

Phase 1 System Requirements Specification (SyRS)

Buffalo NY ITS4US Deployment Project

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16. Abstract <p>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 to 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 and older adults).</p> <p>This document is the System Requirements Specification, which identifies the requirements for the system's components to be developed or procured through this pilot.</p>					
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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, the Phase 1 System Requirements Specification (SyRS), identifies the requirements for the system's components to be developed or procured through this pilot.

1.1. System Requirements Purpose

The SyRS defines the functional, interface, performance, and data requirements for each subsystem. The SyRS builds upon the Concept of Operations (ConOps) and the Performance Measurement Evaluation Support Plan (PMESP) and feeds other key internal documents, as shown in Figure 1. As such, the SyRS will be updated as needed throughout the project to correct any inconsistencies that may arise as the concept continues to mature, information on the technologies to be used becomes available, and the Agile development process identifies gaps and limitations.

Through this SyRS, the Buffalo project team will identify the requirements needed to address the needs identified in the ConOps, ensuring their traceability throughout the deployment of the proposed technologies.

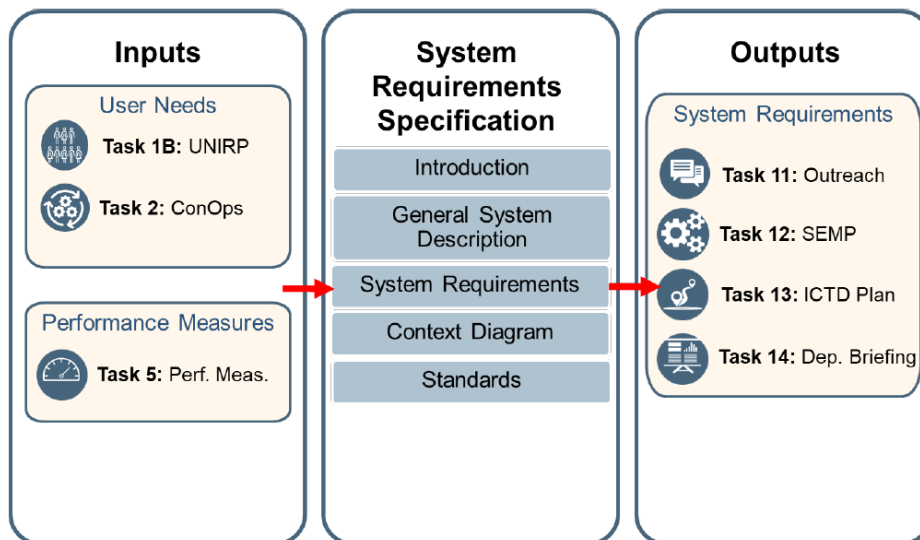


Figure 1. Inputs and outputs of the System Requirements Specification.

Source: FHWA

1.2. Project Overview

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 Trips 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
 - Trip Booking
 - Trip Planning
 - Trip Monitoring and Notifications
 - Geolocation and Mapping
 - Navigation
 - Real-time situation monitor
 - Performance metrics
 - Trip history/ledger
 - User Interface (UI): Mobile application
 - UI: Web and Interactive voice response (IVR)

- **Community Shuttle Subsystem** – The Community Shuttle (CS) 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 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, TIH), augmented communications technologies (Smart Signs), and intersection treatment for hands-free, pedestrian signal requests.
- **Performance Dashboard Subsystem** – The performance measurement dashboard (PMD) subsystem measures and presents the performance of the system to the agency operating the system.

Figure 2 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.

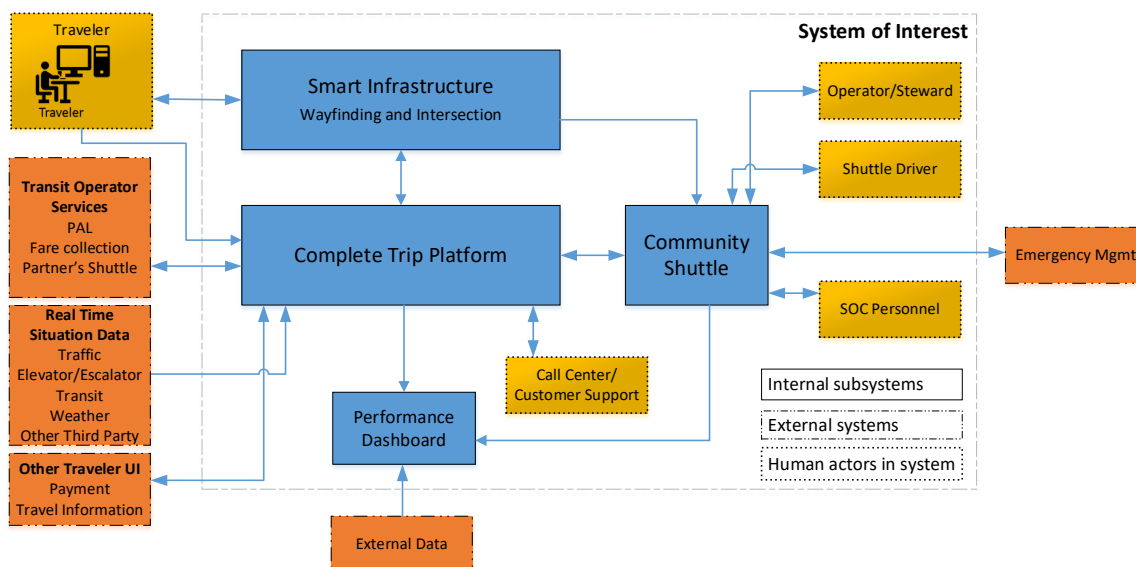


Figure 2. High level context diagram for the Buffalo, NY ITS4US System.

Source: Buffalo, NY ITS4US

1.3. References

This document utilizes information and processes defined in the following documents:

- Phase 1 Concept of Operations (ConOps) – Buffalo NY ITS4US Deployment Project (FHWA-JPO-21-860).

- Phase 1 Performance Measurement and Evaluation Support Plan (PMESP) – Buffalo NY ITS4US Deployment Project (FHWA-JPO-21-878, revised version completed on Oct 25, 2021).

1.4. Acronyms

Table 1 lists the acronyms used in the document.

Table 1. List of acronyms

Acronym	Description
ADA	American Disability Act
API	Application Programming Interfaces
BLE	Bluetooth Low Energy
BNMC	Buffalo Niagara Medical Campus
ConOps	Concept of Operations
CS	Community Shuttle
CTP	Complete Trip Platform
DMP	Data Management Plan
EMC	Emergency Management Center
ETA	Estimated Time of Arrival
ETL	Extract, transform, and load
FHWA	Federal Highway Administration
FMVSS	Federal Motor Vehicle Safety Standards
GBNRTC	Greater Buffalo-Niagara Regional Transportation Council
GOFS	General On-Demand Feed Specification
GSM	Global system for mobile communication
GTFS	General Transit Feed Specification
HDS	Human-Driven Shuttle
HMI	Human Machine Interfaces
IRB	Institutional Review Boards
ITS	Intelligent Transportation System
ITS4US	Intelligent Transportation Systems for Underserved Communities
IVR	Interactive Voice Response
JSON	JavaScript Object Notation
LiDAR	Light Detection and Ranging
LTE	Long term evolution
NITTEC	Niagara International Transportation Technology Coalition
NFC	Near field communication
NFTA	Niagara Frontier Transportation Authority
NTCIP	National Transportation Communications for ITS Protocol
NY	New York
O&M	Operations and maintenance
ODD	Operational Design Domain
OTP	Open Trip Planner
PAL	Paratransit Access Line
PED-X	Pedestrian Crossing
PII	Personally Identifiable Information
PMESP	Performance Measurement Evaluation Support Plan
PMD	Performance Measurement Dashboard

PRG	Priority Request Generator
PROW	Public Right of Way
PRS	Priority Request Server
ROW	Right of way
RTK	Real-time Kinematic
SDS	Self-Driving Shuttle
SI	Smart Infrastructure
SLA	Service Level Agreements
SOC	Shuttle Operations Center
SOI	System of Interest
SRB	Stakeholder review board
SY	System
SyRS	System Requirements Specification
TBD	To be determined
TDM	Travel Demand Management
TED	Time of estimated departure
TIH	Transportation Information Hub
TMDD	Traffic Management Data Dictionary
TNEP	Tag NDEF Exchange Protocol
TSD	Time of service requested
UI	User Interface
URL	Uniform Resource Locator
U.S.	United States
USDOT	United States Department of Transportation
VoIP	Voice Over Internet Protocol
WCAG	Web Compliance Accessibility Guidance
XML	Extensible Markup Language

1.5. Document Overview

The remaining sections are organized as follow:

- Section 2 describes the proposed system.
- Section 3 lists the system level requirements.
- Section 4 details the subsystem level requirements.
- Section 5 provides the interfaces requirements.
- Appendix A traces the requirements to user needs.
- Appendix B details the major changes done to user needs and requirements.

2. General System Description

2.1. System Context

Figure 3 provides the detailed system context diagram for the Buffalo, NY ITS4US Deployment Project. This figure displays the different components and actors of the system of interest (SOI), as well as the external systems that interact with the SOI.

The following subsections describe the key components on the SOI.

2.1.1. Complete Trip Platform

The CTP provides trip planning and travel functions for travelers. The tool is available for registered and non-registered account users. Account holders will be able to interact with other mobility partners for which they have accounts (e.g., Niagara Frontier Transportation Authority (NFTA) paratransit and community shuttle services), personalize their trip preferences and customize hands-free turn-by-turn notifications, and access to wayfinding assets using components specified in the smart infrastructure subsystem. Non-registered travelers will be able to use the trip plan and travel tools to view accessible paths, transit services and alerts about asset status (e.g., elevator / escalator operations). The functions are described in the following sections.

2.1.2. Community Shuttle Subsystem

The CS subsystem will provide demand-responsive transit services within the Fruit Belt neighborhood. The CS consists of the following three components:

1. The SDS component, which will be a demand-responsive shuttle constrained to operate over a pre-defined route (i.e., a set of streets that satisfy the SDS Operational Design Domain, ODD) and pre-designated pick-up/drop-off locations.
2. The HDS, which will provide door-to-door on-demand service.
3. The SOC, which will receive all calls for services and will track the status of each vehicle in the CS fleet.

The envisioned service area for the proposed CS fleet is shown in Figure 4. The services to be provided within this area are detailed in Figure 5.

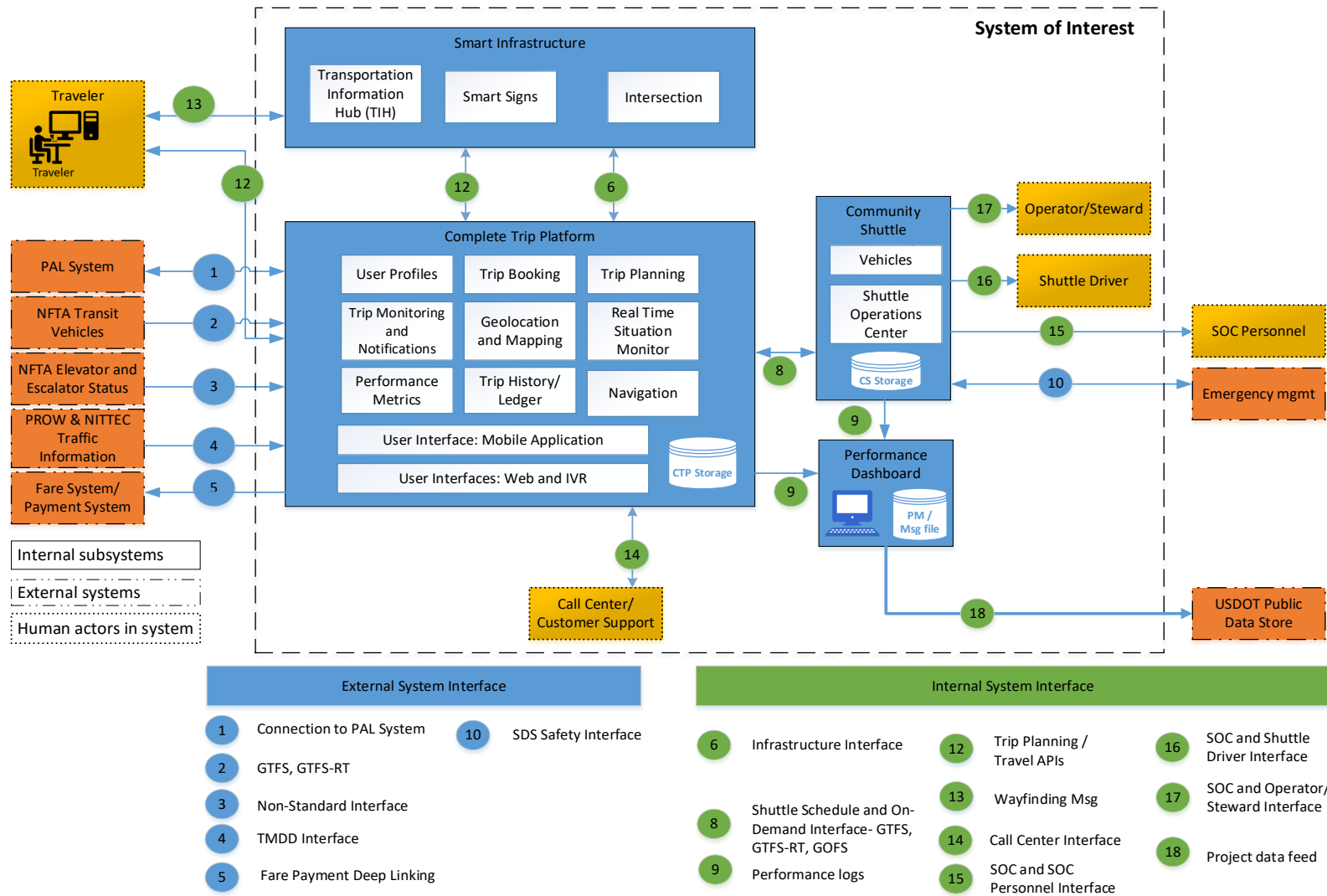


Figure 3. Buffalo, NY ITS4US Full System Deployment Context Diagram with Interfaces and Data Stores.

Source: ICF Buffalo ITS4US

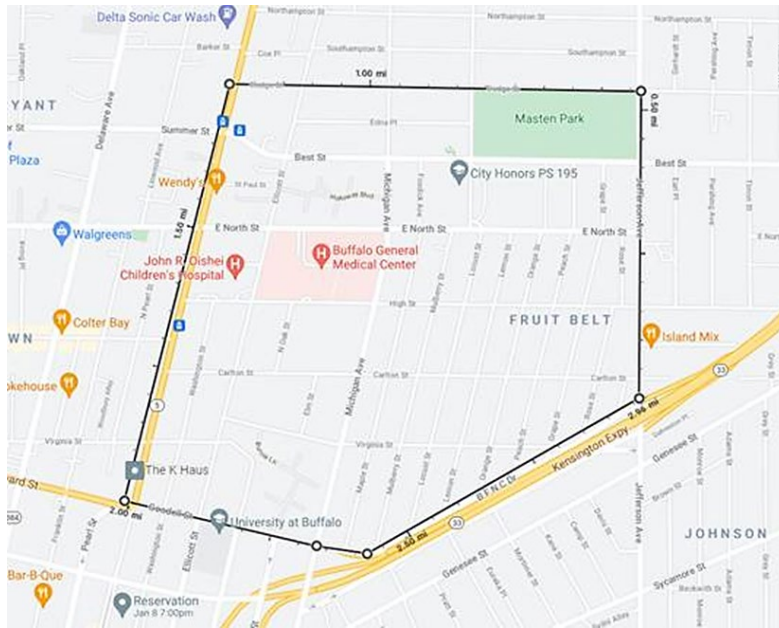


Figure 4. Proposed Service Area for the Community Shuttle.
 Source: Buffalo, NY ITS4US & Google Maps

		Services	Inside Area	Outside Area
Community Shuttle	{	HDS	🚶 🚶	
		SDS	🚶 🚶	
		PAL (spontaneous)*	🚶	
		PAL (regular)**	🚶	🚶
		Other NFTA Serv.	🚶 🚶	🚶 🚶
CTP - PAL eligible		🚶	* PAL (spontaneous) refers to <u>same-day</u> service	
CTP - General Traveler		🚶	**PAL (regular) reservation must be done by 8pm night before the trip	

Figure 5. Community Shuttle Services.
 Source: Buffalo, NY ITS4US

2.1.3. Smart Infrastructure Subsystem

This subsystem includes “smart” wayfinding components used for indoor and outdoor navigation at public right of ways, parking lots, building/facilities, bus shelters and stations, as well as requests for pedestrian crossing at selected signalized intersections—Main St. & Best St. and Ellicott St. & High St. Additionally, transitioning between indoor and outdoor environments will be seamless. Trip planning and navigation functions will be provisioned through the CTP, with the smart infrastructure assets and communications technologies offering travelers with similar turn-by-turn and hands-free functions. The CTP will also drive the interaction between the travelers’ mobile app and the pedestrian signal request.

Many of these smart components and traveler information products (e.g., trip plans, notifications) are supported by planned physical infrastructure improvements and accessible physical features, to be implemented during the next few years to complement or support the proposed system. These improvements will be combined with the digital components to create a “Smart Infrastructure” subsystem.

2.1.4. Performance Measure Dashboard Subsystem

The Performance Measure Dashboard subsystem monitors, integrates, analyzes, and displays performance measures from other subsystems and external sources. The details of the performance measures will be described in the PMESP. The subsystem will include functions to ingest log files from the subsystems and external data sources, storage, analytic and visualization tools to display and access current and historic data sets produced from the integrated system.

2.2. System Modes and States

The Modes of Operation for the Buffalo ITS4US project are described in Table 2. The modes of operation for the system depend on the operations fidelity of each subsystem. To that end, the system modes of operations are described by degraded or failed dependencies among the subsystem components.

Table 2. Modes of Operations for the System

Mode	Definition
Operational (regular)	All interfaces and subsystems are operating normally.
Degraded with communications or data feeds from external systems, smart infrastructure or CTP	<p>This mode occurs when interfaces are degraded or fail due to communications or data feed reduced availability, maintenance, or other impacts.</p> <p>When the CTP subsystem identifies that data on which it depends is not verified, accurate or fails, the subsystem will revert to static information and alert end user or stakeholder about the degradation. The interfaces include real time tracking / estimated time of arrival (ETA) information from NFTA, Paratransit Access Line (PAL), Shuttle vehicles, smart infrastructure assets (facilities, traffic signals, etc.) or the services will revert to their independent subsystem modes of operations (e.g., pedestrian crossing requests will rely on manual actuation).</p>
Degraded with communications or data feeds from smart infrastructure or CTP to Community Shuttle (particularly the SDS).	<p>This mode occurs when external interfaces and services critical to operations or the SDS subsystem impact operations.</p> <p>When critical external information or services that are needed for safe operation of the SDS, the SDS will revert to a Mission Critical Event (Severity 1 or 2) mode of operations. As discussed in the ConOps document, mission critical events (or severity level 1) are those events that render the subsystem or a core set of functions unusable (e.g., failure of the communications system between SDS and SOC or major problems with</p>

Mode	Definition
	<p>core algorithms. Severity level 2 events, on the other hand, are those involving the failure of a major component of the subsystem, severely impacting the core functions of the subsystem, by slowing them down to perform outside of established performance requirements. In such cases, HDS may replace the SDS if sufficient drivers and vehicles are available.</p> <p>When external information or services needed for a component of the subsystem, for example, scheduling or routing, the SDS will revert to a Minor Impact Event (Severity 3) mode of operations.</p>
Degraded as a result of a Major Weather Event (Severity Level 1)	This mode occurs during a significant weather event such as a major snow or ice storm. Under such circumstances, the whole CS subsystem, including both HDS and SDS, may not be able to operate.
Degraded as a result of a Mild Weather Event (Severity Level 2)	This mode occurs during a mild weather event (e.g., light or moderate snow). These weather conditions may prevent the safe operations of the SDS, but still permits the safe operations of HDS. In that case, the mode of operations for the Community Shuttle Subsystem would be degraded and the availability of the services would be constrained.
Degraded as a result of a minor weather event (Severity Level 3)	This occurs during a minor weather event (e.g., light rain). Given the redundancy built in several aspects of the Community Shuttle Subsystem, there should be ways to keep the subsystem operational under such circumstances but with reduced availability. For example, a SDS has a whole suite of sensors for sensing and perception. Given this, the SDS may continue to operate under such conditions.
Degraded when community shuttle services dependent on other subsystems are in reduced availability or impacted.	<p>This mode occurs when external interfaces and services which provide services to travelers (such as TIH, CTP) are degraded or fail due to communications or data feed reduced availability, maintenance, or other impacts.</p> <p>When the community shuttle operations monitor that data on which it depends is not verified, accurate or fails, the component will revert to manual exchange of information. If manual processes are not timely or cannot provide the appropriate information, backup systems and communication channels are available to handle traveler communications. Manual processes will be needed to book, route and dispatch customers.</p>
Failure	Failure mode operates as a mission critical impact. Information provision, communications and services between systems will be manually implemented. If no backup or redundant service is available, the operations will be suspended temporarily.

2.3. Major System Constraints, Assumptions, and Dependencies

The following are some operational policies and constraints identified for the proposed system. We understand that this is an initial list based on our understanding of the proposed system at the time, and therefore these may change during the design and testing phase of the project.

- Position accuracy as there may not be GPS service available in buildings. To mitigate this risk, the proposed concept includes indoor beacons that can provide some localization functions.
- Latency and format of sharing of information between various sources is critical and a data policy needs to be established between various system owners.
- Maintenance policies and requirements for smart infrastructure elements need to be established.
- Integration of smart infrastructure depends on access to power and communications networks. The positioning of the assets may be driven by access to these utilities.
- Service plans for the shuttle service are to be determined including the desired time and location of operation. Trips' origins and destinations will have to be within the service area of the micro-transit subsystem.
- Policies around navigating indoor pathways need to address the security protocols of partner agencies.
- Increased preferences in travel characteristics could limit trip alternatives. In addition, some trip preferences may not be consistent or compatible with mobile handsets and operating systems.
- Any delays in ongoing and planned projects, such as the Middle Main project, could impact the opportunity to leverage their improvements for this deployment project.
- The proposed system will be limited to the budget, manpower and hours of operation established by the Buffalo ITS4US partners and lead for Phase 2.
- The legislative and regulatory framework for self-driving shuttle use needs to be established and be supportive of the SDS use per the system requirements.
- Increased severe weather conditions could have an impact on the SDS operations and its availability for service.
- The CTP in the proposed concept relies on a variety of existing and publicly available open-source software, interfaces, features, and application modules. These features and modules will be re-used or repurposed without "re-inventing the wheel." The Open Trip Planner (OTP) is continuously being improved, and additional functionality and standard feed specifications and interfaces are deployed on an ongoing basis. The specifications ingested by the OTP and external interfaces consumed by third party systems will constrain the system in order to use the services and methods deployed in the system.
- The system will rely on available standards for providing data feeds to the data-driven subsystem. These standards include:
 1. Traffic Management Data Dictionary (TMDD).
 2. General Transit Feed Specification (GTFS) family of standards including GTFS, GTFS real time, GTFS-Flex and perhaps General On-Demand Feed Specification (GOFs) and GTFS-Pathways.
 3. OpenStreetMaps to support the OTP.

The one key assumption of this project is that vendors will be able to provide the necessary components in a manner that comply with the requirements and standards defined in this SyRS document.

2.4. User Characteristics

Table 3 describes the actors of the Travelers group, which are the intended benefactors of the deployment. The traveler actor describes the people living in the Buffalo region, and especially in the neighborhoods surrounding the BNMC who need to live, work and travel in the area. As such, the traveler actor are the end-users of the complete trip platform and services provided by the concept.

Table 3. Proposed System Traveler Actors

Actor	Short Description
Persons with Disability	<p>A person with a disability is defined by the American Disability Act (ADA) as a person who has a physical or mental impairment that substantially limits one or more major life activities, a person who has a history or record of such an impairment, or a person who is perceived by others as having such an impairment¹. For the purpose of this deployment, users with five types of disabilities are identified:</p> <ul style="list-style-type: none"> • Mobility – Travelers with various physical disabilities that affect both gross and fine motor skills that may require a personal assistance device. • Vision – Travelers who are blind or have low vision. • Cognitive – Travelers with cognitive disabilities. • Hearing – Travelers who are completely or partially deaf.
Low Income	Travelers with annual incomes <26K that use and travel in the area.
Older Adults	Travelers who are over the age of 70.
Low English Proficiency	Travelers to BNMC who do not use English as their primary language of communications.
BNMC Employees, Visitors, and Patients	Individuals who work, study, visit, or receive services on the BNMC campus. Some visitors and patients may travel to the BNMC from outside of the Buffalo area.
Caregivers	Individuals who take care of others traveler actors.
Neighborhood Residents	Travelers to, from, within the area that are residents of the Fruit Belt, Masten Park, and Allentown neighborhoods surrounding the BNMC.

Table 4 provides the list of operator/partner users who manage and support the operations of the different components of the proposed system.

¹ Source: <https://www.ada.gov/cguide.htm#anchor62335>

Table 4. Proposed System Operator/Partner Actors.

Actor	Short Description
Shuttle Operations Center	Systems of the public or private entity hired or assigned to manage the operations of the micro transit service defined in the concept, including the SDS and HDS vehicles.
Complete Trip Platform Deployer	Public or private entity hired or assigned to deploy and/or maintain the complete trip platform defined in the concept for the duration of the project.
NFTA Paratransit Operations (PAL)	Systems (call center, web, and phone) and personnel used to support PAL operations.
NFTA Operations	Systems and personnel involved in NFTA bus and rail operations. Also includes public and private traveler information systems currently in use at NFTA (Transit, Moovit, Agency website, phone) and associated personnel.
City of Buffalo Operations	Systems and personnel responsible for the streets, signals, sidewalks, bridges, traffic systems in the deployment area. This actor provides support to the intersection crossing system, as well as writing the law enforcement interaction and emergency management plan.
NITTEC	Systems and personnel responsible for traffic operations collaboration in the Buffalo region. NITTEC also provides data to the complete trip platform and shuttle operations center about transportation network conditions.
Regional Travel Demand Management (TDM) Services	Systems and personnel involved in TDM activities in the region including campus-wide initiative to create a more sustainable and active transportation system for employees on the BNMC, the regional Go Buffalo Niagara TMA, and statewide mobility management services (NSYDOT 511NY Rideshare).
NY State Department of Motor Vehicles	Systems and personnel responsible for permitting self-driving shuttle operations.
Emergency and Law Enforcement Entities	City, state and transit law enforcement and emergency systems and personnel responsible for monitoring emergency, safety of traffic and transit operations. Includes City of Buffalo, NFTA and NY State Police that may have jurisdiction in the system of interest. This actor would engage with the shuttle operations center during operations and respond to emergencies, as well as support the writing of the law enforcement interaction and emergency management plan.
BNMC Campus Entities	<p>Partners included in the BNMC Transportation Management Association. Input from representatives from each of the partner agencies on travel needs for their employees and visitors. User group includes systems and personnel involved in partner's specific parking, access, and traveler services. Five sub-groups are identified here around each for the partner agencies:</p> <ul style="list-style-type: none"> • Roswell Park • VIA • Kaleida Health • University at Buffalo • Buffalo Hearing and Speech Center <p>This actor will support the installation of indoor beacons and touch models to support facility navigation through the complete trip platform.</p>
Call Center Personnel	Human actors involved in call center operations to support the phone-based access of the CTP or the community shuttle. While this is a new actor, there is potential to leverage existing call-center / customer support capabilities.

Actor	Short Description
SOC Personnel	Personnel working as part of the shuttle operations center, supporting the operation and maintenance of the shuttle service.
Shuttle Driver	Drivers of the human driving shuttle. While this is a new actor, there is potential to leverage existing driver capabilities.
Operator / Steward	Operators/stewards in the self-driving shuttle. These would monitor and assist travelers in using the SDS and be prepared to take over in case the system disengages.

2.5. Operational Scenarios

This section describes the ten Use Cases of the Buffalo, NY ITS4US System. The reader is referred to the project's ConOps for a more detailed description of each Use Case.

2.5.1. UC 1: Register Profile and Preferences

This use case describes the processes and interactions with travelers to set up a Complete Trip Platform 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 with their CTP account.

2.5.2. UC 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).

2.5.3. UC 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.

Note: Manual and physical accessibility issues are not included in this use case.

2.5.4. UC 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.

2.5.5. UC 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.

2.5.6. Use Case 6: Ride-hailing Reservation and Dispatch

This use case describes several of the processes and functions of the SOC, and especially those that will be applied and activated when receiving a traveler requests service by the shuttles system.

2.5.7. Use Case 7: Passenger Pick-up, Securement, Travel and Drop-off via the SDS

This use case describes several of the processes and functions of the Shuttles Subsystem which will be applied and activated when a traveler boards a SDS, secures herself onboard the vehicle, travels on the SDS, and finally gets off the SDS at their final or intermediate destination.

2.5.8. Use Case 8: Passenger Pick-up, Securement, Travel and Drop-off via a Human-Driven Shuttle

This use case describes several of the processes and functions of the Shuttles Subsystem, which will be applied and activated when a traveler boards an HDS, has her mobility aid mechanism secured, travels on the shuttle, and finally gets off at their final destination.

2.5.9. Use Case 9: Manage Incidents

This use case describes the processes and functions that will be activated by the shuttles 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.

2.5.10. Use Case 10: Intersection Pedestrian Crossing (PED-X) Request

This use case describes the transmission of a PED-X request message from the CTP to the traffic signal controller. This use case supports the intersection crossing system.

Note: this use case is modeled after the National Transportation Communications for ITS Protocol (NTCIP) 1211 Signal Control and Prioritization architecture and use case scenarios. The terms Priority Request Generator (PRG), Priority Request Server (PRS) and Coordinator (CO) are use case actors in the NTCIP 1211 and will be used in this use case even as the PED-X request is a simple request and does not include a request for priority.

3. System Requirements

This section details the requirements at the system level, providing insight into the Buffalo, NY ITS4US System capabilities, conditions, performance, and constraints. In detail, this section lists the requirements for:

- Functional characteristics
- Performance characteristics
- Security and privacy
- Operations and maintenance
- Policy and regulations
- Lifecycle sustainment

Each requirement table includes three fields:

Req# -- a unique ID for each requirement that is composed of the following REQ-[system/subsystem acronym]-xx [unique number by system/subsystem]. Sub-requirements are designated with the parent number and a decimal number (e.g, xx.yy). A requirement is assigned an acronym for the system or subsystem to which it is allocated as follows:

- CS – community shuttle
- CTP – complete trip platform
- PAL – NFTA PAL Direct service
- PMD – performance management dashboard
- SI – smart infrastructure
- SY – system

Req Title – a title that summarizes the requirement description

Req Description – a well-formed requirements statement.

3.1. System Functional Characteristics

Table 5 details the system functional requirements. It should be noted that human factors, some data, and other types of requirements are imbedded within this functional requirement section.

Table 5. System Functional Requirements.

Req #	Req Title	Req Description
Req-Sy-001	Web browser support	The System shall support leading web browser applications when presenting on a website or mobile website. At a minimum, the System shall support Safari, Chrome, Microsoft Edge, and Firefox.
Req-Sy-003	Components Inventory	The System shall collect and store project components (e.g., smart sign) attributes and locations in an inventory that is available to project subsystems. Location information will be identified relative to the facility in which its components are placed within the project area (e.g., building, floor, bus stop shelter). The inventory file shall at a minimum include asset information such as asset identifier, location, facility, placement date, battery placement, specification and maintenance information. The specific data included will be developed during Phase 2 and will vary by type of component.
Req-Sy-004	Smart Sign Inventory Access	The System shall publish the smart sign inventory to be accessed by authorized systems and subsystems including, but not limited to, the CTP.
Req-Sy-005	Vehicle Accessibility features	The System shall collect and store information on accessibility information available from each CS vehicle used in the system. The information shall include attributes that support the demographic populations using mobility devices (e.g., lift/ramp, type of securement), hearing aids, visual support (text to speech), etc. The data supporting the types of assistive devices will be driven by stakeholder input during the Agile development process.
Req-Sy-006	Trip History and Unique Reference Identifier	The System shall assign a common unique identifier to a trip history to link the trip plan and execution, as well as its multiple trip segments. Trip history will include information about the complete trip associated with each subsystem. The detailed data contained in trip history records will be described for each mode, services, and subsystems during the design processes of each subsystem.

Req #	Req Title	Req Description
Req-Sy-007	Traveler PII Data Removal	The System shall remove PII data from system-wide storage when a traveler requests that their PII be removed from the system.
Req-Sy-008	Call Center	The System shall provide a call center where travelers can call to access CTP registration, trip planning, and CS reservation services.
Req-Sy-009	Access to Spontaneous Mobility Services via CTP	The System shall provide on-demand, same day trip reservations and mobility services to registered CTP travelers.
Req-Sy-009.1	Access to SDS Mobility Services via CTP	The system shall provide community shuttle on-demand ride-hailing services within the project region on the SDS. The SDS shall only operate on designated roads and stop at fixed pickup and dropoff stops.
Req-Sy-009.2	Access to HDS Mobility Services via CTP	The system shall provide community shuttle on-demand door to door services within the project region on the HDS.
Req-Sy-009.3	Access to PAL Spontaneous Services via CTP	The system shall provide paratransit on-demand door to door services within the project region to PAL eligible travelers on NFTA PAL. The PAL shall allow an eligible PAL Direct traveler to book spontaneous (on-demand), same day travel in the geographic area covered by the project.
Req-Sy-009.4	Access to PAL Direct services via CTP	The PAL shall enable eligible paratransit travelers to book their PAL Direct reservations through the CTP subsystem by linking their CTP account with their PAL account credentials.
Req-Sy-011	Geographic Coverage	The System shall provide on-demand and microtransit service (HSD and SDS) in the geographic area covered by the project.

3.2. System Performance Characteristics

Table 6 details the performance requirements that the system shall meet to fulfill the user needs.

Table 6. System Performance Requirements.

Req #	Req Title	Req Description
Req-Sy-012	Trip Planning and Booking Service Level Agreements	The System shall comply with a set of service level agreements (SLA) that meet traveler service levels for generating accessible trip options and operations for on-demand community shuttle service. The SLAs and their performance levels will include, at a minimum, trip plan options and adherence levels for estimated pickup and travel times. The SLA will be determined in Phase 2.
Req-Sy-012.1	CS Response Time	The community shuttle shall execute trip plans within pre-specified time limit from the request (e.g., 60 minutes). The time limit will be determined in Phases 2 and 3 once supply and demand of service is better known.
Req-Sy-012.2	CTP "Trip Plan Generation" Response Time	The CTP shall generate trip plans within pre-specified time limit from initial selection for internal functions. The time limits will be determined in Phases 2 and 3, and do not include end-user computing limitations for rendering and displaying the results.
Req-Sy-012.3	CTP Notification Transmission Response Time	The CTP shall generate and transmit notifications to travelers/end-user devices within a pre-specified time limit from the time the trigger (that caused the notification to be sent) was received to the time the notification was transmitted by the CTP. Different types of notifications will have different time limits and priorities. The time limits will be determined in Phases 2 and 3, and do not include end-user computing limitations for rendering and displaying the results.
Req-Sy-036	CS Health Status Communications Action to the CTP	The CS Shall meet a set of SLAs for health status to the CTP. The types of alerts (e.g., failures, degraded mode, dropped connection, etc.) will drive the pre-specified time limits for reporting. The time limits for detecting, alerting and reacting will be determined in Phases 2 and 3 for each CS mode and alert type.

3.3. System Security and Privacy

Table 7 details the system security and privacy requirements that the system needs to meet in order to fulfill the user needs. These requirements pertain to every subsystem.

Table 7. System Security and Privacy.

Req #	Req Title	Req Description
Req-Sy-013	Data security	The System shall implement a data security plan to secure end-to-end encryptions and security provisions for all data transmitted to and between subsystems and users.
Req-Sy-014	PII data use policy and IRB	The System operators shall develop and publish a data use and privacy policy to disclose to registered account holder information about data collection, use, and dissemination policies related to their personal information. The types of PII and use of data will conform to the IRB provisions.

3.4. System Operations and Maintenance

This section details the operations and maintenance requirement for the system.

3.4.1. System Maintainability

Table 8 details the system maintenance requirements that the system needs to meet to fulfill the user needs. These requirements pertain to every subsystem.

Table 8. System Maintainability Requirements.

Req #	Req Title	Req Description
Req-Sy-015	Operations and Maintenance Plan	The system shall comply with an operations and maintenance (O&M) plan that covers all subsystem operations and maintenance, including but not limited to staffing, hours of operations, operations and maintenance levels, processes for software security and patch updates, preventive maintenance schedules and procedures, system level service level agreements (SLA), and modes of operations. The O&M plan will be developed in Phases 2-3.
Req-Sy-015.1	O&M Plan -- Operations Resources	The O&M Plan shall include plans for staffing, staffing roles and responsibilities, hours of operations, and other resources needed to support operations.
Req-Sy-015.2	O&M Plan -- Incident Management	The O&M Plan shall include plans for establishing and operating incident management flow process from ingestion to closure including troubleshooting, escalation, failure management and work order management. Incident management procedures will

Req #	Req Title	Req Description
		include incident severity and prioritization levels by incident types, as well resolution SLAs by incident severity level. An operations help desk may be required.
Req-Sy-015.3	O&M Plan -- System Monitoring	The O&M Plan shall include provisions for monitoring the system to ensure that each subsystem (and component) is operating effectively and safely. The specific service levels, if not identified in this specification, will be identified in Phase 2.
Req-Sy-015.4	O&M Plan -- Maintenance Levels	The O&M Plan shall describe the maintenance levels and establish preventive maintenance procedures and schedules for all subsystem components.
Req-Sy-015.5	O&M Plan -- Configurable Items	The O&M Plan shall include an inventory of all configurable items.
Req-Sy-015.6	O&M Plan -- Maintenance Procedures	The O&M Plan shall list the maintenance procedures for each component including repair and replacement activities.
Req-Sy-015.7	O&M Plan -- Security Operations	The O&M Plan shall include procedures for monitoring security of the system, subsystem and components. Security provisions may require daily, weekly and annual review of log files, firewall rules, and other monitoring activities to ensure that the system is secure.
Req-Sy-016	Software Change Bulletin	The System shall publish an announcement when software patches, updates or upgrades are planned. The software change bulletin should highlight any changes to data items (schema or semantics), interfaces, or operating systems. The software change process will be part of the change management process (to be included in the Phase 3 Project Management Plan).

3.4.2. System Operations

Table 9 details the system operations requirements that the system needs to meet to fulfill the user needs. These requirements pertain to every subsystem.

Table 9. System Operations Requirements.

Req #	Req Title	Req Description
Req-Sy-032	Mode of Operation -- Normal	The system and subsystems shall operate in normal mode of operation as described in Section 2.2. During normal operations all interfaces and subsystems are operating normally.
Req-Sy-033	Mode of Operation -- Degraded	The system and subsystems shall alert related subsystems when they are operating in degraded mode as described in Section 2.2.
Req-Sy-034	Mode of Operation -- Failure	The system and subsystems shall transition to failure operational mode when or another subsystem detects that it is failing. As described by Section 2.2, Failure mode operates as a mission critical impact. Information provision, communications and services between systems will be manually implemented. If no backup or redundant service is available, the operations will be suspended temporarily.
Req-Sy-037	Customer Cost	The system operators shall charge fares for services that are comparable to existing NFTA services.
Req-Sy-038	Operational Cost	The system operators shall collect information on operational costs on an annual basis.

3.5. System Policy and Regulation

This section details system policies and regulations requirements that meet user needs. These requirements pertain to every subsystem. Note that subsystem/component-specific policies and regulations are detailed within their respective set of requirements.

3.5.1. System Accessibility

Table 10 details system accessibility requirements that meet user needs. These requirements pertain to every subsystem.

Table 10. System Accessibility Requirements

Req #	Req Title	Req Description
Req-Sy-002	Web and mobile user interface accessibility	The System shall comply with Web Compliance Accessibility Guidance (WCAG) 2.1 for all digital information presentation including mobile and web browsers.
Req-Sy-018	Accessible Vehicles	The system shall use vehicles that are accessible for people using mobility devices (e.g., wheelchairs), that is, the vehicle at a minimum, is equipped with a lift or ramp and wheelchair securements.

3.5.2. Standards

Table 11 details system policy related standard requirements that meet user needs. It is important to note that other standard requirements are discussed at the subsystem level.

Table 11. System Standard Requirements.

Req #	Req Title	Req Description
Req-Sy-019	Americans with Disability Act	The System shall comply with the Americans with Disability Act (1990).

3.6. System Lifecycle Sustainment

This section details system policy related standard requirements that meet user needs. The system lifecycle sustainment includes information management requirements, technology renewal, and institutional requirements.

3.6.1. Information Management

Table 12 details information management requirements that include data backup, recovery and retention, data curation and referential integrity requirements that pertain to all subsystems.

Table 12. System Information Management Requirements.

Req #	Req Title	Req Description
Req-Sy-020	Backup System	The system shall provide a backup system that protects persistent, transactional, operational, and archived datasets.
Req-Sy-021	Manual and automated backup	The system shall provide automated and manual backup functions to schedule full and interim backups. Frequency of backups will be determined during the development of the system in Phase 2.
Req-Sy-022	Data Recovery Tool	The system shall provide tools for the system administrator to recover lost or corrupted data. The tools should be configured to provide optimal data recovery based on a Disaster Recovery Plan.
Req-Sy-023	Operational Data Retention	The system shall store data per applicable NFTA data policy for up to five years or the duration of the Buffalo ITS4US project.
Req-Sy-024	PII and Research Data Retention	The system shall store PII data for three years after the Buffalo ITS4US project evaluation is completed or in compliance with IRB provisions.
Req-Sy-025	Linking trip segments	Subsystem log files shall use a common reference (identifier) or a reference that can be associated with the trip plan and reservation used by a traveler in executing their trip.
Req-Sy-026	Dataset Curation Plan	System developers shall develop a curation process plan for each dataset that is consistent with the DMP and PMESP. The dataset includes data collection, ingestion, validation/quality checking, ETL processes, storage, distribution methods, metadata documentation. The frequency of the curation process will be determined in Phase 2.
Req-Sy-026.1	Implement Dataset Curation	Data stewards shall implement the dataset curation plan including quality control procedures.

3.6.2. Technology Renewal

Table 13 details technology renewal requirements that pertain to physical assets obsolesce.

Table 13. System Technology Renewal Requirements.

Req #	Req Title	Req Description
Req-Sy-027	SDS and SOC Technology Review	The System Developers shall review and update the technology of the SDS and SOC on an annual basis to ensure that sensors and components continue to meet safety regulations.
Req-Sy-028	Mobile App Upgrade	The System Developers shall assess and determine major upgrades to the CTP mobile app based on changing mobile technology.

3.6.3. Institutional and Non-technical

Table 14 details institutional requirements that pertain to system lifecycle development and the system rollout.

Table 14. System Institutional Requirements.

Req #	Req Title	Req Description
Req-Sy-029	Agile Stakeholder Engagement	The Agile Development process shall define a process to assign end-users to a stakeholder review board (SRB) which will review user stories and drive priority development.
Req-Sy-030	Agile Backlog	The Agile Development process shall document how software developers will develop, publish, and schedule epics and user stories that will be used as part of their Agile process in collaboration with the SRB.
Req-Sy-031	Agile Sprint Tracking	The Agile Development process shall define how software developers will provide access for the SRB to view sprint assignments and performance statistics including but not limited to sprint schedules, progress, and bug tracking.
Req-Sy-035	Account Linking APIs	The system shall request and integrate an API transaction set from mobility providers to allow account linking. This enables the CTP account holders to link their accounts.
Req-Sy-35.1	PAL Account Linking APIs	The PAL DIRECT shall provide an API transaction set for the CTP to provide an option for CTP customers to link their CTP and PAL accounts.

4. Subsystem Requirements

This section presents the requirements for each subsystem. When possible, each subsystem will contain requirements in the following fields:

- Functional Requirements – including requirements for general operations and performance. Like the system-level requirements, some human factors, data, and other types of requirements are imbedded within functional requirements.
- Data – including requirements for information management.
- Physical – including requirements for construction, durability, adaptability, and environmental conditions.
- Security and Privacy – including requirements for cyber and physical security of the system.
- Human Machine Interfaces (HMI) and Accessibility – including requirements for access to services and usability of the equipment.
- Operations and Maintenance – including requirements for operations and maintenance activities and support of the system.

4.1. Complete Trip Subsystem

The Complete Trip Platform subsystem concept is described in Section 2.1.1. The CTP subsystem includes the requirements listed in the following subsection.

4.1.1. Functional

Table 15 details CTP functional requirements that meet user needs.

Table 15. Complete Trip Platform Functional Requirements.

Req #	Req Title	Req Description
Req-CTP-001	Reservation Planning Services	The CTP shall provide to the traveler the ability to check, book, confirm, change, cancel, and view their reservation for the Community Shuttle or PAL Spontaneous (if eligible).

Req #	Req Title	Req Description
Req-CTP-001.1	Reservations -- check service	The CTP shall provide to the traveler the ability to check service availability using their CTP trip planning application.
Req-CTP-001.2	Reservations -- booking service	The CTP shall provide to the traveler the ability to request and book reservations using their CTP trip planning application.
Req-CTP-001.3	Reservations -- confirm service	The CTP shall provide to the traveler the ability to confirm their reservations using their CTP trip planning application.
Req-CTP-001.4	Reservations -- change service	The CTP shall provide to the traveler the ability to change their reservations after they booked a reservation using their CTP trip planning application.
Req-CTP-001.5	Reservations -- cancel service	The CTP shall provide to travelers the ability to cancel their reservations after they booked a reservation using their CTP trip planning application.
Req-CTP-001.6	Reservations -- view service	The CTP shall provide to the traveler the ability to view their reservations after they booked a reservation in their trip planning application.
Req-CTP-009	Pre-populate Trip Mode Preferences	The CTP shall pre-populate the traveler's preferred trip mode(s) based on their selected preferences.
Req-CTP-010	Pre-populate Trip Location (Origin)	When using a mobile or facility access channel (e.g., mobile app or TIH), the trip plan shall incorporate the location of the device into the trip plan request. The mobile app requires that location tracking is turned on. Note: there is a requirement that allows a user to change any preference at the time of planning or beginning a trip (see Req-CTP-001.4).
Req-CTP-012	Data of Mobility Services in Project Region	The CTP shall incorporate data from mobility service options available to travelers in the project region. The service options include PAL Spontaneous and community shuttle. Service data includes, but is not limited to, modes, operational times, schedules (GTFS), service coverage (GTFS Flex), payment information (optional), pickup / drop off points (for CS SDS shuttle), station pathways (GTFS pathways), and real time status (GTFS real time).
Req-CTP-013	Core Functionality from OTP	The CTP shall use the open trip planner (OTP) to provide the core trip planning, routing, and monitoring functionality, interfaces, and infrastructure. The core

Req #	Req Title	Req Description
		OTP system is described in https://github.com/opentripplanner/OpenTripPlanner .
Req-CTP-014	Multimodal Trip Planner	The CTP shall provide travelers with the option to tailor their trip plans based on their preferences and abilities for the modal services incorporated in this project including indoor and outdoor navigation (via automobile, NFTA bus, light rail and PAL Direct, Community Shuttle, walking, biking, and other mobility options) which provides underserved populations with door-to-door trip plans. The implementation and rollout will be driven by stakeholder input during the Agile Development process.
Req-CTP-015	Updating Trip Plan	The CTP shall allow travelers to update their trip preferences when they plan their trip.
Req-CTP-016	Updating Saved Trips	The CTP shall provide a traveler with the option to save trip information including but not limited to trip plans, trip preferences (by plan).
Req-CTP-018	Augmented functionality	The CTP shall enhance the OTP core functionality to tailor and update trip plans based on traveler preferences and abilities identified by end-user groups during the Agile development process. The preferences and abilities will define new types of notifications, navigation instructions, communication channels (telephone, TIH, web, mobile app) and user interface methods (text, voice, haptic).
Req-CTP-019	Integrated Trip Planning services	The CTP shall include multimodal trip planning, routing, and monitoring of travelers as they plan and execute their trips to ensure seamless and coordinated transfers between trip segments.
Req-CTP-019.1	Integrated Trip Planning -- NFTA fixed route	The CTP shall integrate NFTA transit options in the integrated trip planning mode options. Updates of datasets associated with the service provision will be updated prior to any service change.
Req-CTP-019.2	Integrated Trip Planning -- NFTA PAL options	The CTP shall integrate NFTA paratransit options in the integrated trip planning mode options.
Req-CTP-019.3	Integrated Trip Planning -- CS SDS	The CTP shall integrate Community Shuttle SDS options in the integrated trip planning mode options.

Req #	Req Title	Req Description
Req-CTP-019.4	Integrated Trip Planning -- CS HDS	The CTP shall integrate Community Shuttle HDS options in the integrated trip planning mode options.
Req-CTP-019.5	Integrated Trip Planning -- Other mobility provider options (optional)	As needed, the CTP shall integrate other mobility provider options in the integrated trip planning mode options.
Req-CTP-023	Trip plan optimization for different traveler groups	The CTP shall assign impedance factors to the network used to generate trip plans for groups of traveler types based on common preferences and abilities as well as their executed trip histories in similar geographic areas.
Req-CTP-027	On-line / off-line data usage and tracking	The CTP mobile app and mobile web application shall include an on-line and off-line mode. The features of each mode will follow the mobile operating system protocols (iOS and Android) for tracking and carrier service plans for on-line and off-line use of data usage.
Req-CTP-028	Account settings	The CTP shall provide the capability for users to set up, save, and update preferences for travel beyond the trip preferences currently including in the OTP. The development and rollout of these services will be driven by stakeholder input during the Agile Development Process. At a minimum, the enhanced trip preferences will include the ones listed in Req-CTP-28.1 through req-CTP-28.9
Req-CTP-028.1	Account settings -- mode	The CTP shall provide the capability for users to select mode preference (including PAL Direct, PAL (spontaneous), Community Shuttle SDS or HDS, NFTA).
Req-CTP-028.2	Account settings -- accessibility and support services	The CTP shall provide the capability for users to select accessibility and support services (e.g., travel companion, service animal, and call to third party -- guardian/caregiver).
Req-CTP-028.3	Account settings -- language	The CTP shall provide the capability for users to select language choice (including American Sign Language).
Req-CTP-028.4	Account settings -- notifications	The CTP shall provide the capability for users to select notifications (e.g., intersection PED-X countdown, conveyance status, ETA for reservation services) for a set of notifications. The set of editable notifications will be defined in Phase 2.

Req #	Req Title	Req Description
Req-CTP-028.5	Account settings -- automated request	The CTP shall provide the capability for users to select automated request for service (e.g., hands-off request for PED-X actualization, smart signs).
Req-CTP-028.6	Account settings -- navigation instructions	The CTP shall provide the capability for users to select navigation instructions (hands-free turn by turn, user defined landmarks).
Req-CTP-028.7	Account settings -- communications channels	The CTP shall provide the capability for users to select communications channel to receive trip updates (e.g., web, mobile app, mobile website, call or SMS) including wearables and assistive devices (e.g., Bluetooth enabled hearing aids, canes, watches).
Req-CTP-028.8	Account settings -- favorite places	The CTP shall provide the capability for users to select favorite places including destinations, pickup/dropoff locations, and bus stop.
Req-CTP-028.9	Account settings -- user interface methods	The CTP shall provide the capability for users to select methods of receiving notifications (e.g., voice, text, haptic/vibration).
Req-CTP-037	CTP Registration	The CTP shall provide registration services for travelers to set up their account including establishing a profile, selecting their preferences and saving trip plans.
Req-CTP-039	CTP Account username and password	The CTP shall implement account usernames and passwords including a method for users to reset their password, find their username or password that meets secure two-factor authorization.
Req-CTP-040	Third party access to Traveler Accounts	The CTP shall provide a secure process to allow trusted third parties (guardians/caregivers, call center agent, non-emergency medical transportation assistance program) to access traveler accounts when they are granted access rights.
Req-CTP-041	Assistive Technology Compatibility	The CTP shall connect to and provision notifications to the traveler's preferred assistive technology support device (e.g., wheelchair, hearing aids) including matching communication channel and user interface method. For example, a traveler with hearing disability may request a haptic alert that a new notification was received. The matching of assistive technologies, communications channels, user interface methods and notifications will be driven by stakeholder input during the Agile Development Process.

Req #	Req Title	Req Description
Req-CTP-042	CTP Travel Account Link with PAL Direct	The CTP shall provide a procedure for PAL customers to link their CTP profiles with their PAL account with exchange of minimum PII (contact information, account number) and no sensitive PAL account information (health data).
Req-CTP-045	Transit and mobility service status information	The CTP shall provide a traveler who requests notification of NFTA transit and CS vehicle service's estimated time of arrival and status information with real time information at configurable times prior to the vehicle's arrival. The information is based on the GTFS real time data feed but may be extended to include the variety of notifications on NFTA, CS SDS/HDS, and PAL Direct services. Note: GOFS (spec yet to be published) may be used if it meets the needs of travelers.
Req-CTP-046	Continuous trip planning	When the traveler is using their mobile app for trip execution, the CTP shall continuously update their trip plan to identify seamless and accessible transfers. This includes checking transfers between modes, obstacles / disruptions to travel, and other challenges that may prevent seamless transfer.
Req-CTP-047	Rerouting trip plan	If the traveler sets their preference for trip updates, the CTP shall provide the traveler via their mobile app, an updated trip plan that re-routes their trip if the trip plan encounters challenges (see Req-CTP-046 - Continuous trip planning). <i>Based on yet to be defined business processes, services that require reservations may need to be confirmed prior to rebooking services are conducted.</i>
Req-CTP-050	Geolocate traveler near intersection	The CTP mobile app shall detect when the traveler is approaching an intersection crossing based on their trip plan. Minimum accuracy of detection will be determined in Phase 2.
Req-CTP-051	Generate PED-X request message	The CTP mobile app shall generate a PED-X request to actuate the walk request for a specific crosswalk in a specific direction upon detecting that the traveler is within a configurable distance (or time) of the crosswalk. The specific distance (time) value will be determined during Phase 2.
Req-CTP-052	Transmit PED-X request message	The CTP mobile app (acting as a PRG) shall transmit the PED-X request message to the PED-X gateway (acting as PRS) at a configurable time of service requested (TSD) threshold value (e.g., 30 second before traveler

Req #	Req Title	Req Description
		arrives at the intersection), and continuously generate and transmit request updates with new TSD and time of estimated departure (TED) estimate.
Req-CTP-054	Generate and transmit PED-X request cancel message	The CTP mobile app shall generate a PED-X request cancel message when the app detects that the traveler no longer requires the walk signal actuation.
Req-CTP-055	Generate and transmit PED-X request clear message	The CTP mobile app shall generate a PED-X request Clear message when the app detects that the traveler has crossed the intersection.
Req-CTP-056	CTP countdown	The CTP shall provide the travel mobile app a countdown clock on the time left before the PED-X phase is toggled based on the traveler's preference.
Req-CTP-060	Trip Notification Triggers	The CTP shall trigger real time notifications to travelers as designated by their preferences and at the time and place designated by their trip plan. These include, but are not limited to, landmarks, intersections, or approaching or arriving at pickup/drop off (boarding/alighting) locations for NFTA, CS or PAL. The development and rollout of these triggers and their implementation will be driven by stakeholder input during the Agile Development Process.
Req-CTP-061	Trip Notification of Trip Anomalies	The CTP shall trigger real time notifications when a trip plan is affected by traveler behavior or connection delays. These include but are not limited to: <ul style="list-style-type: none"> a) when traveler travels beyond their alighting / drop off location (for NFTA or CS SDS). b) when a traveler alights a NFTA/CS SDS vehicle earlier than their transition drop off location. c) when a traveler will miss their connection due to early / late arrival of a NFTA or CS SDS reservation.
Req-CTP-062	Trip notification to preferred user interface	The CTP shall provide notifications to travelers using their preferred user interface method. These methods at a minimum include text, voice or haptic. The types of notifications and the method used will be driven by stakeholder input during the Agile development process.
Req-CTP-063	Trip notification preferences	The CTP shall provide an enumerated set of preferences for travelers to select for their account which they can adjust the selections, trigger, and frequency for each trip.

Req #	Req Title	Req Description
		These preferences will be configurable to assign to indoor and outdoor trip segments.
Req-CTP-064	Notification and Alert Priority	The CTP shall allow the traveler to select notification priorities while setting up their trip plan. Safety alerts (such as do not cross intersection) will take priority even over traveler settings. A set of safety alerts will be driven by mobility provider standards and stakeholder driven priorities during the Agile Development Process.
Req-CTP-065	Traveler Assistance	The CTP shall provide an emergency call feature that is configurable by the traveler for them to initiate a call (via telephone, VoIP) to a third party of their choosing including caregiver, guardian, call center, or other trained mobility manager to help with planning or executing their journey.
Req-CTP-066	Trip Planning and mobility options	The CTP shall optimize and rank order of alternative trip plans based on the trip plan parameters and traveler preferences that best match available services, transfers and modes. The optimization, ranking, alternative trip plans, and processes when no trip plans are generated will be driven by stakeholder input during the Agile Development process in Phase 2.
Req-CTP-067	CTP Help Feature	The CTP shall include help features on the website and mobile app that describe the tool features and functions. The Help feature shall be accessible to the Travelers (in Section 2.4) and Call Center staff.
Req-CTP-068	CTP Services on Communications Channels	The CTP registration, profile settings, trip planning, execution and reporting shall be accessible through, at a minimum, the following communication channels: web application, mobile web application, mobile app, and call center agent.
Req-CTP-069	CTP User Interface method	The CTP shall provide notifications and navigation instructions using a variety of user interface methods as selected by the traveler and depending on the functionality of their end-user device including voice (by automated phone alert, mobile app, Voice Over Internet Protocol - VoIP), text (by SMS or mobile app/mobile web application) or vibration (by mobile app or wearable).
Req-CTP-070	CTP UI Method and Communications channel	The CTP shall allow a user to select a notification UI method to be matched to the communication channel. The matching UI methods, notifications and

Req #	Req Title	Req Description
		communication channel will be driven by the stakeholders during the Agile development process.
Req-CTP-071	CTP language notification selection	The CTP shall allow a traveler to choose a language, including American Sign Language, in which they will receive their voice, video or text notifications. The set of languages will be selected during Phase 2 and shall not exceed four languages in addition to English.
Req-CTP-072	CTP language planning selection	The CTP shall allow a traveler to choose a language to use while using the registration, profile settings, planning, and reporting functions. The set of languages will be selected during Phase 2 and shall not exceed four languages in addition to English.
Req-CTP-073	Trusted third party access	The CTP shall allow a traveler to designate a trusted third party who is authorized to access their CTP account, book, modify and cancel reservations, and track their trip. The details of the access, authorization, authentication and audit will be driven by stakeholders during the Agile development process.
Req-CTP-074	User-based access to Traveler Account	The CTP shall implement a process to authenticate a trusted party sign on and access to a traveler's account information.
Req-CTP-075	Audit Third Party Access	The CTP shall log and audit the activities of third parties when they access a traveler's account.
Req-CTP-076	Group Travel	The CTP shall not separate a traveler and their designated travel companions in their trip plan and reservations.
Req-CTP-077	Caregiver Designation	The CTP shall allow a traveler to designate a caregiver or travel companion(s) who should not be separated from the traveler planning a trip.
Req-CTP-078	Traveling with a service animal	The CTP shall allow a traveler to indicate that they will be (are) accompanied by a service animal when they plan or execute a trip. The operating procedures for traveling with a service animal is described by the mobility provider.
Req-CTP-079	Mobility operator service animal policies	The CTP shall enforce the mobility provider's (e.g., CS SDS, HDS, PAL, NFTA) policy by allowing/disallowing a traveler to book a trip if they indicate whether they will be accompanied by a service animal. The mobility provider

Req #	Req Title	Req Description
		will designate whether a service animal is allowed on their vehicles.
Req-CTP-080	Traveler feedback form	The CTP shall provide a traveler feedback form for travelers or other CTP users to provide information on challenges, obstructions or conditions on their trip plan or in the project geographic region. The content and format of this crowd-sourced data shall be driven by stakeholder input during the Agile development process.
Req-CTP-081	CTP ingestion of feedback	The CTP shall develop a process to ingest and integrate the crowd-sourced data into the routing engine and notifications for other travelers (when relevant and timely).
Req-CTP-082	Traveler satisfaction survey tool	The CTP shall provide a configuration tool for project staff to generate customer satisfaction surveys.
Req-CTP-083	Access to Traveler satisfaction survey results	The CTP shall provide a method for designated researchers to access the results of satisfaction survey that removes any PII from the raw data.
Req-CTP-084	CTP ingestion of event datasets	The CTP shall ingest and integrate the planned and unplanned event data into the routing engine and notifications for travelers (when relevant and timely). The datasets will include but are not limited to the following: Traffic, Work zones, Incidents, Weather, Infrastructure and services capacity status (e.g., parking availability), new and existing transit services status (location, estimated time of arrival, delays and closures), and Infrastructure status (e.g., elevator and escalator conditions, sidewalk condition). The datasets and their timing will be driven by stakeholder input during the Agile Development Process.
Req-CTP-085	CTP ingestion of traffic signal control operation data	The CTP shall ingest and integrate traffic signal control phasing data into the routing engine and notifications for other travelers (when relevant and timely). The data will be used to support the Smart Infrastructure PED-X function and to provide automated passenger system (APS) information to travelers arriving at crosswalks.
Req-CTP-086	Report Traveler feedback issue	The CTP shall send a message to the appropriate entities (e.g., BNMC, NFTA or City of Buffalo, facility owner) when a public asset or system issue, event or condition, is reported using the Traveler Feedback Form.

Req #	Req Title	Req Description
		Note: the feedback will not cover emergency issues, events or situations.
Req-CTP-088	UI to Call Center	The CTP shall provide user interface services to support the call center software. The interfaces are built into the OTP core capabilities.
Req-CTP-089	Travel Opt-Out	The CTP shall provide a traveler with the option to opt-out of trip tracking when loading or executing a trip plan. The default setting is for the travel to opt-in to tracking while using their mobile app for executing their trip plan (receiving direction instruction, notifications, etc.).
Req-CTP-091	Travel Opt-in/out Toggle	The CTP shall allow a traveler to toggle from opt-in to opt-out or from opt-out to opt-in of tracking at any time they are using their mobile app.
Req-CTP-095	Self-Monitoring Log	The CTP shall perform self-monitoring and log each health check session and current status in an operational log file. Parameters will be defined in Phase 2.
Req-CTP-096	Self-Monitoring Log Transmission	The CTP shall transmit operational log file to the PMD daily to generate operational performance measures.
Req-CTP-101	Tune location settings	The CTP shall provide instructions to travelers that describe how to configure and calibrate their location sensors to achieve the most accurate location and positioning performance from their mobile app.
Req-CTP-104	CTP publish operational alerts	The CTP shall publish system notifications on the web application (e.g., scrolling announcements) and mobile app, or via the Call Center IVR. Alerts and notifications shall include but are not limited to CS operational status, NFTA operational status, elevator/escalator outages and more.
Req-CTP-104.1	CTP publish operational alert timing	The CTP shall publish system notifications on its various channels (see parent requirement) within 1 minute of their receipt from external sources and maintain the message until receipt of an all clear, expiration time, or manual intervention.
Req-CTP-105	System operational alert tool	The CTP shall provide authorized third parties the ability to manually or automatically insert an operational alert that will be available to travelers through the CTP user interfaces.

Req #	Req Title	Req Description
Req-CTP-106	CTP Marketing Design Guidance	The CTP shall generate a template for quick deployment of web page that follows marketing design guidance. The guidance approach will be specified in the project Outreach Plan (Reference # TBD).
Req-CTP-110	Transmit to Traveler Time to Cross (Don't Walk)	With the information from the PED-X Status Message, the CTP mobile app shall begin the countdown clock that shows the traveler the time until the do not walk sign is actuated—see Req-SI-027 for requirement about when notification of walk/don't walk phase shall be sent.
Req-CTP-110.1	Transmit to Traveler Time to Cross (Don't Walk) -- Clock Time Synchronization	Clock times of the mobile app and traffic signal controller shall be synchronized to minimize latency or errors in the timing.
Req-CTP-110.2	Transmit to Traveler Time to Cross (Don't Walk) -- Countdown	The CTP shall begin countdown within 200ms upon receipt of the data and calculate within a 500ms (1/2 second) error, the timing based on the phase duration.
Req-CTP-111	Monitor for PED-X connectivity	The CTP mobile app shall monitor the connection between the PED-X Gateway and CTP mobile app.
Req-CTP-112	Alert Lack of communications for PED-X connectivity	The CTP mobile app shall alert the traveler requesting PED-X request actuation within 200ms upon detecting communications between the PED-X Gateway and CTP mobile app is degraded or failed.
Req-CTP-113	PED-X anomalies	The CTP mobile app shall manage the transaction request for PED-X actualization responses from the Traffic Signal Controller to identify missed or cancelled status response.
Req-CTP-114	Alert Traveler to PED-X anomalies	The CTP mobile app shall alert the traveler to PED-X responses for missed, cancelled, or other dropped messages that will impact the actuation request within twenty seconds of expected responses. The specific messages and responses will be driven by stakeholder input during the Agile Development Process.
Req-CTP-115	Alert Lack of communications with SDS Passenger Information Systems	The CTP mobile app shall alert the traveler onboard an SDS within one minute of detecting that local communications (e.g., Bluetooth) has degraded or failed.
Req-CTP-116	Smart Sign Inventory Acquisition	The CTP shall acquire and use the Smart Sign Inventory asset information to augment wayfinding, navigation and destination finding functions onboard the mobile app.

Req #	Req Title	Req Description
		The specific procedures and algorithms will be designed in Phase 2. The procedures and algorithms may be located onboard the mobile app or in the subsystem back office.
Req-CTP-119	CTP Travel Account Link with PAL Direct	The CTP shall provide a procedure for PAL customers to link their CTP profiles with their PAL account with exchange of minimum PII (contact information, account number) and no sensitive PAL account information (health data).
Req-CTP-122	PAL vs. System Responsibility	<p>The CTP shall provide a channel for PAL travelers to book PAL Services and notify PAL travelers who book trips through the CTP (and opt in for real time notifications) of their vehicle arrival time.</p> <p>The responsibilities for PAL / PAL DIRECT and the Buffalo ITS4US project will be coordinated during Phases 2 and 3.</p>
Req-CTP-123	Contradictory preferences	The CTP shall check for conflicts among the traveler's input preferences, when planning a trip, and notify the traveler of any identified conflicts.
Req-CTP-124	Preference / notification selection mismatch with end traveler's device	The CTP shall check the compatibility of the traveler's device with the traveler's preferences and inform traveler of any mismatches. The mismatches will be defined when the communication channels, user interface methods, assistive devices and notifications are aligned during the Agile development process.
Req-CTP-125	Trip plan alternatives	The CTP shall inform the traveler of possible, alternate itineraries in case the CTP cannot generate a trip plan.
Req-CTP-126	Reservation process	The CTP developer shall establish the process for booking a trip on the Community Shuttle. The process shall be driven by stakeholder input during the Agile development process and ensure that all selections, origins, destinations, and other accommodations are confirmed by the traveler at the time of booking and prior to the trip initiation.
Req-CTP-127	No-show vehicles	The CTP shall provide an emergency call number that a traveler can use to notify the system in case their shuttle does not show up.

Req #	Req Title	Req Description
Req-CTP-128	Traveler mobile device not linking with indoor/outdoor Smart Signs	The CTP shall notify travelers of any connection error within one minute of detection.
Req-CTP-132	Monitor for Mobility Provider Connectivity	The CTP mobile app shall monitor the connection between a connected mobility provider vehicle and CTP mobile app.
Req-CTP-137	Preferences for Caregivers	The CTP shall allow travelers to specify services for caregivers including sending alerts, having them as travel companions and giving full access to the CTP on their behalf. A full list of services will be driven by stakeholder input during the Agile Development Process.

4.1.2. Data

Table 16 details CTP data requirements related to functional requirements and that meet user needs.

Table 16. Complete Trip Platform Data Requirements.

Req #	Req Title	Req Description
Req-CTP-011	Buffalo and NFTA Service Coverage	The CTP shall provide existing NFTA transit service information for travelers to plan their trips in the Buffalo area. Transit Service data identified for integration with the CTP includes: (a) Static information (operational times, schedules (GTFS), service coverage (GTFS Flex), payment information). (b) Real time status (GTFS real time data).
Req-CTP-017	Multimodal Data	The CTP shall process datasets that enable the provision of multimodal trip planning beyond the core functionality of the OTP. These datasets will evolve over time, and they are identified in the DMP.
Req-CTP-021	Trip Planning Data validation and processing	The CTP shall ingest, validate, and process network data that includes network features, attributes and conditions for different modal networks including roads, transit, mobility (bikes), public right of way (sidewalks, crosswalks), and facility pathway (and conveyance) datasets. Rollout of the ingestion and curation processes

Req #	Req Title	Req Description
		associated with each dataset will be staged to support related functions.
Req-CTP-022	Reference transportation network	The CTP shall relate data from different sources to a reference base map that is used to optimize and generate trip plans.
Req-CTP-048	Sidewalk Data features	The CTP shall include Public Right of Way (PROW) features, attributes and conditions that support the provision of navigation and wayfinding information to travelers about accessible entrances and pathways to bus stops, transit stations and facilities (e.g., parking, offices, hospitals, clinics) in the BNMC area. The scale and resolution of the features will depend on the precision and accuracy of the collection methods and technologies used. In addition, the rendering of these objects will depend on the positioning and tracking sensors used by the traveler's mobile device, a person's visual ability and other factors. The fitness for use for different functions will be assessed as part of the Agile testing process.
Req-CTP-049	Indoor Pathway features	The CTP shall include indoor path and destination features, attributes and conditions that support the provision of wayfinding and destination confirmation information to travelers about facilities in selected facilities in the BNMC campus.
Req-CTP-057	PED-X Request Message	The Ped-X request message shall be adapted from the NTCIP 1211 priority request message which contains the identifier of the mobile app that is desired for Ped-X, a request identifier, the priority strategy requested (crosswalk to actuate the pedestrian signal), time of service requested (TSD), and the time of estimated departure (TED).
Req-CTP-058	PED-X Request Cancel Message	A PED-X request cancel message shall be adapted from NTCIP 1211 priority request cancel message which contains the identifier of the mobile app that is desired for PED-X, a request identifier, the priority strategy requested (crosswalk to actuate the pedestrian signal), TSD, and the TED.
Req-CTP-059	PED-X Request Clear Message	A PED-X request clear message shall conform to the NTCIP 1211 request clear message and include the identifier of the mobile app that is desired for PED-X, a request identifier, the priority strategy requested

Req #	Req Title	Req Description
		(crosswalk to actuate the pedestrian signal), TSD, and the TED.
Req-CTP-092	Trip History and Unique Reference Identifier	The System shall assign planned and actual trip plan segments with a common unique identifier to link various trip segments into a trip history. Trip history will include information about the complete trip associated with each subsystem. The detailed data contained in trip history records will be described for each mode, service, and subsystem during the design processes of each subsystem.
Req-CTP-108	Ingest Work Zone Event data	The CTP shall collect, quality check, and process planned and unplanned work zone event information (location, impact, timing) and integrate impedance factors into the routing engine, trip planning and execution notifications information including construction that impacts streetscape, cross-sections, sidewalks and intersections in a trip plan. The frequency of the update depends on the availability of the data feed and will be determined in Phase 2.
Req-CTP-118	Reservation accommodating traveler assistive devices	The CTP shall include information on traveler assistive devices when booking CS services to ensure that the vehicle accessibility features match traveler needs. The types of assistive devices will be driven by stakeholder input during the Agile development process.
Req-CTP-120	Reservation accommodating traveler preferences	The CTP shall provide an option for travelers to identify their preferred traveler assistive devices when booking CS services to ensure that the vehicle accessibility features match traveler needs. The types of assistive devices will be driven by stakeholder input during the Agile development process.
Req-CTP-133	Account History and PII Removal	The CTP shall, upon request by a registered account holder, shall remove their PII from CTP storage and request removal of PII from system-wide storage.
Req-CTP-134	Account Closure and Removal	The CTP shall provide the registered account holder with an option to close their account and remove their PII (including travel history) from the system.

4.1.3. Physical

Table 17 details CTP physical requirements that meet user needs.

Table 17. Complete Trip Platform Physical Requirements.

Req #	Req Title	Req Description
Req-CTP-026	Communications Channels	The CTP shall include communication channels that include, at a minimum, web application, call center, mobile app, mobile web application, and transportation information hub (TIH).
Req-CTP-094	CTP Reliability	The CTP shall follow reliability and uptime service levels documented in a service level agreement during Phase 2.
Req-CTP-097	Processing Loads	The CTP shall be developed to support 120% of the load expected of services and users during the project duration.
Req-CTP-098	Processing and Load Scalability	The CTP shall be architected to increase the number of processes over time as new users and processes utilize the system beyond the project duration.
Req-CTP-099	Application and Feature Expansion	The CTP shall be architected to expand the functions, features and services provided to stakeholders and travelers beyond the project duration.
Req-CTP-100	Data Broker	The CTP shall support a service oriented architecture and include a data broker that extracts, transforms and loads open standard APIs including REST, JSON, GeoJSON, XML, csv formats.
Req-CTP-103	CTP Operational Modes	The CTP shall operate in accordance to the operational modes detailed in Section 2.2.
Req-CTP-117	Smart Signs using Common communications protocols	The CTP shall interface with smart signs using communication technologies supported by mobile devices (e.g., near field communication - NFC, Bluetooth Low Energy - BLE) without need for specialized functionality to be developed for the mobile app.

4.1.4. Security and Privacy

Table 18 details CTP Security and Privacy requirements that meet user needs.

Table 18. Complete Trip Platform Security and Privacy Requirements.

Req #	Req Title	Req Description
Req-CTP-053	Trusted connection for PED-X actuation	The CTP and Traffic Signal System shall establish a secure tokenization or other trusted method to exchange PED-X request and status messages.
Req-CTP-090	Data Use Disclosure policy	The CTP shall provide and acquire a signed disclosure prior to collecting and using any PII from CTP registered users.
Req-CTP-093	CTP Security	The CTP shall provide end-to-end security for traveler data, particularly PII, and derived data sets. The security requirements, developed for the Smart Columbus PIVOT app apply to this project (see MMTPA Security Final.pdf). The details and application of these provisions to the CTP will be implemented as part of the Agile Development Process.

4.1.5. HMI and Accessibility

Table 19 details CTP HMI and accessibility requirements that meet user needs.

Table 19. Complete Trip Platform HMI and Accessibility Requirements.

Req #	Req Title	Req Description
Req-CTP-008	Reservations APIs	The CTP shall use Application Programming Interfaces (API) provided by the mobility provider for the SDS, HSD, PAL spontaneous and PAL Direct reservation management modules.
Req-CTP-024	Accessibility Feature Compliance	The CTP shall comply with Web Content Accessibility Guidelines (WCAG 2.1) accessibility features (on both the web and mobile platforms).

4.1.6. Operations and Maintenance

Table 20 details CTP operations and maintenance requirements that meet user needs.

Table 20. Complete Trip Platform Operations and Maintenance Requirements.

Req #	Req Title	Req Description
Req-CTP-025	End-User Driven User Experience	The CTP user experience shall be driven by an agile development approach with input from end-users. The end-users will include input from the underserved communities identified in the ConOps (reference from Section 2 of the SyRS).
Req-CTP-087	Traveler Feedback priority	The CTP shall prioritize reporting issues to appropriate entities based on the severity of the issue. The types of events/issues and reporting priorities and channels will be designed during Phase 2.
Req-CTP-102	Test for accuracy	The CTP shall test wayfinding and intersection movement to ensure positional and orientation accuracy is safe for all traveler use. The accuracy needed to ensure safe wayfinding and intersection movement differs by traveler ability, for example, a person with a visual disability requires greater positional precision to avoid stepping into an intersection. Testing will consider traveler's abilities and preferences when verifying safety.
Req-CTP-107	CTP Maintenance levels	The CTP shall document the operations and maintenance procedures needed to sustain the subsystem. The procedures will include but are not limited to security audits, software patches and updates to the back office and mobile apps, upgrades to software as infrastructure software changes, and change management process.

4.2. Smart Infrastructure

4.2.1. Functional

Table 21 details smart infrastructure (PED-X, TIH, and Smart Signs) functional requirements that meet user needs.

Table 21. Smart Infrastructure Functional Requirements.

Req #	Req Title	Req Description
Req-SI-002	PED-X Gateway operation	The PED-X gateway shall not conflict with the operations of the current signal system or physical pedestrian request signal operations.

Req #	Req Title	Req Description
Req-SI-003	Transmit PED-X request message	The PED-X (acting as PRS) shall receive and process the PED-X request message sent by the mobile app (acting as a PRG) to the PED-X gateway within 200ms of its receipt.
Req-SI-004	Log PED-X request	The PED-X gateway shall log the PED-X request message including the message and event times (receipt, forward, and respond).
Req-SI-005	Forward PED-X request	The PED-X gateway shall validate and forward the PED-X request message to the Controller to actuate the walk request phase within 200ms of its receipt.
Req-SI-006	Send PED-X status	The PED-X gateway shall generate a message with the crossing walk time and transmit the PED-X status message to the CTP mobile app within a maximum time of 200ms and maximum rate of 5 seconds after receipt of the initial PED-X request message.
Req-SI-016	TIH thin client for CTP	The TIH shall serve as a thin client implementing the same functionality as the CTP website. A thin client uses resources stored on a central server instead of a localized hard drive—that is, they connect remotely to a server-based computing environment where most applications, sensitive data, and memory, are stored.
Req-SI-017	TIH CTP configuration	The CTP used on the TIH shall be configured to generate a trip plan with the origin at the TIH location. Other default settings (including timing out, logging out of account, and other services) will be driven by stakeholder input during the Agile development process.
Req-SI-018	TIH CTP connection	The TIH shall connect to the CTP central functionality through an internet connection.
Req-SI-021	TIH talking touch model	The TIH shall speak the name of the location in English and up to two other languages to be selected by the facility owner as a user presses a location on the touch model.
Req-SI-022	TIH touch model language selection	The TIH shall allow the user to select the language that is spoken when a location is selected on the touch model.

Req #	Req Title	Req Description
Req-SI-023	TIH touch model content configuration	The TIH touch model shall include a tool to configure and update the messages spoken when a location is selected.
Req-SI-027	Transmit Time to Cross (Don't Walk)	The traffic signal system shall send , with a latency of no more than 1 second via the PED-X gateway, information on the time when the PED-X phase will toggle from walk to do not walk (in the direction requested by the traveler).
Req-SI-028	Public kiosks	The Smart Infrastructure shall deploy a TIH installed at selected location around the BNMC which travelers can use to access CTP registration, trip planning, and CS reservation services.
Req-SI-032	Smart Sign Data Sharing	Upon request, the Smart Signs shall share pre-defined datasets with users of the CTP app.

4.2.2. Data

Table 22 details smart infrastructure data requirements that meet user needs.

Table 22. Smart Infrastructure Data Requirements.

Req #	Req Title	Req Description
Req-SI-007	PED-X Status Message	A PED-X request status message shall conform to the NTCIP 1211 prgTSPRequest format. This includes configuring the data to provide the identifier of the mobile app that sends PED-X request message, a request identifier, the priority strategy requested (crosswalk to actuate the pedestrian signal), and actual time to Walk (estimated TSD) and actual time to Don't Walk (TED).
Req-SI-031	Smart Sign Data Storing	The Smart Signs shall store pre-defined set of data. The dataset will be determined in Phase 2.

4.2.3. Physical

Table 23 details smart infrastructure (PED-X, TIH and Smart Signs) physical requirements that meet user needs.

Table 23. Smart Infrastructure Physical Requirements.

Req #	Req Title	Req Description
Req-SI-001	PED-X Gateway	The SI shall implement a PED-X gateway to verify, store and forward pre-defined pedestrian signal request messages between the CTP mobile app (or authorized devices) with the traffic signal controller.
Req-SI-008	Smart sign durability	The smart sign shall operate in indoor and outdoor environments in the Buffalo, New York environment without degradation: -- operational temperature (-20 to +60°C) -- Waterproof (IP67)
Req-SI-009	Smart sign power	The smart sign shall be powered replaceable battery power with an average life of 5 years (depending on usage) or by 120 AC power source.
Req-SI-011	Smart Signs – BLE Beacons	For smart signs supporting BLE, the smart sign shall include the following specifications: (1) support BLE 5 or above; (2) have a configurable broadcast range of between 50-100 meters for indoor spaces or 200-300 meters for outdoor spaces. The space will dictate the preferred range.
Req-SI-012	Smart Signs – NFC	For smart signs supporting NFC, the smart sign shall include the following specifications: (1) support Tag NDEF Exchange Protocol (TNEP) Technical Specification 1.0; (2) have a broadcast range of 10 cm depending on the location where it is used.
Req-SI-013	Smart sign installation and mounting	The smart sign shall be constructed to be installed using adhesive or screws mounted on a wall, shelter, or pole.
Req-SI-019	TIH equipment	The TIH shall be composed of the following four equipment components: (1) hardened touch screen display with embedded keyboard and track pad. (2) backend processor (e.g., laptop, tablet) with speaker / microphone and Bluetooth interface. (3) touch model of indoor layout of facility (interactive tactile display with talking interface).

Req #	Req Title	Req Description
		<p>(4) connections between touch model and processor, and touch screen and processor.</p> <p>Two configurations will be included one with all components and one without the touch model (and connectors).</p> <p>Power, internet access and installation (including form factors for equipment) shall be provided by the facility owner</p>
Req-SI-020	TIH touch model	The TIH touch model shall represent the layout of the facility including all pathways, conveyances, destinations, and other features needed to support wayfinding through the facility. The information imprinted on the touch model should include destinations in English and Braille.
Req-SI-024	TIH CTP and Touch Model operations	The TIH shall have sufficient processing, persistent and dynamic storage capacity to operate multiple end-devices simultaneously, allowing simultaneous operations of the touch model and CTP website by different users.
Req-SI-029	TIH environmental conditions	<p>The TIH shall operate in indoor and outdoor environments in the Buffalo, New York environment without degradation:</p> <ul style="list-style-type: none"> -- operational temperature (-20 to +60°C) -- Waterproof (IP67)
Req-SI-030	SI durability	The Smart Infrastructure equipment shall be durable and hardened for use. The hardening process shall secure physical, software, user interface devices and other peripherals from harm.

4.2.4. Security and Privacy

Table 24 details smart infrastructure security and privacy requirements that meet user needs.

Table 24. Smart Infrastructure Security and Privacy Requirements.

Req #	Req Title	Req Description
Req-SI-025	PED-X Gateway	The Smart Infrastructure shall employ a secure communications gateway that uses communications channels and protocols that are native to a majority of mobile devices to exchange messages between the CTP mobile app and the Traffic Signal PED-X module.

4.2.5. HMI and Accessibility

Table 25 details smart infrastructure HMI and accessibility requirements that meet user needs.

Table 25. Smart Infrastructure HMI and Accessibility Requirements.

Req #	Req Title	Req Description
Req-SI-014	Smart Sign branding	The smart sign shall comply with marketing guidance established in the Outreach Plan (reference # TBD) so that it is easily recognizable as a Buffalo ITS4US project component.
Req-SI-015	Smart Sign tactile form	The smart sign shall include a tactile overlay using braille to convey information on the current location and smart sign identifier.

4.3. Community Shuttle

This subsection lists the Community Shuttle (CS) requirement (SDS and HDS), including also additional requirements that relate to PAL Spontaneous and PAL Direct. Later versions of the SyRS may edit the requirements presented here or add new ones once more information about potential vendors is known.

It is important to note that PAL Spontaneous and HDS services will leverage the existing PAL Direct application to provide reservations, operations, and reporting services. These two modal services will be configured and implemented using instances of the PAL Direct system and be managed by the NFTA operations staff. They will use the same open architecture APIs configured for the current PAL Direct services within the geographic region. The requirements only specify changes to the existing system that cover the Buffalo ITS4US system.

4.3.1. Functional

Table 26 details the CS functional requirements that meet user needs.

Table 26. Community Shuttle Functional Requirements.

Req #	Req Title	Req Description
Req-CS-019	Monitor Communications	The SDS shall continuously monitor the status of communications network.
Req-CS-020	Alert Steward of Degraded Communications	The SDS shall provide an alert to the safety steward if the connectivity between the SDS and the support infrastructure (e.g., SOC, RTK station) is operating in less than “normal” mode.
Req-CS-022	Incident Management due to Degraded Health	Upon degraded health, the SDS shall trigger an alert to actuate an incident management event such as alerting human steward to take over, stopping, and transitioning from autonomous to manual driving mode. The emergency events and incident management actions for the SDS will be planned and configured during Phase 2.
Req-CS-024	Detect, classify, measure and Interpret Objects	The SDS perception module shall detect, classify, measure objects and vehicle motion, and interpret surrounding environment across 360 degrees, based on input from multiple and redundant sensors as listed in Req CS-014. This shall take place in such a manner to allow the SDS sufficient time to take appropriate action as described in Req-CS-026.
Req-CS-024.1	Detect Vehicles	The SDS shall detect oncoming and stationary vehicles at a specified distance (relative to their speed) to allow the SDS to take appropriate actions to ensure safe and efficient operations.
Req-CS-024.2	Detect Pedestrians	The SDS shall detect pedestrians standing and crossing an intersection. Detection will be based on detecting the pedestrian at a specified distance (relative to their speed) to allow the vehicle to take appropriate actions regarding moving pedestrians.
Req-CS-024.3	Classify Objects	The SDS shall be able to classify and interpret detected objects, including the ability to distinguish between static objects to the side of the road (e.g., snow banks) and pedestrians.
Req-CS-024.4	Driving Rule Compliance	The SDS shall recognize and follow the driving rules associated with the Manual on Uniform Traffic Control Devices (NYSDOT version) for

Req #	Req Title	Req Description
		traffic signals, phases, signs, and other traffic control devices.
Req-CS-025	Motion Planning Algorithm	The SDS motion planning algorithm shall model trajectories for every object through time and space so that the SDS has a dynamic picture of its environment.
Req-CS-026	Operations in Mixed traffic	The SDS shall be able to operate in mixed traffic, within the SDS Operational Design Domain (ODD), alongside other dynamic road users (e.g., moving vehicles, bicyclists, pedestrians, and other vulnerable road users – VRUs).
Req-CS-026.1	ODD Rule Set Compliance	The SDS shall operate according to the driving and environmental conditions specified in the Operational Design Domain (ODD) for the SDS. These include, but are not limited to, the set of road segments, unsignalized and signalized intersections making up the pre-defined fixed route along which the SDS will be deployed as part of the Buffalo ITS4US deployed project. The ODD rule set will be configured during Phase 2.
Req-CS-026.2	Operational Specifications	The SDS shall comply with operating specifications to ensure the comfort of passengers and compliance with rules of the road. These include, but are not limited to, turn dynamics, appropriate car following, collision avoidance, stopping and pulling over in the presence of an emergency vehicle, stopping at the designated pick-up and drop-off locations, emergency stopping, and acceleration/deceleration profiles shall be within comfortable and safe ranges. The operational specifications will be configured during Phase 2.
Req-CS-026.3	Driving During Inclement Weather	The SDS shall operate during mild inclement weather conditions including but not limited to rain, wet surfaces, and mild snow events. The list of conditions that are safe to travel will be defined during Phase 2.
Req-CS-026.4	Avoid Conflicts with Other Vehicles	The SDS shall be able to avoid conflicts with other moving or stationary vehicles, by stopping,

Req #	Req Title	Req Description
		slowing down, and/or following the appropriate right-of-way rules of traffic law.
Req-CS-026.5	Avoid Conflicts with Pedestrians'	The SDS shall be able to avoid conflicts with pedestrians by stopping, slowing down, and appropriately yielding the right of way to pedestrians.
Req-CS-026.6	Avoid Fixed Objects	The SDS shall be able to navigate around fixed objects requiring avoidance, including different objects above, below, to the side, and ahead of the vehicle. The requirement is dependent on the sensor systems detecting fixed and moving objects (see Req-CS-024). Fixed objects include temporary objects such as snowbanks.
Req-CS-026.7	Avoid Moving Objects	The SDS shall be able to navigate around moving objects requiring avoidance, including different objects above, below, to the side, and ahead of the vehicle. The requirement is dependent on the sensor systems detecting fixed and moving objects (see Req-CS-024). Moving objects includes animals, bouncing balls, boxes falling out of a moving vehicle, debris, and other items.
Req-CS-026.8	Navigate with Minimum Clearance	The SDS shall be able to navigate in right of ways with minimum clearance including next to chain link fence, driveways, and other objects in close proximity. Proper clearance values will be determined in Phase 2.
Req-CS-028	Emergency Stop Actions	When performing an emergency stop in autonomous mode, the SDS shall automatically activate the emergency/hazard lights, move the vehicle as far from the travel lanes as possible, and alert emergency services.
Req-CS-029	Designated Pickup/Drop off Stops	The SDS shall stop at designated pick-up and drop-off locations provided by the SOC routing engine to pick up or drop off passengers.
Req-CS-036	On-Demand Routing and Dispatch	The CS shall operate on-demand service managed by their backoffice scheduling, routing and dispatch functions, including path planning and curb use for pick-ups and drop-offs.

Req #	Req Title	Req Description
Req-CS-036.1	SDS on-demand routing and Dispatch	The SDS shall operate on fixed network right of ways in the BNMC and project region providing on-demand services at designated pickup and dropoff points along the network. The SDS backoffice system is called the Shuttle Operations Center (SOC).
Req-CS-036.2	HDS on-demand routing and Dispatch	The HDS shall operate door to door, on-demand service managed by their backoffice scheduling, routing and dispatch services in the BNMC and project region.
Req-CS-036.3	PAL spontaneous routing and Dispatch	The PAL spontaneous service shall operate door to door, on-demand service managed by PAL DIRECT scheduling, routing and dispatch services in the BNMC and project region.
Req-CS-040	Validate Reservation	The Mobility Provider vehicle shall be equipped with a mechanism to verify boarding passengers have a valid reservation (booked through the CTP) to travel their reserved trip (e.g., boarding / alighting location and time).
Req-CS-040.1	Validate SDS Reservation	The SDS shall be equipped with a mechanism to verify boarding passengers have a valid reservation (booked through the CTP) to travel their reserved trip (e.g., boarding / alighting location and time).
Req-CS-040.2	Validate HDS Reservation	The HDS shall be equipped with a mechanism to verify boarding passengers have a valid reservation (booked through the CTP) to travel their reserved trip (e.g., boarding / alighting location and time). The validation may be through inspection by the HDS operator.
Req-CS-040.3	Validate PAL Spontaneous Reservation	The PAL Spontaneous vehicle shall be equipped with a mechanism to verify boarding passengers have a valid reservation (booked through the CTP) to travel their reserved trip (e.g., boarding / alighting location and time). The validation may be through inspection by the PAL operator.
Req-CS-041	SDS User Interface Channels	The SDS shall include user interface channels tailored to traveler needs. The specific features have some variability depending on the SDS provider.

Req #	Req Title	Req Description
Req-CS-041.1	SDS UI Channel – in-vehicle status audio	The SDS shall include an in-vehicle audio that informs passengers as to the status of vehicle operation such as doors closing, departure imminent, destination approaching.
Req-CS-041.2	SDS UI Channel – in-vehicle status visual	The SDS shall include an in-vehicle visual information, ideally through an in-vehicle screen, that shows vehicle status, location and trip progress.
Req-CS-041.3	SDS UI Channel – in-vehicle situational awareness audio/visual	The SDS shall include an in-vehicle visual and audio Information about the environment surrounding the vehicle including a) location, route, certain landmarks; b) traffic accidents and incidents; c) deviations from route or why the SDS may be stopping.
Req-CS-041.4	SDS UI Channel – Braille	The SDS shall include Braille lettering for any in-vehicle functions that require passenger interaction.
Req-CS-041.5	SDS UI Channel – universal icons	The SDS shall use Universal icons for signs in the vehicle
Req-CS-041.6	SDS UI Channel – instructional videos	The SDS shall include instructional videos
Req-CS-041.7	SDS UI Channel – External announcements and visual cues	The SDS shall include external announcements and visual cues about the vehicle number, destination and persons who reserved the vehicle.
Req-CS-041.8	SDS UI Channel – Connection to CTP mobile app	The SDS shall include connection to CTP mobile app, other mobile device, or assistive device through local communication protocol (e.g., Bluetooth)
Req-CS-042	Communicate SDS Status	<p>The SDS passenger information system shall communicate to riders information about the vehicle status, travel path, situational awareness, and public safety messages. At a minimum, the types of information include:</p> <ul style="list-style-type: none"> •Travel information including current location, route, destination, next pickup/dropoff point, landmarks.

Req #	Req Title	Req Description
		<ul style="list-style-type: none"> •Situational awareness about events such as incidents. •Deviations and delays related to trip. •Public safety messages including doors open, board now, secure your seat belt, close door, “watch your step” and other appropriate warnings. <p>The types of information will be driven by the data acquired and the stakeholder priorities during the Agile Development Process.</p>
Req-CS-043	Tracking CS vehicle operations	The CS shall track the location and monitor performance of vehicles in revenue service in real-time.
Req-CS-043.1	Track SDS Performance	The SOC shall track the location and monitor operational performance of vehicles in revenue service in real-time. Operational performance includes all sensor, passenger and communications events, event anomalies, triggers and alerts that are generated by the SDS.
Req-CS-043.2	Track HDS Performance	The HDS operator shall track the location and monitor performance of vehicles in revenue service in real-time.
Req-CS-044	SDS Operational Design Domain (ODD)	The SOC shall describe the SDS ODD rule set that designates and controls where the SDS can operate in autonomous mode.
Req-CS-045	Mobility Provider Booking API Specifications	CS Mobility providers shall specify APIs for use by the CTP to request service booking. Booking services, at a minimum, will include request service availability, book service, and cancel service for one or more travelers. The content of the APIs and orchestration of the API methods will be developed in collaboration during Phase 2 with appropriate CS mobility provider and CTP during Phase 2.
Req-CS-045.1	SDS Booking API Specification	The SDS reservations operator shall provide API specifications for use by the CTP for booking services.

Req #	Req Title	Req Description
Req-CS-045.2	HDS Booking API Specification	The HDS reservations provider shall provide API specifications for use by the CTP for booking services.
Req-CS-045.3	PAL Booking API Specification	PAL DIRECT shall provide API specifications for use by the CTP to verify eligibility and booking services.
Req-CS-046	Booking Status API	The CS Mobility Provider shall provide APIs for use by the CTP to publish information about reservations status. Status information, at a minimum, will include updates to pickup / dropoff times and locations, estimated time of arrival, delays, events/incidents, and other status information. The content of the APIs, orchestration, and operational performance (frequency, latency, and timeliness) of the API methods will be developed in collaboration with the Mobility Provider SDS SOC module and CTP during Phase 2.
Req-CS-046.1	SDS Booking Status API	The CS SDS operator shall provide APIs for use by the CTP to publish information about reservations status.
Req-CS-046.2	HDS Booking Status API	The CS HDS operator shall provide APIs for use by the CTP to publish information about reservations status.
Req-CS-046.3	PAL Booking Status API	The PAL DIRECT developer shall provide APIs for use by the CTP to publish information about reservations status.
Req-CS-049	Mobility Provider Routing Management	The Mobility Provider shall generate vehicle routing and schedules based on operational rules related to the operational strategy in order to meet traveler trip travel requests and reservations. Operational strategies include carpooling, door to door service, microtransit (network or fixed route), etc.
Req-CS-049.1	SDS Scheduling and Routing	The SDS SOC shall generate routing and schedules based on ODD rules for SDS vehicles. Routing will follow pre-defined paths and stop at fixed stops in the geographic region. Schedules will include estimated travel, arrival

Req #	Req Title	Req Description
		and departure times to pick up and drop off passengers.
Req-CS-049.2	HDS Scheduling and Routing	The HDS routing management system shall generate PAL (spontaneous) routing and schedules for on-demand, door to door manifests. These typically will consist of two or more pick-up and drop-off locations, travel times between the stops and estimated arrival and departure times.
Req-CS-049.3	PAL DIRECT Scheduling and Routing	PAL DIRECT shall generate routing and schedules for on-demand, door to door manifests. These typically will consist of two or more pick-up and drop-off locations, travel times between the stops and estimated arrival and departure times.
Req-CS-050	Monitoring SDS Environment	The SOC shall monitor the driving environment (e.g., road characteristics and driving dynamics) to ensure that it conforms to the elements of the SDS Operational Design Domain (ODD) to operate in autonomous mode.
Req-CS-051	Incident Management using Law Enforcement Interaction Plan	The SOC shall ingest, process and evaluate information about incidents along the path of the SDS, or incidents involving the SDS itself, and manage the incident based on detailed procedures developed in the Law Enforcement Interaction Plan.
Req-CS-052	CS Notify EMS	Upon the occurrence of an incident, the CS mobility operator (HSD or SDS) shall notify appropriate emergency management and incident response personnel.
Req-CS-052.1	CS SDS Notify EMS	Upon the occurrence of an incident, the SDS mobility operator shall notify appropriate emergency management and incident response personnel.
Req-CS-052.2	CS HDS Notify EMS	Upon the occurrence of an incident, the HSD mobility operator shall notify appropriate emergency management and incident response personnel.
Req-CS-053	Monitor Passenger Safety	The SDS shall send information on the status of the passengers during an emergency to the

Req #	Req Title	Req Description
		SOC, to allow the SOC operators to remotely monitor the situation.
Req-CS-054	Emergency Communications to Passengers	In case of an emergency, the CS Dispatcher (both SDS SOC and HDS Dispatcher) shall communicate with travelers using the user interface channel(s) as designated by travelers boarding, alighting or traveling on the vehicle. The methods and messages used to communicate with passengers will be driven by stakeholder input during the Agile Development Process.
Req-CS-055	CS Trip Monitor Management	The CS system shall continually recalculate service adherence to determine impacts to traveler trip plans in order to provide updates to the traveler about their travel experience.
Req-CS-055.1	SDS Trip Monitor Management	The SDS system shall continually recalculate SDS service adherence to determine impacts to traveler trip plans in order to provide updates to the traveler about their travel experience.
Req-CS-055.2	HDS Trip Monitor Management	The HDS system shall continually recalculate HDS service adherence to determine impacts to traveler trip plans in order to provide updates to the traveler about their travel experience.
Req-CS-056	Update CTP on Trip Management	The Mobility Provider system shall update the CTP on the status of traveler booking, reservations and travel and impacts to their travel. The information will include sending updates to the CTP on revised ETAs, detours, cancelled trips, or different dropoff locations. The types and format of the information will be driven by the stakeholder reviewer during the Agile Development Process.
Req-CS-056.1	SDS Update CTP on Trip Management	The SDS system shall update the CTP on the status of traveler booking, reservations and travel and impacts to their travel. The information will include sending updates to the CTP on revised ETAs, detours, cancelled trips, or different dropoff locations. The types and format of the information will be driven by the stakeholder reviewer during the Agile Development Process.

Req #	Req Title	Req Description
Req-CS-056.2	HDS Update CTP on Trip Management	The HDS system shall update the CTP on the status of traveler booking, reservations and travel and impacts to their travel. The information will include sending updates to the CTP on revised ETAs, detours, cancelled trips, or different dropoff locations. The types and format of the information will be driven by the stakeholder reviewer during the Agile Development Process.
Req-CS-056.3	PAL DIRECT Update CTP on Trip Management	PAL DIRECT shall update the CTP on the status of traveler booking, reservations and travel and impacts to their travel. The information will include sending updates to the CTP on revised ETAs, detours, cancelled trips, or different dropoff locations. The types and format of the information will be driven by the stakeholder reviewer during the Agile Development Process.
Req-CS-058	Driving Rules / MUTCD	The SDS shall obey driving rules associated with the Manual on Uniform Traffic Control Devices (NYSDOT version) traffic signals, phases, signs, and other traffic control devices.
Req-CS-060	Low Speed Shuttle	The SDS speed shall not exceed 25 mph while in autonomous mode.
Req-CS-061	Pick-up/Drop Off Location Announcement	Upon leaving from a pick-up/drop-off location, the SDS shall make an announcement stating that it is leaving that stop, and shall also announce the next stop it is scheduled to stop at.
Req-CS-065	Determine occupancy status of wheelchair securement systems	The SDS shall have the ability to detect the occupancy status of its available wheelchair securement systems.
Req-CS-066	Pickup / Drop off locations	The SDS pick-up and drop-off points shall be placed in locations that provide protection from weather elements.
Req-CS-068	Pick-up, Drop-off location occupied	The SOC shall identify back-up loading/unloading locations when designated locations are occupied.

Req #	Req Title	Req Description
Req-CS-069	Delay or missed stop caused by re-route (SDS)	The SDS shall inform a traveler of delayed or missed stops caused by rerouting. The details of the messages, timing, and traveler alternative preferences will be driven by stakeholder input during the Agile Development Process.
Req-CS-070	V2X connection lost	The SDS shall revert to manual driving mode when it detects lost or degraded connectivity, and the human steward acknowledges that he/she is able to take control.
Req-CS-90	3D Map Updates	The SDS design shall have the capability to update the 3D High-definition map on a regular basis to account for any changes in the driving environment (e.g., changing road and roadside conditions). Updates will occur as needed or on a frequent basis (to be specified during Phase 2).
Req-CS-92	Open Architecture SDS System	The SDS system (vehicles and SOC) shall support an open architecture to enable integration of third party or after-market equipment and software modules to support passenger information and monitoring systems, vehicle tracking, scheduling, routing, and reservation systems.
Req-CS-079	CS Service Scalability – Multiple passenger routing	The CS shall generate route plans for multiple passenger trip origins and destinations using the most direct routing for the passengers booked on the vehicle to meet on-demand bookings.
Req-CS-079.1	SDS Multiple Passenger routing	The SDS SOC shall generate route plans for multiple passenger trip origins and destinations using the most direct routing for the passengers booked on the vehicle to meet on-demand bookings.
Req-CS-079.2	HDS Multiple Passenger routing	The HDS Dispatcher shall generate route plans for multiple passenger trip origins and destinations using the most direct routing for the passengers booked on the vehicle to meet on-demand bookings.
Req-CS-080	Monitor CS travel anomalies	The CS operator dispatcher shall monitor, either manually through operator alerts or through electronic data analysis, anomalies in the travel speed and stops to identify operating conditions

Req #	Req Title	Req Description
		that impact vehicle travel. This information will be communicated to other entities that monitor the situational awareness of the road network.
Req-CS-080.1	Monitor SDS travel anomalies	The SDS SOC dispatcher shall monitor, either manually through operator alerts or through electronic data analysis, anomalies in the travel speed and stops to identify operating conditions that impact vehicle travel including but not limited to inclement weather. This information will be communicated to other entities that monitor the situational awareness of the road network.
Req-CS-080.2	Monitor HDS travel anomalies	The HDS dispatcher shall monitor, either manually through operator alerts or through electronic data analysis, anomalies in the travel speed and stops to identify operating conditions that impact vehicle travel. This information will be communicated to other entities that monitor the situational awareness of the road network.
Req-CS-087	Accommodations for Service Animals	The CS reservations management shall accommodate and designate service animals when specified in the reservations request.
Req-CS-93	CS Estimated Time of Arrival Service Level	The CS shall arrive at the pickup location (within the area of service) established by the customer within a maximum time of twenty minutes from when a CS vehicle is dispatched. See Req-CTP-045 for status updates / ETA on requested CS services.

4.3.2. Data

Table 27 details general CS data requirements that meet functional requirements and user needs. Note that some data requirements are incorporated into the functional requirements and follow system level data requirements listed in Section 3. Additional data specific requirements may be added in later versions of the SyRS.

Table 27. Community Shuttle Data Requirements.

Req #	Req Title	Req Description
Req-CS-083	Mobility Provider Trip Reporting	The CS shall log trip performance metrics on a daily basis for the PMD to access. The CS shall log trip performance metrics on a daily basis for the PMD to access. Metrics, at a minimum, will include: <ul style="list-style-type: none"> • Total number of trips • Total number of reservations • Total number of revenue miles • Ridership by trip, route, boardings/alightings by stop • On-time performance (by pickup-dropoff times) • Anonymized trip histories (including preferences) • Total number of incidents
Req-CS-083.1	SDS Trip Reporting	The SDS shall log trip performance metrics on a daily basis for the PMD to access.
Req-CS-083.2	HSD Trip Reporting	The HDS shall log trip performance metrics on a daily basis for the PMD to access.
Req-CS-083.3	PAL Trip Reporting	For trips booked through the CTP, PAL DIRECT shall log trip performance metrics on a daily basis for the PMD to access.

4.3.3. Physical

Table 28 details the CS physical requirements that meet user needs. It is important to note that HDS will be using existing NFTA-PAL vehicles that meet NFTA's and ADA's requirements. As such, there is no need to list additional physical requirements specific. However, such type of requirements may be added on later versions of the SyRS.

Table 28. Community Shuttle Physical Requirements.

Req #	Req Title	Req Description
Req-CS-001	Manual and Autonomous Driving	The SDS shall allow for both manual and autonomous driving.
Req-CS-002	Motor Technology	The SDS shall be powered by either electric motor(s), an Internal Combustion Engine (ICE) or a hybrid engine. If electric, the SDS battery shall allow the SDS to operate for between 4 – 6 hours on a single charge. Accepted charge rate should be in excess of 6 kwh

Req #	Req Title	Req Description
Req-CS-003	HVAC system	The SDS shall be equipped with an HVAC system, providing for adequate cooling and heating consistent with passenger comfort in the Buffalo environment, while ensuring that an electric SDS could operate between 4 – 6 hours before needing to be recharged.
Req-CS-004	SDS Capacity	The SDS shall have a capacity for transporting 4 or more passengers plus a safety steward.
Req-CS-005	Manual Control	The SDS shall have an interface for manual control by the steward to perform manual steering, speed control for accelerating and decelerating and emergency braking.
Req-CS-007	Automatic Doors	The SDS shall be equipped with doors that open and close automatically, and manually if needed.
Req-CS-007.1	Automatic Doors – Open	The SDS shall be equipped with doors that open automatically, via a sensor or a button, upon the arrival of the SDS at a pick-up/drop-off location and after its coming to a full stop.
Req-CS-007.2	Automatic Doors – Close	The SDS shall be equipped with doors that close automatically after travelers have gotten off or on the SDS and the SDS is ready to depart from the pick-up/drop-off location.
Req-CS-007.3	Automatic Doors – Malfunction	In cases of malfunctions of the automatic door, the SDS shall allow for manual opening and closing by the human steward as a backup.
Req-CS-008	Ramp / Lift	The SDS shall be equipped with either a lift or an automated wheelchair ramp that deploys automatically when needed for loading/unloading. If equipped with a ramp, the slope of the ramp shall not exceed 1:6.
Req-CS-009	Wheelchair Securement	The SDS shall be equipped with an automated or semi-automated wheelchair securement mechanism for securing/unsecuring passengers with mobility devices (e.g., wheelchair, manual or motorized scooter).
Req-CS-010	Seat Belts	The SDS shall have seat belts for every passenger seat.

Req #	Req Title	Req Description
Req-CS-011	Hand-holds	The SDS shall include hand-holds for passengers boarding, alighting, and sitting in the vehicle.
Req-CS-013	Multiple Redundant Communication Radios	The SDS shall operate multiple and redundant network connections (radios) between the SDS and SOC.
Req-CS-014	Multiple and Redundant Sensor Systems for Perception and Localization	The SDS shall be equipped with multiple and redundant sensor systems for perception, and localization.
Req-CS-014.1	LIDAR Sensor	The SDS shall be equipped with at least one LIDAR sensor.
Req-CS-014.2	RADAR Sensor	The SDS shall be equipped with at least one RADAR sensor.
Req-CS-014.3	Camera-Centric Computer Vision	The SDS shall be equipped with a camera-centric computer vision system.
Req-CS-014.4	Inertial Measurement Unit	The SDS shall be equipped with an inertial measurement unit.
Req-CS-014.5	Localization	For localization, the SDS shall use GPS (with Real-time Kinematic (RTK) positioning for correction), along with a 3D high-definition map.
Req-CS-015	Passenger Communication Equipment	The SDS shall be equipped with communications channels to communicate with passengers as they board, alight or travel on the SDS. The equipment consist of factory installed, after-market or a combination set of devices.
Req-CS-016	Accessible Emergency Button	The SDS shall be equipped with an accessible emergency (panic) button for use by shuttle safety steward and/or passengers during emergencies onboard the shuttle. The accessible button should be within the reach of passengers, well-labelled, and easily identifiable.
Req-CS-016.1	Emergency stop button misuse	The SDS shall have a warning sign describing proper instructions about when and how to use the emergency button which should be posted near the button. The information on the sign will be published in several

Req #	Req Title	Req Description
		languages, including braille, and will be stakeholder driven during the Agile Development Process.
Req-CS-017	Onboard Persistent Storage	The SDS shall be equipped with sufficient persistent storage capability to record operational and sensor data via an onboard data recorder for at least 24 hours of continuous operations. The data will come from the LiDAR, camera and other sensors and collect passenger and engine information.
Req-CS-064	No return trip booking available	The CS shall have a designated safety shuttle service to pick-up stranded travelers, when the shuttle does not have the right equipment to meet passenger needs (e.g., wheelchair securement), or the shuttle is overbooked. Details of the operational procedures will be developed during Phases 2 and 3.
Req-CS-91	External/Internal Monitoring	The SDS shall be equipped with video or CCTV for both external and internal monitoring.

4.3.4. Security and Privacy

Table 29 details the CS security and privacy requirements that meet user needs.

Table 29. Community Shuttle Security and Privacy Requirements.

Req #	Req Title	Req Description
Req-CS-071	Cybersecurity risk assessment	The SDS vendor shall document and assess cybersecurity risks in its design including means to detect unauthorized communications including vehicle control commands.
Req-CS-072	Access to SDS onboard computers	The SDS vehicle system access shall be secured using advanced authentication methods beyond password and physical locking mechanism including a two-step verification process.
Req-CS-073	Security Breach Response	The SDS vehicle system shall include a security alarm that triggers and transmits an alarm when a physical or system security breach is detected.

Req #	Req Title	Req Description
Req-CS-074	Defense against Spoofing Attacks on sensors	The SDS shall apply its multi-sensor fusions to defend against known spoofing attacks on single sensors. Sensors included in the defense include the camera, LiDAR, radar, and GPS.
Req-CS-075	New Software Releases	The SDS and SOC software shall be peer reviewed and verified prior to updating system or vehicle software.
Req-CS-084	Secure Mobility Provider Trip Reporting	The Mobility Provider shall secure traveler PII by anonymizing and encrypting trip history data prior to providing access to PMD. The methods used should align with the provider's privacy policies and the IRB provisions of this project.
Req-CS-084.1	Secure SDS Trip Reporting information	SDS operator shall secure traveler PII by anonymizing and encrypting trip history data prior to providing access to PMD. The methods used should align with the provider's privacy policies and the IRB provisions of this project.
Req-CS-084.2	Secure HDS Trip Reporting information	HDS Operator shall secure traveler PII by anonymizing and encrypting trip history data prior to providing access to PMD. The methods used should align with the provider's privacy policies and the IRB provisions of this project.
Req-CS-084.3	Secure PAL Trip Reporting information	PAL DIRECT shall secure traveler PII by anonymizing and encrypting trip history data prior to providing access to PMD. The methods used should align with the provider's privacy policies and the IRB provisions of this project.

4.3.5. HMI and Accessibility

For this project, we will be using existing NFTA-PAL vehicles that meet NFTA's and ADA's requirements. As such, there is no need for additional HMI and accessibility requirements. However, such type of requirements may be added on later versions of the SyRS. General CS's HMI and accessibility requirements are provided in Table 30.

Table 30. Community Shuttle HMI and Accessibility Requirements.

Req #	Req Title	Req Description
Req-CS-059	FMVSS Compliance	The SDS shall be authorized to operate in public roads in New York State. Authorization may be based on rules, and policy set by NYS and in accordance with federal standards such as Federal Motor Vehicle Safety Standards (FMVSS). Note that exemptions may be required and received for authorization based on the design of the SDS. For example, a possible exception is that some vendor solutions may employ a joystick while in manual mode for steering, speed controls, and braking.
Req-CS-089	Accessible Emergency Exits	All emergency exits onboard the SDS shall be accessible.

4.3.6. Operations and Maintenance

Table 31 details CS operations and maintenance requirements that meet user needs.

Table 31. Community Shuttle Operations and Maintenance Requirements.

Req #	Req Title	Req Description
Req-CS-018	CS Vehicle Health Monitoring	CS vehicles shall monitor the “health” of vehicle assets, particularly sensor and actuator functions, to ensure they are performing to specifications.
Req-CS-018.1	SDS Sensor Health Monitoring	The SDS shall monitor the “health” of all vehicle sensor and system assets, particularly sensor and actuator functions to ensure they are performing to specifications. The complete set of parameters identifying “degraded health” situations will be detailed in Phase 2.
Req-CS-018.2	SDS Communication Health Monitoring	The SDS shall monitor operational status of connectivity and sensor functions such as loss of connectivity to the Autonomous Driving kit or any loss of a sensor. The complete set of parameters identifying “degraded health” situations will be detailed in Phase 2.
Req-CS-018.3	SDS Safety Asset Health Monitoring	The SDS shall monitor operational status of passenger safety functions such as loss of passenger information module. The complete set of parameters identifying “degraded health” situations will be detailed in Phase 2.

Req #	Req Title	Req Description
Req-CS-077	CS Hours of Operations	The CS shall publish the hours of operations for its mobility services.
Req-CS-077.1	SDS Hours of Operations	The SDS operator shall publish the hours of operations for mobility services to travelers (employees and visitors) in the BMNC region.
Req-CS-077.2	HDS Hours of Operations	The HDS operator shall publish the hours of operations for mobility services to travelers (employees and visitors) in the BMNC region.
Req-CS-077.3	PAL Spontaneous Hours of Operations	NFTA shall publish the hours of operations for PAL Spontaneous for travelers (employees and visitors) in the BMNC region.
Req-CS-081	CS Operations and Maintenance Plan	The CS operator shall develop a vehicle operations and maintenance plan that details the elements related to the Buffalo ITS4US project.
Req-CS-081.1	SDS Operational and Maintenance Plan	The SDS operator shall develop a vehicle operations and maintenance plan that details the elements related to the Buffalo ITS4US project.
Req-CS-081.2	HDS Operational and Maintenance Plan	The HDS operator shall develop a HDS vehicle operations and maintenance plan that details the elements related to the Buffalo ITS4US project.
Req-CS-082	CS Operational Performance Data Collection	The CS subsystem shall collect vehicle operational performance data including ridership, on time performance, travel times, and other performance measures. The performance measures, metrics and confounding factors will be described in the PMESP.
Req-CS-082.1	SDS Operational Performance	The CS shall collect SDS performance data including ridership, on time performance, travel times, and other performance measures collected by service operator.
Req-CS-082.2	HDS Operational Performance	The CS shall collect HDS performance data including ridership, on time performance, travel times, and other performance measures collected by the service operator.
Req-CS-082.3	PAL Operation Performance	NFTA PAL services shall collect PAL (spontaneous service) operational performance data including ridership, on time performance, travel times, and other performance measures that corresponds to CTP usage.

4.3.7. Operational Performance

Table 32 lists the operations performance requirements for the community shuttle.

Table 32. CS Operational Performance Requirements.

Req #	Req Title	Req Description
Req-CS-88	Report health status to CTP	The Mobility Provider shall alert the CTP about health status information of the mobility provider planning and operational services whenever the system is in degraded or failure modes.
Req-CS-88.1	Report SDS Operating Status to CTP	The SDS operator shall alert the CTP about health status information of the mobility provider planning and operational services whenever the system is in degraded or failure modes.
Req-CS-88.2	Report HDS Operating Status to CTP	The HDS operator shall alert the CTP about health status information of the HDS planning and operational services whenever the system is in degraded or failure modes.
Req-CS-88.3	Report PAL Operating Status to CTP	The PAL system shall alert the CTP about health status information of the PAL planning and operational services whenever the system is in degraded or failure modes.

4.4. Performance Measurement Dashboard

The following subsections list the requirements for the Performance Measurement Dashboard (PMD).

4.4.1. Functional

Table 33 details the PMD functional requirements that meet user needs.

Table 33. Performance Measurement Dashboard Functional Requirements.

Req #	Req Title	Req Description
Req-PMD-001	Ingesting data	The PMD shall ingest static and streaming datasets created and used by the system subsystems including the datasets identified in the Data Management Plan (as updated throughout Phase 2).

Req #	Req Title	Req Description
Req-PMD-002	Quality checking data	The PMD shall apply quality checking (QC) procedures. The QC procedures will be developed and documented as part of Phase 2 design.
Req-PMD-003	Anonymizing data	The PMD shall not store data/datasets that contain PII or trace data. (PII data storage provisions are specified in Req-PMD-12.)
Req-PMD-005	Metadata	The PMD shall record and enforce the collection of metadata on all datasets stored in the PMD data layer.
Req-PMD-007	Analytic tools	The PMD shall support the data access by third party analysis tools (e.g., R, GIS, and Excel) to meet the performance measures described in the PMES plan.
Req-PMD-008	Data aggregation	The PMD shall provide data services to aggregate and compare datasets based on facts and dimensions (to be identified and standardized during Phase 2 development). The resulting aggregated datasets will compose “data marts” that specialize data based on the most used facts and dimensions.
Req-PMD-009	Presentation formats	The PMD shall present results of data analysis in several formats including tabular, graphs, and graphic visualizations (e.g., maps, isochrones, heat maps, infographics).
Req-PMD-010	Web based presentation	The PMD shall provide configuration tools to post analysis results in web-based format so that they can be displayed in a web browser.
Req-PMD-013	Discovery	The PMD shall provide a library of datasets it stores for users to discover datasets and their metadata. Discovery selections are dependent on role based access (see Req-PMD-006).

4.4.2. Data

Table 34 details the PMD data requirements that meet user needs.

Table 34. Performance Measurement Dashboard Data Requirements.

Req #	Req Title	Req Description
Req-PMD-014	Data Curation of Metric Data	The PMD shall develop and implement a data curation plan to ingest, extract, transform and load the datasets from other subsystems and external sources that support the Performance Measurement and Evaluation Support Plan. These include, but are not limited to, the datasets listed in Req-PDM-14.1 through Req-PDM-14.7.
Req-PMD-014.1	Data Curation of Metric Data crowdsourced data	The PMD shall develop and implement a data curation plan for crowdsourced data from the CTP.
Req-PMD-014.2	Data Curation of Metric Data satisfaction data	The PMD shall develop and implement a data curation plan for satisfaction data from the CTP survey responses.
Req-PMD-014.3	Data Curation of Metric Data CTP performance data	The PMD shall develop and implement a data curation plan for Performance Metrics from the CTP including CTP usage, registration, trip planning, trip booking, trip transit use, trip time and location, trip notification, CTP smart sign (interaction), and CTP smart signal (PED-X).
Req-PMD-014.4	Data Curation of Metric Data reservation data	The PMD shall develop and implement a data curation plan for Shuttle Reservations Management summary datasets.
Req-PMD-014.5	Data Curation of Metric Data – shuttle reporting data	The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets.
Req-PMD-014.6	Data Curation of Metric Data shuttle operations data	The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets, including: <ul style="list-style-type: none"> (1) Requests for service (to calculate on-time performance against actual service). The archived information can be later used to refine the planning and executing of the shuttle operations. (2) Reservation requests including time, pickup and drop-off locations, number of passengers, accessibility preferences, etc. (3) Reservations confirmation with specific time / location of pickup and drop off, number of passengers, confirmation credentials, etc.

Req #	Req Title	Req Description
		<p>(4) GTFS-Flex and GOFS from the flexible operations modes.</p> <p>(5) Shuttle information about current locations, schedule, occupancy and special conditions including number of occupied securements on the shuttle.</p> <p>(6) Information about the operating status of the CS over time.</p>
Req-PMD-014.7	Data Curation of Metric Data additional data	<p>The PMD shall develop and implement a data curation plan for additional data items in the Performance Management Dashboard, including:</p> <p>(1) Data on weather conditions, road closures, etc.</p> <p>(2) Data on operating conditions for key NFTA services, particularly those serving the BNMC.</p> <p>(3) Operational status of other system components such as wayfinding beacons and smart intersection controls.</p> <p>(4) Data on the operating status of the PMD itself.</p>

4.4.3. Physical

Table 35 details the PMD physical requirements that meet user needs.

Table 35. Performance Measurement Dashboard Physical Requirements.

Req #	Req Title	Req Description
Req-PMD-011	Cloud base infrastructure	The PMD shall be hosted in a cloud-based environment that is scalable to accommodate and evolve as storage, processing and access loads increase throughout the project duration.
Req-PMD-012	On-premise data storage	The PMD shall host the PII and Research data on an on-premise data storage system.

4.4.4. Security and Privacy

Table 36 details the PMD security and privacy requirements that meet user needs.

Table 36. Performance Measurement Dashboard Security and Privacy Requirements.

Req #	Req Title	Req Description
Req-PMD-006	Role based access	The PMD shall enforce role-based access to datasets which include discover, publish and subscribe, view, update, delete and create functions by original, anonymized, derived and aggregated datasets. Training may be required to access data.

4.4.5. HMI and Accessibility

At this stage of the project, accessibility requirements are integrated with the functional requirements. Later versions of the SyRS may include HMI/Accessibility specific requirements. Among the requirements are provisions to comply with the Americans for Disability Act (ADA) and the Web Content Accessibility Guidelines (WCAG 2.1) which are designated as system policy (see Section 3.5.1)

5. System Interfaces

Table 37 details the requirements for internal and external system interfaces. It is important to note that these are general interfaces requirements, as each subsystem entails more detailed/specific requirement for their interfaces.

Table 37. System Interfaces Requirements.

Req #	Req Title	Req Description
Req-INT-001	Interface specification	The system shall publish a schema, interface control, or conformance document for each interface ingested or used in the system. The published document should also include guidance on how to implement and access the interface.
Req-INT-002	BLE 5	The system shall conform to the Bluetooth Specification Version 5.0 or higher. See https://www.bluetooth.com/specifications/specs/
Req-INT-003	NFC	The system shall conform to Tag NDEF Exchange Protocol (TNEP) Technical Specification 1.0 and related Near Field Communications protocols ISO/IEC 14443 and ISO/IEC 18000-3. See https://nfc-forum.org/our-work/specification-releases/specifications/nfc-forum-technical-specifications/ .
Req-INT-004	GTFS	The system shall conform to GTFS including Flex and Pathways extensions. See https://developers.google.com/transit/gtfs
Req-INT-005	GTFS real time	The system shall conform to the GTFS real time specification and encoding method. See https://developers.google.com/transit/gtfs-realtime/reference
Req-INT-006	NTCIP 1201/ 1202 Actuated Signal Control Standards	The system shall use NTCIP 1201 Global Message Set and NTCIP 1202 Actuated Signal Control messages set for message exchanged between the Controller and the traffic signal system PED-X module.
Req-INT-007	NTCIP 1211 Signal Control and Prioritization	The system shall use NTCIP 1211 Signal Control and Prioritization Message Sets standard, including related request, status, cancel and clear messages between

Req #	Req Title	Req Description
		priority request generator, priority request service and controller actor.
Req-INT-008	Open Trip Planner API	The system shall use the core Open Trip Planner APIs. See https://github.com/opentripplanner/OpenTripPlanner .
Req-INT-009	Work Zone Data Exchange	The system shall use the Work Zone Data Exchange specification. The most recent version is available from https://github.com/usdot-jpo-ode/wzdx
Req-INT-010	Transcom Data Fusion Engine (DFE)	The system shall use the traffic management specification published by Transcom, which is a profile of the ITE Traffic Management Data Dictionary. See https://xcmtools.xcmdata.org/
Req-INT-011	Reservation API Specifications	The Mobility provider shall document the API specifications for the booking and status APIs including schema, dictionary, and orchestration of API transactions between the reservation modules and third party user interface (e.g., CTP).
Req-INT-011.1	SDS Reservation API Specification	The SDS Operator shall document the API specifications for the SDS (microtransit) booking and status APIs including schema, dictionary, and orchestration of API transactions between the reservation modules and third party user interface (e.g., CTP).
Req-INT-011.2	HDS Reservation API Specification	The HDS Operator shall document the API specifications for the HDS (on-demand, door to door, carpooling) booking and status APIs including schema, dictionary, and orchestration of API transactions between the reservation modules and third party user interface (e.g., CTP).
Req-INT-011.3	PAL DIRECT Reservation API Specification	PAL DIRECT shall document the API specifications for the PAL spontaneous and regular eligibility verification, booking and status APIs including schema, dictionary, and orchestration of API transactions between the reservation modules and third party user interface (e.g., CTP).
Req-INT-013	Internal APIs	The system shall specify internal APIs and data exchange formats using open interface formats such as REST, JSON, GeoJSON, XML, csv formats.

Appendix A. Needs-to-Requirements Traceability Matrix

Table 38 provides the needs to requirement traceability matrix (NRTM), which traces the technical requirements to the needs. This traceability will form the basis for tracking the design, test cases and test procedures to validate and verify that the system is built to meet stakeholder needs.

The NRTM table is constructed with user needs as a subheader to a set of requirements listed directly below it. Needs are distinguished from requirements by the UN prefix of index in the first column, bolded text font and row highlighted in blue. The NRTM is a logical construction that maps one need to many requirements. However, some requirements relate to more than one need. So, in order not to duplicate requirements and create ambiguity in the table, the fourth column, “Related Needs” identifies additional needs that cover provisions that support the associate need.

Table 38. Buffalo, NY ITS4US Deployment Needs-to-Requirements Traceability Matrix.

Req #	Req Title	Req Description	Related Need
UN-E-TP-1	Spontaneous Trip	The system needs to provide the ability to execute spontaneous trips using public transit travel options based on user inputs of origins and destination. This allows travelers the ability to make unanticipated trips or undertake trips for which paratransit services are not available.	
Req-CS-036	On-Demand Routing and Dispatch	The CS shall operate on-demand service managed by their back office scheduling, routing and dispatch functions, including path planning and curb use for pick-ups and drop-offs.	
Req-CS-036.1	SDS on-demand routing and Dispatch	The SDS shall operate on fixed network right of ways in the BNMC and project region providing on-demand services at designated pickup and dropoff points along the network. The SDS backoffice system is called the Shuttle Operations Center (SOC).	

Req #	Req Title	Req Description	Related Need
Req-CS-036.2	HDS on-demand routing and Dispatch	The HDS shall operate door to door, on-demand service managed by their back office scheduling, routing and dispatch services in the BNMC and project region.	
Req-CS-036.3	PAL spontaneous routing and Dispatch	The PAL spontaneous service shall operate door to door, on-demand service managed by PAL DIRECT scheduling, routing and dispatch services in the BNMC and project region.	
Req-CS-93	CS Estimated Time of Arrival Service Level	The CS shall arrive at the pickup location (within the area of service) established by the customer within a maximum time of twenty minutes from when a CS vehicle is dispatched. See Req-CTP-045 for status updates / ETA on requested CS services.	
Req-CTP-001	Reservation Planning Services	The CTP shall provide to the traveler the ability to check, book, confirm, change, cancel and view their reservation for the Community Shuttle or PAL Spontaneous (if eligible).	UN-E-TP-4
Req-CTP-001.1	Reservations – check service	The CTP shall provide to the traveler the ability to check service availability using their CTP trip planning application.	
Req-CTP-001.2	Reservations – booking service	The CTP shall provide to the traveler the ability to request and book reservations using their CTP trip planning application.	
Req-CTP-001.3	Reservations – confirm service	The CTP shall provide to the traveler the ability to confirm their reservations using their CTP trip planning application.	
Req-CTP-001.4	Reservations – change service	The CTP shall provide to the traveler the ability to change their reservations after they booked a reservation using their CTP trip planning application.	

Req #	Req Title	Req Description	Related Need
Req-CTP-001.5	Reservations – cancel service	The CTP shall provide to cancel their reservations after they booked a reservation using their CTP trip planning application.	
Req-CTP-001.6	Reservations – view service	The CTP shall provide to the traveler the ability to view their reservations after they booked a reservation in their trip planning application.	
Req-CTP-008	Mobility Provider Reservations APIs used by CTP	The CTP shall use APIs provided by the mobility provider for the SDS, HSD, PAL Spontaneous and PAL Direct reservation management modules.	
Req-CTP-009	Pre-populate Trip Mode Preferences	The CTP shall pre-populate the traveler’s preferred mode(s) based on their selected preferences.	
Req-CTP-010	Pre-populate Trip Location (Origin)	When using a mobile or facility access channel (e.g., mobile app or TIH), the trip plan shall incorporate the location of the device into the trip plan request. The mobile app requires that location tracking is turned on. Note: there is a requirement that allows a user to change any preference at the time of planning or beginning a trip (see Req-CTP-001.4).	
Req-Sy-009	Access to Spontaneous Mobility Services via CTP	The System shall provide on-demand, same day trip reservations and mobility services to registered CTP travelers.	
Req-Sy-009.1	Access to SDS Mobility Services via CTP	The system shall provide community shuttle on-demand ride-hailing services within the project region on the SDS. The SDS shall only operate on designated roads and stop at fixed pickup and dropoff stops.	

Req #	Req Title	Req Description	Related Need
Req-Sy-009.2	Access to HDS Mobility Services via CTP	The system shall provide community shuttle on-demand door to door services within the project region on the HDS.	
Req-Sy-009.3	Access to PAL Spontaneous Services via CTP	The system shall provide paratransit on-demand door to door services within the project region to PAL eligible travelers on NFTA PAL. The PAL shall allow an eligible PAL Direct traveler to book spontaneous (on-demand), same day travel in the geographic area covered by the project.	
Req-Sy-009.4	Access to PAL Direct services via CTP	The PAL shall enable eligible paratransit travelers to book their PAL Direct reservations through the CTP subsystem by linking their CTP account with their PAL account credentials.	
Req-Sy-012	Trip Planning and Booking Service Level Agreements	The System shall meet a set of SLA that meet traveler service levels for generating accessible trip options and operations for on-demand community shuttle service. The SLAs and their performance levels will include, at a minimum, trip plan options and adherence levels for estimated pickup and travel times. The SLA will be determined in Phase 2.	
UN-E-TP-2	Coverage	While certain aspects of the system are limited to the BNMC campus, the system needs to be useful to users from outside the project boundary specifically around improving access to transit services information for the entire NFTA bus and rail network. This allows the system to support at least some aspects of trip making throughout Buffalo.	
Req-CTP-011	Buffalo and NFTA Service Coverage	The CTP shall provide existing NFTA transit service information for travelers to plan their trips in the Buffalo area. Transit Service data identified for integration with the CTP includes: (a) Static information (operational times, schedules (GTFS), service coverage (GTFS Flex), payment information). (b) Real time status (GTFS realtime data).	

Req #	Req Title	Req Description	Related Need
Req-CTP-012	Data of Mobility Services in Project Region	The CTP shall incorporate data from mobility service options available to travelers in the project region. The service options include PAL Spontaneous and community shuttle. Service data includes, but is not limited to, modes, operational times, schedules (GTFS), service coverage (GTFS Flex), payment information (optional), pickup / drop off points (for CS SDS shuttle), station pathways (GTFS pathways), and real time status (GTFS real time).	
Req-Sy-012.1	CS Response Time	The community shuttle shall execute trip plans within pre-specified time limit from the request (e.g., 60 minutes). The time limit will be determined in Phases 2 and 3, once supply and demand of service is better known.	
UN-E-TP-3	Increased Access	The system needs to increase access of surrounding community to BNMC partner facilities, services, and the transit facilities without the use of personal auto. This is necessary to support the residents in the neighboring community who are older adults or do not have access to a personal automobile	
Req-Sy-011	CS Geographic Coverage	The system shall provide CS on-demand and microtransit service (including HSD and SDS) in the geographic area covered by the project.	
Req-Sy-012.2	CTP “Trip Plan Generation” Response Time	The CTP shall generate trip plans within pre-specified time limit from initial selection for internal functions. The time limits will be determined in Phases 2 and 3, and do not include end-user computing limitations for rendering and displaying the results.	
UN-E-TP-4	Independence	The system needs to support independent travel by travelers with disabilities as much as possible. This is necessary to ensure that travelers feel supported by the system to achieve their own travel and personal objectives	

Req #	Req Title	Req Description	Related Need
Req-CTP-001	Reservation Planning Services	The CTP shall provide to the traveler the ability to check, book, confirm, change, cancel and view their reservation for the Community Shuttle or PAL Spontaneous (if eligible).	UN-E-TP-1
Req-CTP-014	Multimodal Trip Planner	The CTP shall provide travelers with the option to tailor their trip plans based on their preferences and abilities for the modal services incorporated in this project including indoor and outdoor navigation (via automobile, NFTA bus, light rail and PAL Direct, Community Shuttle, walking, biking, and other mobility options) which provides underserved populations with door to door trip plans. The implementation and rollout will be driven by stakeholder input during the Agile Development process.	UN-E-TP-5
UN-E-TP-5	Tailored Trip Planner	The system needs to offer an easy to use multimodal trip planner tailored to underserved communities that encompasses selected mobility options and door to door trip plans. For this project, underserved communities entail people who are senior adults, low income, limited English proficiency, with dementia or other cognitive challenges, who are blind or have limited vision and/or who are deaf or have limited hearing	
Req-CTP-013	Core Functionality from OTP	The CTP shall use the open trip planner (OTP) to provide the core trip planning, routing and monitoring functionality, interfaces and infrastructure. The core OTP system is described in https://github.com/opentripplanner/OpenTripPlanner .	
Req-CTP-014	Multimodal Trip Planner	The CTP shall provide travelers with the option to tailor their trip plans based on their preferences and abilities for the modal services incorporated in this project including indoor and outdoor navigation (via automobile, NFTA bus, light rail and PAL Direct, Community Shuttle, walking, biking, and other mobility options) which provides underserved populations with door to door trip plans. The implementation and rollout will be driven by stakeholder input during the Agile Development process.	UN-E-TP-4
Req-CTP-015	Updating Trip Plan	The CTP shall allow travelers update their trip preferences when they plan their trip.	
Req-CTP-016	Save Trip Information	The CTP shall provide a traveler with the option to save trip information including but not limited to trip plans, trip preferences (by plan).	
Req-CTP-017	Multimodal Data	The CTP shall process datasets that enable the provision of multimodal trip planning beyond the core functionality of the OTP. These datasets will evolve over time and they are identified in the DMP.	

Req #	Req Title	Req Description	Related Need
Req-CTP-018	Augmented functionality	The CTP shall enhance the OTP core functionality to tailor and update trip plans based on traveler preferences and abilities identified by end-user groups during the Agile development process. The preferences and abilities will define new types of notifications, navigation instructions, communication channels (telephone, TIH, web, mobile app) and user interface methods (text, voice, haptic).	
UN-E-TP-6	Integrated Multimodal Service	The system needs to be able to generate and execute multimodal trip plans to, from and around the BNMC campus that integrate with existing transit services. This allows travelers to see all the alternatives available to them (e.g., modes, times, and cost) and to quickly transition from one to another if the traveler desires or needs to, while optimizing the use of available capacity of existing and new systems.	
Req-CTP-019	Integrated Trip Planning services	The CTP shall include multimodal trip planning, routing and monitoring of travelers as they plan and execute their trips to ensure seamless and coordinated transfers between trip segments.	
Req-CTP-019.1	Integrated Trip Planning – NFTA fixed route	The CTP shall integrate NFTA transit options in the integrated trip planning mode options. Updates of datasets associated with the service provision will be updated prior to any service change.	
Req-CTP-019.2	Integrated Trip Planning – NFTA PAL options	The CTP shall integrate NFTA paratransit options in the integrated trip planning mode options.	
Req-CTP-019.3	Integrated Trip Planning – CS SDS	The CTP shall integrate Community Shuttle SDS options in the integrated trip planning mode options.	
Req-CTP-019.4	Integrated Trip Planning – CS HDS	The CTP shall integrate Community Shuttle HDS options in the integrated trip planning mode options.	
Req-CTP-019.5	Integrated Trip Planning – Other mobility provider options (optional)	As needed, the CTP shall integrate other mobility provider options in the integrated trip planning mode options.	

Req #	Req Title	Req Description	Related Need
UN-E-TP-7	Integrated Data Provision	“The system needs to collect and integrate available data from external and internal sources to provide a complete trip plan. External and internal information includes	
Req-CTP-021	Trip Planning Data validation and processing	The CTP shall ingest, validate and process network data that includes network features, attributes and conditions for different modal networks including roads, transit, mobility (bikes), public right of way (sidewalks, crosswalks), and facility pathway (and conveyance) datasets. Rollout of the ingestion and curation processes associated with each dataset will be staged to support related functions.	UN-E-TE-13
Req-CTP-022	Reference transportation network	The CTP shall relate data from different sources to a reference base map that is used to optimize and generate trip plans.	
Req-CTP-023	Trip plan optimization for different traveler groups	The CTP shall assign impedance factors to the network used to generate trip plans for groups of traveler types based on common preferences and abilities as well as their executed trip histories in similar geographic areas.	
UN-E-TP-8	Easy to Use and Flexible App	The system needs to offer an easy to use application that leverages the trip planner and enables successful execution of trips including the ability to support travel while offline (or without connectivity). This ensures that users are able to plan, book and execute trips through online/offline devices	
Req-CTP-024	Accessibility Feature Compliance	The CTP shall comply with Web Content Accessibility Guidelines (WCAG 2.1) accessibility features (on both the web and mobile platforms).	
Req-CTP-025	End-User Driven User Experience	The CTP user experience shall be driven by an agile development approach with input from end-users. The end-users will include input from the underserved communities identified in the ConOps (reference from Section 2 of the SyRS).	

Req #	Req Title	Req Description	Related Need
Req-CTP-026	Communications Channels	The CTP shall include communication channels that include, at a minimum, web application, call center, mobile app, mobile web application, and transportation information hub (TIH).	
Req-CTP-027	On-line / off-line data usage and tracking	The CTP mobile app and mobile web application shall include an on-line and off-line mode. The features of each mode will follow the mobile operating system protocols (iOS and Android) for tracking and carrier service plans for on-line and off-line use of data usage.	UN-E-TS-4
UN-E-TP-9	Trip Accessibility/ Compatibility	The system needs to provide services that are accessible and compatible to user based on their defined preferences. This ensures that travelers are presented with mobility alternatives that align with their preferences and capabilities. For instance, travelers with mobility devices are presented trips that take into consideration any necessary lifts, ramps and securement systems.	
Req-CS-89	Accessible Emergency Exits	Any emergency exit onboard the SDS shall be accessible.	
Req-CTP-028	Account settings	The CTP shall provide the capability for users to set up, save and update preferences for travel beyond the trip preferences currently included in the OTP. The development and rollout of these services will be driven by stakeholder input during the Agile Development Process. At a minimum, the enhanced trip preferences will include the one listed in Req-CTP-28.1 through req-CTP-28.9.	
Req-CTP-028.1	Account settings – mode	The CTP shall provide the capability for users to select mode preferences (including PAL Direct, PAL (spontaneous), Community Shuttle SDS or HDS, NFTA).	
Req-CTP-028.2	Account settings – accessibility and support services	The CTP shall provide the capability for users to select accessibility and support service preferences (e.g., travel companion, service animal, and call to third party – guardian/caregiver).	
Req-CTP-028.3	Account settings – language	The CTP shall provide the capability for users to select language choice (including American Sign Language).	

Req #	Req Title	Req Description	Related Need
Req-CTP-028.4	Account settings – notifications	The CTP shall provide the capability for users to select notifications (e.g., intersection PED-X countdown, conveyance status, ETA for reservation services) for a set of notifications. The set of editable notifications will be defined in Phase 2.	
Req-CTP-028.5	Account settings – automated request	The CTP shall provide the capability for users to select automated request for service preferences (e.g., hands-off request for PED-X actualization, smart signs).	
Req-CTP-028.6	Account settings – navigation instructions	The CTP shall provide the capability for users to select navigation instruction preferences (hands-free turn by turn, user defined landmarks).	
Req-CTP-028.7	Account settings – communications channels	The CTP shall provide the capability for users to select preferences for communications channel to receive trip updates (e.g., web, mobile app, mobile website, call or SMS) including wearables and assistive devices (e.g., Bluetooth enabled hearing aids, canes, watches).	
Req-CTP-028.8	Account settings – favorite places	The CTP shall provide the capability for users to select favorite places including destinations, pickup/dropoff locations, and bus stop.	
Req-CTP-028.9	Account settings – user interface methods	The CTP shall provide the capability for users to select preferences for methods of receiving notifications (e.g., voice, text, haptic/vibration).	
Req-CTP-037	CTP Registration	The CTP shall provide registration services for travelers to set up their account including establishing a profile, selecting their preferences and saving trip plans.	
Req-CTP-039	CTP Account username and password	The CTP shall implement account usernames and passwords including a method for users to reset their password, find their username or password that meets secure two-factor authorization.	
Req-CTP-040	Third party access to Traveler Accounts	The CTP shall provide a secure process to allow trusted third parties (guardians/caregivers, call center agent, non-emergency medical transportation assistance program) to access traveler accounts when they are granted access rights.	

Req #	Req Title	Req Description	Related Need
Req-CTP-118	Reservation accommodating traveler assistive devices	The CTP shall include information on traveler assistive devices when booking CS services to ensure that the vehicle accessibility features match traveler needs. The types of assistive devices will be driven by stakeholder input during the Agile development process.	
UN-E-TP-10	Assistive Technology Compatibility	The system needs to offer a trip planner that yields trip plans that are compatible with assistive technologies. Assistive devices include those that support/improve mobility (e.g., wheelchairs and walkers), cognitive, visual and hearing aids	
Req-CTP-041	Assistive Technology Compatibility	The CTP shall connect to and provision notifications to the traveler's preferred assistive technology support device (e.g., wheelchair, hearing aids) including matching communication channel and user interface method. For example, a traveler with hearing disability may request a haptic alert that a new notification was received. The matching of assistive technologies, communications channels, user interface methods and notifications will be driven by stakeholder input during the Agile Development Process.	
Req-Sy-018	Accessible Vehicles	The system shall use vehicles that are accessible for people using mobility devices (e.g., wheelchairs), that is, the vehicle at a minimum, is equipped with a lift or ramp and wheelchair securements.	
UN-E-TP-11	PAL Profile Integration	The system needs to integrate with PAL Direct to integrate traveler profiles based on their eligibility and preferences. This allows the PAL users to not create another account or re-establish eligibility	
Req-CTP-042	CTP Travel Account Link with PAL Direct	The CTP shall provide a procedure for PAL customers to link their CTP profiles with their PAL account with exchange of minimum PII (contact information, account number) and no sensitive PAL account information (health data).	
UN-E-TP-12	Shuttle Trip Booking, Reservation	The system needs to allow users to book/reserve a ride on a shuttle based on their preferences, location and origins/destination. This is necessary for a system user to use the shuttles to make the trip or use the service to connect to transit	

Req #	Req Title	Req Description	Related Need
Req-CS-040	Validate Reservation	The Mobility Provider vehicle shall be equipped with a mechanism to verify boarding passengers have a valid reservation (booked through the CTP) to travel their reserved trip (e.g., boarding / alighting location and time).	UN-E-TP-13
Req-CS-040.1	Validate SDS Reservation	The SDS shall be equipped with a mechanism to verify boarding passengers have a valid reservation (booked through the CTP) to travel their reserved trip (e.g., boarding / alighting location and time).	
Req-CS-040.2	Validate HDS Reservation	The HDS shall be equipped with a mechanism to verify boarding passengers have a valid reservation (booked through the CTP) to travel their reserved trip (e.g., boarding / alighting location and time). The validation may be through inspection by the HDS operator.	
Req-CS-040.3	Validate PAL Spontaneous Reservation	The PAL spontaneous vehicle shall be equipped with a mechanism to verify boarding passengers have a valid reservation (booked through the CTP) to travel their reserved trip (e.g., boarding / alighting location and time). The validation may be through inspection by the PAL operator.	UN-E-TP-13
Req-CTP-120	Reservation accommodating traveler preferences	The CTP shall provide an option for travelers to identify their preferred traveler assistive devices when booking CS services to ensure that the vehicle accessibility features match traveler needs. The types of assistive devices will be driven by stakeholder input during the Agile development process.	
UN-E-TP-13	PAL Trip Booking	The system needs to allow a PAL-eligible user another way to book PAL trips based on the approved PAL trip policies and eligibility. This allows PAL-eligible users to not switch systems to book trips that may be outside the scope of the system	
Req-CS-040	Validate Reservation	The Mobility Provider vehicle shall be equipped with a mechanism to verify boarding passengers have a valid reservation (booked through the CTP) to travel their reserved trip (e.g., boarding / alighting location and time).	UN-E-TP-12

Req #	Req Title	Req Description	Related Need
Req-CS-040.3	Validate PAL Spontaneous Reservation	The PAL spontaneous vehicle shall be equipped with a mechanism to verify boarding passengers have a valid reservation (booked through the CTP) to travel their reserved trip (e.g., boarding / alighting location and time). The validation may be through inspection by the PAL operator.	UN-E-TP-12
UN-E-TP-14	Cost to User	The system needs to provide options to the users that have comparable or lower costs to existing modes. This ensures equity across income categories and increases use of the system	
Req-Sy-037	Customer Cost	The system operators shall charge fares for services that are comparable to existing NFTA services.	
UN-E-TE-1	Real-time Information	The system should provide real-time information of the arrival time for the transit vehicle to the user who is awaiting the trip	
Req-CS-043	Tracking CS vehicle operations	The CS shall track the location and monitor performance of vehicles in revenue service in real-time.	
Req-CS-043.1	Track SDS Performance	The SDS SOC shall track the location and monitor operational performance of vehicles in revenue service in real-time. Operational performance includes all sensor, passenger and communications events, event anomalies, triggers and alerts that are generated by the SDS.	
Req-CS-043.2	Track HDS Performance	The HDS operator shall track the location and monitor performance of vehicles in revenue service in real-time.	
Req-CS-049	Mobility Provider Routing Management	The Mobility Provider shall generate vehicle routing and schedules based on operational rules related to the operational strategy in order to meet traveler trip travel requests and reservations. Operational strategies include carpooling, door to door service, microtransit (network or fixed route), etc.	

Req #	Req Title	Req Description	Related Need
Req-CS-049.1	SDS Scheduling and Routing	The SDS SOC shall generate routing and schedules based on ODD rules for SDS vehicles. Routing will follow pre-defined paths and stop at fixed stops in the geographic region. Schedules will include estimated travel, arrival and departure times to pick up and drop off passengers.	
Req-CS-049.2	HDS Scheduling and Routing	The HDS routing management system shall generate PAL (spontaneous) routing and schedules for on-demand, door to door manifests. These typically will consist of two or more pick-up and drop-off locations, travel times between the stops and estimated arrival and departure times.	
Req-CS-049.3	PAL DIRECT Scheduling and Routing	PAL DIRECT shall generate routing and schedules for on-demand, door to door manifests. These typically will consist of two or more pick-up and drop-off locations, travel times between the stops and estimated arrival and departure times.	
Req-CS-055	CS Trip Monitor Management	The CS system shall continually recalculate service adherence to determine impacts to traveler trip plans in order to provide updates to the traveler about their travel experience.	
Req-CS-055.1	SDS Trip Monitor Management	The SDS system shall continually recalculate SDS service adherence to determine impacts to traveler trip plans in order to provide updates to the traveler about their travel experience.	
Req-CS-055.2	HDS Trip Monitor Management	The HDS system shall continually recalculate HDS service adherence to determine impacts to traveler trip plans in order to provide updates to the traveler about their travel experience.	
Req-CTP-045	Transit and mobility service status information	The CTP shall provide a traveler who requests notification of NFTA transit and CS vehicle service's estimated time of arrival and status information with real time information at configurable times prior to the vehicle's arrival. The information is based on the GTFS realtime data feed, but may be extended to include the variety of	

Req #	Req Title	Req Description	Related Need
		notifications on NFTA, CS SDS/HDS and PAL Direct services. Note: GOFS (spec yet to be published) may be used if it meets the needs of travelers.	
Req-CTP-046	Continuous trip planning	When the traveler is using their mobile app for trip execution, the CTP shall continuously update their trip plan to identify seamless and accessible transfers. This includes checking transfers between modes, obstacles / disruptions to travel, and other challenges that may prevent seamless transfer.	
Req-CTP-047	Rerouting trip plan	If the traveler sets their preference for trip updates, the CTP shall provide the traveler via their mobile app, an updated trip plan that re-routes their trip if the trip plan encounters challenges (see Req-CTP-046 Continuous trip planning). <i>Based on yet to be defined business processes, services that require reservations may need to be confirmed prior to rebooking services are conducted.</i>	
UN-E-TE-2	Mobility Devices Access	Vehicles in the system need to include lifts, ramps and securement systems necessary for travelers using mobility devices (e.g., wheelchairs).	
Req-CS-008	Ramp / Lift	The SDS shall be equipped with either a lift or an automated wheelchair ramp that deploys automatically when needed for loading/unloading. If equipped with a ramp, the slope of the ramp shall not exceed 1:6.	
Req-CS-009	Wheelchair Securement	The SDS shall be equipped with an automated or semi-automated wheelchair securement mechanism for securing/unsecuring passengers with mobility devices (e.g., wheelchair, manual or motorized scooter).	
Req-CS-041	SDS User Interface Channels	The SDS shall include user interface channels tailored to traveler needs. The specific features have some variability depending on the SDS provider.	UN-E-TE-9

Req #	Req Title	Req Description	Related Need
Req-CS-041.1	SDS UI Channel – in-vehicle status audio	The SDS shall include an in-vehicle audio that informs passengers as to the status of vehicle operation such as doors closing, departure imminent, destination approaching.	UN-E-TE-9
Req-CS-041.2	SDS UI Channel – in-vehicle status visual	The SDS shall include an in-vehicle visual information, ideally through an in-vehicle screen, that shows vehicle status, location and trip progress.	UN-E-TE-9
Req-CS-041.3	SDS UI Channel – in-vehicle situational awareness audio/visual	The SDS shall include an in-vehicle visual and audio Information about the environment surrounding the vehicle including a) location, route, certain landmarks; b) traffic accidents and incidents; c) deviations from route or why the SDS may be stopping.	UN-E-TE-9
Req-CS-041.4	SDS UI Channel – Braille	The SDS shall include Braille lettering for any in-vehicle functions that require passenger interaction.	UN-E-TE-9
Req-CS-041.5	SDS UI Channel – universal icons	The SDS shall use Universal icons for signs in the vehicle	UN-E-TE-9
Req-CS-041.6	SDS UI Channel – instructional videos	The SDS shall include instructional videos	UN-E-TE-9
Req-CS-041.7	SDS UI Channel – External announcements and visual cues	The SDS shall include external announcements and visual cues about the vehicle number, destination and persons who reserved the vehicle.	UN-E-TE-9

Req #	Req Title	Req Description	Related Need
Req-CS-041.8	SDS UI Channel – Connection to CTP mobile app	The SDS shall include connection to CTP mobile app, other mobile device, or assistive device through local communication protocol (e.g., Bluetooth)	UN-E-TE-9
Req-CS-042	Communicate SDS Status	The SDS passenger information system shall communicate to riders information about the vehicle status, travel path, situational awareness, and public safety messages. At a minimum, the types of information include: <ul style="list-style-type: none"> • Travel information including current location, route, destination, next pickup/dropoff point, landmarks. • Situational awareness about events such as incidents. • Deviations and delays related to trip. • Public safety messages including doors open, board now, secure your seat belt, close door, “watch your step” and other appropriate warnings. The types of information will be driven by the data acquired and the stakeholder priorities during the Agile Development Process.	UN-E-TE-9
Req-Sy-005	Vehicle Accessibility Information Collection	The system shall inventory information on accessibility information available from each CS vehicle used in the system. The information shall include attributes that support the demographic populations using mobility devices (e.g., lift/ramp, type of securement), hearing aids, visual support (text to speech), etc. The data supporting the types of assistive devices will be driven by stakeholder input during the Agile development process.	
UN-E-TE-3	Seat Availability (optional)	The system needs to be able to assess whether there are available seats in the transit vehicles based on current use of securement systems as well as crowd size and other requirements (allergies, space requirements)	
Req-CS-065	Determine occupancy status of wheelchair	The SDS shall have the ability to detect the occupancy status of its available wheelchair securement systems.	

Req #	Req Title	Req Description	Related Need
	securement systems		
UN-E-TE-5	Pick-up and Drop-off Zones	The system needs to define a set of drop-off and pick-up zones for all the major partner facilities at BNMC for access to the facility by various types of disability. This would allow for specific paths directly to the appropriate entrance/exit that is necessary for the user. This is particularly important when the user is being dropped off by private services (like transportation network companies, TNCs) that may not be able to access the right drop-off point area due to congestion or other impediments	
Req-CS-029	Designated Pickup/Drop off Stops	The SDS shall stop at designated pick-up and drop-off locations provided by the SOC routing engine to pick up or drop off passengers.	
Req-CS-066	Pickup / Dropoff locations	The SDS pick-up and drop-off points shall be placed in locations that provide protection from weather elements.	UN-E-TE-14, UN-E-TE-13
UN-E-TE-6	Traveler Guidance	The system needs to direct travelers on accessible paths to/from transit stops to buildings within the campus. This enables people who are blind or have low vision to better identify the direction they need to travel. Guidance can be based on user preferences and can include turn-by-turn information	
Req-CTP-048	Sidewalk Data features	The CTP shall include PROW features, attributes and conditions that support the provision of navigation and wayfinding information to travelers about accessible entrances and pathways to bus stops, transit stations and facilities (e.g., parking, offices, hospitals, clinics) in the BNMC area. The scale and resolution of the features will depend on the precision and accuracy of the collection methods and technologies used. In addition, the rendering of these objects will depend on the positioning and tracking sensors used by the traveler's mobile device, a person's visual ability and other factors.	

Req #	Req Title	Req Description	Related Need
		The fitness for use for different functions will be assessed as part of the Agile testing process.	
UN-E-TE-7	Indoor Navigation	The system needs to direct travelers on accessible paths to/from within buildings within the campus. This enables people who are blind or have low vision to better orient, travel and confirm destination once inside the door of the facility. Guidance can be based on user preferences and can include turn-by-turn information	
Req-CTP-049	Indoor Pathway features	The CTP shall include indoor path and destination features, attributes and conditions that support the provision of wayfinding and destination confirmation information to travelers about facilities in selected facilities in the BNMC campus.	
Req-SI-031	Smart Sign Data Storing	The Smart Signs shall store pre-defined set of data. The dataset will be determined in Phase 2.	
Req-SI-032	Smart Sign Data Sharing	Upon request, the Smart Signs shall share pre-defined datasets with users of the CTP app.	UN-E-TE-6
UN-E-TE-8	Intersection Safety Guidance	The system needs to direct users safely across intersections involving conflicts with vehicular traffic. This enables people who are blind or have low vision to be better supported while crossing intersections, and provide additional time for crossing intersection for travelers who need it.	
Req-CTP-050	Geolocate traveler near intersection	The CTP mobile app shall detect when the traveler is approaching an intersection crossing based on their trip plan. Minimum accuracy of detection will be determined in Phase 2.	UN-S-SO-2

Req #	Req Title	Req Description	Related Need
Req-CTP-051	Generate PED-X request message	The CTP mobile app shall generate a PED-X request to actuate the walk request for a specific crosswalk in a specific direction upon detecting that the traveler is within a configurable distance (or time) of the crosswalk. The specific distance (time) value will be determined during Phase 2.	UN-S-SO-2
Req-CTP-052	Transmit PED-X request message	The CTP mobile app (acting as a PRG) shall transmit the PED-X request message to the PED-X gateway (acting as PRS) at a configurable TSD threshold value (e.g., 30 second before traveler arrives at the intersection), and continuously generate and transmit request updates with new TSD and TED estimate.	UN-S-SO-2
Req-CTP-053	Trusted connection for Ped-X actuation	The CTP and Traffic Signal System shall establish a secure tokenization or other trusted method to exchange Ped-X request and status messages.	UN-S-SO-2
Req-CTP-054	Generate and transmit PED-X request cancel message	The CTP mobile app shall generate a PED-X request cancel message when the app detects that the traveler no longer requires the walk signal actuation.	UN-S-SO-2
Req-CTP-055	Generate and transmit PED-X request clear message	The CTP mobile app shall generate a PED-X request Clear message when the app detects that the traveler has crossed the intersection.	UN-S-SO-2
Req-CTP-056	CTP countdown	The CTP shall provide the travel mobile app a countdown clock on the time left before the PED-X phase is toggled based on the traveler's preference.	UN-S-SO-2
Req-SI-007	PED-X Status Message	A PED-X request status message shall conform to the NTCIP 1211 prgTSPRequest format. This includes configuring the data to provide the identifier of the mobile app that sends PED-X request message, a request identifier, the priority strategy requested	

Req #	Req Title	Req Description	Related Need
		(crosswalk to actuate the pedestrian signal), and actual time to Walk (estimated Time service desired -TSD) and actual time to Don't Walk (time of estimated departure- TED).	
UN-E-TE-9	Trip Notifications	The system needs to provide real time notifications to travelers in haptic, audio and visual format. Notifications include, but are not limited to, turn-by-turn directions, estimated time of arrival (ETA), pick up/drop off locations, and next stop when using or waiting for a bus/shuttle/light rail. These reminders help reassure people with dementia and other cognitive challenges, as well as let passengers who are blind or have a visual impairment to get ready for boarding or alighting transit services	
Req-CS-056	Update CTP on Trip Management	The Mobility Provider system shall update the CTP on the status of traveler booking, reservations and travel and impacts to their travel. The information will include sending updates to the CTP on revised ETAs, detours, cancelled trips, or different dropoff locations. The types and format of the information will be driven by the stakeholder reviewer during the Agile Development Process.	UN-S-SO-2
Req-CS-056.1	SDS Update CTP on Trip Management	The SDS system shall update the CTP on the status of traveler booking, reservations and travel and impacts to their travel. The information will include sending updates to the CTP on revised ETAs, detours, cancelled trips, or different dropoff locations. The types and format of the information will be driven by the stakeholder reviewer during the Agile Development Process.	
Req-CS-056.2	HDS Update CTP on Trip Management	The HDS system shall update the CTP on the status of traveler booking, reservations and travel and impacts to their travel. The information will include sending updates to the CTP on revised ETAs, detours, cancelled trips, or different dropoff locations. The types and format of the information will be driven by the stakeholder reviewer during the Agile Development Process.	

Req #	Req Title	Req Description	Related Need
Req-CS-056.3	PAL DIRECT Update CTP on Trip Management	PAL DIRECT shall update the CTP on the status of traveler booking, reservations and travel and impacts to their travel. The information will include sending updates to the CTP on revised ETAs, detours, cancelled trips, or different dropoff locations. The types and format of the information will be driven by the stakeholder reviewer during the Agile Development Process.	
Req-CTP-060	Trip Notification Triggers	The CTP shall trigger real time notifications to travelers as designated by their preferences and at the time and place designated by their trip plan. These include, but are not limited to, landmarks, intersections, or approaching or arriving at pickup/drop off (boarding/alighting) locations for NFTA, CS or PAL. The development and rollout of these triggers and their implementation will be driven by stakeholder input during the Agile Development Process.	
Req-CTP-062	Trip notification to preferred user interface	The CTP shall provide notifications to travelers using their preferred user interface method. These methods at a minimum include text, voice or haptic. The types of notifications and the method used will be driven by stakeholder input during the Agile development process.	
UN-E-TE-10	Notification Preferences	The system needs to provide notifications that accommodates people's preferences and abilities. Preferences include, but are not limited to, frequency and level of detail of guidance/directions (e.g., step-by-step vs turn-by-turn), language, voice messaging, visual guidance, desired margin to arrive before appointments, upcoming stops, location tracking/guidance, and transit routes (e.g., lowest fare, fastest time, and fewer transfers). This ensures that the travelers are able to receive the information that is being conveyed	
Req-CTP-063	Trip notification preferences	The CTP shall provide an enumerated set of preferences for travelers to select for their account which they can adjust the selections, trigger and frequency for each trip. These preferences will be configurable to assign to indoor and outdoor trip segments.	

Req #	Req Title	Req Description	Related Need
UN-E-TE-11	Notification and Alert Priority	The system needs to have the ability to prioritize notifications and alert based on the impact to users. Higher priority notifications may need faster and more redundant ways of information transfer. For example, when notifications require immediate attention, (like vacating the light rail station due to an emergency), the system needs to be able to provide these alerts quickly and maybe all different forms (audio, visual, text) necessary.	
Req-CS-054	Emergency Communications to Passengers	In case of an emergency, the CS Dispatcher (both SDS SOC and HDS Dispatcher) shall communicate with travelers using the user interface channel(s) as designated by travelers boarding, alighting or traveling on the vehicle. The methods and messages used to communicate with passengers will be driven by stakeholder input during the Agile Development Process.	
Req-CTP-064	Notification and Alert Priority	The CTP shall allow the traveler to select notifications priorities while setting up their trip plan. Safety alerts (such as do not cross intersection) will take priority even over traveler settings. A set of safety alerts will be driven by mobility provider standards and stakeholder driven priorities during the Agile Development Process.	
Req-Sy-012.3	CTP Notification Transmission Response Time	The CTP shall generate and transmit notifications to travelers end-user devices within a pre-specified time limit from the time the trigger (that caused the notification to be sent) was received to the time the notification was transmitted by the CTP. Different types of notifications will have different time limits and priorities. The time limits will be determined in Phases 2 and 3, and do not include end-user computing limitations for rendering and displaying the results.	
UN-E-TE-13	Adverse Weather Operations	The system needs to support operations of services in adverse weather. While stakeholders in Buffalo are very experienced and capable in winter weather operations, several scenarios are possible due to adverse weather in Buffalo and systems needs to provide the ability to mitigate the impacts of weather on trip making. Scenarios of interest include (1) Sidewalks, shuttle drop-off bus shelters	

Req #	Req Title	Req Description	Related Need
		not being passable due to delayed snow and ice clearance, (2) Roadway operations are compromised to due to snow and ice conditions	
Req-SI-029	TIH environmental conditions	The TIH shall operate in indoor and outdoor environments in the Buffalo, New York environment without degradation: -- operational temperature (-20 to +60°C) -- Waterproof (IP67)	UN-S-SO-9
UN-E-TE-14	Nighttime Travel	The system needs to support night time travel needs for travelers. While hours of service for shuttle operations are not determined, other aspects of the system need to support traveler use during night time. This is necessary so that the wayfinding, indoor navigation and other information services are available to travelers who will accessing the campus after sunset and work appropriately under diminished lighting.	
Req-CS-077	CS Hours of Operations	The CS shall publish the hours of operations for its mobility services.	
Req-CS-077.1	SDS Hours of Operations	The SDS operator shall publish the hours of operations for mobility services to travelers (employees and visitors) in the BMNC region.	
Req-CS-077.2	HDS Hours of Operations	The HDS operator shall publish the hours of operations for mobility services to travelers (employees and visitors) in the BMNC region.	
Req-CS-077.3	PAL Spontaneous Hours of Operations	NFTA shall publish the hours of operations for PAL Spontaneous for travelers (employees and visitors) in the BMNC region.	

Req #	Req Title	Req Description	Related Need
UN-E-TS-1	Assistance	The system needs to provide a means for travelers to communicate with a trained and designated human operators at any point during the trip through telephone, mobile app, or in person, depending on the stage of their trip (e.g., at home planning, walking, within the shuttle, within a building). This ensures that travelers are able to communicate with a human operator in case of emergencies or even for additional support	
Req-CS-068	Pick-up, Drop-off location occupied	The SOC shall identify back-up pick-up and drop-off locations when designated locations are occupied.	UN-S-SO-14
Req-CTP-065	Traveler Assistance	The CTP shall provide an emergency call feature that is configurable by the traveler for them to initiate a call (via telephone, VoIP) to a third party of their choosing including caregiver, guardian, call center, or other trained mobility manager to help with planning or executing their journey.	
UN-E-TS-2	Matching Assistance to Services	The system needs to match traveler requests for assistance to the right operator based on their current location and preference on the trip. This is important that the support needs are addressed by the responsible entity and customer satisfaction is maintained.	
Req-CTP-066	Trip Planning and mobility options	The CTP shall optimize and rank order of alternative trip plans based on the trip plan parameters and traveler preferences that best match available services, transfers and modes. The optimization, ranking, alternative trip plans, and processes when no trip plans are generated will be driven by stakeholder input during the Agile Development process in Phase 2.	
Req-Sy-35	Account Linking APIs	The system shall request and integrate an API transaction set from mobility providers to allow account linking. This enables the CTP account holders to link their accounts.	

Req #	Req Title	Req Description	Related Need
Req-Sy-35.1	PAL Account Linking APIs	The PAL DIRECT shall provide an API transaction set for the CTP to provide an option for CTP customers to link their CTP and PAL accounts.	
UN-E-TS-3	Traveler Training	The system needs to train users on using each and all aspects of the system. Training could include how to use trip planning, use transit and shuttle services, as well as the wayfinding and intersection movement assistance tools offered as part of the project. This will ensure that all users of the system have a clear idea on what is provided and what the limitations of the system.	
Req-CTP-067	CTP Help Feature	The CTP shall include help features on the website and mobile app that describe the tool features and functions. The Help feature shall be accessible to the Travelers (in Section 2.4) and Call Center staff.	
UN-E-TS-4	Low/non-Smartphone Accessibility	Services used by the system need to be accessible through different non-smartphone interfaces (e.g., telephone, voice, text, symbol, etc.). This is necessary to support the different needs of travelers but also provide services for users that do not have access to smartphone or broadband technology	
Req-CTP-068	CTP Services on Communications Channels	The CTP registration, profile settings, trip planning, execution and reporting shall be accessible through, at a minimum, the following communication channels: web application, mobile web application, mobile app, and call center agent.	
Req-CTP-069	CTP User Interface method	The CTP shall provide notifications and navigation instructions using a variety of user interface methods as selected by the traveler and depending on the functionality of their end-user device including voice (by automated phone alert, mobile app, VoIP), text (by SMS or mobile app/mobile web application) or vibration (by mobile app or wearable).	
Req-CTP-070	CTP UI Method and	The CTP shall allow a user to select a notification UI method to be matched to the communication channel. The matching UI methods, notifications and communication channel will be driven by the stakeholders during the Agile development process.	

Req #	Req Title	Req Description	Related Need
	Communications channel		
Req-CTP-071	CTP language notification selection	The CTP shall allow a traveler to choose a language, including American Sign Language, in which they will receive their voice, video or text notifications. The set of languages will be selected during Phase 2 and shall not exceed four languages in addition to English.	
Req-CTP-072	CTP language planning selection	The CTP shall allow a traveler to choose a language to use while using the registration, profile settings, planning and reporting functions. The set of languages will be selected during Phase 2 and shall not exceed four languages in addition to English.	
Req-CTP-073	Trusted third party access	The CTP shall allow a traveler to designate a trusted third party who is authorized to access their CTP account, book and cancel reservations, and track their trip. The details of the access, authorization, authentication and audit will be driven by stakeholders during the Agile development process.	
Req-CTP-074	User-based access to Traveler Account	The CTP shall implement a process to authenticate a trusted party sign on and access to a traveler's account information.	
Req-CTP-075	Audit Third Party Access	The CTP shall log and audit the activities of third parties when they access a traveler's account.	
Req-CTP-122	PAL vs. System Responsibility	The CTP shall provide a channel for PAL travelers to book PAL Services and notify PAL travelers who book trips through the CTP (and opt in for real time notifications) of their vehicle arrival time. The responsibilities for PAL / PAL DIRECT and the Buffalo ITS4US project will be coordinated during Phases 2 and 3.	

Req #	Req Title	Req Description	Related Need
UN-E-TS-6	Caregiver Travel	The system needs to ensure that that caregivers are not separated from the person they are accompanying and are charged the right cost of their trip under local regulations.	
Req-CTP-137	Preferences for Caregivers	The CTP shall allow travelers to specify services for caregivers including sending alerts, having them as travel companions and giving full access to the CTP on their behalf. A full list of services will be driven by stakeholder input during the Agile Development Process.	
Req-CTP-076	Group Travel	The CTP shall not separate a traveler and their designated travel companions in their trip plan and reservations.	
Req-CTP-077	Caregiver Designation	The CTP shall allow a traveler to designate a caregiver or travel companion(s) who should not be separated from the traveler planning a trip.	
UN-E-TS-7	Service Animals	The system needs to compliant with policies to accommodate passengers with service animals. This is important to ensure that the system is inclusive	
Req-CS-087	Accommodations for Service Animals	The CS reservations management shall accommodate and designate service animals when specified in the reservations request.	
Req-CTP-078	Traveling with a service animal	The CTP shall allow a traveler to indicate that they will be (are) accompanied by a service animal when they plan or execute a trip. The operating procedures for traveling with a service animal is described by the mobility provider.	
Req-CTP-079	Mobility operator service animal policies	The CTP shall enforce the mobility provider's (e.g., CS SDS, HDS, PAL, NFTA) policy by allowing/disallowing a traveler to book a trip if they indicate whether they will be	

Req #	Req Title	Req Description	Related Need
		accompanied by a service animal. The mobility provider will designate whether a service animal is allowed on their vehicles.	
UN-E-TS-8	Crowdsourced Data	The system needs to collect data from its users (that opt-in). Data includes both performance and real time condition information. This is important to improve real time trip planning and execution, as well as to enable the assessment of the system's performance.	
Req-CTP-080	Traveler feedback form	The CTP shall provide a traveler feedback form for travelers or other CTP users to provide information on challenges, obstructions or conditions on their trip plan or in the project geographic region. The content and format of this crowd-sourced data shall be driven by stakeholder input during the Agile development process.	
Req-CTP-081	CTP ingestion of feedback	The CTP shall develop a process to ingest and integrate the crowd-sourced data into the routing engine and notifications for other travelers (when relevant and timely).	
Req-CTP-082	Traveler satisfaction survey tool	The CTP shall provide a configuration tool for project staff to generate customer satisfaction surveys.	
Req-CTP-083	Access to Traveler satisfaction survey results	The CTP shall provide a method for designated researchers to access the results of satisfaction survey that removes any PII from the raw data.	
UN-S-SO-1	Travel Impact Info Integration	The system needs to collect current, planned and/or forecasted information that may impact accessibility, trip planning and execution, traveler information and operations. These include, but are not limited to o Traffic, Work zones, Incidents, Weather, Infrastructure and services capacity status (e.g., parking availability), New and existing transit services status (location, estimated time of arrival,	

Req #	Req Title	Req Description	Related Need
		delays and closures), and Infrastructure status (e.g., elevator and escalator conditions, sidewalk condition)	
Req-CTP-084	CTP ingestion of event datasets	The CTP shall ingest and integrate the planned and unplanned event data into the routing engine and notifications for travelers (when relevant and timely). The datasets will include but are not limited to the following: Traffic, Work zones, Incidents, Weather, Infrastructure and services capacity status (e.g., parking availability), new and existing transit services status (location, estimated time of arrival, delays and closures), and Infrastructure status (e.g., elevator and escalator conditions, sidewalk condition). The datasets and their timing will be driven by stakeholder input during the Agile Development Process.	UN-E-TE-13
UN-S-SO-2	Intersection Movement	The system needs to integrate signal controller information from selected intersections and be able to provide hands-free intersection movement assistance to travelers. This would increase safety when crossing intersections for vulnerable road users around the BNMC.	
Req-CTP-057	PED-X Request Message	The Ped-X request message shall be adapted from the NTCIP 1211 priority request message which contains the identifier of the mobile app that is desired for Ped-X, a request identifier, the priority strategy requested (crosswalk to actuate the pedestrian signal), time of service requested (TSD), and the time of estimated departure (TED).	UN-E-TE-8
Req-CTP-058	PED-X Request Cancel Message	A Ped-X request cancel message shall be adapted from NTCIP 1211 priority request cancel message which contains the identifier of the mobile app that is desired for Ped-X, a request identifier, the priority strategy requested (crosswalk to actuate the pedestrian signal), TSD, and the TED.	UN-E-TE-8
Req-CTP-059	PED-X Request Clear Message	A Ped-X request clear message shall conform to the NTCIP 1211 request clear message and include the identifier of the mobile app that is desired for Ped-X, a request	UN-E-TE-8

Req #	Req Title	Req Description	Related Need
		identifier, the priority strategy requested (crosswalk to actuate the pedestrian signal), TSD, and the TED.	
Req-CTP-085	CTP ingestion of traffic signal control operation data	The CTP shall ingest and integrate traffic signal control phasing data into the routing engine and notifications for other travelers (when relevant and timely). The data will be used to support the Smart Infrastructure PED-X function and to provide automated passenger system (APS) information to travelers arriving at crosswalks.	
Req-SI-027	Transmit Time to Cross (Don't Walk)	The traffic signal system shall send, with a latency of no more than 1 second via the PED-X gateway, information on the time when the PED-X phase will toggle from walk to do not walk (in the direction requested by the traveler).	
UN-S-SO-3	Wayfinding Infrastructure integration	The system needs to integrate updated and/or new communication and information technologies that improves sharing information with travelers traversing on sidewalks and bus shelters. This ensures that travelers can receive information while at selected locations and be guided to their destinations as part of the complete trip.	
Req-CTP-110	Transmit to Traveler Time to Cross (Don't Walk)	With the information from the PED-X Status Message, the CTP mobile app shall begin the countdown clock that shows the traveler the time until the do not walk sign is actuated—see Req-SI-027 for requirement about when notification of walk/don't walk phase shall be sent.	
Req-CTP-110.1	Transmit to Traveler Time to Cross (Don't Walk) – Clock Time Synchronization	Clock times of the mobile app and traffic signal controller shall be synchronized to minimize latency or errors in the timing.	

Req #	Req Title	Req Description	Related Need
Req-CTP-110.2	Transmit to Traveler Time to Cross (Don't Walk) – Countdown	The CTP shall begin countdown within 200ms upon receipt of the data and calculate within a 500ms (1/2 second) error, the timing based on the phase duration.	
Req-CTP-111	Monitor for PED-X connectivity	The CTP mobile app shall monitor the connection between the PED-X Gateway and CTP mobile app.	
Req-CTP-112	Alert Lack of communications for PED-X connectivity	The CTP mobile app shall alert the traveler requesting PED-X request actuation within 200ms upon detecting communications between the PED-X Gateway and CTP mobile app is degraded or failed.	
Req-CTP-113	PED-X anomalies	The CTP mobile app shall manage the transaction request for PED-X actualization responses from the Traffic Signal Controller to identify missed or cancelled status response.	
Req-CTP-114	Alert Traveler to PED-X anomalies	The CTP mobile app shall alert the traveler to PED-X responses for missed, cancelled or other dropped messages that will impact the actuation request within twenty seconds of expected responses. The specific messages and responses will be driven by stakeholder input during the Agile Development Process.	
Req-SI-001	PED-X Gateway	The SI shall implement a PED-X gateway to verify, store and forward pre-defined pedestrian signal request messages between the CTP mobile app (or authorized devices) with the traffic signal controller.	
Req-SI-002	PED-X Gateway operation	The Ped-X gateway shall not conflict with the operations of the current signal system or physical pedestrian request signal operations.	

Req #	Req Title	Req Description	Related Need
Req-SI-003	Receive PED-X request message	The PED-X (acting as PRS) shall receive and process the PED-X request message sent by the mobile app (acting as a PRG) to the PED-X gateway within 200ms of its receipt.	
Req-SI-004	Log PED-X request	The PED-X gateway shall log the PED-X request message including the message and event times (receipt, forward and respond).	
Req-SI-005	Forward PED-X request	The PED-X gateway shall validate and forward the PED-X request message to the Controller to actuate the walk request phase within 200ms of its receipt.	
Req-SI-006	Send PED-X status	The PED-X gateway shall generate a message with the crossing walk time and transmit the PED-X status message to the CTP mobile app within a maximum time of 200ms and maximum rate of 5 seconds after receipt of the initial PED-X request message.	
Req-SI-008	Smart sign durability	The smart sign shall operate in indoor and outdoor environments in the Buffalo, New York environment without degradation: -- operational temperature (-20 to +60°C) -- Waterproof (IP67)	UN-E-TE-13
Req-SI-011	Smart Signs -- BLE Beacons	For smart signs supporting BLE, the smart sign shall include the following specifications: (1) support BLE 5 or above; (2) have a configurable broadcast range of between 50-100 meters for indoor spaces or 200-300 meters for outdoor spaces. The space will dictate the preferred range.	
Req-SI-012	Smart Signs -- NFC	For smart signs supporting NFC, the smart sign shall include the following specifications: (1) support Tag NDEF Exchange Protocol (TNEP) Technical Specification 1.0; (2) have a broadcast range of 10 cm depending on the location where it is used.	

Req #	Req Title	Req Description	Related Need
Req-SI-015	Smart Sign tactile form	The smart sign shall include a tactile overlay using braille to convey information on the current location and smart sign identifier.	
Req-SI-016	TIH thin client for CTP	The TIH shall serve as a thin client implementing the same functionality as the CTP website. A thin client uses resources stored on a central server instead of a localized hard drive--that is, they connect remotely to a server-based computing environment where most applications, sensitive data, and memory, are stored.	UN-S-SO-10
Req-SI-017	TIH CTP configuration	The CTP used on the TIH shall be configured to generate a trip plan with the origin at the TIH location. Other default settings (including timing out, logging out of account, and other services) will be driven by stakeholder input during the Agile development process.	
Req-SI-018	TIH CTP connection	The TIH shall connect to the CTP central functionality through an internet connection.	
Req-SI-019	TIH equipment	The TIH shall be composed of the following four equipment components: (1) hardened touch screen display with embedded keyboard and track pad. (2) backend processor (e.g., laptop, tablet) with speaker / microphone and Bluetooth interface. (3) touch model of indoor layout of facility (interactive tactile display with talking interface). (4) connections between touch model and processor, and touch screen and processor. Two configurations will be included one with all components and one without the touch model (and connectors). Power, internet access and installation (including form factors for equipment) shall be provided by the facility owner.	
UN-S-SO-4	Indoor Navigation Integration	The system needs to integrate with indoor wayfinding technology in partner buildings, particularly entrances, information/reception desks and bathrooms.	

Req #	Req Title	Req Description	Related Need
		This is necessary to ensure that travelers are supported through the last leg of their trip adequately and get confirmation of their destination	
Req-Sy-004	Smart Sign Inventory Access	The system shall publish the smart sign inventory to be accessed by authorized systems and subsystems including, but not limited to, the CTP.	
Req-CTP-117	Smart Signs using Common communications protocols	The CTP shall interface with smart signs using communication technologies supported by mobile devices (e.g., near field communication - NFC, Bluetooth Low Energy - BLE) without need for specialized functionality to be developed for the mobile app.	
Req-Sy-003	Components Inventory	The System shall collect and store project components (e.g., smart sign) attributes and locations in an inventory that is available to project subsystems. Location information will be identified relative to the facility in which its components are placed within the project area (e.g., building, floor, bus stop shelter). The inventory file shall at a minimum include asset information such as asset identifier, location, facility, placement date, battery placement, specification and maintenance information. The specific data included will be developed during Phase 2 and will vary by type of component.	
UN-S-SO-5	Reporting Issues	The system needs to share real-time information with appropriate entities when travelers are reporting vehicle, facility or other system problems and emergencies. This would help minimize the consequences of undesirable travel events	
Req-CS-88	Report health status to CTP	The Mobility Provider shall alert the CTP about health status information of the mobility provider planning and operational services whenever the system is in degraded or failure modes.	

Req #	Req Title	Req Description	Related Need
Req-CS-88.1	Report SDS Operating Status to CTP	The SDS operator shall alert the CTP about health status information of the mobility provider planning and operational services whenever the system is in degraded or failure modes.	
Req-CS-88.2	Report HDS Operating Status to CTP	The HDS operator shall alert the CTP about health status information of the HDS planning and operational services whenever the system is in degraded or failure modes.	
Req-CS-88.3	Report PAL Operating Status to CTP	The PAL system shall alert the CTP about health status information of the PAL planning and operational services whenever the system is in degraded or failure modes.	
Req-CTP-086	Report Traveler feedback issue	The CTP shall send a message to the appropriate entities (e.g., BNMC, NFTA or City of Buffalo, facility owner) when a public asset or system issue, event or condition is reported using the Traveler Feedback Form. Note: the feedback will not cover emergency issues, events or situations.	
Req-CTP-087	Traveler Feedback priority	The CTP shall prioritize reporting issues to appropriate entities based on the severity of the issue. The types of events/issues and reporting priorities and channels will be designed during Phase 2.	
Req-Sy-036	CS Health Status Communications Action to the CTP	The CS Shall meet a set of SLAs for health status to the CTP. The types of alerts (e.g., failures, degraded mode, dropped connection, etc.) will drive the pre-specified time limits for reporting. The time limits for detecting, alerting and reacting will be determined in Phases 2 and 3 for each CS mode and alert type.	
UN-S-SO-6	Offline Use	The system needs to allow reservations and access to the services offered if there is no or limited access to the internet or smartphones. For example, the system may provide travelers to hail a shuttle using a device that is available to anyone (not a personal mobile device) while at a designated shuttle stop. The device will need to comply with ADA regulations for travelers who are blind or have low	

Req #	Req Title	Req Description	Related Need
		vision to ensure that such travelers are familiar with the new system as it would resemble existing ones	
Req-CTP-088	UI to Call Center	The CTP shall provide user interface services to support the call center software. The interfaces are built into the OTP core capabilities.	
Req-SI-020	TIH touch model	The TIH touch model shall, in its physical layout, represent the facility including all pathways, conveyances, destinations and other features needed to support wayfinding through the facility. The information imprinted on the touch model should include destinations in English and Braille.	
Req-SI-021	TIH talking touch model	The TIH shall speak the name of the location in English and up to two other languages to be selected by the facility owner as a user presses a location on the touch model.	
Req-SI-022	TIH touch model language selection	The TIH shall allow the user to select the language that is spoken when a location is selected on the touch model.	
Req-SI-023	TIH touch model content configuration	The TIH touch model shall include a tool to configure and update the messages spoken when a location is selected.	
Req-SI-024	TIH CTP and Touch Model operations	The TIH shall have sufficient processing, persistent and dynamic storage capacity to operate multiple end-devices simultaneously, allowing simultaneous operations of the touch model and CTP website by different users.	
Req-SI-028	Public kiosks	The Smart Infrastructure shall deploy a transportation information hub (TIH) installed at selected location around the BNMC which travelers can use to access CTP registration, trip planning and CS reservation services.	UN-E-TE-5

Req #	Req Title	Req Description	Related Need
Req-SI-030	SI durability	The Smart Infrastructure equipment shall be durable and hardened for use. The hardening process shall secure physical, software, user interface devices and other peripherals from harm, as applicable.	UN-S-SO-9
Req-Sy-008	Call Center	The System shall provide a call center where travelers can call to access CTP registration, trip planning and CS reservation services.	
UN-S-SO-7	Opt-in	The system needs to enable travelers to opt in to tracking services and to receive notifications. This ensures that travelers are in control of the data they share and receive	
Req-CTP-089	Travel Opt-Out	The CTP shall provide a traveler with the option to opt-out of trip tracking when loading or executing a trip plan. The default setting is for the travel to opt-in to tracking while using their mobile app for executing their trip plan (receiving direction instruction, notifications, etc.)	
Req-CTP-090	Data Use Disclosure policy	The CTP shall provide and acquire a signed disclosure prior to collecting and using any PII from CTP registered users.	
Req-CTP-091	Travel Opt-in/out Toggle	The CTP shall allow a traveler to toggle from opt-in to opt-out or from opt-out to opt-in of storing their tracking data when they use their CTP mobile app.	
Req-CTP-133	Account History and PII Removal	The CTP shall, upon request by a registered account holder, shall remove their PII from CTP storage and request removal of PII from system-wide storage.	
Req-CTP-134	Account Closure and Removal Process	The CTP shall provide the registered account holder with an option to close their account and remove their PII (including travel history) from the system.	

Req #	Req Title	Req Description	Related Need
Req-Sy-007	Traveler PII Data Removal	The System shall remove PII data from system-wide storage when a traveler requests that their PII be removed from the system.	
Req-Sy-014	PII data use policy and IRB	The System operators shall develop and publish a data use and privacy policy to disclose to registered account holders information about data collection, use, and dissemination policies related to their personal information. The types of PII and use of data will conform to the IRB provisions.	
UN-S-SO-8	Data Management	The system needs to securely collect, store and share data on the performance of all of its components per agreed upon protocols and agreements. This would allow the project team to monitor and assess the system performance, as well as measure the benefits of the system.	
Req-CS-082	CS Operational Performance Data Collection	The CS subsystem shall collect vehicle operational performance data including ridership, on time performance, travel times, and other performance measures. The performance measures, metrics and confounding factors will be described in the PMESP.	
Req-CS-082.1	SDS Operational Performance	The CS shall collect SDS performance data including ridership, on time performance, travel times, and other performance measures collected by service operator.	
Req-CS-082.2	HDS Operational Performance	The CS shall collect HDS performance data including ridership, on time performance, travel times, and other performance measures collected by the service operator.	
Req-CS-082.3	PAL Operation Performance	NFTA PAL services shall collect PAL (spontaneous service) operational performance data including ridership, on time performance, travel times, and other performance measures that corresponds to CTP usage.	

Req #	Req Title	Req Description	Related Need
Req-CS-083	Mobility Provider Trip Reporting	The CS shall log trip performance metrics on a daily basis for the PMD to access. The CS shall log trip performance metrics on a daily basis for the PMD to access. Metrics, at a minimum, will include: <ul style="list-style-type: none"> • Total number of trips • Total number of reservations • Total number of revenue miles • Ridership by trip, route, boardings/alightings by stop • On-time performance (by pickup-dropoff times) • Anonymized trip histories (including preferences) • Total number of incidents 	
Req-CS-083.1	SDS Trip Reporting	The SDS shall log trip performance metrics on a daily basis for the PMD to access.	
Req-CS-083.2	HSD Trip Reporting	The HDS shall log trip performance metrics on a daily basis for the PMD to access.	
Req-CS-083.3	PAL Trip Reporting	For trips booked through the CTP, PAL DIRECT shall log trip performance metrics on a daily basis for the PMD to access.	
Req-CTP-092	Trip History and Unique Reference Identifier	The System shall assign planned and actual trip plan segments with a common unique identifier to link various trip segments into a trip history. Trip history will include information about the complete trip associated with each subsystem. The detailed data contained in trip history records will be described for each mode, services and subsystems during the design processes of each subsystem.	
Req-CTP-116	Smart Sign Inventory Acquisition	The CTP shall acquire and use the Smart Sign Inventory asset information to augment wayfinding, navigation and destination finding functions onboard the mobile app. The	

Req #	Req Title	Req Description	Related Need
		specific procedures and algorithms will be designed in Phase 2. The procedures and algorithms may be located onboard the mobile app or in the subsystem back office.	
Req-PMD-001	Ingesting data	The PMD shall ingest static and streaming datasets created and used by the system subsystems including the datasets identified in the Data Management Plan (as updated throughout Phase 2).	
Req-PMD-002	Quality checking data	The PMD shall apply quality checking (QC) procedures. The QC procedures will be developed and documented as part of Phase 2 design.	
Req-PMD-003	Anonymizing data	The PMD shall not store data/datasets that contain PII or trace data. (PII data storage provisions are specified in Req-PMD-12.)	
Req-PMD-005	Metadata	The PMD shall record and enforce the collection of metadata on all datasets stored in the PMD data layer.	
Req-PMD-006	Role based access	The PMD shall enforce role-based access to datasets which include discover, publish and subscribe, view, update, delete and create functions by original, anonymized, derived and aggregated datasets. Training may be required to access data.	UN-S-BO-2
Req-PMD-007	Analytic tools	The PMD shall support the data access by or export to third party analysis tools (e.g., R, GIS, and Excel) to meet the performance measures described in the PMES plan.	
Req-PMD-008	Data aggregation	The PMD shall provide data services to aggregate and compare datasets based on facts and dimensions (to be identified and standardized during Phase 2 development). The resulting aggregated datasets will compose "data marts" that specialize data based on the most used facts and dimensions.	

Req #	Req Title	Req Description	Related Need
Req-PMD-009	Presentation formats	The PMD shall present results of data analysis in several formats including tabular, graphs, and graphic visualizations (e.g., maps, isochrones, heat maps, infographics).	
Req-PMD-010	Web based presentation	The PMD shall provide configuration tools to post analysis results in web-based format so that they can be displayed in a web browser.	
Req-PMD-011	Cloud base infrastructure	The PMD shall be hosted in a cloud-based environment that is scalable to accommodate and evolve as storage, processing and access loads increase throughout the project duration.	
Req-PMD-012	On-premise data storage	The PMD shall store the PII and Research data on an on-premise data storage servers.	
Req-PMD-013	Discovery	The PMD shall provide a library of datasets it stores for users to discover datasets and their metadata. Discovery selections are dependent on role based access (see Req-PMD-006).	
Req-PMD-014	Data Curation of Metric Data	The PMD shall develop and implement a data curation plan to ingest, extract, transform and load the datasets from other subsystems and external sources that support the Performance Measurement and Evaluation Support Plan. These include, but are not limited to, the datasets listed in Req-PDM-14.1 through Req-PDM-14.7.	
Req-PMD-014.1	Data Curation of crowdsourced data	The PMD shall develop and implement a data curation plan for crowdsourced data from the CTP.	
Req-PMD-014.2	Data Curation of satisfaction data	The PMD shall develop and implement a data curation plan for satisfaction data from the CTP survey responses.	

Req #	Req Title	Req Description	Related Need
Req-PMD-014.3	Data Curation of CTP performance data	The PMD shall develop and implement a data curation plan for Performance Metrics from the CTP including CTP usage, registration, trip planning, trip booking, trip transit use, trip time and location, trip notification, CTP smart sign (interaction), and CTP smart signal (PED-X).	
Req-PMD-014.4	Data Curation of reservation data	The PMD shall develop and implement a data curation plan for Shuttle Reservations Management summary datasets.	
Req-PMD-014.5	Data Curation of shuttle reporting data	The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets.	
Req-PMD-014.6	Data Curation of shuttle reporting data	The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets, including: <ul style="list-style-type: none"> (1) Requests for service (to calculate on-time performance against actual service). The archived information can be later used to refine the planning and executing of the shuttle operations. (2) Reservation requests including time, pickup and drop-off locations, number of passengers, accessibility preferences, etc. (3) Reservations confirmation with specific time / location of pickup and drop off, number of passengers, confirmation credentials, etc. (4) GTFS-Flex and GOFs from the flexible operations modes. (5) Shuttle information about current locations, schedule, occupancy and special conditions including number of occupied securements on the shuttle. (6) Information about the operating status of the CS over time. 	
Req-PMD-014.7	Data Curation of additional data	The PMD shall develop and implement a data curation plan for additional planned and unplanned data items in the Performance Management Dashboard, including: <ul style="list-style-type: none"> (1) Data on weather conditions, road closures, etc. (2) Data on operating conditions for key NFTA services, particularly those serving the BNMC. 	

Req #	Req Title	Req Description	Related Need
		(3) Operational status of other system components such as wayfinding beacons and smart intersection controls. (4) Data on the operating status of the PMD itself.	
Req-Sy-001	Web browser support	The System shall support leading web browser applications when presenting on a website or mobile website. At a minimum, the System shall support Safari, Chrome, Microsoft Edge, and Firefox.	
Req-Sy-006	Trip History and Unique Reference Identifier	The System shall assign a common unique identifier to a trip history to link the trip plan and execution, as well as its multiple trip segments. Trip history will include information about the complete trip associated with each subsystem. The detailed data contained in trip history records will be described for each mode, services and subsystems during the design processes of each subsystem.	
Req-Sy-019	Americans with Disability Act	The System shall comply with the Americans with Disability Act (1990).	
Req-Sy-020	Backup System	The system shall provide a backup system that protects persistent, transactional, operational and archived datasets.	
Req-Sy-021	Manual and automated backup	The system shall provide automated and manual backup functions to schedule full and interim backups. Frequency of backups will be determined during the development of the system in Phase 2.	
Req-Sy-022	Data Recovery Tool	The system shall provide tools for the system administrator to recover lost or corrupted data. The tools should be configured to provide optimal data recovery based on a Disaster Recovery Plan.	

Req #	Req Title	Req Description	Related Need
Req-Sy-023	Operational Data Retention	The system shall store data per applicable NFTA data policy for up to five years or the duration of the Buffalo ITS4US project.	
Req-Sy-025	Linking trip segments	Subsystem log files shall use a common reference (identifier) or a reference that can be associated with the trip plan and reservation used by a traveler in executing their trip.	
Req-Sy-026	Dataset Curation Plan	System developers shall develop a curation process plan for each dataset that is consistent with the DMP and PMESP. The dataset includes data collection, ingestion, validation/quality checking, ETL processes, storage, distribution methods, metadata documentation. The frequency of the curation process will be determined in Phase 2.	
Req-Sy-026.1	Implement Dataset Curation	Data stewards shall implement the dataset curation plan including quality control procedures.	
UN-S-SO-9	Hardware characteristics	The system needs to use hardware that can withstand tampering and severe weather conditions that are commonly present in the deployment area	
Req-SI-009	Smart sign power	The smart sign shall be powered by replaceable battery power (with an average life of 5 years depending on usage) or by 120 AC power source.	
Req-SI-013	Smart sign installation and mounting	The smart sign shall be constructed to be installed using adhesive or screws mounted on a wall, shelter or pole.	UN-E-TE-13
Req-SI-025	PED-X Gateway	The Smart Infrastructure shall employ a secure communications gateway that uses communications channels and protocols that are native to a majority of mobile devices to exchange messages between the CTP mobile app and the Traffic Signal PED-X module.	

Req #	Req Title	Req Description	Related Need
UN-S-SO-10	Secure Software	The system needs to provide safe and accessible services and software that are secure by design and protects the privacy of its users. This is important as user will not be motivated to use the new system if they feel their personally identifiable information (PII) is not correctly handled and protected	
Req-CS-071	Cybersecurity risk assessment	The SDS vendor shall document and assess cybersecurity risks in its design including means to detect unauthorized communications including vehicle control commands.	
Req-CS-072	Access to SDS onboard computers	The SDS vehicle system access shall be secured using advanced authentication methods beyond password and physical locking mechanism including a two-step verification process.	
Req-CS-073	Security Breach Response	The SDS vehicle system shall include a security alarm that triggers and transmits an alarm when a physical or system security breach is detected.	
Req-CS-074	Defense against Spoofing Attacks on sensors	The SDS shall apply its multi-sensor fusions to defend against known spoofing attacks on single sensors. Sensors included in the defense include the camera, LiDAR, radar and GPS.	
Req-CS-075	New Software Releases	The SDS and SOC software shall be peer reviewed and verified prior to updating system or vehicle software.	
Req-CS-084	Secure Mobility Provider Trip Reporting	The Mobility Provider shall secure traveler PII by anonymizing and encrypting trip history data prior to providing access to PMD. The methods used should align with the provider's privacy policies and the IRB provisions of this project.	
Req-CS-084.1	Secure SDS Trip Reporting information	SDS operator shall secure traveler PII by anonymizing and encrypting trip history data prior to providing access to PMD. The methods used should align with the provider's privacy policies and the IRB provisions of this project.	

Req #	Req Title	Req Description	Related Need
Req-CS-084.2	Secure HDS Trip Reporting information	HDS Operator shall secure traveler PII by anonymizing and encrypting trip history data prior to providing access to PMD. The methods used should align with the provider's privacy policies and the IRB provisions of this project.	
Req-CS-084.3	Secure PAL Trip Reporting information	PAL DIRECT shall secure traveler PII by anonymizing and encrypting trip history data prior to providing access to PMD. The methods used should align with the provider's privacy policies and the IRB provisions of this project.	
Req-CTP-093	CTP Security	The CTP shall provide end-to-end security for traveler data, particularly PII and derived data sets. The security requirements, developed for the Smart Columbus PIVOT app apply to this project (see MMTPA Security Final.pdf). The details and application of these provisions to the CTP will be implemented as part of the Agile Development Process.	
Req-Sy-013	Data security	The system shall implement a data security plan to secure end to end encryptions and security provisions for all data transmitted to and between subsystems and users.	
Req-Sy-024	PII and Research Data Retention	The system shall store PII data for three years after the Buffalo ITS4US project evaluation is completed or in compliance with IRB provisions.	
UN-S-SO-11	System Reliability	The system needs to be reliable so travelers can rely on its availability and proper functioning.	
Req-CS-018	CS Vehicle Health Monitoring	CS vehicles shall monitor the "health" of vehicle assets, particularly sensor and actuator functions, to ensure they are performing to specifications.	
Req-CS-018.1	SDS Sensor Health Monitoring	The SDS shall monitor the "health" of all vehicle sensor and system assets, particularly sensor and actuator functions to ensure they are performing to specifications. The	

Req #	Req Title	Req Description	Related Need
		complete set of parameters identifying “degraded health” situations will be detailed in Phase 2.	
Req-CS-018.2	SDS Communication Health Monitoring	The SDS shall monitor operational status of connectivity and sensor functions such as loss of connectivity to the Autonomous Driving kit or any loss of a sensor. The complete set of parameters identifying “degraded health” situations will be detailed in Phase 2.	
Req-CS-018.3	SDS Safety Asset Health Monitoring	The SDS shall monitor operational status of passenger safety functions such as loss of passenger information module. The complete set of parameters identifying “degraded health” situations will be detailed in Phase 2.	
Req-CS-019	Monitor Communications	The SDS shall continuously monitor the status of communications network.	
Req-CTP-094	CTP Reliability	The CTP shall follow reliability and uptime service levels documented in a service level agreement to be defined during Phase 2.	
Req-CTP-095	Self-Monitoring Log	The CTP shall perform self-monitoring and log each health check session and current status in an operational log file. Parameters will be defined in Phase 2.	
Req-CTP-096	Self-Monitoring Log Transmission	The CTP shall transmit operational log file to the PMD daily to generate operational performance measures.	
UN-S-SO-12	System Scalability	The system needs to be scalable geographically (additional regions) and demographically (more people using the system at the same time) in and around the project region. This would ensure that the system can operate and provide information to travelers as services and operational requirements continue to grow	

Req #	Req Title	Req Description	Related Need
Req-CTP-097	Processing Loads	The CTP shall be developed to support 120% of the load expected of services and users during the project duration.	
Req-CTP-098	Processing and Load Scalability	The CTP shall be architected to increase the number of processes over time as new users and processes utilize the system beyond the project duration.	
Req-CTP-099	Application and Feature Expansion	The CTP shall be architected to expand the functions, features and services provided to stakeholders and travelers beyond the project duration.	
UN-S-SO-13	Open Architecture & Interoperability	The system needs to have an open architecture and be interoperable with existing systems and services. This would ensure that new and legacy capabilities and services can be integrated with the proposed system	
Req-CS-045	Mobility Provider Booking API Specifications	CS Mobility providers shall specify APIs for use by the CTP to request service booking. Booking services, at a minimum, will include request service availability, book service, and cancel service for one or more travelers. The content of the APIs and orchestration of the API methods will be developed in collaboration during Phase 2 with appropriate CS mobility provider and CTP during Phase 2.	
Req-CS-045.1	SDS Booking API Specification	The SDS reservations operator shall provide API specifications for use by the CTP for booking services.	
Req-CS-045.2	HDS Booking API Specification	The HDS reservations provider shall provide API specifications for use by the CTP for booking services.	
Req-CS-045.3	PAL Booking API Specification	PAL DIRECT shall provide API specifications for use by the CTP to verify eligibility and booking services.	UN-E-TP-13

Req #	Req Title	Req Description	Related Need
Req-CS-046	Booking Status API	The CS Mobility Provider shall provide APIs for use by the CTP to publish information about reservations status. Status information, at a minimum, will include updates to pickup / dropoff times and locations, estimated time of arrival, delays, events/incidents, and other status information. The content of the APIs, orchestration, and operational performance (frequency, latency, and timeliness) of the API methods will be developed in collaboration with the Mobility Provider SDS SOC module and CTP during Phase 2.	
Req-CS-046.1	SDS Booking Status API	The CS SDS operator shall provide APIs for use by the CTP to publish information about reservations status.	
Req-CS-046.2	HDS Booking Status API	The CS HDS operator shall provide APIs for use by the CTP to publish information about reservations status.	
Req-CS-046.3	PAL Booking Status API	The PAL DIRECT developer shall provide APIs for use by the CTP to publish information about reservations status.	UN-E-TP-13
Req-CS-92	Open Architecture SDS System	The SDS system (vehicles and SOC) shall support an open architecture to enable integration of third party or after-market equipment and software modules to support passenger information and monitoring systems, vehicle tracking, scheduling, routing, and reservation systems.	
Req-CTP-100	Data Broker	The CTP shall support a service oriented architecture and include a data broker that extracts, transforms and loads open standard APIs including REST, JSON, GeoJSON, XML, csv formats.	
Req-INT-001	Interface specification	The system shall publish a schema, interface control, or conformance document for each interface ingested or used in the system. The published document should also include guidance on how to implement and access the interface.	

Req #	Req Title	Req Description	Related Need
Req-INT-002	BLE 5	The system shall conform to the Bluetooth Specification Version 5.0 or higher. See https://www.bluetooth.com/specifications/specs/	
Req-INT-003	NFC	The system shall conform to Tag NDEF Exchange Protocol (TNEP) Technical Specification 1.0 and related Near Field Communications protocols ISO/IEC 14443 and ISO/IEC 18000-3. See https://nfc-forum.org/our-work/specification-releases/specifications/nfc-forum-technical-specifications/ .	
Req-INT-004	GTFS	The system shall conform to General Transit Feed Specification (GTFS) including Flex and Pathways extensions. See https://developers.google.com/transit/gtfs	
Req-INT-005	GTFS real time	The system shall conform to the GTFS real time specification and encoding method. See https://developers.google.com/transit/gtfs-realtime/reference	
Req-INT-006	NTCIP 1201/1202 Actuated Signal Control Standards	The system shall use NTCIP 1201 Global Message Set and NTCIP 1202 Actuated Signal Control messages set for message exchanged between the Controller and th traffic signal system PED-X module.	
Req-INT-007	NTCIP 1211 Signal Control and Prioritization	The system shall use NTCIP 1211 Signal Control and Prioritization Message Sets standard including related request, status, cancel and clear messages between priority request generator, priority request service and controller actor.	
Req-INT-008	Open Trip Planner API	The system shall use the core Open Trip Planner APIs. See https://github.com/opentripplanner/OpenTripPlanner .	
Req-INT-009	Work Zone Data Exchange	The system shall use the Work Zone Data Exchange specification. The most recent version is available from https://github.com/usdot-jpo-ode/wzdx	

Req #	Req Title	Req Description	Related Need
Req-INT-010	Transcom Data Fusion Engine (DFE)	The system shall use the traffic management specification published by Transcom, which is a profile of the ITE Traffic Management Data Dictionary. See https://xcmtools.xcmdata.org/	
Req-INT-011	Reservation API Specifications	The Mobility provider shall document the API specifications for the booking and status APIs including schema, dictionary, and orchestration of API transactions between the reservation modules and third party user interface (e.g., CTP).	
Req-INT-011.1	SDS Reservation API Specification	The SDS Operator shall document the API specifications for the SDS (microtransit) booking and status APIs including schema, dictionary, and orchestration of API transactions between the reservation modules and third party user interface (e.g., CTP).	
Req-INT-011.2	HDS Reservation API Specification	The HDS Operator shall document the API specifications for the HDS (on-demand, door to door, carpooling) booking and status APIs including schema, dictionary, and orchestration of API transactions between the reservation modules and third party user interface (e.g., CTP).	
Req-INT-011.3	PAL DIRECT Reservation API Specification	PAL DIRECT shall document the API specifications for the PAL spontaneous and regular eligibility verification, booking and status APIs including schema, dictionary, and orchestration of API transactions between the reservation modules and third party user interface (e.g., CTP).	
Req-INT-013	Internal APIs	The system shall specify internal APIs and data exchange formats using open interface formats such as REST, JSON, GeoJSON, XML, csv formats.	
Req-Sy-002	Web and mobile user interface accessibility	The system shall comply with Web Compliance Accessibility Guidance (WCAG) 2.1 for all digital information presentation including mobile and web browsers.	

Req #	Req Title	Req Description	Related Need
Req-Sy-029	Agile Stakeholder Engagement	The Agile Development process shall define a process to assign end-users to a stakeholder review board (SRB) which will review user stories and drive priority development.	
Req-Sy-030	Agile Backlog	The Agile Development process shall document how software developers will develop, publish and schedule epics and user stories that will be used as part of their Agile process in collaboration with the SRB.	
Req-Sy-031	Agile Sprint Tracking	The Agile Development process shall define how software developers will provide access for the SRB to view sprint assignments and performance statistics including but not limited to sprint schedules, progress, and bug tracking.	
UN-S-SO-14	Safety of Services	The system needs to improve safety for both the users of the travel and information services (like the transit and shuttle options) not only for the users but also for the non-users of the system (other pedestrian, vulnerable road users that are using the same facilities as the system users). Overall safety improvements especially in the BNMC region create more support for the system as well as increase the amount of non-single occupancy vehicle travel	
Req-CS-001	Manual and Autonomous Driving	The SDS shall allow for both manual and autonomous driving.	
Req-CS-002	Motor Technology	The SDS shall be powered by either electric motor(s), an Internal Combustion Engine (ICE) or a hybrid engine. If electric, the SDS battery shall allow the SDS to operate for between 4 - 6 hours on a single charge. Accepted charge rate should be in excess of 6 kwh.	
Req-CS-003	HVAC System	The SDS shall be equipped with an HVAC system, providing for adequate cooling and heating consistent with passenger comfort in the Buffalo environment, while ensuring that an electric SDS could operate between 4 - 6 hours before needing to be recharged.	UN-S-SO-9

Req #	Req Title	Req Description	Related Need
Req-CS-004	SDS Capacity	The SDS shall have a capacity for transporting 4 or more passengers, plus a safety steward.	
Req-CS-005	Manual Control	The SDS shall have an interface for manual control by the steward to perform manual steering, speed control for accelerating and decelerating and emergency braking.	UN-S-SO-9
Req-CS-007	Automatic Doors	The SDS shall be equipped with doors that open and close automatically, and manually if needed.	
Req-CS-007.1	Automatic Doors - Open	The SDS shall be equipped with doors that open automatically, via a sensor or a button, upon the arrival of the SDS at a pick-up/drop-off location and after its coming to a full stop.	
Req-CS-007.2	Automatic Doors - Close	The SDS shall be equipped with doors that close automatically after travelers have gotten off or on the SDS and the SDS is ready to depart from the pick-up/drop-off location.	
Req-CS-007.3	Automatic Doors - Malfunction	In cases of malfunctions of the automatic door, the SDS shall allow for manual opening and closing by the human steward as a backup.	
Req-CS-010	Seat Belts	The SDS shall have seat belts for every passenger seat.	
Req-CS-011	Hand-holds	The SDS shall include hand-holds for passengers boarding, alighting, and sitting in the vehicle.	
Req-CS-013	Multiple Redundant	The SDS shall operate multiple and redundant network connections (radios) between the SDS and SOC.	

Req #	Req Title	Req Description	Related Need
	Communication Radios		
Req-CS-014	Multiple and Redundant Sensor Systems for Perception and Localization	The SDS shall be equipped with multiple and redundant sensor systems for perception, and localization.	
Req-CS-014.1	LIDAR Sensor	The SDS shall be equipped with at least one LIDAR sensor.	
Req-CS-014.2	RADAR Sensor	The SDS shall be equipped with at least one RADAR sensor.	
Req-CS-014.3	Camera-Centric Computer Vision	The SDS shall be equipped with a camera-centric computer vision system.	
Req-CS-014.4	Inertial Measurement Unit	The SDS shall be equipped with an inertial measurement unit.	
Req-CS-014.5	Localization	For localization, the SDS shall use GPS (with Real-time Kinematic (RTK) positioning for correction), along with a 3D high-definition map.	
Req-CS-015	Passenger Communication Equipment	The SDS shall be equipped with communications channels to communicate with passengers as they board, alight or travel on the SDS. The equipment consist of factory installed, after-market or a combination set of devices.	

Req #	Req Title	Req Description	Related Need
Req-CS-016	Accessible Emergency Button	The SDS shall be equipped with an accessible emergency (panic) button for use by shuttle safety steward and/or passengers during emergencies onboard the shuttle. The accessible button should be within the reach of passengers, well-labelled, and easily identifiable.	
Req-CS-016.1	Emergency stop button misuse	The SDS shall have a warning sign describing proper instructions about when and how to use the emergency button which should be posted near the button. The information on the sign will be published in several languages, including braille, and will be stakeholder driven during the Agile Development Process.	
Req-CS-017	Onboard Persistent Storage	The SDS shall be equipped with sufficient persistent storage capability to record operational and sensor data via an onboard data recorder for at least 24 hours of continuous operations. The data will come from the LiDAR, camera and other sensors and collect passenger and engine information.	
Req-CS-020	Alert Steward of Degraded Communications	The SDS shall provide an alert to the safety steward if the connectivity between the SDS and the support infrastructure (e.g., SOC, RTK station) is operating in less than "normal" mode.	
Req-CS-022	Incident Management due to Degraded Health	Upon degraded health, the SDS shall trigger an alert to actuate an incident management event such as alerting human steward to take over, stopping and transitioning from autonomous to manual driving mode. The emergency events and incident management actions for the SDS will be planned and configured during Phase 2.	
Req-CS-024	Detect, classify, measure and Interpret Objects	The SDS perception module shall detect, classify, measure objects and vehicle motion, and interpret surrounding environment across 360 degrees, based on input from multiple and redundant sensors as listed in Req CS-014. This shall take place in such a manner to allow the SDS sufficient time to take appropriate action as described in Req-CS-026.	

Req #	Req Title	Req Description	Related Need
Req-CS-024.1	Detect Vehicles	The SDS shall detect oncoming and stationary vehicles at a specified distance (relative to their speed) to allow the SDS to take appropriate actions to ensure safe and efficient operations.	
Req-CS-024.2	Detect Pedestrians	The SDS shall detect pedestrians standing and crossing an intersection. Detection will be based on detecting the pedestrian at a specified distance (relative to their speed) to allow the vehicle to take appropriate actions regarding moving pedestrians.	
Req-CS-024.3	Classify Objects	The SDS shall be able to classify and interpret detected objects, including the ability to distinguish between static objects to the side of the road (e.g., snow banks) and pedestrians.	
Req-CS-025	Motion Planning Algorithm	The SDS motion planning algorithm shall model trajectories for every object through time and space so that the SDS has a dynamic picture of its environment.	
Req-CS-026	Operations in Mixed traffic	The SDS shall be able to operate in mixed traffic, within the SDS Operational Design Domain (ODD), alongside other dynamic road users (e.g., moving vehicles, bicyclists, pedestrians, and other vulnerable road users - VRUs).	
Req-CS-026.1	ODD Rule Set Compliance	The SDS shall operate according to the driving and environmental conditions specified in the Operational Design Domain (ODD) for the SDS. These include, but are not limited to, the set of road segments, unsignalized and signalized intersections making up the pre-defined fixed route along which the SDS will be deployed as part of the Buffalo ITS4US deployed project. The ODD rule set will be configured during Phase 2.	
Req-CS-026.2	Operational Specifications	The SDS shall comply with operating specifications to ensure the comfort of passengers and compliance with rules of the road. These include, but are not limited to, turn dynamics, appropriate car following, collision avoidance, stopping and pulling over in the presence of an emergency vehicle, stopping at the designated pick-up and drop-off locations, emergency stopping, and acceleration/deceleration profiles shall be within	

Req #	Req Title	Req Description	Related Need
		comfortable and safe ranges. The operational specifications will be configured during Phase 2.	
Req-CS-026.3	Driving During Inclement Weather	The SDS shall operate during mild inclement weather conditions including but not limited to rain, wet surfaces, and mild snow events. The list of conditions that are safe to travel will be defined during Phase 2.	UN-E-TE-13
Req-CS-026.4	Avoid Conflicts with Other Vehicles	The SDS shall be able to avoid conflicts with other moving or stationary vehicles, by stopping, slowing down, and/or following the appropriate right-of-way rules of traffic law.	
Req-CS-026.5	Avoid Conflicts with Pedestrians'	The SDS shall be able to avoid conflicts with pedestrians by stopping, slowing down, and appropriately yielding the right of way to pedestrians.	
Req-CS-026.6	Avoid Fixed Objects	The SDS shall be able to navigate around fixed objects requiring avoidance, including different objects above, below, to the side, and ahead of the vehicle. The requirement is dependent on the sensor systems detecting fixed and moving objects (see Req-CS-024). Fixed objects includes temporary objects such as snowbanks.	
Req-CS-026.7	Avoid Moving Objects	The SDS shall be able to navigate around moving objects requiring avoidance, including different objects above, below, to the side, and ahead of the vehicle. The requirement is dependent on the sensor systems detecting fixed and moving objects (see Req-CS-024). Moving objects includes animals, bouncing balls, boxes falling out of a moving vehicle, debris, and other items.	
Req-CS-026.8	Navigate with Minimum Clearance	The SDS shall be able to navigate in right of ways with minimum clearance including next to chain link fence, driveways, and other objects in close proximity. Proper clearance values will be determined in Phase 2.	

Req #	Req Title	Req Description	Related Need
Req-CS-053	Monitor Passenger Safety	The SDS shall send information on the status of the passengers during an emergency to the SOC, to allow the SOC operators to remotely monitor the situation.	
Req-CS-060	Low Speed Shuttle	The SDS speed shall not exceed 25 mph while in autonomous mode.	
Req-CS-061	Pick-up/Drop Off Location Announcement	Upon leaving from a pick-up/drop-off location, the SDS shall make an announcement stating that it is leaving that stop, and shall also announce the next stop it is scheduled to stop at.	
Req-CS-064	No return trip booking available	The CS shall have a designated safety shuttle service to pick-up stranded travelers, when the shuttle does not have the right equipment to meet passenger needs (e.g., wheelchair securement), or the shuttle is overbooked. Details of the operational procedures will be developed during Phases 2 and 3.	
Req-CS-069	Delay or missed stop caused by re-route (SDS)	The SDS shall inform a traveler of delayed or missed stops caused by rerouting. The details of the messages, timing, and traveler alternative preferences will be driven by stakeholder input during the Agile Development Process.	
Req-CS-070	V2X connection lost	The SDS shall revert to manual driving mode when it detects lost or degraded connectivity, and the human steward acknowledges that he/she is able to take control.	
Req-CS-91	External/Internal Monitoring	The SDS shall be equipped with video or CCTV for both external and internal monitoring.	UN-S-SO-9
Req-CTP-061	Trip Notification of Trip Anomalies	The CTP shall trigger real time notifications when a trip plan is affected by traveler behavior or connection delays. These include, but are not limited to: a) when traveler travels beyond their alighting / drop off location (for NFTA or CS SDS). b) when a traveler alights a NFTA/CS SDS vehicle earlier than their transition drop off location.	

Req #	Req Title	Req Description	Related Need
		c) when a traveler will miss their connection due to early / late arrival of a NFTA or CS SDS reservation.	
Req-CTP-123	Contradictory preferences	The CTP shall check for conflicts among the traveler’s input preferences, when planning a trip, and notify the traveler of any identified conflicts.	
Req-CTP-124	Preference / notification selection mismatch with end traveler's device	The CTP shall check the compatibility of the traveler’s device with the traveler’s preferences and inform traveler of any mismatches. The mismatches will be defined when the communication channels, user interface methods, assistive devices and notifications are aligned during the Agile development process.	
Req-CTP-125	Trip plan alternatives	The CTP shall inform the traveler of possible, alternate itineraries in case the CTP cannot generate a trip plan.	
Req-CTP-126	Reservations process	The CTP developer shall establish the process for booking a trip on the Community Shuttle. The process shall be driven by stakeholder input during the Agile development process and ensure that all selections, origins, destinations, and other accommodations are confirmed by the traveler at the time of booking and prior to the trip initiation.	
Req-CTP-127	No-show vehicles	The CTP shall provide an emergency call number that a traveler can use to notify the system in case their shuttle does not show up.	
Req-CTP-128	Traveler mobile device not linking with indoor/outdoor Smart Signs	The CTP shall notify travelers of any connection error within one minute of detection.	

Req #	Req Title	Req Description	Related Need
UN-S-SO-15	Location Accuracy	The system needs to accurately track or geofence travelers using the turn-by-turn directions and notifications (when they opt-in) whether they are traveling indoors or outdoors and even when the system is offline. This accuracy is necessary to ensure that travelers are correctly located in the system and appropriate information is shared based on their preferences. Specific accuracy requirements will be developed in the design stage and build of the safety management plan.	
Req-CTP-101	Tune location settings	The CTP shall provide instructions to travelers that describe how to configure and calibrate their location sensors to achieve the most accurate location and positioning performance from their mobile app.	
UN-S-SO-16	Accuracy of Information Services	The system needs to ensure that information provided by the systems especially around wayfinding and intersection movement assistance do not create safety risks for the users due to reduced latency or misbehavior of information in the system. Specific accuracy requirements will be developed in the design stage and build of the safety management plan.	
Req-CS-90	3D Map Updates	The SDS design shall have the capability to update the 3D High-definition map on a regular basis to account for any changes in the driving environment (e.g., changing road and roadside conditions). Updates will occur as needed or on a frequent basis (to be specified during Phase 2)	
Req-CTP-102	Test for accuracy	The CTP shall test wayfinding and intersection movement to ensure positional and orientation accuracy is safe for all traveler use. The accuracy needed to ensure safe wayfinding and intersection movement differs by traveler ability, for example, a person with a visual disability requires greater positional precision to avoid stepping into an intersection. Testing will consider traveler's abilities and preferences when verifying safety.	

Req #	Req Title	Req Description	Related Need
UN-S-SO-17	Disruptions to the System	When due to external factors, the system services cannot operate, the system needs to have a failure mode of operations that does not degrade safety of the traveling public. The failure mode of operations will vary based on the sub-systems	
Req-CS-028	Emergency Stop Actions	When performing an emergency stop in autonomous mode, the SDS shall automatically activate the emergency/hazard lights, move the vehicle as far from the travel lanes as possible, and alert emergency services.	
Req-CTP-103	CTP Operational Modes	The CTP shall operate in accordance to the operational modes detailed in Section 2.2.	
Req-CTP-115	Alert Lack of communications with SDS Passenger Information Systems	The CTP mobile app shall alert the traveler onboard an SDS within one minute of detecting that local communications (e.g., Bluetooth) has degraded or failed.	
UN-S-BO-1	System Operation Costs	The system needs to provide services that have operational cost comparable to or lower than existing modes. This ensures financial sustainability from the institutional perspective.	
Req-Sy-038	Operational Cost	The system operators shall collect information on operational costs on an annual basis.	
UN-S-BO-4	Shared Use	The system needs to provide as much shared use of services as possible and not function like an extended taxi service. This is important for BNMC partners and system owners that system is seen as supportive of shared transit and not viewed	

Req #	Req Title	Req Description	Related Need
		as a premium ridehailing service that would create difficulties in long-term sustainability	
Req-CS-079	CS Service Scalability - Multiple passenger routing	The CS shall generate route plans for multiple passenger trip origins and destinations using the most direct routing for the passengers booked on the vehicle to meet on-demand bookings.	UN-S-BO-3
Req-CS-079.1	SDS Multiple Passenger routing	The SDS SOC shall generate route plans for multiple passenger trip origins and destinations using the most direct routing for the passengers booked on the vehicle to meet on-demand bookings.	UN-S-BO-3
Req-CS-079.2	HDS Multiple Passenger routing	The HDS Dispatcher shall generate route plans for multiple passenger trip origins and destinations using the most direct routing for the passengers booked on the vehicle to meet on-demand bookings.	UN-S-BO-3
UN-S-BO-5	Filling Transit Gaps	The system needs to act as a first mile and last-mile (FMLM) service to increase the use of existing fixed route services including bus routes and light rail on the campus.	
Req-Sy-011	Geographic Coverage	The System shall provide on-demand and microtransit service (HSD and SDS) in the geographic area covered by the project.	
UN-S-BO-6	Operations Reports	The system needs to report current operating conditions of the complete trip elements. This information is important to have full integration with their ongoing engagement with commuters and visitors to BNMC. This information may also feed in other traveler services that exist in the region	

Req #	Req Title	Req Description	Related Need
Req-CS-080	Monitor CS travel anomalies	The CS operator dispatcher shall monitor, either manually through operator alerts or through electronic data analysis, anomalies in the travel speed and stops to identify operating conditions that impact vehicle travel. This information will be communicated to other entities that monitor the situational awareness of the road network.	
Req-CS-080.1	Monitor SDS travel anomalies	The SDS operator dispatcher shall monitor, either manually through operator alerts or through electronic data analysis, anomalies in the travel speed and stops to identify operating conditions that impact vehicle travel including but not limited to inclement weather. This information will be communicated to other entities that monitor the situational awareness of the road network.	UN-E-TE-13
Req-CS-080.2	Monitor HDS travel anomalies	The HSD dispatcher shall monitor, either manually through operator alerts or through electronic data analysis, anomalies in the travel speed and stops to identify operating conditions that impact vehicle travel. This information will be communicated to other entities that monitor the situational awareness of the road network.	
Req-CTP-104	CTP publish operational alerts	The CTP shall publish system notifications on the web application (e.g., scrolling announcements) and mobile app, or via the Call Center IVR. Alerts and notifications shall include but are not limited to CS operational status, NFTA operational status, elevator/escalator outages and more.	
Req-CTP-104.1	CTP publish operational alert timing	The CTP shall publish system notifications on its various channels (see parent requirement) within 1 minute of their receipt from external sources and maintain the message until receipt of an all clear, expiration time, or manual intervention.	
Req-CTP-105	System operational alert tool	The CTP shall provide authorized third parties the ability to manually or automatically insert an operational alert that will be available to travelers through the CTP user interfaces.	

Req #	Req Title	Req Description	Related Need
Req-CTP-132	Monitor for Mobility Provider connectivity	The CTP mobile app shall monitor the connection between a connected mobility provider vehicle and CTP mobile app.	
Req-Sy-032	Mode of Operation -- Normal	The system and subsystems shall operate in normal mode of operation as described in Section 2.2. During normal operations all interfaces and subsystems are operating normally.	
Req-Sy-033	Mode of Operation -- Degraded	The system and subsystems shall alert related subsystems when they are operating in degraded mode as described in Section 2.2.	
Req-Sy-034	Mode of Operation -- Failure	The system and subsystems shall transition to failure operational mode when or another subsystem detects that it is failing. As described by Section 2.2, Failure mode operates as a mission critical impact. Information provision, communications and services between systems will be manually implemented. If no backup or redundant service is available, the operations will be suspended temporarily.	
UN-S-BO-7	Marketing Guidelines	The system needs to have clear marketing guidelines (e.g., ready-made templates, branding and program information) that can be used for outreach and recruitment. This is necessary to support recruitment and adoption of complete trip elements by underserved populations.	
Req-CTP-106	CTP Marketing Design Guidance	The CTP shall generate a template for quick deployment of web page that follows marketing design guidance. The guidance approach will be specified in the project Outreach Plan (Reference # TBD).	
Req-SI-014	Smart Sign branding	The smart sign shall comply with marketing guidance established in the Outreach Plan (reference # TBD) so that it is easily recognizable as a Buffalo ITS4US project component.	

Req #	Req Title	Req Description	Related Need
UN-S-BO-8	Operations Compliance	The system needs to ensure that operation of its components complies with agreed upon regulations, laws, and restrictions. This ensures that the system does not operate in violation of any private property, local, or state regulations	
Req-CS-024.4	Driving Rule Compliance	The SDS shall recognize and follow the driving rules associated with the Manual on Uniform Traffic Control Devices (NYSDOT version) for traffic signals, phases, signs, and other traffic control devices.	
Req-CS-044	SDS Operational Design Domain (ODD)	The SDS SOC shall describe the SDS Operational Design Domain (ODD) rule set that designates and controls where the SDS can operate in autonomous mode.	
Req-CS-058	Driving Rules / MUTCD	The SDS shall obey driving rules associated with the Manual on Uniform Traffic Control Devices (NYSDOT version) traffic signals, phases, signs, and other traffic control devices.	
Req-CS-059	Authorization to Operate	The SDS shall be authorized to operate in public roads in New York State. Authorization may be based on rules, and policy set by NYS and in accordance with federal standards such as Federal Motor Vehicle Safety Standards (FMVSS). Note that exemptions may be required and received for authorization based on the design of the SDS. For example, a possible exception is that some vendor solutions may employ a joystick while in manual mode for steering, speed controls, and braking.	
UN-S-BO-10	System Maintenance	The system needs to conform to and maintain a maintenance plan that details the procedures and frequency of maintenance of all of the system's components.	
Req-CS-081	CS Operations and	The CS operator shall develop a vehicle operations and maintenance plan that details the elements related to the Buffalo ITS4US project.	

Req #	Req Title	Req Description	Related Need
	Maintenance Plan		
Req-CS-081.1	SDS Operational and Maintenance Plan	The SDS operator shall develop a vehicle operations and maintenance plan that details the elements related to the Buffalo ITS4US project.	
Req-CS-081.2	HDS Operational and Maintenance Plan	The HDS operator shall develop a HDS vehicle operations and maintenance plan that details the elements related to the Buffalo ITS4US project.	
Req-CTP-107	CTP Maintenance levels	The CTP shall document the operations and maintenance procedures needed to sustain the subsystem. The procedures will include but are not limited to security audits, software patches and updates to the back office and mobile apps, upgrades to software as infrastructure software changes, and change management process.	
Req-Sy-015	Operations and Maintenance Plan	The system shall comply with an operations and maintenance (O&M) plan that covers all subsystem operations and maintenance, including but not limited to staffing, hours of operations, operations and maintenance levels, processes for software security and patch updates, preventive maintenance schedules and procedures, system level service level agreements (SLA), and modes of operations. The O&M plan will be developed in Phases 2-3.	
Req-Sy-016	Software Change Bulletin	The System shall publish an announcement when software patches, updates or upgrades are planned. The software change bulletin should highlight any changes to data items (schema or semantics), interfaces, or operating systems. The software change process will be part of the change management process (to be included in the Phase 3 Project Management Plan).	

Req #	Req Title	Req Description	Related Need
Req-Sy-027	SDS and SOC Technology Review	The System Developers shall review and update the technology of the SDS and SOC on an annual basis to ensure that sensors and components continue to meet safety regulations.	
Req-Sy-028	Mobile App Upgrade	The System Developers shall assess and determine major upgrades to the CTP mobile app based on changing mobile technology.	
UN-S-BO-11	Construction Coordination	The system needs to monitor and collect information on the dates and times of construction projects that affect the streetscape, cross-sections, sidewalks and intersections in the corridor. This is necessary to ensure that the system is able to generate appropriate paths are feasible for travel as well as support any adjustments to other services.	
Req-CTP-108	Ingest Work Zone Event data	The CTP shall collect, quality check, and process planned and unplanned work zone event information (location, impact, timing) and integrate impedance factors into the routing engine, trip planning and execution notifications information including construction that impacts streetscape, cross-sections, sidewalks and intersections in a trip plan. The frequency of the update depends on the availability of the data feed and will be determined in Phase 2.	
UN-S-BO-12	Emergency Report	The system needs to notify emergency and law enforcement personnel in case of an emergency on-board the vehicles in the system	
Req-CS-052	CS Notify EMS	Upon the occurrence of an incident, the CS mobility operator (HSD or SDS) shall notify appropriate emergency management and incident response personnel.	
Req-CS-052.1	CS SDS Notify EMS	Upon the occurrence of an incident, the SDS mobility operator shall notify appropriate emergency management and incident response personnel.	

Req #	Req Title	Req Description	Related Need
Req-CS-052.2	CS HDS Notify EMS	Upon the occurrence of an incident, the HSD mobility operator shall notify appropriate emergency management and incident response personnel.	
UN-S-BO-13	Law Enforcement Interaction Plan	The system needs to conform to and maintain a law enforcement interaction plan that describes how and who should be engaged around aspects of system operations. This ensures that law enforcement understands how to interact with different type of travelers in the event of a crisis, as well as to minimize justice interactions and avoid penalizations, especially of users.	
Req-CS-050	Monitoring SDS Environment	The SDS SOC shall monitor the driving environment (e.g., road characteristics and driving dynamics) to ensure that it conforms to the elements of the SDS Operational Design Domain (ODD) to operate in autonomous mode.	
Req-CS-051	Incident Management using Law Enforcement Interaction Plan	The SDS SOC shall ingest, process and evaluate information about incidents along the path of the SDS, or incidents involving the SDS itself, and manage the incident based on detailed procedures developed in the Law Enforcement Interaction Plan .	

Appendix B. Need and Requirement Change Management

User needs and systems requirements may be subject to change based on a number of factors—e.g., changing user needs and priorities, technical readiness, and emerging technical and system level solutions. Changes to the user needs and requirements are guided by the configuration management process described in the Phase 1 User Needs Identification and Requirements Planning (FHWA-JPO-21-855). Any major change to a user need or requirement will include an evaluation and approval by the key stakeholder group(s) most affected by the change. Changes to needs and requirements will be controlled to minimize changes to the project.

As the ITS4US project progresses from Phase 1 to Phases 2 and 3, any impact to the user needs and requirements will be documented and redlined throughout the process. Any change that rises above a simple editorial change will be brought to the attention of a proper stakeholders. Consensus will be documented along with the justification for the change. Reviewed and approved changes will be documented in Table 39

Table 39. Confirmed Changes to Needs and Requirements.

Date	Related Need / Reqt	Proposed Change	Justification
Jan 31, 2022	UN-S-BO-9. Hygiene Protocol: The system needs to conform to and maintain a hygiene protocol that takes into consideration allergies of travelers (e.g., to dogs) and presence of germs, and that details the procedure and frequency of disinfection of the different components of the system. This important to build a safe and clean environment for travelers.	Deprecate Need	As discussed with NFTA, the priority during the height of Covid when the need was proposed, was to ensure that transit buses were perceived as safe for travelers. Since that time, actions have been undertaken by the agency to put these practices in place. As such this need is no longer a priority for the ITS4US project and should be deprecated. Furthermore, general hygiene of shuttles and other equipment fall within each entity’s hygiene protocols. NFTA agrees with this change.

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