrated features including but not limited to Ped-X actuation requests, indoor navigation, TIH operations, reservations and CS dispatch (pickup / drop off), trip execution (turn by turn directions), and real time notifications.

Operational Readiness Concept Briefing

Operational readiness planning and tracking will begin upon initiation of Phase 2 with the development of a first draft Operational Readiness Checklist and Schedule. This Checklist and Schedule will be part of the ORP and will be updated regularly throughout Phase 2 with any new elements that must be tracked and with status of each element on the checklist. The elements in the ORP will be documented, submitted and presented to the USDOT for approval during an operational readiness concept briefing. The outline for the ORP will present STP efforts, results and changes; changes to needs and requirements based on stakeholder priorities and reviews conducted during the STP and Agile demonstrations. The results of the end-to-end validation tests will provide the acceptance criteria described in the ORP. During the briefing the collection readiness criteria, checklist and schedule will be reviewed and recommendations for improvement provided by the USDOT AOR.

Operational Readiness Test and Demonstration Plan

Once the system has been developed and STP completed and the operational readiness briefing review occurs, the NFTA team will incorporate the updates and draft the ORTP and ORDP. The purpose of the ORTP is to document end-to-end processes and ensure the acceptance criteria are verified. The purpose of the ORDP is to ensure that the system operates as is expected and all user needs are validated. The details will include the requirements addressed in the Subsystem, Integration and System testing stages (Verification Testing) and Field Testing (System Validation). The plan will include the verification and validation testing needed to meet system requirements and user needs.

- Verification testing will report the STP was conducted and passed. Additionally, the testing will trace and document the requirements with each design element, acceptance criteria and result. The results will be recorded and tracked in the NRTM. The Verification Testing will implement the ORTP. All major errors and persistent anomalies will be resolved prior to entering the operational readiness demonstrations stage.

- Validation testing will be conducted to demonstrate that the system performs as is expected. The validation testing will focus on key test scenarios and use cases using a "black box" method. Demonstrations will include stakeholders in reviewing system operations. In addition, stakeholders will be recruited to exercise the system through Beta Testing. Stakeholders' observations, comments and their field results will be documented in the ORDP as evidence that the system performs as intended and expected.

The NFTA team will develop a workshop and conduct a walkthrough of the ORP guided by IEEE Standard 1028. The walkthrough will include USDOT AOR, key stakeholders from among the system developers, end-users, and other communities of interest. Comments solicited from participants will be incorporated into the final ORP. Response to the USDOT Comment Resolution matrix will also be addressed and incorporated into the final ORP before submission.

3.1.8 Task 2-H: Installation and Operational Readiness Testing

The objective of this task is to implement the plans from Task 2-G to verify and demonstrate to USDOT and other stakeholders that the pilot meets performance requirements and is fully operational and will be reliable, available, maintainable, and safe.

After the CIP and the ORP have been finalized and approved by the USDOT team, work will update and refine the Installation and Operational Readiness Schedule (IORS). This schedule will help the team to analyze the best way to implement the CIP and ORP. Installation and testing progress will be tracked according to the milestones of initiation: 20% complete, 50% complete, 80% complete, and completed. As technical risks and issues arise, they will be tracked in a document defined by the IORS, and all current risks and issues will be attached to the updates sent to USDOT.

After the ORP have been finalized and approved by the USDOT team, the NFTA will conduct the operational tests to provide evidence of end-to-end operations. The ORP will include a testing schedule. The ORP will be adjusted as needed to accommodate weather and other unplanned events that might arise.

All tests performed for operational readiness will be documented with the results of the tests. Test results will be made available to USDOT and stakeholders via System Test Results Summary (STRS). Once the system is deemed ready for operation according to the ORP demonstrations for operational readiness, a meeting will be scheduled with all stakeholders and the AOR and key federal staff. All demonstrations then will be documented through Test Results Summary Documentation and Operational Readiness Demonstrations, in accordance to the ORP.

3.1.9 Task 2-I: Maintenance and Operations Planning

NFTA shall develop a Comprehensive Maintenance and Operations Plan (CMOP) that identifies the types and number of equipment required to be maintained. This document shall summarize key operational methods and procedures to ensure safe and efficient operations in Phase 3, incorporating elements from the Phase 1 Safety Management Plan as necessary. The CMOP will have a section for operations and another for maintenance. The Operations section of the CMOP will list operating tasks and schedules. The maintenance section will be divided into subsections for vehicles and in-vehicle equipment, indoor/outdoor equipment, management center equipment, and other equipment.

In addition, for each subsystem and component, the following will be addressed: operational and monitoring procedures, maintenance levels (preventive/corrective) for configurable items (hardware, replenishable, and software), and incident management procedures. The incident management procedures will handle any defects, anomalies or other disruptions to the system. The incident management processes will also include a system help desk that is on-call during hours of system operations in Phase 2—this will then be the customer service center in Phase 3. Among the operations and maintenance processes will be:

- Defining **roles and responsibilities** and resource needs (including training, tools, equipment to perform operations and maintenance).
- Describing and implementing **data lifecycle / curation management** processes including data backup and storage.
- Performing **security monitoring**, audits and system updates.
- Collecting and managing **inventory** of configurable items (assets and software) including managing asset warranties, licenses, and other contractual obligations of the vendors.
- Establishing and implementing **Incident management process** to manage anomalies and failures. The incident management process will include troubleshooting procedures, severity levels, work order management flow, roles and responsibilities through the workflow, reporting requirements, help desk approach.
- Establishing and implementing **Software maintenance** (mobile, field, center and infrastructure) processes for all subsystems and interfaces. These will include setting schedules, issuing software bulletins (for software changes, updates, and patches), describing resource needs, and software support approach. For example, software changes (even factory issued updates) should be tested and exercise in a testbed prior to enterprise release. In addition, for mobile apps, this will include provisioning updates to the app stores.

- Establishing a **change management approach** (for upgrading software and refreshing equipment). The change management approach will be documented in the Phase 3 PMP.

- Establishing and implementing **Hardware maintenance** (e.g., vehicles, communications equipment and TIH) processes including preventive and corrective maintenance, and potential vandalism. These will include defining maintenance levels, documenting step by step procedures for preventive, inspection and corrective maintenance procedures (including replacement procedures), setting schedules for preventive maintenance, and defining the hardware support and help support.

A draft of the CMOP will be delivered to USDOT for review. Upon review, the USDOT will provide comments in a Comment Resolution Report. Based on the USDOT review of the revised CMOP, NFTA will deliver a final CMOP.

3.1.10 Task 2-J: Stakeholder Outreach

Building on the Phase 1 Outreach Plan, NFTA will develop a draft Outreach Plan for Phase 2. This plan will provide more details of NFTA's outreach efforts, primarily focusing on preparing and informing stakeholders about the installation and operational readiness testing activities. The team, guided by the Outreach Plan, will oversee and coordinate activities in this task including 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 public. In addition, this task is intended to cover all outreach events held for stakeholders in Phase 2 at the deployment site and the accommodation of requests for site visits by the media, researchers, and other visitors. Some outreach activities will be dependent on progress made in deploying the system; others will not be dependent.

NFTA will submit the updated Phase 2 Outreach Plan to USDOT. Once reviewed by DOT and comments are incorporated, NFTA will update the plan and submit the final version.

Outreach Implementation Schedule

Based on the revised Phase 2 Outreach Plan, NFTA shall create an Outreach Implementation Schedule (OIS). This schedule shall include a work breakdown of all activities required to implement in the Phase 2 Outreach Plan. An initial draft of this shall be provided to the AOR for review and approval. Monthly OIS updates should be provided to the DOT based on the format and content in the approved OIS.

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

Performance Measurement and Evaluation Support Plan (PMESP)

The NFTA Team prepared a PMESP during the Phase 1 activities which details expected processes for end-to-end data collection and the establishment of baseline data to support performance measurement activities. This document will guide the performance measurement and support to the Independent Evaluator (IE) during Phases 2 and 3. The PMESP will be updated at least once throughout Phases 2-3. The PMESP identifies 34 metrics groups across six different performance measures, as illustrated in Table 7.

Table 7. Buffalo ITS4US Pilot Performance Measures and Metrics

No.	Performance Measure
PM#1 Improved Ability of the CTP Users to Make Satisfactory Complete Trips in the Study Area	
1	System user ratings of how accessible door-to-door travel is for trips to, from and within the BNMC.
2	System user ratings of how safe door-to-door travel paths are for trips to, from and within the BNMC, including level, slip-resistant paths.
3	System user ratings of the adequacy and usefulness of information for making trips to, from and within the BNMC
4	System user ratings of the ability to make trips using integrated transit services. to, from and within the BNMC
PM# 2 Usefulness of the CTP Registration and Trip Preferences Processes	
5	System user ratings of the ease of registration process
6	System user ratings of the usefulness of providing preferences to get trip options that satisfy those preferences
PM#3 Usefulness of the CTP Trip Planning and Booking Processes	
7	System user ratings of the ease of planning a door-to-door trip route/path
8	System user ratings of the satisfaction with the specific route/path options provided by the CTP
9	The fraction of trips that are planned using the CTP that are subsequently carried out using the CTP app.
10	The percent of CTP users who use the system to book on-demand transit trips (CS or PAL-spontaneous)
11	System user ratings of the ease and convenience of booking on-demand transit trips (CS or PAL-spontaneous) via the system
12	The percent of CTP users who use the CTP to report incidents or travel conditions during their trips
13	System user ratings of the ease of reporting incidents or conditions encountered during a trip in the CTP
14	System user ratings of the usefulness of reviewing past trip history in the CTP
PM#4 Improved Ability to Find Destinations Efficiently Using the CTP Wayfinding Functionality	
15	The fraction of CTP users who elect to receive **outdoor** wayfinding notifications
16	System user self-reported frequency of using **outdoor** wayfinding notifications
17	The fraction of CTP users who elect to receive **indoor** wayfinding notifications
18	System user self-reported frequency of using **indoor** wayfinding notifications
19	System user ratings of the how useful the **outdoor** wayfinding functionality is in reaching their trip destination on time
20	System user ratings of the how useful the **indoor** wayfinding functionality is in reaching their trip destination on time
21	User ratings of various dimensions of using the CTP **outdoor** wayfinding functionality using the RAPUUD method
22	User ratings of various dimensions of using the CTP **indoor** wayfinding functionality using the RAPUUD method
PM#5 Improved Ability to Cross Specific Intersections Safely Using CTP Smart Signal Functionality	
23	The percent of CTP trips crossing at the relevant intersections who use the smart signal remote activation function.
24	Self-reported fraction of people who cross at the relevant intersections who use the CTP smart signal activation functionality

No.	Performance Measure
25	Perceived ease of use and ratings of other aspects responsiveness of activating the smart signals, using the RAPUUD method
26	Perceived safety of crossing the intersections with smart signals
PM#6 Provision of an Efficient, Reliable, and Safe New On-Demand Transit Shuttle System	
27	Percent of CS trips that arrive at the **boarding** stop within the targeted time allowance of the scheduled arrival time
28	Percent of CS trips that arrive at the **alighting** stop within the targeted time allowance of the scheduled arrival time
29	System user ratings of the how reliable the transit system is in reaching their BNMC trip destination on time
30	Self-reported frequency of using all transit services, including the CS as well as PAL services and NFTA bus and rail lines
31	Percent of transit trips made by PAL-eligible CTP users within the CS service area that are made via the CS or PAL-spontaneous versus regular PAL trips
32	User ratings of CS service in terms of key service aspects – convenience, affordability and safety, as well as other aspects included in the modified RAPUUD questions.
33	Cost efficiency of the HDS and SDS shuttle services in terms of operating cost per passenger trip.
34	Percent of CS bookings for which the earliest available pick-up time is within 45 minutes of the request time.

The performance assessment process is summarized, at a high level, in Section 2.7. The focus of this task is to refine the Phase 1 PMESP, how the performance measurement process will be managed, describe in more detail data collection and processing activities, document the baseline conditions (before ITS4US deployment), and coordinate efforts with the IE. Specifically, the NFTA Team will:

- Establish a Performance Measurement and Evaluation Support Schedule (PMESS) and provide monthly progress updates
- Document pre-deployment performance conditions (i.e., baseline), including data, logbooks, analytical models and other supporting information
- Provide system performance reports
- Update the PMESP
- Support Independent Evaluator activities

PMESS and Monthly Updates

The NFTA will prepare the PMESS, which will define a work breakdown structure required to implement the PMESP and measure/evaluate the performance of the ITS4US Pilot components and overall system. The PMESS will guide the performance measurement and evaluation support activities and be used as a guide to provide USDOT monthly progress reports.

The schedule will include:

- Major PMESP activities and their timeframe
- Key milestones and dates to implement the PMESP successfully
- PMESP deliverables with dates (including performance-related data)
- PMESP dry-run demonstration and the key elements leading up to the demonstration

- Technical issues and risks affecting the execution of the PMESP (as a supplement)

Monthly updates of the PMESS will be provided to USDOT documenting PMESP progress, including percent completion estimates for all major milestones and deliverables. Also included with the monthly updates will be narrative describing activities underway, progress made since the last update, and all technical issues or risks and mitigation actions taken. The PMESS will be updated as necessary during Phase 2 and updates shown in the monthly progress reports

Independent Evaluator Support

Over the course of Phases 2 and 3 of the ITS4US program, the ICF project team will provide access to all drafts and final reports to the IE for review and possible comment. This will be accomplished in the normal course of submission of the documents to ITS JPO. Performance against baseline measurements and targets will be publicly reported throughout Phase 3 in the form of summaries/dashboards of key measures. This information will be available to the IE to use in its final Performance Results Assessment. Any additional information requested by the IE, such as data sources or availability of baseline data or items of clarification, will be provided in cooperation with the ITS JPO.

3.1.12 Task 2-L: Participation in Standards Development

After the System Architecture Document (SAD) and accompanying Standards Plan is completed and finalized by USDOT, the SEL and related technical team members for the ITS4US pilot project will participate in related Standards Development Organization (SDO) working group/committee meetings such as the International Standards Organization and SAE. Efforts through this task will be documented in the SDO-specific Technical Memoranda.

In addition, technical team members will collaborate with other specification development groups such as MobilityData, Open Mobility Foundation (OMF), AARP/SUMC (for the transactional data specification) developing open specifications. Based on USDOT direction, our experts will draft white papers, share our use cases, requirements and lessons learned with these standards groups. In addition, as requested, our team members will work with the USDOT Reference Architecture team to review related service packages and identify potential gaps in the current National ITS Architecture.

3.2 Phase 3 Technical Approach

Upon approval of the Agreement Officer, the project team will start Phase 3 activities to demonstrate the pilot's operations in a real word setting and collect data on its performance.

3.2.1 Task 3-A: Project Management

As a public transit agency, NFTA is experienced in ensuring the ongoing operations of services and in maintaining software systems. Continuing from Phase 2, the project management team will update the PMP, including management procedures if needed, and project schedule. NFTA and key personnel will attend a Phase 3 kick-off meeting in Washington, D.C. or virtually. NFTA will continue to develop Monthly Progress Reports and host/support site-specific meetings and monthly all-site coordination elements, including roundtables.

3.2.2 Task 3-B: System Operations and Maintenance

NFTA is responsible for maintaining the information in the CMOP. Once the CMOP has been completed and Phase 3 has begun, NFTA will create a System Operations and Maintenance Schedule (SOMS). All plans identified in the Phase 1 SMP will be included and highlighted in the SOMS. NFTA shall deliver an initial draft of the SOMS for review and approval. Once approved, NFTA will prepare monthly updates to the SOMS, including 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.

The SOMS will also include an appendix with the schedule that reports the number of participants, vehicles, mobile devices, service area dimensions, smart sign elements, and other relevant countable deployment elements. The SOMS will also include schedule and risk updates.

3.2.3 Task 3-C: Stakeholder Outreach

NFTA will conduct Stakeholder Outreach in Phase 3 as described in the Phase 2 Outreach Plan, including demonstration of the pilot, press conferences, presenting at conferences, and recruitment-focused efforts. A work breakdown structure of development, planning, and implementation of the outreach channels is required to implement the Phase 2 Outreach Plan in Phase 3. These will be created and documented by NFTA in an Outreach Implementation Schedule (OIS). NFTA will provide monthly updates of the OIS, showing the progress of each item, track the progress against the plan, and identify any risks and mitigation activities (which will later be integrated into the Lessons Learned Logbook).

One of the outreach activities in Phase 3 will be an Operational Capability Showcase meant to show the media the capabilities, intent, and value of the deployment. NFTA will prepare a draft and, based on USDOT comments, a final Operational Capability Showcase Plan (OCSP). The showcase will be documented by the NFTA with a draft Operational Capability Showcase Summary (OCSS) indicating how the outcome from the showcase were integrated into site outreach materials, workshops, conferences, and trade shows. NFTA shall prepare a final OCSS addressing comments from USDOT.

The Operational Capability Showcase (OCS) is the capstone of our Phase 2 work that needs to build excitement for the community, engage the media and demonstrate success of our technical work in this phase. Our plan will include the following elements.

- **Location for the OCS**. What facility and where will we be conducting the demonstration
- **Participants**. Who will be participating in the demonstration?
- **Procedure and approach for demonstrating a complete trip journey.** How will we demonstrate a complete trip journey for travelers with different elements baked into the process. For example, having our beta users or participants complete a trip from an origin to destination showcasing the different elements
- **Demonstration** of the SDS and overall shuttle integration with the platform
- **Media strategy**. How will we reach out to the Buffalo and national media? Video and multi-media support.

- **Plan for executive participation** from City of Buffalo, New York State, U.S DOT
- **Partner engagement.** Showcasing the pilot to partners

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

During Phase 3, NFTA will collect and analyze data following the guidance provided in the Phase 2 PMESP (developed in Task 2K). Based on these efforts, NFTA will measure the impact of the technologies, services, components and the overall impact of the deployment on site-identified key performance measures and metrics. Furthermore, as appropriate and directed by USDOT, NFTA shall coordinate with and support the IE and facilitate access to NFTA members and stakeholders.

Performance Measurement and Evaluation Support Schedule

The PMESS will continue to be updated throughout Phase 3, providing more detail on the work breakdown structure if needed. The PMESS will include:

- Major PMESP activities (Phase 3) and their timeframe
- Key Phase 3 milestones and dates to implement the PMESP successfully
- PMESP Phase 3 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 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.

Site Performance Measurement Dashboard

NFTA will leverage all data collection and analysis efforts to develop a dashboard that summarizes all key performance measures and targets achievement status to date. The dashboards will be updated per the PMESS.

PMESP and DMP Updates

When appropriate, the project team will update the PMESP and DMP at least once to account for any changes that may have occurred when transitioning from Phase 2 or during Phase 3. The PMESP update will include any revisions to the performance measures or evaluation designs, as well as any updates on the confounding factors and mitigation approaches.

The DMP update will include changes in management approaches employed to secure, store and share the appropriate data. The updated DMP will also be consistent with the edits made to the PMESP, including changes to the data collected and other supporting information to support the PMESP activities.

3.2.5 Task 3-E: Post-Deployment Transition Planning.

NFTA expects that the deployed system will continue to be used beyond Phase 3 and, as such, will update Phase 1 deliverables. Important aspects to be updated include the main elements of the ConOps, performance measures and targets, operational changes to the deployment, governance framework and processes, partnerships and financial agreements.

Throughout the transition period, NFTA will work in close collaboration with key stakeholders, such as BNMC, to analyze all aspects of the project in order to ensure continuous operation and, if deemed needed and feasible, the potential growth of the service area, system capabilities and number of users.

In Phase 1, NFTA and partners have considered the long-term sustainability of the program in designing the concept as well in engaging the right players. While a lot of things may change in the 42 months of Phases 2 and 3, recognizing the possible pathways for financial transition, sustainability, and scalability are important. Table 8 provides our early thinking on the transition. As part of this task, NFTA will develop a Comprehensive Transition Plan identifying 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.

Table 8. Components on the Transition Plan.

Project Component	Post-Pilot Transition Need	Financial and Technical Sustainability	Scalability
CTP App and related traveler interfaces	By Phase 3, the CTP app will largely be in O&M mode. However, a limited continued investment in this app is necessary to keep the system up to date and relevant and grow the user base. This may include adding new features, supporting users, training, recruiting the user based.	The long-term vision for the app is that this becomes part of the larger traveler management program for New York and aspects of the app be adopted by the mobility management programs in the City and State who continue to operate, fund the app and advocate for its use.	By making it part of the larger mobility management program, the CTP app functionality can be extended to other regions and partners similar to how 511NY Rideshare services have been created.
Shuttle Services	Transition of this aspect of our system is contingent on a few factors. 1) the prevailing business model and capability of SDS in 42 months, 2) the demand and	The financial sustainability of the shuttle is really dependent on the success of the pilot. If successful, there are several options for continuing the program Seeking grants from other private and public sources for shuttle operations (like	There are several ongoing discussions to scalability of shuttle and shuttle-related system elements. At a system-level, One benefit of the pilot is that it improves same-day travel. Lessons

	reaction from the users to the shuttle. By Phase 3, we anticipate the area of the study needing about 3-4 vehicles (a combination of SDS and HDS) operating at least 10 hours a day.	NYSERDA, Wilson Foundation) for operating support. Making aspects of the SDS and HDS part of existing shuttle operations (for NFTA or UB)	learned and aspects of trip reservation and dispatch can directly improve the existing PAL program. From a location perspective, stakeholders and partners have already noted that the shuttle area needs to grow to really become a vital transportation resource and expanding, connecting to downtown, to specific points of interest like shopping, work.
Indoor and Outdoor Navigation	There are ongoing but small costs for maintenance and installation of the physical elements (like beacons, touch screens) to continue support for navigation and wayfinding elements in the CTP. The transition needs to include a simplified approach for getting new facilities integrated into the system.	If the indoor and outdoor navigation features of the app prove popular, the support for these systems will be gathered from the BNMC partners and facilities who are the primary beneficiaries of this aspect of the system.	Currently two buildings/facilities are being proposed but indoor navigation can be enabled for additional buildings within the BNMC campus. More importantly, other large facilities that see significant volumes of travelers with disabilities can also be integrated with the system.
Ped-X Crossing	Post transition, the maintenance of these systems needs to be handed over to the infrastructure owner operator, in this case the City of Buffalo.	The anticipated costs for maintenance for the two intersections are expected to be minimal and largely accommodated in the service contracts that they may have in place already.	There is great promise based on the discussion with City of Buffalo and MioVision that the Ped-X crossing feature, if popular may be included at other intersections around Buffalo and New York as appropriate.

In summary, the transition plan will include, but not be limited to:

- Project successes to be continued and unsuccessful operations to be discontinued, with rationale for each.
- A description of what organizational responsibilities will be taken in the post-deployment period compared to organizational responsibilities in Phase 3.
- Possible areas of improvement for future enhancements for consideration by NFTA.
- Documentation of the financial resources and agreements required to ensure financial sustainability in the post-deployment period for all continuing elements.
- Contingency plans with respect to identified uncertainties and other potential post-deployment issues posing a risk to successful post-deployment operations.

NFTA will deliver a draft Comprehensive Transition Plan to the DOT for review. Upon review, NFTA shall revise the Comprehensive Transition Plan and provide a final version to the DOT.

3.2.6 Task 3-F: Participation in Standards Development

The pilot's technical leads will continue to participate in related Standards Development Organization (SDO) working group/committee meetings, as they did in Phase 2. As part of this support effort, NFTA will document proposed standards updated and new standards, adding these to the SAD standards plan. Before adding new standards to the SAD, the proposed standards must be communicated with the appropriate SDOs. A technical expert working closely with the technical leads will be designated as a backup to attend SDOs when the technical leads might be unable to attend and participate. This approach will enable a representative from the Buffalo pilot to participate in all relevant SDOs consistently

4 Phase 2 and 3 Deployment Schedule

The following sections provide a high-level schedule for Phases 2 and 3. Section 4.2 provides a summary of the potential schedule risks.

4.1 Schedule Summary

Table 9 presents a detailed schedule breakdown of Phases 2 and 3, detailing the deliverables within each phase broken down by quarters (Phase 2 has eight quarters and Phase 3 has six). The schedule will be updated as part of Task 2-A and of the initial program management activities for Phase 2, accounting for any changes in schedule. A Microsoft Project schedule will also be created and updated throughout the duration of Phase 2 and Phase 3. The project milestones for Phases 2 and 3 are provided in Table 10.

Table 9. Buffalo ITS4US Pilot Work Breakdown Structure.

WBS	Task Name	Duration (months)	Start	Finish
2	**Phase 2**			
2.A	Program Management	24	Phase 2-Q1	Phase 2-Q8
2.B	System Architecture and Design	12	Phase 2-Q1	Phase 2-Q4
2.C	Data Management Planning	6	Phase 2-Q1	Phase 2-Q2
2.D	Acquisition and Installation Planning	12	Phase 2-Q1	Phase 2-Q4
2.E	Application Development	21	Phase 2-Q2	Phase 2-Q8
2.F	Participant and Staff Training	18	Phase 2-Q3	Phase 2-Q8
2.G	Operation Readiness Testing and Demo Planning	12	Phase 2-Q2	Phase 2-Q5
2.H	Installation and Operation Readiness Testing	15	Phase 2-Q4	Phase 2-Q8
2.I	Maintenance and Operations Planning	6	Phase 2-Q5	Phase 2-Q6
2.J	Stakeholder Outreach	24	Phase 2-Q1	Phase 2-Q8
2.K	Performance Measurement and Indep. Eval. Support	24	Phase 2-Q1	Phase 2-Q8
2.L	Participation in Standards Development	24	Phase 2-Q1	Phase 2-Q8
3	**Phase 3**			
3.A	Program Management	18	Phase 3-Q1	Phase 3-Q6
3.B	System Operations and Maintenance	18	Phase 3-Q1	Phase 3-Q6
3.C	Stakeholder Outreach	18	Phase 3-Q1	Phase 3-Q6
3.D	Performance. Measurement and Indep. Eval Support	18	Phase 3-Q1	Phase 3-Q6
3.E	Post-Pilot Deployment Transition Planning	9	Phase 3-Q4	Phase 3-Q6
3.F	Participation in Standards Development	18	Phase 3-Q1	Phase 3-Q6

Table 10. Project Milestones.

Phase	Due Date	Milestones
2	award + 4 weeks	Project Management Plan (PMP)
2	award + 6 months	Systems Architecture Document
2	TBD	SAD Walkthroughs
2	award + 12 months	Systems Design Document
2	TBD	SDD Walkthroughs
2	award + 4 months	Software (SW) Development Schedule (a subset of the Master Schedule). Update with Progress/Risk Summary.
2	TBD	Updated Phase 1 Deliverables. Revised Concept of Operations. Revised Systems Requirements. Revised ICTDP.
2	per the SW Development Schedule	Open Source Software (OSS) and Supporting Documentation.
2	award + 13 months	System Test Plan
2	award + 13 months	Operational Readiness Plan (ORP)
2	TBD	ORP Walkthrough
2	award + 13 months	Installation and Operational Readiness Schedule (IORS). IORS Updated with Progress/Risk Summary
2	per the ORP	System Test Results Summary Documentation
2	per the ORP	Operational Readiness Demonstrations
2	award + 17 months	Comprehensive Maintenance and Operations Plan (CMOP)
3	Notice to Proceed (NTP)	**Proposed 20% at scale deployment** CTP functionality will be at 100%. Two facilities equipped for indoor wayfinding. 100 customer accounts PMD at 80% PED-X intersections at 100% Touch Model at 100% TIH at 100% CS at 100%
3	NTP + 2 months	**Proposed 50% at scale deployment** 250 customer accounts PMD at 100%
3	NTP + 4 months	**Proposed 80% at scale deployment** 300 customer accounts
3	NTP + 6 months	**Proposed 100% at scale deployment** 400+ customer accounts
3	NTP + 4 weeks	Phase 3 PMP update
3	NTP + 1 month	System Operations and Maintenance Schedule (SOMS)
3	NTP + 14 month	Comprehensive Transition Plan

4.2 Schedule Risks

NFTA expects that the main risk to the timeline for development, integration, testing and deployment of all components of this pilot project will be the timely procurement of the vendor-related equipment such as the SDS, indoor navigation equipment, and the Ped-X controllers.

NFTA will mitigate this risk through early/proactive engagement with vendors and a prompt procurement process.

NFTA does not expect significant risks to the development schedule to come from lack/limited labor force. While true that the pandemic could very well have an impact on available personnel, the size of the pilot should allow us to fill temporarily empty position more quickly through stablished backup (and already trained) personnel—e.g., it is easier to find 2-4 drivers/stewards than several dozens. The procurement process will also ensure that vendors adhere to strict service agreements, which would include having designated backup staff.

While initially considered a risk, NFTA does not expect significant impact from the ongoing infrastructure projects (planned outside of the scope of this project) which the deployment seeks to leverage. Only one intersection is part of the Middle Main improvement project and the integration will come late enough in Phase 2 consistent with the corridor improvement schedule. NFTA would have ample time and flexibility to identify adequate alternatives to those intersections if need be. NFTA will mitigate this risk by continuing to have frequent conversations with the external project managers to understand its status and any potential delays, and by continuing its conversation with MioVision, the intersection monitoring hardware/software provider for the City of Buffalo.

Finally, delays in issuing procurement related Request for Proposals and RFQs could also be a risk to the overall schedule. NFTA plans to be proactive by engaging with vendors and having the necessary discussions early in the process to ensure a smooth and quick process. For this, NFTA will leverage much of the work and discussions with vendors held throughout Phase 1, as well as existing relationship with vendors from other projects.

Appendix A. Acronyms

Table 14 lists the acronyms used in the document.

Table 11. Acronyms

Acronym	Meaning
ADA	Americans with Disabilities Act
AV	Automated Vehicle
BNMC	Buffalo Niagara Medical Campus
ConOps	Concept of Operations
CTP	Complete Trips Platform
FHWA	Federal Highway Administration
GBNRTC	Greater Buffalo-Niagara Regional Transportation Council
HDS	Human-Driven Shuttles
ICTDP	Integrated Complete Trip Deployment Plan
IPFP	Institutional, Partnership, and Financial Plan
IRB	Institutional Review Board
ITS4US	Intelligent Transportation Systems for Underserved Communities
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
LEP	Limited English Proficiency
MoU	Memorandum of Understanding
NFTA	Niagara Frontier Transportation Authority
NITTEC	Niagara International Transportation Technology Coalition
NY	New York
PAL	Paratransit Access Line
PMESP	Performance Measurement and Evaluation Support Plan
SDS	Self-Driving Shuttles
SOC	Shuttle Operations Center

Acronym	Meaning
SyRS	System Requirements Specification
TIH	Transportation Information Hub
UB	University of Buffalo
U.S.	United States
UI	User Interface
USDOT	U.S Department of Transportation

Appendix B. References

The following are the sources of information cited in this document.

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