

Phase 2 System Requirements Specification (SyRS)

Buffalo, NY ITS4US Deployment Project

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16. Abstract The Buffalo NY ITS4US Deployment Project seeks to improve mobility to, from, and within the Buffalo Niagara Medical Campus by deploying new and advanced technologies with a focus on addressing existing mobility and accessibility challenges. Examples of the technologies to be deployed are electric and self-driving shuttles, a trip planning app that is customized for accessible travel, intersections that use tactile and mobile technologies to enable travelers with disabilities 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). This document is the System Requirements Specification, which identifies the requirements for the system's components to be developed or procured through this pilot.					
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1. Introduction

The Buffalo, New York 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 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 (Allentown, Fruit Belt and Masten Park) with underserved populations (low income, people with disabilities including vision, hearing, mobility challenges and older adults).

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.

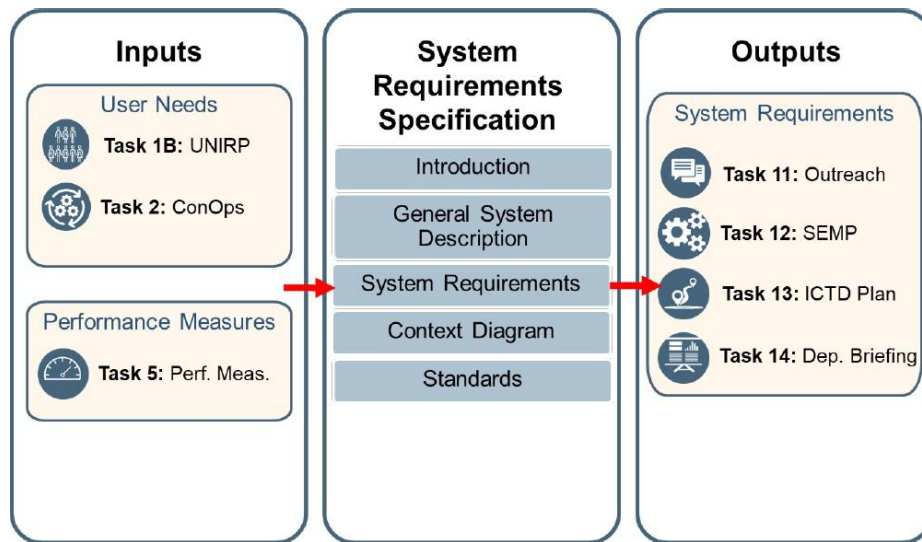


Figure 1. Inputs and outputs of the System Requirements Specification.

Source: FHWA

1.2. Background

Buffalo is moving toward a sustainable future at all levels of society, incorporating actions in the community, government, and private entities in the area. Providing access to the City’s underserved populations to jobs and healthcare is the primary motivation for all the regional partners involved in this deployment. A lack of public transportation that adequately addresses “first/last mile” challenges is a major problem for community mobility, especially for people with disabilities. This often leads to compromised healthcare (e.g., rescheduled or missed appointments, delayed care) and/or dependence on paratransit service, which is much costlier for transit agencies and can be burdensome for riders. The Complete Trip Deployment concept proposed here directly addresses these concerns by:

1. **Focusing on providing transit access to healthcare and jobs** to underserved residents or persons and allowing them to share in the economic development in downtown Buffalo.
2. **Putting technology to work in support of accessible transportation**, bringing leading edge researchers in accessible transportation, transit, and connected automation to solve a transportation need.
3. **By developing a scalable model** for considering accessibility and universal design in transportation technology projects

The deployment location is targeted around the downtown Buffalo area with a focus on travel to and from the Buffalo Niagara Medical Campus (BNMC). The deployment 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—see Figure 2.

More than 16,000 people work or study at the BNMC and more than 1.5 million visit each year for health care and other services, generating significant transportation demand for the area, its visitors, and its employees. The demographics of the surrounding neighborhoods (see Table 1) are emblematic of a broader socioeconomic and racial divide in Buffalo along Main Street, which this deployment seeks to bridge. In Allentown (west of Main Street), the percentage of traditionally underserved populations is significantly less than other neighborhood east of Main Street, namely Fruit Belt and Masten Park. Table 1 indicates percentages for Allentown that are far below average of the Metropolitan Statistical Area (MSA) in many categories, and percentages for Fruit Belt and Masten Park that are above average for the MSA.

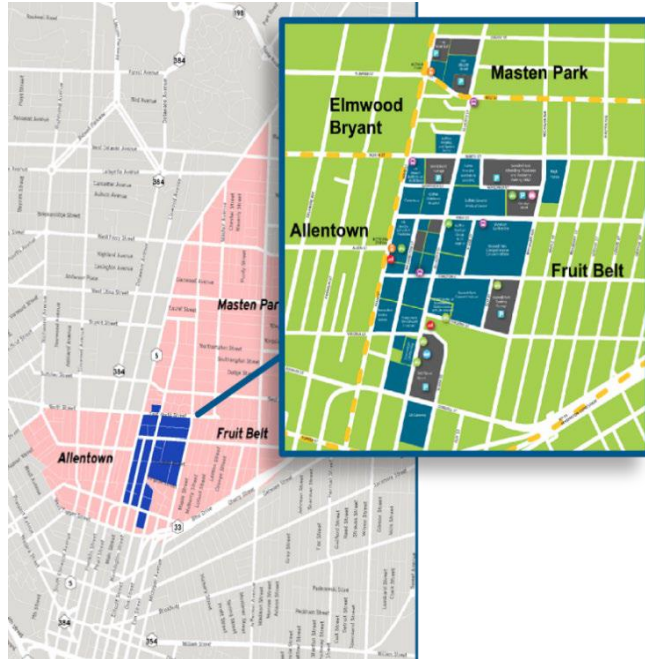


Figure 2. Buffalo Niagara Medical Campus relative to the neighborhoods of focus: Allentown, the Fruit Belt, and Masten Park.

Source: Buffalo, NY ITS4US

While the Allentown neighborhood is not characterized by underserved populations, it contains a high concentration of transit service and commercial activity, including health care offices. Allentown hosts several significant bus lines (including the #20-Elmwood, the #25-Delaware, the #11-Colvin, and the #8-Main) that connect the BNMC and Downtown Buffalo with neighborhoods to the north, carrying over 10,500 riders on an average weekday.

Table 1. Demographics of Targeted Neighborhoods

Geography (ACS 2018 tracts)	Percent 0- vehicle households	Percent population 65+	Percent poverty	Percent Black	Percent Hispanic / Latino	Percent limited English ability	Percent income <\$25k	Percent with a disability (18 to 65 yrs. old)	Percent veteran	Percent commute by transit	Total households	Total population
Fruit Belt	47.0%	21.9%	28.0%	77.0%	8.9%	4.2%	39.5%	20.0%	6.7%	16.1%	976	2,435
Allentown	18.4%	6.2%	28.8%	7.2%	6.6%	0.0%	17.4%	8.0%	7.8%	4.8%	1978	3,143
Masten Park	35.0%	18.5%	34.7%	89.7%	3.1%	2.9%	38.9%	15.2%	6.6%	11.7%	1496	3,208
Buffalo MSA	36.6%	12.0%	31.1%	36.6%	11.6%	4.8%	30.7%	9.7%	5.7%	11.5%	11,0701	255,423

BNMC sits adjacent to the Fruit Belt neighborhood, which has a poverty rate of 28%, and 47% zero-car households. Several community and social services are found within the neighborhood, which is relatively close to the wider array of services and jobs offered in downtown Buffalo. Several bus lines serve the area, although headways are relatively infrequent, ranging between ½ hour and one hour. Access to dispersed jobs in the suburbs via public transportation tends to be difficult. Although accessible to the Fruit Belt residents, the Niagara Frontier Transportation Authority (NFTA) Metro Rail station is 0.25 – 0.75 miles away, a distance that becomes amplified during the winter and for travelers with physical difficulties. While BNMC continues to improve

pedestrian accessibility, sidewalk quality and intersection crossings still are a challenge for wheelchair users and users with audible or visual impairments. The Fruit Belt struggles with aging infrastructure and infrastructure management issues, issues that have been consistently noted in community forums over the years.

This project seeks to improve transportation access for this population and utilize an innovative approach to find the most effective approaches for supporting trip-making. BNMC's user population make it an ideal location to test accessibility designs for safety and usability. The Complete Trip Deployment in Buffalo focuses on two primary trip purposes: employee-related travel and patient/visitor travel to the campus from the three neighborhoods.

1.3. Project Scope

The project seeks to deploy an integrated suite of technologies chosen to address identified needs of users and gaps within the systems and services provided. These technologies include a Complete Trip Platform (CTP), Community Shuttle, Smart Infrastructure and Performance Measure Dashboard (PMD). Figure 3 provides an overview of each of these components.

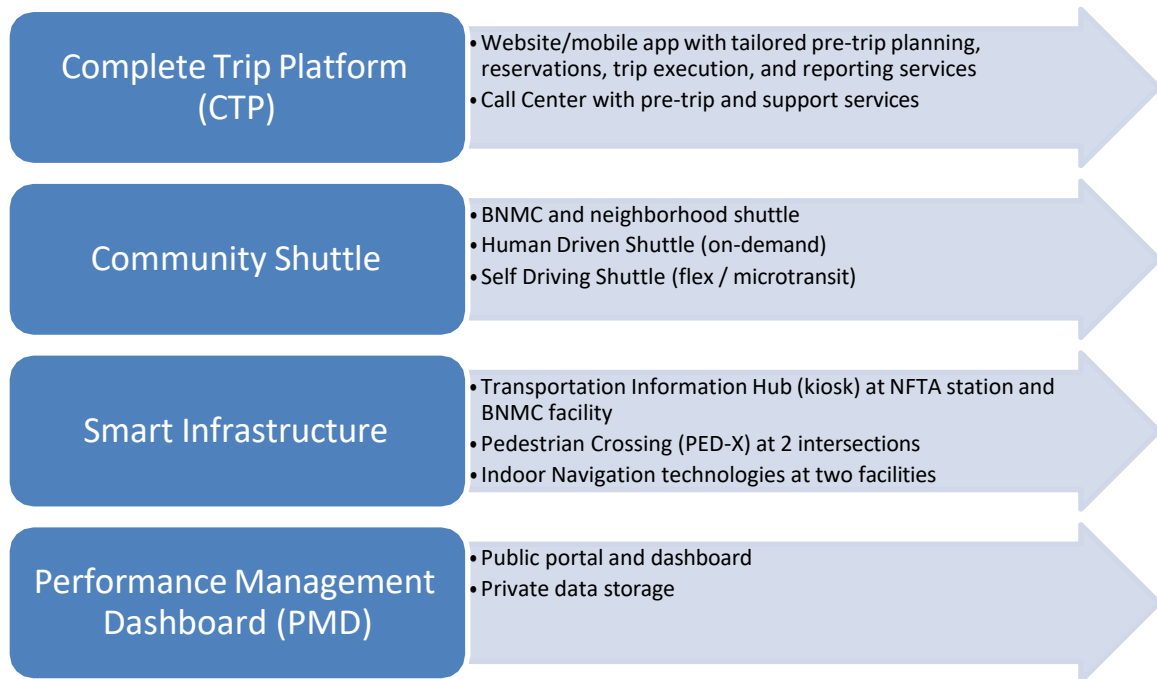


Figure 3. Components of the Buffalo, NY ITS4US System

Source: Buffalo, NY ITS4US

1.4. 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 2 Performance Measurement and Evaluation Support Plan (PMESP) – Buffalo NY ITS4US Deployment Project (FHWA-JPO-21-878).
- Phase 2 System Architecture Document (SAD) - Buffalo NY ITS4US Deployment Project (FHWA-JPO-22-981).

1.5. Acronyms

Table 2 lists the acronyms used in the document.

Table 2. 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

Acronym	Description
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

1.6. 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 made to user needs and requirements.
- Appendix C provides a list of changes made as an update to the current version of the SyRS document from phase 1 to phase 2, including justification for the changes made.

2. System Description

2.1. System of Interest

This section provides a high-level description of the four subsystems of the Buffalo, NY ITS4US system. The following SOI diagrams are updated versions of the Context Diagrams. The diagrams are updated from the previous version of the Phase 1 Concept of Operations (ConOps) (FHWA-JPO-21-860) and Phase 1 System Requirements Specification (SyRS) (FHWA-JPO-21-883) and are consistent with the as-built System Architecture diagram described in the System Architecture Document (SAD).

The high-level context diagram which includes the four subsystems (Smart Infrastructure, CTP, CS, and PMD) is shown in Figure 4. Additional details on the interfaces within and between subsystems are described in the SAD.

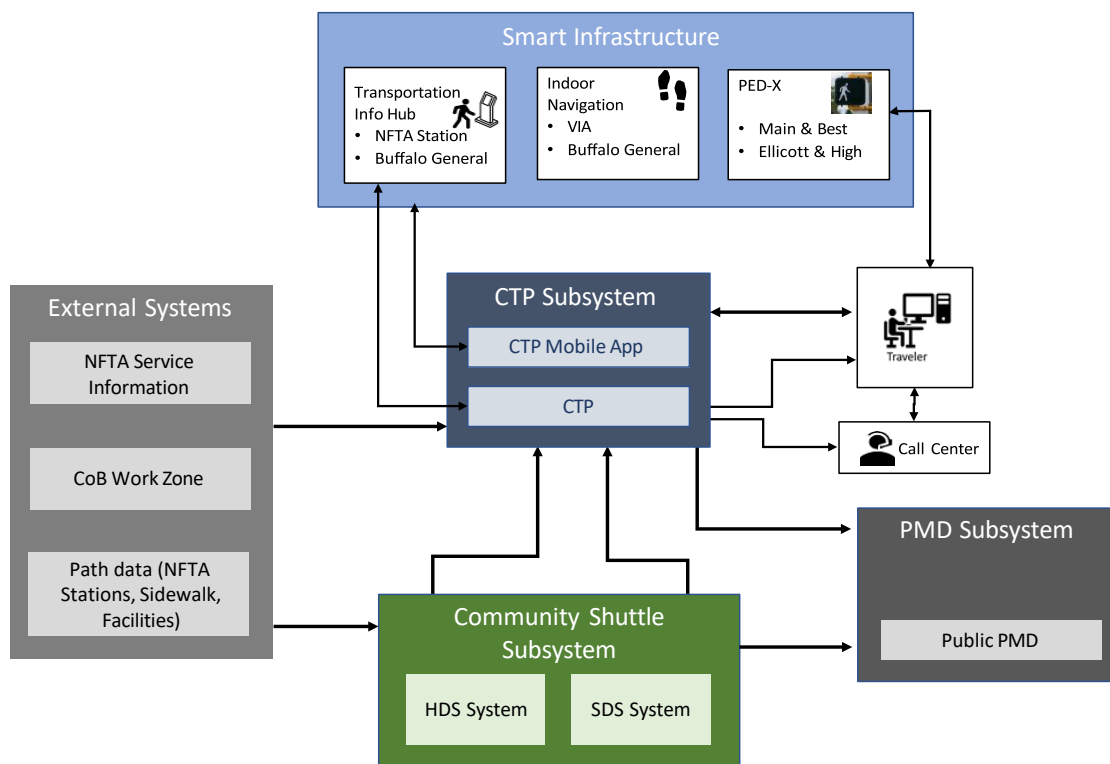


Figure 4. Buffalo Deployment Project Context Diagram

Source: Buffalo, NY ITS4US

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 (e.g., book a trip reservation, check estimated time of arrival) with other mobility partners for which they have accounts (e.g., NFTA paratransit and micro transit shuttle), personalize their trip preferences and customize hands-off turn-by-turn notifications, and access wayfinding assets using components specified in the smart infrastructure subsystem. Non-registered travelers will be able to use the trip planning and travel tools to view accessible paths, transit services and alerts about asset status (e.g., elevator / escalator operations).

2.1.2. Community Shuttle Subsystem

The Community Shuttle (CS) subsystem will provide on-demand mobility services within the Fruit Belt, Masten Park and Allentown neighborhoods and BNMC. Although they share similar interfaces to external components/subsystems, the CS consists of two service types – Self Driving and Human Driven services, each designated as a system within this architecture description. The two systems include:

- **SDS System** is composed of two autonomous vehicles and the shuttle operations center (SOC). The SDS will provide microtransit service on a pre-defined set of road segments that satisfy the Operational Design Domain (ODD) of the SDS.
- **HDS System** is composed of human driven wheelchair accessible vehicles, dispatch, and scheduling software (from the NFTA paratransit fleet) and reservations services. The HDS will provide door-to-door, on-demand service similar to current PAL paratransit service, but available for all registered CTP participants.

The envisioned service area for the proposed community shuttle fleet is shown in Figure 5.

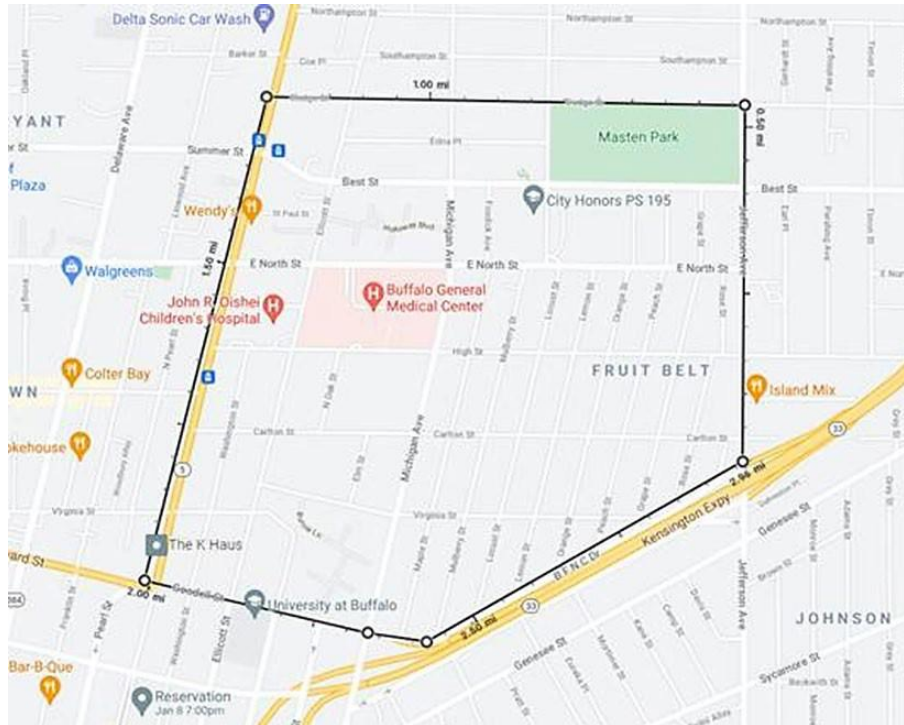


Figure 5. Proposed Service Area for the Community Shuttle

Source: Buffalo, NY ITS4US

Registered CTP users are able to summon the shuttle through the CTP. The operating subsystems of these shuttles are described in the following sections.

2.1.3. Smart Infrastructure Subsystem

Smart Infrastructure (SI) Subsystem supports personalized wayfinding capabilities for travelers. The technologies (modules) include:

- Transportation Information Hub (TIH) modules
- Indoor Navigation modules
- Pedestrian Intersection Crossing (PED-X) modules

SI provides support technologies for trip planning and wayfinding. The SI will be used for public access to trip planning activities, supplementary sensors to support indoor navigation at building / facilities and Metro rail stations, and broker / gateway services for pedestrians to request pedestrian actuation at selected signalized intersections—Main St. & Best St. and Ellicott St. & High St.

The locations identified for the technology deployments provide a logical traveler journey from arriving at the Metro rail station with a TIH, traveling through a PED-X enabled intersection and proceeding to a facility with indoor navigation capabilities. The two primary complete trip smart infrastructure scenarios are depicted in Figure 6.

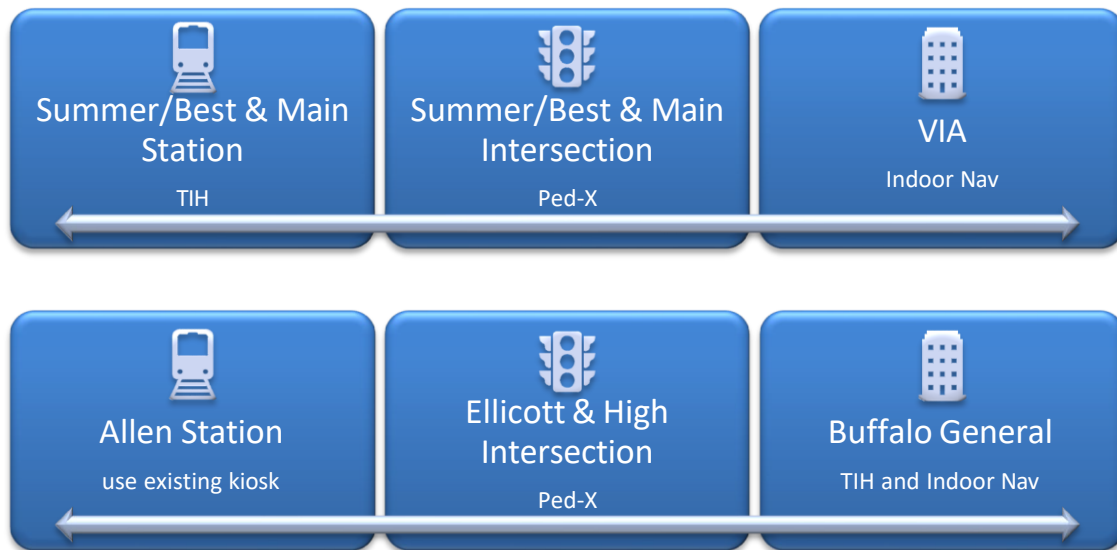


Figure 6. Smart Infrastructure Complete Trip Examples
Buffalo, NY ITS4US

2.1.4. Performance Measure Dashboard Subsystem

The PMD Subsystem monitors, integrates, analyzes, and displays performance measures from other subsystems and external sources. The subsystem includes functions to ingest log files from other subsystems, external data sources, and 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 3. 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 3. Modes of Operations for the System

Mode	Definition
Operational (regular)	All interfaces and subsystems are operating normally.

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Mode	Definition
Degraded with communications or data feeds from external systems, smart infrastructure or CTP	This mode occurs when interfaces are degraded or fail due to communications or data feed reduced availability, maintenance, or other impacts. 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).
Degraded with communications or data feeds from smart infrastructure or CTP to Community Shuttle (particularly the SDS).	This mode occurs when external interfaces and services critical to operations or the SDS subsystem impact operations. 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 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. 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.
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.

Mode	Definition
Degraded when community shuttle services dependent on other subsystems are in reduced availability or impacted.	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. 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.
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. General Transit Feed Specification (GTFS) family of standards including GTFS, GTFS real-time and General On-Demand Feed Specification (GOFS).
 2. 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 4 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 4. Proposed System Traveler Actors

Actor	Short Description
Persons with Disability	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: • 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 5 provides the list of operator/partner users who manage and support the operations of the different components of the proposed system. Actors labeled as new actors did not exist prior to this deployment and have been created to support the system.

Table 5. Proposed System Operator/Partner Actors.

Actor	Short Description
SDS 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.
Complete Trip Platform Deployer (new)	Public or private entity hired or assigned to deploy and/or maintain the complete trip platform defined in the concept.
NFTA	Operate HDS operators and vehicles, Provision of GTFS and GTFS-realtime, and TIH at Metrorail stations.

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

Actor	Short Description
NFTA Paratransit Operations (PAL)	Systems (web) 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	The city in which the Buffalo ITS4US project is deployed. The CoB owns, operates, and plans signal operations of the two designated pedestrian signal crossings and sidewalks in the project coverage area. They manage the roads over which the Self Driving Shuttle (SDS) / Human Driven Shuttle (HDS) will be deployed.
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 deployment area.
BNMC	Organization that facilitates outreach to community.
BNMC Campus Entities	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: • Roswell Park (RP) • VIA • Kaleida Health (KH) • University at Buffalo (UB) • Buffalo Hearing and Speech Center (BHSC)
Call Center Personnel (new)	Human actors involved in call center operations to support the phone-based access of the CTP or the community shuttle. The Call Center will leverage 211/311 services operated by Visual Impairment Advancement in Buffalo. While this is a new actor, there is potential to leverage existing call-center / customer support capabilities.
SDS SOC Personnel	Personnel working as part of the SDS shuttle operations center.
HDS Shuttle Driver	Drivers of the human driven shuttle. While this is a new actor, there is potential to leverage existing driver capabilities.
CTP System Administrator	System Administrator for CTP trip planner and mobile app. The team that operates and maintains the software and infrastructure services.
CTP Vendor	Developer, operator, and maintainer of Complete Trip Platform.
Facility Manager	Manager of a facility (generic definition) that includes traveler support systems like a touch model, kiosk (transportation information hub), or indoor navigation services.
Independent Evaluation	The USDOT independent evaluation team.
PMD System Administrator	Developer, operator, maintainer of PMD.
Self Driving Shuttle (SDS) Steward	The guardian on the SDS who oversees vehicle operations and safety.
SDS Vendor	Service provider of turnkey SDS and Shuttle Operations Center (SOC).

Actor	Short Description
Traffic Signal Control Gateway Vendor	Integrator, operator, maintainer of Gateway to Pedestrian Signal System.

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 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 and light rail, 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 feedback about

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. The focus of this use case is on the SDS since the HDS will default to existing NFTA standard operating procedures.

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. To support cybersecurity provisions, a proxy server can be added to manage messages to the traffic signal controller.

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. A proxy server can manage PED-X function may support the NTCIP 1211 standard.

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 ID -- 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
- INT – system interface
- PMD – performance management dashboard
- Proj – project
- 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 6 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 6. System Functional Requirements.

Req ID	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., beacon) 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). 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 Information Collection	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-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 ID	Req Title	Req Description
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-009.4	Access to PAL services via CTP	The CTP shall provide an eligible paratransit traveler to book a PAL reservations into or out of the project region using their PAL identification.
Req-Sy-011	Geographic Coverage	The System shall provide on-demand and microtransit service (including HDS and SDS) in the geographic area covered by the project.

3.2. System Performance Characteristics

Table 7 details the performance requirements that the system shall meet to fulfill the user needs.

Table 7. System Performance Requirements.

Req ID	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 ID	Req Title	Req Description
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 PMD	The CS Shall meet a set of SLAs for health status to be determined during the test phase. 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. The alerts shall be stored in the operational log file and delivered to the PMD at a specified frequency.

3.3. System Security and Privacy

Table 8 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 8. System Security and Privacy.

Req ID	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 requirements for the system.

3.4.1. System Maintainability

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

Table 9. System Maintainability Requirements.

Req ID	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 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.

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Req ID	Req Title	Req Description
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 10 details the system operations requirements that the system needs to meet to fulfill the user needs. These requirements pertain to every subsystem.

Table 10. System Operations Requirements.

Req ID	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 ID	Req Title	Req Description
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 11 details system accessibility requirements that meet user needs. These requirements pertain to every subsystem.

Table 11. System Accessibility Requirements

Req ID	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 12 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 12. System Standard Requirements.

Req ID	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 13 details information management requirements that include data backup, recovery and retention, data curation and referential integrity requirements that pertain to all subsystems.

Table 13. System Information Management Requirements.

Req ID	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, and metadata documentation. The frequency of the curation process will be determined in Phase 2.

3.6.2. Technology Renewal

Table 14 details technology renewal requirements that pertain to physical assets obsolescence.

Table 14. System Technology Renewal Requirements.

Req ID	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 15 details institutional requirements that pertain to system lifecycle development and the system rollout.

Table 15. System Institutional Requirements.

Req ID	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.

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 16 details CTP functional requirements that meet user needs.

Table 16. Complete Trip Platform Functional Requirements.

Reqt ID	Reqt Title	Reqt 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.
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 ID	Req Title	Req Description
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 community shuttle services. Service data includes, but is not limited to, modes, operational times, schedules (GTFS), service coverage (GTFS Flex), 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 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 services, 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	Save Trip Information	The CTP shall provide a traveler with the option to save trip information including but not limited to trip plans, trip

Req ID	Req Title	Req Description
		preferences (by plan). This function allows a traveler to save a favorite place or favorite trip.
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-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 ID	Req Title	Req Description
Req-CTP-028.1	Account settings - - mode	The CTP shall provide the capability for users to select mode preference (including PAL), 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.
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 (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 (e.g., user defined favorite places for origin, destination, or waypoints).
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 interfacing with native functions on wearables and assistive devices (e.g., Bluetooth enabled hearing aids, canes, watches). The capabilities experienced by the traveler depends on the capabilities of their receiving devices. Note: the CTP capabilities will be tested with device(s) that supports all capabilities.
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). The capabilities experienced by the traveler depends on the capabilities of their receiving devices. Note: the CTP capabilities will be tested with device(s) that supports all capabilities.
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

Req ID	Req Title	Req Description
		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. Note: the CTP capabilities will be tested with device(s) that supports all capabilities.
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 and CS SDS/HDS 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 arrives at

Req ID	Req Title	Req Description
		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-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 or CS. 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: 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 and notifications for each trip. These preferences will be configurable to assign to indoor and outdoor trip plans.
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,

Req ID	Req Title	Req Description
		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, and execution 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-071	CTP language notification selection	The CTP shall allow a traveler to choose a 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 ID	Req Title	Req Description
Req-CTP-079	Mobility operator service animal policies	The CTP shall enforce the mobility provider's 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 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 (OPTIONAL)	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-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-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-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-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 ID	Req Title	Req Description
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 generating GTFS real-time feeds the ability to provide an operational alert that will be available to travelers through the CTP user interfaces.
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-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-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. The responsibilities for PAL / PAL DIRECT and the Buffalo ITS4US project will be coordinated during Phases 2 and 3.
Req-CTP-123	Contradictory preferences	The CTP provide trip plans that do not conflict among the traveler's input preferences, when planning a trip, and provide suggestions if no trips are available.

Req ID	Req Title	Req Description
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-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 17 details CTP data requirements related to functional requirements and that meet user needs.

Table 17. Complete Trip Platform Data Requirements.

Req ID	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). (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 ID	Req Title	Req Description
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.
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 ID	Req Title	Req Description
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 (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.
Req-CTP-135	Traveler PII Data Removal Request-CTP	The CTP shall implement a process for registered account holders to close their account and request the removal of their PII from system-wide storage.

4.1.3. Physical

Table 18 details CTP physical requirements that meet user needs.

Table 18. Complete Trip Platform Physical Requirements.

Req ID	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-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	Indoor Navigation Beacons using BLE Common communications protocols	The CTP shall interface with BLE Beacons 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 19 details CTP Security and Privacy requirements that meet user needs.

Table 19. Complete Trip Platform Security and Privacy Requirements.

Req ID	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 ID	Req Title	Req Description
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 20 details CTP HMI and accessibility requirements that meet user needs.

Table 20. Complete Trip Platform HMI and Accessibility Requirements.

Req ID	Req Title	Req Description
Req-CTP-008	Mobility Provider Reservations APIs used by CTP	The CTP shall use Application Programming Interfaces (API) provided by the mobility provider for the SDS and HDS 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 21 details CTP operations and maintenance requirements that meet user needs.

Table 21. Complete Trip Platform Operations and Maintenance Requirements.

Req ID	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 ID	Req Title	Req Description
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 22 details smart infrastructure (PED-X, TIH, and Smart Signs) functional requirements that meet user needs.

Table 22. Smart Infrastructure Functional Requirements.

Req ID	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-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 ID	Req Title	Req Description
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-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-035	TIH ADA Compliance	The TIH shall be ADA compliant.
Req-SI-036	TIH Connectivity	The TIH shall provide WiFi/Ethernet or Cellular connectivity.
Req-SI-037	TIH Operating System	The TIH shall offer a commercial operating system such as Windows, Android or Linux.
Req-SI-038	TIH Web Access Restriction	The TIH shall provide configuration control to restrict web access to specified Uniform Resource Locators (URL).
Req-SI-033	Indoor Navigation Software Development Kit (SDK)	Vendor shall provide a well-documented Software Development Kit (SDK) that the CTP mobile application will leverage to interact with the Bluetooth Beacons. This SDK will (at a minimum) allow the CTP mobile application to accurately determine the indoor location of the mobile device. Additional capabilities may be included in the SDK that will assist with the presentation of indoor facility maps, planned navigation routes and fixed waypoints.
Req-SI-034	Indoor Map Generation	Vendor shall work with the project team and facility owners to generate Indoor Maps detailing public areas and paths within the target facilities, including waypoints and areas of interest, cross referenced with Bluetooth Beacon placement (via the SDK)

4.2.2. Data

Table 23 details smart infrastructure data requirements that meet user needs.

Table 23. Smart Infrastructure Data Requirements.

Req ID	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).

4.2.3. Physical

Table 24 details smart infrastructure (PED-X, TIH and Smart Signs) physical requirements that meet user needs.

Table 24. Smart Infrastructure Physical Requirements.

Req ID	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	Bluetooth Beacon durability	The Bluetooth Beacon 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	Bluetooth Beacon power	The Bluetooth Beacon 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	The beacon shall meet 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-013	Bluetooth Beacon installation and mounting	Bluetooth Beacons shall be constructed to be installed using adhesive or screws mounted on a wall, shelter, or pole.

Req ID	Req Title	Req Description
Req-SI-019	TIH equipment	The TIH shall be composed of the following two 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. Power, internet access and installation (including form factors for equipment) shall be provided by the facility owner.
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)
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 25 details smart infrastructure security and privacy requirements that meet user needs.

Table 25. Smart Infrastructure Security and Privacy Requirements.

Req ID	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.

4.3. 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 ID	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 traffic signals, phases, signs, and other traffic control devices.

Req ID	Req Title	Req Description
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, 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 ID	Req Title	Req Description
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 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 back office 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 back office scheduling, routing and dispatch services in the BNMC and project region.

Req ID	Req Title	Req Description
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-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-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 ID	Req Title	Req Description
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	The SDS passenger information system shall communicate to information to riders about the vehicle status, travel path, situational awareness, and public safety messages. At a minimum, the types of information include: • 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.
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 ID	Req Title	Req Description
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-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-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 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 ID	Req Title	Req Description
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 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 ID	Req Title	Req Description
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-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-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 ID	Req Title	Req Description
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-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 ID	Req Title	Req Description
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 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-046 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 ID	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: • 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	HDS Trip Reporting	The HDS 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 ID	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-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 ID	Req Title	Req Description
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). Note: this requirement was made optional in the procurement specifications.
Req-CS-010	Seat Belts	The SDS shall have seat belts for every passenger seat. Note: this requirement depends on the vehicle type procured, e.g., a van requires a seat belt, a bus does not. This requirement was made optional in the procurement specifications.
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 ID	Req Title	Req Description
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 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 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 ID	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-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-94	Develop Safety Steward SOP	The SDS vendor shall develop standard operating procedures for safety stewards. The SOP shall cover procedures for normal and degraded operations, incidents due to vehicle, passenger or external events to ensure passenger safety.
Req-CS-95	Manage Safety Steward Operations	The SDS shall provide trained Safety Stewards to operate the SDS during the designated hours of operations.

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 in 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 ID	Req Title	Req Description
Req-CS-059	Authorization to Operate	The SDS shall be authorized to operate on 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 ID	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 ID	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-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.

4.3.7. Operational Performance

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

Table 32. CS Operational Performance Requirements.

Req ID	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 ID	Req Title	Req Description
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.

4.3.8. Project Requirements

Table 33 provides the project requirements for the SDS as part of the procurement process. These requirements were associated with the vendor procurement and are included in the Comprehensive Acquisition Plan (CAP).

Table 33. Project Requirements

Req ID	Req Title	Req Description
Req-Proj-1	Train Safety Steward SOP	The SDS vendor shall recruit and train safety stewards in the SOPs.
Req-Proj-2	SOC Operational Manager	The SDS vendor shall assign an operational manager(s) to the SOC.
Req-Proj-3	SDS Project Manager	The SDS vendor shall assign a key staff person to manage and report to UB staff and participate in meetings with NFTA project staff as needed. A change of project manager shall be approved by UB contracting staff.
Req-Proj-4	Reporting Disengagement Incidents	The SDS vendor and safety steward will be responsible for reporting all disengagement incidents (i.e., when the safety steward had to take over the control of the shuttle), and the reason(s) behind the disengagement.
Req-Proj-5	Buy America Provision	The SDS equipment shall conform to the Buy America Act requirements.
Req-Proj-6	Passenger Outreach and Training	The SDS vendor shall participate in passenger outreach and training including any special events conducted in Phase 2 or 3 of the project.
Req-Proj-7	Operational Readiness Testing and Demonstration	The SDS vendor shall participate in the Operational Readiness Testing and Demonstration (milestone gate to proceed to Phase 3).

Req ID	Req Title	Req Description
Req-Proj-8	Test Planning and Reporting	The SDS vendor shall develop, conduct, and report test plans and test reports consistent with USDOT testing documentation expectations.
Req-Proj-9	TIH Buy America Provision	The TIH equipment shall conform to the Buy America Act requirements.
Req-Proj-10	TIH User Outreach and Training	The vendor shall participate in user outreach and training including any special events conducted in Phase 2 or 3 of the project.
Req-Proj-11	TIH Operational Readiness Testing and Demonstration	The vendor shall participate in the Operational Readiness Testing and Demonstration (milestone gate to proceed to Phase 3).
Req-Proj-12	TIH Test Planning and Reporting	The vendor shall develop, conduct and report test plans and test reports consistent with USDOT testing documentation expectations.
Req-Proj-13	TIH Installation	The TIH vendor shall provide installation requirements and instructions on their equipment.
Req-Proj-14	TIH Operations and Maintenance	The TIH vendor shall provide operations and maintenance during the period of performance.
Req-Proj-15	Indoor Nav Buy America Provision	The Indoor Navigation equipment shall confirm to the Buy America Act requirements.
Req-Proj-16	Indoor Navigation Deployment Services Project Management	Vendor shall assign a key staff person to manage and report to the ICF / facility owner and manage the deployment of all procured components
Req-Proj-17	Indoor Navigation Technical Support	Vendor shall assign a key staff person (or designate a mature process) to facilitate the timely response and resolution of all technical questions or concerns related to all procured components.
Req-Proj-18	Indoor Navigation Operational Readiness Testing and Demonstration	Vendor shall participate in the Operational Readiness Testing and Demonstration (milestone gate to proceed to Phase 3).
Req-Proj-19	Indoor Navigation Component Testing and Reporting	Vendor shall collaborate with the Buffalo ITS4US vendors to develop, conduct and report test plans and test reports consistent with ICF testing documentation expectations. Vendor shall work collaboratively and in a timely manner to resolve any issues identified during testing, as well as provide any other support related to project testing and demonstration (specific to procured components).

Req ID	Req Title	Req Description
Req-Proj-20	Indoor Navigation Operations and Maintenance Services	Vendor may be required to provide Operations and Maintenance Services for procured components for the duration of the planned project. This requirement will be further developed and refined based on the thorough understanding of the vendor's Indoor Navigation components and architecture.

4.4. Performance Measurement Dashboard

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

4.4.1. Functional

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

Table 34. Performance Measurement Dashboard Functional Requirements.

Req ID	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-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

Req ID	Req Title	Req Description
		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 35 details the PMD data requirements that meet user needs.

Table 35. Performance Measurement Dashboard Data Requirements.

Req ID	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-014.2	Data Curation of satisfaction data	The PMD shall develop and implement a data curation plan for satisfaction data from the survey responses.
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 ID	Req Title	Req Description
Req-PMD-014.4	Data Curation of HDS trip reporting data	The PMD shall develop and implement a data curation plan for HDS trip reporting statistics. The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets, including: (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-014.5	Data Curation of SDS trip reporting data	The PMD shall develop and implement a data curation plan for SDS trip reporting statistics. The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets, including: (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 ID	Req Title	Req Description
Req-PMD-014.7	Data Curation of additional data	The PMD shall develop and implement a data curation plan for additional data items in the Performance Management Dashboard, including: (1) Data on weather conditions, road closures, etc. (2) Data on operating conditions for key NFTA services, particularly those serving the BNMC. (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.

4.4.3. Physical

Table 36 details the PMD physical requirements that meet user needs.

Table 36. Performance Measurement Dashboard Physical Requirements.

Req ID	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 37 details the PMD security and privacy requirements that meet user needs.

Table 37. Performance Measurement Dashboard Security and Privacy Requirements.

Req ID	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 38 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 38. System Interfaces Requirements.

Req ID	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 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 ID	Req Title	Req Description
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	Traffic Management Data Dictionary (TMDD)	The system shall use the Traffic Management Data Dictionary (TMDD) Standard v3.1 for the Center-to-Center Communications published by ITE. See https://www.ite.org/technical-resources/standards/tmdd/3-1/
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-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-INT-014	OpenStreetMap	The system shall use the OpenStreetMap (OSM) as the basemap for routing and trip planning functions for transit, shared-use (on-demand), and pedestrian trip planning. In addition, features including locations such as signalized intersections, informal pathways, obstacles to travel (rough surfaces, poles obstructing sidewalks, sidewalk work zones), accessible entrances, etc. should be coded to be consistent with the download used by the CTP for trip planning.

Appendix A. Needs-to-Requirements Traceability Matrix

Table 39 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 39. Buffalo, NY ITS4US Deployment Needs-to-Requirements Traceability Matrix.

Req ID	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 back office system is called the Shuttle Operations Center (SOC).	

Req ID	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-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-046 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.	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-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 ID	Req Title	Req Description	Related Need
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 and HDS 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-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 ID	Req Title	Req Description	Related Need
Req-Sy-009.4	Access to PAL services via CTP	The CTP shall provide an eligible paratransit traveler to book a PAL reservations into or out of the project region using their PAL identification.	
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)). (b) Real time status (GTFS realtime data).	
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 community shuttle services. Service data includes, but is not limited to, modes, operational times, schedules (GTFS), service coverage (GTFS Flex), 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.	

Req ID	Req Title	Req Description	Related Need
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.	UN-S-BO-5
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-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.	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 services, 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

Req ID	Req Title	Req Description	Related Need
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). This function allows a traveler to save a favorite place or favorite trip.	
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-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 ID	Req Title	Req Description	Related Need
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.	
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 ID	Req Title	Req Description	Related Need
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.	
Req-INT-014	OpenStreetMap	The system shall use the OpenStreetMap (OSM) as the basemap for routing and trip planning functions for transit, shared-use (on-demand), and pedestrian trip planning. In addition, features including locations such as signalized intersections, informal pathways, obstacles to travel (rough surfaces, poles obstructing sidewalks, sidewalk work zones), accessible entrances, etc. should be coded to be consistent with the download used by the CTP for trip planning.	
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 ID	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, 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.	

Req ID	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 (e.g., user defined favorite places for origin, destination, or waypoints).	
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 interfacing with native functions on wearables and assistive devices (e.g., Bluetooth enabled hearing aids, canes, watches). The capabilities experienced by the traveler depends on the capabilities of their receiving devices. Note: the CTP capabilities will be tested with device(s) that supports all capabilities.	
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). The capabilities experienced by the traveler depends on the capabilities of their receiving devices. Note: the CTP capabilities will be tested with device(s) that supports all capabilities.	
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 ID	Req Title	Req Description	Related Need
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-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. Note: the CTP capabilities will be tested with device(s) that supports all capabilities.	
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 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 ID	Req Title	Req Description	Related Need
Req-CTP-019.2	Integrated Trip Planning -- NFTA PAL options	The CTP shall integrate NFTA paratransit options in the integrated trip planning mode options.	UN-E-TP-6
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.	UN-E-TS-4
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-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-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 ID	Req Title	Req Description	Related Need
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
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 ID	Req Title	Req Description	Related Need
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 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 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 ID	Req Title	Req Description	Related Need
		notifications on NFTA and CS SDS/HDS 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 ID	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 ID	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 information to riders about the vehicle status, travel path, situational awareness, and public safety messages. At a minimum, the types of information include: • 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 ID	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	

Reqt ID	Reqt Title	Reqt Description	Related Need
		other factors. 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.	
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-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	UN-S-SO-2

Req ID	Req Title	Req Description	Related Need
		second before traveler arrives at the intersection), and continuously generate and transmit request updates with new TSD and TED estimate.	
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-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 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	

Req ID	Req Title	Req Description	Related Need
		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.	
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-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 or CS. The development and rollout of these triggers and their implementation will be driven by stakeholder input during the Agile Development Process.	

Req ID	Req Title	Req Description	Related Need
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 and notifications for each trip. These preferences will be configurable to assign to indoor and outdoor trip plans.	
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 ID	Req Title	Req Description	Related Need
Req-Sy-012.3	CTP Notification Transmission Response Time	The CTP shall generate and transmit notifications to traveler's 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 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 ID	Req Title	Req Description	Related Need
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.	
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	

Req ID	Req Title	Req Description	Related Need
		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.	
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, and execution 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 ID	Req Title	Req Description	Related Need
Req-CTP-071	CTP language notification selection	The CTP shall allow a traveler to choose a 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-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. The responsibilities for PAL / PAL DIRECT and the Buffalo ITS4US project will be coordinated during Phases 2 and 3.	
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-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 ID	Req Title	Req Description	Related Need
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 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 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	

Req ID	Req Title	Req Description	Related Need
		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 (OPTIONAL)	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).	
UN-E-TS-9	Satisfaction	The system needs to periodically gather customer satisfaction with information and travel services provided. This is important to assess of the system's performance as well as support continued engagement with the travelers	
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, delays and closures), and Infrastructure status (e.g., elevator and escalator conditions, sidewalk condition)	

Req ID	Req Title	Req Description	Related Need
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 identifier, the priority strategy requested (crosswalk to actuate the pedestrian signal), TSD, and the TED.	UN-E-TE-8

Req ID	Req Title	Req Description	Related Need
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-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 ID	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	Bluetooth Beacon durability	The Bluetooth Beacon 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	The beacon shall meet 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-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 ID	Req Title	Req Description	Related Need
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 two 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. Power, internet access and installation (including form factors for equipment) shall be provided by the facility owner.	
Req-SI-035	TIH ADA Compliance	The TIH shall be ADA compliant.	
Req-SI-036	TIH Connectivity	The TIH shall provide WiFi/Ethernet or Cellular connectivity.	
Req-SI-037	TIH Operating System	The TIH shall offer a commercial operating system such as Windows, Android or Linux.	
Req-SI-038	TIH Web Access Restriction	The TIH shall provide configuration control to restrict web access to specified Uniform Resource Locators (URL).	
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. This is necessary to ensure that travelers are supported through the last leg of their trip adequately and get confirmation of their destination	

Req ID	Req Title	Req Description	Related Need
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	Indoor Navigation Beacons using BLE Common communications protocols	The CTP shall interface with BLE Beacons 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., beacons) 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). 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-SI-033	Indoor Navigation Software Development Kit (SDK)	Vendor shall provide a well-documented Software Development Kit (SDK) that the CTP mobile application will leverage to interact with the Bluetooth Beacons. This SDK will (at a minimum) allow the CTP mobile application to accurately determine the indoor location of the mobile device. Additional capabilities may be included in the SDK that will assist with the presentation of indoor facility maps, planned navigation routes and fixed waypoints.	
Req-SI-034	Indoor Map Generation	Vendor shall work with the project team and facility owners to generate Indoor Maps detailing public areas and paths within the target facilities, including waypoints and areas of interest, cross referenced with Bluetooth Beacon placement (via the SDK)	

Req ID	Req Title	Req Description	Related Need
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-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-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 PMD	The CS Shall meet a set of SLAs for health status to be determined during the test phase. 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	

Req ID	Req Title	Req Description	Related Need
		alert type. The alerts shall be stored in the operational log file and delivered to the PMD at a specified frequency.	
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 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-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-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 ID	Req Title	Req Description	Related Need
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-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.	
Req-CTP-135	Traveler PII Data Removal Request- CTP	The CTP shall implement a process for registered account holders to close their account and request the removal of their PII from system-wide storage.	
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	

Req ID	Req Title	Req Description	Related Need
		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-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: • 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	HDS Trip Reporting	The HDS shall log trip performance metrics on a daily basis for the PMD to access.	
Req-CTP-092	Trip History and Unique	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	

Req ID	Req Title	Req Description	Related Need
	Reference Identifier	data contained in trip history records will be described for each mode, services and subsystems during the design processes of each subsystem.	
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 ID	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-014.2	Data Curation of satisfaction data	The PMD shall develop and implement a data curation plan for satisfaction data from the survey responses.	
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 ID	Req Title	Req Description	Related Need
Req-PMD-014.4	Data Curation of HDS trip reporting data	The PMD shall develop and implement a data curation plan for HDS trip reporting statistics. The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets, including: (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-014.5	Data Curation of SDS trip reporting data	The PMD shall develop and implement a data curation plan for SDS trip reporting statistics. The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets, including: (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 ID	Req Title	Req Description	Related Need
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: (1) Data on weather conditions, road closures, etc. (2) Data on operating conditions for key NFTA services, particularly those serving the BNMC. (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 ID	Req Title	Req Description	Related Need
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-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.	
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	Bluetooth Beacon power	The Bluetooth Beacon 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	Bluetooth Beacon installation and mounting	Bluetooth Beacons 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	

Req ID	Req Title	Req Description	Related Need
		devices to exchange messages between the CTP mobile app and the Traffic Signal PED-X module.	
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-E-TE-13
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 ID	Req Title	Req Description	Related Need
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-94	Develop Safety Steward SOP	The SDS vendor shall develop standard operating procedures for safety stewards. The SOP shall cover procedures for normal and degraded operations, incidents due to vehicle, passenger or external events to ensure passenger safety.	
Req-CS-95	Manage Safety Steward Operations	The SDS shall provide trained Safety Stewards to operate the SDS during the designated hours of operations.	
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 ID	Req Title	Req Description	Related Need
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 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 ID	Req Title	Req Description	Related Need
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-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 ID	Req Title	Req Description	Related Need
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-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-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	

Req ID	Req Title	Req Description	Related Need
		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-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 the traffic signal system PED-X module.	

Req ID	Req Title	Req Description	Related Need
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-INT-010	Traffic Management Data Dictionary (TMDD)	The system shall use the Traffic Management Data Dictionary (TMDD) Standard v3.1 for the Center-to-Center Communications published by ITE. See https://www.ite.org/technical-resources/standards/tmdd/3-1/	
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).	

Reqt ID	Reqt Title	Reqt Description	Related Need
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-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 ID	Req Title	Req Description	Related Need
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-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 ID	Req Title	Req Description	Related Need
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 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 ID	Req Title	Req Description	Related Need
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 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 ID	Req Title	Req Description	Related Need
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-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 ID	Req Title	Req Description	Related Need
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.	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 ID	Req Title	Req Description	Related Need
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-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 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 ID	Req Title	Req Description	Related Need
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. 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 provide trip plans that do not conflict among conflicts among the traveler's input preferences, when planning a trip, and provide suggestions if no trips are available.	
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 ID	Req Title	Req Description	Related Need
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.	
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	

Req ID	Req Title	Req Description	Related Need
		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.	
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 Safety Steward shall take control of the vehicle, 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.	

Req ID	Req Title	Req Description	Related Need
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 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 ID	Req Title	Req Description	Related Need
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-E-TP-3
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-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 ID	Req Title	Req Description	Related Need
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 generating GTFS real-time feeds the ability to provide an operational alert that will be available to travelers through the CTP user interfaces.	
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 ID	Req Title	Req Description	Related Need
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).	
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 ID	Req Title	Req Description	Related Need
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-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-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 ID	Req Title	Req Description	Related Need
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 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 preventative 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	

Req ID	Req Title	Req Description	Related Need
		change process will be part of the change management process (to be included in the Phase 3 Project Management Plan).	
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 ID	Req Title	Req Description	Related Need
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.	
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 on 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 the appropriate stakeholders. Consensus will be documented along with the justification for the change. Reviewed and approved changes will be documented in Table 40.

Table 40. Confirmed Changes to Needs and Requirements.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
UN-S-BO-9	Title: Hygiene Protocol Description: 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	deprecate	As discussed with NFTA, the priority during the height of COVID-19 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

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				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.
Req-Sy-036	Title: CS Health Status Communications Action to the CTP Description: 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.	Title: CS Health Status Communications Action to the PMD . Description: The CS shall meet a set of SLAs for health status to be determined during the test phase . 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. The alerts shall be stored in the operational log file and delivered to the PMD at a specified frequency.	clarification	Added clarification to identify where and when the health status should be stored.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CS-93	Title: CS Estimated Time of Arrival Service Level Description: 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.	Title: CS Estimated Time of Arrival Service Level Description: 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-046 for status updates / ETA on requested CS services.	correction	Requirement number referenced in the description was incorrect.
Req-CS-94	N/A	Title: Develop Safety Steward SOP requirement. Description: The SDS vendor shall develop standard operating procedures for safety stewards. The SOP shall cover procedures for normal and degraded operations, incidents due to vehicle, passenger or external events to ensure passenger safety.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-1	N/A	Title: Train Safety Steward SOP Description: The SDS vendor shall recruit and train safety stewards in the SOPs.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-7	N/A	Title: Operational Readiness Testing and Demonstration Description: The SDS vendor shall participate in the Operational Readiness Testing and Demonstration (milestone gate to proceed to Phase 3).	contract	These are new project requirements that will be included in a vendor procurement.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-Proj-8	N/A	Title: Test Planning and Reporting Description: The SDS vendor shall develop, conduct, and report test plans and test reports consistent with USDOT testing documentation expectations.	contract	These are new project requirements that will be included in a vendor procurement.
Req-CS-95	N/A	Title: Manage Safety Steward Operations Description: The SDS shall provide trained Safety Stewards to operate the SDS during the designated hours of operations.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-2	N/A	Title: SOC Operational Manager Description: The SDS vendor shall assign an operational manager(s) to the SOC.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-3	N/A	Title: SDS Project Manager Description: The SDS vendor shall assign a key staff person to manage and report to UB staff and participate in meetings with NFTA project staff as needed. A change of project manager shall be approved by UB contracting staff.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-4	N/A	Title: Reporting Disengagement Incidents Description: The SDS vendor and safety steward will be responsible for reporting all disengagement incidents (i.e., when the safety steward had to take over the control of the shuttle), and the reason(s) behind the disengagement.	contract	These are new project requirements that will be included in a vendor procurement.

Need / Req ID	Original Need/Req	Changed Need / Req	Change Type	Justification
Req-Proj-5	N/A	Title: Buy America Provision Description: The SDS equipment shall conform to the Buy America Act requirements.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-6	N/A	Title: Passenger Outreach and Training Description: The SDS vendor shall participate in passenger outreach and training including any special events conducted in Phase 2 or 3 of the project.	contract	These are new project requirements that will be included in a vendor procurement.
Req-CTP-012	Title: Data of Mobility Services in Project Region Description: 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).	Title: Data of Mobility Services in Project Region Description: 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).	tech	Payment was not included because no payment will be included in the ITS4US Pilot.
Req-CTP-028.3	Title: Account settings – language Description: The CTP shall provide the capability for users to select language choice (including American Sign Language).	Title: Account settings – language Description: The CTP shall provide the capability for users to select language choice (including American Sign Language) .	tech	ASL was deemed too complicated to add in during the pilot. Adding ASL will be included as a next generation feature.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-028.6	Title: Account settings – navigation instructions Description: The CTP shall provide the capability for users to select navigation instruction preferences (hands-free turn by turn, user defined landmarks).	Title: Account settings – navigation instructions Description: The CTP shall provide the capability for users to select navigation instruction preferences (hands-free turn by turn, user defined landmarks, or e.g., user defined favorite places for origin, destination or waypoints).	clarification	The requirement is for navigation instruction preferences. All trip plans will include turn by turn instruction. Landmarks were removed because they can be defined as a "favorite place" so it is inclusive of the description.
Req-CTP-028.7	Title: Account settings – communication channels Description: 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).	Title: Account settings – communication channels Description: 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 interfacing with native functions on wearables and assistive devices (e.g., Bluetooth enabled hearing aids, canes, watches). The capabilities experienced by the traveler depends on the capabilities of their receiving devices. Note: the CTP capabilities will be tested with device(s) that supports all capabilities.	clarification	The feature can only utilize native functions in the traveler's personal devices. To that end, a clause was added to emphasize those functions will be leveraged.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-028.9	Title: Account settings – user interface methods Description: The CTP shall provide the capability for users to select preferences for methods of receiving notifications (e.g., voice, text, haptic/vibration).	Title: Account settings – user interface methods Description: The CTP shall provide the capability for users to select preferences for methods of receiving notifications (e.g., voice, text, haptic/vibration). The capabilities experienced by the traveler depends on the capabilities of their receiving devices. Note: the CTP capabilities will be tested with device(s) that supports all capabilities.	clarification	A note was added to clarify the requirement.
Req-CTP-041	Title: Assistive Technology Compatibility Description: 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.	Title: Assistive Technology Compatibility Description: 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. Note: the CTP capabilities will be tested with device(s) that supports all capabilities.	clarification	A note was added to clarify the requirement.

Need / Req ID	Original Need/Req	Changed Need / Req	Change Type	Justification
Req-CTP-068	Title: CTP Services on Communications Channels Description: 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.	Title: CTP Services on Communications Channels Description: The CTP registration, profile settings, trip planning, and 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.	edit	Removed reporting because the summary data is provided through the PMD subsystem
Req-CTP-070	Title: CTP UI Method and Communications channel Description: 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.	Deprecated requirement.	deprecate	The requirement is extraneous. There are other requirements that meet identify communication channel, notifications and method preferences, e.g., Req-CTP-063 to -070.
Req-CTP-071	Title: CTP language notification selection Description: 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.	Title: CTP language notification selection Description: 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.	tech	ASL was deemed too complicated to add in during the pilot. Adding ASL will be included as a next generation feature.

Need / Req ID	Original Need/Req	Changed Need / Req	Change Type	Justification
Req-CTP-081	Title: CTP ingestion of feedback Description: 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).	Title: CTP ingestion of feedback (OPTIONAL) Description: 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).	optional	This was identified as a low priority function, and will be included time and resource-permitted.
Req-CTP-105	Title: System operations alert tool Description: 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.	Title: System operations alert tool Description: The CTP shall provide authorized third parties generating GTFS real-time feeds the ability to manually or automatically insert an provide an operational alert that will be available to travelers through the CTP user interfaces.	edit	Added a more flexible capability for 3rd parties to provide alerts that will be managed by the CTP.
Req-CTP-110	Title: Transmit to Traveler Time to Cross (Don't Walk) Description: 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.	Deprecated requirement.	deprecate	There are safety considerations that cannot be guaranteed because each traveler's mobile device supports different performance. An alternative approach to using the handset to alert the traveler about walk/don't walk phase will be delivered through infrastructure devices.
Req-CTP-110.1	Title: Transmit to Traveler Time to Cross (Don't Walk) -- Clock Time Synchronization Description: Clock times of the mobile app and traffic signal controller shall be synchronized to minimize latency or errors in the timing.	Deprecated requirement.	deprecate	There are safety considerations that cannot be guaranteed because each traveler's mobile device supports different performance. An alternative approach

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				to using the handset to alert the traveler about walk/don't walk phase will be delivered through infrastructure devices.
Req-CTP-116	Title: Smart Sign Inventory Acquisition Description: 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 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.	Deprecated requirement.	deprecate	This requirement is supported by a replacement (e.g., software development kit services) requirement associated with the indoor navigation system.
Req-CTP-124	Title: Preference / notification selection mismatch with end traveler's device Description: 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.	Deprecated requirement.	deprecate	The CTP cannot interrogate each traveler's device to meet this requirement. An information message will be provided to travelers on what their device needs to support for specific functions.

Need / Req ID	Original Need/Req	Changed Need / Req	Change Type	Justification
Req-CTP-016	Title: Save Trip Information Description: The CTP shall provide a traveler with the option to save trip information including but not limited to trip plans, trip preferences (by plan).	Title: Save Trip Information Description: The CTP shall provide a traveler with the option to save trip information including but not limited to trip plans, trip preferences (by plan). This function allows a traveler to save a favorite place or favorite trip.	clarification	Added note to clarify the intention.
Req-CTP-063	Title: Trip notification preferences Description: 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.	Title: Trip notification preferences Description: 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 and notifications for each trip. These preferences will be configurable to assign to indoor and outdoor trip plans segments.	tech	Too many options will prevent generation of a trip plan.
Req-CTP-064	Title: Notification and Alert Priority Description: 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.	Deprecated requirement.	deprecate	Safety cannot be controlled through an app. We will include notifications such as "walk with caution..." Having said that, the app will prioritize the most critical notifications to the traveler based on stakeholder input during the Agile development process.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-089	Title: Travel Opt-Out Description: 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.)	Deprecated requirement.	deprecate	During pilot this will not be implemented because the recruitment agreement will not include a choice to opt-out without dropping out of the pilot.
Req-CTP-091	Title: Travel Opt-in/out Toggle Description: 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.	Deprecated requirement.	deprecate	During pilot this will not be implemented because the recruitment agreement will not include a choice to opt-out without dropping out of the pilot.
Req-CTP-097	Title: Processing Loads Description: The CTP shall be developed to support 120% of the load expected of services and users during the project duration.	Deprecated requirement.	deprecate	During the pilot there will not be enough participants to warrant load testing.
Req-CTP-123	Title: Contradictory preferences Description: The CTP shall check for conflicts among the traveler's input preferences, when planning a trip, and notify the traveler of any identified conflicts.	Title: Contradictory preferences Description: The CTP shall provide trip plans that do not shall check for conflicts among the traveler's input preferences, when planning a trip, and provide suggestions if no trips are available. and notify the traveler of any identified conflicts.	edit	Edited the requirement to clarify meaning.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-Sy-003	Title: Components Inventory Description: 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.	Title: Components Inventory Description: The System shall collect and store project components (e.g., beacon 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.	edit	Updated terminology to remove "smart sign" and replace with beacons.
Req-CTP-082	Title: Traveler satisfaction survey tool Description: The CTP shall provide a configuration tool for project staff to generate customer satisfaction surveys.	Deprecated requirement.	deprecate	The requirement changed to using an independent survey instrument so that the results will go into a secure server overseen by University at Buffalo.
Req-Sy-015.1	N/A	Title: O&M Plan -- Operations Resources Description: The O&M Plan shall include plans for staffing, staffing roles and responsibilities, hours of operations, and other resources needed to support operations.	contract	These are new project requirements that will be included in a vendor procurement.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-Sy-015.2	N/A	Title: O&M Plan -- Incident Management Description: 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 include incident severity and prioritization levels by incident types, as well resolution SLAs by incident severity level. An operations help desk may be required.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Sy-015.3	N/A	Title: O&M Plan – System Monitoring Description: 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.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Sy-015.4	N/A	Title: O&M Plan – Maintenance levels Description: The O&M Plan shall describe the maintenance levels and establish preventative maintenance procedures and schedules for all subsystem components.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Sy-015.5	N/A	Title: O&M Plan -- Configurable Items Description: The O&M Plan shall include an inventory of all configurable items.	contract	These are new project requirements that will be included in a vendor procurement.

Need / Reqt ID	Original Need/Reqt	Changed Need / Reqt	Change Type	Justification
Req-Sy-015.6	N/A	Title: O&M Plan -- Maintenance Procedures Description: The O&M Plan shall list the maintenance procedures for each component including repair and replacement activities.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Sy-015.7	N/A	Title: O&M Plan -- Security Operations Description: 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.	contract	These are new project requirements that will be included in a vendor procurement.
Req-CTP-117	Title: Smart Signs using Common communications protocols Description: 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.	Title: Smart Signs Indoor Navigation Beacons using BLE Common communications protocols Description: The CTP shall interface with smart signs BLE Beacons 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.	edit	Change Smart Sign to Beacon or Indoor Navigation System. At this point we are focusing on BLE beacons as a technology for indoor navigation services.
Req-Sy-015.6	N/A	Title: O&M Plan -- Maintenance Procedures Description: The O&M Plan shall list the maintenance procedures for each component including repair and replacement activities.	contract	These are new project requirements that will be included in a vendor procurement.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-SI-008	Title: Smart sign durability Description: 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)	Title: Bluetooth Beacon Smart-sign durability Description: The Bluetooth Beacons 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)	edit	Change Smart Sign to Bluetooth Beacon or Indoor Navigation System. At this point we are focusing on BLE beacons as a technology for indoor navigation services.
Req-SI-009	Title: Smart sign power. Description: 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.	Title: Bluetooth Beacon Smart-sign power. Description: The Bluetooth beacon 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.	edit	Change Smart Sign to Bluetooth Beacon or Indoor Navigation System. At this point we are focusing on BLE beacons as a technology for indoor navigation services.
Req-SI-011	Title: Smart Signs -- BLE Beacon Description: 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.	Title: Smart Signs -- BLE Beacons Description: For smart signs supporting BLE, The smart-sign beacon shall meet 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.	edit	Change Smart Sign to Beacon or Indoor Navigation System. At this point we are focusing on BLE beacons as a technology for indoor navigation services.

Need / Req ID	Original Need/Req	Changed Need / Req	Change Type	Justification
Req-SI-012	Title: Smart Signs -- NFC Description: 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.	Deprecated requirement	deprecate	Changed Smart Sign to Beacon or Indoor Navigation System. This requirement is no longer applicable.
Req-SI-013	Title: Smart sign installation and mounting Description: The smart sign shall be constructed to be installed using adhesive or screws mounted on a wall, shelter or pole.	Title: Bluetooth Beacon Smart sign Description: Bluetooth Beacons smart sign shall be constructed to be installed using adhesive or screws mounted on a wall, shelter or pole.	edit	Change Smart Sign to Beacon or Indoor Navigation System. At this point we are focusing on BLE beacons as a technology for indoor navigation services.
Req-SI-014	Title: Smart Sign branding Description: 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.	Deprecated requirement	deprecate	The beacons will be invisible to the user, so they will not be branded for the ITS4US project.
Req-SI-015	Title: Smart Sign tactile form Description: The smart sign shall include a tactile overlay using braille to convey information on the current location and smart sign identifier.	Deprecated requirement	deprecate	The beacons will be posted in a place that cannot be touched by a traveler, so this requirement is no longer applicable.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-SI-031	Title: Smart Sign Data Storing Description: The Smart Signs shall store pre-defined set of data. The dataset will be determined in Phase 2.	Deprecated requirement	deprecate	The beacon will support commercial and open standards. No special storage requirements will be expected from the beacons.
Req-SI-032	Title: Smart Sign Data Sharing Description: Upon request, the Smart Signs shall share pre-defined datasets with users of the CTP app.	Deprecated requirement	deprecate	The beacon will support commercial and open standards. No special storage requirements will be expected from the beacons.
Req-Proj-15	N/A	Title: Indoor Nav Buy America Provision Description: The Indoor Navigation equipment shall confirm to the Buy America Act requirements.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-16	N/A	Title: Indoor Navigation Deployment Services Project Management Description: Vendor shall assign a key staff person to manage and report to the ICF / facility owner and manage the deployment of all procured components	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-17	N/A	Title: Indoor Navigation Technical Support Description: Vendor shall assign a key staff person (or designate a mature process) to facilitate the timely response and resolution of all technical questions or concerns related to all procured components.	contract	These are new project requirements that will be included in a vendor procurement.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-Proj-18	N/A	Title: Indoor Navigation Operational Readiness Testing and Demonstration Description: Vendor shall participate in the Operational Readiness Testing and Demonstration (milestone gate to proceed to Phase 3).	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-19	N/A	Title: Indoor Navigation Component Testing and Reporting Description: Vendor shall collaborate with the Buffalo ITS4US vendors to develop, conduct and report test plans and test reports consistent with ICF testing documentation expectations. Vendor shall work collaboratively and in a timely manner to resolve any issues identified during testing, as well as provide any other support related to project testing and demonstration (specific to procured components).	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-20	N/A	Title: Indoor Navigation Operations and Maintenance Services Description: Vendor may be required to provide Operations and Maintenance Services for procured components for the duration of the planned project. This requirement will be further developed and refined based on the thorough understanding of the vendor's Indoor Navigation components and architecture.	contract	These are new project requirements that will be included in a vendor procurement.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-SI-033	N/A	Title: Indoor Navigation Software Development Kit (SDK) Description: Vendor shall provide a well-documented Software Development Kit (SDK) that the CTP mobile application will leverage to interact with the Bluetooth Beacons. This SDK will (at a minimum) allow the CTP mobile application to accurately determine the indoor location of the mobile device. Additional capabilities may be included in the SDK that will assist with the presentation of indoor facility maps, planned navigation routes and fixed waypoints.	tech	These are new project requirements that will be included in a vendor procurement. Although this is a project (contract) requirement, the requirement is assigned a functional requirement identifier because it will be verified through test during the Agile Development process
Req-SI-034	N/A	Title: Indoor Map Generation Description: Vendor shall work with the project team and facility owners to generate Indoor Maps detailing public areas and paths within the target facilities, including waypoints and areas of interest, cross referenced with Bluetooth Beacon placement (via the SDK)	tech	These are new project requirements that will be included in a vendor procurement. Although this is a project (contract) requirement, the requirement is assigned a functional requirement identifier because it will be verified through test during the Agile Development process
Req-SI-019	Title: TIH equipment. Description: 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.	Title: TIH equipment. Description: The TIH shall be composed of the following two 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.	tech	The Touch Model was procured and installed by VIA and BNMC in locations that are not collocated with the kiosk (TIH). To that end, they cannot be integrated with

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
	(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.	(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.		the kiosk, so reference to touch model technology will be removed from the requirements. The TIH and touch model may be integrated in the future if they are collocated.
Req-SI-035	N/A	Title: TIH ADA Compliance Description: The TIH shall be ADA compliant.	contract	This is a flowdown requirement from the award; to that end it was assigned a new project requirements that will be included in a vendor procurement.
Req-SI-036	N/A	Title: TIH Connectivity Description: The TIH shall provide WiFi/Ethernet or Cellular connectivity.	contract	These are new project requirements that will be included in a vendor procurement. Although this is a project (contract) requirement, the requirement is assigned a functional requirement identifier because it will be verified through test during the Agile Development process

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-SI-037	N/A	Title: TIH Operating System Description: The TIH shall offer a commercial operating system such as Windows, Android or Linux.	contract	These are new project requirements that will be included in a vendor procurement. Although this is a project (contract) requirement, the requirement is assigned a functional requirement identifier because it will be verified through test during the Agile Development process
Req-SI-038	N/A	Title: TIH Web Access Restriction Description: The TIH shall provide configuration control to restrict web access to specified Uniform Resource Locators (URL).	contract	These are new project requirements that will be included in a vendor procurement. Although this is a project (contract) requirement, the requirement is assigned a functional requirement identifier because it will be verified through test during the Agile Development process
Req-Proj-13	N/A	Title: TIH Installation Description: The TIH vendor shall provide installation requirements and instructions on their equipment.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-14	N/A	Title: TIH Operations and Maintenance Description: The TIH vendor shall provide operations and maintenance during the period of performance.	contract	These are new project requirements that will be included in a vendor procurement.

Need / Reqt ID	Original Need/Reqt	Changed Need / Reqt	Change Type	Justification
Req-Proj-9	N/A	Title: TIH Buy America Provision. Description: The TIH equipment shall conform to the Buy America Act requirements.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-10	N/A	Title: TIH User Outreach and Training Description: The vendor shall participate in user outreach and training including any special events conducted in Phase 2 or 3 of the project.	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-11	N/A	Title: TIH Operational Readiness Testing and Demonstration Description: The vendor shall participate in the Operational Readiness Testing and Demonstration (milestone gate to proceed to Phase 3).	contract	These are new project requirements that will be included in a vendor procurement.
Req-Proj-12	N/A	Title: TIH Test Planning and Reporting Description: The vendor shall develop, conduct and report test plans and test reports consistent with USDOT testing documentation expectations.	contract	These are new project requirements that will be included in a vendor procurement.
Req-INT-014	N/A	Title: OpenStreetMap. Description: The system shall use the OpenStreetMap (OSM) as the basemap for routing and trip planning functions for transit, shared-use (on-demand), and pedestrian trip planning. In addition, features including locations such as signalized intersections, informal pathways, obstacles to travel (rough surfaces, poles obstructing sidewalks, sidewalk work zones), accessible entrances, etc. should be coded to be consistent with the	tech	This requirement is being added as OSM will be used in the Open Trip Planner, which is the foundation of the CTP subsystem.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
		download used by the CTP for trip planning.		
Req-INT-010	Title: Transcom Data Fusion Engine (DFE) Description: 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/	Title: Traffic Management Data Dictionary (TMDD) Description: The system shall use the Traffic Management Data Dictionary (TMDD) Standard v3.1 for the Center-to-Center Communications published by ITE. See https://www.ite.org/technical-resources/standards/tmdd/3-1/	edit	This requirement was changed from a standard profile to the actual standard.

Need / Req ID	Original Need/Req	Changed Need / Req	Change Type	Justification
Req-CTP-011	Title: Buffalo and NFTA Service Coverage Description: 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).	Title: Buffalo and NFTA Service Coverage Description: 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).	edit	
Req-CS-064	Title: No return trip booking available Description: 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.	Title: No return trip booking available Description: 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.	edit	

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
UN-E-TP-11	Title: PAL Profile Integration Description: 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	Title: PAL Profile Integration Description: 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	deprecate	Need to allow PAL users to make trip plans a. The system will not integrate directly with PAL Direct but rather use an alternate approach to integrate with PAL services to request reservations and integrate them with All Access trip plans. b. Justification: The risk that PAL Direct will be replaced during the course of the project (or post-5 year deployment) will degrade or eliminate the functionality if this design approach is not implemented. Further, vendor negotiation will impact the schedule. c. Requirements that identify an interface to PAL Direct should be replaced by requirements describing a generic interface with PAL services. Remove any requirement that includes PAL Direct as its subject.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CS-036.3	Title: PAL spontaneous routing and Dispatch Description: 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.	Deprecated requirement	deprecate	PAL Spontaneous and the HDS are equivalent services. All travelers whether they are PAL eligible or not can book HDS services. To that end, this requirement is redundant with the HDS requirement to provide on-demand service. Equivalent HDS Requirement: Req-CS-036.2
Req-CS-040.3	Title: Validate PAL Spontaneous Reservation Description: 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.	Deprecated requirement	deprecate	PAL Spontaneous and the HDS are equivalent services. All travelers whether they are PAL eligible or not can book HDS services. To that end, this requirement is redundant with the HDS requirement to provide on-demand service. Equivalent HDS Requirement: Req-CS-040.2
Req-CS-045.3	Title: PAL Booking API Specification Description: PAL DIRECT shall provide API specifications for use by the CTP to verify eligibility and booking services.	Deprecated requirement	deprecate	The PAL booking API specification was replaced by an open API – the NYSDOT Rural App booking API. Equivalent HDS

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				Requirement: Req-CS-045.2
Req-CS-046.3	Title: PAL Booking Status API Description: The PAL DIRECT developer shall provide APIs for use by the CTP to publish information about reservations status.	Deprecated requirement	deprecate	The PAL booking API specification was replaced by an open API – the NYSDOT Rural App booking API. Equivalent HDS Requirement: Req-CS-046.2
Req-CS-049.3	Title: PAL DIRECT Scheduling and Routing Description: 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.	Deprecated requirement	deprecate	The PAL booking API specification was replaced by an open API – the NYSDOT Rural App booking API. Equivalent HDS Requirement: Req-CS-049.2

Need / Req ID	Original Need/Req	Changed Need / Req	Change Type	Justification
Req-CS-056.3	Title: PAL DIRECT Update CTP on Trip Management Description: 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.	Deprecated requirement	deprecate	The PAL booking API specification was replaced by an open API – the NYSDOT Rural App booking API. Equivalent HDS Requirement: Req-CS-056.2
Req-CS-077.3	Title: PAL Spontaneous Hours of Operations Description: NFTA shall publish the hours of operations for PAL Spontaneous for travelers (employees and visitors) in the BMNC region.	Deprecated requirement	deprecate	PAL Spontaneous and the HDS are equivalent services. All travelers whether they are PAL eligible or not can book HDS services. To that end, this requirement is redundant with the HDS requirement to provide on-demand service information. Further, the HDS services cannot be booked or accessed for times the service is not in operation. Equivalent HDS Requirement: Req-CS-077.2

Need / Req't ID	Original Need/Req't	Changed Need / Req't	Change Type	Justification
Req-CS-082.3	Title: PAL Operation Performance Description: 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.	Deprecated requirement	deprecate	PAL Spontaneous and the HDS are equivalent services. All travelers whether they are PAL eligible or not can book HDS services. To that end, this requirement is redundant with the HDS requirement to collect operational performance data. Equivalent HDS Requirement: Req-CS-082.2
Req-CS-083.3	Title: PAL Trip Reporting Description: For trips booked through the CTP, PAL DIRECT shall log trip performance metrics on a daily basis for the PMD to access.	Deprecated requirement	deprecate	This is not technically feasible. SDS and HDS services can be logged.
Req-CS-084.3	Title: Secure PAL Trip Reporting information Description: 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.	Deprecated requirement	deprecate	PAL trip reporting, particularly travel outside of the BNMC area, is not part of the performance metrics. Trip reporting that uses the CTP will be collected, transmitted and processed through the CTP-PMD linkage.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CS-88.3	Title: Report PAL Operating Status to CTP Description: 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.	Deprecated requirement	deprecate	Since there is a high risk of removal of the PAL DIRECT service, this information is not transmitted from PAL DIRECT to the CTP. PAL user will be contacted directly by PAL DIRECT if PAL service is degraded.
Req-INT-011.3	Title: PAL DIRECT Reservation API Specification Description: 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).	Deprecated requirement	deprecate	The PAL booking API specification was replaced by an open API – the NYSDOT Rural App booking API. Regardless, the PAL DIRECT is proprietary. There is an equivalent requirement for HDS API specifications (Req-INT-011.2)
Req-Sy-009.3	Title: Access to PAL Spontaneous Services via CTP Description: 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.	Deprecated requirement	deprecate	PAL Spontaneous and the HDS are equivalent services. All travelers whether they are PAL eligible or not can book HDS services. To that end, this requirement is redundant with the HDS requirement. There is an equivalent requirement for HDS API

Need / Req ID	Original Need/Req	Changed Need / Req	Change Type	Justification
				specifications (Req-Sy-009.2)
Req-Sy-009.4	Title: Access to PAL Direct services via CTP Description: 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.	Deprecated requirement Title: Access to PAL Direct services via CTP Description: 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. The CTP shall provide an eligible paratransit traveler to book PAL reservations into or out of the project region using their PAL identification.	deprecate	PAL eligible travelers will be able to book their travel into the BNMC area using the CTP. The link to match their PAL eligibility will be determined as part of the design process.
Req-Sy-35.1	Title: PAL Account Linking APIs Description: 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.	Deprecated requirement	deprecate	Req-Sy-009.4 covers this requirement. In addition, the parent requirement covers all mode (see Req-Sy-35).

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-122	Title: PAL vs. System Responsibility Description: 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.	Title: PAL vs. System Responsibility Description: 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.	deprecate	A roles/responsibilities table for PAL vs. System will be covered in the COMP. Recommended the requirement be updated to remove parenthetical statement. This is no longer technically feasible.
Req-CS-049.2	Title: HDS Scheduling and Routing Description: 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.	Title: HDS Scheduling and Routing Description: 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.	edit	PAL service is no longer a component of the ITS4US Buffalo System as a significant risk of PAL no longer being available by 2024 is anticipated. The ITS4US Buffalo System will substitute PAL service by providing on-demand service using the human driven shuttle within the BNMC area.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-001	Title: Reservation Planning Services Description: 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).	Title: Reservation Planning Services Description: 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).	edit	Justification: PAL Spontaneous and currently planned HDS are equivalent from a PAL user perspective. To that end, there is no change in the functionality or services offered to PAL-eligible riders. We plan to brand PAL Spontaneous and HDS as Buffalo All Access On-demand service, as such merging the two names into a single service. SDS service will be branded as AV Shuttle (fixed route). Recommendations: Deprecate or remove requirements specifically citing PAL Spontaneous while substituting them with HDS requirements. There is already a one-to-one relationship between PAL Spontaneous and HDS.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-008	Title: Mobility Provider Reservations APIs used by CTP Description: The CTP shall use APIs provided by the mobility provider for the SDS, and HSD, PAL Spontaneous and PAL Direct reservation management modules.	Title: Mobility Provider Reservations APIs used by CTP Description: The CTP shall use APIs provided by the mobility provider for the SDS, and HDS, PAL Spontaneous and PAL Direct reservation management modules.	edit	Need to provide PAL Spontaneous Service per requirements Justification: PAL Spontaneous and currently planned HDS are equivalent from a PAL user perspective. To that end, there is no change in the functionality or services offered to PAL-eligible riders. We plan to brand PAL Spontaneous and HDS as Buffalo All Access On-demand service, as such merging the two names into a single service. SDS service will be branded as AV Shuttle (fixed route).

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-012	Title: Data of Mobility Services in Project Region Description: 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).	Title: Data of Mobility Services in Project Region Description: 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 services. 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).	edit	Need to provide PAL Spontaneous Service per requirements Justification: PAL Spontaneous and currently planned HDS are equivalent from a PAL user perspective. To that end, there is no change in the functionality or services offered to PAL-eligible riders. We plan to brand PAL Spontaneous and HDS as Buffalo All Access On-demand service, as such merging the two names into a single service. SDS service will be branded as AV Shuttle (fixed route).

Need / Req ID	Original Need/Req	Changed Need / Req	Change Type	Justification
Req-CTP-014	Title: Multimodal Trip Planner Description: 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.	Title: Multimodal Trip Planner Description: 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 services-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.	edit	The system will not integrate directly with PAL Direct but rather use an alternate approach to integrate with PAL services to request reservations and integrate them with All Access trip plans. Justification: The risk that PAL Direct will be replaced during the course of the project (or post-5 year deployment) will degrade or eliminate the functionality if this design approach is not implemented. Further, vendor negotiation will impact the schedule.
Req-CTP-028.1	Title: Account settings -- mode Description: The CTP shall provide the capability for users to select mode preferences (including PAL Direct, PAL (spontaneous), Community Shuttle SDS or HDS, NFTA).	Title: Account settings -- mode Description: The CTP shall provide the capability for users to select mode preferences (including PAL, Direct, PAL (spontaneous) , Community Shuttle SDS or HDS, NFTA).	edit	The system will not integrate directly with PAL Direct but rather use an alternate approach to integrate with PAL services to request reservations and integrate them with All Access trip plans. Justification: The risk that PAL Direct will be replaced during the course of the project (or post-5year deployment) will degrade or eliminate

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				the functionality if this design approach is not implemented. Further, vendor negotiation will impact the schedule.
Req-CTP-042	Title: CTP Travel Account Link with PAL Direct Description: 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).	Deprecated requirement	deprecate	Limiting the amount of PII and HIPAA data from PAL systems Justification: Ingesting the information requires a higher degree of security protocol since PAL Direct includes PII and HIPAA data. Client's will be asked if they currently use PAL services during the registration process and require them to input their PAL logon to book PAL service. Assume that credentials will be saved by system. The web form will not link accounts due to PII and

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				the high risk of replacing PAL DIRECT.

Need / Req ID	Original Need/Req	Changed Need / Req	Change Type	Justification
Req-CTP-045	Title: Transit and mobility service status information Description: 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 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.	Title: Transit and mobility service status information Description: 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 notifications on NFTA, and CS SDS/HDS and PAL Direct services. Note: GOFS (spec yet to be published) may be used if it meets the needs of travelers.	edit	The system will not integrate directly with PAL Direct but rather use an alternate approach to integrate with PAL services to request reservations and integrate them with All Access trip plans. Justification: The risk that PAL Direct will be replaced during the course of the project (or post-5-year deployment) will degrade or eliminate the functionality if this design approach is not implemented. Further, vendor negotiation will impact the schedule. PAL Spontaneous and currently planned HDS are equivalent from a PAL user perspective. To that end, there is no change in the functionality or services offered to PAL-eligible riders. We plan to brand PAL Spontaneous and HDS as Buffalo All Access On-demand service, as such merging the two names into a single service. SDS

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				service will be branded as AV Shuttle (fixed route).

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-060	Title: Trip Notification Triggers Description: 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, or CS or PAL. The development and rollout of these triggers and their implementation will be driven by stakeholder input during the Agile Development Process.	Title: Trip Notification Triggers Description: 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, or CS or PAL . The development and rollout of these triggers and their implementation will be driven by stakeholder input during the Agile Development Process.	edit	Need to provide PAL Spontaneous Service per requirements Justification: PAL Spontaneous and currently planned HDS are equivalent from a PAL user perspective. To that end, there is no change in the functionality or services offered to PAL-eligible riders. We plan to brand PAL Spontaneous and HDS as Buffalo All Access On-demand service, as such merging the two names into a single service. SDS service will be branded as AV Shuttle (fixed route). Note: A Stakeholder meeting was already conducted that solicited input for notifications.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-079	Title: Mobility operator service animal policies Description: 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 will designate whether a service animal is allowed on their vehicles.	Title: Mobility operator service animal policies Description: 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 will designate whether a service animal is allowed on their vehicles.	edit	Editorial change
Req-PMD-014.1	Title: Data Curation of crowdsourced data Description: The PMD shall develop and implement a data curation plan for crowdsourced data from the CTP.	Deprecated requirement	deprecate	System will not be collecting crowdsourced data. As there is a feedback feature in the CTP app that can substitute the crowdsourced information, it was determined that it would be redundant to include the crowdsourced data. Information is also being collected from the call centers, the shuttle service feedback forms, and NFTA feedback forms. In regard to real-time information sharing with the users, the crowdsourced data was going to need to be verified by experts before being relayed back to the users, so real-time

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				information sharing was not possible. Therefore, it was determined that the feedback from surveys would be sufficient.
Req-PMD-014.2	Title: Data Curation of satisfaction data Description: The PMD shall develop and implement a data curation plan for satisfaction data from the CTP survey responses.	Title: Data Curation of satisfaction data Description: The PMD shall develop and implement a data curation plan for satisfaction data from the CTP survey responses.	edit	Satisfaction data will be collected using third-party survey tools.

Req-PMD-014.4	Title: Data Curation of reservation data Description: The PMD shall develop and implement a data curation plan for Shuttle Reservations Management summary datasets.	Title: Data Curation of HDS trip reporting data-reservation data Description: The PMD shall develop and implement a data curation plan for HDS trip reporting statistics Shuttle Reservations Management summary datasets. The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets, including: (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.	edit	Refined to curate trip reporting statistics for the human driven shuttle with list of reporting datasets to be included.
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Req-PMD-014.5	Title: Data Curation of shuttle reporting data Description: The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets.	Title: Data Curation of shuttle reporting data SDS trip reporting data Description: The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets SDS trip reporting statistics. The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets, including: (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.	edit	Refined to curate trip reporting statistics for the self driven shuttle with list of reporting datasets to be included.
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Req-PMD-014.6	Title: Data Curation of shuttle reporting data Description: The PMD shall develop and implement a data curation plan for Shuttle Trip Reporting datasets, including: (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.	Deprecated requirement	deprecate	Merged with Req-PMD-014.4 - .5
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Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-056	Title: CTP countdown Description: 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.	Deprecated requirement	deprecate	There are safety considerations that cannot be guaranteed because each traveler's mobile device supports different performance. An alternative approach to using the handset to alert the traveler about walk/don't walk phase will be delivered through infrastructure devices as described in the SAD. The information may be available in future deployments if the technology is more predictable and reduces any latency.
Req-CTP-110.2	Title: Transmit to Traveler Time to Cross (Don't Walk) -- Countdown Description: 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.	Deprecated requirement	deprecate	There are safety considerations that cannot be guaranteed because each traveler's mobile device supports different performance. An alternative approach to using the handset to alert the traveler about walk/don't walk phase will be delivered through infrastructure devices as described in the SAD. The information may be available in future deployments if the

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				technology is more predictable and reduces any latency.
Req-CTP-136	Title: Traveler PII Data Removal - CTP Description: The CTP shall remove a registered account holders PII including travel history from the CTP storage when an account holder removes their account.	Deprecated requirement	deprecate	Editorial Change - Duplicate requirement to Req-CTP-133.
Req-SI-027	Title: Transmit Time to Cross (Don't Walk) Description: 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).	Deprecated requirement	deprecate	There are safety considerations that cannot be guaranteed because each traveler's mobile device supports different performance. An alternative approach to using the handset to alert the traveler about walk/don't walk phase will be delivered through infrastructure devices as described in the SAD. The information may be available in future deployments if the technology is more

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				predictable and reduces any latency.
Req-SI-020	Title: TIH touch model Description: 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.	Deprecated requirement	deprecate	The Touch Model was procured and installed by VIA and BNMC in locations that are not collocated with the kiosk (TIH). To that end, they cannot be integrated with the kiosk, so reference to touch model technology will be removed from the requirements. The TIH and touch model may be integrated in the future if they are collocated.
Req-SI-021	Title: TIH talking-touch model Description: 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.	Deprecated requirement	deprecate	The Touch Model was procured and installed by VIA and BNMC in locations that are not collocated with the kiosk (TIH). To that end, they cannot be integrated with the kiosk, so reference to touch model technology will be removed from the requirements.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				The TIH and touch model may be integrated in the future if they are collocated.
Req-SI-022	Title: TIH touch model language selection Description: The TIH shall allow the user to select the language that is spoken when a location is selected on the touch model.	Deprecated requirement	deprecate	The Touch Model was procured and installed by VIA and BNMC in locations that are not collocated with the kiosk (TIH). To that end, they cannot be integrated with the kiosk, so reference to touch model technology will be removed from the requirements. The TIH and touch model may be integrated in the future if they are collocated.
Req-SI-023	Title: TIH touch model content configuration Description: The TIH touch model shall include a tool to configure and update the messages spoken when a location is selected.	Deprecated requirement	deprecate	The Touch Model was procured and installed by VIA and BNMC in locations that are not collocated with the kiosk (TIH). To that end, they cannot be integrated with the kiosk, so reference to touch model technology will be removed from the requirements. The TIH and touch model may be integrated

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
				in the future if they are collocated.
Req-SI-024	Title: TIH CTP and Touch Model operations Description: 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.	Deprecated requirement	deprecate	The Touch Model was procured and installed by VIA and BNMC in locations that are not collocated with the kiosk (TIH). To that end, they cannot be integrated with the kiosk, so reference to touch model technology will be removed from the requirements. The TIH and touch model may be integrated in the future if they are collocated.

Need / Reqt ID	Original Need/Req	Changed Need / Reqt	Change Type	Justification
Req-CTP-085	Title: CTP ingestion of traffic signal control operation data Description: 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.	Deprecated requirement	deprecate	We are going to deprecate this since we can see the phasing but are not going to ask for the phasing information, therefore, the data is available but will not be used. The information may be used in the future and are available through the technology used by the project.
Req-CS-028	Title: Emergency Stop Actions Description: 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	When performing an emergency stop in autonomous mode, the SDS Safety Steward shall take control of the vehicle, activate the emergency/hazard lights, move the vehicle as far from the travel lanes as possible, and alert emergency services	Operational alignment	Changed to represent current SDS operating protocols

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