Connecting Pedestrians with Disabilities to Adaptive Signal Control for Safe Intersection Crossing and Enhanced Mobility

System Requirements

Year 2 Update – May 2019

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16. Abstract

This project aims to develop a mobile app that enables pedestrians with disabilities to more safely and more efficiently cross signalized intersections. The proposed technology concept is a smart phone app that interacts directly with a real-time, adaptive traffic signal control system at the intersection via Dedicated Short Range Communication (DSRC) radio technology or wireless (cellular) radio technology. Basic capabilities will enhance safety by allowing the user (1) to communicate crossing intent and required crossing time, and receive an extended crossing duration, (2) to receive feedback if movement outside of the crosswalk is detected during crossing, and (3) to dynamically extend the crossing duration if slower than expected crossing progress is observed. Advanced capabilities will include anticipation of the user's arrival at the intersection and minimizing wait time and (2) utilizing real-time bus information to better synchronize user arrival times at bus stops.

This document details the overall requirements of the proposed app, as determined through interaction with potential users and other stakeholders. A requirements traceability matrix is developed and included.

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Chapter 1. Scope

1.1 Identification

This document is the System Requirements Specification (SyRS) of the "Connecting Pedestrians with Disabilities to Adaptive Signal Control for Safe Intersection Crossing and Enhanced Mobility" for the United States Department of Transportation's (USDOT) Accessible Transportation Technology Research Initiative (ATTRI) program.

1.2 Document Overview

This document specifies the system requirements for the system that the project team will develop and demonstrate which will connect pedestrians with disabilities to adaptive signal control systems for purposes of safe intersection crossing and enhanced mobility. The Concept of Operations (ConOps) document was developed as a prerequisite to this document and is recommended reading prior to reading the SyRS. As indicated in the Federal Highways Administration (FHWA) Systems Engineering (SE) Guidebook for Intelligent Transportation Systems (ITS) [3], the ConOps is the initial definition of the system, in which the the project team documents the way the envisioned system is to operate and how the envisioned system will meet the needs and expectations of the stakeholders.

The SyRS builds upon those concepts, particularly the user needs, to document the required functionality, performance, interfaces, and other characteristics of the System. The structure of this SyRS document is based on Institute of Electrical and Electronics Engineers (IEEE) Standard IEEE 29148-2011 Guide for Developing System Requirements Specifications [4] and FHWA SE Guidebook (SEGB) [3].

This SyRS consists of the following chapters:

- Chapter 1 provides an overview of safe intersection crossing application and an introduction to this document.
- Chapter 2 lists the documents used as background information and the sources of requirements.
- Chapter 3 provides the list of requirements for the safe intersection crossing application.
- Chapter 4 lists the Verification Method for each requirement from Chapter 3.
- Chapter 5 provides the Traceability Matrices tracing each requirement to User Needs and vice versa.
- Chapter 6 contains a glossary of terms, and a list of abbreviations and acronyms.

The purpose of requirements engineering is to transform the stakeholder and user needs into the functional view of a system that will meet those needs, typically in the form . This process builds a representation of a future system that will meet stakeholder needs and that, as far as constraints permit, does not imply any specific design or implementation. It results in measurable system requirements that specify, from the supplier's perspective, what characteristics it is to possess and with what magnitude in order to satisfy stakeholder requirements. This process also helps with identifying standards, boundaries, interfaces (internal and external), system functions, and design constraints.

The project will span two years with each year consisting a systems development cycle containing phases for ConOps and requirements specification, system design, development, test and demonstration. The first year was focused on the basic safe crossing features with the second year incorporating additional, more advanced features. This "Year 2" SyRS encompasses both the Year 1 and Year 2 requirements. Requirements engineering process is both iterative and recursive, and the SyRS will be a live document. Furthermore, as this project is using an agile approach for developing the *Safe Intersection Crossing* system, this SyRS will be updated periodically to reflect the evolving system design and development at subsequent stages of the project.

1.3 System Overview

This project will develop and demonstrate assistive services that ensure safe passage of injured veterans, older adults, and other persons with blindness, low vision, cognitive, or mobility related disabilities when crossing signalized intersections. It will leverage the smart traffic signal infrastructure to further provide these persons with significant mobility enhancements.

These services will be accessible to users via smartphones that are equipped with either Dedicated Short-Range Communication (DSRC) capability, or 3G/4G wireless capability. This will allow them to (1) access real-time information from the traffic signal infrastructure and nearby vehicles and (2) to actively influence traffic signal control decisions, which in turn will control vehicle movements at the intersection. The system is envisioned as a smartphone app that will provide accessible interfaces that allow pedestrians to:

- Communicate personalized intersection crossing constraints (e.g., movement speed, crossing direction) to the signal system
- Receive sufficient crossing time, and necessary information (e.g., geometric information about the intersection) to facilitate safe crossing, and
- Be alerted when a crossing movement indicates safety concerns (e.g., moving outside of the crosswalk).

Real-time monitoring of crossing performance will also be used to automatically extend the green time in real-time when appropriate. The system will also enable users to provide pre-planned pedestrian route and destination information (e.g., walking path and target bus stop) to the traffic signal infrastructure, which can be used in conjunction with other real-time information

(e.g., bus locations and routes) to adapt signal phase timings preemptively as the pedestrian approaches the intersection. This will lead to shorter and more reliable pedestrian travel times, and more efficient travel connections. Moreover, since the real-time traffic signal control system is optimizing all detected traffic flows at a given intersection, the approach will yield compound benefits in areas with large concentrations of disadvantaged pedestrians (e.g., near elder care facilities, retirement homes, schools for persons with disabilities, etc). A graphic identifying the principal components of the safe intersection crossing system is provided in Figure 1-1.

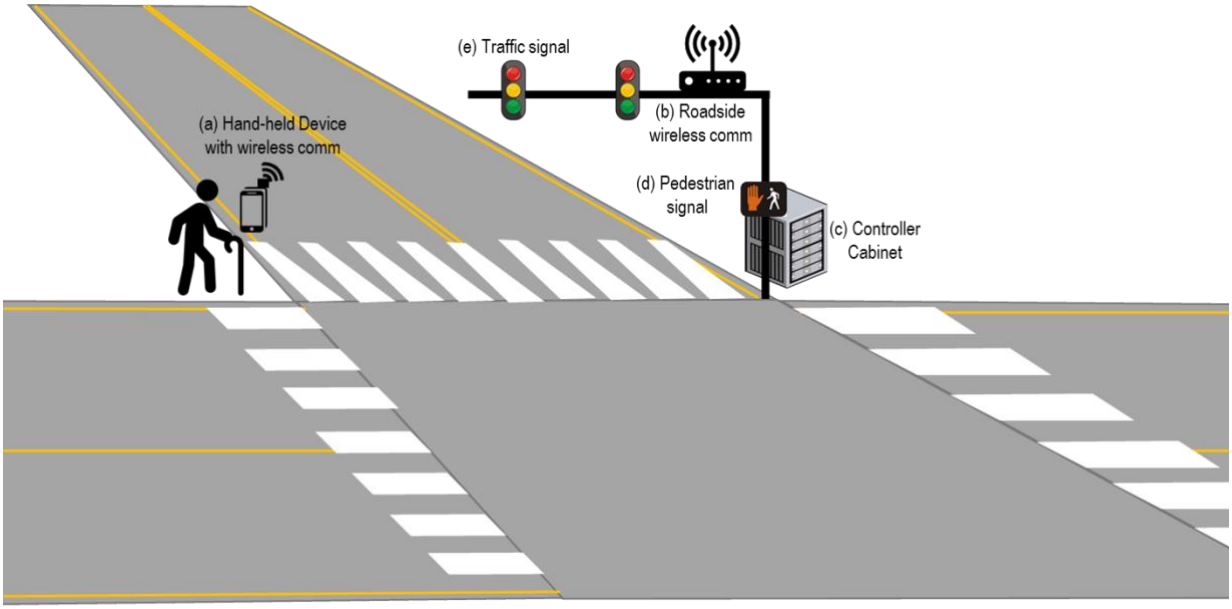

Figure 1-1: Components of the Safe Intersection Crossing System

1.4 Users and Other Involved Stakeholders

The local disability community will be the primary stakeholder group of the safe intersection crossing app. Individuals from this community will play two roles within the process. First, individuals will be engaged during the Phase 1 design process in Year 1 to develop understanding of user needs, requirements, and challenges. Second, a larger number of individuals will be recruited to participate in both the Year 1 and Year 2 Phase 3 field test experiments of the prototype system. While our mobile app development perspective will be on universal design, our prototyping effort and field–testing will focus on blind pedestrians.

On October 24, 2017, an initial meeting of stakeholders was held to illicit important user needs. The meeting included individuals from the following local Pittsburgh organizations in addition to members of the Safe Intersection crossing project team. This group will be responsible for the design, development and evaluation of the safe intersection crossing app:

1. Blind and Vision Rehabilitation Services of Pittsburgh (BVRS) – Representation from BVRS included the Associate Director of Accessibility Technology and an Orientation and Mobility (O&M) Specialist. O&M Specialists are the individuals responsible for

training blind individuals to safely cross signalized intersections. An experienced O&M Specialist has trained 100s of individuals, and consequently, can be expected to bring a much broader range of user experiences and requirements to the PedPal mobile app design effort than the singular perspective of an individual person with visual disabilities.

2. Golden Triangle Council of the Blind – Three individuals from this organization participated.
3. Disability training and technology experts –In addition to the O&M specialist mentioned above, participation also included
    a. Tessa McCarthy, an Assistant Professor at the University of Pittsburgh who runs a MS program in Teaching for the Visually Impaired. This is a program that certifies O&M Specialists and offers a second source of expertise in mobility for people who are blind or have low vision.
    b. Catherine Getchal, the director of Disability Services at Carnegie Mellon University (CMU)and herself a blind person.
    c. Aaron Steinfeld, a Research Professor of Robotics at CMU who heads the Rehabilitation Engineering Research Center on Accessible Public Transportation and has had a long line of involvement in accessibility research.
4. The Pittsburgh Cultural Trust – Vanesa Braun, director of accessibility and herself a blind person participated from the Pittsburgh Cultural Trust.
5. The Western Pennsylvania School for Blind Children (WPSBC) – Jillian Pritts, a senior administrator from WPSBC, also participated. During the meeting, WPSBC offered the project use of a simulated intersection that they maintain on their grounds in the Pittsburgh East End for purposes of teaching intersection crossing skills to their students. It is anticipated that the project will make use of this intersection to perform periodic added capability demonstrations.
6. The Western Pennsylvania School for the Deaf (WPSD) – Joyce Marawich of the WPSD attended, along with 4 deaf individuals of different ages, to provide perspective on the crossing challenges faced by deaf individuals.
7. Goodwill Industries – Adirenne Tolentino of Goodwill Disabilities Services, and a member for the Port Authority of Allegheny County's Committee for Accessible Transportation, was also a participant.

Underrepresented at this initial meeting were older adults, people with mobility disability, and veterans with disabilities. To address this issue, the project team has subsequently reached out to and met separately with the following organizations:

8. PathVU – PathVU is another recipient of a 2017 ATTRI award, to further develop their wheelchair-based technology. We have had discussions with Eric Sinagra, the project PI, about possible synergies and opportunities for collaboration between our respective projects down the road. In May, 2019, we developed a joint white paper outlining a plan

for integration of our PedPal street crossing functionality into PathVU's navigation app, which we intend to pitch to potential follow-on funding sources.

9. University of Pittsburgh Human Engineering Laboratories – Major focus of these laboratories is on technology and services for disabled veterans. Rory Cooper, the director, was unable to join our initial stakeholder meeting due to a conflict but has expressed his interest and willingness to contribute to our design analysis. We have subsequently met with researchers in his lab to better understand unique requirements of disabled veterans, and we intend to reach out to this group in recruiting such individuals for the year two field tests.
10. Older adults – Older adults represent another segment of the population who can have difficulties in safely navigating signalized intersections, and appropriate organizations (e.g., local centers for independent living) were contacted to find one or more representatives from this community to support user needs determination. During the first year of the project, the project team reached out to local centers and to communities of older adults when recruiting field test participants, and we expect to do the same in recruiting participants for the Year 2 field test.
11. The Port Authority of Allegheny County – The Port Authority provides a major mode of transportation around the city for individuals with disabilities. Since it is actively exploring the use of DSRC-based communication with Surtrac controlled intersections, their inputs into the Phase 1 design process were important. Further, since our Year 2 development plan includes a capability to help synchronize pedestrian and bus arrivals at a given bus stop, we have had attempted (thus far unsuccessfully) to get the Port Authority to accelerate their plans to equip the buses running through the Surtrac deployment area with DSRC on-board units to provide support for our Year 2 testing. Since this no longer seems likely, we will use another real-time arrival information source (e.g., as provided by the Transit mobile app) to support our Year 2 demonstration and field test plans.

Chapter 2. Documents

This chapter identifies all needed standards, policies, laws, concepts of operations, concept exploration documents and other reference material that supports the requirements. This chapter is divided into two sections. The first section lists the documents that are explicitly referenced as part of this document. The second section lists the documents or other resources that were used for background information and as a source for potential requirements during the development of this SyRS though there may not be a direct reference.

2.1 Referenced Documents

1. Connecting Pedestrians with Disabilities to Adaptive Signal Control for Safe Intersection Crossing and Enhanced Mobility: Concept of Operations (ConOps), Year 2 Draft, June 2019.
2. Connecting Pedestrians with Disabilities to Adaptive Signal Control for Safe Intersection Crossing and Enhanced Mobility: Data Management Plan, Draft, May, 2019
3. Federal Highways Administration Systems Engineering Guidebook for Intelligent Transportation Systems. Release 3.0, Nov 21, 2009
4. IEEE 29148-2011 - ISO/IEC/IEEE International Standard - Systems and software engineering -- Life cycle processes --Requirements engineeringINCOSE Systems Engineering Handbook version
5. Real-Time Adaptive Traffic Signal Control for Urban Road Networks: The East Liberty Pilot Test, Stephen F. Smith, Gregory J. Barlow, Xiao-Feng, Zachary B. Rubinstein, Technical Report, July 2013
6. Smart Urban Signal Networks: Initial Application of the SURTRAC Adaptive Traffic Signal Control System, Stephen F. Smith, Gregory J. Barlow, Xiao-Feng, Zachary B. Rubinstein, Proceedings 23rd International Conference on Automated Planning and Scheduling, Rome, Italy, June 2013.
7. IEEE 1609.0-2013 - IEEE Guide for Wireless Access in Vehicular Environments (WAVE) - Architecture
8. IEEE 1609.2 Standard for Wireless Access in Vehicular Environments (WAVE) - Security Services for Applications and Management Messages. Note: This standard defines three types of end entities, or potential certificate holders: Identified, Identified Not Localized, and WAVE Service Announcement (WSA) Signer. It says that future versions of this standard will also define end entities of type Anonymous.
9. IEEE 1609.3-2016 - IEEE Standard for Wireless Access in Vehicular Environments (WAVE) -- Networking ServicesIEEE 1609.4 Standard for Wireless Access in Vehicular Environments (WAVE) - MultiChannel Operations

10. SAE J2735 Standard specifying Dedicated Short Range Communications (DSRC) message set dictionary
11. IEEE 802.11p Standard to add wireless access in vehicular environments (WAVE), adding enhancement required to support Intelligent Transportation Systems (ITS) applications.

2.2 Other Sources

12. Web Content Accessibility Guidelines (WCAG): https://www.w3.org/WAI/intro/wcag
13. BBC Standards and Guidelines for Mobile Accessibility: http://www.bbc.co.uk/guidelines/futuremedia/accessibility/mobile

Chapter 3. System Requirements

This chapter of the document lists the System Requirements. The System level requirements are divided into the following types:

1. Functional Requirements: which specify functions, behaviors or tasks to be performed by the System.
2. Performance Requirements: which specify quantifiable characteristics of the System's operations.
3. Interface Requirements: which specify external interfaces to the System, including the interface with the user.
4. Data Requirements: which specify the ingesting, storing and accessing of relevant data or information within the System. Please note that these requirements, listed below, are focused on system data. For information on data management for project activities, please refer the Data Management Plan, listed in Section 2.1 above.

3.1 Requirements

This section provides the high-level requirements for the System, i.e. — "What the system shall do". They are organized by the types of requirements and are mostly extracted from the *needs* identified in *Connecting Pedestrians with Disabilities to Adaptive Signal Control for Safe Intersection Crossing and Enhanced Mobility: Concept of Operations* (listed as reference [1] in Section 2.1 above).

System Overview

The system here refers to the overall system developed by the team that will make the safe intersection crossing possible. As described in the ConOps listed in Section 2.1 above, this system consists of two major subsystems: the Pedestrian Device Subsystem (PDS) and the Intersection Infrastructure Subsystem (IIS).

The Pedestrian Device Subsystem (PDS) consists of the mobile smartphone that the pedestrian will hold and utilize for assistance, the installed Safe Intersection Crossing (PedPal) mobile phone app and (optionally) a DSRC extension attached to the smartphone. The PDS should have accurate localization services, native 3G/4G communication capability, and optionally an extension for DSRC communication capability. Additionally, the pedestrian device must support the configurable feedback options (audible, visual or tactile) required for the planned user interface.

The Intersection Infrastructure Subsystem (IIS) consists of a traffic signal controller component, a DSRC roadside Unit (RSU) and a Surtrac2 adaptive signal controller. The Surtrac2 component of the IIS includes all the hardware and software that interacts with the intersection signal system and will be installed at or near the signal system at the intersection. It is the unit that interacts with both the intersection's traffic signal system and the PDS.

Requirements Overview

While the majority of the requirements are *shall* statements, there are some that are left as *should* statements. *Should* is used to indicate a goal which must be addressed by the design team but may not be formally verified. These are the requirements that require highly accurate location technologies or external data sources. However, the design team will focus on meeting the intent of these requirements to the extent achievable and where possible by utilizing other resources to enhance the system accuracy.

It is important to note that as the team makes more progress in the design of the proposed system, these requirements may be revised or enhanced, and revised or additional details added to this specification.

The status field for each requirement will have one of the following values:

- ***Satisfied*** – The requirement was met with the Year 1 prototype system and will be again for the Year 2 prototype system.
- ***Partially Satisfied*** – The requirement was partially met for the Year 1 prototype system and should be completed in the Year 2 prototype system.
- ***Not Done*** – The requirement was not addressed in Year 1 will be met with the Year 2 prototype system.
- ***Defer*** – The requirement, while valid, has been deferred until after Year 2, due to technical limitations, or other feasibility considerations.
- ***Remove*** – The requirement has been removed for the reason listed in the Notes field.

Table 3-1, **Table 3-2**, **Table 3-3** and **Table 3-4** provides categorized lists of the system requirements. For each requirement the following information is provided.

- **Requirement ID**: The numerical identifier of the requirements prepended by the label "SR-".
- **Requirement Description**: the textual description of the requirement.

- **Requirement Status**: consisting of one of the following values.
    - Satisfied: The requirement was met by the Year 1 prototype system and will be again for the Year 2 prototype system.
    - Partially Satisfied: The requirement was partially met by the Year 1 prototype system and will fully met as part of the Year 2 prototype system.
    - Not Done: The requirement was not addressed in Year 1 and will be met by the Year 2 prototype system.
    - Deferred: requirement was not met by the Year 1 prototype system, nor will it be met by the Year 2 prototype system. It will be considered for a future version of the prototype system.
    - Removed: requirement has been removed for the reason noted.
- **Notes**: Notes concerning the disposition or status of the requirement.
- **Requirements Type**: consisting of one of the following values.
    - Data: for requirements which describe the ingesting, storing and accessing of relevant data or information within the System. Please note that these requirements, listed below, are focused on system data. For information on data management of project activities, please refer the Data Management Plan, listed in Section **Error! Reference source not found.** above.
    - Functional: for requirements which describe functions, behaviors or tasks to be performed by the System.
    - Interface: for requirements which specify external interfaces to the System, including the interface with the user.
    - Performance: for requirements which specify quantifiable characteristics of the System's operations.

3.2 System Performance Requirements

The table below contains a list of the sytem requirements categorizes with the type of “Performance”, and which will specify quantifiable characteristics of the System’s operations.

Table 3-1: System Performance Requirements

Req. ID	System Performance Requirement Description	Status	Notes
SR-081	The system shall be capable of identifying a location (i.e. coordinates) of interest at the intersection	Partially Satisfied	Accuracy of identification will depend on accuracy of the app's localization method, and will be quantified as part of the app's performance evaluation
SR-082	The system shall correctly identify the intersection at which the user is located.	Satisfied	
SR-083	The system shall correctly identify the intersection corner at which the user is located.	Partially Satisfied	Accuracy of identification will depend on accuracy of the app's localization method, and will be quantified as part of the app's performance evaluation
SR-084	The system shall correctly determine whether a user has begun crossing an intersection and is delayed to the extent that the current GREEN phase must be extended.	Not Done	Accuracy of progress monitoring will depend on accuracy of the app's localization method, and will be quantified as part of the app's performance evaluation
SR-085	The system shall correctly detect when a user veers outside of the crosswalk.	Not Done	Accuracy of detection will depend on accuracy of the app's localization method and will be quantified as part of the app's performance evaluation. There will not be multiple levels of alarming for increasing distance of deviation.

Req. ID	System Performance Requirement Description	Status	Notes
SR-086	The system shall increase blind users' perceived safety crossing an intersection.	Partially Satisfied	This requirement is subjective and will be evaluated through surveys conducted with field test participants. Year 1 field test evidence indicates YES.
SR-087	The system shall reduce the number of cycles a blind user waits to feel safe crossing the intersection.	Partially Satisfied	
SR-088	The system shall increase the percentage of new intersections crossed by a user.	Remove	This requirement has been removed as it is somewhat of a derivative of SR-087, and there does not seem to be any way to measure its satisfaction other than to ask participants if the PedPal mobile app would encourage them to cross new intersections. Given this, it seems not useful and has been removed.
SR-089	The system shall decrease the total time it takes for the user to cross an intersection (from arrival at the intersection to completion of the crossing) compared to the user's unassisted crossing time.	Partially Satisfied	Need to determine the achievable threshold by further analysis.
SR-090	The system shall improve the user travel time through a sequence of intersections from the user's baseline travel time.	Partially Satisfied	Need to determine the achievable threshold by further analysis.

3.3 System Interface Requirements

The table below contains a list of the sytem requirements categorizes with the type of “Interface”, and which will specify external interfaces to the System, including the interface with the user.

Table 3-2: System Interface Requirements

Req. ID	System Interface Requirement Description	Status	Notes
SR-001	The system shall ensure that provided information (alerts, navigation, etc.) follows universal design standards to allow accessibility for different types of disabilities.	Satisfied	
SR-002	The system shall provide accessible interfaces and content that follows Web Content Accessibility Guidelines (WCAG)	Satisfied	The WCAG information can be found at https://www.w3.org/WAI/intro/wcag
SR-003	The system shall provide accessible interfaces and content that follows BBC Standards and Guidelines for Mobile Accessibility.	Satisfied	The BBC Guideline can be found at http://www.bbc.co.uk/guidelines/futuremedia/accessibility/mobile
SR-004	The system should follow Apple’s recommended advice on accessible applications.	Satisfied	iPhone's native accessibility features are incorporated into PedPal. They consist of voice-over, font resizing, and screen zoom capability.
SR-005	The system shall have audio components to provide audible notifications and alerts.	Satisfied	Voiceover capability is integrated into the app.
SR-006	The system shall have the option of slowly delivering aural (ear or hearing) information.	Satisfied	This is accomplished through the iPhone's native speed control functionality within the voiceover capability.

Req. ID	System Interface Requirement Description	Status	Notes
SR-007	The system shall be capable of providing mono aural information.	Satisfied	This requirement is to accommodate people with hearing loss when there is a big tonal range situation.
SR-008	The system shall be capable of providing visual alerts and notifications.	Satisfied	
SR-009	The system shall be capable of providing vibratory alerts and notifications.	Partially Satisfied	A vibration alert is currently given as feedback when the user successfully hits the "start crossing" button. Depending on the accuracy of the localization mechanism that is adopted in Year 2, this button may be retained to provide a baseline for measuring pedestrian progress through the intersection. We also expect to introduce vibratory alerts in the case where a pedestrian veers outside of the crosswalk
SR-010	The system shall have the option of delivering visual information slowly.	Satisfied	The native iPhone voiceover capability can be used to vary the speed at which various information that is displayed visually will be delivered to the user.
SR-011	The system shall have the option of repeating visual information when needed (i.e. requested by user).	Satisfied	This same voice over capability provides the ability to repeat visually-displayed information any time that the user swipes over it. Addiitonally, information about characteristics of the current corner (e.g., presence/location of curb cuts) can be repeatedly queried by the user.
SR-012	The system shall facilitate visual interface (reading of the instructions, etc.) in visually difficult situations (e.g. bright light, dark, etc.)	Satisfied	

Req. ID	System Interface Requirement Description	Status	Notes
SR-013	The system should be capable of providing the user with confirmation throughout tasks.	Partially Satisfied	This confirmation includes information such as: halfway through and crossing completed. The system currently provides confirmation of whatever actions are taken through the mobile app user interface. Once a localization mechanism is put in place, the app will take responsibility for recording the start and end times of crossing.
SR-014	The system shall provide the option to the user for adjusting (i.e. reducing or increasing) the number of notifications user receives.	Partially Satisfied	The ability to vary frequency of the countdown is already done. The ability to toggle information about diagonal crossing options on and off will be added and provide another way of adjusting the number of notifications that the user will receive.
SR-015	The system shall be able to receive commands from a user through text input.	Remove	This requirement has been removed as the PDS interface does not emphasize textual input. Any textual inputs (e.g. new destination) would be done via a third-party application.
SR-016	The system shall be able to receive commands from the user through voice communication	Satisfied	
SR-017	The system shall be capable of announcing upcoming task or step.	Satisfied	
SR-018	The system should be capable of displaying upcoming task or step with text descriptions.	Satisfied	

Req. ID	System Interface Requirement Description	Status	Notes
SR-019	The system shall be able to adjust level of assistance based on user profile (e.g., disability type).	Satisfied	
SR-020	The system shall have the option of varying the level of assistance (e.g., verbosity).	Partially Satisfied	The frequency at which countdown information is presented can be varied in the PedPal mobile app's settings. In Year 2 we will add the ability to toggle whether the user is presented with diagonal crossing options on and off in the settings.
SR-023	The system shall have the option of providing direction using clock position.	Defer	Deferred due to the challenge of acquiring sufficiently precise user location
SR-024	The system shall have the option of providing cardinal directions (e.g. East, Northwest).	Defer	Deferred due to the challenge of acquiring sufficiently precise user location.
SR-025	The system should have the option of providing relative directions (e.g. left, right, behind, in front of).	Defer	Deferred due to the challenge of acquiring sufficiently precise user location
SR-029	The system shall be capable of communicating with a traffic signal system.	Satisfied	This requirement is referring to DSRC radio equipped traffic signal systems enabling V2I communications. In Year 2 the system will incorporate a cellular P2I communication option.
SR-030	The system shall be able to collect the signal phase and timing data from the traffic signal system.	Satisfied	

Req. ID	System Interface Requirement Description	Status	Notes
SR-031	The system shall be able to interact with the traffic signal system to influence signal timing and duration.	Satisfied	
SR-032	The system shall be capable of communicating with a Smart Phone device.	Satisfied	Currently, this requires the smart phone to communicate via a connected DSRC radio subsystem. In Year 2, the smart phone's native cellular communication capability will also be used.
SR-034	The system should be capable of providing the user with information about the upcoming intersection (cross/don't cross signaling, how many streets crossing and crossing options, etc.)	Satisfied	
SR-040	The system shall be able to collect personalized intersection crossing constraints from the user.	Satisfied	
SR-041	The system should be able to communicate to the user on which intersection the user is located.	Satisfied	

Req. ID	System Interface Requirement Description	Status	Notes
SR-042	The system should be able to communicate with the user the exact corner of the intersection at which (s)he is standing.	Partially Satisfied	This is difficult due to the challenge of acquiring sufficiently precise user location. In Year 1, the capability was to be provided for simple 2 phase intersections. In Year 2, the capability should be provided for more complex types of intersections based on more precise user location. The team plans to investigate alternate approaches such as DSRC signal-strength estimation, introduction of external Bluetooth beacons at the intersection, and localization based on multiple GPS devices to improve accuracy of GPS-based location services.
SR-050	The system should inform users with intersection geometric information (e.g., curb cut locations).	Remove	This requirement has been removed as it is redundant with SR-046
SR-051	The system should inform users with obstacle information (e.g., work zone) about the intersection	Not Done	This information might be available from a J2735 message either broadcast over DSRC or sent via cellular connectivity. In any event, this requirement will be considered low priority - in principle, this information would be provided by a third-party service and would be treated in the same manner as curb cut database information. It is considered non-essential for Year 2 field test experiments
SR-052	The system shall be capable of alerting the user to wait when the signal indicates No Walk.	Satisfied	

Req. ID	System Interface Requirement Description	Status	Notes
SR-053	The system should provide the ability to use pre-planned route and destination information (e.g., walking path)	Not Done	It is anticipated that the pedestrian will ultimately use a third-party app for navigation. For Year 2, we will define an API and simulate interoperability by loaded pre-planned route and destination information from a file.
SR-054	The system shall be capable of alerting the user to wait when the signal indicates "Walk", but there is not enough time remaining for the user to cross.	Not Done	Notification will be via audio signal (if voice-over is enabled) and visual signal
SR-055	The system shall be capable of notifying the user of how much time is remained of a specific signal phase (walk or no-walk)	Satisfied	Notification will be via audio signal (if voice-over is enabled) and visual signal
SR-056	The system shall communicate with the user whether an intersection has a traffic island.	Not Done	Information on the presence of a traffic island will be communicated with other information about the corner (see SR-046). Notification will be via audio signal (if voice-over is enabled) and visual signal.
SR-058	The system shall allow users to enter their crossing direction.	Satisfied	
SR-059	The system shall allow users to indicate their intent to cross in the mobile application.	Satisfied	

Req. ID	System Interface Requirement Description	Status	Notes
SR-064	The system shall be capable of informing the user to cross when the signal indicates Walk and there is enough time left for the user to cross.	Satisfied	
SR-073	The system shall enable the user to notify the system of his/her delay crossing an intersection.	Remove	This requirement has been removed as pedestrians should not be encouraged to interact with the PDS while crossing the intersection, and the signal timing should be adjusted by the system with out this interaction.
SR-074	The system should be capable of communicating the user's delay to the traffic signal system in real time.	Not Done	In progress, but dependent upon acquiring sufficiently precise user location.
SR-076	The system should notify the user of her/his deviation from the crosswalk.	Not Done	In progress, but dependent upon acquiring sufficiently precise user location. Notification will be via audio signal and/or haptic feedback, but this has not be decided.
SR-077	The system should provide directional guidance to help the user get back in the safe zone path in case of a drift.	Not Done	In progress, but dependent upon acquiring sufficiently precise user location. Notification will be via audio signal.
SR-078	The system should notify the user of his delay crossing an intersection.	Remove	This requirement has been removed as pedestrians should not be encouraged to interact with the PDS while crossing the intersection, and the signal timing should be adjusted by the system with out this interaction.

3.4 System Functional Requirements

The table below contains a list of the sytem requirements categorizes with the type of "**Functional**", and which will specify functions, behaviors or tasks to be performed by the System

Table 3-3: System Functional Requirements

Req. ID	System Functional Requirement Description	Status	Notes
SR-021	The system shall provide the user with an option to cancel receiving directions and alerts.	Satisfied	This is accomplished by hitting the "back" button (which is actually labeled "streets")
SR-022	The system shall have the option to be completely turned off.	Satisfied	
SR-026	The system shall be capable of recognizing when there is no connectivity with the intersection (e.g., traffic signal system).	Satisfied	The PedPal mobile app infers that it is not connected to an intersection at any point in time based on the fact that no MAP or SPaT messages are being received.
SR-027	The system shall be capable of communicating "no connectivity with the intersection" to the user.	Satisfied	Currently the PedPal mobile app shows "No nearby intersection detected" when it is not connected to the intersection
SR-028	The system shall have an option for the user to communicate her/his progress in case of unreliable or unavailable GPS.	Remove	This requirement has been removed due to fact that we do not want the user to be concentrating on interacting with the device during crossing, and instead want the user to concentrate on crossing.
SR-033	The system should be able to adjust the signal timing plan based on the user's speed.	Satisfied	

Req. ID	System Functional Requirement Description	Status	Notes
SR-035	The system shall be able to recognize the intersection (e.g., intersection of Maine and 3rd).	Satisfied	
SR-036	The system should be able to locate the corner of the intersection at which the user is positioned (e.g., southwest corner of Maine and 3rd).	Partially Satisfied	This is difficult due to the challenge of acquiring sufficiently precise user location. In Year 1, the capability was provided for simple 2-phase intersections. In Year 2, the capability should be provided for more complex types of intersections based on more precise user location. The team plans to investigate alternate approaches such as DSRC signal-strength estimation, introduction of external Bluetooth beacons at the intersection, and localization based on multiple GPS devices to improve accuracy of GPS-based location services.
SR-037	The system should be able to identify where the user is standing (side walk or street).	Defer	Deferred due to the challenge of acquiring sufficiently precise user location. More detailed information on the intersection geometry will be provided to the pedestrian. Will rely on the pedestrian to find the appropriate crossing position.
SR-038	The system should be able to determine location of crosswalk corridor, which is the rectangular path defined by the crosswalk pattern borders, extended onto the sidewalk it adjoins.	Defer	Deferred due to the challenge of acquiring sufficiently precise user location. More detailed information on the intersection geometry will be provided to the pedestrian. The system will rely on the pedestrian to find the appropriate crossing position.

Req. ID	System Functional Requirement Description	Status	Notes
SR-039	The system should be able to determine location of crosswalk corridor relative to the user.	Defer	Deferred due to the challenge of acquiring sufficiently precise user location. More detailed information on the intersection geometry will be provided to the pedestrian. Will rely on the pedestrian to find the appropriate crossing position.
SR-043	The system should be able to communicate to the user contextual information on the built environment around an intersection.	Not Done	This capability could involve a third-party similar to PathVu and could lead to a synergistic ATTRI demo at some point in the future. In Year 2, we will simulate interaction with such a third-party service to provide relevant information about the corner to the user (e.g., single curb cut, multiple curb cuts at crosswalk, etc.)
SR-044	The system should be able to provide guidance to the user in locating the crosswalk corridor (the rectangular path defined by the crosswalk pattern borders, extended onto the sidewalk it adjoins).	Defer	Deferred due to the challenge of acquiring sufficiently precise user location. More detailed information on the intersection geometry will be provided to the pedestrian. Will rely on the pedestrian to find the appropriate crossing position.
SR-045	The system should be able to provide a notification when the user locates the crosswalk corridor.	Defer	Deferred due to the challenge of acquiring sufficiently precise user location. More detailed information on the intersection geometry will be provided to the pedestrian. Will rely on the pedestrian to find the appropriate crossing position.

Req. ID	System Functional Requirement Description	Status	Notes
SR-046	The system should have the capability of providing information about the corner (e.g., presence and type of curb cuts) to users with visual impairments to help him/her orient an navigate to the crosswalk	Not Done	This will be provided in lieu of SR-037, SR-038, SR-039, SR-044 and SR-045
SR-047	The system should have the capability to guide the user to the starting location of the crosswalk.	Remove	This requirement has been removed as it is redundant with SR-044
SR-048	The system should be able to provide an alert when the user is not inside of crosswalk corridor.	Not Done	This is difficult due to the challenge of acquiring sufficiently precise user location. The team plans to investigate alternate approaches such as DSRC signal-strength estimation, introduction of external Bluetooth beacons at the intersection, and localization based on multiple GPS devices to improve accuracy of GPS-based location services.
SR-049	The system should be able to provide confirmation when the user is inside of crosswalk corridor.	Not Done	This is difficult due to the challenge of acquiring sufficiently precise user location. Once SR-048 is satisfied, then SR-049 will be satisfied by default - i.e., unless the system raises an alarm the pedestrian can assume he/she are still within the crosswalk.
SR-057	The system shall be able to provide guidance, notifications, and alerts in order to assist the users in crossing the intersection.	Partially Satisfied	Countdown information together with don't cross/OK to cross information is provided as guidance. Alerting the user when movement outside of the crosswalk is detected will be added in Year 2.

Req. ID	System Functional Requirement Description	Status	Notes
SR-060	The system should be able to determine direction of the user relative to crossing direction.	Partially Satisfied	In progress, but dependent upon acquiring sufficiently precise user location. This functionality already works for simplified 2-phase intersections; and will be extended to more complex intersection in Year 2, pending resolution of the issue with localization accuracy.
SR-061	If the user intends to make two consequent crosses at an intersection, the system shall provide information that enables the user to determine which cross should occur first.	Satisfied	This requirement is to help the user to minimize wait time. However, instead of dictating a crossing direction to the user, the app presents both crossing options but also includes information about which crossing direction is currently green and how much time in that green phase remains. So the user has all the information to determine which cross should be taken first.
SR-062	The system shall be able to provide real time information (signal phase, timing, etc.) about the traffic signal system.	Satisfied	
SR-063	The system shall be able to notify the user when Walk time is extended.	Satisfied	
SR-065	The system should have the capability of coordinating the signal timing plans with anticipated user arrivals.	Not Done	
SR-066	The system shall have the capability to notify the traffic signal system of the intersection crossing intention of the user.	Satisfied	

Req. ID	System Functional Requirement Description	Status	Notes
SR-067	The system should be able to determine the user speed crossing an intersection.	Not Done	In progress, but dependent upon acquiring sufficiently precise user location. The team plans to investigate alternate approaches such as DSRC signal-strength estimation, introduction of external Bluetooth beacons at the intersection, and localization based on multiple GPS devices to improve accuracy of GPS-based location services.
SR-068	The system should be capable of computing time required for a user to cross a specific intersection.	Satisfied	
SR-069	The system should have the capability to track the user's progress through the crosswalk (from one corner to the other).	Not Done	In progress, but dependent upon acquiring sufficiently precise user location. The team plans to investigate alternate approaches such as DSRC signal-strength estimation, introduction of external Bluetooth beacons at the intersection, and localization based on multiple GPS devices to improve accuracy of GPS-based location services. It needs to be determined how often the progress should be updated (e.g., every second).
SR-070	The system should be capable of identifying the user's delays in crossing an intersection.	Not Done	In progress, but dependent upon acquiring sufficiently precise user location. The team plans to investigate alternate approaches such as DSRC signal-strength estimation, introduction of external Bluetooth beacons at the intersection, and localization based on multiple GPS devices to improve accuracy of GPS-based location services.

Req. ID	System Functional Requirement Description	Status	Notes
SR-071	The system should be capable of identifying the users' drift from the crosswalk when crossing an intersection.	Not Done	In progress, but dependent upon acquiring sufficiently precise user location. The team plans to investigate alternate approaches such as DSRC signal-strength estimation, introduction of external Bluetooth beacons at the intersection, and localization based on multiple GPS devices to improve accuracy of GPS-based location services.
SR-072	The system should be capable of communicating with the user regarding his/her progress crossing an intersection.	Not Done	In progress, but dependent upon acquiring sufficiently precise user location. The team plans to investigate alternate approaches such as DSRC signal-strength estimation, introduction of external Bluetooth beacons at the intersection, and localization based on multiple GPS devices to improve accuracy of GPS-based location services.
SR-075	The system shall have the capability to allow for dynamic extension of minimum crossing time constraint if an unexpected delay is detected	Partially Satisfied	Everything but the actual detection of the unexpected delay has been implemented.
SR-079	The system should have the capability to advise users on how to exit the crosswalk by providing guidance to the exit point (whether there is a curb or a cut-out, grade, etc.)	Defer	Deferred due to the challenge of acquiring sufficiently precise user location. More detailed information on the intersection geometry will be provided to the pedestrian. Will rely on the pedestrian to find the appropriate crossing position.

Req. ID	System Functional Requirement Description	Status	Notes
SR-080	The system shall be able to provide a notification when the user successfully crosses an intersection.	Not Done	In progress, but dependent upon acquiring sufficiently precise user location. Note that by "provide a notification" we do not necessarily mean the app should make an announcement. Currently, when the user clicks the "complete crossing" button, the UI switches back to the select crossing option screen (in case the user wants to do a 2nd cross at this intersection). With adequate localization we are hoping to remove this button. If additional notification of completion is necessary, then this should necessarily be a setting that can be turned off (because it could get annoying) by the user.
SR-099	The system shall be able to ingest, store and access a user's travel plan,	Not Done	
SR-101	The system shall be able to determine, prior to the user's arrival, if an upcoming intersection is adjacent to the user's bus route transfer point	Not Done	
SR-102	The system shall be able to ingest or determine the user's embarkation bus stop and desired bus route number.	Not Done	Our assumption is that the system will be ingesting bus stop and route information (possibly through a third-party app like Transit) and the system will determine whether the bus stop is relevant to the current intersection that is being approched.
SR-103	The system shall be able to determine, prior to the user's arrival, the user's expected arrival time at the intersection.	Not Done	

Req. ID	System Functional Requirement Description	Status	Notes
SR-104	The system shall be able to determine if there is an approaching bus with the desired bus route number.	Not Done	Capability depends on an ongoing companion project with Port Authority of Allegheny County and/or interoperability with a third-party app like Transit.
SR-105	The system shall be able to estimate the time at which the bus is expected to depart from the bus stop	Not Done	Capability depends on an ongoing companion project with Port Authority of Allegheny County and/or interoperability with a third-party app like Transit.
SR-106	The system shall be able to determine if additional crossing time must be allocated to ensure that the bus remains at the bus stop until the user can embark.	Not Done	
SR-107	The system shall be able to allocate the additional crossing time to ensure that the bus remains at the bus stop until the user can embark.	Not Done	

3.5 System Data Requirements

The table below contains a list of the sytem requirements categorizes with the type of "**Data**", and which will specify the ingesting, storing and accessing of relevant data or information within the System. Please note that these requirements, listed below, are focused on system data. For information on data management for project activities, please refer to *Connecting Pedestrians with Disabilities to Adaptive Signal Control for Safe Intersection Crossing and Enhanced Mobility: Data Management Plan*, listed as reference [2] in Section 2.1 above.

Table 3-4: System Data Requirements

Req. ID	System Data Requirement Description	Status	Notes
SR-091	The system should ingest, store and access relevant information about the intersection and its corners, including presence and location of curb cuts at corners to facilitate entry into the crosswalk and presence of traffic islands in different crossing directions.	Not Done	This will be provided in lieu of SR-037, SR-038, SR-039, SR-042, SR-044 and SR-045, pending the availability of external resources. Companion requirement with SR-046.
SR-092	The system should be able to ingest, store, and access information on an intersection's traffic signal system.	Satisfied	
SR-093	The system should be able to ingest, store, and access information on an intersection's traffic signal system's operational status.	Defer	Deferred as there is no mechanism or third-party service that currently provides dynamic information about a traffic signal's operational status. It is possible in the future through integration of the Surtrac traffic control system with an overall traffic management system that such information could be provided. Hence, we propose to keep this requirement but defer it to a future follow-on effort.

Req. ID	System Data Requirement Description	Status	Notes
SR-094	The system should be able to ingest, store, and access information on whether an intersection is equipped for DSRC communications	Satisfied	
SR-095	The system shall be able to ingest, store, and access MAP message data.	Satisfied	
SR-096	The system shall be able to ingest, store and access SPaT message data.	Satisfied	
SR-097	The system should have a data validation process.	Partially Satisfied	
SR-098	The system should be able to ingest, store and access data from external sources (e.g., through appropriate APIs)	Not Done	
SR-100	The system shall collect information about what kind of assistive technology or mobility aid the pedestrian is using.	Satisfied	
SR-108	The system shall not store any PII data.	Satisfied	

Chapter 4. Verification Methods

Since the project team is employing an iterative and agile process for developing the safe intersection crossing prototype system, some aspects of verification will occur during the design and development. However, it is anticipated that the project team will verify and validate all the requirements during the evaluation phases. The key objective is to have flexibility to allow selected events to be taken out of sequence when the risk is acceptable. This will ensure that we can address issues and challenges early in the process.

For each requirement, one of the following methods of verification will be listed:

- **Demonstration** – This method will be used for requirements that the system can be demonstrated without external test equipment. Demonstration method describes a qualitative exhibition of functional performance, usually accomplished with no or minimal instrumentation. Demonstration (a set of test activities with system stimuli selected by the system developer) may be used to show that system or subsystem response to stimuli is suitable. Demonstration may be appropriate when requirements or specifications are given in statistical terms (e.g., mean time to repair, average power consumption, etc.).
- **Inspection** – This method is verification through a visual comparison. Inspection method describes an examination of the item against applicable documentation to confirm compliance with requirements. Inspection is used to verify properties best determined by examination and observation (e.g., - paint color, weight, etc.).
- **Formal Test** – This method will be used for requirements that require some external piece of test equipment or real-world testing. Formal Test describes an action by which the operability, supportability, or performance capability of an item is verified when subjected to controlled conditions that are real or simulated. This verification method often uses special test equipment or instrumentation to obtain very accurate quantitative data for analysis.
- **Analysis** – This method will be used for requirements that are met indirectly through a logical conclusion or mathematical analysis of a result. Analysis method usually includes the use of analytical data, or simulations under defined conditions to show theoretical compliance. Analysis method is used where testing to realistic conditions cannot be achieved or is not cost-effective.

Appendix A provides the complete System Requirements Traceability Matrix outlining the verification method for each requirement listed in the sections above.

Chapter 5. Requirements Traceability and Linkage to System Design

5.1 Needs to Requirements Traceability

Almost all of the requirements outlined in this chapter trace back to the stakeholder needs which were documented in the ConOps document. The System Requirements Traceability Matrix in Appendix A identifies the sources of each of the requirements. The Appendix B. Requirements to Use Case Mapping Matrix in Appendix B shows the mapping of each requirement to the use case or use cases that will exercise this requirement.

Our team is maintaining this System Requirements Traceability Matrix through the end of the project and will ensure that all the changes are tracked and recorded through this matrix.

5.2 Requirements to Architecture Components

The two major subsystems (the PDS and the IIS) were discussed in the ConOps and have been referenced in this requirements document. These requirements will form the basis of the design architecture that will describe the roles and capabilities of the subsystems in the overall system. This distinction is also made in the System Requirements Traceability Matrix in Appendix A.

The details of the system architecture and subsystems are provided in the system design architecture document.

The source of each requirement is defined in the format “ConOps/Location/Identifier”, where “Location” refers to the location within the ConOps and the optional “Identifier” refers to futher guidance on the source of the requirement, such as which use case, or which list item.

Appendix A. Requirements Traceability Matrix

The table below …

Table 5-1: Requirements Traceability Matix

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-001	The system shall ensure that provided information (alerts, navigation, etc.) follows universal design standards to allow accessibility for different types of disabilities.	Satisfied	SRA Discussion	Interface	Demo	PDS
SR-002	The system shall provide accessible interfaces and content that follows Web Content Accessibility Guidelines (WCAG)	Satisfied	SRA Discussion	Interface	Demo	PDS
SR-003	The system shall provide accessible interfaces and content that follows BBC Standards and Guidelines for Mobile Accessibility.	Satisfied	SRA Discussion	Interface	Demo	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-004	The system should follow Apple's recommended advice on accessible app.	Satisfied	SRA Discussion	Interface	Demo	PDS
SR-005	The system shall have audio components to provide audible notifications and alerts.	Satisfied	ConOps/Ch6/DDF/Table1	Interface	Inspection	PDS
SR-006	The system shall have the option of slowly delivering aural (ear or hearing) information.	Satisfied	ConOps/Ch6/DDF/Table1	Interface	Inspection	PDS
SR-007	The system shall be capable of providing mono aural information.	Satisfied	ConOps/Ch6/DDF/Table1	Interface	Demo	PDS
SR-008	The system shall be capable of providing visual alerts and notifications.	Satisfied	ConOps/Ch6/DDF/Table1	Interface	Demo	PDS
SR-009	The system shall be capable of providing vibratory alerts and notifications.	Partially Satisfied	ConOps/Ch6/DDF/Table1	Interface	Demo	PDS
SR-010	The system shall have the option of delivering visual information slowly.	Satisfied	ConOps/Ch6/DDF/Table1	Interface	Inspection	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-011	The system shall have the option of repeating visual information when needed (i.e. requested by user).	Satisfied	ConOps/Ch6/UC11	Interface	Inspection	PDS
SR-012	The system shall facilitate visual interface (reading of the instructions, etc.) in visually difficult situations (e.g. bright light, dark, etc.)	Satisfied	ConOps/Ch6/DDF/Table1	Interface	Inspection	PDS
SR-013	The system should be capable of providing the user with confirmation throughout tasks.	Partially Satisfied	ConOps/Ch6/DDF/Table1	Interface	Demo	PDS
SR-014	The system shall provide the option to the user for adjusting (i.e. reducing or increasing) the number of notifications user receives.	Partially Satisfied	ConOps/Ch6/DDF/Table1	Interface	Demo	PDS
SR-015	The system shall be able to receive commands from a user through text input.	Remove	ConOps/Ch6/UC1	Interface	Demo	PDS
SR-016	The system shall be able to receive commands from the user through voice communication	Satisfied	ConOps/Ch6/DDF/Table1	Interface	Demo	PDS
SR-017	The system shall be capable of announcing upcoming task or step.	Satisfied	ConOps/Ch6/DDF/Table1	Interface	Demo	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-018	The system should be capable of displaying upcoming task or step with text descriptions.	Satisfied	ConOps/Ch6/DDF/Table1	Interface	Demo	PDS
SR-019	The system shall be able to adjust level of assistance based on user profile (e.g., disability type).	Satisfied	ConOps/Ch4/DCC/Table 1	Interface	Demo	PDS
SR-020	The system shall have the option of varying the level of assistance (e.g., verbosity).	Partially Satisfied	ConOps/Ch4/DCC/Table 1	Interface	Demo	PDS
SR-021	The system shall provide the user with an option to cancel receiving directions and alerts.	Satisfied	ConOps/Ch5/UC12	Functional	Demo	PDS
SR-022	The system shall have the option to be completely turned off.	Satisfied	ConOps/Ch5/UC12	Functional	Demo	PDS
SR-023	The system shall have the option of providing direction using clock position.	Defer	ConOps/Ch4/DCC/Table 1	Interface	Demo	PDS
SR-024	The system shall have the option of providing cardinal directions (e.g. East, Northwest).	Defer	ConOps/Ch6/DDF/Table1	Interface	Demo	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-025	The system should have the option of providing relative directions (e.g. left, right, behind, in front of).	Defer	ConOps/Ch6/DDF/Table1	Interface	Demo	PDS
SR-026	The system shall be capable of recognizing when there is no connectivity with the intersection (e.g., traffic signal system).	Satisfied	ConOps/Ch5/UC5	Functional	Formal Test	IIS
SR-027	The system shall be capable of communicating "no connectivity with the intersection", with the user.	Satisfied	ConOps/Ch5/UC5	Functional	Formal Test	PDS
SR-028	The system shall have an option for the user to communicate her/his progress in case of unreliable or unavailable GPS.	Remove	ConOps/Ch7/Improvement #1	Functional	Demo	PDS
SR-029	The system shall be capable of communicating with a traffic signal system.	Satisfied	ConOps/Ch5/UC1	Interface	Formal Test	IIS
SR-030	The system shall be able to collect the signal phase and timing data from the traffic signal system.	Satisfied	ConOps/Ch5/UC1	Interface	Formal Test	PDS
SR-031	The system shall be able to interact with the traffic signal system to influence signal timing and duration.	Satisfied	ConOps/Ch5/UC1	Interface	Formal Test	IIS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-032	The system shall be capable of communicating with a Smart Phone device.	Satisfied		Interface	Formal Test	PDS
SR-033	The system should be able to adjust signal timing plan based on the user's speed.	Satisfied	ConOps/Ch7/Improvement #3	Functional	Formal Test	IIS
SR-034	The system should be capable of providing the user with information about the upcoming intersection (cross/don't cross signaling, how many streets crossing and crossing options, etc.)	Satisfied	ConOps/Ch5/UC9	Interface	Formal Test	PDS
SR-035	The system shall be able to recognize the intersection (e.g., intersection of Maine and 3rd).	Satisfied	ConOps/Ch5/UC10	Functional	Formal Test	PDS
SR-036	The system should be able to locate the corner of the intersection at which the user is positioned (e.g., southwest corner of Maine and 3rd).	Partially Satisfied	ConOps/Ch5/UC10	Functional	Formal Test	PDS
SR-037	The system should be able to identify where the user is standing (side walk or street).	Defer	ConOps/Ch5/UC10	Functional	Formal Test	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-038	The system should be able to determine location of crosswalk corridor.	Defer	ConOps/Ch5/UC10	Functional	Formal Test	PDS
SR-039	The system should be able to determine location of crosswalk corridor relative to the user.	Defer	ConOps/Ch5/UC10	Functional	Formal Test	PDS
SR-040	The system shall be able to collect personalized intersection crossing constraints from the user.	Satisfied	ConOps/Ch5/Use Cases	Interface	Formal Test	PDS
SR-041	The system should be able to communicate to the user on which intersection the user is located.	Satisfied	ConOps/Ch5/UC10	Interface	Demo	PDS
SR-042	The system should be able to communicate with the user the exact corner of the intersection at which (s)he is standing.	Partially Satisfied	ConOps/Ch5/UC10	Interface	Demo	PDS
SR-043	The system should be able to communicate to the user contextual information on the built environment around an intersection.	Not Done	ConOps/Ch5/UC10	Functional	Demo	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-044	The system should be able to provide guidance to the user in locating the crosswalk corridor (the rectangular path defined by the crosswalk pattern borders, extended onto the sidewalk it adjoins).	Defer	ConOps/Ch5/UC10	Functional	Demo	PDS
SR-045	The system should be able to provide a notification when the user locates the crosswalk corridor.	Defer	ConOps/Ch5/UC10	Functional	Demo	PDS
SR-046	The system should have the capability of providing information about the corner (e.g., presence and type of curb cuts) to users with visual impairments to help him/her orient an navigate to the crosswalk	Not Done	ConOps/Ch6/Operational Impact #5	Functional	Formal Test	PDS
SR-047	The system should have the capability to guide the user to the starting location of the crosswalk.	Remove	ConOps/Ch6/Operational Impact #5	Functional	Formal Test	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-048	The system should be able to provide an alert when the user is not inside of crosswalk corridor.	Not Done	ConOps/Ch6/Operational Impact #5	Functional	Formal Test	PDS
SR-049	The system should be able to provide confirmation when the user is inside of crosswalk corridor.	Not Done	ConOps/Ch6/Operational Impact #5	Functional	Formal Test	PDS
SR-050	The system should inform users with intersection geometric information (e.g., curb cut locations).	Remove	ConOps/Ch6/Operational Impact #5	Interface	Formal Test	PDS
SR-051	The system should inform users with obstacle information (e.g., work zone) about the intersection	Not Done	ConOps/Ch6/Operational Impact #5	Interface	Formal Test	PDS
SR-052	The system shall be capable of alerting the user to wait when the signal indicates No Walk.	Satisfied	ConOps/Ch5/UC8	Interface	Formal Test	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-053	The system should provide the ability to use pre-planned route and destination information (e.g., walking path)	Not Done	ConOps/Ch4/Mobile App UI	Interface	Formal Test	PDS
SR-054	The system shall be capable of alerting the user to wait when the signal indicates "Walk", but there is not enough time remaining for the user to cross.	Not Done	ConOps/Ch5/UC3	Interface	Formal Test	PDS
SR-055	The system shall be capable of notifying the user of how much time is remained of a specific signal phase (walk or no-walk)	Satisfied	ConOps/Ch4/Modes of Operation	Interface	Formal Test	PDS
SR-056	The system shall communicate with the user whether an intersection has a traffic island.	Not Done	ConOps/Ch5/UC1-5, UC6-14	Interface	Formal Test	PDS
SR-057	The system shall be able to provide guidance, notifications, and alerts in order to assist the users in crossing the intersection.	Partially Satisfied	ConOps/Ch4/DCC/Table 1	Functional	Demo	PDS
SR-058	The system shall provide the option for the user to enter crossing direction.	Satisfied	ConOps/Ch6/UC1	Interface	Demo	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-059	The system shall provide the option for the user to indicate intent to cross.	Satisfied	ConOps/Ch6/UC1	Interface	Demo	PDS
SR-060	The system should be able to determine direction of the user relative to crossing direction.	Partially Satisfied	ConOps/Ch5/UC10	Functional	Formal Test	PDS
SR-061	If the user intends to make two consequent crosses at an intersection, the system shall provide information that enables the user to determine which cross should occur first.	Satisfied	ConOps/Ch5/UC8	Functional	Formal Test	PDS
SR-062	The system shall be able to provide real time information (signal phase, timing, etc.) about the traffic signal system.	Satisfied	ConOps/Ch6/UC1-4,6-14	Functional	Formal Test	PDS
SR-063	The system shall be able to notify the user when Walk time is extended.	Satisfied	ConOps/Ch5/UC2	Functional	Formal Test	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-064	The system shall be capable of informing the user to cross when the signal indicates Walk and there is enough time left for the user to cross.	Satisfied	ConOps/Ch5/UC2	Interface	Formal Test	PDS
SR-065	The system should have the capability of coordinating the signal timing plans with anticipated user arrivals.	Not Done	ConOps/Ch4/Surtrac ATSC	Functional	Formal Test	IIS
SR-066	The system shall have the capability to notify the traffic signal system of the intersection crossing intention of the user.	Satisfied	ConOps/Ch6/Operational Impact #3	Functional	Formal Test	IIS
SR-067	The system should be able to determine the user speed crossing an intersection.	Not Done	ConOps/Ch5/UC7	Functional	Analysis	PDS
SR-068	The system should be capable of computing time required for a user to cross a specific intersection.	Satisfied	ConOps/Ch5/UC1	Functional	Analysis	PDS
SR-069	The system should have the capability to track the user's progress through the crosswalk (from one corner to the other).	Not Done	ConOps/Ch6/Operational Impact #4	Functional	Formal Test	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-070	The system should be capable of identifying the user's delays in crossing an intersection.	Not Done	ConOps/Ch5/UC7	Functional	Formal Test	PDS
SR-071	The system should be capable of identifying the users' drift from the crosswalk when crossing an intersection.	Not Done	ConOps/Ch5/UC6	Functional	Formal Test	PDS
SR-072	The system should be capable of communicating with the user regarding his/her progress crossing an intersection.	Not Done	ConOps/Ch4/Mobile App UI	Functional	Formal Test	PDS
SR-073	The system shall enable the user to notify the system of his/her delay crossing an intersection.	Remove	ConOps/Ch5/UC7	Interface	Demo	PDS
SR-074	The system should be capable of communicating the user's delay to the traffic signal system in real time.	Not Done	ConOps/Ch5/UC7	Interface	Formal Test	PDS
SR-075	The system shall have the capability to allow for dynamic extension of minimum crossing time constraint if an unexpected delay is detected	Partially Satisfied	ConOps/Ch4/Surtrac ATSC	Functional	Formal Test	IIS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-076	The system should notify the user of her/his deviation from the crosswalk.	Not Done	ConOps/Ch5/UC6	Interface	Formal Test	PDS
SR-077	The system should provide directional guidance to help the user get back in the safe zone path in case of a drift.	Not Done	ConOps/Ch5/UC10	Interface	Formal Test	PDS
SR-078	The system should notify the user of his delay crossing an intersection.	Remove	ConOps/Ch5/UC7	Interface	Formal Test	PDS
SR-079	The system should have the capability to advise users on how to exit the crosswalk by providing guidance to the exit point (whether there is a curb or a cut-out, grade, etc.)	Defer	ConOps/Ch6/Operational Impact #2	Functional	Formal Test	PDS
SR-080	The system shall be able to provide a notification when the user successfully crosses an intersection.	Not Done	ConOps/Ch4/DCC/Table 1	Functional	Formal Test	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-081	The system shall be capable of identifying a location (i.e. coordinates) of interest at the intersection	Partially Satisfied	ConOps/Ch5/UC6	Performance	Analysis	PDS
SR-082	The system shall correctly identify the intersection at which the user is located.	Satisfied	ConOps/Ch7/Performance Measures	Performance	Analysis	PDS
SR-083	The system shall correctly identify the intersection corner at which the user is located.	Partially Satisfied	ConOps/Ch7/Performance Measures	Performance	Analysis	PDS
SR-084	The system shall correctly determine whether a user has begun crossing an intersection and is delayed to the extent that the current GREEN phase must be extended.	Not Done	ConOps/Ch7/Performance Measures	Performance	Analysis	PDS
SR-085	The system shall correctly detect when a user veers outside of the crosswalk.	Not Done	ConOps/Ch7/Performance Measures	Performance	Analysis	PDS
SR-086	The system shall increase blind users' perceived safety crossing an intersection.	Partially Satisfied	ConOps/Ch7/Performance Measures	Performance	Analysis	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-087	The system shall reduce the number of cycles a blind user waits to feel safe crossing the intersection.	Partially Satisfied	ConOps/Ch7/Performance Measures	Performance	Analysis	PDS
SR-088	The system shall increase the percentage of new intersections crossed by a user.	Remove	ConOps/Ch7/Performance Measures	Performance	Analysis	PDS
SR-089	The system shall decrease total time it takes for the user to cross an intersection (from arrival at the intersection to completion of the crossing) from the user's unassisted crossing time.	Partially Satisfied	ConOps/Ch7/Performance Measures	Performance	Analysis	PDS
SR-090	The system shall improve the user travel time through a sequence of intersections from the user's baseline travel time.	Partially Satisfied	ConOps/Ch7/Performance Measures	Performance	Analysis	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-091	The system should ingest, store and access relevant information about the intersection and its corners, including presence and location of curb cuts at corners to facilitate entry into the crosswalk and presence of traffic islands in different crossing directions.	Not Done	ConOps/Ch5/UC1-5,UC6-14	Data	Inspection	PDS
SR-092	The system should be able to ingest, store, and access information on an intersection's traffic signal system.	Satisfied	ConOps/Ch5/UC1	Data	Inspection	PDS
SR-093	The system should be able to ingest, store, and access information on an intersection's traffic signal system's operational status.	Defer	ConOps/Ch5/UC5	Data	Inspection	PDS
SR-094	The system should be able to ingest, store, and access information on whether an intersection is equipped for DSRC communications	Satisfied	ConOps/Ch5/UC1	Data	Inspection	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-095	The system shall be able to ingest, store, and access MAP message data.	Satisfied	SRA Discussion	Data	Demo	PDS
SR-096	The system shall be able to ingest, store and access SPaT message data.	Satisfied	SRA Discussion	Data	Demo	PDS
SR-097	The system should have a data validation process.	Partially Satisfied	SRA Discussion	Data	Inspection	PDS
SR-098	The system should be able to ingest, store and access data from external sources (e.g., through appropriate APIs)	Not Done	SRA Discussion	Data	Demo	PDS
SR-109	The system shall not store any PII data.	Not Done	SRA Discussion	Data	Inspection	PDS
SR-100	The system shall be able to ingest, store and access a user's travel plan,	Satisfied	ConOps/Ch5/UC14	Functional	Demo	PDS
SR-101	The system shall collect information about what kind of assistive technology or mobility aid the pedestrian is using.	Not Done	SRA Discussion	Data	Inspection	PDS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-102	The system shall be able to determine, prior to the user's arrival, if an upcoming intersection is adjacent to the user's bus route transfer point	Not Done	ConOps/Ch5/UC14	Functional	Demo	PDS
SR-103	The system shall be able to ingest or determine the user's embarkation bus stop and desired bus route number.	Not Done	ConOps/Ch5/UC14	Functional	Demo	PDS
SR-104	The system shall be able to determine, prior to the user's arrival, the user's expected arrival time at the intersection.	Not Done	ConOps/Ch5/UC14	Functional	Demo	PDS
SR-105	The system shall be able to determine if there is an approaching bus with the desired bus route number.	Not Done	ConOps/Ch5/UC14	Functional	Demo	IIS
SR-106	The system shall be able to estimate the time at which the bus is expected to depart from the bus stop	Not Done	ConOps/Ch5/UC14	Functional	Demo	IIS

ID	Requirement Description	Status	Source (ConOps Reference)	Category	Verification Method	Subsystem
SR-107	The system shall be able to determine if additional crossing time must be allocated to ensure that the bus remains at the bus stop until the user can embark.	Not Done	ConOps/Ch5/UC14	Functional	Demo	IIS
SR-108	The system shall be able to allocate the additional crossing time to ensure that the bus remains at the bus stop until the user can embark.	Satisfied	ConOps/Ch5/UC14	Functional	Demo	IIS

Appendix B. Requirements to Use Case Mapping Matrix

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-001	The system shall ensure that provided information (alerts, navigation, etc.) follows universal design standards to allow accessibility for different types of disabilities.	X	X	X	X	X	X	X	X	X	X	X	X	X	X

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-002	The system shall provide accessible interfaces and content that follows Web Content Accessibility Guidelines (WCAG)	X	X	X	X	X	X	X	X	X	X	X	X	X	X

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-003	The system shall provide accessible interfaces and content that follows BBC Standards and Guidelines for Mobile Accessibility.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-004	The system should follow Apple's recommended advice on accessible applications.	X	X	X	X	X	X	X	X	X	X	X	X	X	X

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-005	The system shall have audio components to provide audible notifications and alerts.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-006	The system shall have the option of slowly delivering aural (ear or hearing) information.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-007	The system shall be capable of providing mono aural information.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-008	The system shall be capable of providing visual alerts and notifications.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-009	The system shall be capable of providing vibratory alerts and notifications.	X	X	X	X	X	X	X	X	X	X	X	X	X	X

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-010	The system shall have the option of delivering visual information slowly.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-011	The system shall have the option of repeating visual information when needed (i.e. requested by user).											X			
SR-012	The system shall facilitate visual interface (reading of the instructions, etc.) in visually difficult situations (e.g. bright light, dark, etc.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-013	The system should be capable of providing the user with confirmation throughout tasks.	X	X	X	X			X							
SR-014	The system shall provide the option to the user for adjusting (i.e. reducing or increasing) the number of notifications user receives.	X	X	X	X	X	X	X	X						

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-015	The system shall be able to receive commands from a user through text input.														
SR-016	The system shall be able to receive commands from the user through voice communication	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-017	The system shall be capable of announcing upcoming task or step.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-018	The system should be capable of displaying upcoming task or step with text descriptions.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-019	The system shall be able to adjust level of assistance based on user profile (e.g., disability type).	X	X	X	X	X	X	X	X	X	X	X	X	X	X

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-020	The system shall have the option of varying the level of assistance (e.g., verbosity).	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-021	The system shall provide the user with an option to cancel receiving directions and alerts.												X		
SR-022	The system shall have the option to be completely turned off.												X		
SR-023	The system shall have the option of providing direction using clock position.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-024	The system shall have the option of providing cardinal directions (e.g. East, Northwest).	X	X	X	X	X	X	X	X	X	X	X	X	X	X

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-025	The system should have the option of providing relative directions (e.g. left, right, behind, in front of).	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-026	The system shall be capable of recognizing when there is no connectivity with the intersection (e.g., traffic signal system).					X									
SR-027	The system shall be capable of communicating "no connectivity with the intersection" to the user.					X									
SR-028	The system shall have an option for the user to communicate her/his progress in case of unreliable or unavailable GPS.														
SR-029	The system shall be capable of communicating with a traffic signal system.	X													

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-030	The system shall be able to collect the signal phase and timing data from the traffic signal system.	X													
SR-031	The system shall be able to interact with the traffic signal system to influence signal timing and duration.	X													
SR-032	The system shall be capable of communicating with a Smart Phone device.	X	X	X	X		X	X	X	X	X	X	X	X	X
SR-033	The system should be able to adjust the signal timing plan based on the user's speed.	X	X	X	X			X							
SR-034	The system should be capable of providing the user with information about the upcoming intersection (cross/don't cross signaling, how many streets crossing and crossing options, etc.)									X					

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-035	The system shall be able to recognize the intersection (e.g., intersection of Maine and 3rd).										X				
SR-036	The system should be able to locate the corner of the intersection at which the user is positioned (e.g., southwest corner of Maine and 3rd).										X				
SR-037	The system should be able to identify where the user is standing (side walk or street).										X				
SR-038	The system should be able to determine location of crosswalk corridor, which is the rectangular path defined by the crosswalk pattern borders, extended onto the sidewalk it adjoins.										X				
SR-039	The system should be able to determine location of crosswalk corridor relative to the user.										X				

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-040	The system shall be able to collect personalized intersection crossing constraints from the user.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-041	The system should be able to communicate to the user on which intersection the user is located.										X				
SR-042	The system should be able to communicate with the user the exact corner of the intersection at which (s)he is standing.										X				
SR-043	The system should be able to communicate to the user contextual information on the built environment around an intersection.										X				
SR-044	The system should be able to provide guidance to the user in locating the crosswalk corridor (the rectangular path defined by the crosswalk pattern borders, extended onto the sidewalk it adjoins).										X				

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-045	The system should be able to provide a notification when the user locates the crosswalk corridor.										X				
SR-046	The system should have the capability of providing information about the corner (e.g., presence and type of curb cuts) to users with visual impairments to help him/her orient an navigate to the crosswalk										X	X			
SR-047	The system should have the capability to guide the user to the starting location of the crosswalk.														
SR-048	The system should be able to provide an alert when the user is not inside of crosswalk corridor.						X								
SR-049	The system should be able to provide confirmation when the user is inside of crosswalk corridor.						X								

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-050	The system should inform users with intersection geometric information (e.g., curb cut locations).														
SR-051	The system should inform users with obstacle information (e.g., work zone) about the intersection										X	X			
SR-052	The system shall be capable of alerting the user to wait when the signal indicates No Walk.								X						
SR-053	The system should provide the ability to use pre-planned route and destination information (e.g., walking path)									X					X
SR-054	The system shall be capable of alerting the user to wait when the signal indicates "Walk", but there is not enough time remaining for the user to cross.			X											

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-055	The system shall be capable of notifying the user of how much time is remained of a specific signal phase (walk or no-walk)	X	X	X	X		X	X	X	X	X	X	X	X	X
SR-056	The system shall communicate with the user whether an intersection has a traffic island.	X	X	X	X		X	X	X	X	X	X	X	X	X
SR-057	The system shall be able to provide guidance, notifications, and alerts in order to assist the users in crossing the intersection.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-058	The system shall allow users to enter their crossing direction.	X													
SR-059	The system shall allow users to indicate their intent to cross in the mobile application.	X													

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-060	The system should be able to determine direction of the user relative to crossing direction.										X				
SR-061	If the user intends to make two consequent crosses at an intersection, the system shall provide information that enables the user to determine which cross should occur first.								X						
SR-062	The system shall be able to provide real time information (signal phase, timing, etc.) about the traffic signal system.	X	X	X	X		X	X	X	X	X	X	X	X	X
SR-063	The system shall be able to notify the user when Walk time is extended.		X												
SR-064	The system shall be capable of informing the user to cross when the signal indicates Walk and there is enough time left for the user to cross.		X												

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-065	The system should have the capability of coordinating the signal timing plans with anticipated user arrivals.									X					X
SR-066	The system shall have the capability to notify the traffic signal system of the intersection crossing intention of the user.	X	X	X	X		X	X	X	X	X	X	X	X	X
SR-067	The system should be able to determine the user speed crossing an intersection.							X							
SR-068	The system should be capable of computing time required for a user to cross a specific intersection.	X													
SR-069	The system should have the capability to track the user's progress through the crosswalk (from one corner to the other).							X							

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-070	The system should be capable of identifying the user's delays in crossing an intersection.							X							
SR-071	The system should be capable of identifying the users' drift from the crosswalk when crossing an intersection.						X								
SR-072	The system should be capable of communicating with the user regarding his/her progress crossing an intersection.							X							
SR-073	The system shall enable the user to notify the system of his/her delay crossing an intersection.														
SR-074	The system should be capable of communicating the user's delay to the traffic signal system in real time.							X							

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-075	The system shall have the capability to allow for dynamic extension of minimum crossing time constraint if an unexpected delay is detected							X							
SR-076	The system should notify the user of her/his deviation from the crosswalk.						X								
SR-077	The system should provide directional guidance to help the user get back in the safe zone path in case of a drift.										X				
SR-078	The system should notify the user of his delay crossing an intersection.							X							
SR-079	The system should have the capability to advise users on how to exit the crosswalk by providing guidance to the exit point (whether there is a curb or a cut-out, grade, etc.)	X	X	X	X		X	X	X	X	X	X	X	X	X

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-080	The system shall be able to provide a notification when the user successfully crosses an intersection.	X	X	X	X		X	X	X	X	X	X	X	X	X
SR-081	The system shall be capable of identifying a location (i.e. coordinates) of interest at the intersection						X								
SR-082	The system shall correctly identify the intersection at which the user is located.	X	X	X	X						X				
SR-083	The system shall correctly identify the intersection corner at which the user is located.	X	X	X	X						X				
SR-084	The system shall correctly determine whether a user has begun crossing an intersection and is delayed to the extent that the current GREEN phase must be extended.							X							

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-085	The system shall correctly detect when a user veers outside of the crosswalk.						X								
SR-086	The system shall increase blind users' perceived safety crossing an intersection.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-087	The system shall reduce the number of cycles a blind user waits to feel safe crossing the intersection.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-088	The system shall increase the percentage of new intersections crossed by a user.														
SR-089	The system shall decrease the total time it takes for the user to cross an intersection (from arrival at the intersection to completion of the crossing) compared to the user's unassisted crossing time.	X	X	X	X	X	X	X	X	X	X	X	X	X	

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-090	The system shall improve the user travel time through a sequence of intersections from the user's baseline travel time.	X	X	X	X	X	X	X	X	X	X	X	X	X	
SR-091	The system should ingest, store and access relevant information about the intersection and its corners, including presence and location of curb cuts at corners to facilitate entry into the crosswalk and presence of traffic islands in different crossing directions.	X	X	X	X		X	X	X	X	X	X	X	X	X
SR-092	The system should be able to ingest, store, and access information on an intersection's traffic signal system.	X													
SR-093	The system should be able to ingest, store, and access information on an intersection's traffic signal system's operational status.					X									
SR-094	The system should be able to ingest, store, and access information on whether an intersection is equipped for DSRC communications	X													

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-095	The system shall be able to ingest, store, and access MAP message data.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-096	The system shall be able to ingest, store and access SPaT message data.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-097	The system should have a data validation process.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SR-098	The system should be able to ingest, store and access data from external sources (e.g., through appropriate APIs)											X			X
SR-099	The system shall be able to ingest, store and access a user's travel plan,														X

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-100	The system shall collect information about what kind of assistive technology or mobility aid the pedestrian is using.									X	X	X		X	X
SR-101	The system shall be able to determine, prior to the user's arrival, if an upcoming intersection is adjacent to the user's bus route transfer point														X
SR-102	The system shall be able to ingest or determine the user's embarkation bus stop and desired bus route number.														X
SR-103	The system shall be able to determine, prior to the user's arrival, the user's expected arrival time at the intersection.														X
SR-104	The system shall be able to determine if there is an approaching bus with the desired bus route number.														X

ID	Requirement Description	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12	UC13	UC14
SR-105	The system shall be able to estimate the time at which the bus is expected to depart from the bus stop														X
SR-106	The system shall be able to determine if additional crossing time must be allocated to ensure that the bus remains at the bus stop until the user can embark.														X
SR-107	The system shall be able to allocate the additional crossing time to ensure that the bus remains at the bus stop until the user can embark.														X
SR-108	The system shall not store any PII data.	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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