

Phase 1 User Needs Identification and Requirements Planning (UNIRP)

Buffalo, NY ITS4US Deployment Project

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16. Abstract The Complete Trip Deployment Pilot in Buffalo seeks to expand its current Go Niagara Medical Campus (BNMC), which provides information on mobility to/from the campus. The pilot deployment will improve mobility to, from and within the BNMC by deploying new and advance technologies with a focus on addressing existing mobility and access challenges. Examples of the technologies to be deployed are electric self-driving shuttles, trip planning app that is customized for accessible travel, intersections that use tactile and mobile technologies to enable travelers with disabilities navigate intersections and outdoor/indoor wayfinding. The pilot 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 and hearing impaired, wheelchair users and older adults). The pilot will be deployed in three phases (planning, design/deployment and demonstration), with the first one taking all 12 months of 2021. This document describes the project team's approach to user need and system requirements identification, documentation, and management. It is important to clarify that no needs or requirements are listed in this document.					
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1. Introduction

The User Needs Identification and Requirements Planning Document (UNIRP) defines the processes that will be used to generate, coordinate, approve, and support the configuration control of user needs and system requirements for the ITS4US Complete Trip Deployment in Buffalo, NY project.

The user needs and requirements development processes are critical efforts that must occur early in the project lifecycle, likely before any decisions about design and development processes are made.

This document also forms the foundation of the Systems Engineering Management Plan (SEMP) that will be delivered later in Task 12, which will detail all of the systems engineering processes that will be employed on this project.

1.1. Project Background

Providing access to the City of Buffalo's underserved populations to jobs and healthcare is the primary motivation for all the regional partners involved in this Complete Trip 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 mandated paratransit service, which is much costlier for transit agencies and 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 citizens and allow them share in the economic development in downtown Buffalo.
2. **Putting technology to work to support accessible transportation**, bringing leading edge researchers in accessible transportation, transit, and connected automation to solve a real need.
3. **By developing a scalable model** for considering accessibility and universal design in transportation technology projects

The pilot 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 1.

The deployment is one of the Phase 1 Complete Trip – ITS4US Deployment Program projects selected to showcase innovative business partnerships, technologies, and practices that promote independent mobility for all travelers regardless of location, income, or disability.

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), key demographic metrics—such as percentage of zero vehicle households, black population, percentage of people over the age of 65, and households with income of less than \$25,000—are far below average for the Metropolitan Statistical Area (MSA). Conversely, in the Fruit Belt and Masten Park neighborhoods (east of Main Street), these metrics are above average for the MSA.



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%	110701	255,423

BNMC sits adjacent to the Fruit Belt neighborhood, which has a poverty rate of 25%, 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 via public transportation to dispersed jobs in the suburbs 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. 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 experimental approach to find the most effective approaches for supporting trip-making. In detail, this project seeks to deploy an integrated suite of technologies, namely:

- An Open Trip Planner (OTP) based transit trip planning app that is customized for accessible travel.
- An electric self-driving feeder shuttle service that is integrated with the app that provides circulation in BNMC campus.
- Two universally designed intersections that use tactile and mobile technologies to enable travelers with disabilities navigate intersections.
- Low-cost sidewalk interventions on BNMC properties to improve accessibility.
- Improvements to outdoor wayfinding and integration of indoor wayfinding with select partners within the BNMC campus.

1.2. Intended Audience

This UNIRP is a foundational document that is intended for the following audiences:

- Project partners and stakeholders – For the project partners in Buffalo, the document provides the definitions of the anticipated users of the pilot and the methods anticipated as part of the user needs gathering effort. Section 2.2 provides an initial list of partners and stakeholders groups
- United States Department of Transportation (USDOT) – For USDOT, this document describes the approach by which the deployment users are engaged; and also the processes by which the user needs will be maintained and used for downstream system engineering processes.

1.3. UNIRP Update Process

While the UNIRP is a living document, the processes established in Sections 2 and 3 are expected and required to be stable. The UNIRP will be monitored quarterly and, if needed, updated to account for the following primary changes:

- Recommended edits/additions/deletions to user groups and definitions.
- Additions/deletion of user needs identification processes.
- Changes to configuration control processes including tools, methods used to manage requirements.

It should be noted that if a significant change is made, then the UNIRP will be updated following that change. All minor updates will be addressed in our quarterly revision of the document.

Finally, the process stated here is for updating the UNIRP document itself. The process to manage changes and updates to needs and requirements are discussed in Section 4.

1.4. Applicable Documents

The UNIRP serves as an initial step of the general system engineering process and identifies a set of information that will be used in the creation of the following documents:

- Concept of Operations (ConOps)
- System Requirements (SyRS)
- Systems Engineering Management Plan (SEMP)

2. User Needs Identification

2.1. Introduction to User Needs

A robust identification and clear description of user needs is a foundational step in the System Engineering process. User needs represent the gaps in the current system and the needs of the stakeholders, to which all of subsequent systems engineering processes (e.g., conceptualization of the proposed system and definition of the requirements of such system) must trace back to.

This project will follow the following critical element when writing the user needs for this project:

- Each need should be **Uniquely Identifiable**, with an unique number and title.
- Each need should describe a **Major Desired Capability (MDC)** in the system.
- Each need should be **Solution Free**, without any reference to technologies or approaches (existing or proposed).
- Each need should **Capture Rationale** as to why it should be address by the new system.

User needs for the deployment will be grouped by the areas below.

- **Personalized pre-trip planning:** Ability for a person to plan a personalized trip that meets their abilities and preferences.
- **Personalized Trip Execution:** Ability for a person to execute a personalized trip that meets their abilities and preferences.
- **Inclusive Infrastructure:** Ability for a person to safely cross an intersection, ability to provide information to pedestrian regarding potential obstacles in their path (e.g., snow and sub-optimal infrastructure), **Also includes needs around** curb cuts, accessible sidewalks and bus stops.
- **External wayfinding and Indoor navigation:** This refers to directions to get to the final destination, including outdoor and indoor navigation.
- **Trip Connectivity and Mode Transfer needs:** This includes the need to address the first- and last- mile challenge (e.g., connect between the location of a transit or metro stop to the final destination), information on transfer options, real-time transit arrival and departure information.
- **Real-time information** - These needs are oriented around collecting and reporting current condition of the transportation system for both operations and traveler information.
- **Business needs** – These needs are more oriented around business operations of various system components envisioned as part of the complete trip system.

Example User Need:

T-22. Paratransit Access Line (PAL) Users accessing Public Fixed Route Transit. The system needs to provide the ability for PAL users to execute same day trip or non-paratransit trip using public transit travel options based on user inputs of origins and destination. This allows a PAL user the ability to make unanticipated trips or undertake trips for which paratransit services are not available.

2.2. User Needs Groups

The Complete Trip Deployment in Buffalo, NY will have two key groups of users: *Travelers* and *Institutions*.

- The **traveler user group** accounts for people with disabilities, people in the targeted neighborhoods and general travelers who are either employees or visitors to the campus. The following sections provides the anticipated user types for the pilot.
- The **Operator/Partner user group** accounts for infrastructure owners and operators (IOOs) of transit/local roadways (e.g. NFTA), public health partners (e.g., BNMC) and other agencies/employers in the area of interest. Note that institutional users are not the same as stakeholders. *Institutional users in this context are defined as the center, field, vehicle and traveler information systems that are necessary for the complete trip deployment.*

2.2.1. Travelers User Group Types

Table 2 identifies the traveler user group types of interest to the deployment. Note that user group types are not mutually exclusive.

Table 2. Traveler User Group Definitions

Population	Type of Disability	Abbreviation	Short Description
Persons with Disabilities (PWD)	A person with a disability is defined by the 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 impairment ¹ . For the purpose of this deployment, users with four types of disabilities are identified.		
	Mobility	PWD-M	This category of users includes various physical disabilities that affect both gross and fine motor skills that may require a personal assistance device.

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

	Vision	PWD-V	This category of users include those with minor to serious vision impairment resulting in a decreased ability to see.
	Cognitive	PWD-C	This category of users include a variety of medical conditions that impair cognitive functions.
	Hearing	PWD-H	This category of users include those that are completely or partially deaf.
	Paratransit Access Line (PAL)-Eligible	PAL-Eligible	This category of users is eligible based on NFTA's criteria for door-to-door transportation services on the PAL line.
Low Income	NA	LI	Residents and travelers with annual incomes <26K that use and traverse the BNMC.
Older Adults	NA	OA	Residents and travelers to BNMC over the age of 70.
Low English Proficiency	NA	LEP	Residents and travelers to BNMC who do not use English as their primary language of communications.
General/All	NA	GA	Category for all other travelers as well needs that are generally applicable.

2.2.2. Operator/Partner User Group Types

Table 3 lists the operator/partner users of the complete trip system. Note that as system concepts are developed, additional institutional users may be added to this list.

Table 3. Operator/Partner User Group Definitions

User Group	Abbreviation	Short Description
NFTA Paratransit Operations (PAL)	NFTA-PAL	Systems (call center, web, and phone) and personnel used to support PAL operations
NFTA Operations	NFTA-Ops	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	CoB-Ops	Systems and personnel responsible for the streets, signals, sidewalks, bridges, traffic systems in the deployment area
NITTEC	NITTEC	Systems and personnel responsible for traffic operations collaboration in the Buffalo region.
Regional Travel Demand Management (TDM) Services	TDM	Systems and personnel involved in travel demand management activities in the region including campus-wide initiative to create a more sustainable and active transportation system for employees on the Buffalo Niagara Medical Campus (BNMC TMA), statewide mobility management services (NSYDOT 511NY Rideshare)
NYS Department of Motor Vehicles	NYSDMV	Systems and personnel responsible for permitting self-driving shuttle operations

Emergency and Law Enforcement Entities	EM	City, state and transit law enforcement and emergency systems and personnel responsible for monitoring emergency, safety of traffic and transit operations. Includes City of Buffalo, NFTA and NY State Police that may have jurisdiction in the system of interest.
BNMC Campus Entities	BNMC BNMC-RP BNMC-Via BNMC-KH BNMC-UB BNMC-BHSC	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 <ul style="list-style-type: none"> • Roswell Park (RP) • Via • Kaleida Health (KH) • University at Buffalo (UB) • Buffalo Hearing and Speech Center (BHSC)

2.3. User Needs Identification Processes

User Needs are gathered through four primary processes:

- Literature Review, Data and Existing Planning Documents
- Partner Interviews
- Traveler Focus Groups
- User Needs Definition Workshop

The process flow for user needs identification is shown in Figure 2. As can be seen, the process is sequential, which allows the project team to modify/update the user needs as we progress from one to another. It should be noted that until regulations and safety guidance related to COVID-19 change, all stakeholder/user engagements in this initial phase of the project will take place in a virtual environment.

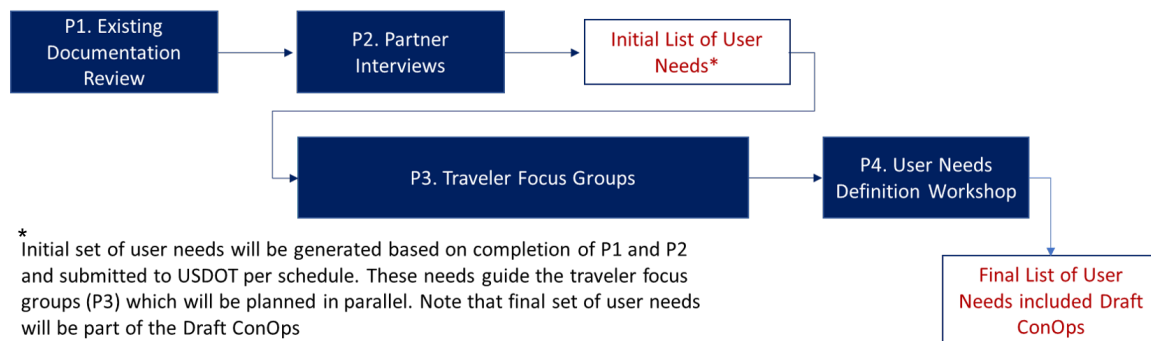


Figure 2. User Needs Identification Process

2.3.1. Literature Review, Data and Existing Planning Documents

Literature/findings of previous and ongoing efforts, including project proposals are used as a starting point to define user needs. The following is an initial list of resources that the project team will review:

- Information gathered as part of the ITS4US Complete Trip Deployment in Buffalo, NY project proposal.
 - National Center for Mobility Management: “The Complete Trip: Helping Customers Make a Seamless Journey”.
 - USDOT “Vehicle-to-Pedestrian Research at the USDOT: White Paper” (2017).
 - STCS Pre-Trip Planning and Virtualization: Project Report - Leveraging Innovative Technology to Develop the Smart Travel Concierge System to Facilitate Pre-Trip Planning and Virtualization for Individuals with Cognitive Disabilities.
 - Intelligent transport systems — Indoor navigation for personal and vehicle ITS station —Part 1: General information and use case definition (2016).
 - Census/demographic data for Buffalo and its Metropolitan Statistical Areas.
- USDOT Reports
 - Multimodal and Accessible Travel Standards Assessment project interviews of leading advocacy groups for underserved communities on barriers and practices to mitigate barriers (internal notes) for Complete Trip travel.
 - Smart Columbus mobile app concept of operations and foundational efforts
- Existing Planning Studies
 - Four Neighborhoods, 1 Community, BNMC Report
 - Main Street Smart Corridor Plan, City of Buffalo (2020)
 - GBNRTC & NFTA Transit Oriented Development (TOD) Study
 - Congress for the New Urbanism, The Future of Mobility: Remaking Buffalo for the 21st Century
 - 2021 Streetscape Project
 - Central Business District North Transportation Study (2017)
 - Buffalo Niagara Medical Campus Comprehensive Transportation Study (2010)
 - Residential Parking Benefits District Study, Fruit Belt Neighborhood, Buffalo, NY (2016)
- Existing technical reports
 - Self-Driving Electric Vehicles for Smart and Sustainable Mobility, NYSEDA report by University of Buffalo (UB)
 - NYU Research on Pedestrian Safety Countermeasures for Visually Impaired and Blind Community in New York City
 - Transit Technology - New York Open Trip Planner, New York 511NY Rideshare, NFTA Fare System Upgrade]
 - Regional Smart Mobility Initiatives - NITTEC: A Connected Region - ATCMTD Initiative
 - UB, Accessible Public Transportation: Designing Service for Riders with Disabilities
 - UB, DR-06 Pedestrian Winter Accessibility
 - Autonomous Vehicles: Driving Employment for People with Disabilities
 - Fully Accessible Autonomous Vehicles Checklist
 - AVs & Increased Accessibility Workshop Series
 - NFTA-Metro 2019-2020 Annual Performance Report
 - Advancing Smart Card and NFC Technologies at the Buffalo Niagara Medical Campus (2017)
- Existing data on travel

- Detail on travel patterns by the populations of importance (e.g., percent of trips to/from BNMC involving people with disabilities). It is possible this data may be hard to obtain or only available at a highly aggregated level
- Analysis of NFTA Americans with Disabilities Act (ADA) database on trip origins and destinations
- Known travel data (volumes, origination location) to/from BNMC, as well as if this data includes any segmentation data (e.g., travel mode to/from BNMC for employees/visitors)
- Pre-pandemic on-demand on-demand shuttle ridership for Kaleida employees, patients and visitors.

In particular, the listed planning studies have all conducted significant stakeholder outreach as part of their scope gathering detailed feedback on traveler needs and desires. Existing data on travel may also reveal implied travel needs for users. Technical studies listed here have also considered various travel needs.

2.3.2. Partner Interviews

A significant portion of user needs gathering, especially for the institutional user group are expected through 1-on-1 or small group interviews. These structured interviews will be conducted by the project team and will either be 1 hour (1-on-1) or 90 minutes (for a small group interview). Due to ongoing pandemic restrictions, all interviews will be virtual. Prior to the interview, the project team will send out the following:

- 1 page fact sheet explaining the Complete Trip Deployment
- Interview guide with specific questions for the partner

Interview with partner agencies are expected in early April 2021, with a short interview summary created for each partner interview. All interviews are recorded for note taking purposes and transcribed.

A draft list of user needs will be generated at the end of partner interviews and submitted to USDOT since the schedule calls for a Needs Summary to be submitted in mid-April.

2.3.3. Traveler Focus Groups

This approach will collect the needs of the travel users through small, targeted interactions with representatives of anticipated traveler types. An initial list of representatives will be identified through the previous partner interviews and our team's knowledge and prior working experience with the disability community in Buffalo. This will also serve as an opportunity to introduce the project to the community, identify potential participants of the travel monitoring and start capturing the interest/buy-in from potential users of the system during its demonstration in Phase 3. The team will reach out to the following organizations to gather their inputs and recruit travelers for focus groups.

- AARP New York
- Age Friendly Erie County
- Allentown Association

- Buffalo Center for Health Equity
- Erie County Senior Services
- Fruit Belt Coalition
- Heart of the City/Interim Director Fruit Belt Community Land Trust
- Local Initiative Support Coalition WNY
- Masten Block Club Coalition
- Population Health Collaborative
- WNY Independent Living
- Aspire of WNY
- Center for Self Advocacy
- Deaf Action Center
- National Federation of the Blind, Buffalo Chapter
- Northeast ADA Center
- People Centered Services
- People Inc.
- WNY Independent Living Inc, Center for Self Advocacy

Focus groups and traveler-related sessions will be held virtually and tentatively take place around mid-April / early May 2021 and be largely completed before the submission of the Draft Concept of Operations (ConOps).

Focus groups may also take advantage of existing forums and accessibility advisory committees such as the one hosted by NFTA. Project team members like Open Door Organizations and the UB IDEA Center will leverage their existing connections with various accessibility related stakeholder groups to identify the best forums to conduct the focus groups as well as the best set of tools/methods to deliver these focus groups. Focus groups may also leverage existing transportation coalitions like the Fruit Belt Coalition.

The focus groups will be structured around the concept of user journeys to and from BNMC and seek to identify the pain points associated with travel for the group. User-focused journeys provide a clear and targeted description of travelers to elicit needs from non-technical users. We acknowledge the potential for participant to raise varying needs, even in targeted focus groups (e.g., visual and cognitive needs). To this end, the team will present typical journeys and ask users to describe their current experiences, challenges, barriers and constraints in their travels, accounting for all their needs. The discussion will also engage in how to lower the barriers for

more seamless travel and describe examples of strategies to lower the barriers and improve mobility. Exact protocols for gathering input from different traveler groups are still being defined.

A facilitation plan will be developed and used as a guide in conducting these focus groups. The project team anticipates that 4-6 focus groups may be needed to adequately cover the diversity of the travel groups.

2.3.4. Final User Needs Definition Workshop

The project team will conduct an internal user needs and concept definition workshop to validate and organize findings from the other user need gathering processes. The workshops will be held virtually and are for the internal team and is scheduled for May 13-14. All major stakeholders will be invited to the 2-hour workshop where the project team will walk through the findings of the user engagement and validate the final set of user needs. These user needs will form the basis of the draft ConOps.

2.3.5. Use Case Decomposition

Broadly, use-cases are decomposed following the logic provided below for the traveler group. Use-cases or scenarios start with a major scenario and progressively decompose the scenarios to address a specific set of user needs. The following decomposition illustrates the anticipated use-cases for the traveler group but the final list of use-cases will be determined in the Concept of Operations. It is likely that some of these scenarios may be combined or decomposed differently to best illustrate the concept. The following list is illustrative of the types of scenarios being considered.

- Major Scenario #1: Traveler Arriving/Leaving at Campus
 - S1.1 ADA Eligible Transit Travel
 - Scenario1.1.1 Paratransit Access Line to/from Campus
 - Scenario 1.1.1.1 Pre-Trip Planning
 - Described By disability type
 - Scenario 1.1.1.2 Trip Selection
 - Scenario 1.1.1.3 Trip Execution
 - S1.2. Non-ADA Eligible or Fixed Route Transit Travel
 - Scenario1.2.1 Fixed Route (Bus) Line to/from Campus
 - Scenario 1.2.1.1 Pre-Trip Planning
 - Scenario 1.2.1.2 Trip Selection
 - Scenario 1.2.1.2 Trip Execution

- Scenario 1.2.3 Fixed Route (Rail) Line to/from Campus
 - Scenario 1.2.3.1 Pre-Trip Planning
 - Scenario 1.2.3.2 Trip Selection
 - Scenario 1.2.3.3 Trip Execution
 - S1.3 Personal Vehicle Travel
- Major Scenario #2: Traveler Navigating Campus
 - Scenario 2.1 Walking from transit or parking to partner facilities on external paths
 - Scenario 2.1.1 Intersection crossing
 - Scenario 2.1.2 External Wayfinding
 - Scenario 2.2 Using self-driving shuttle
 - Scenario 2.2.1 Hail Trip
 - Scenarios 2.2.2 Execute Trip
 - Scenario 2.3 Walking from transit or parking to partner facilities on external paths

Linking our use-cases to user-needs is through the user needs framework created by the team. All of the traveler related user needs includes the following categories:

1. Unique ID – provides an unique identifying code for each need.
2. Population Group – provides insight into the population group being represented by the need.
3. Types of Disability – details the type disability associated with the population group.
4. Travel Modes – refers to the mode of travel addressed by the need, for the selected population groups and, when applicable, their disability.
5. Geographic Context – determines whether the trip is taking place within the BNMC campus or to/from the campus.
6. Trip Context – indicates the traveler purpose when visiting the campus.
7. Need Area – refers to the element of the complete trip being address by the need.
8. Need Title – provides a unique title for the need.
9. Need Statement – details the need for the selected categories previously identified.

A particular need title and statement applies to a selection of choices from bullets 2 to 7 as shown in the figure below. This framework (Figure 3) allows the team to continuously monitor the user needs and update them as information from ongoing user engagement becomes available. Since the framework is set up as a sortable table, needs can be quickly sorted into useful categories. This approach would allow us to take higher-level user needs to system design. For example, this framework allows us to filter all needs that apply to:

1. A particular population (PWDs, Older Adults) – this helps the team engage that population group effectively in our interviews and focus groups
2. A particular mode – this helps team refine our thinking on specific modal needs. For instance, by selecting the self-driving shuttle, all needs associated with that mode are collated for further analysis by the team.

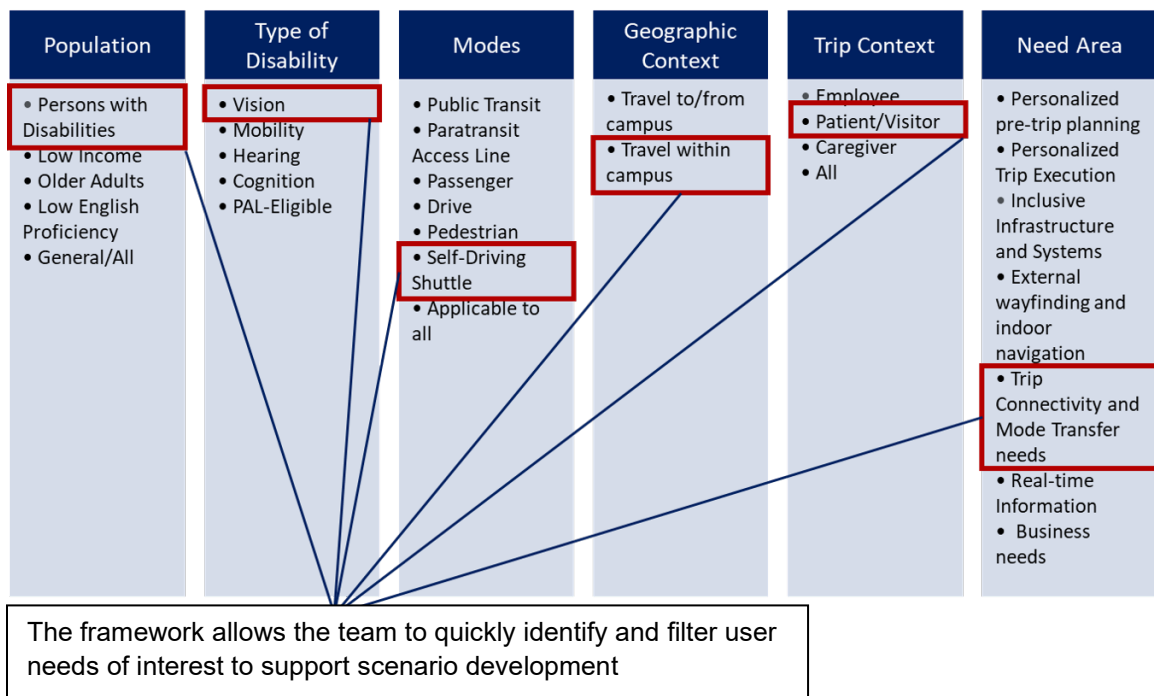


Figure 3. Framework to User Needs Development

This framework allows us to tie the scenarios to the user needs. For instance

- Scenario 2.2. Using Self-Driving Shuttle would include all needs where the mode Self-Driving Shuttle is listed as well those needs which are applicable to all.

2.4. Mapping User Groups to Processes

Table 4 maps the identified user groups to the user need identification process. The primary unknowns are the exact dates and forums for the remaining traveler focus groups.

Table 4. Mapping User Needs to User Need Identification Process

Group	Primary User Need Identification Process
NFTA Paratransit Users	Traveler Focus Group: Leverage NFTA Accessibility Advisory Committee
Low Income Residents in Deployment Neighborhood Target Area	Traveler Focus Group: Leverage local coalitions like Fruit Belt Coalition
Travelers to BNMC with Disabilities	Traveler Focus Group: TBD
Older travelers to BNMC	Traveler Focus Group: TBD
General visitors and employees at BNMC	Partner Interview: Go BNMC
NFTA PAL Service Dispatch Operations	Partner Interview: NFTA
Go BNMC	Partner Interview: Go BNMC
NFTA Fixed Route Bus Operations	Partner Interview: NFTA
NFTA Rail Operations	Partner Interview: NFTA
NFTA Traveler Information Systems	Partner Interview: NFTA
BNMC Partner Agency Transportation Coordinators	Partner Interviews: BNMC Member Agencies
City of Buffalo Division of Engineering	Partner Interview: City of Buffalo
NITTEC	Partner Interview: NITTEC

2.5. Concept of Operations Development

User needs form the basis of the concept of operations. The complete set of user needs of the system, identified to that date, will be documented in the ConOps and will be used to define major functional capability of the desired system. Process-wise, the ConOps development begins in earnest and in parallel to the user needs gathering. As the user needs are being gathered, the team will assemble information to support the followings of the ConOps.

1. Scope overview
2. Existing conditions and baseline inventory

The complete set of user needs and the user engagement will drive the development of the Justification of Changes section of the ConOps. The team will then develop the desired system capability and subsequent chapters of the ConOps based on the user needs. Internal meetings

and workshops will guide the development of the desired system capability as well as the operational scenarios.

Subsequent to the draft ConOps, a walkthrough of the ConOps with a review panel consisting of USDOT and regional stakeholders allows for further refinement of the Concept including refining the user needs if necessary.

2.5.1. ConOps Development Schedule

Table 5 includes the ConOps development schedule.

Table 5. ConOps development schedule.

Task Name	Duration	Start	Finish
Stakeholder ConOps Review Panel Roster	4 wks	Tue 4/6/21	Mon 5/3/21
Stakeholder ConOps Review Panel Roster (Draft)	2 wks	Tue 4/6/21	Mon 4/19/21
USDOT Review	1 wk	Tue 4/20/21	Mon 4/26/21
Stakeholder ConOps Review Panel Roster (Final)	1 wk	Tue 4/27/21	Mon 5/3/21
Needs Summary	4 wks	Tue 4/6/21	Mon 5/3/21
Needs Summary (Draft)	2 wks	Tue 4/6/21	Mon 4/19/21
USDOT Review	1 wk	Tue 4/20/21	Mon 4/26/21
Needs Summary (Final)	1 wk	Tue 4/27/21	Mon 5/3/21
Concept of Operations	15 wks	Tue 4/6/21	Mon 7/19/21
Concept of Operations (Draft)	7 wks	Tue 4/6/21	Mon 5/24/21
ConOps Walkthrough Briefing Deck	1 wk	Tue 5/18/21	Mon 5/24/21
ConOps Comment Resolution Report (Draft)	2 wks	Tue 5/25/21	Mon 6/7/21
Concept of Operations (Final)	3 wks	Tue 6/8/21	Mon 6/28/21
ConOps Comment Resolution Report (Final)	3 wks	Tue 6/8/21	Mon 6/28/21
ConOps Webinar (public)	3 wks	Tue 6/29/21	Mon 7/19/21

2.5.2. ConOps Walkthrough

The project team will provide a walkthrough of the ConOps. At the time of this document, the project team has the following considerations:

- The project team will develop a walkthrough plan following, to the extent possible, the IEEE Standard 1028. The plan will detail the structure, length, logistics and expected participants of the walkthrough.
- The project team will develop a walkthrough workbook and share it with participants at least 1 week prior to the walkthrough. The workbook will have an easy to follow list of sections that detail the user needs, the conceptual system and its components, and user stories to provide insight into how users can interact with the proposed system,. The workbook will also have space for notetaking and redlining.
 - The walkthrough main purpose will be to verify that the user needs are comprehensive and meet the criteria of well-written needs (see Section 2.1), and that the concept design addressed these needs.
- The expected length of the walkthrough is around 2-4 days—this will be better defined once the system is fully conceptualized. Unfortunately, the walkthrough will likely be

conducted virtually rather than in-person. Given the challenges of conducting a virtual multi-day walkthrough, the team will continue to define the walkthrough format over the next couple of months

The following sections illustrate the team's current thinking on the walkthrough process.

2.5.2.1. ConOps Walkthrough Purpose

The purpose of the walkthrough is to primarily assess the following

1. Ensure that the list of user needs is comprehensive, with no needs missing.
2. Evaluate the adequacy of the user need and identify if the criteria was met (i.e., uniquely identifiable, major desired capability, solution free, and capture rationale).
3. Verify desired system capabilities are solution-free and trace directly to the user needs.
4. Evaluate whether operational scenarios adequately and in a non-technical manner describe the core functions of the system and link directly to user needs.
5. Identify if constraints, user classes, and impacts are correctly defined for subsequent system engineering steps.

2.5.2.2. ConOps Walkthrough Proposed Structure

The ConOps walkthrough will be held in blocks over 2-4 days that enables effective validation of the ConOps while ensuring that stakeholder time commitments are appropriately managed. The project team anticipates two hour blocks but the duration of the block may be determined by the content in that section under review (see Table 6).

Table 6. Walkthrough Structure

Walkthrough	Activity	Project Team Attendees	Stakeholder groups	Pre-Work	Output
Block 1 – Opening Session	Overall presentation of the ConOps	USDOT, Noblis, Project Team	Invite both institutional and traveler group here	Review word document of Draft ConOps	Initial feedback from broad group of stakeholders
Block 2- Technical Session – Needs Validation Review	User Needs Review	USDOT, Noblis, Project Team	Specific stakeholders will be identified by user needs areas. User needs will be grouped	Prior editorial feedback on user needs	Comments, revisions to the user needs

Walkthrough	Activity	Project Team Attendees	Stakeholder groups	Pre-Work	Output
Block 3- Technical Session: Desired System Capability Review	Review of desired system capability, user classes and functions	USDOT, Noblis, Project Team	All institutional stakeholder group	Review of context diagram, feedback on users	Comments, revisions to Desired System
Block 4 – Technical Session: Operational Scenario Review	Review of operational scenarios	USDOT, Noblis and Project Team	Specific stakeholders will be identified by scenarios. User needs will be grouped	Editorial review of operational scenarios	Comments, revisions to existing scenarios and identification of missing scenarios
Block 5 – Walkthrough Summary Recap	Summarize walkthrough feedback	USDOT, Noblis, Project Team	All institutional group stakeholders will be invited.		Walkthrough summary report

2.6. Agile Development Considerations

No agile development considerations are anticipated for the ConOps. Regardless, if any agile process is introduced to the ConOps development, we expect that this will have no effect on the document itself and user needs as these will be maintained separately from any agile processes.

3. Requirements Planning

3.1. Introduction to Requirements Planning

The International Council on Systems Engineering (INCOSE) *Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities*² defines systems requirements as the foundation of the system definition, architecture and design. Each requirement described in his project will be traced to one or more user need. This relation will be documented to ensure that the system ultimately meets all of the user needs.

This project will follow the guidance of the handbook for defining and structuring well-formed systems requirements. As such, the following criteria will be used to from system requirement:

- **Necessary** – avoiding unnecessary effort in the form of processing, maintenance and verification.
- **Implementation Independent** – avoiding external influence in the system design.
- **Concise** – clearly stating only one need, without requiring any explanations, rationale, definitions, or descriptions of system use.
- **Feasible** – being achievable within the project scope and resources.
- **Complete** – providing the information necessary to stand alone without the need of further explanation.
- **Consistent** – not contradicting nor duplicating other requirements.
- **Bounded** – defining the required scope for the solution to be met.
- **Traceable** – being linked to its source, needs and related requirements that might be impacted by changes to it.
- **Verifiable** – being able to be verified by inspection, analysis, test or demonstration.
- **Allocate-able** – being part of an appropriate component within the system hierarchy.
- **Style-compliant** – following the established template in terms of content and format.

Good requirements will generally take the form: [Actor] [Action] [Target] [Constraint] [Localization]. For example:

The Complete Trip App [Actor] shall provide [Action] audio notifications of the estimated arrival time for the self-driving shuttle [Target] based on the user's location identified in the App [localization].

If a requirement cannot be stated in this format, then the project team will define the functionality using multiple requirements—following the criteria mentioned above.

² INCOSE (2015). *Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities*. 4h Edition.

3.2. Requirement Decomposition

The scope of the system, subsystem and components identified four major components of the system described below. It is important to note that the extent of the system will depend on the needs summary and ConOps generated in Task 2. The project team will document once a hierarchy is developed using the categories, concepts and groups below. Note that this is an initial list and more could be added later on when the system is fully conceptualized and here is more clarity in the necessary system/subsystem/components.

- **General:** These requirements specify high level requirements, regulatory, compliance, and other policy level requirements. Requirements may include environmental conditions, construction policies, phases, and references to overall policies that drive the system lifecycle processes and work.
- **Component Level Requirements** are described below:
 - **Functional:** These are the usually the most important requirements, as they specify what functions they system must perform. The requirements that specify how an application must work are usually considered functional requirements.
 - **Physical:** Physical requirements are those requirements that specify the physical characteristics of a devices, equipment, materials and other physical infrastructure objects. The physical also includes computing infrastructure and equipment such as cloud or on-premise environments.
 - **Performance:** Performance requirements are those requirements that specify how the system has to perform. This would include things like providing an alert within a specific timeframe, specifying a specific data rate, or how accurate the data the system/subsystem/component must be.
 - **User Interface:** For user facing applications, requirements describe presentation, channelization and accessibility of information to the user by device form factor (e.g., web, mobile, kiosk, other). The user interface includes haptic, visual, auditory, and tactical presentation of information to all users.
- **Communication:** These requirements define the communications infrastructure and equipment, and the Open Systems Interconnection (OSI) profiles, frequencies, channels, monitoring tools and performance needed to implement the interconnectivity of the components / subsystems throughout the system.
- **Security:** These requirements define what level of security would be necessary for specific parts of the system/subsystem/component. This would include any special data storage requirements for things like Personally Identifiable Information (PII) or financial transactions.
- **Interface:** Interface requirements define any constraints on how the system/subsystem/component exchanges information with other another system/subsystem/component including encoding, message content, orchestration, and standard profiles. Where standards exist, a validated specification or protocol requirement list (PRL) is expected.

3.3. System Requirements Traceability

A needs to requirement traceability matrix (NRTM) will be developed to manage, control and trace needs to requirements. The NRTM will also serve as the single source of truth for the requirements definition. The NRTM format is a tool that provides capabilities to ensure consistency, completeness, and cross tabulation of characteristics based on any of the columns in the matrix. In addition, each requirement may be extended to incorporate and track changes throughout the system development lifecycle. Table 7 provides the fields the development team expect to have in the NRTM.

Table 7. Fields in the Requirement Traceability Matrix.

Column Heading	Description
Req. ID	A unique identifier for each requirement.
Subsystem	Subsystem of the system will be defined in the ConOps.
Component	A component is a child of a subsystem. System components will be defined in the ConOps.
Requirement Type	Category described by the type of requirement 1 General 2 Component 2.1 Functional 2.2 Physical 2.3 Performance 2.4 User Interface: 3 Communication 4 Security 5 Interface.
Need ID	The need corresponds to a unique identifier defined in the ConOps.
Need Description	The need description as described in the ConOps.
Req. Title	A title for the requirement.
Req. Description	A description for the requirement.
Priority	Requirement priority -- High [H], Medium [M], Low [L]
Required	Describes if the requirement is mandatory [M] or optional [O] or conditional on another requirement [C-#] where # is the requirement ID it is dependent on.
Verification Test	Describes how the requirement should be verified. The verification categories include: observation, compliance test, test.
Date Inserted	The original date wherein the requirement was inserted into the spreadsheet.
Inserted By	Initials of the person who inserted the original requirement.
Req. Source	The source for the requirement, if extracted from another specification or document.

3.4. System Requirements Document Development

The SysRs document will be developed per the following schedule.

Table 8. SyRS development schedule.

Task Name	Duration	Start	Finish
Stakeholder SyRS Review Panel Roster	4 wks	Tue 8/3/21	Mon 8/30/21
Stakeholder SyRS Review Panel Roster (Draft)	2 wks	Tue 8/3/21	Mon 8/16/21
USDOT Review	1 wk	Tue 8/17/21	Mon 8/23/21
Stakeholder SyRS Review Panel Roster (Final)	1 wk	Tue 8/24/21	Mon 8/30/21
SyRS Document	17 wks	Tue 6/29/21	Mon 10/25/21
SyRS Document (Draft)	12 wks	Tue 6/29/21	Mon 9/20/21

SyRS Walkthrough Workbook	12 wks	Tue 6/29/21	Mon 9/20/21
Walkthrough Comment Resolution Report (Draft)	2 wks	Tue 9/21/21	Mon 10/4/21
SyRS Document (Final)	3 wks	Tue 10/5/21	Mon 10/25/21
Walkthrough Comment Resolution Report (Final)	3 wks	Tue 10/5/21	Mon 10/25/21

3.4.1. SyRS Walkthrough

The project team will provide a walkthrough of the SyRS as part of Task 6 of this Phase. The project team expects to conduct the walkthrough in person. However, the project team will plan to have a flexible approach to accommodate a virtual or hybrid environment if needed be (i.e., both in person and virtual through video conferencing platform such as Adobe Connect, Google Meet or Teams). The platform to be used will be selected closer to the completion of the SyRS and based on the easiest of access to all participating parties.

At the time of this document, the project team has the following considerations:

- The project team will develop a walkthrough plan following, to the extent possible, the IEEE Standard 1028. The plan will detail the structure, length, logistics and expected participants of the walkthrough. The reasons for deviations from the standard, if any, will be noted in the walkthrough plan and will largely be to accommodate virtual participation and staggered stakeholder involved.
- The project team will develop a walkthrough workbook and share it with participants in advance of the walkthrough. The workbook will have an easy to follow list of requirements and key SyRS sections, as well as space for notetaking and redlining.
 - The walkthrough main purpose will be to verify that the requirements are complete relative to the needs and to validate that they are well formed (e.g., necessary, concise and implementation-free) —as explained in Section 3.1.
- The expected length of the walkthrough is around 2-4 days—this will be better defined once the system is fully conceptualized.

3.5. Agile Development Considerations

No agile development considerations are needed for the development of high-level requirements. However, once the requirements are approved, the project team expects to take on a more agile execution approach especially for portions of the deployment involving software development. The product backlog will be created based on the high-level requirements developed as part of the systems engineering effort per the guidelines provided by USDOT.

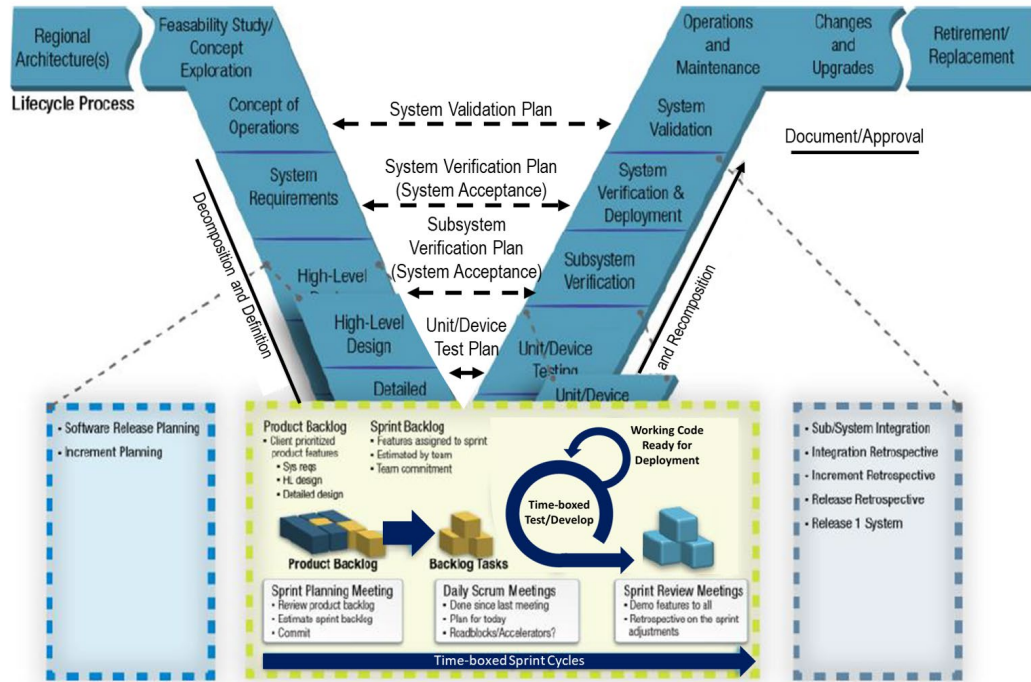


Figure 4. Using high-level system requirements to build product backlog for agile development (Source: USDOT/Noblis, 2017)

The project team recognizes that the ConOps will define the use-cases which can be treated as equivalent epics for the software development portion of the pilot. The user stories will be based on the needs identified and be developed to support the epics identified in the ConOps. Multiple requirements may be met by one user story.

4. Configuration Management

The project team will closely monitor the user needs and requirements and update the ConOps and SyRS as needed. Since all requirements and design trace to user needs, changing a requirement or a user need without the proper analysis can result in total rework to sections of the system, which would increase cost and incur delay.

4.1. Configuration Management Processes

The project team understands that user needs and requirements will change as the project moves from conceptualization to deployment. Three major processes are included in our configuration management.

4.1.1. High-Level Requirements and Needs Baseline

During the conceptualization stage (Tasks 2 and 6 in Phase 1), the project team will develop an initial set of needs and requirements following the process described in Figure 2. After a first round of validation (through the walkthroughs) and document approval by USDOT, this initial set of needs will become the baseline list of needs and requirements.

- The **initial** list of needs and high-level requirements will be developed through efforts that include a series of data collection and validation efforts.
- The initial list of needs and requirements will be **baselined** upon completion of their respective walkthrough and approval by USDOT of the final ConOps and SyRS. Once baselined, any deviations from the needs or requirements have to be reported back to USDOT, especially if they are not being addressed as part of future development activities.

4.1.2. Requirement Management Tools

The team is investigating the possibility using a requirements management (RM) tool that can provide a highly traceable, collaborative environment for maintaining, versioning, updating requirements while being able to integrate with other software development lifecycle tools.

The early steps in the project development process starting with user needs identification, concept of operations development and high-level system requirements are expected to follow a traditional waterfall approach.

For system design and development, while no decisions have been made yet, the team expects to follow an agile approach for several aspects of the system. Once the high-level requirements are baselined, a combination of Confluence/Jira is likely to be used for managing the software

development portions of this effort. This approach has been used extensively by various members of the project team.

4.1.3. Need and Requirement Change Management

If a change is needed to a high-level need or requirement, it would generally mean that a major system functionality was at risk and the change would be handled by the change management process defined in the project management plan. In summary, anyone within the project team, external stakeholders and the contract sponsors can request a change to the needs and requirements. Changes are considered *minor*, if they are mainly editorial and are used to reflect the updated status of the system without changing the scope of the project, or *major* changes, if they are beyond editorial and impact scope and overall approach of the project.

Changes to the user needs may fall into the following categories:

1. New user need. A need that was not included in our baseline but has been unearthed as part of the development activities. The impact of adding new needs will be different based on the timing of the need identification as well its scope. In terms of timing, the team hopes to limit new user needs to the early phases of planning but will consider needs as they are identified and follow the change management process.
2. Modifications to existing user needs - Changes to the existing needs can be suggested to clarify intent and refine scope. The project manager will triage these requests that go beyond minor edits through the change management process
3. Deletion of user needs – Needs may be deleted for various reasons including it no longer being a priority. In these cases, the change management process will be used to make sure the deletion does not significantly alter scope or affect project goals.

While all minor changes may not be necessarily logged (e.g., edits to the text to fix typos), all changes will be tracked, with major changes to baselined needs and requirements being logged and will require a formal and written request, which should include:

1. Name of the individual submitting the change
2. Organization
3. Description of the change
4. Justification of the change

The project leadership will log each change request with a unique tracking number and a status tag (open, accepted, denied) within a Change Log file located in the Teams site.

The project leadership will share the nature of the major changes with the USDOT COR. Upon approval to investigate the change, the project leadership will analyze the impact of the change on cost, schedule and resources needed to execute the change. Depending on the nature of the change, the project leadership may elect to do a high-level review or a full cost-schedule analysis. Based on the analysis, the project leadership will provide a recommendation along with

the analysis. The USDOT CO will be the final approver of any change requests that may impact contractual terms of the project.

4.2. Authoritative Source of User Needs and Requirements

The project team will maintain a controlled version of the ConOps (including the user needs) and the SyRS (including the requirements and the NRTM). The latest version of the documents will be saved in the project's Teams site, to which only the project team has access to. These latest version of the documents will be the authoritative source of user needs and requirements.

Controlled versions of the ConOps documents are those that are accepted and published by USDOT. In addition, for the near-term, the controlled list of user needs and requirements will be maintained in an Excel file for traceability purposes on the project collaboration site on Teams. In the future, the user needs, requirements and stories will be linked through Jira/Confluence with access provided to USDOT, Noblis and the project team.

Appendix A. Acronyms

Table 9 list the acronyms used in the document.

Table 9. List of acronyms

Acronym	Description
BNMC	Buffalo Niagara Medical Campus
ConOps	Concept of Operations
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronics Engineers
INCOSE	International Council on Systems Engineering
IOOs	Infrastructure Owners and Operators
MDC	Major Desired Capability
MSA	Metropolitan Statistical Area
NFTA	Niagara Frontier Transportation Authority
NRTM	Needs-to-Requirements Traceability Matrix
OTP	Open Trip Planner
SEMP	Systems Engineering Management Plan
SyRS	System Requirements
UNIRP	User Needs Identification and Requirements Planning
USDOT	United States Department of Transportation

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