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

System Requirements

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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. 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

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.

Document Overview

This document outlines the system requirements for the system (the app) that will be built to help connect pedestrians with disabilities to adaptive signal control for purposes of safe intersection crossing and enhanced mobility. The ConOps is a prerequisite to this document and is recommended reading prior to the SyRS. The ConOps describes the characteristics of the System from the user's viewpoints. The SyRS builds upon those concepts, particularly the User Needs, to document the required functionality, performance, interfaces, and other characteristics for the System. The structure of this SyRS document is based on Institute of Electrical and Electronics Engineers (IEEE) Standard 1233-1998 IEEE Guide for Developing System Requirements Specifications and Federal Highway Administration's (FHWA) System Engineering Guidebook (SEGB) that adapted IEEE-1233.

This System Requirement document 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 the Requirements Analysis Process is to transform the stakeholder, requirement-driven view of desired services into a technical view of a required product that could deliver those services. This process builds a representation of a future system that will

meet stakeholder requirements and that, as far as constraints permit, does not imply any specific 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 requirements analysis process is both iterative and recursive. As this project is using an agile approach for developing the *Safe Intersection Crossing* system, the requirements document would be a live document and will reflect the current thinking and updated changes at each stage of the project.

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, and leverage 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 Dedicated Short-Range Communication (DSRC) capability, allowing them to (1) access real-time information from traffic signal infrastructure and nearby vehicles and (2) to actively influence traffic signal control decisions and 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 app 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, leading 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.

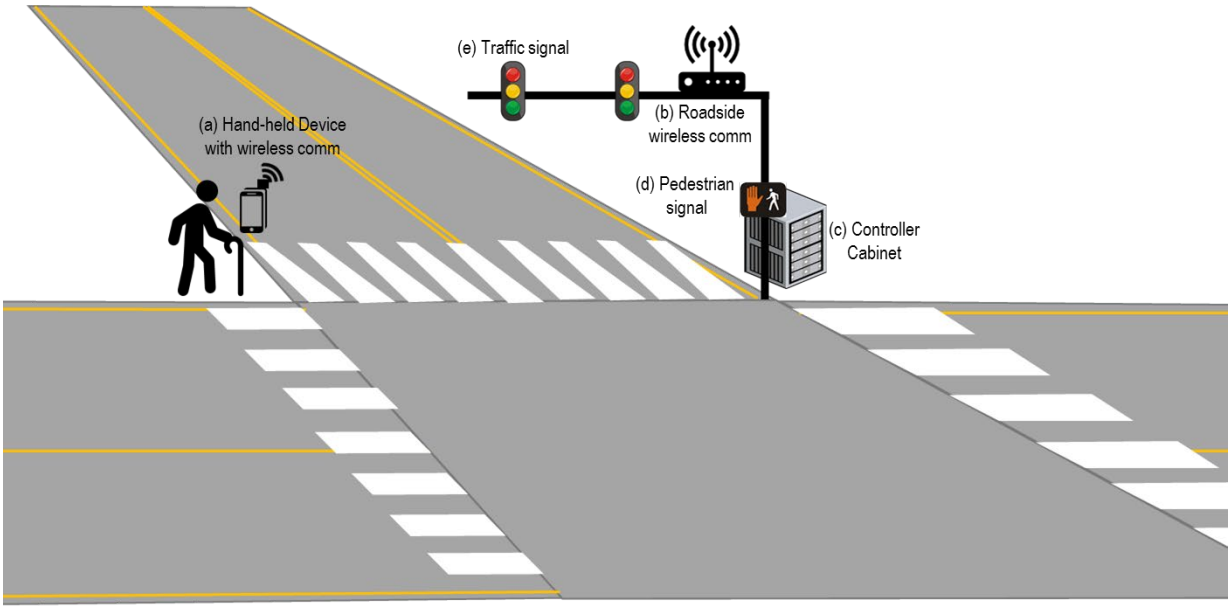

Figure 1: Components of the Safe Intersection Crossing System

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 to develop understanding of user requirements, needs and challenges. Second, a larger number of individuals will be recruited to participate in Phase 3 field test experiments of the prototype device. While our app development perspective will be on universal design, our prototyping effort and field–testing will focus on visually impaired pedestrians.

On October 24, 2017, an initial meeting of stakeholders was held to illicit important user requirements. 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 visually impaired 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 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 the visually impaired.
    b. Catherine Getchal, the director of Disability Services at CMU and herself a blind person.
    c. Aaron Steinfeld, a Research Professor of Robotics at Carnegie Mellon University 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 where older adults, people with mobility disability, and veterans with disabilities, and we intend to follow up with representative individuals and organizations from these communities. Although they were not able to attend our initial stakeholders meeting, we have also been in contact with the following organizations and will solicit their input individually in subsequent meetings:

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, and intend to keep this conversation going and additionally discuss user requirements.
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 and put us in touch with others that could help.

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) will be contacted to find one or more representatives from this community to support user requirements analysis.

Our team is also planning to reach out to the Port Authority of Allegheny County, since they provide a major mode of transportation around the city for individuals with disabilities, and are actively exploring the use of DSRC-based communication with Surtrac controlled intersections. Further, since our year two development plan includes a capability to help synchronize pedestrian and bus arrivals at a given bus stop, our refinement of this part of the overall CONOPs requires their involvement.

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.

Referenced Documents

- Connecting Pedestrians with Disabilities to Adaptive Signal Control for Safe Intersection Crossing and Enhanced Mobility: Concept of Operations (ConOps)
- IEEE Std. 1233 – IEEE Guide for Developing System Requirements Specifications
- INCOSE Systems Engineering Handbook version
- 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
- 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.
- 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.
- IEEE 1609.4 Standard for Wireless Access in Vehicular Environments (WAVE) - MultiChannel Operations
- SAE J2735 Standard specifying Dedicated Short Range Communications (DSRC) message set dictionary
- IEEE 802.11p Standard to add wireless access in vehicular environments (WAVE), adding enhancement required to support Intelligent Transportation Systems (ITS) applications.

Other Sources

- Web Content Accessibility Guidelines (WCAG): https://www.w3.org/WAI/intro/wcag

- 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 actionable behaviors of the System.
2) Performance Requirements: which specify quantifiable characteristics of System operations.
3) Interface Requirements: which define the System external interfaces to Systems (the outside world).
4) Data Requirements: define the data stored within the System.

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 the ConOps.

The system here refers to the overall system developed by the team that will make the safe intersection crossing possible. This system consists of two major subsystems: the Mobile Subsystem and the Surtrac2 Subsystem.

The Mobile Subsystem includes the mobile app and DSRC extension attached to the smartphone that the pedestrian will hold and utilize for assistance. That is the subsystem that the user directly interfaces with.

The Surtrac2 Subsystem 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. That is the unit that interacts with both the intersection signal system and the Mobile Subsystem. The Surtrac2 Subsystem will be a revised version of the Surtrac system that CMU previously developed.

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 system design, these requirements will be enhanced and more details added to them.

Table 1: System Performance Requirements

Req. ID	Requirement Description	Notes
SR-91	The mobile system shall be capable of identifying a location (i.e. coordinates).	Need to figure out what reliability threshold is achievable by the current location identification technologies.
SR-92	The system shall correctly identify the intersection the user is at.	Need to figure out the achievable accuracy threshold based on the current location identification technologies.
SR-93	The system shall correctly identify the intersection corner the user is at.	Need to figure out the achievable accuracy threshold based on the current location identification technologies.
SR-94	The system shall correctly identify that a user is delayed crossing an intersection.	Need to figure out the achievable accuracy threshold based on the current location identification technologies.
SR-95	The system shall correctly detect the users' deviation from the path.	Need to figure out the achievable accuracy threshold based on the current location identification technologies.
SR-96	The system shall increase the users' perceived safety crossing an intersection.	Will be determined using survey respondents agreeing that they feel safer using the app.
SR-97	The system shall reduce the number of cycles the user waits to feel safe crossing the intersection to 0.	
SR-98	The system shall increase the percentage of new intersections crossed by a user.	This requirement will indicate the user's level of confidence with the tool.
SR-99	The system shall decrease percentage of total duration of the time from start-finish crossing an intersection.	Need to determine the achievable threshold by further analysis.
SR-100	The system shall improve the user travel time (rush hour, mid-day).	Need to determine the achievable threshold by further analysis.
SR-101	The mobile system shall communicate intersection crossing information (alerts, coordinates, etc.) with the user in a timely manner.	The design team to determine the threshold latency for information exchange.

Req. ID	Requirement Description	Notes
SR-102	The Surtrac2 system shall communicate intersection crossing information (alerts, coordinates, etc.) with the Mobile system in a timely manner.	The design team to determine the threshold latency for information exchange.
SR-103	The Surtrac2 system shall communicate user information (arrival; time, speed, etc.) with the intersection signal system in a timely manner.	The design team to determine the threshold latency for information exchange.

Table 2: System Interface Requirements

Req. ID	Requirement Description	Notes
SR-1	The mobile system shall provide accessible interfaces and content that follows universal design standards.	
SR-2	The mobile system shall provide accessible interfaces and content that follows Web Content Accessibility Guidelines (WCAG)	WCAG: https://www.w3.org/WAI/intro/wcag
SR-3	The mobile system shall provide accessible interfaces and content that follows BBC Standards and Guidelines for Mobile Accessibility.	BBC Guideline: http://www.bbc.co.uk/guidelines/futuremedia/accessibility/mobile
SR-4	The mobile system should follow Apple's recommended advice on accessible app.	
SR-5	The mobile system shall have audio components to provide audible notifications and alerts.	
SR-6	The mobile system shall have the option of reducing the narration speed when delivering aural (ear or hearing) information.	
SR-7	The mobile system shall be capable of providing monotone aural information.	This requirement is to accommodate people with hearing loss when there is a big tonal range situation.

Req. ID	Requirement Description	Notes
SR-8	The mobile system shall be capable of flashing visual alerts and notifications.	
SR-9	The mobile system shall be capable of providing vibratory alerts and notifications.	
SR-11	The mobile system shall have the option of repeating visual information when needed (i.e. requested by user).	
SR-12	The mobile system shall facilitate visual interface (reading of the instructions, etc.) in visually difficult situations (e.g. bright light, dark, etc.)	
SR-13	The mobile system should be capable of providing the user with confirmation throughout tasks.	Confirmation information such as: half way through, at intersection, intersection crossing completed, etc.
SR-14	The mobile system shall provide the option to the user for adjusting (i.e. reducing or increasing) the amount of notifications user receives.	
SR-15	The mobile system shall be able to receive commands from a user through text input.	
SR-16	The mobile system shall be able to receive commands from the user through voice communication	
SR-17	The mobile system shall be capable of announcing upcoming task or step.	
SR-18	The mobile system should be capable of displaying upcoming task or step with text descriptions.	
SR-19	The mobile system shall be able to adjust level of assistance based on user profile (e.g., disability type).	
SR-20	The mobile system shall provide the user with the option of choosing the level of assistance (e.g., verbosity) based on familiarity of the user with the area.	

Req. ID	Requirement Description	Notes
SR-24	The mobile system shall have the option of providing cardinal directions.	
SR-25	The mobile system should have the option of providing relative directions (e.g. left, right, behind, in front of).	
SR-31	The mobile system shall be capable of communicating with the Surtrac2 system.	
SR-32	The Surtrac2 system shall be capable of communicating with a traffic signal system.	
SR-33	The mobile system shall be able to collect the signal phase and timing data from the Surtrac2 system.	
SR-34	The Surtrac2 system shall be able to collect the signal phase and timing data from the intersection signal system.	
SR-35	The Surtrac2 system shall be able to interact with the traffic signal system to influence signal timing and duration.	
SR-36	The mobile system shall integrate a Smart Phone with a DSRC sleeve to enable communication with the signal system.	
SR-39	The mobile system should be capable of providing the user with information about the upcoming intersection (If it's signalized, walk/no-walk signal, how many streets crossing, etc.).	
SR-45	The mobile system shall be able to collect personalized intersection crossing constraints from the user.	
SR-46	The mobile system shall be able to communicate to the user which intersection the user is at.	
SR-47	The mobile system should be able to communicate with the user the exact corner of the intersection he is standing at.	Hard to know and pending location identification technologies accuracy.
SR-55	The mobile system should inform the user with intersection geometric information (e.g., curb cut locations).	Hard to know and pending external data availability and location identification technologies accuracy.

Req. ID	Requirement Description	Notes
SR-56	The mobile system should inform the user with obstacle information (e.g., pothole or construction) about the intersection.	Hard to know and pending external data availability and location identification technologies accuracy.
SR-57	The mobile system shall be capable of alerting the user to wait when the signal indicates No Walk.	
SR-58	The mobile system should provide users with pre-planned route and destination information (e.g., walking path).	Pending external data resources availability.
SR-59	The mobile system shall communicate with the Surtrac2 system that the user intends to cross the intersection.	
SR-60	The Surtrac2 system shall communicate with the intersection signal system that the user intends to cross the intersection.	
SR-61	The Surtrac2 system shall communicate with the mobile system of the phase and time remaining of that phase of the signal system.	
SR-62	The mobile 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.	
SR-63	The mobile system shall be capable of notifying the user of how much time is remained of a specific signal phase (walk or no-walk)	
SR-64	The mobile system shall communicate with the user whether an intersection has a traffic island. If the information is not available, the notification shall say so.	
SR-66	The mobile system shall provide the option for the user so he can enter his crossing direction.	
SR-67	The mobile system shall provide the option for the user so he can indicate his intent to cross.	
SR-73	The mobile 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.	

Req. ID	Requirement Description	Notes
SR-83	The mobile system shall enable the user to notify the mobile system of his/her delay crossing an intersection.	
SR-84	The mobile system should be capable of communicating the user's delay to the surtrac2 system in real time.	Hard to know and pending location identification technologies accuracy.
SR-86	The mobile system should notify the user of his drift from the crosswalk.	Hard to know and pending location identification technologies accuracy.
SR-87	The mobile system should provide directional guidance to help the user get back in the safe zone path in case of a drift.	Hard to know and pending location identification technologies accuracy
SR-88	The mobile system should notify the user of his delay crossing an intersection.	Hard to know and pending location identification technologies accuracy.

Table 3: System Functional Requirements

Req. ID	Requirement Description	Notes
SR-21	The mobile system shall provide the user with an option to cancel receiving directions and alerts.	
SR-22	The mobile system shall have the option to be completely turned off.	
SR-23	The mobile system shall have the option of providing direction using clock position.	This could be a challenge acquiring precise user location and is pending location identification technologies accuracy.
SR-26	The mobile system shall be capable of recognizing when there is no connectivity with the intersection (e.g., traffic signal mobile system).	
SR-27	The Surtrac2 system shall be capable of recognizing when there is no connectivity with the traffic signal system.	
SR-28	The mobile system shall be capable of communicating "no connectivity with the intersection", with the user.	
SR-29	The Surtrac2 system shall be capable of communicating "no connectivity with the signal system", with the mobile system.	

Req. ID	Requirement Description	Notes
SR-30	The mobile system shall have an option for the user to communicate his progress in case of unreliable or unavailable GPS.	
SR-37	The Surtrac2 system shall be able to influence adjustment of signal timing plan based on the pedestrian speed.	
SR-38	The Surtrac2 system shall be able to communicate with the mobile system any change to signal phase and timing.	
SR-40	The mobile system shall be able to recognize the intersection (e.g., intersection of Maine and 3rd).	
SR-41	The mobile system should be able to locate the intersection at which the user is positioned (e.g., southwest corner of Maine and 3rd).	Hard to know and pending location identification technologies accuracy.
SR-42	The mobile system should be able to identify where the user is standing (side walk or street).	Hard to know and pending location identification technologies accuracy.
SR-43	The mobile system should be able to determine location of crosswalk corridor.	Hard to know and pending location identification technologies accuracy. Crosswalk corridor is the rectangular path defined by the crosswalk pattern borders, extended onto the sidewalk it adjoins.
SR-44	The mobile system should be able to determine location of crosswalk corridor relative to the user.	Hard to know and pending location identification technologies accuracy.
SR-48	The mobile system should be able to communicate with the user contextual information on the built environment around an intersection.	Hard to know and pending external data availability and location identification technologies accuracy. Contextual information includes GIS and crowdsourced based information on curb cuts, bus stop locations, side walk grade and slope.
SR-49	The mobile 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).	
SR-50	The mobile system should be able to provide a notification when the user locates crosswalk corridor.	

Req. ID	Requirement Description	Notes
SR-51	The mobile system should have the capability to provide information on crosswalk entrance points, such as cut-outs, grade, and geometry, facilitating entry into the crosswalk for those with visual disability.	Hard to know and pending location identification technologies accuracy.
SR-52	The mobile system should have the capability to guide the user to the starting location of the crosswalk.	
SR-53	The mobile system should be able to provide an alert when the user is not inside of crosswalk corridor.	Hard to know and pending location identification technologies accuracy.
SR-54	The mobile system should provide confirmation when the user is inside of crosswalk corridor.	Hard to know and pending location identification technologies accuracy.
SR-65	The mobile system shall be able to provide guidance, notifications, and alerts in order to assist the users in crossing the intersection.	
SR-68	The mobile system should be able to determine direction of the user relative to crossing direction.	Hard to know and pending location identification technologies accuracy.
SR-69	If the user intends to make two consequent crosses at an intersection, the Surtrac2 system shall be capable of determining which cross should occur first.	This requirement is to minimize wait time.
SR-70	The surtrac2 system shall be able to provide the mobile system with real time information (signal phase, timing, etc.) about the traffic signal system.	
SR-71	The mobile system shall be able to provide the user with real time information (signal phase, timing, etc.) about the traffic signal system.	
SR-72	The mobile system shall be able to notify the user when Walk time is extended.	
SR-74	The surtrac2 system should have the capability of coordinating the signal timing plans with anticipated user arrivals.	
~~SR-75~~	~~Conops: Chapter 5 Surtrac Adaptive Traffic Signal Control~~	This is a duplicate of SR-59
SR-76	The surtrac2 system shall have the capability to notify the traffic signal system of the intersection crossing intention of the user.	

Req. ID	Requirement Description	Notes
SR-77	The mobile system should be able to determine the user speed crossing an intersection.	Hard to know and pending location identification technologies accuracy.
SR-78	The mobile system shall be capable of computing time required for a user to cross a specific intersection.	Hard to know and pending location identification technologies accuracy.
SR-79	The mobile system should have the capability to track the user's progress through the crosswalk (from one corner to the other).	Hard to know and pending location identification technologies accuracy. Need to determine how often the progress should be updated (e.g., every second).
SR-80	The mobile system should be capable of identifying the user's delays in crossing an intersection.	Hard to know and pending location identification technologies accuracy.
SR-81	The mobile system should be capable of identifying the users' drift from a safe zone when crossing an intersection.	Hard to know and pending location identification technologies accuracy.
SR-82	The mobile system should be capable of communicating with the user of his progress crossing an intersection.	Hard to know and pending location identification technologies accuracy.
SR-85	The surtrac2 system shall have the capability to allow for dynamic extension of minimum crossing time constraint if an unexpected delay is detected	
SR-89	The mobile 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.)	Hard to know and pending location identification technologies accuracy.
SR-90	The mobile system shall be able to provide a notification when the user successfully crosses an intersection.	

Table 4: System Data Requirements

Req. ID	Requirement Description	Notes
SR-104	The mobile system should have the data that an intersection has a traffic island.	Pending availability of external resources.
SR-105	The mobile system should have the data that an intersection is signalized.	
SR-106	The mobile system should have the data that an intersection signal mobile system is operational.	
SR-107	The mobile system should have the data that an intersection signal mobile system is DSRC equipped.	
SR-108	The system shall be able to ingest MAP message data.	
SR-109	The system shall be able to ingest SPaT message data.	
SR-110	The system should have a data validation process.	
SR-111	The system should be able to ingest external data format (e.g., by applying appropriate APIs)	
SR-112	The system shall not store any Personally Identifiable Information (PII).	
SR-113	The mobile system shall collect data about the type of assistive tools (e.g. wheelchair, cane, dog, etc.) that the user is using.	
SR-114	The system shall track the performance of the system by recording anonymized data of pedestrians (who use the intersection crossing mobile system) crossing the intersections.	The data storage requirement is TBD.

Chapter 4. Verification Methods

Since we're employing an iterative and agile process for developing the safe intersection crossing prototype, the verification will occur during the design and development as well. However, it is anticipated that the 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

Needs to Requirements Traceability

Almost all of the requirements outlined in this chapter trace back to the stakeholder requirements which were documented in the ConOps document. The System Requirements Traceability Matrix in Appendix A identifies the sources of each of the requirements.

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.

Requirements to Architecture Components

The two major subsystems (the mobile and the Surtrac2 subsystems) were discussed 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.

Appendix A. Requirements Traceability Matrix

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-1	The mobile system shall provide accessible interfaces and content that follows universal design standards.		Interface Requirement	Demonstration	Mobile Subsystem
SR-2	The mobile system shall provide accessible interfaces and content that follows Web Content Accessibility Guidelines (WCAG)	System Requirements Analysis Discussions	Interface Requirement	Demonstration	Mobile Subsystem
SR-3	The mobile system shall provide accessible interfaces and content that follows BBC Standards and Guidelines for Mobile Accessibility.	System Requirements Analysis Discussions	Interface Requirement	Demonstration	Mobile Subsystem
SR-4	The mobile system should follow Apple's recommended advice on accessible app.	System Requirements Analysis Discussions	Interface Requirement	Demonstration	Mobile Subsystem
SR-5	The mobile system shall have audio components to provide audible notifications and alerts.	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Inspection	Mobile Subsystem
SR-6	The mobile system shall have the option of reducing the narration speed when delivering aural (ear or hearing) information.	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Inspection	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-7	The mobile system shall be capable of providing monotone aural information.	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-8	The mobile system shall be capable of flashing visual alerts and notifications.	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-9	The mobile system shall be capable of providing tactile (vibration) alerts and notifications.	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-10	The mobile system shall have the option of delivering visual information slowly.	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Inspection	Mobile Subsystem
SR-11	The mobile system shall have the option of repeating visual information when needed (i.e. requested by user).	Conops/ Operational Scenarios/ Use Case 13	Interface Requirement	Inspection	Mobile Subsystem
SR-12	The mobile system shall facilitate visual interface (reading of the instructions, etc.) in visually difficult situations (e.g. bright light, dark, etc.)	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Inspection	Mobile Subsystem
SR-13	The mobile system should be capable of providing the user with confirmation throughout tasks.	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Demonstration	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-14	The mobile system shall provide the option to the user for adjusting (i.e. reducing or increasing) the amount of notifications user receives.	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-15	The mobile system shall be able to receive commands (e.g., crossing direction) from a user through text input.	Conops/ Operational Scenarios/ Use Case 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-16	The mobile system shall be able to receive commands from the user through voice communication	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-17	The mobile system shall be capable of announcing upcoming task or step.	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-18	The mobile system should be capable of displaying upcoming task or step with text descriptions.	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-19	The mobile system shall be able to adjust level of assistance based on user profile (e.g., disability type).	Conops/ Chapter 4/ Description of Desired Changes	Interface Requirement	Demonstration	Mobile Subsystem
SR-20	The mobile system shall have the option of choosing the level of assistance (e.g., verbosity) based on familiarity of the user with the area.	Conops/ Chapter 4/ Description of Desired Changes	Interface Requirement	Demonstration	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-21	The mobile system shall provide the user with an option to cancel receiving directions and alerts.	Conops/ Operational Scenarios/ Use Case 14	Functional Requirement	Demonstration	Mobile Subsystem
SR-22	The mobile system shall have the option to be completely turned off.	Conops/ Operational Scenarios/ Use Case 14	Functional Requirement	Demonstration	Mobile Subsystem
SR-23	The mobile system shall have the option of providing direction using clock position.	Conops/ Chapter 4/ Description of Desired Changes	Functional Requirement	Demonstration	Mobile Subsystem
SR-24	The mobile system shall have the option of providing cardinal directions.	Conops/ Operational Scenarios/ Desired Design Features/Table 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-25	The mobile system should have the option of providing relative directions (e.g. left, right, behind, in front of).	Conops/ Operational Scenarios/ Desired Design Features/ Table 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-26	The mobile system shall be capable of recognizing when there is no connectivity with the intersection (e.g., traffic signal mobile system).	Conops/ Operational Scenarios/ Use Case 5	Functional Requirement	Formal Test	Mobile Subsystem
SR-27	The Surtrac2 system shall be capable of recognizing when there is no connectivity with the traffic signal system.	Conops/ Operational Scenarios/ Use Case 5	Functional Requirement	Formal Test	Surtrac2 Subsystem
SR-28	The mobile system shall be capable of communicating "no connectivity with the intersection", with the user.	Conops/ Operational Scenarios/ Use Case 5	Functional Requirement	Formal Test	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-29	The Surtrac2 system shall be capable of communicating "no connectivity with the signal system", with the mobile system.	Conops/ Operational Scenarios/ Use Case 5	Functional Requirement	Formal Test	Surtrac2 Subsystem
SR-30	The mobile system shall have an option for the user to communicate his progress in case of unreliable or unavailable GPS.	Conops/Chapter 8/ Acquisition and incorporation of personalized crossing constraints	Functional Requirement	Demonstration	Mobile Subsystem
SR-31	The mobile system shall be capable of communicating with the Surtrac2 system.	Conops/ Operational Scenarios/ Use Case 1	Interface Requirement	Formal Test	Mobile Subsystem
SR-32	The Surtrac2 system shall be capable of communicating with a traffic signal system.	Conops/ Operational Scenarios/ Use Case 1	Interface Requirement	Formal Test	Surtrac2 Subsystem
SR-33	The mobile system shall be able to collect the signal phase and timing data from the Surtrac2 system	Conops/ Operational Scenarios/ Use Case 1	Interface Requirement	Formal Test	Mobile Subsystem
SR-34	The Surtrac2 system shall be able to collect the signal phase and timing data from the intersection signal system.	Conops/ Operational Scenarios/ Use Case 1	Interface Requirement	Formal Test	Surtrac2 Subsystem
SR-35	The Surtrac2 system shall be able to interact with the traffic signal system to influence signal timing and duration.	Conops/ Operational Scenarios/ Use Case 1	Interface Requirement	Formal Test	Surtrac2 Subsystem
SR-36	The mobile system shall integrate a Smart Phone with a DSRC sleeve to enable communication with the signal system.	Conops/Chapter 5/ Mobile app – RSE Connectivity	Interface Requirement	Formal Test	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-37	The Surtrac2 system should be able to influence adjustment of signal timing plan based on the pedestrian speed.	Conops/Chapter 8/ Active monitoring and attention to crossing progress	Functional Requirement	Formal Test	Surtrac2 Subsystem
SR-38	The Surtrac2 system should be able to communicate with the mobile system any change to signal phase and timing.	Conops/Chapter3/ Existing Surtrac System	Functional Requirement	Formal Test	Surtrac2 Subsystem
SR-39	The mobile system should be capable of providing the user with information about the upcoming intersection (If it's signalized, walk/no-walk signal, how many streets crossing, etc.)	Conops/ Operational Scenarios/ Use Case 9	Interface Requirement	Formal Test	Mobile Subsystem
SR-40	The mobile system shall be able to recognize the intersection (e.g., intersection of Maine and 3rd).	Conops/ Operational Scenarios/ Use Case 10-12	Functional Requirement	Formal Test	Mobile Subsystem
SR-41	The mobile system should be able to locate the intersection at which the user is positioned (e.g., southwest corner of Maine and 3rd).	Conops/ Operational Scenarios/ Use Case 10-12	Functional Requirement	Formal Test	Mobile Subsystem
SR-42	The mobile system should be able to identify where the user is standing (side walk or street).	Conops/ Operational Scenarios/ Use Case 15	Functional Requirement	Formal Test	Mobile Subsystem
SR-43	The mobile system should be able to determine location of crosswalk corridor.	Conops/ Operational Scenarios/ Use Case 10-12	Functional Requirement	Formal Test	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-44	The mobile system should be able to determine location of crosswalk corridor relative to the user.	Conops/ Operational Scenarios/ Use Case 10-12	Functional Requirement	Formal Test	Mobile Subsystem
SR-45	The mobile system shall be able to collect personalized intersection crossing constraints from the user.	Conops/ Chapter 5 Operational Concept/ Use Cases	Interface Requirement	Formal Test	Mobile Subsystem
SR-46	The mobile system should be able to communicate to the user which intersection the user is at.	Conops/ Operational Scenarios/ Use Case 12	Interface Requirement	Demonstration	Mobile Subsystem
SR-47	The mobile system should be able to communicate with the user the exact corner of the intersection he is standing at.	Conops/ Operational Scenarios/ Use Case 12	Interface Requirement	Demonstration	Mobile Subsystem
SR-48	The mobile system should be able to communicate with the user contextual information on the built environment around an intersection.	Conops/ Operational Scenarios/ Use Case 10-12	Functional Requirement	Demonstration	Mobile Subsystem
SR-49	The mobile 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).	Conops/ Operational Scenarios/ Use Case 10-12	Functional Requirement	Demonstration	Mobile Subsystem
SR-50	The mobile system should be able to provide a notification when the user locates crosswalk corridor.	Conops/ Operational Scenarios/ Use Case 10-12	Functional Requirement	Demonstration	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-51	The mobile system should have the capability to provide information on crosswalk entrance points, such as cut-outs, grade, and geometry, facilitating entry into the crosswalk for those with visual impairments.	Conops/ Chapter 7/ Operational Impacts/Locating the start of the crosswalk	Functional Requirement	Formal Test	Mobile Subsystem
SR-52	The mobile system should have the capability to guide the user to the starting location of the crosswalk.	Conops/ Chapter 7/ Operational Impacts/Locating the start of the crosswalk	Functional Requirement	Formal Test	Mobile Subsystem
SR-53	The mobile system should be able to provide an alert when the user is not inside of crosswalk corridor.	Conops/ Chapter 7/ Operational Impacts/Locating the start of the crosswalk	Functional Requirement	Formal Test	Mobile Subsystem
SR-54	The mobile system should provide confirmation when the user is inside of crosswalk corridor.	Conops/ Chapter 7/ Operational Impacts/Locating the start of the crosswalk	Functional Requirement	Formal Test	Mobile Subsystem
SR-55	The mobile system should inform the user with intersection geometric information (e.g., curb cut locations).	Conops/Chapter 7/ Operational Impacts/Traversing a crosswalk	Interface Requirement	Formal Test	Mobile Subsystem
SR-56	The mobile system should inform the user with obstacle information (e.g., pothole or construction) about the intersection	Conops/Chapter 7/ Operational Impacts/Traversing a crosswalk	Interface Requirement	Formal Test	Mobile Subsystem
SR-57	The mobile system shall be capable of alerting the user to wait when the signal indicates No Walk.	Conops/ Operational Scenarios/ Use Case 8	Interface Requirement	Formal Test	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-58	The mobile system should provide users with pre-planned route and destination information (e.g., walking path).	Conops/ Chapter 5/ Mobile App User Interfaces (UI)	Interface Requirement	Formal Test	Mobile Subsystem
SR-59	The mobile system shall communicate with the Surtrac2 system that the user intends to cross the intersection.	Conops/ Chapter 6/ Use case 14	Interface Requirement	Formal Test	Surtrac2 Subsystem
SR-60	The Surtrac2 system shall communicate with the intersection signal system that the user intends to cross the intersection.	Conops/ Chapter 6/ Use case 14	Interface Requirement	Formal Test	Surtrac2 Subsystem
SR-61	The Surtrac2 system shall communicate with the mobile system of the phase and time remaining of that phase of the signal system.	Conops/ Operational Scenarios/ Use Case 3	Interface Requirement	Formal Test	Surtrac2 Subsystem
SR-62	The mobile 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.	Conops/ Operational Scenarios/ Use Case 3	Interface Requirement	Formal Test	Mobile Subsystem
SR-63	The mobile system shall be capable of notifying the user of how much time is remained of a specific signal phase (walk or no-walk)	Conops/ Chapter 5/ Modes of Operation	Interface Requirement	Formal Test	Mobile Subsystem
SR-64	The mobile system shall communicate with the user whether an intersection has a traffic island. If the information is not available, the notification shall say so.	Conops/ Operational Scenarios/ Use Case 15	Interface Requirement	Formal Test	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-65	The mobile system shall be able to provide guidance, notifications, and alerts in order to assist the users in crossing the intersection.	Conops/ Chapter 6/ Description of Desired Changes/ Table 1	Functional Requirement	Demonstration	Mobile Subsystem
SR-66	The mobile system shall provide the option for the user so he can enter his crossing direction.	Conops/ Operational Scenarios/ Use Case 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-67	The mobile system shall provide the option for the user so he can indicate his intent to cross.	Conops/ Operational Scenarios/ Use Case 1	Interface Requirement	Demonstration	Mobile Subsystem
SR-68	The mobile system should be able to determine direction of the user relative to crossing direction.	Conops/ Operational Scenarios/ Use Case 10	Functional Requirement	Formal Test	Mobile Subsystem
SR-69	If the user intends to make two consequent crosses at an intersection, the Surtrac2 system shall be capable of determining which cross should occur first.	Conops/ Operational Scenarios/ Use Case 8	Functional Requirement	Formal Test	Surtrac2 Subsystem
SR-70	The surtrac2 system shall be able to provide the mobile system with real time information (signal phase, timing, etc.) about the traffic signal system.	Conops/ Chapter 6/ Use cases 1-15	Functional Requirement	Formal Test	Surtrac2 Subsystem
SR-71	The mobile system shall be able to provide the user with real time information (signal phase, timing, etc.) about the traffic signal system.	Conops/ Chapter 6/ Use cases 1-15	Functional Requirement	Formal Test	Mobile Subsystem
SR-72	The mobile system shall be able to notify the user when Walk time is extended.	Conops/ Chapter 6/ Use case 2	Functional Requirement	Formal Test	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-73	The mobile 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.	Conops/ Operational Scenarios/ Use Case 2	Interface Requirement	Formal Test	Mobile Subsystem
SR-74	The surtrac2 system should have the capability of coordinating the signal timing plans with anticipated user arrivals.	Conops/ Chapter 5/ Surtrac Adaptive Traffic Signal Control	Functional Requirement	Formal Test	Surtrac2 Subsystem
SR-76	The surtrac2 system shall have the capability to notify the traffic signal system of the intersection crossing intention of the user.	Conops: Chapter 7/ Operational Impacts	Functional Requirement	Formal Test	Surtrac2 Subsystem
SR-77	The mobile system should be able to determine the user speed crossing an intersection.	Conops/ Operational Scenarios/ Use Case 7	Functional Requirement	Analysis	Mobile Subsystem
SR-78	The mobile system should be capable of computing time required for a user to cross a specific intersection.	Conops/ Operational Scenarios/ Use Case 1	Functional Requirement	Analysis	Mobile Subsystem
SR-79	The mobile system should have the capability to track the user's progress through the crosswalk (from one corner to the other).	Conops/ Chapter 7 / Operational Impacts	Functional Requirement	Formal Test	Mobile Subsystem
SR-80	The mobile system should be capable of identifying the user's delays in crossing an intersection.	Conops/ Operational Scenarios/ Use Case 7	Functional Requirement	Formal Test	Mobile Subsystem
SR-81	The mobile system should be capable of identifying the users' drift from a safe zone when crossing an intersection.	Conops/ Operational Scenarios/ Use Case 6	Functional Requirement	Formal Test	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-82	The mobile system should be capable of communicating with the user of his progress crossing an intersection.	Conops/ Chapter 5 Mobile App User Interface (UI) for Use of Pre-Planned Routes	Functional Requirement	Formal Test	Mobile Subsystem
SR-83	The mobile system shall enable the user to notify the mobile system of his/her delay crossing an intersection.	Conops/ Operational Scenarios/ Use Case 7	Interface Requirement	Demonstration	Mobile Subsystem
SR-84	The mobile system should be capable of communicating the user's delay to the surtrac2 system in real time.	Conops/ Operational Scenarios/ Use Case 7	Interface Requirement	Formal Test	Mobile Subsystem
SR-85	The surtrac2 system shall have the capability to allow for dynamic extension of minimum crossing time constraint if an unexpected delay is detected	Conops/ Chapter 5/ Surtrac Adaptive Traffic Signal Control	Functional Requirement	Formal Test	Surtrac2 Subsystem
SR-86	The mobile system should notify the user of his drift from the crosswalk.	Conops/ Operational Scenarios/ Use Case 6	Interface Requirement	Formal Test	Mobile Subsystem
SR-87	The mobile system should provide directional guidance to help the user get back in the safe zone path in case of a drift.	Conops/ Operational Scenarios/ Use Case 10	Interface Requirement	Formal Test	Mobile Subsystem
SR-88	The mobile system should notify the user of his delay crossing an intersection.	Conops/ Operational Scenarios/ **Use Case 7**	Interface Requirement	Formal Test	Mobile Subsystem
SR-89	The mobile 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.)	Conops/ Chapter 7 /Operational Impacts	Functional Requirement	Formal Test	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-90	The mobile system shall be able to provide a notification when the user successfully crosses an intersection.	Conops/ Chapter 4 /Description of Desired Changes	Functional Requirement	Formal Test	Mobile Subsystem
SR-91	The mobile system shall be capable of identifying a location (i.e. coordinates).	Conops/ Operational Scenarios/ Use Case 6	Performance Requirement	Analysis	Mobile Subsystem
SR-92	The system shall correctly identify the intersection the user is at.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-93	The system shall correctly identify the intersection corner the user is at.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-94	The system shall correctly identify that a user is delayed crossing an intersection.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-95	The system shall correctly detect the users' deviation from the path.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-96	The system shall increase the users' perceived safety crossing an intersection.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-97	The system shall reduce the number of cycles the user waits to feel safe crossing the intersection to 0.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-98	The system shall increase the percentage of new intersections crossed by a user.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-99	The system shall decrease percentage of total duration of the time from start-finish crossing an intersection.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-100	The system shall improve the user travel time (rush hour, mid-day).	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-101	The mobile system shall communicate intersection crossing information (alerts, coordinates, etc.) with the user in a timely manner.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-102	The Surtrac2 system shall communicate intersection crossing information (alerts, coordinates, etc.) with the Mobile system in a timely manner.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-103	The Surtrac2 system shall communicate user information (arrival; time, speed, etc.) with the intersection signal system in a timely manner.	Conops/ Chapter 8/ Performance Measures	Performance Requirement	Analysis	Mobile Subsystem
SR-104	The mobile system should have the data if an intersection has a traffic island.	Conops/ Operational Scenarios/ Use Case 15	Data Requirement	Inspection	Mobile Subsystem
SR-105	The mobile system should have the data if an intersection is signalized.	Conops/ Operational Scenarios/Use Case 1	Data Requirement	Inspection	Mobile Subsystem
SR-106	The mobile system should have the data if an intersection signal mobile system is operational.	Conops/ Operational Scenarios/ Use Case 5	Data Requirement	Inspection	Mobile Subsystem

Req. ID	Requirement Description	Source of the Requirement	Requirement Category	Verification Method	Subsystem
SR-107	The mobile system should have the data if an intersection signal mobile system is DSRC equipped.	Conops/ Operational Scenarios/Use Case 1	Data Requirement	Inspection	Mobile Subsystem
SR-108	The system shall be able to ingest MAP message data.	System Requirements Analysis Discussions	Data Requirement	Demonstration	Mobile Subsystem
SR-109	The system shall be able to ingest SPaT message data.	System Requirements Analysis Discussions	Data Requirement	Demonstration	Mobile Subsystem
SR-110	The system should have a data validation process.	System Requirements Analysis Discussions	Data Requirement	Inspection	Mobile Subsystem
SR-111	The system should be able to ingest external data format (e.g., by applying appropriate APIs)	System Requirements Analysis Discussions	Data Requirement	Demonstration	Mobile Subsystem
SR-112	The system shall not store any PII data.	System Requirements Analysis Discussions	Data Requirement	Inspection	Mobile Subsystem
SR-113	The mobile system shall collect data about the type of assistive tools (e.g. wheelchair, cane, dog, etc.) that the user is using.	System Requirements Analysis Discussions	Data Requirement	Inspection	Mobile Subsystem
SR-114	The system shall track the performance of the system by recording anonymized data of pedestrians (who use the intersection crossing mobile system) crossing the intersections.	System Requirements Analysis Discussions	Data Requirement	Formal Test	Mobile Subsystem

U.S. Department of Transportation
ITS Joint Program Office – HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free “Help Line” 866-367-7487

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