Sharing Data between Mobile Devices, Connected Vehicles and Infrastructure

Task 10: D2X Hub Prototype Acceptance Test Plan and Summary Report

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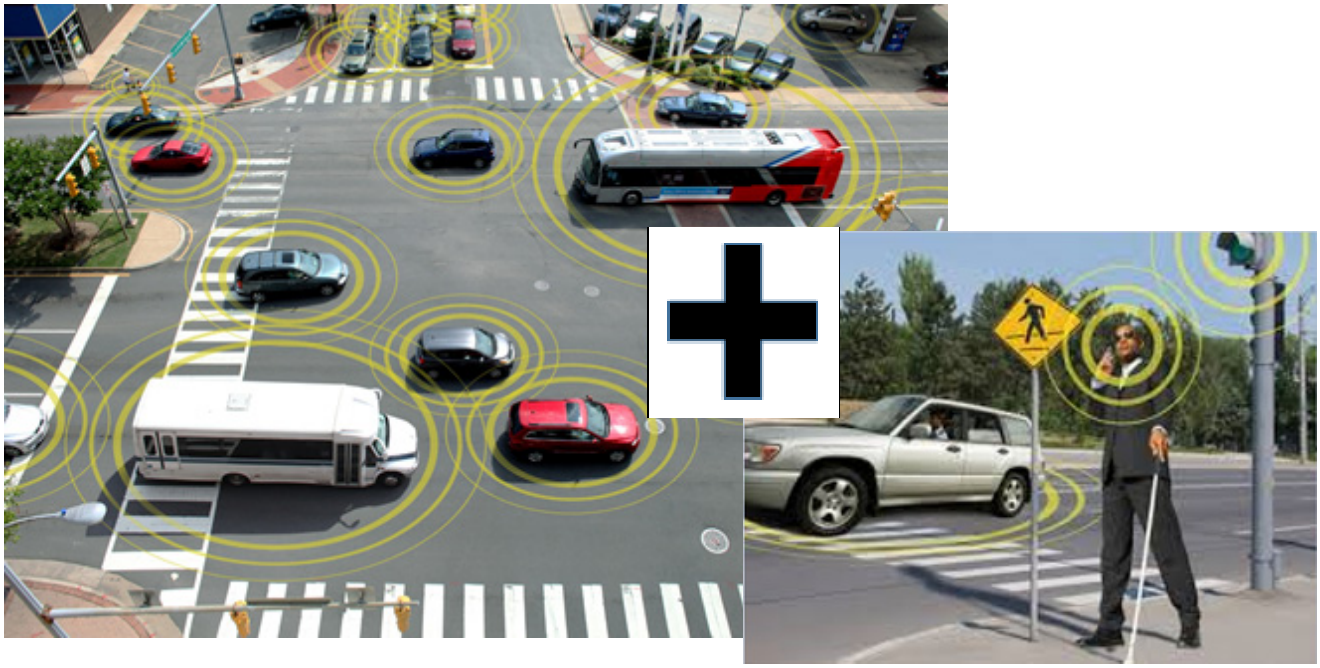
Final Report — October 27, 2017
FHWA-JPO-18-621



U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology

Produced by Battelle Memorial Institute under DTFH61-12-D-00046
U.S. Department of Transportation
- Office of the Assistant Secretary for Research and Technology
- Federal Highway Administration

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-JPO-18-621		

4. Title and Subtitle	5. Report Date
Sharing Data between Mobile Devices, Connected Vehicles and Infrastructure Task 10: D2X Hub Prototype Acceptance Test Plan and Summary Report	October 27, 2017 6. Performing Organization Code
7. Author(s)	**8. Performing Organization Report No.**
Dave Valentine, Ben Paselsky, Margaret Hailemariam, Rama Boyapati	
9. Performing Organization Name and Address	**10. Work Unit No. (TRAIS)**
Battelle 505 King Avenue Columbus, Ohio 43201	**11. Contract or Grant No.** DTFH61-12-D-00046 / 5015
12. Sponsoring Agency Name and Address	**13. Type of Report and Period Covered**
United States Department of Transportation ITS Joint Program Office Office of the Assistant Secretary for Research and Technology 1200 New Jersey Avenue, SE Washington, DC 20590	Final Report **14. Sponsoring Agency Code**

15. Supplementary Notes

Government Task Monitor – Jon Obenberger

16. Abstract

This Devices to Everything (D2X) Acceptance Test Plan (ATP) and Summary Report provides the plan, test cases, and test procedures that were used to verify Prototype System (version 2.0) system requirements, as well as a summary of results of the testing executed. Version 2.0 of the Prototype System is the subject of the larger-scale Field Test to be conducted after successful Acceptance Testing.

17. Key Words	18. Distribution Statement
Connected Vehicle, Mobile Device, Personal Mobility Message, Personal Safety Message, Basic Safety Message, Test Case, Coordinated Message, Experimental Prototype System, Acceptance Test Plan	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	96	N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Revision History

Revision	Date	Change Description	Affected Sections/Pages
1	5/12/2017	Draft Release	
2	10/27/2017	Final Release to address comments	All Sections

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Chapter 1 Scope

The purpose and vision of this experimental research task order is to enable the support in exchanging messages with pedestrian Mobile Devices within the public right of way, to enhance the safety and mobility of these pedestrian trips, and to enable the public agencies to improve how they manage traffic, which includes travelers using Mobile Devices.

This document contains the system's Acceptance Test Plan (ATP) and test procedures associated with the Prototype System (version 2.0) developed as part of the *Sharing Data between Mobile Devices, Connected Vehicles and Infrastructure* (formerly called "Coordination of Mobile Devices for Connected Vehicle Applications") task order. This document has been written with the assumption that the reader possesses a general knowledge associated with the connected vehicle technologies and applications and the systems engineering process.

This document was developed based on the contents of the approved "Task 3: System Requirements Specifications (SysRS) for Coordination of Mobile Devices for Connected Vehicle Applications (Final from July 14, 2016)" document.

This ATP defines the tests to be conducted to verify that the Prototype System (version 2.0) satisfies the system requirements. The Prototype System under test was modified following testing at Turner Fairbank Highway Research Center (TFHRC) to address findings and lessons learned from those tests, and to facilitate transit vs taxi as the mobility mode used for scheduling. Rather than re-conducting previously developed tests and procedures to verify the system requirements, the tests and associated procedures were customized as necessary to best evaluate the revised Prototype System. 'Success' is defined as the demonstration of anticipated functions and features in accordance with tests identified in the ATP. Corrective action will be taken to resolve any issues if a given function does not pass per the ATP. It is important to note that the performance of some functions is predicated on the availability of accurate inputs, and there is uncertainty regarding the ability of corrective action to resolve such issues.

It needs to be noted that the test plan and associated test procedures were developed for those system requirements that are shown in the last column ("EPS Req") within the requirements tables of the Final SysRS document.

1.1 Background

The United States Department of Transportation (U.S. DOT) has conducted significant research on the use, benefits, and operational issues associated with using dedicated short-range communications (DSRC) and Cellular Devices in both vehicular and infrastructure-based communications. Specifically, the benefits are intended to improve the safety, mobility and environmental impact on our surface transportation system. When the concept of connected vehicle environment first emerged, DSRC was conceived as an enabler for the mobility-impaired and other travelers with unique needs. However, the unprecedented adoption of smartphones and similar devices in the general population has necessitated a renewed analysis of its role in the broader connected vehicle environment. To date,

less research has been conducted on implementation pathways, policy and institutional impediments, as well as the feasibility of deployment of low-latency wireless communications on Mobile Devices in concert with the current cellular and Wi-Fi communications protocols. In particular, key questions and issues exist related to the expected impact that personal Mobile Devices (e.g., tablets, smartphones, etc.), that are also equipped with DSRC technology, will have on channel utilization and error-rates in the connected vehicle environment. If saturation is reached, it will likely degrade the anticipated benefits of connected vehicle safety applications by requiring more processing of radio messages than can be performed in low-latency required situations. It is with these considerations that this research is being initiated, the objectives of which are:

1. Examine the feasibility and benefits of utilizing non-DSRC communication mechanisms for the transmission of mobility and safety messages.
2. Develop and test modifications to the existing mobility and safety messages to make them applicable for Mobile Devices.
3. Create and demonstrate potential methods for coordinating messages and communications related to safety and mobility between Mobile Devices, vehicles, and infrastructure.

Importantly, the scope of this document and the system described herein is limited to an experimental system that will be used to design, test, and demonstrate new communication messages and message types as well as explore the effectiveness and potential mechanisms for coordinating these messages across multiple Mobile Devices, vehicles, and roadside infrastructure. This is intended as a research project and therefore does not seek to identify, define, summarize, or propose a system suitable for immediate wide-scale deployment.

1.2 Document Identification

This document is the Task 10 Prototype Acceptance Test Plan deliverable of the *Sharing Data between Mobile Devices, Connected Vehicles and Infrastructure* task order, which is being conducted by Battelle Memorial Institute for the Federal Highway Administration (FHWA) under Contract Number DTFH61-12-D-00046. This document defines the test plan and test procedures for Acceptance Testing the Prototype System, version 2.0.

1.3 Document Overview

This document consists of the following sections and content:

- Chapter 2 (Referenced Documents) describes any external documentation referenced throughout this document.
- Chapter 3 (Prototype Acceptance Test Objectives) describes the purpose and outcomes of the Prototype Acceptance Test Plan.
- Chapter 4 (Prototype System Testing Approach) provides an overview of the approach used for the system testing.
- Chapter 5 (Acceptance Test Plan) details a series of tests to be performed to verify the system components meet the requirements. In addition, it describes the testing environment, the roles and responsibilities as well as the resources used for testing.

- Appendix A contains Requirements Traceability Matrix linking the system requirements defined in the SysRS for Coordination of Mobile Devices for Connected Vehicle Applications (Final from July 14, 2016)" document (FHWA-JPO-16-423) with the test procedures defined in Chapter 5 of this document.
- Appendix B contains Requirements Traceability Matrix for those requirements that were identified in the SysRq document but are not part of the Prototype System requirements.
- Appendix C summarizes the Acceptance Test results.
- Appendix D contains Acronyms and Abbreviations.
- Appendix E contains Terms and Definitions.

1.4 Intended Audience

The primary audience for this document is U.S. DOT staff and other identified stakeholders who are leading or are interested in understanding the impact of safety and mobility messages from Mobile Devices within the envisioned connected vehicle environment where DSRC, Cellular, Wi-Fi, Bluetooth and other communication protocols are utilized by both vehicles and Mobile Devices. Additional audiences include the system developers, engineers, and any others who will assist in the development of a fully deployed Connected Vehicle environment.

Chapter 2 Referenced Documents

This research is sponsored by the U.S. Department of Transportation as part of on-going research related to the connected vehicle program. As such, there are a number of reports, presentations, and documents on the various aspects of the connected vehicle program that can be found at http://www.its.dot.gov/research_archive.htm. The findings, schematics, results, and conclusions in these documents were routinely consulted and are incorporated in this document. Specific references in the following sections pertain only to documents and works that are not included in this public document repository.

2.1 Non-Government Publications

Institute of Electrical and Electronics Engineers (IEEE)

IEEE 829-2006	IEEE Standard for Software and System Test Documentation
IEEE 1016-2009	IEEE Standard for Information Technology – Systems Design – Software Design Description
IEEE 1609.3,.4,.5-2010	IEEE Family of Standards for Wireless Access in Vehicular Environments (WAVE) define an architecture and a complementary, standardized set of services and interfaces that collectively enable secure vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications.
IEEE 802.11™-2012	IEEE Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks--Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

Society of Automotive Engineers (SAE)

J2735:2016	Object Dedicated Short Range Communications (DSRC) Message Set Dictionary – published
J2945/1:2016	On-Board System Requirements for V2V Safety Communications – published
J2945.9 – draft	Performance Requirements for Safety Communications to Vulnerable Road Users

National Transportation Communications for ITS Protocol (NTCIP)

1201:2005 V02.27	Global Object Definitions
1202v03 – draft	Object Definitions for Actuated Traffic Signal Controllers (ASC) – version 03 will include data elements and messages that are coordinated with the SAE J2735 standard, but also data elements for addressing pedestrian and bicycle needs at signalized intersections.

Wi-Fi Alliance

Wi-Fi Peer-to-Peer Services Technical Specification Package v1.2
See (http://www.wi-fi.org/discover-wi-fi/wi-fi-direct) for more

Battelle Memorial Institute

FHWA-JPO-16-422	Task 3: Concept of Operations Document *(ConOps)* for Coordination of Mobile Devices for Connected Vehicle Applications (July 13, 2016)
FHWA-JPO-16-423	Task 3: System Requirements Specifications *(SysRS)* for Coordination of Mobile Devices for Connected Vehicle Applications (July 14, 2016)
FHWA-JPO-17-476	Task 10: System Architecture and Design Document *(SA/DD)* for Sharing Data between Mobile Devices, Connected Vehicles, and Infrastructure (October 25, 2017)

2.2 Order of Precedence

In the event of a conflict between the text of this document and the references cited herein, the inconsistencies should be brought to the attention of the project manager. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

Chapter 3 Prototype Acceptance Test Plan Objectives

The Prototype System for the *Sharing Data between Mobile Devices, Connected Vehicles and Infrastructure* task order centers on potentially expanding the connected vehicle environment by coordinating Mobile Devices of pedestrians with each other and with compatible on-board units deployed within vehicles. The Prototype System includes application software, which supports several new and SAE J2735:201509 defined types of messages:

- Personal Safety Message (PSM) – defined in SysRS.
- A variety of coordination messages (all new):
    - Personal Mobility Message (PMM),
    - PMM Response (PMM-RSP) message,
    - PMM Arrival (PMM-ARRIVE) message.
- Basic Safety Messages (BSM) – defined in SAE J2735:201509 (formatting and encoding).

These message types are defined and/or referenced within the Task 10: System Architecture and Design Document (SA/DD).

The main objective of the ATP is to verify that the Prototype System properly coordinates messages sent via Mobile Devices of pedestrians with other Mobile Devices as well as those devices deployed in vehicles in a connected vehicle environment. The test will execute the system such that all system requirements are verified. The ATP describes the operation of the Prototype System, the performance measures, and the data that will be collected for verifying the prototype. After the tests in this ATP have been executed and collected data analyzed, a Field Test will be conducted in accordance with the Prototype Field Test Plan / Experimental Plan, which is designed to answer the research questions posed by the contract.

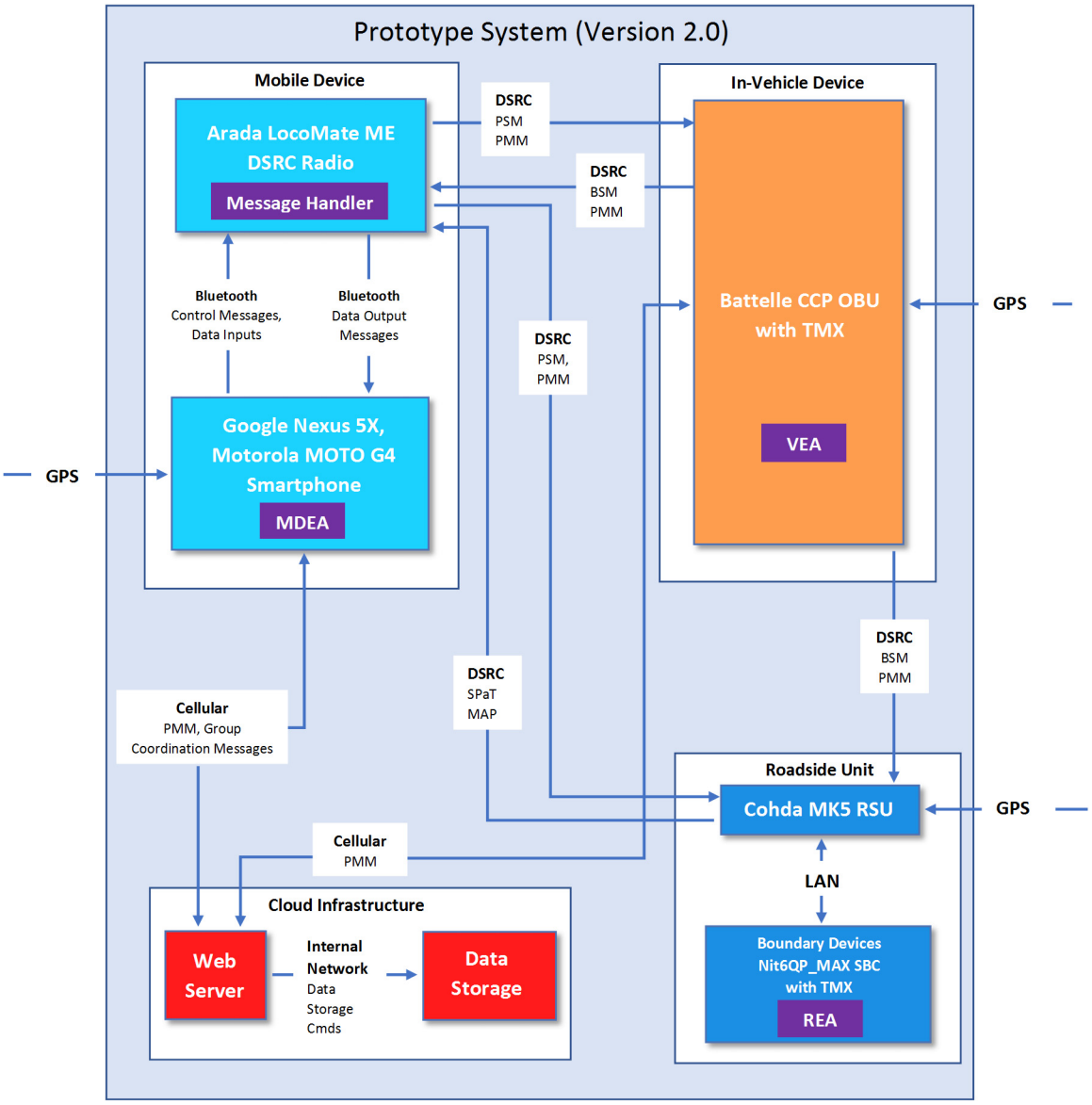
Chapter 4 Prototype System Testing Approach

4.1 System Overview

This section provides a brief synopsis of the Prototype System. Figure 4-1 shows the major components of the system, including communication media interfaces and messages. A main instance of the Mobile Device is shown in the upper left, complete with all interfaces to/from the other major functional components. The entire Prototype System centers on the Mobile Devices and their interaction with each other as well as with other components such as In-Vehicle Devices, Roadside Units (RSUs), and the Cloud infrastructure. Vehicles include equipped vehicles, meaning those vehicles that support Dedicated Short Range Communications (DSRC) and, as a minimum, BSM message broadcasting. The Cloud infrastructure is used for relaying travel requests to a vehicle capable of transporting passengers and for coordinating groups of travelers.

- Mobile Device Subsystem
  - Smartphone (Google Nexus 5X and Motorola G4 PLAY)
  - DSRC Communications Hardware (Arada LocoMate™ ME OBU)
  - Mobile Device Experimental Application (MDEA) software
  - DSRC Message Handler software
- In-Vehicle Device Subsystem
  - Battelle Common Computing Platform (CCP) with hosted Cohda DSRC Radio
  - In-Vehicle Experimental Application (VEA) plug-in software running on Transportation Message eXchange (TMX) framework
- RSU Subsystem
  - Cohda MK5 RSU
  - Boundary Device with Transportation Message eXchange (TMX) framework
  - Roadside Unit Experimental Application (REA) software

  Note: The system design documented in the System Architecture and Design Document uses a CCP for the RSU. Due to CCP range limitations that were not fully resolved by the timeframe of this testing, a functionally equivalent Cohda MK5 RSU with Boundary Device was used as a deviation from the design. The same REA software is used for either equipment configuration.
- Cloud Infrastructure Subsystem
  - Computational Platform (Microsoft Windows Azure)
  - Cloud API software



Source: Battelle, May 2017

Figure 4-1. Prototype System 'System Architecture' Diagram

4.2 Testing Overview

The ATP is conducted following the principles of systems engineering and the principles of IEEE 829-2008 (Standard for Software and System Test Documentation). Functionality of the integrated Prototype System will be tested per the specified requirements, though in some cases performance of a subsystem will be evaluated while the integrated Prototype System is exercised. The objective of this series of tests is to verify that the Prototype System properly coordinates messages sent via Mobile Devices of pedestrians to other pedestrians' Mobile Devices and to on-board units within vehicles in the connected vehicle environment. This section outlines the testing approach and

schedule that will be followed to test the Prototype System performance in accordance with the system requirements. The Test Cases introduced in Section 5.4 are designed to verify each system requirement targeted at the Prototype System. Each test case will be recorded and reported in the detailed format of the test summary report for further evaluation including (for example) metrics, event files, screen shots and other necessary files to document the results of the test procedures. Any discrepancies found during acceptance testing will be recorded in test logs. The acceptance test conductors will record test discrepancies including a description of the discrepancy in the test log. The cause of the discrepancy will be investigated to allow resolution of the issue. Discrepancies are reported based on the "Priority" levels, which are described as:

- Critical (1) – When testing cannot continue and has to be terminated. The software application or module associated with the test procedure cannot be used.
- Serious (2) – When the application is behaving in a manner that is different from the requirement causing a failure in the application function.
- Moderate (3) – When testing can continue and a workaround can be managed through the misbehaving functionality of the application.
- Cosmetic (4) – When a defect occurs that would affect only the non-functional aspects of the software elements.
- Recommendations (5) – When a suggestion for improving the application is presented.

4.2.1 Schedule

Table 4-1 shows the schedule for Acceptance Testing to be conducted at Battelle, Columbus.

Table 4-1. Prototype Acceptance Testing Schedule

Activity	Expected Start Date	Expected Duration
ATP Test Case Execution (5 iterations)	05/15/2017	1.5 days
5.4.1 PSM Test Cases		
5.4.2 PMM Test Cases		
5.4.3 BSM Test Cases		
5.4.4 Ad-Hoc Travel Group Test Cases		
5.4.5 Message Logging Test Cases		
5.4.6 Safety Test Cases		
5.4.7 SPaT and MAP Support		
Implementation of Fixes (as needed)	05/16/2017	2 days
Repeat Failed Tests / Regression Testing (5 iterations)	05/18/2017	1.5 days

Source: Battelle

Chapter 5 Acceptance Test Plan

Battelle will conduct the ATP to verify the Prototype System is functioning properly prior to the Prototype Field Test. The ATP will be conducted at Battelle and will ensure that the Prototype System is functioning in accordance with the system requirements in the SysRS document. Whereas the subsequent Prototype Field Test will execute a separate set of scenarios designed to test hypotheses and answer the research questions posed by the contract.

5.1 Testing Environment

For Acceptance Testing and subsequent Field Testing, the system hardware components that comprise the Prototype System are the same and include Mobile Devices, In-Vehicle Devices, Roadside Units, and Cloud Infrastructure. Additional test hardware may include laptops, cameras, and other required equipment to log test case results. Each hardware component will communicate with other hardware components via DSRC Radio or Cloud/cellular to transfer safety, mobility, coordination and RSU message types.

The developed system software applications that will be used during testing include the Mobile Device Experimental Application (MDEA), the DSRC Message Handler (for the Mobile Device), the In-Vehicle Experimental Application (VEA), the RSU Experimental Application (REA), and the Cloud API.

ATP testing will be conducted in the controlled environment of Battelle's parking lot, where a test area will be cordoned off for execution of the test cases as specified in this plan.

5.2 Roles and Responsibilities

The testing procedures will be conducted by the Test Director, the Test Leader, the Test Engineer, and the Test Support Personnel. All of these roles will be filled by Battelle employees. All of the roles will be filled by Battelle Staff that have been actively involved with the management, design, and development of the *Sharing Data between Mobile Devices, Connected Vehicles and Infrastructure* project. Table 5-1 identifies each role, a preliminary list of staff who could fill each role, and the responsibility of the individuals filling each role.

Table 5-1. Roles and Responsibilities

Role		Description
Test Director	David Valentine	Supervises all test activities including planning, reviewing all test team deliverable, and managing all personnel within test team
Test Leader	Ben Paselsky	Leads the execution of each specific test case by coordinating all actions between other roles and ensuring all data was collected
Test Engineer	Greg Baumgardner	Supports executing tests, setup and monitoring equipment, collecting data during test, and analyzing test results
Test Support Personnel	Rama Boyapati, Margaret Hailemariam	Support the success of the test procedure through various activities such as executing tests, collecting logs and test data, etc.

Source: Battelle

5.3 Resources

The resources that will be used to test the Prototype System include:

- Prototype System – summarized in Paragraph 4.1
- Two rental vehicles – one minivan and one sedan
  - The mini-van was used to act as a transit vehicle (referred to as Simulated Transit Vehicle in the test cases)
  - The sedan is referred to as a Light-Duty Vehicle in the test cases
- Test Team – listed in Section 5.2
- Battelle 5th Avenue parking lot
- This ATP document
- Ancillary test equipment – CV Inspector tool, laptops, etc.

5.4 Acceptance Test Cases

This section identifies the Acceptance Test Cases for each of the system requirements defined in the SysRS that have been identified for use within the Prototype System.

Test cases are precedents of the test procedures that include information on the type of test performed. They are the tests that will be performed to verify the functionality of the Prototype System. The tables that follow include information on each ATP test such as the Test Case ID, Test Case Name, and the Test Method/Configuration Comments to identify each test and run a Test Script.

Each test will be repeated a minimum of five (5) times to ensure representative results. Empirical data collected during testing will be used to assess the ability of the system to meet requirements as judged by the Expected Result for each test step. In most cases, “Pass” or “Fail” will be visually observed and recorded in the test log by the test team during the test. In some cases, digital data logs will be reviewed to determine if Expected Result have been met after the test has been completed.

Note: The Acceptance Test Summary Report that will be submitted to FHWA after the successful completion of the ATP will document inspection, test artifacts and results from the analysis of data collected during ATP testing to verify SysRS compliance.

For all the test cases below, the following settings will be used in MDEA:

- Wi-Fi Direct Timeout = 10 seconds
  - This setting is the period within which a Wi-Fi direct request made to join an existing group can be accepted. If not accepted within this timeframe, a new group is created by the mobile user.

- DSRC Timeout = 20 seconds
  - This setting is the period within which a ride request response over DSRC can be fulfilled before the mobile device will switch to cellular mode (i.e., when a bus is not within range).

- In Vehicle Detection = UseGps
  - This is the setting used to determine if the mobile device is in the vehicle. 'UseGPS' denotes that the mobile device accelerometer is utilized.
  - Another operational option is the use of Bluetooth beacon.
  - Other options also exist for non-operational diagnostic purposes.

- Send Psm Control = UseAllRules
  - This is the only normal operating mode for PSM management.
  - Other options exist for non-operational diagnostic purposes.

- Normal Loc Log (switch) = OFF
  - This is the normal operating mode for Local Logging (collection of a voluminous number of log files not necessary for normal operations). Selecting 'ON' is to support non-operational diagnostic purposes.

- Status Messages (switch) = ON
  - This setting allows for the collection of a small subset of status change-based messaging (collection of a more modest number of log files). Collection of these log files is not required for normal operations, but can be beneficial for testing and/or investigation into problems with the system during normal operations.

- Simulated Location (switch) = OFF
  - 'OFF' is the normal operating mode. Selecting 'ON' permits the simulation of vehicle position to support non-normal diagnostic purposes.

- Simulated Path (switch) = OFF
  - OFF' is the normal operating mode. Selecting 'ON' permits the simulation of vehicle path determination to support non-normal diagnostic purposes.

- Safety Zone Detection = UseMap
  - 'UseMap' is the normal operating mode for system detection of whether the mobile device is within a safety zone.
  - Other options exist for non-operational diagnostic purposes.

5.4.1 Personal Safety Message

Test Case

Test Case ID	5.4.1.1
Test Case Name	PSM – Broadcasting PSM with Light-Duty Vehicle Within a Specified Radius (Transmit Timing)
Test Objective	• Verify the ability of the Mobile Device to broadcast PSMs via DSRC media in a configurable transmission interval in 0.1 second intervals • Verify the ability of the Mobile Device to transmit PSMs only when the Mobile Device determines a Light-Duty vehicle is within a specified radius of the mobile device
System Requirements	FR 1.01, FR 1.02, FR 1.08, SIR 1.01, SIR 1.02, SIR 1.03, SIR 1.04, SIR 1.05, SIR 1.06, SIR 1.07, SIR 1.08, SIR 1.09, PR 1.03, PR 1.04, PR 5.01
Verification Method	Test
Test Method/ Configuration Comments	• DSRC capable hardware is connected to the mobile device and the MDEA application is installed • A pedestrian holding a mobile device is standing five (5) meters perpendicular to the edge of the roadway at the bus stop in a safe zone • DSRC capable hardware is installed on the Light-Duty vehicle and the VEA application is installed • The Light-Duty vehicle is stationed south of the crosswalk and moves north toward the pedestrian ○ From a stop, the Light-Duty vehicle must achieve a constant speed of 25 mph over a distance of approximately 600 feet

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	The Light-Duty Vehicle accelerates up to twenty-five (25) mph.	None			
2	Light-Duty Vehicle maintains constant speed of twenty-five (25) mph.	None			
3	The Light-Duty Vehicle comes within 100 meters of the pedestrian.	Mobile Device begins broadcasting PSMs via DSRC. This is verified by inspection using CV Inspector. A detailed inspection is performed using data recorded on the MDEA data log.			
4	Inspect the PSM data recorded on the RSU log.	Following data should have been logged: Location Speed Heading Number of Pedestrians Radius of Protection Path History (20 seconds) Path Prediction (5 seconds)			
5	The Light-Duty Vehicle decelerates to a stop.	Mobile Device stops broadcasting PSMs. This is verified by inspection using CV Inspector. A detailed inspection is performed using data recorded on the MDEA data log.			

Test Case

Test Case ID	5.4.1.2
Test Case Name	PSM – Cease Broadcasting PSMs when In-Vehicle; Mobile Device Accelerometer Sensor Functionality to Detect Passenger Entry into and Exiting from the Vehicle
Test Objective	• Verify the ability of the Mobile Device to cease broadcasting PSMs when it has detected that it has entered a vehicle • Demonstrate prototype capability to detect passenger entry into vehicle • Demonstrate prototype capability to detect passenger exiting from vehicle
System Requirement	FR 1.03, FR 1.04, PR 5.03, FR 6.01, FR 6.02, FR 6.03, FR 6.04, FR 7.02, FR 7.05
Verification Method	Test
Test Method/ Configuration Comments	• DSRC capable hardware is installed on the Vehicle and the VEA application is installed • A Simulated Transit Vehicle starts from a location south of the simulated transit Stop and approaches the simulated transit stop • A Light-Duty vehicle approaches the simulated transit Stop from the north • DSRC capable hardware is connected to the mobile device and the MDEA application is installed • A pedestrian holding a mobile device is positioned at the simulated transit stop • A Tablet running CV Inspector application to verify that the mobile device broadcasting DSRC messages is positioned at the simulated transit stop • Countdown timer to measure status change time to detect entry or exit events

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	Passenger is waiting at simulated Transit Stop and a Simulated Transit Vehicle approaches.	MDEA displays its vehicle status indicator as a red not-in-vehicle icon. This is verified by visual inspection of the MDEA display. Inspect the CV Inspector to verify the reception of PSM.			
2	Simulated Transit Vehicle stops at the stop.	MDEA continues to indicate vehicle status icon as red not-in-vehicle icon. This is verified by visual inspection of the MDEA display			
3	Light-Duty Vehicle passes the Simulated Transit Stop.	MDEA broadcasts PSMs via DSRC. This is verified by inspection using CV Inspector. Inspect the RSU log to verify the reception of PSMs at one-tenth of a second frequency.			
4	Passenger embarks Simulated Transit Vehicle and vehicle starts to move. A test Observer in the vehicle starts the countdown timer from 10 seconds.	MDEA updates its vehicle status indicator to a green in-vehicle icon within 10 seconds of vehicle starting to move. This is verified by visual inspection of the MDEA display and the countdown timer.			
5	At the moment, the mobile device application updates its vehicle status to green in-vehicle icon the test observer notes whether or not the countdown has expired.	Inspect the CV Inspector to verify that the PSM broadcasting has ceased.			
6	Light-Duty Vehicle passes in the opposite direction.	MDEA does not broadcast PSMs via DSRC. This is verified by inspection using CV Inspector. A detailed inspection is performed using data recorded on the RSU data log.			
7	Simulated Transit Vehicle drives away with pedestrian in vehicle.	None			

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
8	Simulated Transit Vehicle stops, passenger disembarks the vehicle (closed door) and starts to walk away from the vehicle. A test Observer outside of the vehicle starts the countdown timer from 10 seconds as the passenger steps outside.	Mobile device application updates its vehicle status to not-in-vehicle red icon within 10 seconds of passenger exiting the vehicle. This is verified by visual inspection of the MDEA display and the countdown timer.			
9	At the moment the mobile device application updates its vehicle status to not-in-vehicle the test observer notes whether or not the countdown has expired. Simulated Transit Vehicle drives away.	Inspect the CV Inspector to verify the reception of PSMs.			

Test Case

Test Case ID	5.4.1.3
Test Case Name	PSM – Cease Broadcasting PSMs After Joining an Ad-Hoc Travel Group
Test Objective(s)	• Verify the ability of the mobile device to cease broadcasting PSMs when it has joined an ad-hoc travel group
System Requirement	FR 1.05, SIR 1.05, SIR 1.07, PR 5.02
Verification Method	Test
Test Method/ Configuration Comments	• DSRC capable hardware is installed on the Vehicle and the VEA application is installed • DSRC capable hardware is connected to two Mobile Devices and the MDEA application is installed on both devices • Traveler X holding a mobile device is positioned at the simulated transit stop and has already coordinated travel with a Vehicle • Traveler Y holding a mobile device is positioned at the simulated transit stop and has not yet attempted to coordinate travel • A Tablet running CV Inspector application to verify DSRC messages is positioned at the simulated transit stop

Test Script

Step	Test Action	Expected Results	Pass/Fail P	Pass/Fail F	Actual Results
1	Light-Duty vehicle passes the simulated transit Stop.	Traveler X MDEA broadcasts PSMs via DSRC. This is verified by inspection using CV Inspector. Traveler Y MDEA broadcasts PSMs via DSRC. This is verified by inspection using CV Inspector.			
2	Ad-Hoc Travel Group forms. (See Test Case 5.4.4.1 – Steps 1 through 4)	Traveler Y MDEA transitions to 'in travel group' This is verified by inspecting the Traveler 2 MDEA Log.			
3	The Light-Duty vehicle passes the simulated transit Stop.	PSMs sent from Traveler X MDEA are received by the Light-Duty vehicle. Traveler Y MDEA does not broadcast PSMs. This is verified by inspection using CV Inspector. A detailed inspection is performed using data recorded on the Traveler X and Traveler Y MDEA data Logs.			

Test Case

Test Case ID	5.4.1.4
Test Case Name	PSM – Broadcasting PSM with Pedestrian in Unsafe Zone
Test Objective(s)	• Verify the ability of the mobile device to detect transitions from a safe to an unsafe zone and to broadcast PSMs when it is in an unsafe zone. *Note: the intent of this requirement is to allow a travel group member to broadcast PSMs when positioned in the roadway while remaining part of the travel group*
System Requirement	FR 1.06
Verification Method	Test
Test Method/ Configuration Comments	• DSRC capable hardware is connected to the mobile device and the MDEA application is installed • A pedestrian travel group member (traveler Y, not the group leader) is holding a mobile device at a simulated transit stop in a safe zone • Tablet running CV Inspector application to verify DSRC messages

Test Script

Step	Test Action	Expected Results	Pass/Fail P	Pass/Fail F	Actual Results
1	Ad-Hoc Travel Group forms. (See Test Case 5.4.4.1 – Steps 1 through 4)				
2	Traveler Y stands still in a safe zone five (5) meters perpendicular from the roadway. Light-Duty vehicle passes the simulated transit Stop.	Traveler Y MDEA detects that it is in a safe zone and will display the grey safety indicator icon. This is verified by inspecting the MDEA logs. The MDEA does not broadcast PSMs. This is verified by inspection using CV Inspector.			
3	Traveler Y walks into the crosswalk halfway across the roadway – an unsafe zone – and stands still. Light-Duty vehicle passes the simulated transit Stop.	Traveler Y MDEA detects that it is in an unsafe zone and will display the red safety indicator icon (as determined by the vehicle lanes specified in the received MAP file). This is verified by inspecting the MDEA logs. The MDEA broadcasts PSMs via DSRC. This is verified by inspection using CV Inspector.			
4	Traveler Y walks back to the starting point to the safe zone five (5) meters perpendicular from the roadway.	Traveler Y MDEA detects that it is in a safe zone. This is verified by inspecting the MDEA logs. The MDEA does not broadcast PSMs. This is verified by inspection using CV Inspector.			

5.4.2 Personal Mobility Message

Test Case

Test Case ID	5.4.2.1
Test Case Name	PMM – Submitting Trip Requests – Single User
Test Objective	• Verify users are able to enter and submit trip requests • Verify users are able to enter and submit trip details through the application
System Requirement	FR 2.01, FR 2.01.01, FR 2.02, FR 2.03, FR 2.03.01, FR 2.04, FR 2.06, SIR 2.01, SIR 2.02, SIR 2.03, SIR 2.04, SIR 2.05, SIR 2.06, SIR 2.07, SIR 2.08, SIR 3.01, SIR 3.02, SIR 3.03, SIR 15.01, SIR 15.02, PR 5.04, PR 5.06
Verification Method	Test
Test Method/ Configuration Comments	• DSRC capable hardware is connected to the Mobile Device and the MDEA is installed and initiated for use • A pedestrian holding a mobile device is standing at a simulated transit stop in a safe zone • DSRC capable hardware is connected to the In-Vehicle Device and the VEA is installed and initiated for use • The Simulated Transit Vehicle is stationed within the DSRC range *Note: Devices are placed within 1000m (generally accepted DSRC range given clear line of sight) of each other with a clear line of sight* • User interacts with the MDEA to enter and submit trip request to Simulated Transit Vehicle

Test Script

Step	Test Action	Expected Results	Pass/Fail P	Pass/Fail F	Actual Results
1	Traveler X arrives at a stop.	None			
2	Traveler X prepares to Schedule a trip.	MDEA displays “Trip Information” display. This is verified by inspection of the MEDA log.			
3	Traveler X enters trip request information including current Location, the Number of Travelers (associated to the Mobile Device user), Pickup Time, Origin, Mode of Transport, travel route, and Mobility Needs into the MDEA.	None			
4	Traveler X submits trip request information.	MDEA checks for any existing travelers via Cloud. This is verified by inspection of the MDEA log. Traveler X MDEA broadcasts PMM via DSRC. This is verified by inspection of the MDEA log. Vehicle VEA receives PMM via DSRC. This is verified by inspection of the VEA Log.			
5	VEA receives a Ride Request.	The VEA accepts the request.			
6	VEA accepts Ride Request.	Vehicle VEA sends a PMM-RSP message via DSRC. This is verified by inspection of the VEA log. MDEA is notified with Accepted PMM request. This is verified by inspection of the MDEA Log.			

Test Case

Test Case ID	5.4.2.2
Test Case Name	PMM – Communicate with Cloud Infrastructure via Cellular
Test Objective	• Verify PMMs can be transmitted via various communications media
System Requirement	FR 2.03, FR 2.03.04, FR 2.06, PR 5.03, PR 5.04
Verification Method	Test
Test Method/ Configuration Comments	• Cellular communications capable hardware is connected to the Mobile Device and the MDEA Applications installed and initiated for use • A pedestrian holding a mobile device is standing at a simulated transit stop in a safe zone • DSRC capable hardware is connected to the In-Vehicle Device and the VEA is installed and initiated for use • The Simulated Transit Vehicle is stationed outside of DSRC range

Test Script

Step	Test Action	Expected Results	Pass/Fail P	Pass/Fail F	Actual Results
1	Traveler X arrives at a stop and enters trip request information. (See Test Case 5.4.2.1, Steps 1-3)				
2	Traveler X submits trip request information.	MDEA checks for any existing travelers via Cloud. This is verified by inspection of the MDEA log. Traveler X MDEA broadcasts PMM via DSRC. This is verified by inspection of the MDEA log. MDEA does not receive PMM-RSP in configurable interval. This is verified by inspection of the MDEA log. MDEA sends PMM to the cloud via Cellular. This is verified by inspection of the MDEA log. The cloud infrastructure receives the PMM. This is verified by inspection of the cloud infrastructure log. Vehicle VEA receives PMM via Cellular. This is verified by inspection of the VEA Log.			
3	VEA receives a Ride Request.	The VEA will accept the request. This is verified by visual inspection of the VEA display.			
4	VEA accepts Ride Request.	VEA sends PMM-RSP to the cloud via Cellular. This is verified by inspection of the VEA log. The cloud infrastructure receives the PMM-RSP. This is verified by inspection of the cloud infrastructure log. Vehicle MDEA receives PMM-RSP via Cellular. This is verified by inspection of the MDEA Log.			

Test Case

Test Case ID	5.4.2.3
Test Case Name	PMM – Canceling Trip Requests
Test Objective	• Verify users are able to cancel trip requests
System Requirement	FR 2.03, FR 2.05, FR 2.06, FR 2.08, SIR 4.01, PR 5.4.2.3, PR 5.04
Verification Method	Test
Test Method/ Configuration Comments	• DSRC capable hardware is connected to the Mobile Device and the MDEA Applications installed and initiated for use • A pedestrian holding a mobile device is standing at a simulated transit stop in a safe zone • DSRC capable hardware is connected to the In-Vehicle Device and the VEA is installed and initiated for use • The Simulated Transit Vehicle is stationed within the DSRC range *Note: Devices are placed within 1000m (generally accepted DSRC range given clear line of sight) of each other with a clear line of sight*

Test Script

Step	Test Action	Expected Results	Pass/Fail P	Pass/Fail F	Actual Results
1	Traveler X arrives at a stop and arranges travel with a Vehicle. (See Test Case 5.4.2.1, Steps 1-6)				
2	Traveler X submits a trip cancellation request.	Traveler X MDEA broadcasts PMM-request for 0 regular and handicap seats via DSRC. This is verified by inspection of the MDEA log. Vehicle VEA receives PMM-Request containing 0 regular and handicap seats via DSRC. This is verified by inspection of the VEA Log.			
3	VEA receives a Ride Cancellation.	The currently-active trip will be removed from the display now that it has been canceled. This is verified by visual inspection of the VEA display.			

Test Case

Test Case ID	5.4.2.4
Test Case Name	PMM – Sending Arrival Messages
Test Objective	• Verify Vehicles are able to send arrival messages • Verify Vehicles are able to send arrival details through the application
System Requirement	FR 2.09, FR 2.10, SIR 5.01, SIR 5.02, SIR 5.04, SIR 15.02, SIR 15.04, SIR 15.05
Verification Method	Test
Test Method/ Configuration Comments	• DSRC capable hardware is connected to the Mobile Device and the MDEA Applications installed and initiated for use • A pedestrian holding a mobile device is standing at a simulated transit stop in a safe zone • DSRC capable hardware is connected to the In-Vehicle Device and the VEA is installed and initiated for use • The Simulated Transit Vehicle is stationed within the DSRC range *Note: Devices are placed within 1000m (generally accepted DSRC range given clear line of sight) of each other with a clear line of sight*

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	Traveler X arrives at a stop and arranges travel with a Vehicle. (See Test Case 5.4.2.1, Steps 1-6)				
2	Simulated Transit Vehicle arrives Traveler X's stop.	Simulated Transit Vehicle VEA broadcasts PMM-ARRIVE via DSRC at configured interval. This is verified by inspection of the VEA log. Traveler X MDEA receives PMM-ARRIVE via DSRC. This is verified by inspection of the MDEA Log.			
3	Traveler X receives arrival message.	An action screen will be displayed to the traveler that the Vehicle is about to arrive. This is verified by visual inspection of the MDEA display.			
4	Traveler X enters Simulated Transit Vehicle and departs from the stop.	Simulated Transit Vehicle VEA ceases broadcasting PMM-ARRIVE via DSRC. This is verified by inspection of the VEA log.			

5.4.3 Basic Safety Message

Test Case

Test Case ID	5.4.3.1
Test Case Name	BSM – Vehicle Experimental Application Functionality
Test Objective	• Verify ability to generate BSMs by vehicles equipped with DSRC Radio and VEA Application • Verify BSM message contents • Verify ability to receive BSMs by vehicles equipped with DSRC Radio and VEA Application • Verify the ability of MDEAs to receive the BSMs generated by VEAs
System Requirement	FR 4.01, FR 4.01.01, FR 4.02, FR 4.03, SIR 7.01, SIR 7.02, SIR 7.03, SIR 7.04, SIR 15.07
Verification Method	Test
Test Method/ Configuration Comments	• DSRC capable hardware is installed on the vehicle and VEA application is installed • Other DSRC equipped vehicles transmitting BSMs in the DSRC area • Tablet running CV Inspector application to verify DSRC messages • Access to RSU admin web portal to verify BSM message activity

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	Launch VEA Application if it's not running.	VEA application starts up and starts to broadcast BSM messages.			
2	Launch CV Inspector Application.	Application is initialized and a map zoomed into the test area is displayed. Observe BSM message traffic on the CV Inspector. Verify that the location of the vehicle is updated on the map as the vehicle is moving 2-3 times per second.			
3	Open a browser and browse to RSU web admin portal at IP Address _____	Browser displays the RSU login page.			
4	Log in to the portal using username:_____ password:_____ and click on the "View Message Activity" under Main Menu.	Browser displays BSM module status, showing number of processed BSMs to indicate reception of a BSM message.			
5	Browse to the message log screen and filter data for BSM messages or log in to the database and execute the following query: <insert query>.	The BSM message data is displayed. Inspect data to verify vehicle location, vehicle speed, vehicle heading, and vehicle size are logged. Inspect the timestamps to indicate that BSMs are being logged every tenth of a second.			

5.4.4 Ad-hoc Travel Group

Test Case

Test Case ID	5.4.4.1
Test Case Name	ATG – Creating Coordination between the Mobile Devices of Travelers – Multiple Travelers ATG – Leaving an Ad-Hoc Travel Group Based on Distance – Multiple Travelers ATG – Leaving an Ad-Hoc Travel Group by Choice – Multiple Travelers ATG – Disbanding Ad-Hoc Travel Group When Entering a Vehicle or any other Reason
Test Objective	• Verify travelers are able to temporarily be grouped into ad-hoc travel group and transmit trip request through the application • Verify travelers are able to transmit trip requests as a group (with a leader) rather than transmitting individual messages from every member of the group • Verify the ad-hoc group leader is able to enter and submit ad-hoc group trip details through the application • Verify that an Ad-Hoc Travel Group Leader's Mobile Device can detect when a Mobile Device within the Ad-Hoc Travel Group leaves the Travel Group by exceeding the configurable distance from the Transit stop • Verify that an Ad-Hoc Group Leader's Mobile Device can detect when a Mobile Device within the Ad-Hoc Travel Group requests to leave the Travel Group • Verify that Ad-Hoc Travel Group Leader's Mobile Device can disband an Ad-Hoc Travel Group when entering a vehicle
System Requirement	FR 2.07, FR 5.01, FR 5.01.01, FR 5.01.03, FR 5.02, FR 5.03, FR 5.03.01, FR 5.04, FR 5.05, FR 5.06, FR 5.06.01, FR 5.07, FR 5.08, FR 5.09, FR 5.10, FR 5.11, SIR 8.01, SIR 8.02, SIR 8.03, SIR 8.04, SIR 8.05, SIR 8.06, SIR 8.07, SIR 8.10, SIR 8.11, SIR 8.20, SIR 8.21, SIR 8.22, SIR 8.30, SIR 8.31, SIR 15.08, SIR 20.01, PR 5.06
Verification Method	Test

Test Method/ Configuration Comments	• Maximum travel group size is set to four (4) travelers
	• DSRC capable hardware is connected to the Mobile Devices and the MDEA is installed and initiated for use in each
	• Pedestrians holding Mobile Devices are standing five (5) meters perpendicular to the edge of the roadway at the crosswalk in a safe zone
	• DSRC capable hardware is connected to the In-Vehicle Device and the VEA is installed and initiated for use
	• The Simulated Transit Vehicle is stationed within the DSRC range
	Note: Devices are placed within 1000m (generally accepted DSRC range given clear line of sight) of each other with a clear line of sight.
	  • Users interact with the MDEA to enter and submit trip request to Vehicle
	  • Mobile Device leaves Ad-Hoc Travel Group if exceeding distance range from simulated transit stop
	  • Ad-Hoc Travel Group Members interact with the Mobile Device and requests to leave the Ad-Hoc Travel Group manually
	  • Ad-Hoc Travel Group Leader's MDEA detects vehicle entry and disbands group

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	Traveler X arrives at a stop. Schedules a trip. (See Test Script for Test Case 5.4.2.1 – Steps 1 through 4)	Ride Request Monitor looks for a local group for the same trip. None is found. MDEA establishes a new Group ABC, Leader 1, adds self as Pending member and enters Leader mode.			
2	Simulated Transit Vehicle receives a Ride Request.	Ride Request Monitor identifies a new PMM request with the Origin, Departure Time, Seat Type, travel route, and Vehicle Type requested. The VEA accepts the request.			
3	VEA accepts Ride Request.	Vehicle sends a PMM-RSP message via DSRC. MDEA is notified of accepted PMM request.			
4	Traveler Y arrives at a stop. Schedules a trip from the same origin location as Traveler X.	Ride Request Monitor looks for a local group for the same trip. One (1) is found. MDEA asks to be added to existing Group ABC via Cloud. MDEA of Leader receives request, adds Traveler Y to Pending Members and returns acceptance for Traveler Y to become follower within Group ABC. MDEA of Traveler Y receives response and enters Follower mode. MDEA of Traveler X (Group ABC Leader), creates new Pending PMM Request to dispatch to Vehicle, reflecting two (2) seats required.			
5	Simulated Transit Vehicle receives updated Ride Request.	Ride Request Monitor identifies an updated PMM request with the Origin, Departure Time, Seat Type, Vehicle route and Vehicle Type requested. The VEA accepts the request.			
6	VEA Accepts the PMM Request displayed on VEA.	Group ABC Leader receives a PMM-RSP from VEA indicating it has accepted PMM Request for two (2) seats.			

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
7	Traveler Z arrives at a stop. Schedules a trip from the same origin location as Traveler X and Y.	Ride Request Monitor looks for a local group for the same trip. One (1) is found. MDEA asks to be added to existing Group ABC via Cloud. MDEA of Leader receives request, adds Traveler Z to Pending Members and returns acceptance for Traveler Z to become follower within Group ABC. MDEA of Traveler Z receives response and enters Follower mode. MDEA of Traveler X (Group ABC Leader), creates new Pending PMM Request to dispatch to Vehicle/Transit Vehicle, reflecting three (3) seats required.			
8	Simulated Transit Vehicle receives updated Ride Request.	Ride Request Monitor identifies an updated PMM request with the Origin, Departure Time, Seat Type, Vehicle route and Vehicle Type requested.			
9	VEA Accepts the updated PMM Request displayed on VEA.	VEA accepts updated PMM Request. Group ABC Leader receives a PMM-RSP from VEA indicating it has accepted PMM Request for three (3) seats.			
10	Traveler W arrives at a stop. Schedules a trip from the same origin location as Traveler X, Y, and Z.	Ride Request Monitor looks for a local group for the same trip. One (1) is found. MDEA asks to be added to existing Group ABC via Cloud. MDEA of Leader receives request, adds Traveler W to Pending Members and returns acceptance for Traveler W to become follower within Group ABC. MDEA of Traveler W receives response and enters Follower mode. MDEA of Traveler X (Group ABC Leader), creates new Pending PMM Request to dispatch to Simulated Transit Vehicle, reflecting four (4) seats required.			
11	Simulated Transit Vehicle receives updated Ride Request.	Ride Request Monitor identifies an updated PMM request with the Destination, Departure Time, Seat Type, vehicle route and Vehicle Type requested.			
12	VEA Accepts the updated PMM Request displayed on VEA.	VEA accepts updated PMM Request. Group ABC Leader receives a PMM-RSP from VEA indicating it has accepted PMM Request for four (4) seats.			

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
13	Traveler V arrives at a stop. Schedules a trip from the same origin location as Traveler X, Y, Z, and W.	Ride Request Monitor looks for a local group for the same trip. One (1) is found. MDEA asks to be added to existing Group ABC via Cloud. MDEA of Leader receives request, determines the max group size (4) has been reached and rejects the request. MDEA of Traveler V creates new PMM Request for a new Group DEF.			
14	Simulated Transit Vehicle receives new Ride Request.	Ride Request Monitor identifies a new PMM request with the Origin, Departure Time, Seat Type, Vehicle route and Vehicle Type requested.			
15	VEA Accepts the new PMM Request displayed on VEA.	VEA accepts new PMM Request. Group DEF Leader receives a PMM-RSP from VEA indicating it has accepted PMM Request for one (1) seat.			
15	Ad-Hoc Travel Group Member W walks away from the transit stop exceeding the simulated transit stop range (e.g., 200 meters). 75 m was selected as range from simulated transit stop for ease of testing.	Ad-Hoc Travel Group Leader's MDEA detects change in group. Ad-Hoc Travel Group Leader's MDEA automatically updates PMM with number of seats requested and sends it to the Vehicle via DSRC/Cellular.			
16	Simulated Transit Vehicle Receives Updated Ride Request.	The VEA accepts the request.			
17	VEA enters acceptance of updated PMM into VEA.	VEA sends a PMM-RSP message via DSRC. MDEA is notified with Accepted PMM request.			
18	Ad-Hoc Travel Group Member Z requests to leave the Travel Group by submitting cancel request manually.	Ad-Hoc Travel Group Leader's Mobile Device receives the cancel request via cloud. Ad-Hoc Travel Group Leader's Mobile Device automatically creates and sends an updated (group) PMM to Vehicle via DSRC/cellular.			

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
19	VEA Receives Updated Ride Request.	The VEA accepts the request.			
20	VEA enters acceptance of updated PMM into VEA.	VEA sends a PMM-RSP message via DSRC. MDEA is notified with Accepted PMM request.			
21	Traveler V requests to leave the Travel Group DEF by submitting cancel request manually.	Traveler V's Mobile Device automatically creates and sends an updated (group) PMM to Vehicle via DSRC/cellular.			
22	VEA Receives Updated Ride Request.	The VEA accepts the request.			
23	VEA enters acceptance of updated PMM into VEA.	VEA sends a PMM-RSP message via DSRC. MDEA is notified with Accepted PMM request for zero travelers thus cancelling the trip request.			
24	Simulated Transit Vehicle approaches and arrives at Simulated Transit stop.	VEA sends PMM-ARRIVE with location and arrival time to Group Leader MDEA via DSRC of Group ABC. Group ABC leader's MDEA forwards the Arrival message to the followers. The MDEAs notify all travelers about the vehicle arrival using a display.			
25	Ad-Hoc Travel Group (Traveler X and Traveler Y) enters Vehicle.	None			
26	Simulated Transit Vehicle starts moving	MDEA updates its vehicle status to "In Vehicle" within 10 seconds of the vehicle start time. MDEA sends Coordination End message to all Travel Group members to disband group. Log of "Uncoordinated" status will show on Group Leader MDEA and a Status of "In Vehicle".			

5.4.5 Message Logging

Test Case

Test Case ID	5.4.5.1
Test Case Name	MGL – RSU DSRC Message Logging
Test Objective	• Verify all DRSC messages are logged and timestamped
System Requirement	FR 10.01, SIR 16.01, SIR 20.05, PR 1.20, PR 1.21, PR 1.23, PR 1.24
Verification Method	Test
Test Method/ Configuration Comments	• Access to database on RSU • Access to a database browser tool

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	Query the RSU database to verify that DSRC messages are being logged by executing the query: _____	The query returns data for all DSRC messages that are logged including the millisecond-based timestamps of when the message was transmitted.			

Test Case

Test Case ID	5.4.5.2
Test Case Name	MGL – Cloud Service Message Logging
Test Objective	• Verify all messages are logged and timestamped in the Cloud
System Requirement	FR 10.02, SIR 16.02
Verification Method	Test
Test Method/ Configuration Comments	• Access to database on Azure Cloud Service • Access to a Cloud Service Studio to view data

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	Query the Azure database to verify that cellular messages are being logged by executing the query: Select * from PMMRequests where RequestDate > “TBD” and RequestDate < “TBD”; Select * from PMMResponses where RequestDate > “TBD” and RequestDate < “TBD”.	The query returns data for all cellular messages that are logged including the millisecond-based timestamps of when the message was transmitted.			

Test Case

Test Case ID	5.4.5.3
Test Case Name	MGL – Mobile Device Experimental Application Message Logging
Test Objective	• Verify all sent and received mobile device messages are logged and timestamped • Verify all messages displayed to the users on the mobile device are logged
System Requirement	FR 10.03, FR 10.04
Verification Method	Test
Test Method/ Configuration Comments	• Access to database on Mobile Device • Access to SQLiteManager

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	Query the MDEA's database to verify messages being logged by executing the query:	The query returns data for all sent and received messages including the millisecond-based timestamps of when the message was transmitted.			
2	View the message activity log.	All message displayed to the users are logged with timestamps of occurrence.			

Test Case

Test Case ID	5.4.5.4
Test Case Name	MGL – Vehicle Experimental Application Message Logging
Test Objective	• Verify all messages sent and received by the vehicle are logged and timestamped • Verify all messages displayed to the driver of the vehicle are logged
System Requirement	FR 10.05, FR 10.06
Verification Method	Test
Test Method/ Configuration Comments	• Access to Vehicle Experimental Application log files • Access to Vehicle Experimental Application database • Access to Application Admin Portal • Access to a database browser tool

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	Query the VEA's database to verify messages being logged by executing the query:	The query returns data for all sent and received messages including the millisecond-based timestamps of when the message was transmitted.			
2	View the message activity log.	All message displayed to the users are logged with timestamps of occurrence.			

5.4.6 Safety

Test Case

Test Case ID	5.4.6.1
Test Case Name	SFY – Safety Notifications (Mobile Device User in Unsafe Zone)
Test Objective(s)	• Verify the ability of the MDEA to provide an advisory notification to the pedestrian • Verify the ability of the VEA to provide an advisory notification to the driver • Verify the ability of the MDEA to provide an alert notification to the pedestrian • Verify the ability of the VEA to provide an alert notification to the driver • Verify the ability of the MDEA to provide a warning notification to the pedestrian • Verify the ability of the VEA to provide a warning notification to the driver
System Requirement	FR 11.01, FR 11.02, FR 11.03, FR 11.04, FR 11.05, FR 11.06
Verification Method	Test
Test Method/ Configuration Comments	• DSRC capable hardware is installed on the vehicle and the VEA application is installed • DSRC capable hardware is connected to the mobile device and the MDEA application is installed • The pedestrian must be holding the mobile device in the path of the vehicle

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	The Light-Duty vehicle accelerates up to 25 mph.	None			
2	The Light-Duty vehicle maintains constant speed of 25 mph.	None			
3	The Light-Duty vehicle comes within 100 meters of the mobile device. (The Light-Duty vehicle is moving toward the pedestrian.)	Mobile device issues advisory to pedestrian. This is verified by inspection of the MDEA and detailed analysis of the MDEA Logs. Light-Duty Vehicle issues advisory to driver. This is verified by inspection of the VEA and detailed analysis of the VEA Logs.			
4	The Light-Duty vehicle comes within 57 meters of the mobile device. (The Light-Duty vehicle is moving toward the pedestrian.)	Mobile device issues alert to pedestrian. This is verified by inspection of the MDEA and detailed analysis of the MDEA Logs. Light-Duty Vehicle issues alert to driver. This is verified by inspection of the VEA and detailed analysis of the VEA Logs.			
5	The Light-Duty vehicle comes within 49 meters of the mobile device. (The Light-Duty vehicle is moving toward the pedestrian.)	Mobile device issues warning to pedestrian. This is verified by inspection of the MDEA and detailed analysis of the MDEA Logs. Light-Duty Vehicle issues warning to driver. This is verified by inspection of the VEA and detailed analysis of the VEA Logs.			

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
6	The Light-Duty vehicle passes the location where the pedestrian is standing. (The Light-Duty vehicle is moving away from the pedestrian.)	Mobile device ceases issuing warning to pedestrian. Mobile device ceases issuing alert to pedestrian. This is verified by inspection of the MDEA and detailed analysis of the MDEA Logs. Light-Duty Vehicle ceases issuing warning to driver. Light-Duty Vehicle ceases issuing alert to driver. This is verified by inspection of the VEA and detailed analysis of the VEA Logs.			
7	The Light-Duty vehicle continues until it is more than 25 meters of the mobile device.	Mobile device does not issue advisory to pedestrian. This is verified by inspection of the MDEA and detailed analysis of the MDEA Logs. Light-Duty Vehicle does not issue advisory to driver. This is verified by inspection of the VEA and detailed analysis of the VEA Logs.			
8	The Light-Duty vehicle decelerates to a stop.	None			

5.4.7 SPAT and MAP Support

Test Case

Test Case ID	5.4.7.1
Test Case Name	SMP – SPAT and MAP message support
Test Objective(s)	• Verify the ability of the MDEA to receive SPAT and MAP messages
System Requirement	SIR 9.01, SIR 9.02, SIR 9.03, SIR 10.01, SIR 10.02, SIR 10.03, SIR 10.04, SIR 15.10, SIR 15.11, PR 1.01, PR 1.02, PR 1.15, PR 2.02
Verification Method	Testing
Test Method/ Configuration Comments	• Availability of an RSU connected to a Signal Controller to broadcast SPAT and MAP messages • DSRC capable hardware is connected to the mobile device and the MDEA application is installed • Tablet running CV Inspector application to verify DSRC messages

Test Script

Step	Test Action	Expected Results	Pass/Fail		Actual Results
			P	F	
1	Observe signal controller and CV Inspector to monitor the simulated signal status.	CV Inspector display reflects the status of the simulated signal controller phases and actuations on a map using the SPAT and MAP message data.			
2	Inspect MDEA log for SPAT and MAP messages.	SPAT and MAP messages are logged at 1 second and 5 second frequencies respectively.			

Appendix A. Requirements Traceability Matrix

Appendix A contains matrices that relate the test cases with various requirements presented in the SysRS document associated with this project. Only requirements that are specified as being included in the Prototype System (defined in the SysRS document) are included in this section. Furthermore, the method by which each requirement is verified is listed in the *Verification Method* column. The four fundamental methods along with a general explanation of each is listed below[1].

- Test: Direct measurement of system operation. Defined inputs are provided and outputs are measured to verify that the requirements have been met.
- Demonstration: Witnessing system operation in the expected or simulated environment without need for measurement data.
- Inspection: Direct observation of requirements such as construction features, workmanship, dimensions and other physical characteristics, and software language.
- Analysis: Verification using logical, mathematical, and/or graphical techniques. Analysis is frequently used when verification by test would not be feasible or would be prohibitively expensive.

[1] U.S.D.O.T. Systems Engineering for Intelligent Transportation Systems. An Introduction for Transportation Professionals. http://ops.fhwa.dot.gov/publications/seitsguide/seguide.pdf

Functional Requirements

The functional requirements to enable Mobile Devices to operate in the Connected Vehicle environment are defined in the next table.

Table A-1. Functional Requirements Table

FR ID	Functional Requirement Title	Functional Requirement Description	Test Case #	Verification Method
FR 1.0 Personal Safety Message (PSM) Functional Requirements				
FR 1.01	Broadcasting PSMs	Mobile Devices shall broadcast PSMs via DSRC communications media.	5.4.1.1	Test
FR 1.02	PSM Broadcasting Frequency	Mobile Devices shall be able to send PSMs in configurable transmission intervals in 0.1 second frequency intervals.	5.4.1.1	Test
FR 1.03	Stop broadcasting PSMs	Mobile Devices shall stop broadcasting PSMs when the mobile device has detected to have entered a vehicle.	5.4.1.2	Test
FR 1.04	Restarting broadcasting PSMs	Mobile Devices shall automatically restart the broadcast of the PSMs when exiting a vehicle.	5.4.1.2	Test
FR 1.05	Stop broadcasting PSMs	Mobile Devices shall stop broadcasting PSMs when the mobile device has coordinated with a group leader (for crossing street or taxi/transit service). The sub-requirement below contains an exception to this rule.	5.4.1.3	Test
FR 1.06	Sending PSMs when in unsafe zone	A mobile device shall broadcast PSMs when the mobile device has detected that the pedestrian is in an unsafe zone. *NOTES:* *An "Unsafe Zone" is in a lane in which vehicle may travel including a roadway shoulder, a pedestrian crosswalk, or any area within one meter of the edge of the roadway* *A "Safe Zone" is on a sidewalk or zone in which a vehicle must cross a physical obstacle to collide with pedestrian*	5.4.1.4	Test
FR 1.08	PSM Transmit Timing	Mobile Devices shall transmit PSMs only when the mobile device determines a vehicle is within a specified radius of the mobile device. The specified radius is dependent on the vehicle's speed. The radius calculation is the same as the advisory display distance. Note: This is in accordance with the J2945-9, Clause 6.3.3 standard.	5.4.1.1	Test

Table A-1. Functional Requirements Table (Continued)

FR ID	Functional Requirement Title	Functional Requirement Description	Test Case #	Verification Method
FR 2.0 Personal Mobility Message (PMM) Functional Requirements				
FR 2.01	Creating PMMs	A user of a mobile device shall be provided with an interface into the MDEA to enter trip request information.	5.4.2.1	Test
FR 2.01.01	Generating PMM Content	A user of a mobile device shall be able to enter their desired pickup time, pickup location, number of passengers included in the trip request, and mobility needs such as number of wheelchairs in party as part of the trip request information (PMM).	5.4.2.1	Test
FR 2.02	Sending PMMs	A mobile device shall send a PMM to an entity that can process the trip request. *Note: the PMM could be sent either to a dispatching center or directly to a vehicle.*	5.4.2.1	Test
FR 2.03	Transmitting PMMs over various communications media	A mobile device shall broadcast a PMM via various communications media, as defined by the following sub-requirements.	5.4.2.1 5.4.2.2 5.4.2.3	Test
FR 2.03.01	Transmitting PMMs – First Attempt – Communicate Directly with Vehicles in DSRC Range	A mobile device shall broadcast a PMM first over DSRC to potential passenger-transporting vehicles	5.4.2.1	Test
FR 2.03.02	Transmitting PMM – Second Attempt – Communicate with RSE via DSRC	If no response is received within a configurable amount of time from a passenger-transportation and responding vehicle, a mobile device shall broadcast the PMM to an RSE (connected to cloud infrastructure) via DSRC.	Not supported by the Prototype	
FR 2.03.03	Transmitting PMM – Third Attempt – Communicate with RSE via Wi-Fi Direct	If no response is received within a configurable amount of time via an RSE, a mobile device shall broadcast the PMM to an RSE (connected to cloud infrastructure) via Wi-Fi Direct.	Not supported by the Prototype	
FR 2.03.04	Transmitting PMM – Fourth Attempt – Communicate with Cloud Infrastructure via cellular	If no response is received within a configurable amount of time via DSRC, a mobile device shall send the PMM over cellular communications media to either a passenger-transport vehicle or a vehicle dispatch center, which in turn would dispatch a suitable vehicle.	5.4.2.2	Test
FR 2.04	Receiving a PMM acknowledgement receipt via DSRC	A mobile device shall be able to receive a PMM acknowledgement via DSRC.	5.4.2.1	Test

Table A-1. Functional Requirements Table (Continued)

FR ID	Functional Requirement Title	Functional Requirement Description	Test Case #	Verification Method
FR 2.05	Receiving a PMM acknowledgement receipt via cellular	A mobile device shall be able to receive a PMM acknowledgement via cellular communications media.	5.4.2.2	Test
FR 2.06	Generating PMM Response content	The PMM acknowledgement shall include the PMM Request ID of the original PMM trip request and an indicator whether the responding vehicle supports DSRC as a communications media.	5.4.2.1 5.4.2.2	Test
FR 2.07	Updating a PMM	A mobile device shall be able to create and transmit an updated PMM if new travelers have joined or left an ad-hoc travel group while ensuring that the PMM maintains its PMM unique identification number.	5.4.4.1	Test
FR 2.08	Manually cancelling a PMM	A mobile device shall be able to transmit a trip cancellation by setting pedestrian count to 0 in PMM-Request.	5.4.2.3	Test
FR 2.09	Sending a PMM arrival message	A vehicle shall be able to create and transmit a PMM-ARRIVE message to the mobile device of the original PMM trip request at pre-configured intervals.	5.4.2.4	Test
FR 2.10	Receiving a PMM arrival message	A mobile device shall be able to receive a PMM-ARRIVE message from the vehicle responding to the original PMM trip request.	5.4.2.4	Test
FR 4.0 Basic Safety Message (BSM) Functional Requirements (those applicable to the Sharing Data between Mobile Devices, Connected Vehicles and Infrastructure project)				
FR 4.01	Generating BSMs	Equipped vehicles shall be able to generate BSMs.	5.4.3.1	Test
FR 4.01.01	Generating BSM Content	Equipped vehicles shall be able to generate BSM content including vehicle location, vehicle speed, vehicle heading, and vehicle size, as a minimum.	5.4.3.1	Test
FR 4.02	Broadcasting BSMs	Equipped vehicles shall be able to transmit BSMs to other equipped vehicles, equipped Mobile Devices, and other entities via DSRC communications media.	5.4.3.1	Test
FR 4.03	Receiving BSMs	Mobile Devices and equipped vehicles shall be able to receive BSMs broadcasted by vehicles via DSRC communications media.	5.4.3.1	Test

Table A-1. Functional Requirements Table (Continued)

FR ID	Functional Requirement Title	Functional Requirement Description	Test Case #	Verification Method
FR 5.0 Ad-Hoc Travel Group Functional Requirements				
FR 5.01	Sending mobile device itinerary to other Mobile Devices	A mobile device shall be able to send its active PMM to other Mobile Devices via Wi-Fi-Direct communications media. *Note: Wi-Fi-Direct method was replaced with cellular/Cloud as an approved system enhancement. This requirement is therefore interpreted to apply to cellular/Cloud.*	5.4.4.1	Test
FR 5.02	Requesting the creation of an ad-hoc travel group	A mobile device shall automatically transmit a coordination request message to other Mobile Devices with the same PMM information in terms of departure location, departure time, and destination location to request the creation of an ad-hoc travel message. *Note: for the EPS, the same itinerary means the exact same itinerary. Future research will have to determine whether locations along the path of a traveler are suitable to qualify for 'same' itinerary.*	5.4.4.1	Test
FR 5.03	Generating Travel Group Coordination Confirmation Message	A mobile device shall be able to generate and send an ad-hoc travel group coordination confirmation.	5.4.4.1	Test
FR 5.03.01	Generating Travel Group Coordination Confirmation Message Content	A mobile device shall be able to generate the coordination confirmation message content including the travel group creation request identifier, a travel group identifier, and a group status indicator.	5.4.4.1	Test
FR 5.04	Determining an ad-hoc travel group travel leader	The first mobile device to send a coordination confirmation message shall automatically become the travel group leader.	5.4.4.1	Test
FR 5.05	Limiting travel group size	The EPS shall include a capability within a mobile device's MDEA to limit the number of Mobile Devices that can be joined into an ad-hoc travel group.	5.4.4.1	Test
FR 5.06	Generating Travel Group Coordination Message	A mobile device shall be able to generate an ad-hoc travel group Coordination Message.	5.4.4.1	Test
FR 5.06.01	Generating Travel Group Coordination Message Content	A mobile device shall be able to generate the Coordination Message content including the travel group identifier, and a group status indicator.	5.4.4.1	Test

Table A-1. Functional Requirements Table (Continued)

FR ID	Functional Requirement Title	Functional Requirement Description	Test Case #	Verification Method
FR 5.07	Maintaining an ad-hoc travel group	A mobile device shall send a Coordination Message (coordination heartbeat message) to the travel group leader mobile device within a configurable frequency.	5.4.4.1	Inspect
FR 5.08	Leaving an ad-hoc travel group based on distance	The travel group leader's mobile device shall detect when another mobile device within the ad-hoc travel group leaves the travel group by exceeding the configurable distance between the transit stop and the leaving group member and then automatically creates and sends an updated (group) PMM. *Note This might be simulated via a manual input into and sent from the leaving mobile device during the demonstration*.	5.4.4.1	Test
FR 5.09	Leaving an ad-hoc travel group based on request	The travel group leader's mobile device shall detect when another mobile device within the ad-hoc travel group requests to leave the travel group and then automatically creates and sends an updated (group) PMM. *Note This might be simulated via a manual input into and sent from the leaving mobile device during the demonstration*.	5.4.4.1	Test
FR 5.10	Disbanding an ad-hoc travel group when entering a vehicle	A mobile device shall be able to detect when it enters a vehicle and automatically disjoin the ad-hoc travel group it belonged to (effectively dissolving the ad-hoc travel group).	5.4.4.1	Test
FR 5.11	Normal disbanding an ad-hoc travel group	The travel group leader's mobile device shall generate and send a coordination end message to all other Mobile Devices within the ad-hoc travel group when the group is to be dissolved for any other reasons than entering a vehicle and the distance between the travel group leader's mobile device and that of a group member exceeding a configurable distance. (example: Leader exceeds configurable distance from transit stop) *Note This will be simulated via a manual input into and send from the travel group leader's mobile device during the demonstration*.	5.4.4.1	Test
FR 6.0 Entering and Leaving Light-Duty Vehicle Functional Requirements				
FR 6.01	Detecting when entering DSRC equipped Light-Duty vehicle	A mobile device shall be able to detect when it enters a DSRC-equipped Light-Duty vehicle.	5.4.1.2	Test

Table A-1. Functional Requirements Table (Continued)

FR ID	Functional Requirement Title	Functional Requirement Description	Test Case #	Verification Method
FR 6.02	Detecting when entering non-DSRC equipped Light-Duty vehicle	A mobile device shall be able to detect when it enters a non-DSRC-equipped Light-Duty vehicle.	5.4.1.2	Test
FR 6.03	Detecting when exiting DSRC equipped Light-Duty vehicle	A mobile device shall be able to detect when it exits a DSRC-equipped Light-Duty vehicle.	5.4.1.1	Test
FR 6.04	Detecting when exiting non-DSRC equipped Light-Duty vehicle	A mobile device shall be able to detect when it exits a non-DSRC-equipped Light-Duty vehicle.	5.4.1.2	Test
FR 7.0 Entering and Leaving Transit Vehicle Functional Requirements				
FR 7.01	Detecting when entering DSRC equipped Transit Vehicle	A mobile device shall be able to detect when it enters a DSRC-equipped Transit Vehicle.	5.4.1.2	Test
FR 7.02	Detecting when entering non-DSRC equipped Transit Vehicle	A mobile device shall be able to detect when it enters a non-DSRC-equipped Transit Vehicle.	5.4.1.2	Test
FR 7.04	Detecting when exiting DSRC equipped Transit Vehicle	A mobile device shall be able to detect when it exits a DSRC-equipped Transit Vehicle.	5.4.1.2	Test
FR 7.05	Detecting when exiting non-DSRC equipped Transit Vehicle	A mobile device shall be able to detect when it exits a non-DSRC-equipped Transit Vehicle.	5.4.1.2	Test
FR 10.0 Message Logging Functional Requirements				
FR 10.01	Recording all DSRC communications within RSE	A RSU (both intersection and transit stop-based) shall record all messages transmitted via DSRC communications media using millisecond-based timestamps of occurrence.	5.4.5.1	Test
FR 10.02	Recording all cellular communications via cloud infrastructure system	The cloud infrastructure shall capture and record all messages sent via cellular communications media using millisecond-based timestamps of occurrence.	5.4.5.2	Test
FR 10.03	Recording all sent and received communications within Mobile Device	A mobile device shall record all messages transmitted and received over any communications media using millisecond-based timestamps of occurrence.	5.4.5.3	Test
FR 10.04	Recording all displayed messages within Mobile Device	A mobile device shall record any information output to the screen of the mobile device using millisecond-based timestamps of occurrence.	5.4.5.3	Test

Table A-1. Functional Requirements Table (Continued)

FR ID	Functional Requirement Title	Functional Requirement Description	Test Case #	Verification Method
FR 10.05	Recording all sent and received communications within Vehicle	A vehicle shall record all messages transmitted and received over any communications media using millisecond-based timestamps of occurrence.	5.4.5.4	Test
FR 10.06	Recording all displayed messages within vehicle	A vehicle shall record any information output to the screen of the vehicle's on-board device using millisecond-based timestamps of occurrence.	5.4.5.4	Test
FR 11.0 Safety Functional Requirements (applicable to the Prototype System)				
FR 11.01	Displaying Advisory within Vehicle	A vehicle shall display an advisory to the vehicle driver when it receives a PSM and determines that it is approaching the mobile device and the mobile device is in an unsafe zone. The alert is displayed. The distance (between vehicle and mobile device) at which an alert is displayed is dependent on the vehicle's speed, explained in Appendix C of the SysRS.	5.4.6.1	Test
FR 11.02	Displaying Alert within Vehicle	A vehicle shall display an alert to the vehicle driver when the vehicle receives a PSM and determines that it is approaching the mobile device and the mobile device is in an unsafe zone. The alert is displayed. The distance (between vehicle and mobile device) at which an alert is displayed is dependent on the vehicle's speed, explained in Appendix C of the SysRS.	5.4.6.1	Test
FR 11.03	Displaying Warning within Vehicle	A vehicle shall display a warning to the vehicle driver when the vehicle receives a PSM and determines that it is approaching the vulnerable road user and the vulnerable road user is in the vehicle's lane of travel. The distance (between vehicle and mobile device) at which a warning is displayed is dependent on the vehicle's speed, explained in Appendix C of the SysRS.	5.4.6.1	Test
FR 11.04	Displaying Advisory within Mobile Device	A mobile device shall display an advisory when it has received a BSM and determines that a vehicle is approaching. The distance (between vehicle and mobile device) at which an advisory is displayed is dependent on the vehicle's speed, explained in Appendix C of the SysRS.	5.4.6.1	Test

Table A-1. Functional Requirements Table (Continued)

FR ID	Functional Requirement Title	Functional Requirement Description	Test Case #	Verification Method
FR 11.05	Displaying Alert within Mobile Device	A mobile device shall display an alert when it has received a BSM and determines that a vehicle is approaching and the mobile device is in an unsafe zone. The distance (between vehicle and mobile device) at which an alert is displayed is dependent on the vehicle's speed, explained in Appendix C of the SysRS.	5.4.6.1	Test
FR 11.06	Displaying Warning within Mobile Device	A mobile device shall display an alert when it has received a BSM and detects that a vehicle is approaching and the mobile device is in the vehicle's lane of travel. The distance (between vehicle and mobile device) at which a warning is displayed is dependent on the vehicle's speed, explained in Appendix C of the SysRS.	5.4.6.1	Test

Source: Battelle

System Interface Requirements

As specified above the system requirements below only include those required for use within the Prototype System Acceptance Tests.

Table A-2. System Interface Requirements Table

SIR ID	System Interface Requirement Title	System Interface Requirement Description	Test Case #	Verification Method
SIR 1.0 Personal Safety Message (PSM) Requirements				
SIR 1.01	PSM Broadcasting Frequency	The PSM shall be broadcasted in user-defined transmission intervals adjustable in 0.1 second intervals. *Note: This is consistent with SAE J2735 standard for broadcast frequency, although the frequency is not defined (unlike the BSM where the frequency is required to be 0.1 seconds).*	5.4.1.1	Inspection
SIR 1.02	PSM Location (lat/long/elev)	The PSM shall specify the pedestrian location expressed in 1/10th integer microdegrees (longitude and latitude with reference to the horizontal datum). Elevation shall be expressed in signed units of 10 cm steps above or below the reference ellipsoid. *Note: This is consistent with SAE J2735 PSM definition for location.*	5.4.1.1	Inspection
SIR 1.03	PSM Speed	The PSM shall specify the pedestrian speed in meters/second in 0.1 m/s increments. *Note: This is consistent with the SAE J2735 PSM definition for speed.*	5.4.1.1	Inspection
SIR 1.04	PSM Heading	The PSM shall specify the pedestrian heading, expressed in signed units of 0.0125 degrees from North (same units as in BSMs). *Note: This is consistent with SAE J2735 PSM definition for heading.*	5.4.1.1	Inspection
SIR 1.05	PSM Number of Pedestrians	The PSM shall specify a number of travel group members included in the PSM. *Note: This field will increase/decrease as travelers join/disband from a travel group. The group leader would be sending a PSM for the entire group. There is an optional field in the SAE J2735 PSM definition called 'NumberOfParticipantsInCluster' but only defines small (2-5 people), medium (6-10 people), or large groups (>10).*	5.4.1.1 5.4.1.3	Inspection

Table A-2. System Interface Requirements Table (Continued)

SIR ID	System Interface Requirement Title	System Interface Requirement Description	Test Case #	Verification Method
SIR 1.06	PSM Radius of Protection	The PSM shall specify a 'radius of protection' expressed in 0.1 meter increments that is reflective of the number of pedestrians included in the PSM. *Note: This is consistent with SAE J2735 PSM definition for PersonalClusterRadius defining the radius in meters around a cluster of users.*	5.4.1.1	Inspection
SIR 1.07	PSM Radius of Protection expandable	The PSM 'radius of protection' shall be expandable, depending on *the number of pedestrians included in the PSM.* *Note: This is consistent with SAE J2735 PSM definition for PersonalClusterRadius defining the radius in meters around a cluster of users.*	5.4.1.1 5.4.1.3	Inspection
SIR 1.08	PSM Path History	The PSM shall specify the pedestrian path history for up to the last 20 seconds. *Note: This is consistent with SAE J2735 PSM definition for path history although J2735 does not specify the length of the path history to include. We are limiting this to 20 seconds and even that might be too long for this project*	5.4.1.1	Inspection
SIR 1.09	PSM Path Prediction	The PSM shall specify the pedestrian path prediction for up to the next 5 seconds. *Note: This is consistent with SAE J2735 PSM definition for path prediction, although J2735 does not specify the prediction time into the future. We are limiting this to 5 seconds because non-motorized travel is highly variable and hard to predict.*	5.4.1.1	Inspection
SIR 2.0 Personal Mobility Message (PMM) Requirements				
SIR 2.01	PMM Request ID	The PMM shall specify a unique Request ID.	5.4.2.1	Inspection
SIR 2.02	PMM Location (lat/long/elev)	The PMM shall specify the pedestrian location expressed in 1/10th integer microdegrees (longitude and latitude with reference to the horizontal datum). Elevation shall be expressed in signed units of 10 cm steps above or below the reference ellipsoid.	5.4.2.1	Inspection
SIR 2.03	PMM Number of Travelers	The PMM shall specify the number of travelers included in the PMM.	5.4.2.1	Inspection
SIR 2.04	PMM Pickup Time	The PMM shall specify the pickup time expressed in Universal Coordinated Time (UTC) in 0.1 second increments.	5.4.2.1	Inspection

Table A-2. System Interface Requirements Table (Continued)

SIR ID	System Interface Requirement Title	System Interface Requirement Description	Test Case #	Verification Method
SIR 2.05	PMM Pickup Location	The PMM shall specify the pickup location expressed in 1/10th integer microdegrees (longitude and latitude with reference to the horizontal datum). *NOTE: this does not define how a mobile device user might actually select the location via the display of the mobile device.*	5.4.2.1	Inspection
SIR 2.06	PMM Destination	The PMM shall specify destination location expressed in 1/10th integer microdegrees (longitude and latitude with reference to the horizontal datum). *NOTE: this does not define how a mobile device user might actually select the location via the display of the mobile device.*	5.4.2.1	Inspection
SIR 2.07	PMM Mode of Transport	The PMM shall specify a preferred method of desired transportation from the following (values are mutually exclusive): • Transit • Taxi • Ride-sharing service • No preference	5.4.2.1	Inspection
SIR 2.08	PMM Mobility Needs	The PMM shall specify any mobility needs requirements from the following (values are not mutually exclusive): • Wheelchair • Needs Seat • No special needs *NOTE: other mobility needs can be listed within an updated version at a later time.*	5.4.2.1	Inspection
SIR 3.0 Personal Mobility Acknowledgement Message (PMM-RSP) Requirements				
SIR 3.01	PMM-RSP Request ID	The PMM-RSP shall contain the same unique Request ID used in the PMM to which the PMM-RSP responds.	5.4.2.1	Inspection
SIR 3.02	PMM-RSP Location	The PMM-RSP shall specify the location of the vehicle responding to the PMM, expressed in 1/10th integer microdegrees (longitude and latitude with reference to the horizontal datum). Elevation shall be expressed in signed units of 10 cm steps above or below the reference ellipsoid.	5.4.2.1	Inspection

Table A-2. System Interface Requirements Table (Continued)

SIR ID	System Interface Requirement Title	System Interface Requirement Description	Test Case #	Verification Method
SIR 3.03	PMM-RSP DSRC Support Indicator	The PMM-RSP shall specify whether the responding vehicle is capable of sending BSM and other messages over DSRC with allowable values of: • 0 = no DSRC support • 1 = DSRC support	5.4.2.1	Inspection
SIR 4.0 Personal Mobility Cancel Message (PMM-CANCEL) Requirements				
SIR 4.01	PMM-CANCEL Request ID	The PMM-CANCEL shall contain the same unique Request ID used in the PMM to which the PMM-CANCEL responds.	5.4.2.3	Inspection
SIR 5.0 Personal Mobility Arrival Estimate Message (PMM-ARRIVE) Requirements				
SIR 5.01	PMM-ARRIVE Request ID	The PMM-ARRIVE shall contain the same unique Request ID used in the PMM to which the PMM-ARRIVE responds.	5.4.2.4	Inspection
SIR 5.02	PMM-ARRIVE Location (lat/long/elev)	The PMM-ARRIVE shall specify the location of the vehicle responding to the PMM, expressed in 1/10th integer microdegrees (longitude and latitude with reference to the horizontal datum).	5.4.2.4	Inspection
SIR 5.04	PMM-ARRIVE Visible Vehicle ID	The PMM-ARRIVE shall specify a visible indication of the vehicle responding to the PMM, expressed as free form text. *Note: this text field will only be completed once by the vehicle operator and will be used by the receiving PMM-originating mobile device so that the traveler can visibly identify the vehicle.*	5.4.2.4	Inspection
SIR 7.0 Basic Safety Message (BSM) Requirements (those applicable to the Prototype System)				
SIR 7.01	BSM Location (lat/long/elev)	The BSM shall specify the vehicle location expressed in 1/10th integer microdegrees (longitude and latitude with reference to the horizontal datum). Elevation shall be expressed in signed units of 10 cm steps above or below the reference ellipsoid.	5.4.3.1	Inspection
SIR 7.02	BSM Speed	The BSM shall specify the vehicle speed in meters/second in 0.1 m/s increments.	5.4.3.1	Inspection

Table A-2. System Interface Requirements Table (Continued)

SIR ID	System Interface Requirement Title	System Interface Requirement Description	Test Case #	Verification Method
SIR 7.03	BSM Heading	The BSM shall specify the vehicle heading, expressed in unsigned units of 0.0125 degrees from North such that 28799 such degrees represent 359.9875 degrees. North shall be defined as the axis prescribed by the WGS-84 coordinate system and its reference ellipsoid. Headings "to the east" are defined as the positive direction. A value of 28800 shall be used when unavailable.	5.4.3.1	Inspection
SIR 7.04	BSM Vehicle Size	The BSM shall specify the width and length of the vehicle, expressed in 1 cm increments.	5.4.3.1	Inspection
SIR 8.0 Coordination Messages for Ad-Hoc Travel Groups Requirements				
SIR 8.01	Coordination Message types using the same travel group ID	Coordination message types for the same Ad-hoc Travel Group shall use the same unique, randomly assigned identification number for the duration that the ad-hoc travel group exists.	5.4.4.1	Inspection
SIR 8.02	Coordination Request Message ID	The coordination request message shall include a unique, randomly assigned identification number.	5.4.4.1	Inspection
SIR 8.03	Coordination Request Number of Requesters	The coordination request message shall specify the number of pedestrians included in the group making this request to join others in an Ad-hoc travel group.	5.4.4.1	Inspection
SIR 8.04	Coordination Request Pickup Time	The coordination request message shall specify the pickup time expressed in UTC time in 1 minute increments.	5.4.4.1	Inspection
SIR 8.05	Coordination Request Pickup Location (lat/long/elev)	The coordination request message shall specify the pickup location expressed in 1/10th integer microdegrees (longitude and latitude with reference to the horizontal datum). Elevation shall be expressed in signed units of 10 cm steps above or below the reference ellipsoid. *NOTE: this does not define how a mobile device user might actually select the location via the display of the mobile device.*	5.4.4.1	Inspection

Table A-2. System Interface Requirements Table (Continued)

SIR ID	System Interface Requirement Title	System Interface Requirement Description	Test Case #	Verification Method
SIR 8.06	Coordination Request Destination (lat/long/elev)	The coordination request message shall specify destination location expressed in 1/10th integer microdegrees (longitude and latitude with reference to the horizontal datum). Elevation shall be expressed in signed units of 10 cm steps above or below the reference ellipsoid. *NOTE: this does not define how a mobile device user might actually select the location via the display of the mobile device.*	5.4.4.1	Inspection
SIR 8.07	Coordination Request Mode of Transport	The coordination request message shall specify a preferred method of desired transportation from the following (values are mutually exclusive): • Transit • Taxi • Ride-sharing service • No preference	5.4.4.1	Inspection
SIR 8.10	Coordination Confirmation Message ID	The coordination confirmation message shall include the same unique, randomly assigned identification number as in the Coordination Request message.	5.4.4.1	Inspection
SIR 8.11	Coordination Confirmation Travel Group ID	The coordination confirmation message shall include a unique, randomly assigned identification number for an ad-hoc travel group, which is assigned by the travel group leader's mobile device.	5.4.4.1	Inspection
SIR 8.20	Coordination Heartbeat Message ID	The coordination heartbeat message shall include the same unique, randomly assigned identification number as in the Coordination Request message.	5.4.4.1	Inspection
SIR 8.21	Coordination Heartbeat Travel Group ID	The coordination heartbeat message shall include a unique, randomly assigned identification number for an ad-hoc travel group, which is assigned by the travel group leader's mobile device.	5.4.4.1	Inspection
SIR 8.22	Coordination Heartbeat Frequency	The coordination heartbeat message shall be send in user –definable.	5.4.4.1	Inspection
SIR 8.30	Coordination End Message ID	The coordination end message shall include the same unique, randomly assigned identification number as in the Coordination Request message.	5.4.4.1	Inspection

Table A-2. System Interface Requirements Table (Continued)

SIR ID	System Interface Requirement Title	System Interface Requirement Description	Test Case #	Verification Method
SIR 8.31	Coordination End Travel Group ID	The coordination end message shall include a unique, randomly assigned identification number for an ad-hoc travel group, which is assigned by the travel group leader's mobile device.	5.4.4.1	Inspection
SIR 9.0 Signal Phase and Timing (SPaT) Message Requirements				
SIR 9.01	SPaT Broadcasting Frequency	The SPaT Message shall be broadcasted once every second.	5.4.7.1	Inspection
SIR 9.02	Status of Signal Controller	The SPaT Message shall contain information regarding the status of the signal controller, including at a minimum, the cycle time, the current time in the cycle, and timing plans for all approaches, including pedestrians.	5.4.7.1	Inspection
SIR 9.03	Prediction of Duration and Phases	The SPaT Message shall contain a prediction of the timing and duration of upcoming phases.	5.4.7.1	Inspection
SIR 10.0 MAP Message Requirements				
SIR 10.01	MAP Broadcasting Frequency	The MAP Message shall be broadcasted once every 5 seconds.	5.4.7.1	Inspection
SIR 10.02	Geographic information for Lanes in Intersection	The MAP Message shall contain geographic information for all movements (connecting approaches) in the intersection.	5.4.7.1	Inspection
SIR 10.03	Geographic information for Lanes for approaches	The MAP Message shall contain geographic information for all lanes for all approaches.	5.4.7.1	Inspection
SIR 10.04	Types of Lanes	The MAP Message shall contain information about each lane type of each lane (e.g. vehicle, bike, pedestrian, etc.)	5.4.7.1	Inspection
SIR 15.0 Data Exchange Communications Media System Interface Requirements				
SIR 15.01	PSM over DSRC	The EPS shall support the exchange of PSM via DSRC communications media.	5.4.2.1	Inspection
SIR 15.02	PMM, PMM-RSP, PMM-CANCEL over DSRC	The EPS shall support the exchange of the PMM, PMM-RSP, and PMM-CANCEL via DSRC communications media.	5.4.2.1 5.4.2.3	Inspection
SIR 15.04	PMM, PMM-RSP, PMM-CANCEL over Cellular	The EPS shall support the exchange of the PMM, PMM-RSP, and PMM-CANCEL via cellular communications media.	5.4.2.2	Inspection
SIR 15.05	PMM-ARRIVE over DSRC	The EPS shall support the exchange of the PMM-ARRIVE via DSRC communications media.	5.4.2.4	Inspection

Table A-2. System Interface Requirements Table (Continued)

SIR ID	System Interface Requirement Title	System Interface Requirement Description	Test Case #	Verification Method
SIR 15.07	BSM over DSRC	The EPS shall support the exchange of the BSM via DSRC communications media.	5.4.3.1	Inspection
SIR 15.08	Any Coordination Message type over Wi-Fi-Direct	The EPS shall support the exchange of any Coordination Message type (Coordination Request, Coordination Confirmation, Coordination Heartbeat, and Coordination End messages) via Wi-Fi-Direct communications media. *Note: Wi-Fi-Direct method was replaced with cellular/Cloud as an approved system enhancement. This requirement is therefore interpreted to apply to cellular/Cloud.*	5.4.4.1	Inspection
SIR 15.09	Mobile Device Detection via Bluetooth iBeacon	The EPS shall support the detection of Bluetooth-enabled Mobile Devices via Bluetooth communications media using Bluetooth iBeacon technology when entering a Bluetooth iBeacon-equipped vehicle. *Note: Bluetooth detection method was replaced with Accelerometer sensor detection as an approved system enhancement. Therefore, this requirement no longer applies.*		
SIR 15.10	SPaT over DSRC	The EPS shall support the exchange of Signal Phase and Timing (SPaT) messages via DSRC communications media.	5.4.7.1	Inspection
SIR 15.11	MAP over DSRC	The EPS shall support the exchange of MAP messages via DSRC communications media.	5.4.7.1	Inspection
SIR 16.0 Recording Interface Requirements				
SIR 16.01	RSE to receive all DSRC communications	A RSU shall be able to receive all messages transmitted via DSRC communications media.	5.4.5.1	Inspection
SIR 16.02	Cloud Infrastructure equipment to receive all cellular communications	A cloud infrastructure equipment shall be able to receive all messages sent via cellular communications media.	5.4.5.2	Inspection
SIR 17.0 General System Interface Requirements				
SIR 17.01	Conform to existing, standardized data element definitions	The data elements used to transfer data from one EPS component to another shall be drawn from existing data exchange standards to the maximum extent possible.		Inspection
SIR 17.01.01	Use J2735:2016 if MSGs and DEs fulfill requirements	The data elements, if defined and fulfilling all other System Interface requirements, shall be drawn from existing interface standards and guidance documents including:		Inspection

Table A-2. System Interface Requirements Table (Continued)

SIR ID	System Interface Requirement Title	System Interface Requirement Description	Test Case #	Verification Method
		• SAE J2735:2016 published version • SAE J2945/1:2016 published version • SAE J2945/9 (November 2016 draft)		
SIR 20.0 Data Exchange Sequences				
SIR 20.01	Forming and Splitting of Travel Groups	Defines the data exchange sequence for forming and splitting of travel groups. This includes the ad-hoc determination of the travel 'group leader' mobile device, which will retain the communications with devices outside of the travel group.	5.4.4.1	Inspection
SIR 20.03	Requesting and Entering a Ride with a DSRC-equipped Light-Duty vehicle	Defines the data exchange sequence to request and enter a Light-Duty vehicle that has DSRC equipment on board.	5.4.1.2	Inspection
SIR 20.05	Requesting and Entering a Ride with a DSRC-equipped Transit Vehicle	Defines the data exchange sequence to request and enter a DSRC-equipped Transit Vehicle that is also equipped with a Bluetooth iBeacon. Note: Bluetooth detection method was removed in favor of accelerometer method as an approved system enhancement. Requirement is interpreted to apply to a Transit Vehicle that is not equipped with a Bluetooth iBeacon.	5.4.1.2	Inspection

Source: Battelle

Performance Requirements

As specified above the performance requirements below only include those required for use within the Experimental Prototype System (EPS) Acceptance Tests.

Table A-3. Performance Requirements Table

PR ID	Performance Requirement Title	Performance Requirement Description	Test Case #	Verification Method
PR 1.0 Mobile Device Performance Requirements				
PR 1.01	Mobile device lane level positioning accuracy	A mobile device shall detect the accuracy of its position. *Note: In order for applications to work as intended, it is expected that position can be estimated with Lane Level Positioning Accuracy, defined to be 30 cm.*	5.4.7.1	Inspection
PR 1.02	Mobile device unsafe zone detection accuracy	A mobile device shall detect whether the pedestrian is in an "unsafe zone". *NOTES:* - *An "Unsafe Zone" is in a lane in which vehicle may travel including a roadway shoulder, a pedestrian crosswalk, or any area within one meter of the edge of the roadway* - *A "Safe Zone" is on a sidewalk or zone in which a vehicle must cross a physical obstacle to collide with pedestrian*	5.4.7.1	Inspection
PR 1.03	Mobile device path history (20 secs)	A mobile device shall detect and record its path history for the last 20 seconds.	5.4.1.1	Inspection
PR 1.04	Mobile device path prediction (5 secs)	A mobile device shall predict and record its path for the next 5 seconds.	5.4.1.1	Inspection
PR 1.07	Mobile Device RF Performance Requirements	A mobile device shall conform to RF performance requirements for DSRC communications as outlined in SAE 2945-1, Clause 6.4 *Note: this Requirement is for any message sent/received via DSRC.*		Analysis
PR 1.11	Capture 90% of Coordination Messages sent over Wi-Fi-Direct	A mobile device shall receive and capture 90% of coordination messages transmitted over Wi-Fi-Direct communication media at a distance of 10 meters or less. *Note: Wi-Fi-Direct method was replaced with cellular/Cloud as an approved system enhancement. This requirement is therefore interpreted to apply to cellular/Cloud.*	All DSRC test cases	Analysis
PR 1.15	Display Message Content within 0.1 seconds after receipt of message content	A mobile device shall display message contents, whose information is to be displayed to the user, within 0.1 seconds after the message has been received by the mobile device.	5.4.7.1	Analysis

Table A-3. Performance Requirements Table (Continued)

PR ID	Performance Requirement Title	Performance Requirement Description	Test Case #	Verification Method
PR 1.16	Detecting when entering Light-Duty vehicle within 3 seconds of entering 90% of times	A mobile device shall be able to detect within 3 seconds of entering a Light-Duty vehicle 90% of the time. *Note: Accelerometer method is expected to meet a performance target of 10 seconds (after vehicle starts to move).*	5.4.1.2	Analysis
PR 1.17	Detecting when entering Light-Duty vehicle before vehicle has traveled 10 meters 90% of times	A mobile device shall be able to detect the entering of a Light-Duty vehicle before the vehicle has traveled 10 meters 90% of the time. *Note: The distance travelled by the vehicle is not deemed as the accurate parameter to verify the in-vehicle status of mobile device. This method is therefore interpreted to apply to time travelled in seconds.*		Analysis
PR 1.18	Detecting when exiting Light-Duty vehicle within 3 seconds of exiting 90% of times	A mobile device shall be able to detect within 3 seconds of exiting a Light-Duty vehicle 90% of the time. *Note: Accelerometer method is expected to meet a performance target of 10 seconds*	5.4.1.2	Analysis
PR 1.19	Detecting when exiting Light-Duty vehicle before vehicle has traveled 10 meters 90% of times	A mobile device shall be able to detect the exiting of a Light-Duty vehicle before the vehicle has traveled 10 meters 90% of the time. *Note: The distance travelled by the vehicle is not deemed as the accurate parameter to verify the in-vehicle status of mobile device. This method is therefore interpreted to apply to time travelled in seconds.*		Analysis
PR 1.20	Detecting when entering Transit Vehicle within 3 seconds of entering 90% of times	A mobile device shall be able to detect within 3 seconds of entering a Transit Vehicle 90% of the time. *Note: Accelerometer method is expected to meet a performance target of 10 seconds (after vehicle starts to move).*	5.4.1.2	Analysis
PR 1.21	Detecting when entering Transit Vehicle before vehicle has traveled 10 meters 90% of times	A mobile device shall be able to detect the entering of a Transit Vehicle before the vehicle has traveled 10 meters 90% of the time. *Note: The distance travelled by the vehicle is not deemed as the accurate parameter to verify the in-vehicle status of mobile device. This method is therefore interpreted to apply to time travelled in seconds.*	5.4.6.1	Analysis

Table A-3. Performance Requirements Table (Continued)

PR ID	Performance Requirement Title	Performance Requirement Description	Test Case #	Verification Method
PR 1.23	Detecting when exiting Transit Vehicle within 3 seconds of exiting 90% of times	A mobile device shall be able to detect within 3 seconds of exiting a Transit Vehicle 90% of the time. *Note: Accelerometer method is expected to meet a performance target of 10 seconds*	5.4.1.2	Analysis
PR 1.24	Detecting when exiting Transit Vehicle before vehicle has traveled 10 meters 90% of times	A mobile device shall be able to detect the exiting of a Transit Vehicle before the vehicle has traveled 10 meters 90% of the time. *Note: The distance travelled by the vehicle is not deemed as the accurate parameter to verify the in-vehicle status of mobile device. This method is therefore interpreted to apply to time travelled in seconds.*		Analysis
PR 2.0 Vehicle Performance Requirements				
PR 2.01	Vehicle RF Performance Requirements	A vehicle shall conform to RF performance requirements for DSRC communications as outlined in SAE 2945-1, Clause 6.4 *Note: This Requirement is for any message sent/received via DSRC.*	All DSRC test cases	Analysis
PR 2.02	Vehicle lane level positioning accuracy	A vehicle shall detect the accuracy of its position. *Note: In order for applications to work as intended, it is expected that position can be estimated with Lane Level Positioning Accuracy, defined to be 30 cm.*	5.4.7.1	Analysis
PR 3.0 Transit Stop RSE Performance Requirements				
PR 3.01	Transit Stop RSE RF Performance Requirements	A Transit Stop RSE shall conform to RF performance requirements for DSRC communications as outlined in SAE 2945-1, Clause 6.4 *Note: This Requirement is for any message sent/received via DSRC.*		Analysis
PR 4.0 Intersection RSE Performance Requirements				
PR 4.01	Intersection RSE RF Performance Requirements	An Intersection RSE shall conform to RF performance requirements for DSRC communications as outlined in SAE 2945-1, Clause 6.4 *Note: This Requirement is for any message sent/received via DSRC.*		Analysis
PR 5.0 Transmission Interface Performance Requirements				
PR 5.01	No interference between PSMs and BSMs	The transmission of PSMs shall not interfere with the transmissions of other PSM or with BSM messages.	5.4.1.1	Analysis
PR 5.02	No interference of PMMs with PSMs and BSMs	The transmission of PMMs shall not interfere with the transmissions of PSM or BSM messages.	5.4.1.3	Analysis

Table A-3. Performance Requirements Table (Continued)

PR ID	Performance Requirement Title	Performance Requirement Description	Test Case #	Verification Method
PR 5.03	No interference of Coordination Messages with PSMs and BSMs	The transmission of coordination messages for Ad-hoc Travel Groups shall not interfere with the transmissions of either PSM or BSM messages.	5.4.2.1 5.4.2.2 5.4.2.3	Analysis
PR 5.04	No interference of Coordination Messages with PMMs	The transmission of coordination messages for Ad-hoc Travel Groups shall not interfere with the transmissions of the different PMM message types.	5.4.2.1 5.4.2.2 5.4.2.3	Analysis
PR 5.06	No interference of Coordination Messages with Coordination Messages from another ad-hoc travel group	The transmission of coordination messages from an Ad-hoc Travel Group shall not interfere with the transmissions of coordination messages from another Ad-hoc Travel Group.	5.4.2.1 5.4.4.1	Analysis
PR 5.07	No interference of Coordination Messages with Coordination Messages from several other ad-hoc travel groups	The transmission of coordination messages from an Ad-hoc Travel Group shall not interfere with the transmissions of coordination messages from other Ad-hoc Travel Groups.		Analysis

Source: Battelle

Security Requirements

As specified above the security requirements below only include those required for use within the Experimental Prototype System (EPS) Acceptance Tests.

Table A-4. Security Requirements Table

SR ID	Security Requirement Title	Security Requirement Description	Test Case #	Verification Method
SR 1.0 DSRC Security Requirements				
SR 1.04	Comply with SAE Guidance Standards	The DSRC Radios within the Mobile Devices, vehicles, and RSUs shall comply with the relevant SAE J2945-1 requirements, which references other security-related standards. For example, IEEE 1602.2 is referenced in J2945-1, Clause 6.5.2 – BSM Signing. Additionally, the use of SCMS is referenced in J2945-1, Clause 6.6 – Security Management. NOTE: see Section 2.1 for the versions of the references standards that are applicable at the time this document was submitted.		Inspection

Source: Battelle

Note: The above requirements are objective (should) requirements due to the likelihood that the SCMS will not be available in time for EPS system deployment.

Data Requirements

As specified above the data requirements below only include those required for use within the Experimental Prototype System (EPS) Acceptance Tests.

Table A-5. Data Requirements Table

DR ID	Data Requirement Title	Data Requirement Description	Test Case #	Verification Method
DR 1.0 Mobile Device Data Requirements				
DR 1.01	Store all mobile device data transmissions for the duration of test plan execution	A mobile device shall be able to store all data exchanges / data transmissions regardless of the communications media sent during the execution of the entire test plan.		Inspection
DR 1.02	Store all mobile device screen displays for the duration of test plan execution	A mobile device shall be able to store all user-facing displays on the mobile device screen sent during the execution of the entire test plan.		Inspection
DR 2.0 Vehicle Data Requirements				
DR 2.01	Store all vehicle data transmissions for the duration of test plan execution	A vehicle shall be able to store all data exchanges / data transmissions regardless of the communications media sent during the execution of the entire test plan.		Inspection
DR 2.02	Store all vehicle screen displays for the duration of test plan execution	A vehicle shall be able to store all user-facing displays on the vehicle display screen sent during the execution of the entire test plan.		Inspection
DR 3.0 RSE Data Requirements				
DR 3.01	Store all RSE DSRC data transmissions	A roadside device (both intersection and transit stop-based) shall be able to store all DSRC data exchanges / data transmissions. *Note: The storage device should be able to store all data received via DSRC during a small-scale demonstration lasting less than 3 days.*		Inspection
DR 4.0 Cloud Infrastructure Data Requirements				
DR 4.01	Store all RSE cellular data transmissions for the duration of test plan execution	A device connected to the cloud infrastructure shall be able to store all cellular data exchanges / data transmissions sent during the execution of the entire test plan.		Inspection

Source: Battelle

Reliability Requirements

As specified above the reliability requirements below only include those required for use within the Experimental Prototype System (EPS) Acceptance Tests.

Table A-6. Reliability Requirements Table

RR ID	Reliability Requirement Title	Reliability Requirement Description	Test Case #	Verification Method
RR 1.0 Mobile Device Reliability Requirements				
RR 1.01	Mobile Device operates for at least 3 hours	A mobile device shall be able to operate for at least 3 hours before needing to recharge.		Analysis
RR 1.02	MDEA runs without need to restart	The MDEA installed and executed on a mobile device shall run without the need for restart/reboot for the duration of a complete test procedure.		Inspection
RR 1.03	DSRC infrastructure available for entire test period without interruptions or lack of coverage at test facility	The DSRC infrastructure shall be available and operational without any interruptions of coverage within the test facility for the duration of the entire test plan.		Inspection
RR 1.04	Cellular infrastructure available for entire test period without interruptions or lack of coverage at test facility	The cellular infrastructure shall be available and operational without any interruptions of coverage within the test facility for the duration of the entire test plan.		Inspection
RR 2.0 Vehicle Reliability Requirements				
RR 2.01	VEA operates for at least 3 hours	A VEA installed and executed on in-vehicle equipment shall be able to operate for at least 3 hours before needing to recharge. *Notes: this is a non-issue if the in-vehicle equipment is powered by the battery of the vehicle, but important if powered by external, on-equipment battery.*		Analysis
RR 2.02	VEA runs without need to restart	The VEA installed and executed on a mobile device shall run without the need for restart/reboot for the duration of a complete test procedure.		Inspection

Table A-6. Reliability Requirements Table (Continued)

RR ID	Reliability Requirement Title	Reliability Requirement Description	Test Case #	Verification Method
RR 2.03	Bluetooth iBeacon operates for at least 6 hours	A Bluetooth iBeacon device installed on a vehicle, used for the purpose of allowing a mobile device sense when it is inside of the vehicle, shall be able to operate for at least 6 hours without the need of recharging. *Note: this is a non-issue if the Bluetooth equipment is powered by the battery of the vehicle, but important if powered by external, on-equipment battery.*		Analysis
RR 3.0 RSE Reliability Requirements				
RR 3.01	RSE operates for at least 3 hours	RSE (both intersection and transit stop-based) shall be able to operate for at least 3 hours before needing to recharge. *Note: this is a non-issue if the RSE is powered by AC power, but important if powered by external, on-equipment battery.*		Analysis
RR 3.02	RSE application runs without need to restart	The application installed and executed on RSE (both intersection and transit stop-based) shall run without the need for restart/reboot for the duration of a complete test procedure.		Inspection
RR 4.0 Cloud Infrastructure Reliability Requirements				
RR 4.01	Cloud infrastructure operates for entire test plan duration	The cloud infrastructure shall be able to operate without needing to restart or recharge.		Inspection
RR 4.02	Cloud infrastructure runs without need to restart	The cloud infrastructure shall run without the need for restart/reboot for the duration of a complete test procedure.		Inspection
RR 4.03	Cellular infrastructure available for entire test period without interruptions or lack of coverage at test facility	The cloud infrastructure shall be available and operational without any interruptions or coverage within the test facility of the entire test plan.		Inspection

Source: Battelle

Appendix B. Requirements Not Addressed by This Project

Appendix B contains requirements that were identified in the SysRq document but are not part of the Prototype System requirements.

Functional Requirements

Table B-1. Functional Requirements Not Required for the Prototype System

FR ID	Functional Requirement Title	Functional Requirement Description	EPS Req
FR 1.0 Personal Safety Message (PSM) Functional Requirements			
FR 1.07	Restarting broadcasting PSMs	Mobile devices shall automatically restart the broadcast of the PSMs when the pedestrian signal indicates "Walk".	N
FR 2.0 Personal Mobility Message (PMM) Functional Requirements			
FR 2.11	Sending PMM at a location outside of DSRC range	A mobile device shall be able to transmit a PMM while "at home." *Note: "At home" generally refers to the residence of a traveler, but more specifically, refers to a location that is not in the vicinity of a taxi/transit stop, out of DSRC range of any connected vehicles and RSEs.* *Note: The EPS will operate under the constraint that the coordination of travel between mobile devices and vehicles will only occur at the pickup location, but for a fully deployed system, a mobile device should be able to send a PMM from any location.*	N
FR 3.0 Surrogate Basic Safety Message (Surrogate BSM) Functional Requirements			
FR 3.01	Generating Surrogate BSMs	Mobile devices shall be able to generate Surrogate BSMs when detecting the entrance into a non-equipped vehicle (passenger or transit).	N
FR 3.01.01	Generating Surrogate BSM Content	Mobile devices shall be able to generate the Surrogate BSM content including mobile device location, speed, heading, and an indicator that this message is a Surrogate BSM sent by a mobile device (and not a 'normal' BSM sent by a vehicle).	N
FR 3.02	Broadcasting Surrogate BSMs	Mobile devices shall be able to broadcast Surrogate BSMs to other equipped vehicles, equipped mobile devices, and other entities via DSRC communications media.	N
FR 3.03	Receiving Surrogate BSMs	Vehicles and mobile devices shall be able to receive Surrogate BSMs broadcasted by a mobile device located in non-equipped vehicles and transmitted via DSRC communications media.	N

Table B-1. Functional Requirements Not Required for the Prototype System (Continued)

FR ID	Functional Requirement Title	Functional Requirement Description	EPS Req
FR 8.0 Intersection/Crosswalk Positioning Functional Requirements			
FR 8.01	Detecting Intersection Corner Position	A mobile device shall be able to determine at which intersection corner it is positioned at an RSE-equipped intersection.	N
FR 8.02	Detecting Desired Crosswalk	A mobile device shall be able to determine which crosswalk the user desires to use at an RSE-equipped intersection.	N
FR 8.03	Detecting when entering a crosswalk	A mobile device shall be able to determine when it enters a crosswalk at an RSE-equipped intersection.	N
FR 9.0 Ad-hoc Intersection Crossing Group Functional Requirements			
FR 9.01	Sending Intersection Crossing Request to Intersection	A mobile device shall be able to send a Request to Cross Street Message to an intersection via DSRC communications media.	N
FR 9.02	Requesting the creation of an ad-hoc Intersection Crossing group	A mobile device shall automatically transmit a Request to Cross Street Message to other mobile devices via Wi-Fi-Direct	N
FR 9.03	Relaying Request to Cross Street Confirmation Message	A mobile device shall be able to relay a Request to Cross Street Confirmation Message received from an Intersection RSE to other mobile devices via Wi-Fi-Direct communications media.	N
FR 9.04	Determining an ad-hoc intersection crossing group leader	The first mobile device to send an Intersection Crossing Request message shall automatically become the intersection crossing group leader.	N
FR 9.05	Generating Intersection Crossing Group Coordination Message	A mobile device shall be able to generate all data elements required for a Request to Cross Street Message.	N
FR 9.05.01	Generating Intersection Crossing Group Coordination Message Content	A mobile device shall be able to generate the Request to Cross Street Message content including the current corner location, intended crosswalk, and crossing speed.	N
FR 9.06	Disbanding an ad-hoc intersection crossing group	The intersection crossing group shall disband when the crosswalk changes to the “Walk” phase.	N

Table B-1. Functional Requirements Not Required for the Prototype System (Continued)

FR ID	Functional Requirement Title	Functional Requirement Description	EPS Req
FR 11.0 Safety Functional Requirements (applicable to the EPS)			
FR 11.07	Display Pedestrian in Crosswalk Warning within Vehicle	A vehicle shall display a Pedestrian in Crosswalk Warning to the vehicle driver when the vehicle is approaching an intersection and the vehicle detects that a pedestrian is in the crosswalk crossing against the pedestrian signal.	N
FR 11.08	Display Pedestrian in Crosswalk Warning within Mobile Device	A mobile device shall display a Pedestrian in Crosswalk Warning to the pedestrian when the mobile device detects that the pedestrian is in the crosswalk crossing against the pedestrian signal (pedestrian's signal indication is not WALK).	N

Source: Battelle

System Interface Requirements

Table B-2. System Requirements Not Required for the Prototype System

SIR ID	System Interface Requirement Title	System Interface Requirement Description	EPS Req
SIR 2.0 Personal Mobility Message (PMM) Requirements			
SIR 2.09	PMM ETA Threshold	The PMM shall allow a user to enter a maximum acceptable deviation value for the originally issued Estimated Time of Arrival (contained in the PMM-RSP Message). *Note: Should this value be exceeded, the responding vehicle application will reissue the PMM Arrive message.*	N
SIR 5.0 Personal Mobility Arrival Estimate Message (PMM-ARRIVE) Requirements			
SIR 5.03	PMM-ARRIVE ETA	The PMM-ARRIVE shall specify the estimated time of arrival of the vehicle responding to the PMM, expressed in 1 second increments.	N
SIR 6.0 Surrogate Basic Safety Message (Surrogate BSM) Requirements			
SIR 6.01	Surrogate BSM Location (lat/long/elev)	The Surrogate BSM shall specify the passenger location expressed in 1/10th integer microdegrees (longitude and latitude with reference to the horizontal datum). Elevation shall be expressed in signed units of 10 cm steps above or below the reference ellipsoid.	N
SIR 6.02	Surrogate BSM Speed	The Surrogate BSM shall specify the passenger speed in meters/second in 0.1 m/s increments.	N
SIR 6.03	Surrogate BSM Heading	The Surrogate BSM shall specify the passenger heading, expressed in unsigned units of 0.0125 degrees from North (same units as in BSMs).	N
SIR 6.04	Surrogate BSM Indicator	The Surrogate BSM shall specify that it is a Surrogate BSM by including a Surrogate BSM indicator in message broadcast, with the potential, mutually exclusive values of: - 0 = not a Surrogate BSM - 1 = Surrogate BSM	N
SIR 7.0 Basic Safety Message (BSM) Requirements (those applicable to the EPS)			
SIR 7.05	BSM Vehicle Travel Lane	The BSM shall indicate the vehicle's lane of travel.	N
SIR 11.0 Alight Vehicle Message Requirements			
SIR 11.01	Request ID	The Alight Vehicle Message shall contain the same unique request ID used in the original PMM that was used to coordinate the trip.	N
SIR 11.02	Exit Location	The Alight Vehicle Message shall contain the exit location (by name or by latitude/longitude)	N

Table B-2. System Requirements Not Required for the Prototype System (Continued)

SIR ID	System Interface Requirement Title	System Interface Requirement Description	EPS Req
SIR 11.03	Time to Arrival Estimation	The Alight Vehicle message shall contain an approximation of the amount of time until the passenger is expected to alight the vehicle.	N
SIR 12.0 Request to Cross Street Message			
SIR 12.01	Request ID	The Request to Cross Street Message shall specify a unique Request ID	N
SIR 12.02	Intersection Corner Indicator	The Request to Cross Street Message shall specify which intersection corner the pedestrian is currently on.	N
SIR 12.03	Crosswalk Indicator	The Request to Cross Street Message shall specify which crosswalk the pedestrian intends to use.	N
SIR 12.04	Number of Pedestrians	The Request to Cross Street Message shall specify the number of pedestrians in the crossing group.	N
SIR 12.05	Minimum Pedestrian Crossing Speed	The Request to Cross Street Message shall specify the crossing speed of the group member with the slowest crossing speed.	N
SIR 13.0 Crossing Street Acknowledgement Message			
SIR 13.01	Request ID	The Crossing Street Acknowledgement Message shall contain the same unique request ID used in the original Request to Cross Street Message that was used to coordinate the crossing.	N
SIR 14.0 Traveler Information Requirements			
SIR 14.01	Broadcasting Frequency	Traveler Information (e.g. weather information, car share information, bike share availability, etc.) shall be broadcasted once every 60 seconds from Transit Stop RSE.	N
SIR 15.0 Data Exchange Communications Media System Interface Requirements			
SIR 15.03	PMM, PMM-RSP, PMM-CANCEL over Wi-Fi Direct	The EPS shall support the exchange of the PMM, PMM-RSP, and PMM-CANCEL via Wi-Fi Direct communications media.	N
SIR 15.06	Surrogate BSM over DSRC	The EPS shall support the exchange of the Surrogate BSM via DSRC communications media.	N
SIR 15.12	Exit Vehicle Message over Wi-Fi Direct	The EPS shall support the exchange of Exit Vehicle Messages via Wi-Fi Direct	N
SIR 15.13	Request to Cross Street over DSRC	The EPS shall support the exchange of Request to Cross Street Messages via DSRC communications media.	N
SIR 15.14	Crossing Street Acknowledgement over DSRC	The EPS shall support the exchange of Crossing Street Acknowledgement Messages via DSRC communications media.	N

Source: Battelle

Performance Requirements

Table B-3. Performance Requirements Table Not Required for the Prototype System

PR ID	Performance Requirement Title	Performance Requirement Description	EPS Req
PR 1.0 Mobile Device Performance Requirements			
PR 1.05	Mobile device – Determining Vehicle Size and Length	A mobile device shall determine the length and width of the vehicle in which it is located. *Note: this is not currently technically possible (except if the vehicle sends this information), but it is a requirement.*	N
PR 1.22	Capture 90% of Alight Vehicle Messages sent over Wi-Fi-Direct	A mobile device shall receive and capture 90% of Alight Vehicle messages transmitted by a vehicle that the mobile device is inside of over Wi-Fi-Direct communication media.	N
PR 1.25	Detecting at which intersection corner 90% of times.	A mobile device shall be able to detect which corner of an intersection it is currently located 90% of the time.	N
PR 1.26	Detecting when entering a crosswalk 99% of times.	A mobile device shall be able to detect when it is in a crosswalk within 1 second of entering the crosswalk 99% of the time.	N
PR 1.27	False Enter Crosswalk Detection rate in less than 5% of street crossing instances.	A mobile device shall falsely position itself in a crosswalk in fewer than 5% of crossing instances with the pedestrian waits to cross the street in a location no less than 3 meters from any curb.	N
PR 3.0 Transit Stop RSE Performance Requirements			
PR 3.02	Protocol Translator	A Transit Stop RSE shall act as a protocol translator. Receiving PMMs via DSRC or Wi-Fi Direct, the RSE must be able to receive the message and translate into a format which can be received and understood by the cloud infrastructure and any entities that may access the cloud infrastructure.	N
PR 3.03	Relay Messages between Travelers and Cloud Service	A Transit Stop RSE shall relay PMMs from travelers to the cloud infrastructure, and relay PMM-RSPs from the cloud infrastructure to travelers.	N
PR 3.03.01	Relay Messages between Travelers and a TMC (or other transportation management agency)	A Transit Stop RSE shall relay PMMs from travelers to the cloud infrastructure, which can be accessed by a TMC or other transportation management agency. *Note: For the EPS, this will be demonstrated by locally saving messages received by the Transit Stop RSE.*	N
PR 3.04	Communications Media – DSRC	A Transit Stop RSE shall send any messages to a traveler via DSRC if the traveler sent messages to the Transit Stop RSE via DSRC.	N

Table B-3. Performance Requirements Table Not Required for the Prototype System (Continued)

PR ID	Performance Requirement Title	Performance Requirement Description	EPS Req
PR 3.05	Communications Media – Wi-Fi Direct	A Transit Stop RSE shall send any messages to a traveler via Wi-Fi Direct if the traveler sent messages to the Transit Stop RSE via Wi-Fi Direct.	N
PR 4.0 Intersection RSE Performance Requirements			
PR 4.02	Protocol Translator	An Intersection RSE must be able to translate Request to Cross Street Messages received into a format that can be received and understood by the signal controller.	N
PR 4.03	Send Request to Cross Street Messages to Cloud Service	An Intersection RSE shall relay Request to Cross Street Messages from travelers to the cloud infrastructure.	N
PR 4.03.01	Relay Messages between Travelers and a TMC (or other transportation management agency)	An Intersection RSE shall relay Request to Cross Street Messages from travelers to the cloud infrastructure, which can be accessed by a TMC or other transportation management agency. *Note: For the EPS, this will be demonstrated by locally saving messages received by the Intersection RSE.*	N
PR 5.0 Transmission Interference Performance Requirements			
PR 5.05	No interference of Surrogate BSMs with PSMs and BSMs	The transmission of Surrogate BSMs shall not interfere with the transmissions of PSM or BSM messages.	N

Source: Battelle

Security Requirements

Table B-4. Security Requirements Table Not Required for the Prototype System

SR ID	Security Requirement Title	Security Requirement Description	EPS Req
SR 1.0 DSRC Security Requirements			
SR 1.01	Interface mobile devices with SCMS	The DSRC radios of the mobile devices used in the EPS system should interface with the U.S. DOT provided SCMS for security key provisioning and management.	N
SR 1.02	Interface vehicles with SCMS	The DSRC radios within the vehicles used in the EPS system should interface with the U.S. DOT provided SCMS for security key provisioning and management.	N
SR 1.03	Interface RSEs with SCMS	The DSRC radios within the roadside receivers used in the EPS system should interface with the U.S. DOT provided SCMS for security key provisioning and management.	N

Source: Battelle

Data Requirements

Table B-5. Data Requirements Table Not Required for the Prototype System

DR ID	Data Requirement Title	Data Requirement Description	EPS Req
DR 3.0 Roadside Equipment Data Requirements			
DR 3.02	Offload/Download Data Stored in RSE	It must be possible to offload / download the stored data via manual or automatic local or remote download mechanisms.	N

Source: Battelle

Appendix C. Test Summary Results

Appendix C provides a summary of the test results, including pass/fail metrics according to the test steps for each Test Case. This report does not include analysis and findings which will be the subject of the separate Field Test Evaluation Report to follow the Field Test.

All test cases were typically executed a minimum of 10 times (iterations) at Battelle. Observations that could be made on the MDEA, VEA, or CV Inspector displays, as well as actual physical events were recorded in the test log "real-time" as specified by the test scripts. Digital data logs from the Mobile Devices, Vehicle OBU, and RSU were archived and later inspected as specified by the test scripts. Observations and Inspections versus Expected Results (as specified in the test scripts) were used to determine "pass" or "fail" for each test script step. Metrics were prepared for each Test Case as shown in Table C-1, Test Results Summary. This table provides the step pass rate for each Test Case, which is the percentage of pass-fail steps that passed over all iterations. This metric provides a general measure of how well each functional area performed.

Note: A 10% tolerance was applied to the performance thresholds on Safety Notifications, since they are impossible to pass without doing so. This is to account for the latency in receiving messages upon which calculations are based, the time to calculate if the threshold is met, and the time to issue notifications. This tolerance was applied based upon distance, such that a tolerance of about 11 meters or 1 second is applied for vehicle speeds of 25 mph.

The purpose of Acceptance Testing was to assess the D2X Hub prototype system readiness for Field Test. The subject system is an experimental system to answer research questions. As such, there is not a specific threshold for an "acceptable" level of overall system performance.

Based on the results summarized in Table C-1, a level of performance was achieved that will allow the system to meet Field Test objectives; the system is expected to yield the data necessary to answer the research questions posed in the contract. The software applications and underlying messages to incorporate mobile devices into the CV environment are functioning correctly. Given a performance level sufficient for Field Test, step passage rates of less than 100% are the kind of instructive outcomes sought by this research. The system is ready for Field Test.

Table C-1. Test Results Summary

Test Case		Step Pass Rate
5.4.1.1	PSM – Broadcasting PSM with Vehicle Within a Specified Radius (Transmit Timing)	94%
5.4.1.2	PSM – Cease Broadcasting PSMs when In-Vehicle; Mobile Device Accelerometer Sensor Functionality to Detect Passenger Entry into and Exiting from Vehicle	81%
5.4.1.3	PSM – Cease Broadcasting PSMs After Joining an Ad-Hoc Travel Group	100%
5.4.1.4	PSM – Broadcasting PSM with Pedestrian in Unsafe Zone	97%
5.4.2.1	PMM – Submitting Trip Requests – Single User	100%
5.4.2.2	PMM – Communicate with Cloud Infrastructure via Cellular	100%
5.4.2.3	PMM – Canceling Trip Requests	100%
5.4.2.4	PMM – Sending Arrival Messages	100%
5.4.3.1	BSM – Vehicle Experimental Application Functionality	100%
5.4.4.1	ATG – Creating Coordination between the Mobile Devices of Travelers – Multiple Travelers ATG – Leaving an Ad-Hoc Travel Group Based on Distance – Multiple Travelers ATG – Leaving an Ad-Hoc Travel Group by Choice – Multiple Travelers ATG -- Disbanding Ad-Hoc Travel Group When Entering a Vehicle or any other Reason	99.6%
5.4.5.1	MGL – RSU DSRC Message Logging	100%
5.4.5.2	MGL – Cloud Service Message Logging	100%
5.4.5.3	MGL – Mobile Device Experimental Application Message Logging	100%
5.4.5.4	MGL – Vehicle Experimental Application Message Logging	100%
5.4.6.1	SFY – Safety Notifications (Mobile Device User in Unsafe Zone)	89%
5.4.7.1	SMP – SPAT and MAP message support	100%

Source: Battelle

Appendix D. Acronyms and Abbreviations

ASC	Actuated Traffic Signal Controller
ATG	Ad-Hoc Travel Group
ATP	Acceptance Test Plan
BSM	Basic Safety Message
CAN	Controller-Area Network
CCP	Common Computing Platform
ConOps	Concept of Operations
CV	Connected Vehicle
CVRIA	Connected Vehicle Reference Implementation Architecture
DEA	Device Experimental Applications
DSRC	Dedicated Short Range Communications
EPS	Experimental Prototype System
FHWA	Federal Highway Administration
FR	Functional Requirement
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transportation Systems
LAN	Local Area Network
LTE	Long-Term Evolution
MAC	Medium Access Control
MAP	Map Data
MDEA	Mobile Device Experimental Application
NTCIP	National Transportation Communications for ITS Protocol
OBE	On-Board Equipment
OBU	On-board Unit
PHY	Physical Layer
PMM	Personal Mobility Message
PMM-ARRIVE	Personal Mobility Message Arrival Message
PMM-CANCEL	Personal Mobility Message Cancel Message
PMM-RSP	Personal Mobility Message Response Message
PR	Performance Requirement

PSM	Personal Safety Message
RSE	Roadside Equipment
RSU	Roadside Unit
SA/DD	System Architecture and Design Document
SAE	Society of Automotive Engineers
SFY	Safety
SIR	System Interface Requirement
SPaT	Signal Phasing and Timing
SysReqs	System Requirements
TFHRC	Turner-Fairbank Highway Research Center
TMC	Transit Management Center
TMX	Transportation Message eXchange
U.S. DOT	U.S. Department of Transportation
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VEA	Vehicle Experimental Application
VRU	Vulnerable Experimental Applications
WAVE	Wireless Access in Vehicular Environment
Wi-Fi	Wireless Fidelity

Appendix E. Terms and Definitions

Basic Safety Message (BSM)	Connected vehicle message type which contains vehicle safety-related information that is broadcast to surrounding vehicles;
Bluetooth	Short range wireless technology used to exchange data between enabled devices
Cellular	Uses short-range radio stations to cover areas of communication.
Connected Vehicle	A vehicle that can communicate with other vehicles and infrastructure via communication media such as DSRC, Wi-Fi, cellular or Bluetooth.
Coordinated	Messages are coordinated when one or more Mobile Devices have boarded a single vehicle (i.e. multiple passengers have boarded a bus), and are interpreted as a single, cohesive sender/recipient.
CV Inspector	An application that verifies if the Mobile Device is broadcasting messages to Connected Vehicles.
Destination	The end point of a traveler's trip.
DSRC	Dedicated Short-Range Communications; a low-latency, high-reliability, two-way communications tool used for sending transportation safety messages.
Emergency Vehicle Alert Message	Connected vehicle message type which is used to communicate warnings to surrounding vehicles that an emergency vehicle is operating within the vicinity;
Light Sensor	Hardware sensor that measures ambient light.
Light-Duty Vehicle	Of or relating to vehicles that way less than $4,000 lbs.
Link	A trip chain phase in which the traveler is in transit.
Message Type	Type of personal safety or personal mobility message that is transmitted based on the technology used and level of coordination available.
Mobile Hardware Sensor	Reports raw data from a particular sensor on the mobile device
Mobile Network	A wireless radio network distributed over a large geographic area with fixed location transceivers spread across it. These receivers work together to provide radio coverage over the entirety of the geographic area allowing a large number of Mobile Devices to communicate with each other.
Mobile Software Sensor	Interprets data from one or more hardware sensors to provide an imputed output
National ITS Architecture	Common framework for the planning, development and integration of ITS deployments.
Node	A trip chain phase in which the traveler is located at a transition point, such as a bus stop or train station.

Not Transmitting	The state in which a mobile phone user has not opted in to exchanging safety and mobility messages
Operating System	The prerequisite mobile device software (e.g. Android, iOS, etc.) that manages all other applications.
Opt-In	User action required to begin transmission of safety and mobility messages via mobile device.
Opt-Out	User action required to end transmission of safety and mobility messages via mobile device.
Origin	The starting point of a traveler's trip.
Personal Mobility Message (PMM)	Similar to PDM, message intended for the exchange of mobility messages between individual travelers and vehicles/infrastructure, via mobile device.
Personal Safety Message (PSM)	Similar to BSM, message intended to transmit low-latency, urgent safety messages between individual travelers and vehicles/infrastructure, via mobile device
Proximity	Hardware sensor that measures the distance between the sensor and a nearby object.
Road Condition Message	Connected vehicle message type which provides information on roadway surface conditions, such as the presence of ice
Rotation Vector	Software sensor that describes the orientation of the screen of a mobile device.
Step Detector/ Counter	Software sensor that uses accelerometer data to estimate when a step has been taken.
Test Case	A set of conditions or variables that a Tester can determine if system meets requirements.
Transit Vehicle	Large vehicles mainly used for public transportation as well as support services.
Transmitting	The state in which a traveler has opted in and is sending/receiving messages via mobile device
Traveler advisory message	Connected vehicle message type which Provides congestion, travel time, and signage information.
Uncoordinated	Messages are coordinated when one or more mobile devices. Mobile Devices have boarded a single vehicle (i.e. multiple passengers have boarded a bus), and are interpreted as a single, cohesive sender/recipient.
Weather Condition Message	Connected vehicle message type which communicates area specific weather information
Wi-Fi	Local area wireless technology that allows enabled devices to connect to the Internet

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

Toll-Free “Help Line” 866-367-7487
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FHWA-JPO-18-621