Requirements Document

Transit Bus Stop Pedestrian Warning Application

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16. Abstract

This document describes the System Requirements for the Transit Bus Stop Pedestrian Warning (TSPW) application. The requirements describe the system of interest for the implementation team including the required functions and performance along with the method of verification.

The term "performance requirements" does not establish or imply a requirement for public agencies or other infrastructure owners and operators. Rather, it reflects the systems engineering process that leads to identifying how well, and under what conditions, a physical of functional attribute will function. Documentation of performance requirements allows manufacturers and suppliers to competitively design products that will satisfactorily perform in an inter-operable system, as anticipated by customers.

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Chapter 1 Scope

1.1 Scope

This System Requirements document for the Transit Bus Stop Pedestrian Warning Application (TSPW) captures the requirements towards fulfilling the technical objectives as stated in FHWA Contract No.: DTFH61-12-D-00040/5015.

The term “performance requirements” does not establish or imply a requirement for public agencies or other infrastructure owners and operators. Rather, it reflects the systems engineering process that leads to identifying how well, and under what conditions, a physical of functional attribute will function. Documentation of performance requirements allows manufacturers and suppliers to competitively design products that will satisfactorily perform in an inter-operable system, as anticipated by customers.

1.2 Document Overview

The intended audience for this Applications Requirements document is the system developers, stakeholders (e.g., transit agencies and bus manufacturers) and other participants in the TSPW project.

The remainder of this document consists of the following sections and content:

Section 2 (Applicable Documents) describes the external documentation referenced throughout this document.

Section 3 (System Requirements) describes the system requirements for the system of interest.

Section 4 (Verification) describes the methods to be used during verification and outlines the verification method for each requirement.

Section 5 (Preparation for Delivery) describes how the product will be prepared for ultimate delivery.

Section 6 (Notes) provides acronyms, and abbreviations used throughout the document.

Chapter 2 Applicable Documents

2.1 General

Specifications

- DSRC Roadside Unit (RSU) Specifications Document, Version 4.0_April 15, 2014, http://www.its.dot.gov/testbed/PDF/USDOT_RSUSpecification4%200_Final.pdf

Standards

Institute of Electrical and Electronics Engineers (IEEE)

IEEE 1609.2	Wireless Access in Vehicular Environments (WAVE) – Security Services for Applications and Management Messages
IEEE 802.11p	IEEE Standard for Information technology – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Wireless Access in Vehicular Environments

Society of Automotive Engineers (SAE)

SAE J1113	Electromagnetic Compatibility Measurement Procedures and Limits for Components of Vehicles, Boats (up to 15 m), and Machines (Except Aircraft) (16.6 Hz to 18 GHz)
SAE J1211	Handbook for Robustness Validation of Automotive Electrical/Electronic Modules
SAE J1708	Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications
SAE J1850	Class B Data Communications Network Interface
SAE J1939	Serial Control and Communications Heavy Duty Vehicle Network, SAE International
SAE J2735 R41	Dedicated Short-Range Communications (DSRC) Message Set Dictionary, SAE International

International Organization for Standardization

ISO 9141-2	Road vehicles – Diagnostic systems – Part 2: CARB requirements for interchange of digital information
ISO 11898	Road vehicles – Controller area network (CAN)
ISO 14230-4	Road vehicles – Diagnostic systems – Keyword Protocol 2000 – Part 4: Requirements for emission-related systems

ISO 15765-4	Road vehicles – Diagnostic communication over Controller Area Network (DoCAN) – Part 4: Requirements for emissions-related systems
Other	
GMW3089	General Motors Local Area Network (GMLAN) Single Wire Controller Area Network (SWCAN) Physical and Data Link Layers Specification
ANSI/IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
100008379-0004B	Transit Safety Retrofit Package Development Revised Applications Requirements Document
100008379-0001E	Transit Safety Retrofit Package Development TRP Concept of Operations
100064453-0024	E-TRP System Requirements Document
FHWA-JPO-16-332	TSPW Concept of Operations

2.2 Order of Precedence

While this requirements document is based on inputs collected from several documents and stakeholder meetings, the main contribution was from the TSPW Concept of Operations (FHWA-JPO-16-332). It should be noted however, that a number of decisions have taken place to modify the scenarios outlined within the Concept of Operations document since its release including:

1. Mobile device warnings will not be provided to pedestrians if they are in the roadway. This decision was made to reduce distraction to the mobile device carrier while in the most dangerous detection zone.
2. Pedestrian warnings to DSRC-Enabled Personally Owned Vehicles while a transit vehicle is not at a transit stop (Scenarios 65-72) will not be enabled.

In the event of other conflicts between the text of this document and the references cited herein (except for related specification sheets), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

Chapter 3 Requirements

3.1 Item Definition

The TSPW application will be developed as an application to be combined with and leveraging the components and technologies developed under the Enhanced Transit Safety Retrofit Package (E-TRP) system. It will include additional capabilities to enhance and improve transit vehicle and pedestrian safety in an operational context. The combined E-TRP System + TSPW application will consist of two physically separate systems; an on-board, transit vehicle-based system and a roadside based system at each of the selected transit stops. Both systems will share some common hardware and software subsystems, as well as having unique subsystem to themselves.

3.1.1 Hardware Components

There are several hardware components that coordinate to fulfill the functional and performance requirements of the E-TRP system. Figure 3-1 and the subsections below further illustrate the conceptual hardware architecture for the E-TRP system.

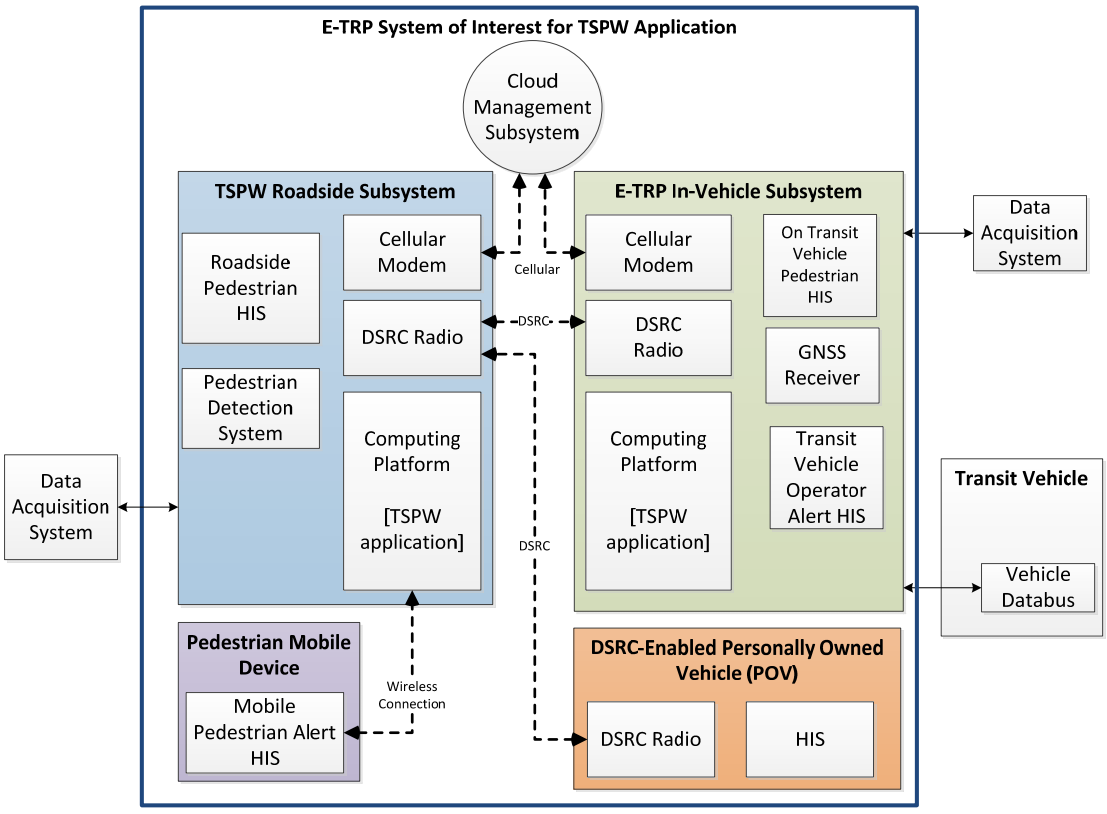


Figure 3-1. E-TRP System of Interest for the TSPW Application

Source: Battelle

3.1.1.1 Common Computing Platform

The Common Computing Platform (CCP) is effectively a hardened, small form factor, single board computer that serves as the interface to the components of the E-TRP system. The CCP, shown in concept in Figure 3-2, will be installed in both the transit vehicles and in the roadside. The transit vehicle CCP installation is expected to interface to the vehicle data bus, Transit Vehicle Operator HIS, power distribution system and other on-board components. The roadside installation is expected to interface to the Roadside Pedestrian HIS, Pedestrian Detection Subsystem and other support electronics. Additionally for the purposes of the test deployment, there will be a connection between the CCP and an externally hosted Data Acquisition system. This Data Acquisition System will provide data collection solely for the purposes of determining system performance during verification testing and evaluation during the deployment.

3.1.1.2 DSRC Radio

The E-TRP DSRC radio will be a mature DSRC solution and will be deployed both within the In-Vehicle Subsystem and Roadside Subsystems. Many of today's offerings are a computing and communications platform specifically designed for the development, implementation, testing, and evaluation of 5.9 GHz DSRC V2V/V2I applications.

Source: Stealth.com

Figure 3-2. Illustration of Conceptualized Common Computing Platform

3.1.1.3 Cellular Modem

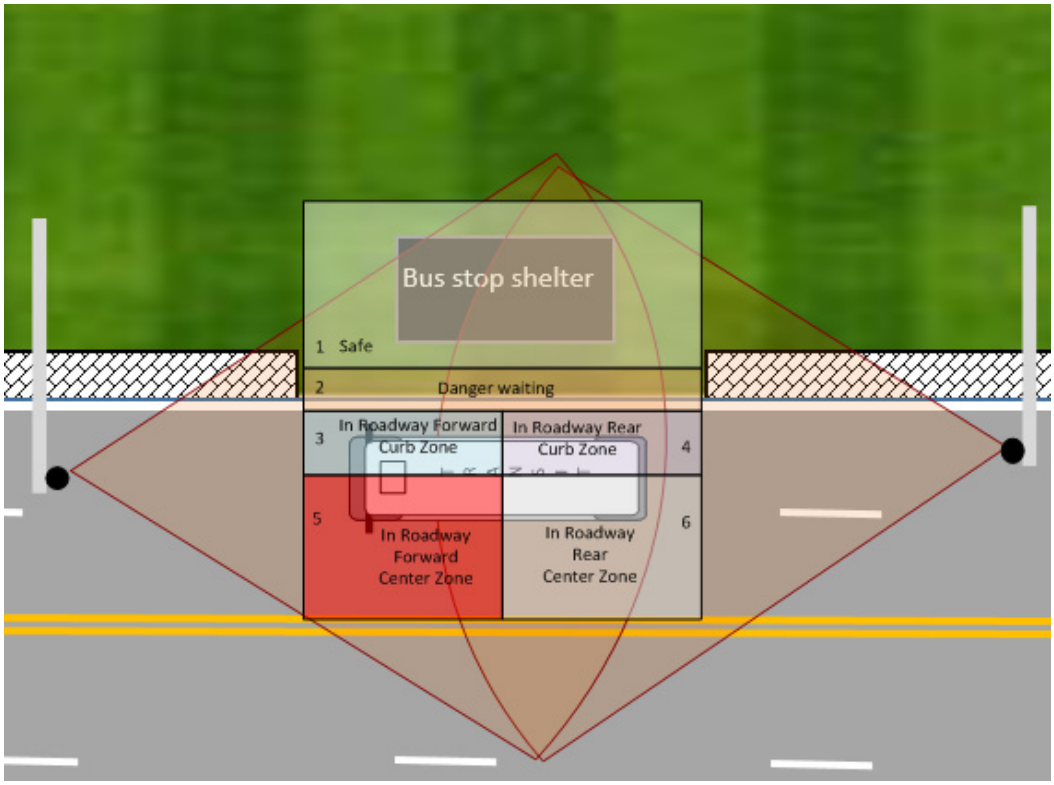
The cellular modem will likely take the form of an embedded mini PCI express (mPCIe) card and provide a complete, ready-to-integrate communications modem likely utilizing 4G LTE standards. The cellular modem will serve as the primary communications method between the CCP and the Cloud-based Management System. The cellular modem will be installed in both the transit vehicle and roadside installations.

3.1.1.4 Pedestrian Detection System

Pedestrian detection will be implemented at the transit stop utilizing an off the shelf but emerging technology. Ideally, the solution would be capable of discerning between pedestrians, bicyclists and vehicles across a wide operating environment, including below freezing, at night, and in rain and snow. Accurate detection of multiple pedestrians at the same time is required. The system should also be capable of detecting pedestrians that are both in motion (walking on the street) as well as standing still (waiting in the sidewalk apron).

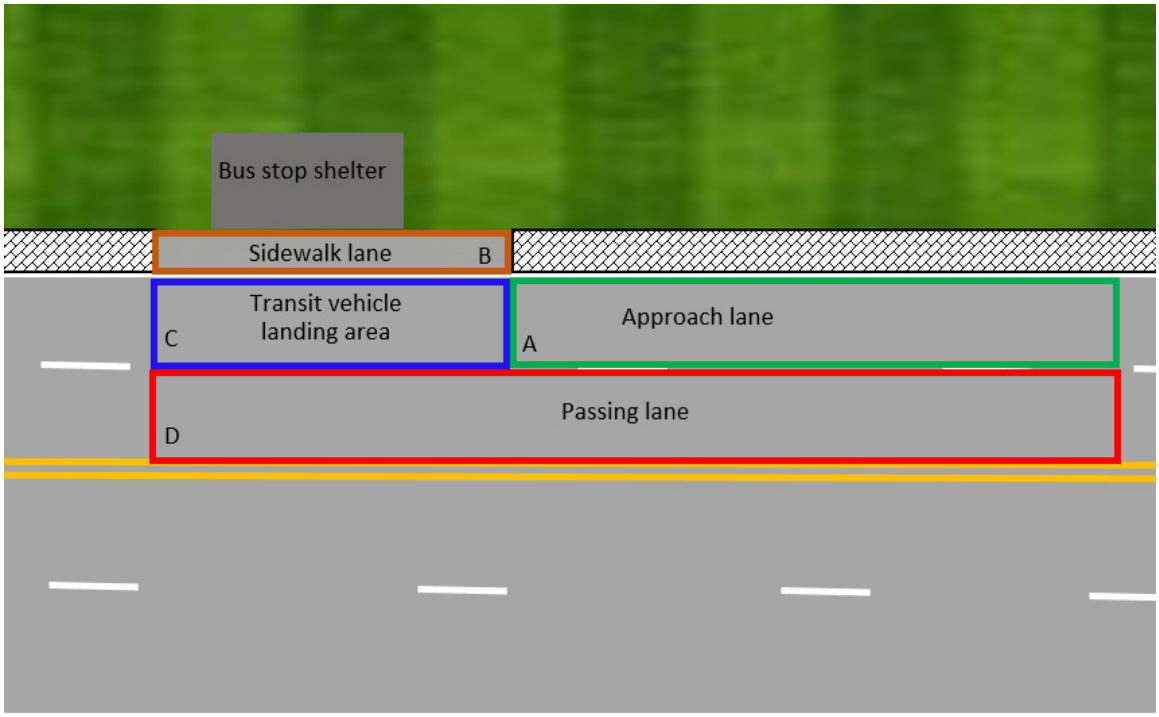
Figure 3-3 and Figure 3-4 provide an overview of the basic configuration expected at a transit stop. Figure 3-3 illustrates the approximate locations where pedestrians will be detected in the pedestrian waiting area and within the Transit Vehicle Landing Zone. Figure 3-4 illustrates the travel lanes of interest to the transit vehicle. These lanes, which include the Approach Lane, Sidewalk Lane, Bus Landing Zone and Passing Lane are used by the Transit Vehicle to locate itself with respect to the transit stop and the Pedestrian Detection Zones. The Pedestrian Detection Zones and Bus Lanes together constitute the “TSPW Enabled Area”.

As observed Figure 3-3, there are six Pedestrian Detection Zones of interest. The subsections below describe the location and purpose of each zone.



Source: Battelle

Figure 3-3. Illustration of an Example Transit Stop with an Installed Pedestrian Detection System



Source: Battelle

Figure 3-4. Illustration of an Example Transit Stop with Identified Vehicle Location Lanes

3.1.1.4.1 Zone 1: Waiting Zone – Safe

Pedestrians in this zone are considered to be safe from being struck by vehicles. This zone encompasses the area away from the roadway including the area within a shelter house, regardless of the location of the shelter house.

3.1.1.4.2 Zone 2: Waiting Zone – Danger

This zone encompasses the area of the transit stop waiting area where a part of a moving transit vehicle (e.g., side mirror) could traverse.

3.1.1.4.3 Zone 3: In Roadway Forward Curb Zone

The In Roadway Forward Curb Zone encompasses the roadway in the lane closest to the transit stop and roughly one-half the width (curb-side) of the transit vehicle and one-half of the total length of the transit stop waiting area near the front of a stopped transit vehicle. Pedestrians in this zone would be considered to be at risk of being struck by vehicles.

3.1.1.4.4 Zone 4: In Roadway Rear Curb Zone

The In-Roadway Rear Curb Zone encompasses the roadway in the lane closest to the transit stop and roughly one-half of the total width (curb-side) of the transit vehicle and one-half of the total length of the transit waiting area to the rear of the stopped transit vehicle. Pedestrians in this zone would be considered to be at risk of being struck by vehicles.

3.1.1.4.5 Zone 5: In Roadway Forward Center Zone

The In Roadway Forward Center Zone encompasses the roadway in the lane closest to the transit stop starting laterally at the mid-point of the lane and extending to the mid-point of the adjacent lane, or further, if possible. The zone longitudinally encompasses roughly one-half the length of the transit stop waiting area to the front of the transit vehicle. Pedestrians in this zone would be considered to be at risk of being struck by vehicles.

3.1.1.4.6 Zone 6: In Roadway Rear Center Zone

The In Roadway Rear Center Zone encompasses the roadway in the lane closest to the transit stop starting laterally at the mid-point of the lane and extending to the mid-point of the adjacent lane, or further, if possible. The zone longitudinally encompasses roughly one-half the length of the transit stop waiting area to the rear of the transit vehicle. Pedestrians in this zone would be considered to be at risk of being struck by vehicles.

3.1.1.5 Global Navigation Satellite System (GNSS) Receiver

The Global Navigation Satellite System (GNSS) Receiver will provide positioning and timing services to the In-Vehicle Subsystem. Reasonably accurate positioning services are required to place the transit vehicle with respect to a transit stop. It is also a required component to determine the relative position of the transit vehicle with respect to a remotely operated vehicle that may be approaching the transit vehicle from behind.

3.1.1.6 Human Interface System

The purpose of the TSPW Human Interface Systems (HIS) are to provide an indication to the system users of an unsafe situation. For the TSPW application, there is one HIS for the Transit Vehicle Operator, and three interfaces for pedestrians as described in more detail below.

3.1.1.6.1 Transit Vehicle Operator HIS

The purpose of the Transit Vehicle Operator HIS is to provide an indication to the transit vehicle driver that a pedestrian has been detected near the transit vehicle or within the predicted path of the transit vehicle. The overall concept of the HIS is to provide the operator with information in a non-distracting and timely fashion to improve safety by reducing that change of pedestrian collision. Driver interface methods may include the use of LED indicators strategically placed at various spots in the driver's field of view or audible tones, to indicate an alert or warning event with some form of indication of directionality or display screens displaying icons indicating alerts to the vehicle operator.

3.1.1.6.2 Mobile Pedestrian HIS

The TSPW application includes providing alerts to waiting riders and pedestrians in the zones around the transit stop of oncoming, departing, and transit vehicles at the transit stop. This communication is expected to be conducted wirelessly and may consist of "instant message" type notifications that will provide both a visual, audible, and tactile alert to the owner of the mobile device. Other than installation of the application and configuration of the communications interface, no other modifications to the mobile device is expected.

3.1.1.6.3 Transit Vehicle Pedestrian HIS

The transit vehicles will include hardware that will enable the vehicle itself to provide a pedestrian walking in front the transit vehicle with a visual and/or audible alert warning the pedestrian of an on-

coming vehicle traveling in the same direction as, and passing, the transit vehicle. This mechanism is designed to provide additional protection to pedestrians crossing in front of the transit vehicle who are prevented from seeing on-coming traffic by the transit vehicle.

3.1.1.6.4 Roadside Pedestrian HIS

The purpose of the Roadside Pedestrian HIS is to provide pedestrians with an audible and visual alert that they are in danger of being struck by a transit vehicle. It is envisioned that this warning system will consist of a digital message sign capable of displaying text messages, flashing, and emitting an audible tone. Additionally, this digital message sign will provide traveler information about approaching transit vehicles. Figure 3-5 illustrates a typical message that would be displayed on this digital media.

Source: Battelle

Figure 3-5. Illustration of Dynamic Message Sign for Waiting Rider

3.1.1.6.5 DSRC-Enabled Personally Owned Vehicle HIS

The DSRC-Enabled Personally Owned Vehicle (POV) HIS provides alerts to non-transit vehicles of at-risk pedestrians in the roadway while a transit vehicle is at a transit stop. The POV operator can receive both inform and warn alerts depending on the location of the pedestrian and the POV as it approaches the transit stop.

3.1.1.7 Cloud-Based Management System

The E-TRP Cloud-Based Management System (CMS) will serve as a remote portal for two primary functions: remote data storage and remote fleet management. Both the transit vehicle based and the roadside based CCPs will be collecting a large amount of data during operations. Sources of this data include inputs from cameras, vehicle CAN bus data, and data from the safety applications. Rather than permanently store all of this data locally on each CCP during the entire period of operation, the data will be periodically transferred to a cloud-based database for collection, storage, archival, and analysis. In addition to sending the collected operational data, the CCP will also periodically send status messages to the CMS to allow for near-real time monitoring of the deployed system. For example, a system administrator would be able to log into a fleet management portal and view a dashboard of the operational status of each installed system, with summaries of the type and quantity of alerts provided to the transit vehicle operator.

3.1.1.8 DSRC-Enabled Personally Owned Vehicle

The DSRC-Enabled Personally Owned Vehicle represents a non-transit vehicle that may pass through a transit stop area while a transit vehicle is present boarding or offloading passengers. This vehicle would employ a DSRC radio to communicate with the transit stop roadside components to determine if pedestrians are in the roadway and are at risk of being struck.

3.1.1.9 Pedestrian Mobile Device

Pedestrians interacting with the transit stop will be able to choose to subscribe to traveler advisory and pedestrian inform and warn alerts for transit vehicle approaching and departing the transit stop. The pedestrian's mobile device would need to have a TSPW application installed in order to participate with the TSPW system.

3.1.2 Software Components

The TSPW application improves safety of pedestrians and transit riders by providing alerting and notification to the transit vehicle operator and pedestrians of pedestrians in danger of being struck by a transit vehicle within a transit stop. Table 3-1 summarizes the functionality of the TSPW safety applications.

Table 3-1. Summary of Functionality of Applications

Functionality	Applications
	Transit Bus Stop Pedestrian Warning Application
Application Input	• Obtains position and time information for the transit vehicle (Latitude, Longitude, Timestamp, Heading, Speed, Elevation) • Obtains position and time information for the POV (Latitude, Longitude, Timestamp, Heading, Speed, Elevation) • Receives Geometric Intersection Description (GID) Map information from infrastructure DSRC broadcast • Receives status of bus stop detection zones (pedestrians detected, zones affected, etc.) from infrastructure DSRC broadcast • Obtains vehicle information (Speed, Brake Status, Gear Position)
Processing	• Determine position and status of transit vehicle and/or other DSRC-enabled vehicles relative to the pedestrians. • Determine if transit vehicle movement, and pedestrian activity warrant inform or warn alert. • Determine if POV movement, and pedestrian activity warrant inform or warn alert.
Application Output	Provide real-time situational awareness to the transit vehicle driver, POV driver, and pedestrians

Source: Battelle

3.1.3 Requirement Nomenclature

Each requirement has two required parts (requirement unique identifier and statement) and may have one optional part (requirement descriptive text) using the following template.

[Requirement Unique Identifier] Requirement statement
Note: Requirement descriptive text

Requirement Unique Identifier

Every requirement begins with a requirement unique identifier that uniquely identifies the requirement within this document starting with Sys_Req_001.

3.1.3.1 Requirement Statement

Immediately following the requirement Unique Identifier, the requirement is stated in the form “The <system/subsystem of interest> shall…”

3.1.3.2 Requirement Descriptive Text

Optionally, following the requirement statement, and in italics, descriptive text may be included to provide clarifying statements for the requirement.

3.1.3.3 Requirement Terms

In this specification, certain terms are used in a very specific manner. The reader should understand the uses of the terms shall, will, should, and may:

- Requirements use “shall”
- Statements of fact use “will”
- Goals use “should”
- Requirements that depend on some stated constraint use “may.”

All “shall” statements (requirements) must be verifiable; otherwise, compliance cannot be demonstrated.

The term “implement” is used to indicate a feature that should be put into effect. These items were specified by a stakeholder, with limited or no further functionality or performance defined.

3.2 Interfaces

The following subsections outline the Power, Communications, Physical and User interface requirements for the E-TRP system with enabled TSPW application.

3.2.1 Power Interface

The E-TRP In-Vehicle Subsystem must operate on 12 VDC as provided commonly by transit vehicles. The Roadside Subsystem must operate on 120 VAC commonly found in signal controller cabinets.

3.2.1.1 In-Vehicle Subsystem Power Interface

[Sys_Req_071] The E-TRP In-Vehicle Subsystem shall operate on 12 Volts Direct Current (VDC).

[Sys_Req_070] The E-TRP In-Vehicle Subsystem should consume no more than 10 Milliamps when powered via 12 VDC in Standby mode.

3.2.1.2 TSPW Roadside Subsystem Power Interface

[Sys_Req_295] The TSPW Roadside Subsystem shall operate on 120 Volts Alternating Current (VAC), 60 Hz.

3.2.2 Communications Interface

A number of physical interfaces were identified by various stakeholders to the E-TRP system. For the In-Vehicle Subsystem, these interfaces can be broken down into physical implementations of wireless and vehicle interfaces. The Roadside Subsystem interfaces must comply with the RSU Specification v4.0.

3.2.2.1 In-Vehicle Subsystem Interfaces

The following subsections outline the specific interface protocols required by the In-Vehicle Subsystem. These protocols were specified during stakeholder engagement or were derived based on the earlier TRP product deployment.

3.2.2.1.1 Wireless Communications Interface Protocols

[Sys_Req_056] The E-TRP In-Vehicle Subsystem shall implement a Wi-Fi interface with internal antenna.

[Sys_Req_057] The E-TRP In-Vehicle Subsystem shall implement a Bluetooth Classic interface.

[Sys_Req_058] The E-TRP In-Vehicle Subsystem shall implement Bluetooth Low Energy (BLE) interface.

[Sys_Req_060] The E-TRP In-Vehicle Subsystem shall implement a 4G cellular interface.

[Sys_Req_061] The E-TRP In-Vehicle Subsystem shall implement a DSRC 5.9 GHz interface.

[Sys_Req_144] E-TRP In-Vehicle Subsystem messages transmitted over the DSRC 5.9 GHz interface shall be compliant with SAE J2735.

3.2.2.1.2 Vehicle Communications Interface Protocols

[Sys_Req_083] The E-TRP In-Vehicle Subsystem shall implement an ISO 15765-4 (CAN) interface.

[Sys_Req_084] The E-TRP In-Vehicle Subsystem shall implement an ISO 14230-4 (Keyword Protocol 2000) interface.

[Sys_Req_085] The E-TRP In-Vehicle Subsystem shall implement an ISO 9141-2 (Asian, European, Chrysler vehicles) interface.

[Sys_Req_086] The E-TRP In-Vehicle Subsystem shall implement a SAE J1850 VPW (GM Vehicles) interface.

[Sys_Req_087] The E-TRP In-Vehicle Subsystem shall implement a SAE J1850 PWM (Ford Vehicles) interface.

[Sys_Req_088] The E-TRP In-Vehicle Subsystem shall implement an ISO 15765 interface.

[Sys_Req_089] The E-TRP In-Vehicle Subsystem shall implement an ISO 11898 (raw CAN) interface.

[Sys_Req_090] The E-TRP In-Vehicle Subsystem shall implement a GMLAN Single Wire CAN (GMW3089) interface.

[Sys_Req_091] The E-TRP In-Vehicle Subsystem shall implement a Ford Medium Speed CAN (MS CAN) interface.

[Sys_Req_092] The E-TRP In-Vehicle Subsystem shall implement a SAE J1939 bus interface.

[Sys_Req_093] The E-TRP In-Vehicle Subsystem should implement a SAE J1708 interface.
Note: The SAE J1708 interface may be implemented via external conversion equipment.

[Sys_Req_094] The E-TRP In-Vehicle Subsystem shall be able to simultaneously receive and process data from an ISO 15765 bus AND any of the other protocols listed as required in this document.

[Sys_Req_155] The E-TRP In-Vehicle Subsystem shall be able to simultaneously receive and process data from two J1939 databus channels.

3.2.2.2 TSPW Roadside Subsystem Interfaces

[Sys_Req_296] The TSPW Roadside Subsystem DSRC Radio shall implement interfaces compliant with the RSU Specification v4.0.

[Sys_Req_297] TSPW Roadside Subsystem messages transmitted over the DSRC 5.9 GHz interface shall be compliant with SAE J2735.

3.2.3 Physical Interface

All E-TRP equipment must physically fit within and securely attach to their host platforms.

[Sys_Req_113] The E-TRP In-Vehicle Subsystem shall implement a method for secure physical attachment to the host vehicle.

3.2.4 User Interface

The following sections describe how the TSPW application will operate, with the primary focus centered on the transit vehicle operator as well as persons at the transit stop either waiting for a transit vehicle or as pedestrians. The TSPW application will generate alerts for system participants to know they have entered or exited a TSPW Enabled Area, for Traveler Information, and to Inform or Warn travelers and vehicle operators of pedestrians during dangerous and potentially dangerous situations.

The TSPW system has three primary participants which need to receive information – Transit Vehicle Operators, Pedestrians at the transit stop and private citizens operating DSRC-Enabled Personally Owned Vehicles near transit stops. Transit Vehicle Operators interface with the TSPW system via a Transit Vehicle Operator HIS located within the Transit Vehicle. Pedestrians interface with the TSPW system in one or more of three possible ways including the Pedestrian Roadside HIS, the Mobile Pedestrian HIS, or from the transit vehicle itself (On-Transit Vehicle Pedestrian HIS). Private citizens operating DSRC-Enabled Personally Owned Vehicles interface with the DSRC-Enabled Personally Owned Vehicle HIS in their vehicle.

Requirments for each HIS location are described in-turn within sections 3.2.4.2 through 3.2.4.6 below.

There is the potential for 4 types of alerts to be provided, however each HIS does not provide every alert type. The types of alerts are:

1. System Ready Alert (SRA) – This alert informs the user that they are within a TSPW Enabled Area (the area around, on approach to and within the transit stop) and to expect the possibility of other alerts to be provided. This type of alert is provided via the Transit Vehicle Operator HIS (TVO-SRA) and Mobile Pedestrian HIS (MP-SRA).
2. Informational (Inform) Alert (IA) – An Inform Alert refers to an indication that a potentially dangerous situation could occur. Inform alerts are provided via the Transit Vehicle Operator HIS (TVO-IA), Roadside Pedestrian HIS (RP-IA), Mobile Pedestrian HIS (MP-IA), and DSRC-Enabled Personally Owned Vehicle HIS (POV-IA).

3. Warning (Warn) Alert (WA) – A Warn Alert refers to an indication that a dangerous situation is likely to occur. Warn alerts are provided via the Transit Vehicle Operator HIS (TVO-WA), On Transit Vehicle Pedestrian HIS (OTVP-WA), Roadside Pedestrian HIS (RP-WA), and DSRC-Enabled Personally Owned Vehicle HIS (POV-WA).
4. Traveler Advisory Messages (TAM) – Traveler Advisory Messages can indicate that a transit vehicle is either approaching a transit stop or is currently at a stop. Traveler Advisory Messages are provided via the Roadside Pedestrian HIS (Approaching (RP-TAM-Approach), At Stop (RP-TAM-Stop)) and the Mobile Pedestrian HIS Approaching (MP-TAM-Approach).

Based in the scenarios outlined in the TSPW Concept of Operations, alerts are to be provided under the following conditions:

3.2.4.1 User Interface – TSPW Enabled Alert Area

[Sys_Req_276] The location where the TSPW application begins to provide alerts shall be configurable based on the distance a transit vehicle is from entering a TSPW pedestrian detection zones and the speed of the transit vehicle.

[Sys_Req_261] All TSPW application alerts shall stop once the transit vehicle has completely exited (or passed-by) the TSPW Enabled Area.

3.2.4.2 User Interface – TSPW – Transit Vehicle Operator HIS

The Transit Vehicle Operator HIS provides the transit vehicle operator System Ready alerts to let the operator know they have entered a TSPW Enabled Area and inform and warn alerts for at-risk pedestrians.

[Sys_Req_001] The E-TRP In-Vehicle Subsystem shall not obstruct the Transit Vehicle driver's field of view.

[Sys_Req_159] The E-TRP subsystem Transit Vehicle Operator HIS shall be configurable to either provide or not provide alerts, maintaining all other required functionality, including alert logging.
Note: The suppression of alerts is known as "Cloaked Mode." Cloaked mode will be used during a baselining period at the beginning of operational fielding.

3.2.4.2.1 Transit Vehicle Operator HIS System Ready Alert (TVO-SRA)

[Sys_Req_215] The TSPW application shall provide a TVO-SRA when the transit vehicle is within a TSPW Enabled Area.

[Sys_Req_247] The TVO-SRA shall end once the transit vehicle has completely departed or passed by all TSPW pedestrian detection roadway zones.

3.2.4.2.2 Transit Vehicle Operator HIS Inform Alert (TVO-IA)

An informational alert or “inform alert” refers to an indication that a potentially dangerous situation could occur.

[Sys_Req_219] While the TSPW enabled transit vehicle is within the TSPW Enabled Area, in motion and approaching the pedestrian detection roadway zones,

-if a pedestrian is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a TVO-IA.

[Sys_Req_224] While the TSPW enabled transit vehicle is approaching and in motion within any pedestrian detection roadway zone,

-if a pedestrian is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a TVO-IA.

[Sys_Req_235] While the TSPW enabled transit vehicle is stopped within the pedestrian detection roadway zones,

-if a pedestrian is located within the center roadway zones (zones 5 or 6)

the TSPW application shall provide a TVO-IA.

[Sys_Req_236] While the TSPW enabled transit vehicle is departing and in motion within both the forward and rear pedestrian detection roadway zones,

-if a pedestrian is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a TVO-IA.

[Sys_Req_242] While the TSPW enabled transit vehicle is departing and in motion within the forward pedestrian detection roadway zones,

-if a pedestrian is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a TVO-IA.

3.2.4.2.3 Transit Vehicle Operator HIS Warn Alert (TVO-WA)

[Sys_Req_223] While the TSPW enabled transit vehicle is within the TSPW Enabled Area, in motion and approaching pedestrian detection zones,

-if a pedestrian is located within any pedestrian detection roadway zone (zones 3-6)

the TSPW application shall provide a TVO-WA.

[Sys_Req_225] While the TSPW enabled transit vehicle is approaching and in motion within any pedestrian detection roadway zone,

-if a pedestrian is located within any pedestrian detection roadway zone (zones 3-6)

the TSPW application shall provide a TVO-WA.

[Sys_Req_240] While the TSPW enabled transit vehicle is departing and in motion within both the forward and rear pedestrian detection roadway zones,

-if a pedestrian is located within any pedestrian detection roadway zone (zones 3-6)

the TSPW application shall provide a TVO-WA.

[Sys_Req_246] While the TSPW enabled transit vehicle is departing and in motion within the forward pedestrian detection roadway zones,

-if a pedestrian is located within any forward pedestrian detection roadway zone (zone 3 or 5)

the TSPW application shall provide a TVO-WA.

3.2.4.2.4 Transit Vehicle Operator HIS Inform/Warn Alert End

[Sys_Req_248] Once detected pedestrians are clear of the zones causing a TVO-IA, the TVO-IA shall be deactivated.

[Sys_Req_333] Once detected pedestrians are clear of the zones causing a TVO-WA, the TVO-WA shall be deactivated.

[Sys_Req_282] Once the transit vehicle has completely passed a zone where detected pedestrians are causing a TVO-IA, the TVO-IA shall be deactivated.

[Sys_Req_334] Once the transit vehicle has completely passed a zone where detected pedestrians are causing a TVO-WA, the TVO-WA shall be deactivated.

3.2.4.2.5 Transit Vehicle Operator HIS NON-Alert

[Sys_Req_280] Once the TSPW enabled transit vehicle has departed the rear pedestrian detection roadway zones a pedestrian located within the rear pedestrian detection roadway zones (zone 4 or 6) shall NOT cause a TVO-WA.

[Sys_Req_279] While the TSPW enabled transit vehicle is stopped within the pedestrian detection roadway zones, a pedestrian located within the Danger Waiting Zone (zone 2) shall NOT cause a TVO-IA.

[Sys_Req_335] While the TSPW enabled transit vehicle is stopped within the pedestrian detection roadway zones, a pedestrian located within the curbside pedestrian detection roadway zones (zone 3 or 4) shall NOT cause a TVO-WA.

3.2.4.2.6 Transit Vehicle Operator HIS Alert Priority

[Sys_Req_231] If multiple simultaneous alerts occur for the Transit Vehicle Operator HIS, the highest priority alert shall be presented.

[Sys_Req_289] The Transit Vehicle Operator HIS alert priority (from highest to lowest priority) shall be: TVO-WA, TVO-IA, TVO-SRA.

3.2.4.3 User Interface – TSPW – On Transit Vehicle Pedestrian HIS

The On Transit Vehicle Pedestrian HIS is a vehicle-based (vehicle-mounted) system for alerting pedestrians of critically dangerous situations near the front of the transit vehicle.

[Sys_Req_200] The TSPW vehicle pedestrian HIS shall be configurable to either provide or not provide alerts, maintaining all other required functionality, including alert logging.
Note: The suppression of alerts is known as "Cloaked Mode." Cloaked mode will be used during a baselining period at the beginning of operational fielding.

3.2.4.3.1 On Transit Vehicle Pedestrian HIS Warn Alert (OTVP-WA)

[Sys_Req_232] While the TSPW enabled transit vehicle is approaching and in motion within any pedestrian detection roadway zone,

-if a pedestrian is located within any pedestrian detection roadway zone (zones 3-6)

the TSPW application shall provide a OTVP-WA.

[Sys_Req_241] While the TSPW enabled transit vehicle is departing and in motion within both the forward and rear pedestrian detection roadway zones,

-if a pedestrian is located within any forward pedestrian detection roadway zone (zone 3 or 5)

the TSPW application shall provide a OTVP-WA.

[Sys_Req_249] While the TSPW enabled transit vehicle is stopped within the pedestrian detection roadway zones,

-if a pedestrian is located within the forward center pedestrian detection zone (zone 5) AND

-if a DSRC-Enabled Personally Owned Vehicle is detected to be approaching from behind the transit vehicle in the adjacent-left lane,

the TSPW application shall provide a OTVP-WA.

3.2.4.3.2 On Transit Vehicle Pedestrian HIS Alert End

[Sys_Req_260] Once detected pedestrians are clear of the zones causing an OTVP-WA, the OTVP-WA shall be deactivated.

[Sys_Req_290] Once the transit vehicle has completely passed a zone where detected pedestrians are causing an OTVP-WA, the OTVP-WA shall be deactivated.

3.2.4.3.3 On Transit Vehicle Pedestrian HIS NON-Alert

[Sys_Req_281] While the TSPW enabled transit vehicle is within the TSPW Enabled Area, in motion and approaching pedestrian detection zones, a pedestrian located within the Danger Waiting Zone (zone 2) or any pedestrian detection roadway zone (zones 3-6) shall NOT cause an OTVP-WA.

[Sys_Req_283] While

- the TSPW enabled transit vehicle is stopped within pedestrian detection roadway zones (zones 3-6) AND

- no DSRC-Enabled Personally Owned Vehicles are approaching from behind the transit vehicle

a pedestrian located within the Danger Waiting Zone (zone 2) or any pedestrian detection roadway zone (zones 3-6) shall NOT cause an OTVP-WA.

[Sys_Req_284] While

- the TSPW enabled transit vehicle is departing and in motion within both the forward and rear pedestrian detection roadway zones AND

- if the front of the transit vehicle has departed the forward pedestrian detection roadway zones (zone 3 or 5)

a pedestrian located within the Danger Waiting Zone (zone 2) or any pedestrian detection roadway zone (zones 3-6) shall NOT cause an OTVP-WA.

[Sys_Req_285] While

- the TSPW enabled transit vehicle is departing and in motion within the forward pedestrian detection roadway zones AND

- the front of the transit vehicle has departed the forward roadway zones (zone 3 or 5)

a pedestrian located within the Danger Waiting Zone (zone 2) or any pedestrian detection roadway zone (zones 3-6) shall NOT cause an OTVP-WA.

3.2.4.4 User Interface – TSPW – Roadside Pedestrian HIS

The Roadside Pedestrian HIS provides pedestrians and waiting transit riders alerts for unsafe conditions and traveler information about transit vehicles approaching or at the transit stop.

[Sys_Req_201] The TSPW Roadside Pedestrian HIS shall be configurable to either provide or not provide alerts, maintaining all other required functionality, including alert logging.
Note: The suppression of alerts is known as "Cloaked Mode." Cloaked mode will be used during a baselining period at the beginning of operational fielding.

3.2.4.4.1 Roadside Pedestrian HIS – Transit Vehicle Traveler Advisory Message – Vehicle Approaching (RP-TAM-Approach)

[Sys_Req_216] While the TSPW enabled transit vehicle is within the TSPW Enabled Area, in motion and approaching a TSPW pedestrian detection roadway zones, the TSPW application shall provide a RP-TAM-Approach alert including the vehicle route number.

3.2.4.4.2 Roadside Pedestrian HIS – Transit Vehicle Traveler Advisory Message – Vehicle at Stop (RP-TAM-Stop)

[Sys_Req_233] Once the TSPW enabled transit vehicle is stopped within the pedestrian detection roadway zones, the TSPW application shall provide a RP-TAM-Stop Alert, including the vehicle route number.

3.2.4.4.3 Roadside Pedestrian HIS Inform Alerts (RP-IA)

[Sys_Req_218] While the TSPW enabled transit vehicle is within the TSPW Enabled Area, in motion and approaching pedestrian detection roadway zones,

-if a pedestrian is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a RP-IA.

[Sys_Req_230] While the TSPW enabled transit vehicle is approaching and in motion within any pedestrian detection roadway zone,

-if a pedestrian is located within the danger waiting zone (zone 2)

the TSPW application shall provide a RP-IA.

[Sys_Req_234] While the TSPW enabled transit vehicle is stopped within the pedestrian detection roadway zones,

-if a pedestrian is located within the center pedestrian detection roadway zones (zone 5 or 6)

the TSPW application shall provide a RP-IA.

[Sys_Req_237] While the TSPW enabled transit vehicle is departing and in motion within both the forward and rear pedestrian detection roadway zones,

-if a pedestrian is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a RP-IA.

[Sys_Req_243] While the TSPW enabled transit vehicle is departing and in motion within the forward pedestrian detection roadway zones,

-if a pedestrian is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a RP-IA.

3.2.4.4.4 Roadside Pedestrian HIS Warn Alert (RP-WA)

[Sys_Req_222] While the TSPW enabled transit vehicle is within the TSPW Enabled Area, in motion and approaching pedestrian detection roadway zones,

-if a pedestrian is located within any pedestrian detection roadway zone (zones 3-6)

the TSPW application shall provide a RP-WA.

[Sys_Req_227] While the TSPW enabled transit vehicle is approaching and in motion within any pedestrian detection roadway zone,

-if a pedestrian is located within any pedestrian detection roadway zone (zones 3-6)

the TSPW application shall provide a RP-WA.

[Sys_Req_239] While the TSPW enabled transit vehicle is departing and in motion within both the forward and rear pedestrian detection roadway zones,

-if a pedestrian is located within any pedestrian detection roadway zone (zones 3-6)

the TSPW application shall provide a RP-WA.

[Sys_Req_245] While the TSPW enabled transit vehicle is departing and in motion within the forward pedestrian detection roadway zones,

-if a pedestrian is located within any forward pedestrian detection roadway zone (zone 3 or 5)

the TSPW application shall provide a RP-WA.

3.2.4.4.5 Roadside Pedestrian Alert End

[Sys_Req_226] The RP-TAM-Approach alert shall deactivate once the transit vehicle stops within the pedestrian detection roadway zone or passes the transit stop.

[Sys_Req_286] The RP-TAM-Stop Alert shall deactivate once the front of the transit vehicle moves out of the forward pedestrian detection roadway zones.

[Sys_Req_257] Once detected pedestrians are clear of the zones causing a RP-IA, the RP-IA shall be deactivated.

[Sys_Req_338] Once detected pedestrians are clear of the zones causing a RP-WA, the RP-WA shall be deactivated.

[Sys_Req_336] Once the transit vehicle has completely passed a zone where detected pedestrians are causing a RP-IA, the RP-IA shall be deactivated.

[Sys_Req_337] Once the transit vehicle has completely passed a zone where detected pedestrians are causing a RP-WA, the RP-WA shall be deactivated.

3.2.4.4.6 Roadside Pedestrian HIS Alert Priority

[Sys_Req_255] If multiple simultaneous alerts occur for the Roadside Pedestrian HIS, the highest priority alert shall be presented to the roadside pedestrians.

[Sys_Req_291] The Roadside Pedestrian HIS alert priority (from highest to lowest priority) shall be: RP-WA, RP-IA.

[Sys_Req_339] The Roadside Pedestrian HIS Traveler Advisory alert priority (from highest to lowest priority) shall be: RP-TAM-Stop Alert, RP-TAM-Approach Alert.

3.2.4.4.7 Roadside Pedestrian HIS NON-Alert

[Sys_Req_287] While the TSPW enabled transit vehicle is stopped within the pedestrian detection roadway zones, pedestrians located within the Danger Waiting Zone (zone 2) or curbside pedestrian detection roadway zones (zones 3-4) shall not cause a RP-IA or RP-WA.

[Sys_Req_288] Once the TSPW enabled transit vehicle has departed the rear pedestrian detection roadway zones a pedestrian located within the rear pedestrian detection roadway zones (zone 4 or 6) shall NOT cause a RP-WA or RP-IA.

3.2.4.5 User Interface – TSPW – Mobile Pedestrian HIS

The Mobile Pedestrian HIS provides alerts to pedestrians who subscribe to receive alerts from the TSPW system. Mobile alerts are specific to the location of the subscribed mobile device.

3.2.4.5.1 Mobile Pedestrian HIS – System Ready Alert (MP-SRA)

[Sys_Req_311] The TSPW application shall provide a MP-SRA to subscribed mobile devices within the TSPW Enabled Area when the transit vehicle is within a TSPW Enabled Area.

[Sys_Req_312] The MP-SRA shall end once the subscribed mobile device has departed the TSPW Enabled Area.

3.2.4.5.2 Mobile Pedestrian HIS – Traveler Advisory Message – Vehicle Approaching (MP-TAM-Approach) Alert

[Sys_Req_217] While the TSPW enabled transit vehicle is within the TSPW Enabled Area, in motion and approaching pedestrian detection roadway zones, the TSPW application shall provide MP-TAM-Approach Alerts, including the vehicle route number, to subscribed mobile devices.

[Sys_Req_228] While the TSPW enabled transit vehicle is approaching and in motion within any pedestrian detection roadway zone, the TSPW application shall provide MP-TAM-Approach Alerts, including the vehicle route number, to subscribed mobile devices.

3.2.4.5.3 Mobile Pedestrian HIS Inform Alerts (MP-IA)

[Sys_Req_220] While the TSPW enabled transit vehicle is within the TSPW Enabled Area, in motion and approaching pedestrian detection roadway zones,

-if a subscribed mobile device is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a MP-IA to the subscribed mobile device.

[Sys_Req_229] While the TSPW enabled transit vehicle is approaching and in motion within any pedestrian detection roadway zone,

-if a subscribed mobile device is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a MP-IA to the subscribed mobile device.

[Sys_Req_238] While the TSPW enabled transit vehicle is departing and in motion within both the forward and rear pedestrian detection roadway zones,

-if a subscribed mobile device is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a MP-IA to the subscribed mobile device.

[Sys_Req_244] While the TSPW enabled transit vehicle is departing and in motion within the forward pedestrian detection roadway zones,

-if a subscribed mobile device is located within the Danger Waiting Zone (zone 2)

the TSPW application shall provide a MP-IA to the subscribed mobile device.

3.2.4.5.4 Mobile Pedestrian HIS Alert End

[Sys_Req_258] Once the subscribed mobile device has moved from a pedestrian detection zone causing a MP-IA, the MP-IA shall be deactivated.

[Sys_Req_264] Once the transit vehicle has completely passed a zone where detected pedestrians are causing a MP-IA, the MP-IA shall be deactivated.

3.2.4.5.5 Mobile Pedestrian HIS NON-Alert

[Sys_Req_221] If a pedestrian is located within any pedestrian detection roadway zone no TSPW mobile alerts shall be provided to that pedestrian.

[Sys_Req_292] While the TSPW enabled transit vehicle is stopped within the pedestrian detection roadway zones, a pedestrian located within the Danger Waiting Zone (zone 2) or curbside pedestrian detection roadway zones (zone 3 or 4) shall NOT cause a MP-IA.

3.2.4.5.6 Mobile Pedestrian Alert Priority

[Sys_Req_254] If multiple simultaneous alerts occur for the Mobile Pedestrian HIS the highest priority alert shall be presented.

[Sys_Req_293] The Mobile Pedestrian HIS alert priority (from highest to lowest priority) shall be: MP-WA, MP-IA, MP-TAM-Approach Alert, and then MP-SRA.

3.2.4.6 User Interface – TSPW – DSRC-Enabled Personally Owned Vehicle HIS

A DSRC-Enabled Personally Owned Vehicle is a non-transit vehicle with DSRC capabilities that approaches a transit stop from behind a transit vehicle. These vehicles may use the TSPW application to be alerted to pedestrians that may be hidden by a transit vehicle already at or near a transit stop.

[Sys_Req_340] The location where the TSPW application begins to provide alerts shall be configurable based on the distance a POV is from entering a TSPW pedestrian detection zones and the speed of the vehicle.

3.2.4.6.1 DSRC-Enabled Personally Owned Vehicle HIS Inform Alerts (POV-IA)

[Sys_Req_250] If:

- a transit vehicle is stopped within the pedestrian detection roadway zones AND

- a DSRC-Enabled Personally Owned Vehicle is approaching from behind the transit vehicle and in the same lane AND

- a pedestrian is located within the forward center pedestrian detection roadway zone (zone 5)

the TSPW application shall provide a POV-IA.

3.2.4.6.2 DSRC-Enabled Personally Owned Vehicle HIS Warn Alerts (POV-WA)

[Sys_Req_251] If:

- a transit vehicle is stopped within the pedestrian detection roadway zones, AND

- a DSRC-Enabled Personally Owned Vehicle is approaching from behind the transit vehicle in the same lane AND

- a pedestrian is located within the rear pedestrian detection roadway zones (zone 4 or 6)

the TSPW application shall provide a POV-WA.

[Sys_Req_252] If:

- a transit vehicle is stopped within the pedestrian detection roadway zones, AND

- a DSRC-Enabled Personally Owned Vehicle is approaching from behind the transit vehicle in the adjacent-left lane AND

- a pedestrian is located within pedestrian detection roadway zones (zones 4, 5, or 6)

the TSPW application shall provide a POV-WA.

3.2.4.6.3 DSRC-Enabled Personally Owned Vehicle HIS Alert End

[Sys_Req_259] Once detected pedestrians are clear of the zones causing a POV-IA, the POV-IA shall be deactivated.

[Sys_Req_341] Once detected pedestrians are clear of the zones causing a POV-WA, the POV-WA shall be deactivated.

[Sys_Req_342] Once the POV has completely passed a zone where detected pedestrians are causing a POV-IA, the POV-IA shall be deactivated.

[Sys_Req_343] Once the POV has completely passed a zone where detected pedestrians are causing a POV-WA, the POV-WA shall be deactivated.

3.2.4.6.4 DSRC-Enabled Personally Owned Vehicle HIS Alert Priority

[Sys_Req_256] If multiple simultaneous alerts occur for the DSRC-Enabled Personally Owned Vehicle HIS, the highest priority alert shall be presented.

[Sys_Req_294] The Transit Vehicle Operator HIS alert priority (from highest to lowest priority) shall be: POV-WA, and then POV-IA.

3.2.4.7 TSPW Alert ID

[Sys_Req_205] The TSPW application shall assign a unique identifier to each TSPW alert.

3.3 Performance Characteristics

The following subsections outline the performance for the system of interest including the functions, physical characteristics, electromagnetic radiation performance, and environmental conditions under which the system shall operate.

3.3.1 Functional Characteristics

The system of interest shall have the following functional characteristics.

3.3.1.1 Transit Bus Stop Pedestrian Warning Application

[Sys_Req_266] The TSPW application shall detect the presence of pedestrians within the Danger Waiting Zone which represents the area of the transit stop passenger waiting area where a part of a moving transit vehicle could traverse.

[Sys_Req_267] The TSPW application shall detect the presence of pedestrians within the In Roadway Forward Curb Zone which encompasses the roadway in the lane closest to the transit stop and roughly one-half the width (curb-side) of the transit vehicle and one-half of the total length of the transit stop waiting area near the front of a stopped transit vehicle.

[Sys_Req_268] The TSPW application shall detect the presence of pedestrians within the In-Roadway Rear Curb Zone which encompasses the roadway in the lane closest to the transit stop and roughly one-half of the total width (curb-side) of the transit vehicle and one-half of the total length of the transit waiting area to the rear of the stopped transit vehicle.

[Sys_Req_269] The TSPW application shall detect the presence of pedestrians within the In Roadway Forward Center Zone which encompasses the roadway in the lane closest to the transit stop starting laterally at the mid-point of the lane and extending to the mid-point of the adjacent lane, or further, if possible and longitudinally encompassing roughly one-half the length of the transit stop waiting area to the front of the transit vehicle.

[Sys_Req_270] The TSPW application shall detect the presence of pedestrians within the In Roadway Rear Center Zone which encompasses the roadway in the lane closest to the transit stop starting laterally at the mid-point of the lane and extending to the mid-point of the adjacent lane, or further, if possible and longitudinally encompassing roughly one-half the length of the transit stop waiting area to the rear of the transit vehicle.

[Sys_Req_271] The TSPW application shall detect DSRC-enabled vehicles entering the TSPW Enabled Area.

[Sys_Req_272] The TSPW application shall detect which lane approaching DSRC-Enabled Personally Owned Vehicles occupy, the Approach Lane or the Passing Lane.

[Sys_Req_273] The TSPW application shall detect the location of approaching TSPW-enabled Transit Vehicles with respect to the TSPW Enabled Area and pedestrian detection zones.

[Sys_Req_274] The TSPW application shall detect whether a TSPW-enabled transit vehicle is moving or is stopped.

3.3.1.2 Logging

The E-TRP system will need to log data while operating. This data may be used to confirm operation, track performance, or for debugging. The data associated with logging may also be used for formal evaluation assessment.

3.3.1.2.1 E-TRP In-Vehicle Platform Logging Service

[Sys_Req_156] The E-TRP In-Vehicle Subsystem shall implement a logging service.

[Sys_Req_044] All E-TRP In-Vehicle Subsystem logs shall be associated with the date and time, synchronized to GNSS time, of the logged event.

[Sys_Req_344] All E-TRP In-Vehicle Subsystem log timestamps shall use Coordinated Universal Time (UTC) as a reference.

[Sys_Req_139] All E-TRP In-Vehicle Subsystem logs shall be associated with a unique vehicle ID.

[Sys_Req_157] The E-TRP In-Vehicle Subsystem shall store all logs for a minimum of 48 hours.

[Sys_Req_107] The E-TRP In-Vehicle Subsystem shall transfer data files to a remotely hosted cloud management subsystem, when connected in both Operational and Standby modes such that no data files are lost, deleted or corrupted.

[Sys_Req_174] The E-TRP In-Vehicle Subsystem shall store all DSRC messages utilized by the E-TRP system as transmitted by the E-TRP in-vehicle subsystem.
Note: It is expected that for evaluation purposes a separate DAS system will be provided that will record all DSRC messages sent or received by the E-TRP in-vehicle subsystem.

[Sys_Req_175] The E-TRP In-Vehicle Subsystem shall store all E-TRP system generated DSRC messages received by the E-TRP in-vehicle subsystem.
Note: It is expected that for evaluation purposes a separate DAS system will be provided that will record all DSRC messages sent or received by the E-TRP in-vehicle subsystem.

3.3.1.2.2 E-TRP In-Vehicle Platform Logging Events

[Sys_Req_158] The E-TRP In-Vehicle Subsystem shall store a log of all transit vehicle operator HIS state transitions including pre-state, Triggering Alert ID and post state.

[Sys_Req_040] The E-TRP In-Vehicle Subsystem shall store a log of all service brake state transitions including pre-state and post state.

[Sys_Req_149] The E-TRP In-Vehicle Subsystem shall store a log of all Gear Position state transitions including pre-state and post state.

[Sys_Req_154] The E-TRP In-Vehicle Subsystem shall store a log of all operational mode changes including the trigger causing the mode change.

[Sys_Req_051] The E-TRP In-Vehicle Subsystem shall store the vehicle latitude and longitude at 1 second intervals.

[Sys_Req_043] The E-TRP In-Vehicle Subsystem shall store the vehicle speed at 1 second intervals.

[Sys_Req_152] The E-TRP In-Vehicle Subsystem shall store the vehicle heading at 1 second intervals.

3.3.1.2.3 TSPW In-Vehicle Application Logging Events

[Sys_Req_041] The TSPW application shall store a log of each alert activation including alert type, alert ID and associated roadside location ID.

[Sys_Req_153] The TSPW application shall store a log of each alert deactivation including alert type, alert ID and associated roadside location ID.

[Sys_Req_196] The TSPW application shall store a log of all On Transit Vehicle Pedestrian HIS state transitions including pre-state and post state.

3.3.1.2.4 TSPW Roadside Platform Logging Service

[Sys_Req_298] The TSPW Roadside Subsystem shall implement a logging service.

[Sys_Req_299] All TSPW Roadside Subsystem logs shall be associated with the date and time, synchronized to GNSS time, of the logged event.

[Sys_Req_345] All TSPW Roadside Subsystem log timestamps shall use Coordinated Universal Time (UTC) as a reference.

[Sys_Req_301] All TSPW Roadside Subsystem logs shall be associated with a unique roadside location ID.

[Sys_Req_300] The TSPW Roadside Subsystem shall transfer data files to a remotely hosted cloud management subsystem, when connected in both Operational and Standby modes such that no data files are lost, deleted or corrupted.

[Sys_Req_302] The TSPW Roadside Subsystem shall store all TSPW system generated DSRC messages transmitted by the TSPW Roadside Subsystem.
Note: It is expected that for evaluation purposes a separate DAS system will be provided that will record all DSRC messages sent or received by the TSPW roadside subsystem.

[Sys_Req_303] The TSPW Roadside Subsystem shall store all TSPW system generated DSRC messages received by the TSPW Roadside Subsystem.
Note: It is expected that for evaluation purposes a separate DAS system will be provided that will record all DSRC messages sent or received by the TSPW roadside subsystem.

3.3.1.2.5 TSPW Roadside Platform Log Events

[Sys_Req_304] The TSPW Roadside Subsystem shall log a record of all operational mode changes including the trigger causing the mode change.

3.3.1.2.6 TSPW Roadside Application Log Events

[Sys_Req_214] The TSPW application shall log when a pedestrian detection zone is triggered and an enabled transit vehicle is within the TSPW area.

[Sys_Req_180] If an enabled transit vehicle is within the TSPW Enabled Area, the TSPW application shall store an image of a pedestrian detection zone when triggered.

[Sys_Req_197] The TSPW roadside application shall store a log of all Roadside Pedestrian HIS state transitions including pre-state, triggering Alert ID and post state.

[Sys_Req_198] The TSPW application shall store a log of all alerts provided to mobile application subscribers, including the triggering Alert ID.

3.3.1.3 Modes of Operation

3.3.1.3.1 In-Vehicle Subsystem Modes of Operation

[Sys_Req_063] The E-TRP In-Vehicle Subsystem shall implement an operational mode.
Note: Operational mode describes a mode when the transit vehicle is operating and the E-TRP subsystem is functioning without degradation.

[Sys_Req_067] The E-TRP In-Vehicle Subsystem shall implement an operational degraded mode.
Note: Operational-degraded mode describes a mode when the transit vehicle is operating and the E-TRP in-vehicle subsystem is running with some functionality degraded.

[Sys_Req_064] The E-TRP In-Vehicle Subsystem shall implement a non-operational standby mode.
Note: Standby mode describes a mode when the transit vehicle is not operating and the E-TRP in-vehicle subsystem is in power saving mode.

[Sys_Req_065] The E-TRP In-Vehicle Subsystem shall implement a non-operational maintenance mode.
Note: Maintenance mode describes a mode when the E-TRP in-vehicle subsystem is powered enough for maintenance support, but the main applications may or may not be using processor or memory resources by executing programming instructions.

[Sys_Req_066] The E-TRP In-Vehicle Subsystem shall implement a non-operational off mode.
Note: Off mode describes a mode when the E-TRP in-vehicle subsystem is not powered and will not respond to triggers to transition to other modes.

3.3.1.3.2 In-Vehicle Subsystem Mode Transitions

[Sys_Req_068] The E-TRP In-Vehicle Subsystem shall transition from Operational Mode to Standby Mode when the transit vehicle ignition transitions from on to off.

[Sys_Req_069] The E-TRP In-Vehicle Subsystem shall transition from Standby Mode to Operational Mode when the transit vehicle ignition transitions from off to on.

[Sys_Req_076] The E-TRP In-Vehicle Subsystem shall transition from Standby Mode into Operational Mode within 2 minutes after sensing vehicle ignition.

[Sys_Req_075] The E-TRP In-Vehicle Subsystem should transition from Standby Mode into Operational Mode within 15 seconds after sensing vehicle ignition.

[Sys_Req_119] The E-TRP In-Vehicle Subsystem shall transition from Standby Mode to Maintenance Mode when triggered remotely by a maintainer.

[Sys_Req_121] The E-TRP In-Vehicle Subsystem shall transition from Maintenance Mode to Standby Mode when triggered remotely by a maintainer.

[Sys_Req_125] The E-TRP In-Vehicle Subsystem shall automatically attempt to recover from a fault, and if successful transition from degraded to an operational state.

[Sys_Req_126] If power is lost while in an Operational mode, the E-TRP In-Vehicle Subsystem shall automatically transition from Off to Operational once power is restored.

[Sys_Req_117] The E-TRP In-Vehicle Subsystem should automatically transition to non-operational mode “Off” if the transit vehicle engine is off and the transit vehicle battery drops below a configurable value.

3.3.1.3.3 TSPW Roadside Subsystem Modes of Operation

[Sys_Req_305] The TSPW Roadside Subsystem shall implement an operational mode.
Note: Operational mode describes a mode when the roadside subsystem is operating without degradation.

[Sys_Req_306] The TSPW Roadside Subsystem shall implement an operational degraded mode.
Note: Operational-degraded mode describes a mode when the roadside subsystem is operating with some functionality degraded.

[Sys_Req_307] The TSPW Roadside Subsystem shall implement a non-operational off mode.
Note: Off mode describes a mode when the roadside subsystem is not powered and will not respond to triggers to transition to other modes.

3.3.1.3.4 TSPW Roadside Subsystem Mode Transitions

[Sys_Req_308] The TSPW Roadside Subsystem shall automatically attempt to recover from a subsystem fault, and if successful transition from degraded to an operational state.

[Sys_Req_309] If power is lost while in an Operational mode, the TSPW Roadside Subsystem shall automatically transition from Off to Operational once power is restored.

3.3.1.4 Time

[Sys_Req_073] The E-TRP system shall maintain time in all operational and non-operational modes.

[Sys_Req_077] The E-TRP system shall synchronize its system time with GNSS time upon transition from a non-operational to an operational mode.

[Sys_Req_078] The E-TRP system shall synchronize its system time with GNSS time at a configurable interval between 1 and 1440 minutes.
Note: Once a minute to once a day.

3.3.1.5 Configuration

[Sys_Req_074] The E-TRP system shall maintain the system configuration in all operational and non-operational modes.

3.3.1.6 Data Warehousing

[Sys_Req_108] The E-TRP cloud management subsystem shall host a database to store all data files generated by E-TRP components.

3.3.1.7 Location Services

[Sys_Req_146] The E-TRP In-Vehicle Subsystem shall calculate the position of the transit vehicle.

[Sys_Req_147] The E-TRP In-Vehicle Subsystem shall calculate the speed of the transit vehicle.

[Sys_Req_148] The E-TRP In-Vehicle Subsystem shall calculate the heading of the transit vehicle.

[Sys_Req_124] The E-TRP In-Vehicle Subsystem shall implement a positioning service capable of 2.5 meter accuracy circular error probability.

[Sys_Req_123] The E-TRP In-Vehicle Subsystem should implement a positioning service capable of 1 meter accuracy circular error probability.

3.3.1.8 Communications Range

[Sys_Req_133] The E-TRP system shall have a DSRC radio range of at least 100 meters line of sight from vehicle to roadside equipment.

3.3.2 Physical Characteristics

[Sys_Req_047] The E-TRP In-Vehicle Subsystem Common Computing Platform shall be no larger than 5.5 inches tall (with respect to the mounting surface) by 11 inches x 8.5 inches.
Note: About the size of a FedEx Medium Priority Mail Flat Rate Box

[Sys_Req_048] The E-TRP In-Vehicle Subsystem Common Computing Platform should be no larger than 2 inches tall (with respect to the mounting surface) by 8 inches x 4 inches.
Note: About the size of a red masonry brick.

3.3.3 Electromagnetic Radiation

[Sys_Req_114] The E-TRP In-Vehicle Subsystem shall be compliant with the electromagnetic compatibility requirements of SAE J1113, including procedures -2, -4, -11, -13, -21, -22, -26, -27, 41, 42j.

3.3.4 Environmental Conditions

3.3.4.1 Temperature

[Sys_Req_050] The E-TRP In-Vehicle Subsystem shall operate at automotive temperatures consistent with SAE J1211 Interior-Instrument Panel-Other (-40 C to 85 C).

[Sys_Req_310] The TSPW Roadside Subsystem shall operate at temperatures between -10 C to 60 C.

3.3.4.2 Humidity

Not Specified

3.3.4.3 Shock and Vibration

[Sys_Req_112] The E-TRP In-Vehicle Subsystem shall be resistant to permanent damage from shock and vibrations normally associated with automotive electrical components and consistent with SAE J1211.

3.3.4.4 Water Resistance

[Sys_Req_346] The TSPW Roadside Subsystem components shall be at least NEMA 4 compliant.

3.4 Supportability

3.4.1 Availability

[Sys_Req_150] The E-TRP system Inherent Availability should be 98%
Note: This requirement serves as a goal for the E-TRP system. Inherent Availability (Ai) is MTBF/MTBF+MTTR (MTBF= Mean Time Between Failure, MTTR = Mean Time to Repair) excludes preventative or scheduled maintenance and logistic time (travel time, paperwork, etc.).

3.4.2 Reliability

[Sys_Req_151] The E-TRP system should have a Mean Time to Repair (MTTR) of less than or equal to 2 hours.

3.4.3 Maintainability

This section outlines the functions and interfaces required to properly maintain the E-TRP system in the field.

Within this section the term “wireless” means the interface uses radio frequency energy to communicate without a physical wire between the two end points.

The term “local” or “locally” means the communications happens with both end points present on or very near (within several feet) of the transit vehicle.

The term “remote” or “remotely” means the communications happens with one end point a significant distance from the transit vehicle (hundreds of feet to hundreds of miles).

3.4.3.1 Status Monitoring

[Sys_Req_095] The E-TRP In-Vehicle Subsystem shall implement physical indicator of the power state of the on-board computational platform.
Note: Off, Standby and Operating are example states.

[Sys_Req_096] The E-TRP In-Vehicle Subsystem shall implement physical indicator that a system fault has occurred, and which fault group.

[Sys_Req_097] The E-TRP In-Vehicle Subsystem should implement physical indicator of the operational state of the Bluetooth connection.

[Sys_Req_098] The E-TRP In-Vehicle Subsystem should implement physical indicator of the operational state of the DSRC connection.

[Sys_Req_099] The E-TRP In-Vehicle Subsystem should implement physical indicator of the operational state of the GNSS connection.

[Sys_Req_100] The E-TRP In-Vehicle Subsystem should implement physical indicator of the operational state of the cellular connection.

[Sys_Req_101] The E-TRP In-Vehicle Subsystem should implement physical indicator of the operational state of the Wi-Fi connection.

[Sys_Req_102] The E-TRP In-Vehicle Subsystem should implement physical indicator of the operational state of the vehicle data-bus connection.

[Sys_Req_105] All E-TRP subsystems shall implement an interface allowing status to be remotely monitored.

3.4.3.2 Software Maintainability

[Sys_Req_079] The E-TRP In-Vehicle Subsystem computing component shall implement a Type A HDMI receptacle connector for use as a connection for a local terminal display for system maintenance.

[Sys_Req_080] The E-TRP In-Vehicle Subsystem computing component shall implement a Type A, USB receptacle for use as connection for a local keyboard for system maintenance.

[Sys_Req_082] All configurable software and firmware components of the E-TRP system shall be programmable via an external connector.

[Sys_Req_081] All configurable software and firmware components of the E-TRP system should be programmable remotely, over the air.

[Sys_Req_118] The E-TRP In-Vehicle Subsystem shall implement an interface for a maintainer to remotely wake up the equipment for maintenance purposes.

[Sys_Req_120] The E-TRP In-Vehicle Subsystem shall implement an interface for a maintainer to remotely put the subsystem into standby mode from maintenance mode.

3.4.3.3 Data Maintainability

[Sys_Req_103] The E-TRP system components shall implement an interface to extract data files on-demand from the unit locally via wire.

[Sys_Req_104] The E-TRP In-Vehicle Subsystem shall implement an interface to extract data files on-demand from the unit locally via Wi-Fi.

[Sys_Req_106] The E-TRP In-Vehicle Subsystem shall implement an interface to extract data files on-demand from the unit remotely.

3.4.3.4 System Reset

[Sys_Req_111] The E-TRP In-Vehicle Subsystem shall implement a method for a local maintainer to physically reset the In Vehicle Subsystem.

[Sys_Req_109] The E-TRP subsystems shall implement an interface to reset/reboot the unit remotely via cellular.

[Sys_Req_110] The E-TRP In-Vehicle Subsystem shall implement an interface to reset/reboot the unit remotely via Wi-Fi.

3.4.3.5 Cellular Provisioning

[Sys_Req_062] If the E-TRP In-Vehicle Subsystem implements a Subscriber Identification Module (SIM) card, the SIM card shall be accessible via an access panel.

3.4.3.6 Accessibility

[Sys_Req_143] The E-TRP In-Vehicle Subsystem electrical connections shall be accessible for disconnection and reconnection by maintenance personnel without equipment disassembly or dismounting.

3.4.4 Transportability

Not Specified

3.5 Design and Construction

Not Specified

3.5.1 Materials

Not Specified

3.5.2 Nameplates or Product Markings

Not Specified

3.5.3 Workmanship

Not Specified

3.5.4 Expandability

Not Specified

3.5.5 Interchangeability

Not Specified

3.5.6 Human Engineering

Not Specified

3.5.7 Safety

[Sys_Req_116] The E-TRP In-Vehicle Subsystem shall prevent electrical discharge to occur such that damage to host vehicle is caused.

3.5.8 Security

[Sys_Req_127] The E-TRP system components shall be packaged such that they are resistant to tampering by unauthorized personnel.

[Sys_Req_193] The E-TRP system DSRC communications channels shall be protected from unauthorized modification.

[Sys_Req_194] The E-TRP system should interface with the U.S. DOT provided Security Credential Management System (SCMS) for security key provisioning and management.
Note: This is an objective (should) requirement due to the likelihood that the SCMS will not be available in time for E-TRP system deployment.

[Sys_Req_347] The E-TRP system maintenance interfaces shall be protected from unauthorized access.

3.6 Documentation

Not Specified

3.7 Logistics

Not Specified

3.8 Personnel and Training

Not Specified

Chapter 4 Verification

The E-TRP system (along with the included safety applications) is expected to consist of multiple subsystems that exchange data through messages using DSRC and/or cellular communication. The verification of those subsystems will be completed over three phases. Phase I of the verification process consists of test cases typically performed in the laboratory and on the benchtop. Where needed, simulators and test applications are used to supply input data. Outputs from each component are verified by inspection and analysis of component outputs and output logs. After verifying that the subsystem elements meet their requirements, the elements are assembled into subsystems and the subsystem requirements are verified in Phase II of the acceptance testing. Phase II tests the functionality and performance of subsystems, paying particular attention to the interfaces and the data and messages exchanged across those interfaces. Phase II test cases are typically conducted using functional vehicles in the garage and in nearby parking lots. Finally, all subsystems are integrated into the complete system for testing, inspection, analysis and demonstration according to Phase III to verify that requirements for the complete system are met. In the case of this project, the Phase III test cases will be demonstrated prior to full-scale deployment in GCRTA vehicles and transit stops. U.S. DOT representatives are welcome to attend the Phase II and/or Phase III acceptance testing. A few requirements require significant data collection in order to verify compliance. For those requirements, verification will be deferred until after the field testing so that the field test data may be used for the analysis. These requirements are assigned to the Phase IV Column.

4.1 Verification Methods

Acceptable methods of verification are documented in this section.

4.1.1 Analysis (A)

A verification method that utilizes established technical or mathematical models or simulations, algorithms, charts, graphs, circuit diagrams, or other scientific principles and procedures to provide evidence that stated requirements are met.

4.1.2 Demonstration (D)

A verification method that generally denotes the actual operation, adjustment, or re-configuration of items to provide evidence that the designed functions were accomplished under specific scenarios.

4.1.3 Inspection (I)

A verification method that consists of investigation, without the use of special laboratory appliances or procedures, of items to determine conformance to those specified requirements. Examination is generally nondestructive and typically includes the use of sight, hearing, smell, touch; simple physical manipulation of the system when it is safe to do so. Inspection can also be applied to the project work

products. For instance, verifying that software is developed using a certain programming language would be verified by inspection.

4.1.4 Test (T)

A verification method that generally denotes the determination of properties by instrumentation and measurement. This method includes functional operation, and involves the application of established scientific principles and procedures.

Table 4-1. Requirements Verification Matrix

Requirement/Verification Cross-Reference Matrix

METHOD OF VERIFICATION
NA – NOT APPLICABLE
A – ANALYSIS
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PHASES OF VERIFICATION
I – Laboratory-Based Verification
II – Garage / Controlled Parking Lot Verification
III – Live Environment Verification
IV – Post-Fielding

Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.2.1.1 In-Vehicle Subsystem Power Interface	[Sys_Req_070]: Standby current	T			
3.2.1.1 In-Vehicle Subsystem Power Interface	[Sys_Req_071]: Input Voltage DC	D			
3.2.1.2 TSPW Roadside Subsystem Power Interface	[Sys_Req_295]: TSPW Roadside Equipment – Input Voltage AC	D			
3.2.2.1.1 Wireless Communications Interface Protocols	[Sys_Req_056]: Interface – Wi-Fi	A			
3.2.2.1.1 Wireless Communications Interface Protocols	[Sys_Req_057]: Interface – Bluetooth – Classic	A			
3.2.2.1.1 Wireless Communications Interface Protocols	[Sys_Req_058]: Interface – Bluetooth – Low Energy	A			
3.2.2.1.1 Wireless Communications Interface Protocols	[Sys_Req_060]: Interface – 4G Cellular	A			
3.2.2.1.1 Wireless Communications Interface Protocols	[Sys_Req_061]: Interface – DSRC 5.9 GHz	A			
3.2.2.1.1 Wireless Communications Interface Protocols	[Sys_Req_144]: In-vehicle subsystem messages compliant with J2735	T			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_083]: Interface – CAN – ISO 15765-4	A			

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix					
METHOD OF VERIFICATION NA – NOT APPLICABLE A – ANALYSIS D – DEMONSTRATION I – INSPECTION T – TEST		PHASES OF VERIFICATION I – Laboratory-Based Verification II – Garage / Controlled Parking Lot Verification III – Live Environment Verification IV – Post-Fielding			
Document Section	**Requirement ID and Name**	**Verification Phase**			
		I	**II**	**III**	**IV**
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_084]: Interface – ISO 14230-4 (Keyword Protocol 2000)	A			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_085]: Interface – ISO 9141-2 (Asian, European, Chrysler vehicles)	A			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_086]: Interface – SAE J1850 VPW (GM Vehicles) interface.	A			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_087]: Interface – SAE J1850 PWM (Ford Vehicles) interface	A			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_088]: Interface – ISO 15765 interface	A			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_089]: Interface – ISO 11898 (raw CAN) interface.	A			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_090]: Interface – GMLAN Single Wire CAN (GMW3089) interface	A			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_091]: Interface – Ford Medium Speed CAN (MS CAN) interface	A			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_092]: Interface – SAE J1939 bus interface	A			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_093]: Interface – SAE J1708 interface	A			

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_094]: Interface – HSCAN + other protocol	A			
3.2.2.1.2 Vehicle Communications Interface Protocols	[Sys_Req_155]: Simultaneous communications on two J1939 channels	T			
3.2.2.2 TSPW Roadside Subsystem Interfaces	[Sys_Req_296]: TSPW Roadside DSRC Radio Specification Compliance	A			
3.2.2.2 TSPW Roadside Subsystem Interfaces	[Sys_Req_297]: TSPW Roadside subsystem messages compliant with J2735	T			
3.2.3 Physical Interface	[Sys_Req_113]: In-Vehicle Subsystem Physical Attachment		D		
3.2.4.1 User Interface – TSPW Enabled Alert Area	[Sys_Req_261]: TSPW Enabled Area End		D		
3.2.4.1 User Interface – TSPW Enabled Alert Area	[Sys_Req_276]: Configurable TSPW Transit Vehicle Alert Start		D		
3.2.4.1 User Interface – TSPW – Transit Vehicle Operator HIS	[Sys_Req_001]: User Interface – Obstructed View			D	
3.2.4.1 User Interface – TSPW – Transit Vehicle Operator HIS	[Sys_Req_159]: E-TRP Vehicle Operator HIS Cloaked Mode		D		
3.2.4.2.1 Transit Vehicle Operator HIS System Ready Alert (TVO-SRA)	[Sys_Req_215]: User Interface – TSPW – TVO-SRA		D		

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.2.4.2.1 Transit Vehicle Operator HIS System Ready Alert (TVO-SRA)	[Sys_Req_247]: User Interface – TSPW – TVO-SRA – Deactivation		D		
3.2.4.2.2 Transit Vehicle Operator HIS Inform Alert (TVO-IA)	[Sys_Req_219]: User Interface – TSPW – TVO-IA – In motion and approaching roadway zones		D		
3.2.4.2.2 Transit Vehicle Operator HIS Inform Alert (TVO-IA)	[Sys_Req_224]: User Interface – TSPW – TVO-IA – Approaching and in motion within any roadway zone		D		
3.2.4.2.2 Transit Vehicle Operator HIS Inform Alert (TVO-IA)	[Sys_Req_235]: User Interface – TSPW – TVO-IA – Stopped within Roadway Zones		D		
3.2.4.2.2 Transit Vehicle Operator HIS Inform Alert (TVO-IA)	[Sys_Req_236]: User Interface – TSPW – TVO-IA – Departing still within all Roadway Zones		D		
3.2.4.2.2 Transit Vehicle Operator HIS Inform Alert (TVO-IA)	[Sys_Req_242]: User Interface – TSPW – TVO-IA – Departing Still Within Forward Roadway Zones		D		
3.2.4.2.3 Transit Vehicle Operator HIS Warn Alert (TVO-WA)	[Sys_Req_223]: User Interface – TSPW – TVO-WA – In motion, approaching roadway zones		D		
3.2.4.2.3 Transit Vehicle Operator HIS Warn Alert (TVO-WA)	[Sys_Req_225]: User Interface – TSPW – TVO-WA – Approaching and in motion within any roadway zone		D		
3.2.4.2.3 Transit Vehicle Operator HIS Warn Alert (TVO-WA)	[Sys_Req_240]: User Interface – TSPW – TVO-WA – Departing Still Within All Roadway Zones		D		
3.2.4.2.3 Transit Vehicle Operator HIS Warn Alert (TVO-WA)	[Sys_Req_246]: User Interface – TSPW – TVO-WA – Departing Still Within Forward Roadway Zones		D		

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.2.4.2.4 Transit Vehicle Operator HIS Inform/Warn Alert End	[Sys_Req_248]: User Interface – TSPW – TVO-IA Alert Deactivation – Pedestrian departure		D		
3.2.4.2.4 Transit Vehicle Operator HIS Inform/Warn Alert End	[Sys_Req_282]: User Interface – TSPW – TVO-IA Deactivation – Passed the Zones		D		
3.2.4.2.4 Transit Vehicle Operator HIS Inform/Warn Alert End	[Sys_Req_333]: User Interface – TSPW – TVO-WA Alert Deactivation – Pedestrian departure		D		
3.2.4.2.4 Transit Vehicle Operator HIS Inform/Warn Alert End	[Sys_Req_334]: User Interface – TSPW – TVO-WA Deactivation – Passed the Zones		D		
3.2.4.2.5 Transit Vehicle Operator HIS NON-Alert	[Sys_Req_279]: User Interface – TSPW – TVO-IA NON-Alert – Stopped within Roadway Zones		D		
3.2.4.2.5 Transit Vehicle Operator HIS NON-Alert	[Sys_Req_280]: User Interface – TSPW – Transit Vehicle Operator NON-Alert – Departing Still Within Forward Roadway Zones		D		
3.2.4.2.5 Transit Vehicle Operator HIS NON-Alert	[Sys_Req_335]: User Interface – TSPW – TVO-WA NON-Alert – Stopped within Roadway Zones		D		
3.2.4.2.6 Transit Vehicle Operator HIS Alert Priority	[Sys_Req_231]: User Interface – TSPW – Transit Vehicle Operator Alert Priority		D		
3.2.4.2.6 Transit Vehicle Operator HIS Alert Priority	[Sys_Req_289]: User Interface – TSPW -Transit Vehicle Operator Alert Priority List		D		
3.2.4.1 User Interface – TSPW – On Transit Vehicle Pedestrian HIS	[Sys_Req_200]: TSPW Vehicle Pedestrian HIS Cloaked Mode		D		

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.2.4.2.1 On Transit Vehicle Pedestrian HIS Warn Alert (OTVP-WA)	[Sys_Req_232]: User Interface – TSPW – OTVP-WA – Approaching and in motion within any roadway zone		D		
3.2.4.2.1 On Transit Vehicle Pedestrian HIS Warn Alert (OTVP-WA)	[Sys_Req_241]: User Interface – TSPW – OTVP-WA – Departing Still Within All Roadway Zones		D		
3.2.4.2.1 On Transit Vehicle Pedestrian HIS Warn Alert (OTVP-WA)	[Sys_Req_249]: User Interface – TSPW – OTVP-WA – Stop Within Roadway Zones – Vehicle approaching from behind and to the left of the transit vehicle		D		
3.2.4.2.2 On Transit Vehicle Pedestrian HIS Alert End	[Sys_Req_260]: User Interface – TSPW – OTVP-WA Deactivation – Pedestrians are clear		D		
3.2.4.2.2 On Transit Vehicle Pedestrian HIS Alert End	[Sys_Req_290]: User Interface – TSPW – OTVP-WA Deactivation – Passed the Zones		D		
3.2.4.3.3 On Transit Vehicle Pedestrian HIS NON-Alert	[Sys_Req_281]: User Interface – TSPW – On Transit Vehicle Pedestrian HIS NON-Alert – In motion and approaching roadway zones		D		
3.2.4.3.3 On Transit Vehicle Pedestrian HIS NON-Alert	[Sys_Req_283]: User Interface – TSPW – On Transit Vehicle Pedestrian HIS NON-Alert – Stopped within Roadway Zones – No Personally Owned Vehicles		D		
3.2.4.3.3 On Transit Vehicle Pedestrian HIS NON-Alert	[Sys_Req_284]: User Interface – TSPW – On Transit Vehicle Pedestrian HIS NON-Alert – Departing Still Within All Roadway Zones		D		

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.2.4.3.3 On Transit Vehicle Pedestrian HIS NON-Alert	[Sys_Req_285]: User Interface – TSPW – On Transit Vehicle Pedestrian HIS NON-Alert – Departing Still Within forward roadway zones		D		
3.2.4.1 User Interface – TSPW – Roadside Pedestrian HIS	[Sys_Req_201]: TSPW Roadside Pedestrian HIS Cloaked Mode		D		
3.2.4.1.1 Roadside Pedestrian HIS – Transit Vehicle Traveler Advisory Message – Vehicle Approaching (RP-TAM-Approach)	[Sys_Req_216]: User Interface – TSPW – Roadside Pedestrian Transit Vehicle Traveler Advisory Message – Vehicle Approaching		D		
3.2.4.3.2 Roadside Pedestrian HIS – Transit Vehicle Traveler Advisory Message – Vehicle At Stop (RP-TAM-Stop)	[Sys_Req_233]: User Interface – TSPW – Roadside Pedestrian Transit Vehicle Traveler Advisory Message – Vehicle At Stop		D		
3.2.4.1.3 Roadside Pedestrian HIS Inform Alerts (RP-IA)	[Sys_Req_218]: User Interface – TSPW – RP-IA – In motion and approaching roadway zones		D		
3.2.4.1.3 Roadside Pedestrian HIS Inform Alerts (RP-IA)	[Sys_Req_230]: User Interface – TSPW – RP-IA – Approaching and in motion within any roadway zone		D		
3.2.4.1.3 Roadside Pedestrian HIS Inform Alerts (RP-IA)	[Sys_Req_234]: User Interface – TSPW – RP-IA – Stopped within Roadway Zones		D		
3.2.4.1.3 Roadside Pedestrian HIS Inform Alerts (RP-IA)	[Sys_Req_237]: User Interface – TSPW – RP-IA– Departing still within all Roadway Zones		D		
3.2.4.1.3 Roadside Pedestrian HIS Inform Alerts (RP-IA)	[Sys_Req_243]: User Interface – TSPW – RP-IA – Departing still within forward Roadway Zones		D		

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.2.4.1.4 Roadside Pedestrian HIS Warn Alert (RP-WA)	[Sys_Req_222]: User Interface – TSPW – RP-WA – In motion and approaching roadway zones		D		
3.2.4.1.4 Roadside Pedestrian HIS Warn Alert (RP-WA)	[Sys_Req_227]: User Interface – TSPW – RP-WA – Approaching and in motion within any roadway zone		D		
3.2.4.1.4 Roadside Pedestrian HIS Warn Alert (RP-WA)	[Sys_Req_239]: User Interface – TSPW – RP-WA – Departing Still Within All Roadway Zones		D		
3.2.4.1.4 Roadside Pedestrian HIS Warn Alert (RP-WA)	[Sys_Req_245]: User Interface – TSPW – RP-WA – Departing Still Within Forward Roadway Zones		D		
3.2.4.1.5 Roadside Pedestrian Alert End	[Sys_Req_226]: User Interface – TSPW – RP-TAM-Approach Alert End		D		
3.2.4.1.5 Roadside Pedestrian Alert End	[Sys_Req_257]: User Interface – TSPW – RP-IA Deactivation – Pedestrians Clear		D		
3.2.4.1.5 Roadside Pedestrian Alert End	[Sys_Req_286]: User Interface – TSPW – RP-TAM-Stop Alert End		D		
3.2.4.1.5 Roadside Pedestrian Alert End	[Sys_Req_336]: User Interface – TSPW – RP-IA Deactivation – Transit Vehicle passed the zone		D		
3.2.4.1.5 Roadside Pedestrian Alert End	[Sys_Req_337]: User Interface – TSPW – RP-WA Deactivation – Transit Vehicle passed the zone		D		
3.2.4.1.5 Roadside Pedestrian Alert End	[Sys_Req_338]: User Interface – TSPW – RP-WA Deactivation – Pedestrians Clear		D		

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix					
METHOD OF VERIFICATION NA – NOT APPLICABLE A – ANALYSIS D – DEMONSTRATION I – INSPECTION T – TEST		PHASES OF VERIFICATION I – Laboratory-Based Verification II – Garage / Controlled Parking Lot Verification III – Live Environment Verification IV – Post-Fielding			
Document Section	**Requirement ID and Name**	**Verification Phase**			
		I	**II**	**III**	**IV**
3.2.4.1.6 Roadside Pedestrian HIS Alert Priority	[Sys_Req_255]: User Interface – TSPW -Roadside Pedestrian Alert Priority		D		
3.2.4.1.6 Roadside Pedestrian HIS Alert Priority	[Sys_Req_291]: User Interface – TSPW – Roadside Pedestrian Safety Alert Priority List		D		
3.2.4.1.6 Roadside Pedestrian HIS Alert Priority	[Sys_Req_339]: User Interface – TSPW – Roadside Pedestrian Traveler Advisory Alert Priority List		D		
3.2.4.4.7 Roadside Pedestrian HIS NON-Alert	[Sys_Req_287]: User Interface – TSPW – Roadside Pedestrian NON-Alert – Stopped within Roadway Zones		D		
3.2.4.4.7 Roadside Pedestrian HIS NON-Alert	[Sys_Req_288]: User Interface – TSPW – Roadside Pedestrian NON-Alert – Departed Rear Zones		D		
3.2.4.5.1 Mobile Pedestrian HIS – System Ready Alert (MP-SRA)	[Sys_Req_311]: User Interface – TSPW – MP-SRA		D		
3.2.4.5.1 Mobile Pedestrian HIS – System Ready Alert (MP-SRA)	[Sys_Req_312]: User Interface – TSPW – MP-SRA – Deactivation		D		
3.2.4.5.2 Mobile Pedestrian HIS – Traveler Advisory Message – Vehicle Approaching (MP-TAM-Approach) Alert	[Sys_Req_217]: User Interface – TSPW – MP-TAM-Approach Alert		D		
3.2.4.5.2 Mobile Pedestrian HIS – Traveler Advisory Message – Vehicle Approaching (MP-TAM-Approach) Alert	[Sys_Req_228]: User Interface – TSPW – MP-TAM-Approach Alert – Approaching and in motion within any roadway zone		D		

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

METHOD OF VERIFICATION
NA – NOT APPLICABLE
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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.2.4.5.3 Mobile Pedestrian HIS Inform Alerts (MP-IA)	[Sys_Req_220]: User Interface – TSPW – MP-IA – In motion and approaching roadway zones		D		
3.2.4.5.3 Mobile Pedestrian HIS Inform Alerts (MP-IA)	[Sys_Req_229]: User Interface – TSPW – MP-IA – Approaching and in motion within any roadway zone		D		
3.2.4.5.3 Mobile Pedestrian HIS Inform Alerts (MP-IA)	[Sys_Req_238]: User Interface – TSPW – MP-IA – Departing still within all Roadway Zones		D		
3.2.4.5.3 Mobile Pedestrian HIS Inform Alerts (MP-IA)	[Sys_Req_244]: User Interface – TSPW – MP-IA – Departing still within forward Roadway Zones		D		
3.2.4.5.4 Mobile Pedestrian HIS Alert End	[Sys_Req_258]: User Interface – TSPW – MP-IA Deactivation – Pedestrian has cleared		D		
3.2.4.5.4 Mobile Pedestrian HIS Alert End	[Sys_Req_264]: User Interface – TSPW – MP-IA Deactivation – Transit Vehicle passed the zone		D		
3.2.4.5.5 Mobile Pedestrian HIS NON-Alert	[Sys_Req_221]: User Interface – TSPW – Mobile Alert Suppression in Roadway Zones		D		
3.2.4.5.5 Mobile Pedestrian HIS NON-Alert	[Sys_Req_292]: User Interface – TSPW – Mobile Pedestrian NON-Alert – Stopped within Roadway Zones		D		
3.2.4.5.6 Mobile Pedestrian Alert Priority	[Sys_Req_254]: User Interface – TSPW -Mobile Pedestrian Alert Priority		D		
3.2.4.5.6 Mobile Pedestrian Alert Priority	[Sys_Req_293]: User Interface – TSPW -Mobile Pedestrian Alert Priority List		T		

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix					
METHOD OF VERIFICATION NA – NOT APPLICABLE A – ANALYSIS D – DEMONSTRATION I – INSPECTION T – TEST		PHASES OF VERIFICATION I – Laboratory-Based Verification II – Garage / Controlled Parking Lot Verification III – Live Environment Verification IV – Post-Fielding			
Document Section	**Requirement ID and Name**	**Verification Phase**			
		I	**II**	**III**	**IV**
3.2.4.5 User Interface – TSPW – DSRC-Enabled Personally Owned Vehicle HIS	[Sys_Req_340]: Configurable TSPW POV Alert Start		D		
3.2.4.5.1 DSRC-Enabled Personally Owned Vehicle HIS Inform Alerts (POV-IA)	[Sys_Req_250]: User Interface – TSPW – POV-IA – Same Lane as Transit Vehicle		D		
3.2.4.5.2 DSRC-Enabled Personally Owned Vehicle HIS Warn Alerts (POV-WA)	[Sys_Req_251]: User Interface – TSPW – POV-WA – Same Lane as Transit Vehicle		D		
3.2.4.5.2 DSRC-Enabled Personally Owned Vehicle HIS Warn Alerts (POV-WA)	[Sys_Req_252]: User Interface – TSPW – POV-WA – Adjacent Lane of Transit Vehicle		D		
3.2.4.5.3 DSRC-Enabled Personally Owned Vehicle HIS Alert End	[Sys_Req_259]: User Interface – TSPW – POV-IA Alert Deactivation – Pedestrians Clear		D		
3.2.4.5.3 DSRC-Enabled Personally Owned Vehicle HIS Alert End	[Sys_Req_341]: User Interface – TSPW – POV-WA Alert Deactivation – Pedestrians Clear		D		
3.2.4.5.3 DSRC-Enabled Personally Owned Vehicle HIS Alert End	[Sys_Req_342]: User Interface – TSPW – POV-IA Deactivation – Vehicle passed the zone		D		
3.2.4.5.3 DSRC-Enabled Personally Owned Vehicle HIS Alert End	[Sys_Req_343]: User Interface – TSPW – POV-WA Deactivation – Vehicle passed the zone		D		

Table 4-1. Requirements Verification Matrix (Continued)

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.2.4.5.4 DSRC-Enabled Personally Owned Vehicle HIS Alert Priority	[Sys_Req_256]: User Interface – TSPW – DSRC-Enabled Personally Owned Vehicle Alert Priority		D		
3.2.4.5.4 DSRC-Enabled Personally Owned Vehicle HIS Alert Priority	[Sys_Req_294]: User Interface – TSPW – DSRC-Enabled Personally Owned Vehicle Alert Priority List		T		
3.2.4.7 TSPW Alert ID	[Sys_Req_205]: TSPW – Alert ID	I			
3.3.1.1 Transit Bus Stop Pedestrian Warning Application	[Sys_Req_266]: Pedestrian Detection within Danger Waiting Zone (Zone 2)	D			
3.3.1.1 Transit Bus Stop Pedestrian Warning Application	[Sys_Req_267]: Pedestrian Detection within In Roadway Forward Curb Zone (Zone 3)	D			
3.3.1.1 Transit Bus Stop Pedestrian Warning Application	[Sys_Req_268]: Pedestrian Detection within In Roadway Rear Curb Zone (Zone 4)	D			
3.3.1.1 Transit Bus Stop Pedestrian Warning Application	[Sys_Req_269]: Pedestrian Detection within In Roadway Forward Center Zone (Zone 5)	D			
3.3.1.1 Transit Bus Stop Pedestrian Warning Application	[Sys_Req_270]: Pedestrian Detection within In Roadway Rear Curb Center (Zone 6)	D			
3.3.1.1 Transit Bus Stop Pedestrian Warning Application	[Sys_Req_271]: Detect approaching DSRC Enabled Vehicles		D		
3.3.1.1 Transit Bus Stop Pedestrian Warning Application	[Sys_Req_272]: Detect Lane of Approaching DSRC Enabled Vehicles		D		

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix					
METHOD OF VERIFICATION NA – NOT APPLICABLE A – ANALYSIS D – DEMONSTRATION I – INSPECTION T – TEST		PHASES OF VERIFICATION I – Laboratory-Based Verification II – Garage / Controlled Parking Lot Verification III – Live Environment Verification IV – Post-Fielding			
Document Section	**Requirement ID and Name**	**Verification Phase**			
		I	**II**	**III**	**IV**
3.3.1.1 Transit Bus Stop Pedestrian Warning Application	[Sys_Req_273]: Detect Location of Approaching TSPW-enabled Transit Vehicles		D		
3.3.1.1 Transit Bus Stop Pedestrian Warning Application	[Sys_Req_274]: Detect whether TSPW-enabled Transit Vehicles are moving or are stopped		D		
3.3.1.5.1 E-TRP In-Vehicle Platform Logging Service	[Sys_Req_044]: E-TRP In-vehicle Logging – Date and Time Association	I			
3.3.1.5.1 E-TRP In-Vehicle Platform Logging Service	[Sys_Req_107]: E-TRP In-vehicle Logging – Transfer to remote database	T			
3.3.1.5.1 E-TRP In-Vehicle Platform Logging Service	[Sys_Req_139]: E-TRP In-vehicle Logging – Vehicle ID Association	I			
3.3.1.5.1 E-TRP In-Vehicle Platform Logging Service	[Sys_Req_156]: E-TRP In-vehicle Logging Service	I			
3.3.1.5.1 E-TRP In-Vehicle Platform Logging Service	[Sys_Req_157]: E-TRP In-vehicle Log Storage	T			
3.3.1.5.1 E-TRP In-Vehicle Platform Logging Service	[Sys_Req_174]: E-TRP In-vehicle Logging – DSRC Messages Transmitted	T			
3.3.1.5.1 E-TRP In-Vehicle Platform Logging Service	[Sys_Req_175]: E-TRP In-vehicle Logging – DSRC Messages Received	T			
3.3.1.5.1 E-TRP In-Vehicle Platform Logging Service	[Sys_Req_344]: E-TRP In-vehicle Logging – Date and Time Reference	I			

Table 4-1. Requirements Verification Matrix (Continued)

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.3.1.5.2 E-TRP In-Vehicle Platform Logging Events	[Sys_Req_040]: E-TRP Logging – Service Brake State Change		D		
3.3.1.5.2 E-TRP In-Vehicle Platform Logging Events	[Sys_Req_043]: E-TRP Logging – Vehicle Speed – 1 Hz		D		
3.3.1.5.2 E-TRP In-Vehicle Platform Logging Events	[Sys_Req_051]: E-TRP Logging – Vehicle Position – 1 Hz	D			
3.3.1.5.2 E-TRP In-Vehicle Platform Logging Events	[Sys_Req_149]: E-TRP Logging – Gear Position State Change		D		
3.3.1.5.2 E-TRP In-Vehicle Platform Logging Events	[Sys_Req_152]: E-TRP Logging – Heading – 1 Hz	D			
3.3.1.5.2 E-TRP In-Vehicle Platform Logging Events	[Sys_Req_154]: E-TRP Logging – Operational Mode Change	D			
3.3.1.5.2 E-TRP In-Vehicle Platform Logging Events	[Sys_Req_158]: E-TRP Logging – In-vehicle operator HIS Logging	D			
3.3.1.5.2 TSPW In-Vehicle Application Logging Events	[Sys_Req_041]: TSPW Logging – Alert Activation Logging	D			
3.3.1.5.2 TSPW In-Vehicle Application Logging Events	[Sys_Req_153]: TSPW Logging – Alert Deactivation Logging	D			
3.3.1.5.2 TSPW In-Vehicle Application Logging Events	[Sys_Req_196]: TSPW Logging – In-vehicle transit vehicle pedestrian HIS Logging	D			

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.3.1.5.4 TSPW Roadside Platform Logging Service	[Sys_Req_298]: TSPW Roadside Logging Service	T			
3.3.1.5.4 TSPW Roadside Platform Logging Service	[Sys_Req_299]: TSPW Roadside Logging – Date and Time Association	I			
3.3.1.5.4 TSPW Roadside Platform Logging Service	[Sys_Req_300]: TSPW Roadside Logging – Transfer to remote database	T			
3.3.1.5.4 TSPW Roadside Platform Logging Service	[Sys_Req_301]: TSPW Roadside Logging – Location ID Association	I			
3.3.1.5.4 TSPW Roadside Platform Logging Service	[Sys_Req_302]: TSPW Roadside Logging – DSRC Messages Transmitted	T			
3.3.1.5.4 TSPW Roadside Platform Logging Service	[Sys_Req_303]: TSPW Roadside Logging – DSRC Messages Received	T			
3.3.1.5.4 TSPW Roadside Platform Logging Service	[Sys_Req_345]: TSPW Roadside Logging – Date and Time Reference	I			
3.3.1.5.5 TSPW Roadside Platform Log Events	[Sys_Req_304]: TSPW Roadside Logging – Operational Mode Change		D		
3.3.1.5.5 TSPW Roadside Application Log Events	[Sys_Req_180]: TSPW Logging – Roadside – Pedestrian Detection Image		D		
3.3.1.5.5 TSPW Roadside Application Log Events	[Sys_Req_197]: TSPW Logging – Roadside HIS Logging	D			

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

METHOD OF VERIFICATION
NA – NOT APPLICABLE
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PHASES OF VERIFICATION
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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.3.1.5.5 TSPW Roadside Application Log Events	[Sys_Req_198]: TSPW Logging – Mobile HIS Logging	D			
3.3.1.5.5 TSPW Roadside Application Log Events	[Sys_Req_214]: TSPW Logging – Roadside – Pedestrian Detection Events		D		
3.3.1.6.1 In-Vehicle Subsystem Modes of Operation	[Sys_Req_063]: Operational Mode		D		
3.3.1.6.1 In-Vehicle Subsystem Modes of Operation	[Sys_Req_064]: Non-Operational Mode – Standby		D		
3.3.1.6.1 In-Vehicle Subsystem Modes of Operation	[Sys_Req_065]: Non-Operational Mode – Maintenance	D			
3.3.1.6.1 In-Vehicle Subsystem Modes of Operation	[Sys_Req_066]: Non-Operational Mode – Off	D			
3.3.1.6.1 In-Vehicle Subsystem Modes of Operation	[Sys_Req_067]: Operational Mode – Degraded	D			
3.3.1.6.2 In-Vehicle Subsystem Mode Transitions	[Sys_Req_068]: Mode Transition: Operational to Standby		D		
3.3.1.6.2 In-Vehicle Subsystem Mode Transitions	[Sys_Req_069]: Mode Transition: Standby to Operational		D		
3.3.1.6.2 In-Vehicle Subsystem Mode Transitions	[Sys_Req_075]: Mode Transition Timing – Objective	D			

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.3.1.6.2 In-Vehicle Subsystem Mode Transitions	[Sys_Req_076]: Mode Transition Timing – Threshold	D			
3.3.1.6.2 In-Vehicle Subsystem Mode Transitions	[Sys_Req_117]: Mode Transition: Standby to Off – Low Battery Shutdown	D			
3.3.1.6.2 In-Vehicle Subsystem Mode Transitions	[Sys_Req_119]: Mode Transition: Standby to Maintenance	D			
3.3.1.6.2 In-Vehicle Subsystem Mode Transitions	[Sys_Req_121]: Mode Transition: Maintenance to Standby	D			
3.3.1.6.2 In-Vehicle Subsystem Mode Transitions	[Sys_Req_125]: Mode Transition: Degraded to Operational	D			
3.3.1.6.2 In-Vehicle Subsystem Mode Transitions	[Sys_Req_126]: Mode Transition: Off to Operational		D		
3.3.1.6.3 TSPW Roadside Subsystem Modes of Operation	[Sys_Req_305]: TSPW Roadside Operational Mode		D		
3.3.1.6.3 TSPW Roadside Subsystem Modes of Operation	[Sys_Req_306]: TSPW Roadside Operational Mode – Degraded		D		
3.3.1.6.3 TSPW Roadside Subsystem Modes of Operation	[Sys_Req_307]: TSPW Roadside Non-Operational Mode – Off	D			
3.3.1.6.4 TSPW Roadside Subsystem Mode Transitions	[Sys_Req_308]: TSPW Roadside Mode Transition: Degraded to Operational	D			

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.3.1.6.4 TSPW Roadside Subsystem Mode Transitions	[Sys_Req_309]: TSPW Roadside Mode Transition: Off to Operational		D		
3.3.1.7 Time	[Sys_Req_073]: Time	T			
3.3.1.7 Time	[Sys_Req_077]: Time Synchronization on mode transition		D		
3.3.1.7 Time	[Sys_Req_078]: Time Synchronization – Periodicity	D			
3.3.1.8 Configuration	[Sys_Req_074]: Keep Configuration in all modes	D			
3.3.1.9 Data Warehousing	[Sys_Req_108]: Data Log Storage		D		
3.3.1.10 Location Services	[Sys_Req_123]: Location Accuracy – Objective		T		
3.3.1.10 Location Services	[Sys_Req_124]: Location Accuracy – Threshold		T		
3.3.1.10 Location Services	[Sys_Req_146]: Calculate Location	D			
3.3.1.10 Location Services	[Sys_Req_147]: Calculate Speed	D			

Table 4-1. Requirements Verification Matrix (Continued)

Requirement/Verification Cross-Reference Matrix

METHOD OF VERIFICATION
NA – NOT APPLICABLE
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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.3.1.10 Location Services	[Sys_Req_148]: Calculate Heading	D			
3.3.1.11 Communications Range	[Sys_Req_133]: DSRC Range		T		
3.3.2 Physical Characteristics	[Sys_Req_047]: In-Vehicle Size – Threshold	T			
3.3.2 Physical Characteristics	[Sys_Req_048]: In-Vehicle Size – Objective	T			
3.3.3 Electromagnetic Radiation	[Sys_Req_114]: Electromagnetic compatibility	T			
3.3.4.1 Temperature	[Sys_Req_050]: E-TRP In-Vehicle Subsystem Computational Platform – Operational Temperature	A			
3.3.4.1 Temperature	[Sys_Req_310]: TSPW Roadside Equipment Operational Temperature	A			
3.3.4.3 Shock and Vibration	[Sys_Req_112]: Shock and Vibe	T			
3.3.4.4 Water Resistance	[Sys_Req_346]: TSPW Roadside Equipment Weather Resistance	A			

Table 4-1. Requirements Verification Matrix (Continued)

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.4.1 Availability	[Sys_Req_150]: Availability				A
3.4.2 Reliability	[Sys_Req_151]: Reliability				A
3.4.3.1 Status Monitoring	[Sys_Req_095]: Indicator – Power State	D			
3.4.3.1 Status Monitoring	[Sys_Req_096]: Indicator – Fault State	D			
3.4.3.1 Status Monitoring	[Sys_Req_097]: Indicator – Bluetooth State	D			
3.4.3.1 Status Monitoring	[Sys_Req_098]: Indicator – DSRC State	D			
3.4.3.1 Status Monitoring	[Sys_Req_099]: Indicator – GPS State	D			
3.4.3.1 Status Monitoring	[Sys_Req_100]: Indicator – Cellular State	D			
3.4.3.1 Status Monitoring	[Sys_Req_101]: Indicator – Wi-Fi State	D			
3.4.3.1 Status Monitoring	[Sys_Req_102]: Indicator – Vehicle Bus State	D			

Table 4-1. Requirements Verification Matrix (Continued)

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.4.3.1 Status Monitoring	[Sys_Req_105]: Interface – Remote Status Monitoring	D			
3.4.3.2 Software Maintainability	[Sys_Req_079]: Local Terminal Display	D			
3.4.3.2 Software Maintainability	[Sys_Req_080]: Local Keyboard	D			
3.4.3.2 Software Maintainability	[Sys_Req_081]: Software Programmability – OTA	D			
3.4.3.2 Software Maintainability	[Sys_Req_082]: Software Programmability – Locally	D			
3.4.3.2 Software Maintainability	[Sys_Req_118]: Interface – Remote transition from Standby to Maintenance mode	D			
3.4.3.2 Software Maintainability	[Sys_Req_120]: Interface – Remote transition from Maintenance to Standby mode	D			
3.4.3.3 Data Maintainability	[Sys_Req_103]: Interface – Local Wired Data Extraction	D			
3.4.3.3 Data Maintainability	[Sys_Req_104]: Interface – Local Wireless Data Extraction	D			
3.4.3.3 Data Maintainability	[Sys_Req_106]: Interface – Remote Data Extraction	D			

Table 4-1. Requirements Verification Matrix (Continued)

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Document Section	Requirement ID and Name	Verification Phase			
		I	II	III	IV
3.4.3.4 System Reset	[Sys_Req_109]: Interface – Remote Reboot via Cellular	D			
3.4.3.4 System Reset	[Sys_Req_110]: Interface – Remote Reboot via Wi-Fi	D			
3.4.3.4 System Reset	[Sys_Req_111]: Interface – Reset	D			
3.4.3.5 Cellular Provisioning	[Sys_Req_062]: Access Door for SIM card	I			
3.4.3.6 Accessibility	[Sys_Req_143]: Connector Accessibility			I	
3.5.7 Safety	[Sys_Req_116]: Electrical Discharge	A			
3.5.8 Security	[Sys_Req_127]: Tamper Resistant			I	
3.5.8 Security	[Sys_Req_193]: DSRC Communications Channel Security	T			
3.5.8 Security	[Sys_Req_194]: SCMS Interface	T			
3.5.8 Security	[Sys_Req_347]: Maintenance Communications Channel Security	T			

Chapter 5 Preparation for Delivery

Not Specified

APPENDIX A. Definitions, Acronyms and Initialisms

Abbreviation / Acronym	Definition
CAN	Controller-Area Network
CCP	Common Computing Platform
CMS	Cloud-based Management System
COTS	Commercial-Off-The-Shelf
DAS	Data Acquisition System
DSRC	Dedicated Short-Range Communication
E-TRP	Enhanced Transit Safety Retrofit Package
FHWA	Federal Highway Administration
GCRTA	Greater Cleveland Regional Transit Authority
GID	Geometric Intersection Description
GNSS	Global Navigation Satellite System
HIS	Human Interface Subsystem
IEEE	Institute of Electrical and Electronics Engineers
LED	Light-emitting Diode
MAC	Medium Access Control
mPCIe	mini PCI express
MP-IA	Mobile Pedestrian – Inform Alert
MP-TAV-Approach	Mobile Pedestrian HIS Traveler Advisory Message – Vehicle Approaching Alert
OTVP-IA	On Transit Vehicle Pedestrian – Inform Alert
OTVP-WA	On Transit Vehicle Pedestrian – Warn Alert
PHY	Physical Layer
POV-IA	DSRC-Enabled Personally Owned Vehicle – Inform Alert
POV-WA	DSRC-Enabled Personally Owned Vehicle – Warn Alert
RP-IA	Roadside Pedestrian HIS – Inform Alert
RP-TAM-Approach	Roadside Pedestrian HIS Traveler Advisory Message – Vehicle Approaching Alert
RP-TAM-Stop	Roadside Pedestrian HIS Traveler Advisory Message – Vehicle At Stop Alert
RP-WA	Roadside Pedestrian HIS – Warn Alert
RSU	Roadside Unit
SAE	Society of Automotive Engineers
TRP	Transit Safety Retrofit Package
TSPW	Transit Bus Stop Pedestrian Warning Application

Abbreviation / Acronym	Definition
TVO-IA	Transit Vehicle Operator HIS Inform Alert
TVO-SRA	Transit Vehicle Operator HIS System Ready Alert
TVO-WA	Transit Vehicle Operator HIS Warn Alert
U.S. DOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
WAVE	Wireless Access in Vehicular Environments
Wi-Fi	Wireless Fidelity

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