

# Transit Safety Retrofit Package Development

## Applications Requirements Document

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**Final Report — May 28, 2014**

**FHWA-JPO-14-118**



U.S. Department of Transportation

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<b>16. Abstract</b> <p>This Application Requirements Document for the Transit Safety Retrofit Package (TRP) Development captures the system, hardware and software requirements towards fulfilling the technical objectives stated within the contract.</p> <p>To achieve the objective of the study, the TRP project includes developing, testing, installing, and maintaining retrofit packages on three transit buses drawn from the University of Michigan transit fleets; developing two new transit safety applications (Pedestrian Warning and Vehicle Turning Right in Front of a Transit Vehicle); and collecting and providing data from the equipped buses to the Volpe Center for an independent evaluation.</p> <p>The specific objective of the TRP project is to design and develop safety applications for transit vehicles that can communicate V2V as well as V2I for enhanced transit vehicle and pedestrian safety. Ultimately, it is of interest to determine if DSRC technologies can be combined with on-board applications to provide real-time alerting of pedestrians in crosswalks as well as right turning vehicles in front of the transit vehicle.</p>					
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# Chapter 1 Scope

This Application Requirements Document for the Transit Safety Retrofit Package (TRP) Development captures the requirements towards fulfilling the technical objectives as stated in Contract No. DTFH61-12-C-00007.

## Document Overview

The intended audience for this Applications Requirements document is the system developers, Safety Pilot Test Conductor, and United States Department of Transportation (U.S. DOT) Connected Vehicle Program Managers who are managing the Safety Pilot Model Deployment. Additional audience members for this document may be transit agencies and bus manufacturers.

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

Chapter 2 (Referenced Documents) describes the external documentation referenced throughout this document.

Chapter 3 (Overview) describes an overview of the system of interest, the stakeholder requirements, the system constraints and assumptions, and the corresponding systems requirements.

Chapter 4 (Applications Requirements) describes the applications requirements for the system of interest.

Chapter 5 (Verification) describes the methods to be used during verification and outlines the verification method for each requirement.

Chapter 6 (Notes) provides traceability to stakeholder requirements and traceability to systems requirements.

Appendix A provides definitions for terms, acronyms, and abbreviations used throughout the document.

## Chapter 2 Referenced Documents

### 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 (Local Area Network) LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Wireless Access in Vehicular Environments

### Society of Automotive Engineers (SAE)

SAE J1939	Serial Control and Communications Heavy Duty Vehicle Network, SAE International
SAE J2735	Dedicated Short-Range Communications (DSRC) Message Set Dictionary, SAE International

### Battelle Drawings/Documents

100008379-0001	Transit Safety Retrofit Package (TRP) Concept of Operations (CONOPS)
100008379-0004	Transit Safety Retrofit Package (TRP) Applications Requirements
100008379-0003	Transit Safety Retrofit Package (TRP) Vehicle Install Test Plan
60606-018A	Interface Control Document for the Signal Phase and Timing and Related Messages for V-I Applications

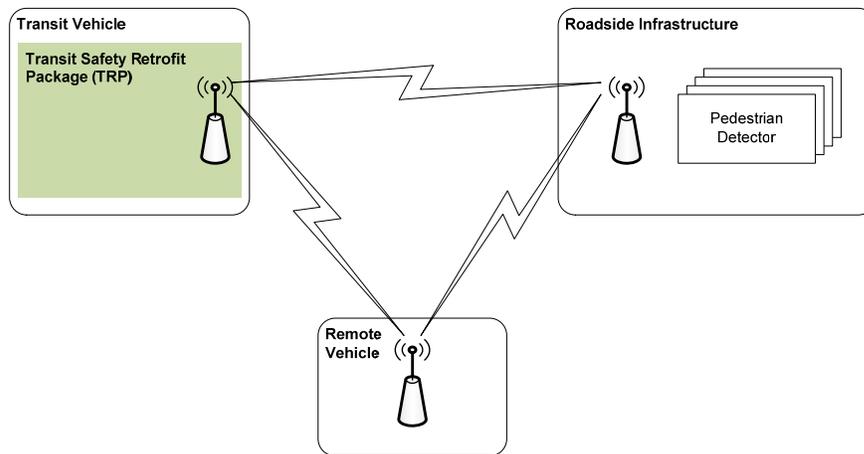
## Order of Precedence

In the event of a conflict 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 Overview

## System Overview and Context

The system-of-interest for TRP Development is a demonstration system where three transit buses are equipped with retrofit connected vehicle safety packages, including two new transit safety applications. The buses will participate as “retrofitted” vehicles in the Safety Pilot Model Deployment in Ann Arbor, Michigan and support further research beyond the deployment. How the system-of-interest fits into the overall system context and its physical and interface boundary are illustrated in Figure 3-1.



Source: Battelle

**Figure 3-1. System of Interest**

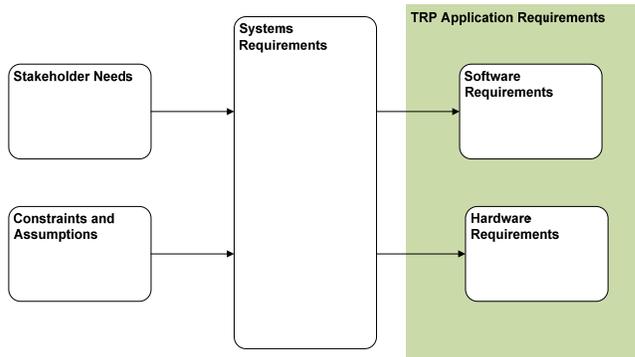
The TRP is a standalone set of equipment that is installed on a Transit Vehicle. The TRP interoperates with other model deployment vehicles and Safety Pilot Model Deployment Roadside Unit (RSU) according to IEEE 802.11p and 1609.2 standards and the J2735 message standards.

Using J2735 Basic Safety Messages (BSMs) received from other Safety Pilot Model Deployment Remote Vehicles, and Signal Phase and Timing (SPAT) and Map Messages (MAP) from Roadside Units along with on-board Transit Vehicle information received from an on-board data bus and sensors installed specifically for the test, the TRP will provide five safety applications broken down into two categories – TRP Safety Applications and Basic Safety Applications. The TRP Safety Applications include Pedestrian in Crosswalk Warning (PCW) and Vehicle Turning Right in Front of Bus Warning (VTRW). Basic Safety Applications include Curve Speed Warning (CSW), Emergency Electronic Brake Lights (EEBL), and Forward Collision Warning (FCW).

Pedestrian Detectors, while not specifically part of the TRP system, are being provided for this effort. The Pedestrian Detectors are installed as a component of the PCW Roadside Infrastructure, which interfaces with the Pedestrian Detectors to provide detection information wirelessly to the TRP via an RSU located at the intersection. The effort to process the detection and corresponding wireless transmission is being performed under a separate effort from the TRP development.

A more descriptive overview of the TRP System is described in the TRP CONOPS document (100008379-0001).

The following sections capture the Stakeholder Requirements and the Constraints and Assumptions for the TRP. These inputs were used to formulate Systems Requirements. The TRP Applications Requirements are a flow down from the Systems Requirements which are a flow down from Stakeholder Requirements, Constraints and Assumptions. A pictorial representation of the formulation of the TRP Applications Requirements are shown in Figure 3-2.



Source: Battelle

**Figure 3-2. Document Architecture**

Systems Requirements were allocated to corresponding Hardware and/or Software Requirements. The set of Hardware and Software Requirements comprise the TRP Applications Requirements (Chapter 4).

## Stakeholder Requirements

[STK\_001] The TRP System shall warn the Transit Vehicle Driver when a pedestrian is in an instrumented crosswalk which intersects the Transit Vehicle's planned left or right turn path at the intersection.

[STK\_002] The TRP System shall caution the Transit Vehicle Driver when a pedestrian service call is requested for an instrumented crosswalk which intersects the Transit Vehicle's planned left or right turn path at the intersection.

[STK\_003] The TRP System shall warn the Transit Vehicle Driver when a vehicle transmitting Basic Safety Messages is making a right turn in front of a Transit Vehicle leaving a bus stop.

[STK\_004] The TRP System shall caution the Transit Vehicle Driver when a vehicle transmitting Basic Safety Messages is located on the left of a Transit Vehicle leaving a bus stop

[STK\_005] The TRP System shall host three safety applications: Emergency Electronic Brake Lights, Forward Collision Warning, and Curve Speed Warning as deployed by the Commercial Vehicle Retrofit device.

[STK\_006] The TRP System shall have a logging system capable of capturing the changes in state of the hosted applications, and the state of the transit vehicle as it pertains to the inputs to the applications at the time of the transition.

## System Constraints and Assumptions

[CONS\_ASSUM\_001] Intersection will be equipped with an Econolite signal controller.

[CONS\_ASSUM\_002] The TRP System will transmit compliant Basic Safety Messages.

[CONS\_ASSUM\_003] The SPAT system will send the status of pedestrian movement in each crosswalk in the SPAT message.

[CONS\_ASSUM\_004] The TRP equipment shall be installed on three (3) 2011 Gillig Low Floor 40 Transit Vehicles.

[CONS\_ASSUM\_005] The SPAT system will send the status of each crosswalk button state in the SPAT message.

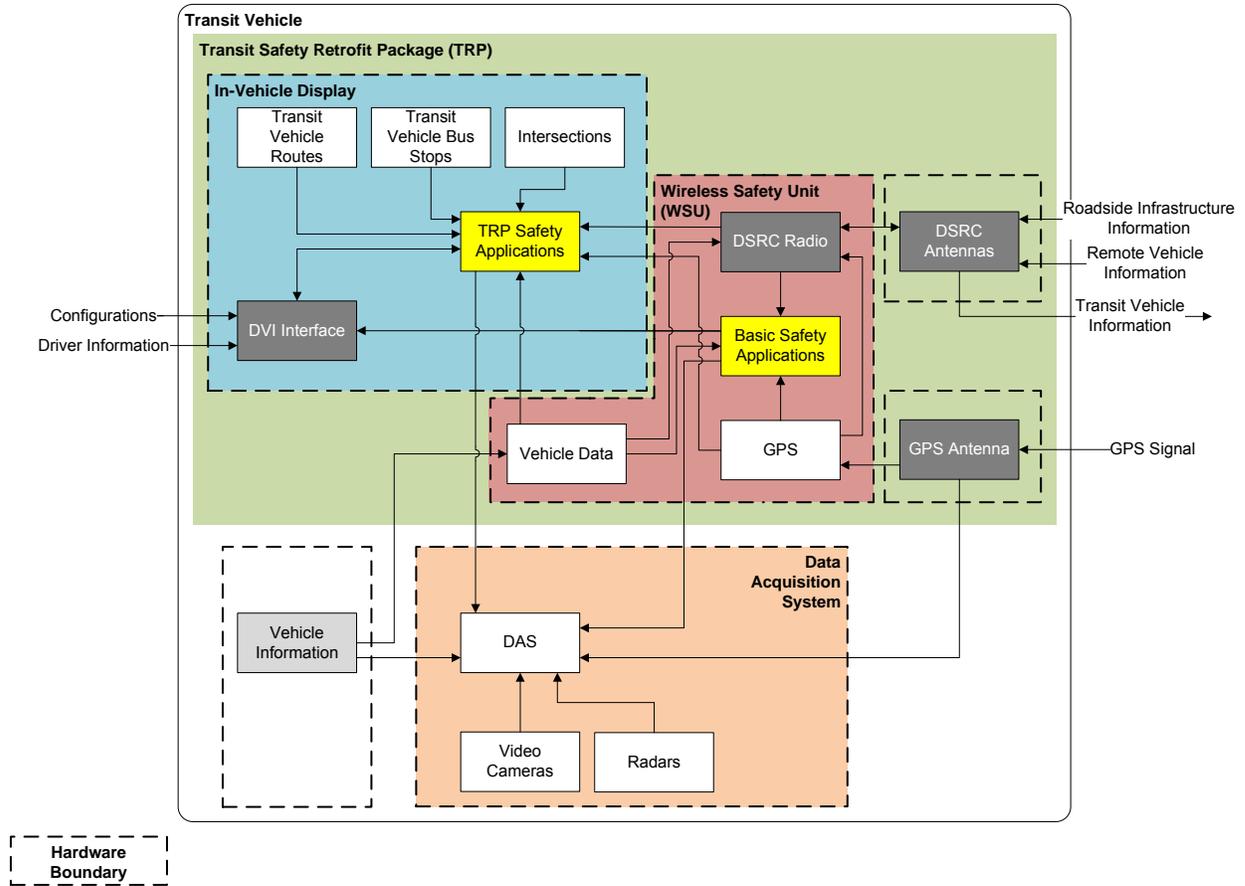
[CONS\_ASSUM\_006] (Deleted)

[CONS\_ASSUM\_007] SPAT Message will include the current or next signal state of all mapped pedestrian lanes.

[CONS\_ASSUM\_008] SPAT Message will include information to indicate the presence of one or more pedestrians (or the objects) in the crosswalk.

## Systems Requirements

The relationship between the requirements presented in this section and the TRP architecture is depicted in Figure 3-3. Specifically, requirements correspond to the yellow-shaded architecture elements (applications) and dark gray-shaded elements with white text (hardware). The other architecture elements for which requirements are not provided are those elements pertaining to input data (e.g., Transit Vehicle Routes) or elements that are not, strictly speaking, part of the TRP system (e.g., DAS).



Source: Battelle

**Figure 3-3. Relationship Between Requirements and TRP Architecture Components**

## Non Functional Requirements

[SYSREQ\_002] The installed TRP equipment shall not obstruct the Transit Vehicle driver’s field of view.

[SYSREQ\_003] The TRP shall operate on the voltage supplied by the Transit Vehicle.

[SYSREQ\_004] The TRP shall operate in -20°C to +65°C Operating Temperature.

[SYSREQ\_005] The TRP Pedestrian Detectors shall be installed at two crosswalks and at one intersection.

[SYSREQ\_006] The TRP Pedestrian Detectors shall be pole mountable

[SYSREQ\_007] The TRP Pedestrian Detectors shall be compatible with voltages provided within Econolite signal control cabinets.

[SYSREQ\_008] The TRP Pedestrian Detectors shall operate in -30°C to +70°C Operating Temperature.

[SYSREQ\_009] The TRP Pedestrian Detectors shall be waterproof.

[SYSREQ\_010] The TRP On-vehicle system shall consume less than 150 Watts steady-state.

## **Curve Speed Warning**

[SYSREQ\_011] The TRP shall host the Commercial Vehicle CSW application on the Transit Vehicle.

## **Emergency Electronic Brake Lights**

[SYSREQ\_012] The TRP shall host the Commercial Vehicle EEBL application on the Transit Vehicle.

## **Forward Collision Warning**

[SYSREQ\_013] The TRP shall host the Commercial Vehicle FCW application on the Transit Vehicle.

## **Transit Vehicle Display**

[SYSREQ\_014] The TRP shall suppress VTRW aural and visual alerts when the Transit Vehicle is in the park gear.

[SYSREQ\_015] The TRP shall provide aural and visual indication when a PCW event occurs.

[SYSREQ\_016] The TRP shall provide aural and visual indication when a VTRW event occurs.

[SYSREQ\_017] The TRP shall provide aural and visual indication when a CSW event occurs.

[SYSREQ\_018] The TRP shall provide aural and visual indication when an EEBL event occurs.

[SYSREQ\_019] The TRP shall provide aural and visual indication when a FCW event occurs.

[SYSREQ\_020] The TRP latency from safety application event detection to aural and visual display shall be less than 250 milliseconds

[SYSREQ\_021] The TRP System Latency for pedestrian detection shall be no more than 2 sec from detecting pedestrian to warning.

[SYSREQ\_022] The TRP System Latency for right turning vehicle shall be no more than 2 sec from receipt of path prediction of right turn conflict data to warning.

[SYSREQ\_023] The TRP System will display the alerts regardless of traffic signal status.

[SYSREQ\_024] (Deleted)

[SYSREQ\_025] The TRP system shall provide a display to the Transit Vehicle Driver that indicates that the application is operational even when there is no caution or warning.

[SYSREQ\_026] When the Transit Vehicle is located in a lane in the Geometric Intersection Description (GID) map, the TRP shall present the intersection display including any PCW cautions or warnings.

[SYSREQ\_027] When the Transit Vehicle exits the boundary of a GID Map, the TRP shall return to its default operational screen showing the connected status of the TRP System.

## Logging

[SYSREQ\_028] The system shall log all alerts issued to the driver including the parameters that triggered the alerts.

[SYSREQ\_030] The system shall have a mechanism for which the data can be retrieved from the system without any data loss.

[SYSREQ\_031] Each TRP System data log shall be associated with the primary keys DeviceID, Time and TripID.

[SYSREQ\_032] For logging, the Time primary key shall be implemented as an incremental counter in units of centiseconds (each 10 Hertz [Hz] record increments by 10).

[SYSREQ\_033] For logging, the DeviceID primary key shall be implemented as a Unique device Identification (ID) assigned by test conductor. (Note: This ID is made up of the lower 2 bytes of the BSM.)

[SYSREQ\_034] For logging, the Trip primary key shall be implemented as an incremental counter based on each ignition cycle.

## Pedestrian in Crosswalk Warning

[SYSREQ\_036] A PCW caution shall be displayed if the crosswalk button has been activated and that crosswalk intersects the Transit Vehicle's planned left or right turn route at the intersection.

[SYSREQ\_037] A PCW warning shall be displayed if a pedestrian has been detected in a crosswalk that intersects the Transit Vehicle's planned left or right turn route at the intersection.

[SYSREQ\_038] The PCW warning shall take priority over the PCW caution at the same crosswalk.

[SYSREQ\_039] The TRP system shall only display alerts for crosswalks associated with turns at instrumented intersections and on the transit vehicle route.

[SYSREQ\_040] The TRP software application shall receive and process MAP and SPAT messages as defined in the SPaT Interface Control Document (ICD) (60606-018A).

[SYSREQ\_041] The Pedestrian Detector shall send a pedestrian detected signal when a pedestrian is present in the crosswalk monitored by the pedestrian detector.

## Vehicle Turning Right in Front of Bus Warning

[SYSREQ\_042] The TRP shall detect whether a vehicle is turning right in front of transit vehicle via the position and heading data received in a basic safety message.

[SYSREQ\_043] The VTRW application shall become active (enter a state in which alerts will be generated when conditions warrant) when the transit vehicle stops within a bus stop geographic zone.

[SYSREQ\_044] The VTRW application shall remain active until the transit vehicle leaves the bus stop geographic zone.

[SYSREQ\_045] The VTRW application shall only alert when the transit vehicle indicates an intended bus stop departure. Bus stop departure intention is indicated when the transit vehicle is in forward gear and the foot brake is disengaged.

[SYSREQ\_046] A VTRW caution shall be displayed if a remote vehicle which originates directly behind the transit vehicle at a bus stop begins to pass to the left of the transit vehicle as the transit vehicle is departing a bus stop.

[SYSREQ\_047] A VTRW warning shall be displayed if a remote vehicle which originates directly behind the transit vehicle at a bus stop passes to the left of the transit vehicle as the transit vehicle is departing a bus stop and the remote vehicle's position and heading indicates an intent to return to or cross the lane of the transit vehicle.

## Interfaces

[SYSREQ\_048] The TRP shall receive Signal Phase and Timing for Pedestrian Lanes and Pedestrian presence detection from the SPAT system.

[SYSREQ\_052] The TRP shall be able to receive the intersection geometry (MAP) message from the SPAT system.

[SYSREQ\_053] The TRP System shall generate and transmit Basic Safety Messages in compliance with SAE standard J2735 version 2009-11.

[SYSREQ\_054] The TRP shall be able to interoperate with other model deployment vehicles and Safety Pilot Model Deployment RSU according to IEEE 802.11p and 1609.x standards and the J2735 message standards.

[SYSREQ\_055] The TRP shall be able to transmit a SAE J2735 Basic Safety Message (BSM) at least once every 100 milliseconds.

[SYSREQ\_056] The TRP shall be able to receive and decode a SAE J2735 BSM.

[SYSREQ\_057] The TRP shall have access to the Transit Vehicle's current position.

[SYSREQ\_058] The TRP shall have access to the Transit Vehicle's speed.

[SYSREQ\_059] The TRP should have access to the Transit Vehicle's gear position.

[SYSREQ\_060] The TRP shall have access to the Transit Vehicle's brake status.

[SYSREQ\_061] The TRP shall have access to the Transit Vehicle's longitudinal acceleration.

[SYSREQ\_062] The TRP shall have access to the Transit Vehicle's yaw rate.

[SYSREQ\_063] (Deleted)

[SYSREQ\_064] The TRP shall be able to receive and decode a SAE J2735 MAP message.

[SYSREQ\_065] The TRP shall be able to receive and decode a SAE J2735 SPAT message.

[SYSREQ\_066] The TRP shall be able to receive and decode a SAE J2735 Traveler Information Message.

[SYSREQ\_067] The TRP shall have access to Intersection IDs where the Pedestrian Detection equipment exists.

[SYSREQ\_068] The TRP shall have the ability to access and store configuration data, including but not limited to, Vehicle Unique ID, Vehicle Length, and Vehicle Type.

# Chapter 4 TRP Applications Requirements

The TRP Applications Requirements shall conform to the requirements listed in Chapter 4 and shall be verified with methods listed in Chapter 1 of this document. TRP Applications Requirements that trace back to the Systems Requirements have the system requirement number (i.e., SYS\_REQ\_###) identified after the requirement with square brackets [###]. The TRP Applications Requirements have been broken out into Hardware and Software shall conform to the requirements listed.

## Hardware Requirements

### Transit Vehicle Hardware

[HWREQ\_002] The installed TRP equipment shall not obstruct the Transit Vehicle driver's field of view. [002]

[HWREQ\_003] The TRP shall operate on the voltage supplied by the Transit Vehicle. [003]

[HWREQ\_004] The TRP shall operate in -20°C to +65°C Operating Temperature. [004]

[HWREQ\_005] The TRP shall consume less than 150 Watts steady-state. [010]

[HWREQ\_006] The TRP shall provide aural and visual indication when PCW, VTRW, CSW, EEBL, or FCW events occur. [015, 016, 017, 018, 019]

[HWREQ\_007] The TRP latency from safety application event detection to aural and visual display shall be less than 250 milliseconds. [020]

[HWREQ\_008] The TRP System Latency for pedestrian detection shall be 2 sec from detecting pedestrian to warning. [021]

[HWREQ\_009] The TRP System Latency for right turning vehicle shall be 2 sec from receipt of path prediction of right turn conflict data to warning. [022]

[HWREQ\_010] (Deleted)

[HWREQ\_011] The TRP system shall provide a display to the transit vehicle driver that indicates that the application is operational even when there is no alert. [025]

[HWREQ\_012] The system shall log all alerts issued to the driver including the parameters that triggered the alerts. [028]

[HWREQ\_014] The system shall have a mechanism for which the data can be retrieved from the system without any data loss. [030]

[HWREQ\_015] The TRP shall implement a 5.9 Gigahertz (GHz) transceiver that is compatible to interoperate with other model deployment vehicles and Safety Pilot Model Deployment RSU according to IEEE 802.11p and 1609.x standards and the J2735 message standards. [054]

[HWREQ\_016] The TRP shall be able to receive messages from other vehicles that are located behind, left, right or in front of the transit vehicle.

[HWREQ\_017] The TRP shall have access to the Transit Vehicle's current Global Positioning System (GPS) position. [057]

[HWREQ\_018] The TRP shall have access to the Transit Vehicle's current GPS time. [057]

[HWREQ\_019] The TRP shall have access to the Transit Vehicle's speed. [058]

[HWREQ\_020] The TRP should have access to the Transit Vehicle's gear position. [059]

[HWREQ\_021] The TRP shall have access to the Transit Vehicle's brake status. [060]

[HWREQ\_022] The TRP shall have access to the Transit Vehicle's longitudinal acceleration. [061]

[HWREQ\_023] The TRP shall have access to the Transit Vehicle's yaw rate. [062]

[HWREQ\_024] The TRP shall have the ability to access and store configuration data in non-volatile memory. (Note: Examples of typical configuration data include Vehicle Unique ID, Vehicle Length, Vehicle Type, Bus Stop Locations) [063, 067, 068]

## **Pedestrian Detectors**

[HWREQ\_025] The TRP Pedestrian Detectors shall be installed at two crosswalks and at one intersection. [005]

[HWREQ\_026] The TRP Pedestrian Detectors shall be pole mountable. [006]

[HWREQ\_027] The TRP Pedestrian Detectors shall be compatible with voltages provided within Econolite signal control cabinets. [007]

[HWREQ\_028] The TRP Pedestrian Detectors shall operate in -30°C to +70°C Operating Temperature. [008]

[HWREQ\_029] The TRP Pedestrian Detectors shall be waterproof. [009]

[HWREQ\_030] The TRP Pedestrian Detectors shall send a pedestrian detected signal when a pedestrian is present in the crosswalk monitored by the pedestrian detector. [041]

## **Software Requirements**

### **Curve Speed Warning**

[SWREQ\_001] The TRP shall host the Commercial Vehicle CSW application on the Transit Vehicle. [011]

## Emergency Electronic Brake Lights

[SWREQ\_002] The TRP shall host the Commercial Vehicle EEBL application on the Transit Vehicle. [012]

## Forward Collision Warning

[SWREQ\_004] The TRP shall host the Commercial Vehicle FCW application on the Transit Vehicle. [013]

## Transit Vehicle Display

[SWREQ\_005] The TRP should suppress VTRW aural and visual alerts when the Transit Vehicle is in the park gear. [014]

[SWREQ\_006] The TRP shall provide aural and visual indication when a PCW event occurs. [015]

[SWREQ\_007] The TRP shall provide aural and visual indication when a VTRW event occurs. [016]

[SWREQ\_008] The TRP shall provide aural and visual indication when a CSW event occurs. [017]

[SWREQ\_009] The TRP shall provide aural and visual indication when an EEBL event occurs. [018]

[SWREQ\_010] The TRP shall provide aural and visual indication when a FCW event occurs. [019]

[SWREQ\_020] The TRP shall prioritize PCW, VTRW, CSW, EEBL, and FCW events in the following order, with (number 1 being the highest priority):

1. PCW warning alert
2. VTRW warning alert
3. PCW caution alert
4. VTRW caution alert
5. FCW warning alert
6. EEBL warning alert
7. FCW caution alert
8. EEBL caution alert
9. CSW warning alert
10. CSW caution alert

[SWREQ\_011] The TRP latency from safety application event detection to aural and visual display shall be less than 250 milliseconds. [020]

[SWREQ\_012] The TRP System Latency for pedestrian detection shall be 2 sec from detecting pedestrian to warning. [021]

[SWREQ\_013] The TRP System Latency for right turning vehicle shall be 2 sec from receipt of path prediction of right turn conflict data to warning. [022]

[SWREQ\_014] The TRP System shall display the alerts regardless of traffic signal status. [023]

[SWREQ\_015] (Deleted)

[SWREQ\_016] The TRP system shall provide a display to the Transit Vehicle Driver that indicates that the application is operational even when there is no alert. [025]

[SWREQ\_017] When the Transit Vehicle is located in a lane in the GID map, the display changes to indicate the intersection display including any PCW or VTRW alerts. [026]

[SWREQ\_018] When the Transit Vehicle is not located in a lane in a GID Map, the display returns to its default operational screen showing the connected status of the TRP System. [027]

## Logging

[SWREQ\_019] The system shall log all alerts issued to the driver including the parameters that triggered the alerts. [028]

[SWREQ\_021] The system shall have a mechanism for which the data can be retrieved from the system without any data loss. [030]

[SWREQ\_022] Each TRP System data log shall be associated with the primary keys DeviceID, Time and TripID. [031]

[SWREQ\_023] For logging, the Time primary key shall be implemented as an incremental counter in units of centiseconds (each 10hz record increments by 10). [032]

[SWREQ\_024] For logging, the DeviceID primary key shall be implemented as a Unique device ID assigned by test conductor. (Note: This ID is made up of the lower 2 bytes of the BSM.) [033]

[SWREQ\_025] For logging, the Trip primary key shall be implemented as an incremental counter based on each ignition cycle. [034]

## Pedestrian in Crosswalk Warning

[SWREQ\_028] A PCW caution shall be indicated if the crosswalk button has been activated and that crosswalk intersects the Transit Vehicle's planned left or right turn route at the intersection. [036]

[SWREQ\_029] A PCW warning shall be displayed if a pedestrian has been detected in a crosswalk that intersects the Transit Vehicle's planned left or right turn route at the intersection. [037]

[SWREQ\_030] The PCW warning shall take priority over the PCW caution at the same crosswalk. [038]

[SWREQ\_031] The TRP system shall only display alerts for crosswalks associated with turns at instrumented intersections and on the transit vehicle route. [039]

[SWREQ\_032] The TRP software application shall receive and process MAP and SPAT message as defined by the SPAT development contractor. [040]

## Vehicle Turning Right in Front of Bus Warning

[SWREQ\_033] The TRP shall detect whether a vehicle is turning right in front of transit vehicle via the position and heading data received in a BSM. [042]

[SWREQ\_034] The VTRW application shall be activated when the transit vehicle stops within a bus stop geographic zone. [043]

[SWREQ\_035] The VTRW application shall remain active until the transit vehicle leaves the bus stop geographic zone. [044]

[SWREQ\_036] The VTRW application shall only alert when the transit vehicle indicates an intended an intended bus stop departure. Bus stop departure intention is indicated when the transit vehicle is in forward gear and the foot brake is disengaged. [045]

[SWREQ\_037] A VTRW caution shall be displayed if a remote vehicle which originates directly behind the transit vehicle at a bus stop begins to pass to the left of the transit vehicle as the transit vehicle is departing a bus stop. [046]

[SWREQ\_038] A VTRW warning shall be displayed if a remote vehicle which originates directly behind the transit vehicle at a bus stop passes to the left of the transit vehicle as the transit vehicle is departing a bus stop and the remote vehicle's position and heading indicates an intent to return to or cross the lane of the transit vehicle. [047]

## Interfaces

[SWREQ\_039] The TRP shall receive Signal Phase and Timing for Pedestrian Lanes and Pedestrian presence detection from the SPAT system. [048]

[SWREQ\_043] The TRP shall be able to receive the intersection geometry (MAP) message from the SPAT system. [052]

[SWREQ\_044] The TRP System shall generate and transmit Basic Safety Messages in compliance with SAE standard J2735 version 2009-11. [053]

[SWREQ\_045] The TRP shall be able to interoperate with other model deployment vehicles and Safety Pilot Model Deployment RSU according to IEEE 802.11p and 1609.x standards and the J2735 message standards. [054]

[SWREQ\_046] The TRP shall be able to transmit a SAE J2735 BSM at least once every 100 milliseconds. [056]

[SWREQ\_047] The TRP shall be able to receive and decode a SAE J2735 BSM. [057]

[SWREQ\_048] The TRP shall be able to receive and decode a SAE J2735 MAP message. [064]

[SWREQ\_049] The TRP shall be able to receive and decode a SAE J2735 SPAT message. [065]

[SWREQ\_050] The TRP shall be able to receive and decode a SAE J2735 Traveler Information Message. [066]

[SWREQ\_051] The TRP shall calculate the Transit Vehicle's current GPS position using the GPS interface. [057]

[SWREQ\_052] The TRP shall calculate the Transit Vehicle's current GPS time using the GPS interface. [058]

[SWREQ\_053] The TRP shall calculate the Transit Vehicle's speed. [058]

[SWREQ\_054] The TRP should calculate the Transit Vehicle's gear position. [059]

[SWREQ\_055] The TRP shall calculate the Transit Vehicle's brake status. [060]

[SWREQ\_056] The TRP shall calculate the Transit Vehicle's longitudinal acceleration. [061]

[SWREQ\_057] The TRP shall calculate the Transit Vehicle's yaw rate. [062]

[SWREQ\_058] (Deleted)

[SWREQ\_059] (Deleted)

[SWREQ\_060] The TRP shall be able to read and store Transit Vehicle's Vehicle Unique ID from non-volatile memory. [068]

[SWREQ\_061] The TRP shall be able to read and store Transit Vehicle's vehicle length from non-volatile memory. [068]

[SWREQ\_062] The TRP shall be able to read and store Transit Vehicle's vehicle type from non-volatile memory. [068]

[SWREQ\_063] The TRP shall be able to access the remote vehicle path history from a BSM of adequately equipped remote vehicles from non-volatile memory. [056]

# Chapter 5 Verification

This chapter describes how and when the performance specification will be verified in order to ascertain that the system of interest conforms to the requirements in Chapter 4 of this specification. The specification developer is to include the verification requirements and boundary conditions that will be used to verify each requirement. Chapter 4 should be arranged in an orderly sequence that will indicate clearly the method of verification that will be applied for each requirement. A cross reference matrix will provide correlation of each Chapter 3 requirement to the appropriate Chapter 4 verification method.

## Verification Methods

Acceptable methods of verification are documented in this section.

### Analysis (A)

Analysis is 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.

### Demonstration (D)

Demonstration is 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.

### 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.

### Test (T)

Testing is 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.

## Verification of Product Conformance

This section specifies the verification requirement and/or approach per requirement type. Where testing standards apply, they will be documented. Each requirement in Chapter 4 shall be reflected in

Chapter 5 along with the verification method that will be used. Verification classes for the product consist of: Bench Tests of Software, Controlled Environment Test, Demonstration of Integrated Applications, and Verification by U.S. Government/Test Conductor. Bench Tests of Software is a class of verification that uses a laboratory environment to stimulate the system of interest. The use of typical laboratory equipment such as multimeters, oscilloscopes, power supplies, simulators, and the like are used to perform verification. Controlled Environment Test is a class of verification that utilizes the system of interest in its intended application within a controlled environment. The controlled environment allows for verification of functionality in an environment that is as close to the intended environment while allowing for repeatability of tests. Demonstration of Integrated Applications is a class of verification that utilizes the system of interest either within the intended environment or a representative environment to demonstrate functionality of the system. Verification by US Government/Test Conductor is a class of verification where the system of interest is delivered to client and the client (US Government/Test Conductor) verifies functionality for interoperability within the deployment area.

**Table 5-1. Requirements Verification Matrix**

Requirement/Verification Cross-Reference Matrix						
<p><u>METHOD OF VERIFICATION</u>                      NA – NOT APPLICABLE                      A – ANALYSIS                      D – DEMONSTRATION APPLICATIONS                      I – INSPECTION CONDUCTOR                      T – TEST</p>			<p><u>CLASSES OF VERIFICATION</u>                      I – BENCH TESTS OF SOFTWARE                      II – CONTROLLED ENVIRONMENT TEST                      III – DEMONSTRATION OF INTEGRATED                      IV – VERIFICATION BY US GOVT/TEST</p>			
Chapter 4 Requirement			Verification Class			
Para.	Title	Requirement ID	I	II	III	IV
4.0	TRP Applications Requirements	N/A				
4.1	Hardware Requirements	N/A				
4.1.1	Transit Vehicle Hardware	HWREQ_002			I	
4.1.1	Transit Vehicle Hardware	HWREQ_003			T	
4.1.1	Transit Vehicle Hardware	HWREQ_004	A			
4.1.1	Transit Vehicle Hardware	HWREQ_005	T			
4.1.1	Transit Vehicle Hardware	HWREQ_006	D		D	
4.1.1	Transit Vehicle Hardware	HWREQ_007	T			
4.1.1	Transit Vehicle Hardware	HWREQ_008		T		
4.1.1	Transit Vehicle Hardware	HWREQ_009		T		
4.1.1	Transit Vehicle Hardware	HWREQ_011	D		D	
4.1.1	Transit Vehicle Hardware	HWREQ_012	T	T		
4.1.1	Transit Vehicle Hardware	HWREQ_014	A			
4.1.1	Transit Vehicle Hardware	HWREQ_015				D
4.1.1	Transit Vehicle Hardware	HWREQ_016			D	
4.1.1	Transit Vehicle Hardware	HWREQ_017	D	D	D	
4.1.1	Transit Vehicle Hardware	HWREQ_018	D	D	D	
4.1.1	Transit Vehicle Hardware	HWREQ_019	D	D	D	
4.1.1	Transit Vehicle Hardware	HWREQ_020	D	D	D	
4.1.1	Transit Vehicle Hardware	HWREQ_021	D	D	D	
4.1.1	Transit Vehicle Hardware	HWREQ_022	D	D	D	
4.1.1	Transit Vehicle Hardware	HWREQ_023	D	D	D	
4.1.1	Transit Vehicle Hardware	HWREQ_024	D	D	D	

**Table 5-1. Requirements Verification Matrix (Continued)**

Requirement/Verification Cross-Reference Matrix						
<u>METHOD OF VERIFICATION</u>			<u>CLASSES OF VERIFICATION</u>			
NA – NOT APPLICABLE			I – BENCH TESTS OF SOFTWARE			
A – ANALYSIS			II – CONTROLLED ENVIRONMENT TEST			
D – DEMONSTRATION APPLICATIONS			III – DEMONSTRATION OF INTEGRATED			
I – INSPECTION CONDUCTOR			IV – VERIFICATION BY US GOVT/TEST			
T – TEST						
Chapter 4 Requirement			Verification Class			
Para.	Title	Requirement ID	I	II	III	IV
4.1.2	Pedestrian Detectors	HWREQ_025			D	
4.1.2	Pedestrian Detectors	HWREQ_026			D	
4.1.2	Pedestrian Detectors	HWREQ_027			D	
4.1.2	Pedestrian Detectors	HWREQ_028	A			
4.1.2	Pedestrian Detectors	HWREQ_029	A			
4.1.2	Pedestrian Detectors	HWREQ_030	D			
4.2	Software Requirements	N/A				
4.2.1	Curve Speed Warning	SWREQ_001	D		D	
4.2.2	Emergency Electronic Brake Lights	SWREQ_002	D		D	
4.2.3	Forward Collision Warning	SWREQ_004	D		D	
4.2.4	Transit Vehicle Display	SWREQ_005	D			
4.2.4	Transit Vehicle Display	SWREQ_006	D	D	D	
4.2.4	Transit Vehicle Display	SWREQ_007	D	D	D	
4.2.4	Transit Vehicle Display	SWREQ_008	D		D	
4.2.4	Transit Vehicle Display	SWREQ_009	D		D	
4.2.4	Transit Vehicle Display	SWREQ_010	D		D	
4.2.4	Transit Vehicle Display	SWREQ_020	D		D	
4.2.4	Transit Vehicle Display	SWREQ_011	T			
4.2.4	Transit Vehicle Display	SWREQ_012	T			
4.2.4	Transit Vehicle Display	SWREQ_013	T			
4.2.4	Transit Vehicle Display	SWREQ_014	T			
4.2.4	Transit Vehicle Display	SWREQ_016	D	D	D	
4.2.4	Transit Vehicle Display	SWREQ_017	D		D	

**Table 5-1. Requirements Verification Matrix (Continued)**

Requirement/Verification Cross-Reference Matrix						
<u>METHOD OF VERIFICATION</u>			<u>CLASSES OF VERIFICATION</u>			
NA – NOT APPLICABLE			I – BENCH TESTS OF SOFTWARE			
A – ANALYSIS			II – CONTROLLED ENVIRONMENT TEST			
D – DEMONSTRATION APPLICATIONS			III – DEMONSTRATION OF INTEGRATED			
I – INSPECTION CONDUCTOR			IV – VERIFICATION BY US GOVT/TEST			
T – TEST						
Chapter 4 Requirement			Verification Class			
Para.	Title	Requirement ID	I	II	III	IV
4.2.4	Transit Vehicle Display	SWREQ_018	D		D	
4.2.5	Logging	SWREQ_019	D			
4.2.5	Logging	SWREQ_021	A			
4.2.5	Logging	SWREQ_022	D			
4.2.5	Logging	SWREQ_023	D			
4.2.5	Logging	SWREQ_024	D			
4.2.5	Logging	SWREQ_025	D			
4.2.6	Pedestrian in Crosswalk	SWREQ_028	D	D	D	
4.2.6	Pedestrian in Crosswalk	SWREQ_029	D	D	D	
4.2.6	Pedestrian in Crosswalk	SWREQ_030	D	D	D	
4.2.6	Pedestrian in Crosswalk	SWREQ_031	D		D	
4.2.6	Pedestrian in Crosswalk	SWREQ_032	D			
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_033	D	D	D	
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_034	D			
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_035	D			
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_036	D	D	D	
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_037	D	D	D	
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_038	D			
4.2.8	Interfaces	SWREQ_039	D	D		

**Table 5-1. Requirements Verification Matrix (Continued)**

Requirement/Verification Cross-Reference Matrix						
<u>METHOD OF VERIFICATION</u>			<u>CLASSES OF VERIFICATION</u>			
NA – NOT APPLICABLE			I – BENCH TESTS OF SOFTWARE			
A – ANALYSIS			II – CONTROLLED ENVIRONMENT TEST			
D – DEMONSTRATION APPLICATIONS			III – DEMONSTRATION OF INTEGRATED			
I – INSPECTION CONDUCTOR			IV – VERIFICATION BY US GOVT/TEST			
T – TEST						
Chapter 4 Requirement			Verification Class			
Para.	Title	Requirement ID	I	II	III	IV
4.2.8	Interfaces	SWREQ_043	D			
4.2.8	Interfaces	SWREQ_044	A			
4.2.8	Interfaces	SWREQ_045				D
4.2.8	Interfaces	SWREQ_046	T			
4.2.8	Interfaces	SWREQ_047	D			
4.2.8	Interfaces	SWREQ_048	D			
4.2.8	Interfaces	SWREQ_049	D			
4.2.8	Interfaces	SWREQ_050	D			
4.2.8	Interfaces	SWREQ_051	D			
4.2.8	Interfaces	SWREQ_052	D			
4.2.8	Interfaces	SWREQ_053	D			
4.2.8	Interfaces	SWREQ_054	D			
4.2.8	Interfaces	SWREQ_055	D			
4.2.8	Interfaces	SWREQ_056	D			
4.2.8	Interfaces	SWREQ_057	D			
4.2.8	Interfaces	SWREQ_060	D			
4.2.8	Interfaces	SWREQ_061	D			
4.2.8	Interfaces	SWREQ_062	D			
4.2.8	Interfaces	SWREQ_063	D			

Source: Battelle

# Chapter 6 Notes

## Traceability Matrix

### Systems Requirements to Stakeholder Requirements Traceability

Table 6-1. System Requirements to Stakeholder Requirements Matrix

Para	Title	Req. ID	STK_001	STK_002	STK_003	STK_004	STK_005	STK_006
3.4	Systems Requirements	N/A						
3.4.1	Non Functional Requirements	SYSREQ_002						
3.4.1	Non Functional Requirements	SYSREQ_003						
3.4.1	Non Functional Requirements	SYSREQ_004						
3.4.1	Non Functional Requirements	SYSREQ_005						
3.4.1	Non Functional Requirements	SYSREQ_006						
3.4.1	Non Functional Requirements	SYSREQ_007						
3.4.1	Non Functional Requirements	SYSREQ_008						
3.4.1	Non Functional Requirements	SYSREQ_009						
3.4.1	Non Functional Requirements	SYSREQ_010						
3.4.2	Curve Speed Warning	SYSREQ_011					x	
3.4.3	Emergency Electronic Brake Lights	SYSREQ_012					x	
3.4.4	Forward Collision Warning	SYSREQ_013					x	
3.4.5	Transit Vehicle Display	SYSREQ_014	x	x	x	x		
3.4.5	Transit Vehicle Display	SYSREQ_015	x	x				
3.4.5	Transit Vehicle Display	SYSREQ_016			x	x		
3.4.5	Transit Vehicle Display	SYSREQ_017					x	
3.4.5	Transit Vehicle Display	SYSREQ_018					x	
3.4.5	Transit Vehicle Display	SYSREQ_019					x	
3.4.5	Transit Vehicle Display	SYSREQ_020						
3.4.5	Transit Vehicle Display	SYSREQ_021						

**Table 6-1. System Requirements to Stakeholder Requirements Matrix (Continued)**

Para	Title	Req. ID	STK_001	STK_002	STK_003	STK_004	STK_005	STK_006
3.4.5	Transit Vehicle Display	SYSREQ_022						
3.4.5	Transit Vehicle Display	SYSREQ_023						
3.4.5	Transit Vehicle Display	SYSREQ_025						
3.4.5	Transit Vehicle Display	SYSREQ_026	x	x	x	x		
3.4.5	Transit Vehicle Display	SYSREQ_027						
3.4.6	Logging	SYSREQ_028						x
3.4.6	Logging	SYSREQ_030						x
3.4.6	Logging	SYSREQ_031						
3.4.6	Logging	SYSREQ_032						
3.4.6	Logging	SYSREQ_033						
3.4.6	Logging	SYSREQ_034						
3.4.7	Pedestrian in Crosswalk Warning	SYSREQ_036		x				
3.4.7	Pedestrian in Crosswalk Warning	SYSREQ_037	x					
3.4.7	Pedestrian in Crosswalk Warning	SYSREQ_038	x	x				
3.4.7	Pedestrian in Crosswalk Warning	SYSREQ_039						
3.4.7	Pedestrian in Crosswalk Warning	SYSREQ_040	x	x				
3.4.7	Pedestrian in Crosswalk Warning	SYSREQ_041	x					
3.4.8	Vehicle Turning Right in Front of Bus Warning	SYSREQ_042			x			
3.4.8	Vehicle Turning Right in Front of Bus Warning	SYSREQ_043						
3.4.8	Vehicle Turning Right in Front of Bus Warning	SYSREQ_044			x			
3.4.8	Vehicle Turning Right in Front of Bus Warning	SYSREQ_045			x			
3.4.8	Vehicle Turning Right in Front of Bus Warning	SYSREQ_046			x			
3.4.8	Vehicle Turning Right in Front of Bus Warning	SYSREQ_047			x			
3.4.9	Interfaces	SYSREQ_048						
3.4.9	Interfaces	SYSREQ_052						
3.4.9	Interfaces	SYSREQ_053						

**Table 6-1. System Requirements to Stakeholder Requirements Matrix (Continued)**

<b>Para</b>	<b>Title</b>	<b>Req. ID</b>	<b>STK_001</b>	<b>STK_002</b>	<b>STK_003</b>	<b>STK_004</b>	<b>STK_005</b>	<b>STK_006</b>
3.4.9	Interfaces	SYSREQ_054						
3.4.9	Interfaces	SYSREQ_055						
3.4.9	Interfaces	SYSREQ_056						
3.4.9	Interfaces	SYSREQ_057						
3.4.9	Interfaces	SYSREQ_058						
3.4.9	Interfaces	SYSREQ_059						
3.4.9	Interfaces	SYSREQ_060						
3.4.9	Interfaces	SYSREQ_061						
3.4.9	Interfaces	SYSREQ_062						
3.4.9	Interfaces	SYSREQ_064						
3.4.9	Interfaces	SYSREQ_065						
3.4.9	Interfaces	SYSREQ_067						
3.4.9	Interfaces	SYSREQ_068						

Source: Battelle

## Hardware/Software Requirements to Systems Requirements Traceability

*SYSREQ\_002 thru SYSREQ\_034*

**Table 6-2. Hardware/Software to System Requirements (SYSREQ\_002 thru SYSREQ\_034) Matrix**

Para	Title	Req. ID	SYSREQ_002	SYSREQ_003	SYSREQ_004	SYSREQ_005	SYSREQ_006	SYSREQ_007	SYSREQ_008	SYSREQ_009	SYSREQ_010	SYSREQ_011	SYSREQ_012	SYSREQ_013	SYSREQ_014	SYSREQ_015	SYSREQ_016	SYSREQ_017	SYSREQ_018	SYSREQ_019	SYSREQ_020	SYSREQ_021	SYSREQ_022	SYSREQ_023	SYSREQ_025	SYSREQ_026	SYSREQ_027	SYSREQ_028	SYSREQ_030	SYSREQ_031	SYSREQ_032	SYSREQ_033	SYSREQ_034			
4.0	TRP Applications Requirements																																			
4.1	Hardware Requirements																																			
4.1.1	Transit Vehicle Hardware	HWREQ_002	x																																	
4.1.1	Transit Vehicle Hardware	HWREQ_003		x																																
4.1.1	Transit Vehicle Hardware	HWREQ_004			x																															
4.1.1	Transit Vehicle Hardware	HWREQ_005									x																									
4.1.1	Transit Vehicle Hardware	HWREQ_006														x	x	x	x	x																
4.1.1	Transit Vehicle Hardware	HWREQ_007																			x															
4.1.1	Transit Vehicle Hardware	HWREQ_008																				x														
4.1.1	Transit Vehicle Hardware	HWREQ_009																					x													
4.1.1	Transit Vehicle Hardware	HWREQ_011																							x											
4.1.1	Transit Vehicle Hardware	HWREQ_012																											x							
4.1.1	Transit Vehicle Hardware	HWREQ_014																												x						
4.1.1	Transit Vehicle Hardware	HWREQ_015																																		
4.1.1	Transit Vehicle Hardware	HWREQ_016																																		
4.1.1	Transit Vehicle Hardware	HWREQ_017																																		
4.1.1	Transit Vehicle Hardware	HWREQ_018																																		
4.1.1	Transit Vehicle Hardware	HWREQ_019																																		
4.1.1	Transit Vehicle Hardware	HWREQ_020																																		
4.1.1	Transit Vehicle Hardware	HWREQ_021																																		
4.1.1	Transit Vehicle Hardware	HWREQ_022																																		
4.1.1	Transit Vehicle Hardware	HWREQ_023																																		
4.1.1	Transit Vehicle Hardware	HWREQ_024																																		

**Table 6-2. Hardware/Software to System Requirements (SYSREQ\_002 thru SYSREQ\_034) Matrix (Continued)**

Para	Title	Req. ID	SYSREQ_002	SYSREQ_003	SYSREQ_004	SYSREQ_005	SYSREQ_006	SYSREQ_007	SYSREQ_008	SYSREQ_009	SYSREQ_010	SYSREQ_011	SYSREQ_012	SYSREQ_013	SYSREQ_014	SYSREQ_015	SYSREQ_016	SYSREQ_017	SYSREQ_018	SYSREQ_019	SYSREQ_020	SYSREQ_021	SYSREQ_022	SYSREQ_023	SYSREQ_025	SYSREQ_026	SYSREQ_027	SYSREQ_028	SYSREQ_030	SYSREQ_031	SYSREQ_032	SYSREQ_033	SYSREQ_034		
4.1.2	Pedestrian Detectors	HWREQ_025				x																													
4.1.2	Pedestrian Detectors	HWREQ_026					x																												
4.1.2	Pedestrian Detectors	HWREQ_027						x																											
4.1.2	Pedestrian Detectors	HWREQ_028							x																										
4.1.2	Pedestrian Detectors	HWREQ_029								x																									
4.1.2	Pedestrian Detectors	HWREQ_030																																	
4.2	Software Requirements																																		
4.2.1	Curve Speed Warning	SWREQ_001										x																							
4.2.2	Emergency Electronic Brake Lights	SWREQ_002											x																						
4.2.3	Forward Collision Warning	SWREQ_004												x																					
4.2.4	Transit Vehicle Display	SWREQ_005													x																				
4.2.4	Transit Vehicle Display	SWREQ_006														x																			
4.2.4	Transit Vehicle Display	SWREQ_007															x																		
4.2.4	Transit Vehicle Display	SWREQ_008																x																	
4.2.4	Transit Vehicle Display	SWREQ_009																	x																
4.2.4	Transit Vehicle Display	SWREQ_010																			x														
4.2.4	Transit Vehicle Display	SWREQ_020																				x													
4.2.4	Transit Vehicle Display	SWREQ_011																																	
4.2.4	Transit Vehicle Display	SWREQ_012																					x												
4.2.4	Transit Vehicle Display	SWREQ_013																																	
4.2.4	Transit Vehicle Display	SWREQ_014																																	
4.2.4	Transit Vehicle Display	SWREQ_016																																	
4.2.4	Transit Vehicle Display	SWREQ_017																																	
4.2.4	Transit Vehicle Display	SWREQ_018																																	
4.2.4	Transit Vehicle Display	SWREQ_019																																	
4.2.4	Transit Vehicle Display	SWREQ_020																																	
4.2.4	Transit Vehicle Display	SWREQ_021																																	
4.2.4	Transit Vehicle Display	SWREQ_022																																	
4.2.4	Transit Vehicle Display	SWREQ_023																																	
4.2.4	Transit Vehicle Display	SWREQ_025																																	
4.2.4	Transit Vehicle Display	SWREQ_026																																	
4.2.4	Transit Vehicle Display	SWREQ_027																																	
4.2.4	Transit Vehicle Display	SWREQ_028																																	
4.2.4	Transit Vehicle Display	SWREQ_030																																	
4.2.4	Transit Vehicle Display	SWREQ_031																																	
4.2.4	Transit Vehicle Display	SWREQ_032																																	
4.2.4	Transit Vehicle Display	SWREQ_033																																	
4.2.4	Transit Vehicle Display	SWREQ_034																																	
4.2.5	Logging	SWREQ_019																																	
4.2.5	Logging	SWREQ_021																																	



**Table 6-2. Hardware/Software to System Requirements (SYSREQ\_002 thru SYSREQ\_034) Matrix (Continued)**

Para	Title	Req. ID	SYSREQ_002	SYSREQ_003	SYSREQ_004	SYSREQ_005	SYSREQ_006	SYSREQ_007	SYSREQ_008	SYSREQ_009	SYSREQ_010	SYSREQ_011	SYSREQ_012	SYSREQ_013	SYSREQ_014	SYSREQ_015	SYSREQ_016	SYSREQ_017	SYSREQ_018	SYSREQ_019	SYSREQ_020	SYSREQ_021	SYSREQ_022	SYSREQ_023	SYSREQ_025	SYSREQ_026	SYSREQ_027	SYSREQ_028	SYSREQ_030	SYSREQ_031	SYSREQ_032	SYSREQ_033	SYSREQ_034	
4.2.8	Interfaces	SWREQ_051																																
4.2.8	Interfaces	SWREQ_052																																
4.2.8	Interfaces	SWREQ_053																																
4.2.8	Interfaces	SWREQ_054																																
4.2.8	Interfaces	SWREQ_055																																
4.2.8	Interfaces	SWREQ_056																																
4.2.8	Interfaces	SWREQ_057																																
4.2.8	Interfaces	SWREQ_060																																
4.2.8	Interfaces	SWREQ_061																																
4.2.8	Interfaces	SWREQ_062																																
4.2.8	Interfaces	SWREQ_063																																

Source: Battelle

**SYSREQ\_036 thru SYSREQ\_068**

**Table 6-3. Hardware/Software to System Requirements (SYSREQ\_036 thru SYSREQ\_068) Matrix**

Para	Title	Req. ID	SYSREQ_036	SYSREQ_037	SYSREQ_038	SYSREQ_039	SYSREQ_040	SYSREQ_041	SYSREQ_042	SYSREQ_043	SYSREQ_044	SYSREQ_045	SYSREQ_046	SYSREQ_047	SYSREQ_048	SYSREQ_052	SYSREQ_053	SYSREQ_054	SYSREQ_055	SYSREQ_056	SYSREQ_057	SYSREQ_058	SYSREQ_059	SYSREQ_060	SYSREQ_061	SYSREQ_062	SYSREQ_064	SYSREQ_065	SYSREQ_067	SYSREQ_068
4.0	TRP Applications Requirements																													
4.1	Hardware Requirements																													
4.1.1	Transit Vehicle Hardware	HWREQ_002																												
4.1.1	Transit Vehicle Hardware	HWREQ_003																												
4.1.1	Transit Vehicle Hardware	HWREQ_004																												
4.1.1	Transit Vehicle Hardware	HWREQ_005																												
4.1.1	Transit Vehicle Hardware	HWREQ_006																												
4.1.1	Transit Vehicle Hardware	HWREQ_007																												
4.1.1	Transit Vehicle Hardware	HWREQ_008																												
4.1.1	Transit Vehicle Hardware	HWREQ_009																												
4.1.1	Transit Vehicle Hardware	HWREQ_011																												
4.1.1	Transit Vehicle Hardware	HWREQ_012																												
4.1.1	Transit Vehicle Hardware	HWREQ_014																												
4.1.1	Transit Vehicle Hardware	HWREQ_015																x												
4.1.1	Transit Vehicle Hardware	HWREQ_016																												
4.1.1	Transit Vehicle Hardware	HWREQ_017																				x								
4.1.1	Transit Vehicle Hardware	HWREQ_018																				x								
4.1.1	Transit Vehicle Hardware	HWREQ_019																					x							
4.1.1	Transit Vehicle Hardware	HWREQ_020																						x						
4.1.1	Transit Vehicle Hardware	HWREQ_021																							x					
4.1.1	Transit Vehicle Hardware	HWREQ_022																								x				
4.1.1	Transit Vehicle Hardware	HWREQ_023																									x			
4.1.1	Transit Vehicle Hardware	HWREQ_024																											x	x
4.1.2	Pedestrian Detectors	HWREQ_025																												
4.1.2	Pedestrian Detectors	HWREQ_026																												
4.1.2	Pedestrian Detectors	HWREQ_027																												

**Table 6-3. Hardware/Software to System Requirements (SYSREQ\_036 thru SYSREQ\_068) Matrix (Continued)**

Para	Title	Req. ID	SYSREQ_036	SYSREQ_037	SYSREQ_038	SYSREQ_039	SYSREQ_040	SYSREQ_041	SYSREQ_042	SYSREQ_043	SYSREQ_044	SYSREQ_045	SYSREQ_046	SYSREQ_047	SYSREQ_048	SYSREQ_052	SYSREQ_053	SYSREQ_054	SYSREQ_055	SYSREQ_056	SYSREQ_057	SYSREQ_058	SYSREQ_059	SYSREQ_060	SYSREQ_061	SYSREQ_062	SYSREQ_064	SYSREQ_065	SYSREQ_067	SYSREQ_068	
4.1.2	Pedestrian Detectors	HWREQ_028																											x		
4.1.2	Pedestrian Detectors	HWREQ_029																													
4.1.2	Pedestrian Detectors	HWREQ_030						x																							
4.2	Software Requirements																														
4.2.1	Curve Speed Warning	SWREQ_001																													
4.2.2	Emergency Electronic Brake Lights	SWREQ_002																													
4.2.3	Forward Collision Warning	SWREQ_004																													
4.2.4	Transit Vehicle Display	SWREQ_005																													
4.2.4	Transit Vehicle Display	SWREQ_006																													
4.2.4	Transit Vehicle Display	SWREQ_007																													
4.2.4	Transit Vehicle Display	SWREQ_008																													
4.2.4	Transit Vehicle Display	SWREQ_009																													
4.2.4	Transit Vehicle Display	SWREQ_010																													
4.2.4	Transit Vehicle Display	SWREQ_020																													
4.2.4	Transit Vehicle Display	SWREQ_011																													
4.2.4	Transit Vehicle Display	SWREQ_012																													
4.2.4	Transit Vehicle Display	SWREQ_013																													
4.2.4	Transit Vehicle Display	SWREQ_014																													
4.2.4	Transit Vehicle Display	SWREQ_016																													
4.2.4	Transit Vehicle Display	SWREQ_017																													
4.2.4	Transit Vehicle Display	SWREQ_018																													
4.2.5	Logging	SWREQ_019																													
4.2.5	Logging	SWREQ_021																													
4.2.5	Logging	SWREQ_022																													
4.2.5	Logging	SWREQ_023																													
4.2.5	Logging	SWREQ_024																													
4.2.5	Logging	SWREQ_025																													

**Table 6-3. Hardware/Software to System Requirements (SYSREQ\_036 thru SYSREQ\_068) Matrix (Continued)**

Para	Title	Req. ID	SYSREQ_036	SYSREQ_037	SYSREQ_038	SYSREQ_039	SYSREQ_040	SYSREQ_041	SYSREQ_042	SYSREQ_043	SYSREQ_044	SYSREQ_045	SYSREQ_046	SYSREQ_047	SYSREQ_048	SYSREQ_052	SYSREQ_053	SYSREQ_054	SYSREQ_055	SYSREQ_056	SYSREQ_057	SYSREQ_058	SYSREQ_059	SYSREQ_060	SYSREQ_061	SYSREQ_062	SYSREQ_064	SYSREQ_065	SYSREQ_067	SYSREQ_068
4.2.6	Pedestrian in Crosswalk	SWREQ_028	x																											
4.2.6	Pedestrian in Crosswalk	SWREQ_029		x																										
4.2.6	Pedestrian in Crosswalk	SWREQ_030			x																									
4.2.6	Pedestrian in Crosswalk	SWREQ_031				x																								
4.2.6	Pedestrian in Crosswalk	SWREQ_032					x																							
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_033							x																					
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_034								x																				
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_035									x																			
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_036										x																		
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_037											x																	
4.2.7	Vehicle Turning Right in Front of Bus Warning	SWREQ_038												x																
4.2.8	Interfaces	SWREQ_039													x															
4.2.8	Interfaces	SWREQ_043														x														
4.2.8	Interfaces	SWREQ_044															x													
4.2.8	Interfaces	SWREQ_045																x												
4.2.8	Interfaces	SWREQ_046																		x										
4.2.8	Interfaces	SWREQ_047																			x									
4.2.8	Interfaces	SWREQ_048																									x			
4.2.8	Interfaces	SWREQ_049																										x		
4.2.8	Interfaces	SWREQ_050																												
4.2.8	Interfaces	SWREQ_051																				x								
4.2.8	Interfaces	SWREQ_052																					x							
4.2.8	Interfaces	SWREQ_053																						x						
4.2.8	Interfaces	SWREQ_054																							x					

**Table 6-3. Hardware/Software to System Requirements (SYSREQ\_036 thru SYSREQ\_068) Matrix (Continued)**

Para	Title	Req. ID	SYSREQ_036	SYSREQ_037	SYSREQ_038	SYSREQ_039	SYSREQ_040	SYSREQ_041	SYSREQ_042	SYSREQ_043	SYSREQ_044	SYSREQ_045	SYSREQ_046	SYSREQ_047	SYSREQ_048	SYSREQ_052	SYSREQ_053	SYSREQ_054	SYSREQ_055	SYSREQ_056	SYSREQ_057	SYSREQ_058	SYSREQ_059	SYSREQ_060	SYSREQ_061	SYSREQ_062	SYSREQ_064	SYSREQ_065	SYSREQ_067	SYSREQ_068
4.2.8	Interfaces	SWREQ_055																						x						
4.2.8	Interfaces	SWREQ_056																								x				
4.2.8	Interfaces	SWREQ_057																								x				
4.2.8	Interfaces	SWREQ_060																												x
4.2.8	Interfaces	SWREQ_061																												x
4.2.8	Interfaces	SWREQ_062																												x
4.2.8	Interfaces	SWREQ_063																		x										

Source: Battelle

## APPENDIX A. Acronyms and Abbreviations

<b>BSM</b>	Basic Safety Messages
<b>CONOPS</b>	Concept of Operations
<b>CSW</b>	Curve Speed Warning
<b>DSRC</b>	Dedicated Short-Range Communication
<b>EEBL</b>	Emergency Electronic Brake Lights
<b>FCW</b>	Forward Collision Warning
<b>GHz</b>	Gigahertz
<b>GID</b>	Geometric Intersection Description
<b>GPS</b>	Global Positioning System
<b>Hz</b>	Hertz
<b>ID</b>	Identification
<b>IEEE</b>	Institute of Electrical and Electronics Engineers
<b>LAN</b>	Local Area Network
<b>MAC</b>	Medium Access Control
<b>MAP</b>	Map Message
<b>PCW</b>	Pedestrian in Crosswalk Warning
<b>RSU</b>	Roadside Unit
<b>SAE</b>	Society of Automotive Engineers
<b>SPAT</b>	Signal Phase and Timing
<b>TBD</b>	To Be Determined
<b>TRP</b>	Transit Safety Retrofit Package
<b>U.S. DOT</b>	United States Department of Transportation
<b>VTRW</b>	Vehicle Turning Right in Front of Bus Warning
<b>WAVE</b>	Wireless Access in Vehicular Environments

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