# Prototype Development and Demonstration for Response, Emergency Staging, Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.)

## Technical Report on Prototype Development and Field Testing of R.E.S.C.U.M.E. Applications

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**16. Abstract**

This document is the final project technical report for the development and field testing of the Response, Emergency Staging, Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.) application bundle, with a focus on the Incident Zone (INC-ZONE) and Response Staging (RESP-STG) applications. These two applications together comprise a tightly integrated bundle that is a key research and development effort within the Dynamic Mobility Applications (DMA) portion of the Connected Vehicle Program. This report describes the R.E.S.C.U.M.E. application bundle design, along with the subsequent field testing and demonstration of the INC-ZONE and RESP-STG applications including results and observations.

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# Table of Contents

## List of Tables

## List of Figures

# Executive Summary

The objective of the Dynamic Mobility Applications (DMA) research program is to foster the release of high-value, open-source applications that use synthesized, multisource ITS data to transform surface transportation management and information. This document is the final project report on the development and field demonstration of the Response, Emergency Staging, Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.) application bundle, with a focus on the Incident Zone (INC-ZONE) and Response Staging (RESP-STG) applications under the DMA Program. These two applications comprise a tightly integrated bundle that is a key research and development effort within the DMA portion of the Connected Vehicle Program. This report describes the R.E.S.C.U.M.E. application bundle design, along with the subsequent acceptance testing and field demonstration of the INC-ZONE and RESP-STG applications including results and conclusions of the effort.

The RESP-STG application provides situational awareness to and coordination among emergency responders—upon dispatch and while en-route—to establish incident scene work zones both upon initial arrival and staging of assets, and afterward, if circumstances require, additional dispatch and staging. It provides valuable input to responder and dispatcher decisions and actions. A range of data is provided through mobile devices and other types of communication to help support emergency responder vehicle routing, staging, and secondary dispatch decision-making.

The INC-ZONE application improves protection of personnel at incident sites from the threat of oncoming vehicles, particularly where those vehicles are being operated outside of recommended speed, and lane guidance where there have been crashes, incidents, or other events impacting traffic such as stalled vehicles or vehicles pulled over for moving violations. The INC-ZONE application includes an in-vehicle messaging system that provides oncoming drivers with merging and speed guidance around an incident. The INC-ZONE application also provides in-vehicle alerts and warnings to drivers in violation of speed and lane closure restrictions, both for the protection of the drivers and incident zone personnel. Finally, the INC-ZONE application includes a warning system for on-scene workers when a vehicle approaching or in the incident zone is being operated unsafely (outside of safe parameters for the conditions).

The R.E.S.C.U.M.E. Prototype System consists of multiple of components which exchange data through messages using Dedicated Short Range Communications (DSRC) and cellular communication. The primary functional components of the implemented R.E.S.C.U.M.E. Prototype System include the following:

- Oncoming Vehicle Subsystem
  - Computational Platform and User Interface (Samsung Galaxy S-4)
  - DSRC Communication Hardware (Arada)
  - Vehicle Data Interface (VITAL™)
  - Oncoming Vehicle User Interface

- Responder Vehicle Subsystem
  - Computational Platform and User Interface (Ruggedized Laptop)
  - DSRC Communication Hardware (Arada)
  - Vehicle Data Interface (VITAL™)
  - Responder Personal Trunked Radio (Personal Alerting Safety Subsystem [PASS])
  - Responder Vehicle INC-ZONE User Interface
  - Responder Vehicle CapWIN Mobile RESP-STG User Interface

- Internet Hosted Services
  - RESP-STG Application Cloud Components (CapWIN Cloud)
  - Regional GPS Correction Data

R.E.S.C.U.M.E. Prototype System Acceptance Testing was conducted according to the principles of system engineering verification testing. Individual system components were tested against their requirements in a laboratory integration test environment (Phase I). Then the system components were integrated and tested in a laboratory or garage integration test environment (Phase II). Finally the integrated system testing was conducted on a closed course test track (Phase III). This series of tests confirmed and demonstrated to the United States Department of Transportation (U.S. DOT) that the R.E.S.C.U.M.E. Prototype System was fully functional and sufficiently robust to support refinement and follow-on field demonstration of INC-ZONE and RESP-STG.

On November 13, 2014 the Battelle Team conducted a field demonstration of the applications for the U.S. DOT at the Maryland Police and Correctional Training Commissions Driver Training Facility in Sykesville, Maryland. That demonstration simulated a medical emergency where a driver becomes ill, pulls to the side of the road and calls 9-1-1. The U.S. DOT and visitors observed and experienced first-hand:

- The evolution of the incident as a Patrol car arrives, followed by an EMS/Ambulance and a Maryland State Highway Administration Coordinated Highways Action Response Team (CHART) Emergency Response Unit (ERU) vehicle.
- The tools that responders have to establish incident zones both upon initial arrival and staging of assets.
- The establishment of an incident zone and a safety zone that was broadcast to oncoming vehicles.
- The tools for improved situational awareness to and coordination among emergency responders—upon dispatch and while en-route—to establish incident scene work zones both upon initial arrival and staging of assets, and afterward, if circumstances require, additional dispatch and staging.
- The warnings received by responders when oncoming vehicles approached hazardously, breaching the safety zones.
- The lane closure, merging and reduced speed advisories, alerts, warnings and imminent collision stop messages that were given to approaching vehicle drivers both for the protection of the drivers and incident zone personnel.
- Application of latest technology advancements by the U.S. DOT to enhanced safety for responders, crash victims, and the traveling public, as well as reducing the impact

that incidents have on the normal operations of roadways, whether it be traffic incidents, or routine operations such as an officer issuing a citation.

The responder and driver warnings that were demonstrated to participants are based upon connected vehicle technology. The vehicles were connected wirelessly, meaning they are continuously communicating their location, speed and heading to each other, using 5.9 GHz DSRC, an enhanced Wi-Fi band specifically reserved for to vehicle safety and mobility communications. The demonstration showed how connected vehicles can deliver warnings to drivers, to help prevent crashes and improve mobility around incidents.

# Chapter 1 Introduction

Through the DMA Program, U.S. DOT desires to improve current operational practices and transform management of future surface transportation systems. The DMA program is designed to enhance deployment of the technologies and applications and promote collaboration in research and development of the transformative mobility applications. The DMA Program's current phase involves application prototype development and testing and coordinated research activities on a portfolio of selected high-priority mobility applications. Development of the R.E.S.C.U.M.E. System is informed by prior research in the Connected Vehicle Program and other Intelligent Transportation Systems (ITS) programs, as well as the development of this and other concurrent applications from other DMA projects.

The R.E.S.C.U.M.E. bundle developed in this project includes two applications, INC-ZONE and RESP-STG. The RESP-STG application provides situational awareness to and coordination among emergency responders—upon dispatch and while en-route—to establish incident scene work zones both upon initial arrival and staging of assets, and afterward, if circumstances require, additional dispatch and staging. The INC-ZONE application improves protection of personnel at incident sites from the threat of oncoming vehicles, particularly where those vehicles are being operated outside of recommended speed, and lane guidance where there have been crashes, incidents, or other events impacting traffic such as stalled vehicles or vehicles pulled over for moving violations. The R.E.S.C.U.M.E. application bundle concept incorporates vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), infrastructure-to-vehicle (I2V), and center-to-center communications (referred to collectively as V2X). The automated V2X communications are predicated on DSRC capabilities and associated infrastructure, but communications are not constrained to DSRC. For example, emergency responders will communicate via Mobile Data Terminals (MDTs) over a cellular connection, in addition to their existing radios, while operations centers will communicate with each other largely through secure telecommunications networks.

It is important to note that in addition to the development of the INC-ZONE and RESP-STG applications, foundational work was conducted on the Emergency Communications for Evacuation (EVAC) application. EVAC is one of three complementary applications within the R.E.S.C.U.M.E. bundle. An analysis of the Regional Integrated Transportation Information Systems' (RITIS) and CapWIN's ability to serve as an Information Broker that is conceptualized to support the EVAC application is documented in the Information Broker Framework Analysis report. That report also provides guidance on minimum functions that are required to enable the Information Broker and EVAC application in other regions nationally.

## Document Identification

This document is the final project report for the development and field demonstration of the R.E.S.C.U.M.E. application bundle, with a focus on the INC-ZONE and RESP-STG applications. This report describes the R.E.S.C.U.M.E. application bundle design, along with the subsequent field testing and demonstration of the INC-ZONE and RESP-STG applications including results and observations. This work was performed by Battelle and the University of Maryland – Center for Advanced Transportation Technology (UMD CATT).

# Document Organization

This report is organized into chapters as follows:

- Chapter 2. Referenced Documents
- Chapter 3. R.E.S.C.U.M.E. Application Descriptions
- Chapter 4. R.E.S.C.U.M.E. Prototype System Design and Development Overview
- Chapter 5. R.E.S.C.U.M.E. Prototype Component, System and Application Acceptance Testing
- Chapter 6. R.E.S.C.U.M.E. Prototype System and Application Field Demonstration
- Chapter 7. R.E.S.C.U.M.E. Demonstration
- Chapter 8. Small-Scale Demonstration of Responder Staging Application
- Chapter 9. Summary and Conclusions
- Appendix A. Prototype Component, System and Application Acceptance Testing Summary
- Appendix B. Acronyms and Abbreviations.

# Chapter 2 Referenced Documents

Table 2-1 identifies the R.E.S.C.U.M.E. Prototype Project Documents referred to herein.

**Table 2-1. R.E.S.C.U.M.E. Prototype Project Documents.**

| Number | Document Title |
|---|---|
| FHWA-JPO-13-063 | R.E.S.C.U.M.E. Concept of Operations |
| FHWA-JPO-13-064 | R.E.S.C.U.M.E. Report on Functional and Performance Requirements, and High-Level Data and Communication Needs |
| FHWA-JPO-14-TBD | R.E.S.C.U.M.E. Prototype Acceptance Test Plan |
| FHWA-JPO-14-TBD | R.E.S.C.U.M.E. Prototype System Design Document |
| FHWA-JPO-14-TBD | R.E.S.C.U.M.E. Prototype System Architecture |
| FHWA-JPO-14-TBD | R.E.S.C.U.M.E. Functional and Performance Requirements |
| FHWA-JPO-14-TBD | R.E.S.C.U.M.E. Concept of Operations |
| FHWA-JPO-14-TBD | R.E.S.C.U.M.E. Prototype Acceptance Test Summary |
| FHWA-JPO-14-TBD | R.E.S.C.U.M.E. Demonstration and Site Plan for INC-ZONE and RESP-STG Task 3 Demonstrations |
| FHWA-JPO-15-TBD | INC-ZONE and RESP-STG Final Prototype Demonstration Report |
| FHWA-JPO-15-TBD | R.E.S.C.U.M.E. Information Framework Analysis Report |

Source: Battelle

# Chapter 3 R.E.S.C.U.M.E. Application Descriptions

The following sections contain descriptions of each of the R.E.S.C.U.M.E. applications. Additional details of each application may be found in the R.E.S.C.U.M.E. Prototype System Design Document.

## INC-ZONE Application Description

The INC-ZONE application is a communication approach that improves protection of personnel at incident sites from the threat of oncoming vehicles, particularly where those vehicles are being operated outside of recommended speed, and lane guidance where there have been crashes, incidents, or other events impacting traffic such as stalled vehicles or vehicles pulled over for moving violations.

The INC-ZONE application features an in-vehicle messaging system that provides oncoming drivers with merging and speed guidance around an incident. The INC-ZONE application also provides in-vehicle alerts and warnings to oncoming drivers in violation of speed and lane closure restrictions, both for the protection of the drivers and incident zone personnel. Finally, the INC-ZONE application includes a warning system for on-scene workers when a vehicle approaching or in the incident zone is being operated outside of safe parameters for the conditions.

Although there are similarities such as the possible need for lane closures, incident zones and construction work zones are fundamentally different in nature. Specifically, a construction work zone is typically pre-planned and usually involves only a single agency (or at most a few agencies), while an incident zone is unplanned and frequently involves inter-agency responses. Incident zones are the focus of INC-ZONE.

Persons found in an incident zone could include crash victims, law enforcement, emergency medical services (EMS), fire and rescue, hazardous materials (HAZMAT) Response, towing and recovery, and roadway/infrastructure repair workers.

### Description of Inputs

Incident details are first entered by the scene commander using CapWIN at the scene of the incident, including lane closure restrictions, which may be changed as the incident zone evolves. These details are used to establish a pre-defined safety zone, or buffer zone, around the incident zone and pre-determined threshold inputs for issuing advisory, alert, and warning messages to oncoming vehicles.

The Oncoming Vehicle Application Component uses a number of inputs for determining the issuance of advisory, alert, and warning messages. The oncoming vehicle receives a number of inputs regarding its current operating status from vehicle data systems. An exchange of information must also occur between the responder vehicle, which defines an incident zone, and

an oncoming vehicle which enters the incident zone for a threat determination to be made. Many inputs come from DSRC messages sent from responder vehicles located within the incident zone. The responder vehicle broadcasts an incident map to all oncoming vehicles to distribute the threat calculation required to each oncoming vehicle. This map includes speed and lane closure restrictions for the incident zone and adjacent roadway.

Specifically, the Traveler Information Message (TIM), which contains the incident zone location and map data and advised or posted speed for the incident zone, is used for messages related to speed restrictions and lane closures. The Emergency Vehicle Alert (EVA) message provides the location of the nearest responder vehicle to oncoming vehicles using global positioning system (GPS) in its Arada radio, and is used for the determination of collision warning messages. These two messages are broadcast from responder vehicles to oncoming vehicles for calculating the threat determination and issuing appropriate advisory, alert, and warning messages to oncoming drivers.

Threats to responders in the incident zone are issued by the threatening oncoming vehicle itself, based on the description of the incident zone and the location of the responder vehicles in the incident zone, as well as vehicle operating characteristics and positioning data of the oncoming vehicle itself. The oncoming vehicle sends a terse A la Carte Message (ACM) message to the responder vehicle with the result of the threat determination calculation. This eliminates the need to communicate the content of a Basic Safety Message (BSM) to the responder vehicle for this application.

The Responder Vehicle Application Component takes incident descriptions entered in CapWIN, in particular lane closure data as well as the location of the incident, and merges that data with its own responder vehicle-based sensor data to compile and issue TIM and EVA messages via DSRC to oncoming vehicles. The Responder Vehicle Application Component issues alert and warning messages to the responder's PASS based primarily on the Oncoming Vehicle ACM Threat Messages that are sent via DSRC from individual oncoming vehicles. Each of these threat messages indicate an oncoming vehicle's threat status based on the messages being issued via the driver-vehicle interface (DVI) to the driver of the oncoming vehicle.

## Description of Threat Determination

The Oncoming Vehicle Application Component uses the inputs described above to determine what message should be issued to the driver and when. This determination is based on the oncoming vehicle speed and location relative to the incident zone, responder vehicles within the incident zone, and the safety zone or buffer zone around and prior to the incident zone where reduced speeds and lane closures apply. The relative locations or distances prior to the incident zone and safety zone are primarily based upon guidance and standards within the Manual of Uniform Traffic Control Devices (MUTCD), as well as the content of the messages. Although used for roadside signage, this guidance is applicable for advanced placement distances for issuing messages to oncoming drivers and includes the consideration of deceleration rates, perception-reaction time, speeds, incident zone buffer space, and visibility distances.

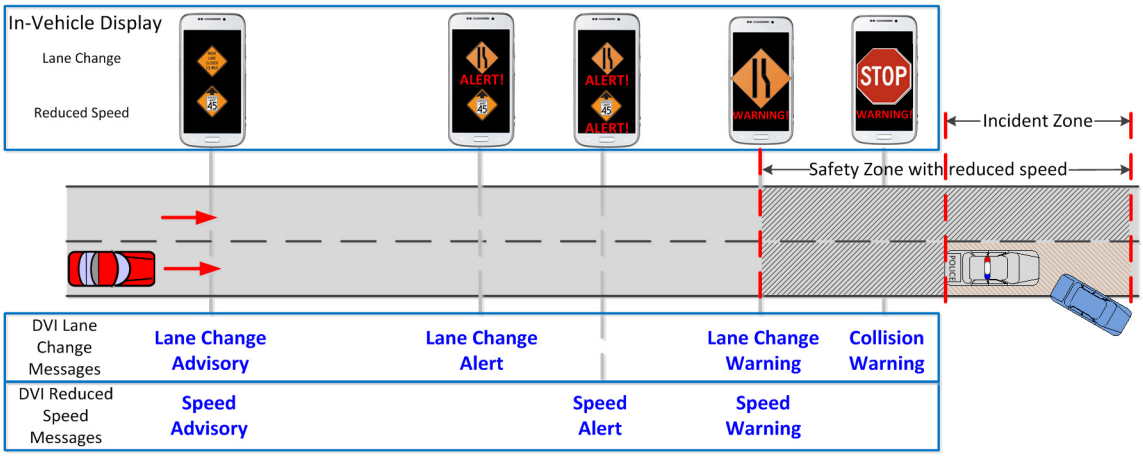
## Description of the Oncoming Vehicle Alerts and Warnings

The INC-ZONE application issues various in-vehicle messages to the driver of an oncoming vehicle via the driver vehicle interface, as shown in Figure 3-1. The application issues advisories and alerts to notify drivers in time for them to slow to the advisory or posted speed prior to the safety zone, and advisories and warnings to maintain a speed at or below that advisory or posted speed within the safety zone. The application also issues vehicle-specific, in-vehicle advisory, alert, and warning messages of upcoming shoulder or lane closures within the incident zone. Messages regarding the need for oncoming vehicles to reduce speed and change lanes are displayed simultaneously. If the oncoming vehicle continues to approach the incident zone in a closed lane, an imminent collision warning is issued based on proximity to the nearest responder vehicle within the incident zone.

Additional details on threat determination for issuing in-vehicle alerts and warnings to drivers of oncoming vehicles can be found in the R.E.S.C.U.M.E. Prototype System Design Document.

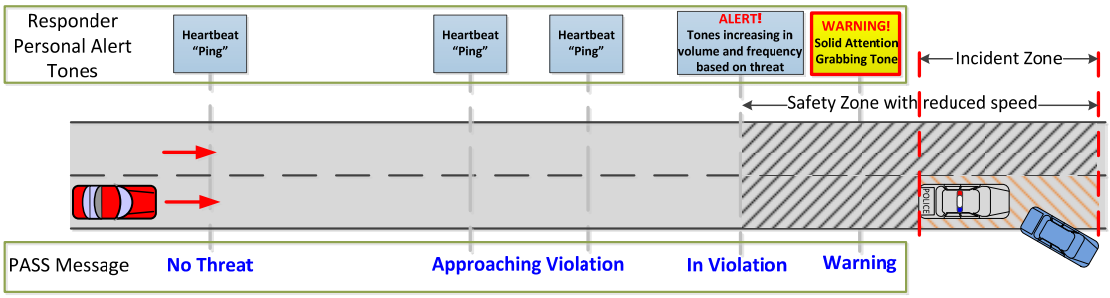
## Description of the Responder Alerts and Warnings

The INC-ZONE application issues a series of escalating threat messages to on-scene workers in the incident zone regarding risks posed by oncoming vehicle speed or lane violations, as illustrated in Figure 3-2. Oncoming vehicles send messages via DSRC to the responder vehicle regarding their threat level, thereby triggering the issuance of an appropriate message from the responder vehicle to the on-scene responders' personal alert safety system. The escalating threat message set is based on when oncoming vehicles are approaching a speed or lane violation, in violation of established speed or lane closures within the established safety zone, and a collision-imminent direct threat warning.




Source: Battelle

**Figure 3-1. Illustration of the Issuance of In-Vehicle Advisory, Alert and Warning Messages based on Oncoming Vehicle Proximity to the Safety Zone, Incident Zone, and Responding Vehicle.**




Source: Battelle

**Figure 3-2. Illustration of the Issuance of Responder PASS Advisory, Alert and Warning Messages based on the Threat of an Oncoming Vehicle Threat based on its Proximity to the Safety Zone, Incident Zone, and Responding Vehicle.**

# RESP-STG Application Description

The RESP-STG application provides situational awareness to and coordination among emergency responders—upon dispatch and while en-route—to establish incident scene work zones both upon initial arrival and staging of assets, and afterward, if circumstances require, additional dispatch and staging. It provides valuable input to responder and dispatcher decisions and actions. A range of data is provided through mobile devices and other types of communication to help support emergency responder vehicle routing, staging, and secondary dispatch decision-making.

Improving situational awareness of public safety responders while they are en-route can help establish incident scene work zones that are safe for responders, travelers and crash victims while being less disruptive to traffic. Situational awareness information can also provide valuable input to responder and dispatcher decisions and actions.

## Description of Inputs

A range of data is provided through mobile devices and other types of communications to help support emergency responder vehicle routing, staging, and secondary dispatch decision-making. These data include staging plans, satellite imagery, GIS map graphics, camera images, current weather data, and traffic conditions. Incident details are entered by the scene commander using CapWIN at the scene of the incident, including details regarding speed and lane closure restrictions, which may be changed as the incident zone evolves.

## Description of RESP-STG Functions

The RESP-STG application is a collection of integrated functions designed to minimize the adverse effects on mobility and safety caused by an incident affecting the roadways. This is achieved by increasing the preparedness and situational awareness of the emergency responders upon dispatch and while en-route to an incident scene. Awareness of this information in advance enables critical, time-saving, and potentially life-saving decisions to be made prior to arrival on scene. These decisions in turn enable the responders to clear the incidents sooner and to enhance the incident staging to facilitate mobility.

### *Vehicle and Equipment Staging*

The Vehicle and Equipment Staging function supplies the en-route responders with additional information they can use to determine where to stage personnel and equipment prior to their arrival on-scene. This function is responsible for accessing a database of still photographs, satellite imagery, GIS overlays, video feeds, and modeling programs (e.g., predicted HAZMAT plumes) to provide a visual representation of the scene to facilitate the staging of equipment. Additional components such as the current traffic conditions and existing vehicles already on-scene are also critical components integrated into the situational awareness picture developed and provided by the Vehicle and Equipment Staging function.

A range of data is provided through the communications function, and uses that information together with on-board databases and Internet-accessible sources to develop a multi-layered spatial representation of the incident. The arriving responder's approach and likely staging are projected onto the incident as an additional layer.

### *Emergency Responder Status Reporting*

The Emergency Responder Status Reporting function continuously monitors the location of the en-route responder vehicles as well as the vehicles already on-scene (via the INC-ZONE and/or Information Broker). The function develops and maintains the current position of the responder's vehicles. Other information such as traffic encountered, speed, heading, and route to destination are also captured and processed by this function. This information is forwarded to the INC-ZONE and Information Broker via the Communications function.

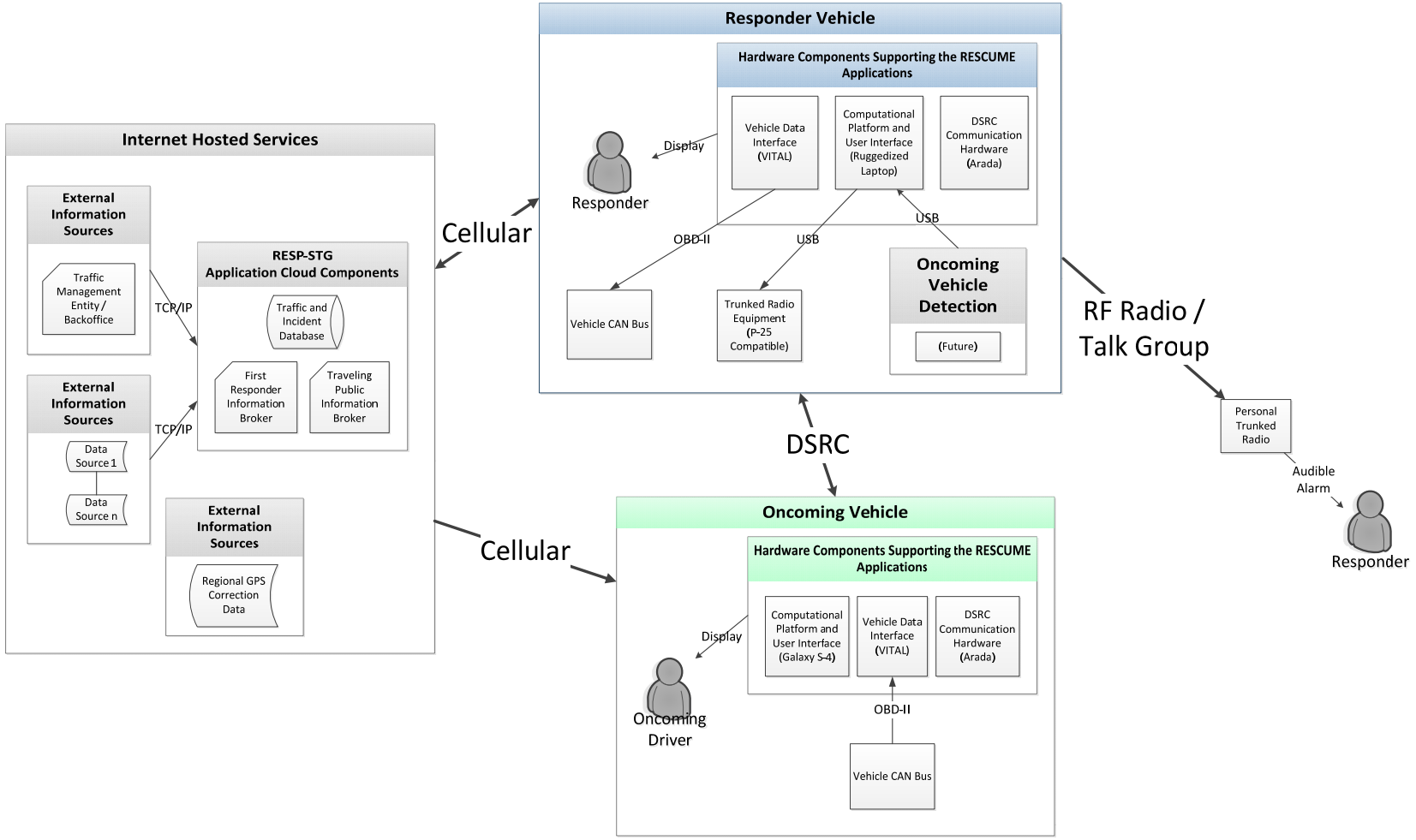
# Chapter 4 R.E.S.C.U.M.E. Prototype System Design and Development Overview

This chapter of the report describes the prototype connected vehicle communications system that supports the applications described in the previous chapter. This chapter is organized under the following headings:

- R.E.S.C.U.M.E. Prototype System Architecture
- R.E.S.C.U.M.E. Prototype System Components
- Oncoming Vehicle Subsystem
- Responder Vehicle Subsystem
- Internet Hosted Services
- DSRC Messages
- Visualization Tools
- RESP-STG Component Description

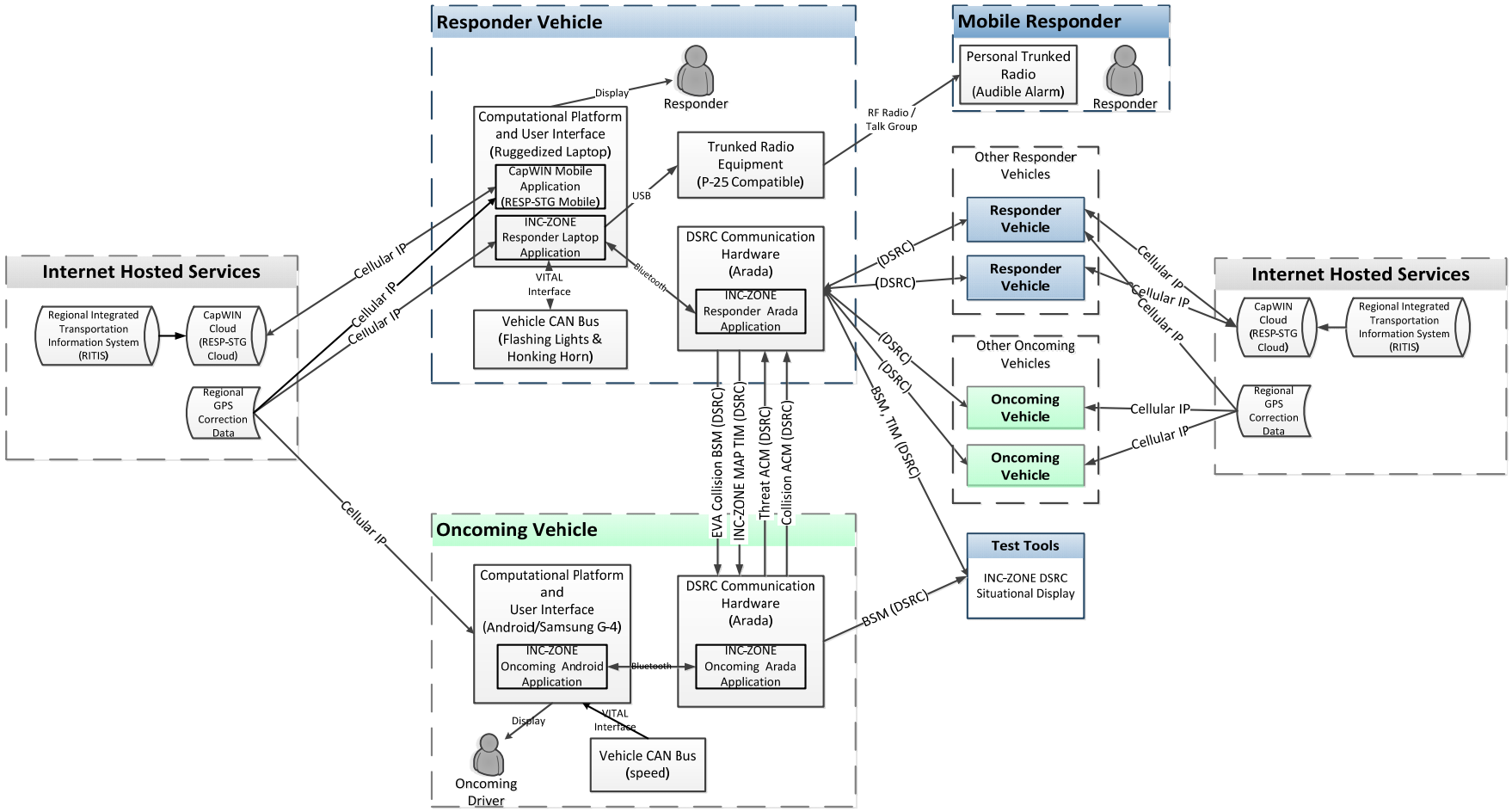
## R.E.S.C.U.M.E. Prototype System Architecture

The R.E.S.C.U.M.E. Prototype System consists of multiple of components which exchange data through messages using DSRC and cellular communication. Figure 4-1 shows a R.E.S.C.U.M.E. system-level diagram identifying the components and primary communication modes between components of the system. This figure represents a comprehensive system including current and future capabilities that are described in detail in the R.E.S.C.U.M.E. Prototype System Architecture Document. Figure 4-2 provides a more detailed view of the R.E.S.C.U.M.E. Prototype System as it was implemented for the purposes of this project and as it was demonstrated to the U.S. DOT. The figure also shows the communication modes and key messages that are exchanged between DSRC components necessary to support the multiple R.E.S.C.U.M.E. scenarios and applications. This system has the functionality and capabilities necessary to support future refinements and demonstrations under consideration by the U.S. DOT.




Source: Battelle

**Figure 4-1. Physical Diagram of the R.E.S.C.U.M.E. Prototype System.**




Source: Battelle

**Figure 4-2. Schematic of the Implemented R.E.S.C.U.M.E. Prototype System Showing Communication Modes and Key DSRC Messages Transmitted between Components.**

# R.E.S.C.U.M.E. Prototype System Components

Following is a summary of the R.E.S.C.U.M.E. system and its components. More detail can be found in the R.E.S.C.U.M.E. Prototype System Design Document.

The primary functional components of the implemented R.E.S.C.U.M.E. Prototype System, shown in Figure 4-1 and Figure 4-2 are the following:

- Oncoming Vehicle Subsystem
  - Computational Platform and User Interface (Samsung Galaxy S-4)
  - DSRC Communication Hardware (Arada)
  - Vehicle Data Interface (VITAL™)
  - Oncoming Vehicle User Interface
- Responder Vehicle Subsystem
  - Computational Platform and User Interface (Ruggedized Laptop)
  - DSRC Communication Hardware (Arada)
  - Vehicle Data Interface (VITAL™)
  - Responder Personal Trunked Radio (PASS)
  - Responder Vehicle INC-ZONE User Interface
  - Responder Vehicle CapWIN Mobile RESP-STG User Interface
- Internet Hosted Services
  - RESP-STG Application Cloud Components (CapWIN Cloud)
  - Regional GPS Correction Data

The following additional component is used for testing and demonstration:

- INC-ZONE DSRC Situational Display

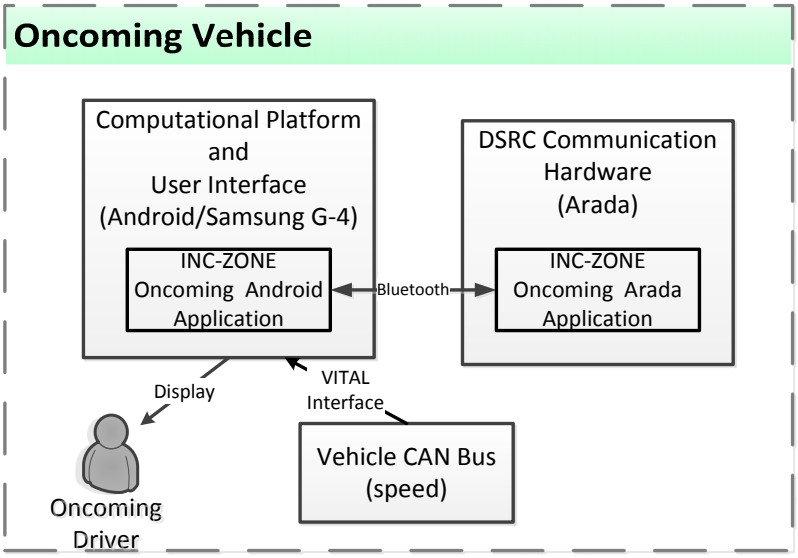
Following is an overview of each subsystem and component.

# Oncoming Vehicle Subsystem

The components deployed in the oncoming vehicle to support the R.E.S.C.U.M.E. Prototype are the Computational Platform and User Interface (Samsung Galaxy S-4), and DSRC Communication Hardware (Arada), Vehicle Data Interface (VITAL™), which are each described below.

## Computational Platform and User Interface

The Computational Platform and User Interface in the oncoming vehicles is the Samsung Galaxy S4 smartphone running the Android operating system, shown in Figure 4-3. The mobile device interfaces with the DSRC radio module in the nomadic device via Bluetooth connections, and receives and delivers INC-ZONE messages for the driver.





Source: Samsung website

**Figure 4-3. Samsung Galaxy S4 Smartphone used as Oncoming Vehicle Computational Platform and User Interface.**

The features of this component include:

1. Provide a cellular interface to external data resources (i.e., in support of the Differential Global Positioning System [DGPS] correction data to provide improved locational accuracy via the Internet)
2. Interfacing with the DSRC radio module via a Bluetooth connection to receive incident zone descriptions and send collision threat alarms and warnings.

3. Generation of collision and threat alarms based on incident zone descriptions and vehicle status.
4. Graphical user interface to communicate the following to the user:
    - INC-ZONE speed and lane closure advisory, alert and warning messages
    - INC-ZONE imminent collision warning messages

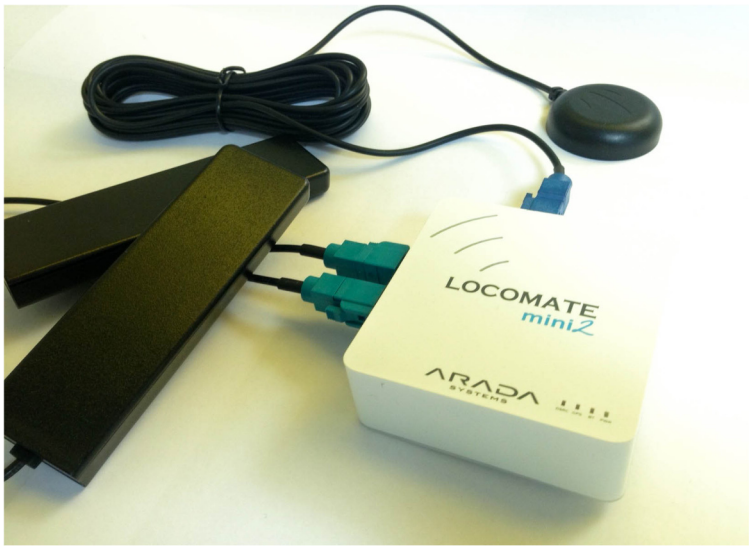
## DSRC Communications Hardware (Arada Radio)

The DSRC Communication Hardware used for the R.E.S.C.U.M.E. project was from Arada Systems. The hardware integrates GPS, Bluetooth integrates GPS, Bluetooth and high-power 802.11p DSRC radios. It is fully compliant with Omni-Air's certification and used in worldwide deployments including the U.S. DOT's Safety Pilot in Ann Arbor, Michigan. For Acceptance Testing, Battelle used the Battery Powered Locomate ME OBU with integral GPS and DSRC antenna, also known as the "Backpack", shown in Figure 4-4. The backpack form factor is used with the Samsung smart phone as an integrated nomadic device. For Field Demonstration, Battelle used Arada System's LocoMate™ Mini 2 OBU, which allowed the use of external GPS and DSRC antennas, as shown in Figure 4-5. Both units use the same chips and software, but are enclosed in a different form factor case.

Source: Arada/Battelle

**Figure 4-4. Arada Locomate ME Battery Powered DSRC Communication Hardware, also known as "The Backpack".**

The Arada units receive messages from the cellular network via the Bluetooth paired Computational Platform mobile device. The DSRC Communication Hardware also hosts the Oncoming Vehicle-based INC-ZONE Application which is the core in-vehicle application that processes real-time data. The DSRC Communications Hardware transmits and receives DSRC messages including the BSM, EVA, TIM, and ACM to and from other DSRC radios that are in range. These include receipt of EVA Collision BSMs and INC-ZONE Map TIM messages from Responder Vehicle DSRC Communication Hardware and transmission of Threat ACM and Collision ACM messages to Responder Vehicle DSRC Communication Hardware, when required.




Source: Arada/Battelle

**Figure 4-5. Arada Locomate "Mini2" DSRC Radio with External GPS and DSRC Antenna.**

## Vehicle Data Interface

The INC-ZONE Oncoming Vehicle Subsystem uses the Battelle VITAL™ OBD-II module (see Figure 4-6) to obtain a vehicle's telematics data and, where needed, send commands to vehicle systems. The module transmits the data via Bluetooth to the Computational Platform and User Interface for use in processing and decision making. Specifications for the module are provided in the INC-ZONE and RESP-STG Final Prototype Demonstration Report.


Source: Battelle

**Figure 4-6. VITAL™ OBD-II Module.**

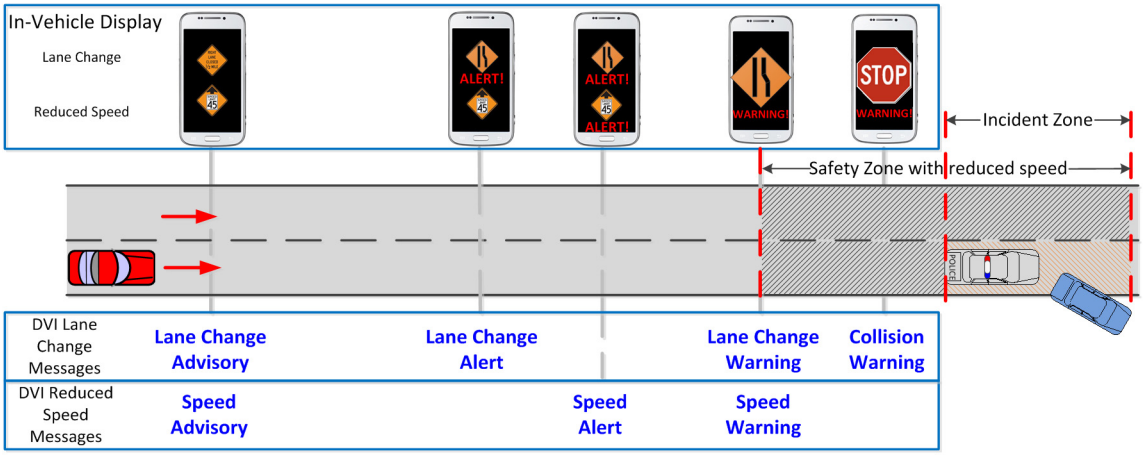
## GPS Positioning Module

Accurate determination of whether an oncoming vehicle is approaching a responder vehicle in an unsafe manner requires lane level positioning accuracy. Based upon best available data during the design of the R.E.S.C.U.M.E. system it was expected that DGPS could provide the accuracy needed to support the R.E.S.C.U.M.E. application. DGPS is an enhancement to satellite-based GPS systems that uses fixed ground-based reference stations to correct for error and improve location accuracy. DGPS correction data was used to improve the accuracy of the location services within the Arada Systems DSRC Communication Hardware component. An Internet-based, regional source of correction data from the Ohio Department of Transportation was used in the June 2014 Prototype Acceptance Testing in Ohio. While DGPS was more accurate than GPS alone, testing during the June demonstration showed that the position could drift as much as a lane over a few hours of time, making it necessary to periodically reset the position of stationary vehicles.

For the Field Demonstration, Battelle modified the design to use Precise Point Positioning (PPP), a method that performs precise position determination to within a meter using a single receiver. The PPP position was implemented using a Ublox PPP demonstration kit, providing the GPS position inputs directly into the Arada radio. As described by Ublox, PPP technology is made possible by stabilizing measurements of the distance between Global Navigation Satellite System (GNSS) satellites and the receiver (pseudo-ranges) using carrier phase tracking. Additional accuracy is achieved from ionospheric correctional data received from satellite-based augmentation systems, such as Wide Area Augmentation System (WAAS; U.S.), European Geostationary Navigation Overlay Service (EGNOS; Europe), Multi-functional Satellite Augmentation System (MSAS; Japan) and upcoming GPS-aided geo-augmented navigation (GAGAN; India). The Ublox implementation of PPP uses correctional data received from satellites rather than locally provided DGPS corrections. Battelle tests of the PPP system demonstrated much improved accuracy and reduction of drift over time to roughly a meter.

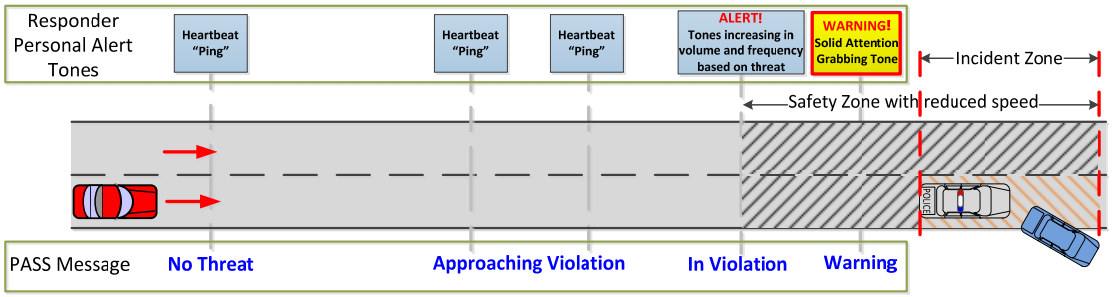
## Oncoming Vehicle INC-ZONE User Interface Message Examples

Figure 4-7 and Figure 4-8, repeated from Chapter 3 for convenience, illustrate INC-ZONE in-vehicle signage and responder message concepts. The figures show the vehicle approaching an incident zone. The box above the roadway in Figure 4-7 illustrates the *in-vehicle signage* displays on the vehicle driver interface. The boxes above the roadway in Figure 4-8 illustrate *responder messages* displayed to on-scene workers with a PASS. These illustrations portray the oncoming vehicle with a graphical DVI display and the responder messages as audio-based. As the vehicle approaches the incident zone illustrated in Figure 4-7, the Oncoming Vehicle Application Component receives a wireless EVA and TIM from the responding vehicle containing the incident zone location and map data, and advised or posted speed for the safety zone, which is a buffer area that includes the incident zone.




Source: Battelle

**Figure 4-7. Illustration of the Issuance of In-Vehicle Advisory, Alert and Warning Messages based on Oncoming Vehicle Proximity to the Safety Zone, Incident Zone, and Responding Vehicle.**




Source: Battelle

**Figure 4-8. Illustration of the Issuance of Responder PASS Advisory, Alert and Warning Messages based on the Threat of an Oncoming Vehicle Threat based on its Proximity to the Safety Zone, Incident Zone, and Responding Vehicle.**

Figure 4-9 through Figure 4-12 provide screen captures of the oncoming vehicle Driver User Interface Messages on the Android Device for the R.E.S.C.U.M.E. Applications. The screens were implemented to be as simple and clear as possible with the goal of displaying advisories, alerts and warnings to oncoming vehicle drivers in sufficient time for them to take appropriate action. Icons for lane closure and speed reduction were taken from the MUTCD. Note that human factors or industrial design was not part of the scope of this project.


Source: Battelle

**Figure 4-9. Advisory-Lane Closed Ahead, Advisory-Reduce Speed Ahead.**


Source: Battelle

**Figure 4-11. Warning-Lane Closed, Merge Immediately.**


Source: Battelle

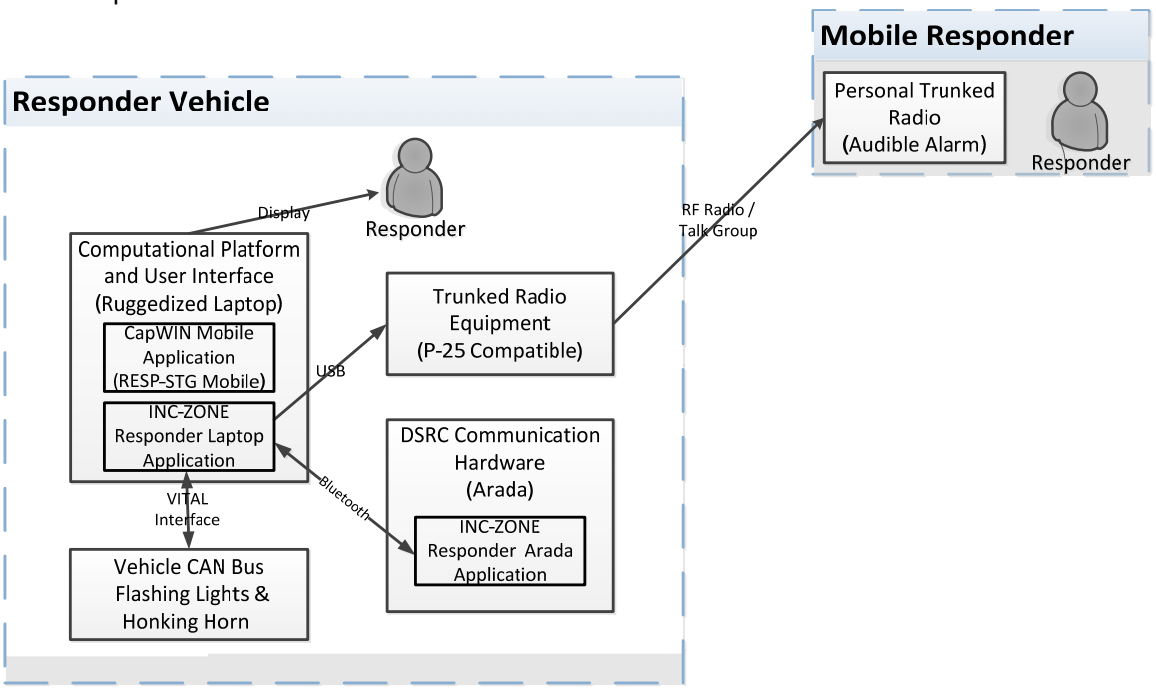
**Figure 4-10. Alert-Lane Closed, Merge Quickly, Alert-Reduce Speed.**


Source: Battelle

**Figure 4-12. Warning-Imminent Collision, STOP.**

# Responder Vehicle Subsystem

The components deployed in the responder vehicle to support the R.E.S.C.U.M.E. Prototype are the Computational Platform and User Interface (Ruggedized Laptop), DSRC Communication Hardware (Arada), and Vehicle Data Interface (VITAL™). The Computational Platform and User Interface (Ruggedized Laptop) for the responder vehicle and the Responder Personal Trunked Radio (PASS) are described below. The DSRC Communication Software (Arada) and Vehicle Data Interface (VITAL™) in the responder vehicle are the same pieces of equipment that are described above for the oncoming vehicle. The VITAL™ module is used in the Responder Vehicle Subsystem to activate the horn and flash vehicle lights when required to issue warnings to the responder.




Source: Battelle

## Responder Vehicle Computational Platform and User Interface

The Computational Platform and User Interface in the responder vehicle is a ruggedized laptop running the Windows 7 operating system[1] shown in Figure 4-13. The features of this component are:

1. Provide a cellular interface to external data resources (e.g., in support of the DGPS correction data via the Internet).
2. Provide an interface with the resident CapWIN application for lane closures in the incident zone.

[1] Battelle was informed that the standard operating system used by responder agencies for ruggedized laptops has transitioned from Windows XP to Windows 7.

3. Provide an interface with the DSRC radio module via a Bluetooth connection to send and receive incident zone map descriptions and collision threat alarms.

Source: Battelle

**Figure 4-13. Panasonic Ruggedized Laptop used as the Responder Vehicle Computational Platform and User Interface.**

## Responder Radio Interface

The personal alarm safety system for responders is illustrated in Figure 4-14. It consists of

- Motorola APX 6500 mobile radio commonly used by first responder agencies.
- Motorola APX 6000 portable radio
- Universal Serial Bus (USB) / Microphone Extender cable assembly.
- Injects audible alarms into the APX 6500 palm microphone generated by the responder INC-ZONE application.
- USB connection to the responder's laptop, no modifications to the responder radio.

Both radios are typical of currently deployed responder communication gear. For the purposes of the testing conducted here, the radio utilizes the Multi-Agency Radio Communication System (MARCS) 700/800 MHz radio and data network utilizing trunked technology to provide statewide interoperability for public safety and first responders.

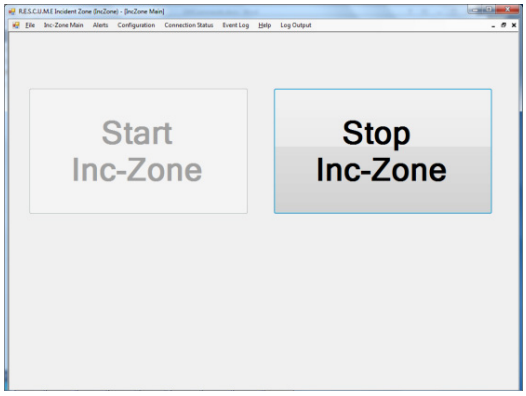
Communication with the responder's P-25 radio equipment is accomplished via an inline cable connector inserted with the palm microphone cable plugged into the P-25 radio. The inline cable connector is modified to allow control of the talk key over a USB connection from the ruggedized laptop in the responder vehicle. The USB connection allows the ruggedized laptop to not only key the microphone, but also to output a tone to the microphone speaker of a programmable duration. The P-25 radio, in turn, is configured to broadcast input from the microphone connection to a pre-defined talk group for the personal radio worn by the responder. In this way, threat and alarm notifications generated by the INC-ZONE application are communicated directly to dismounted responders (responders who have left their vehicle). Normal operation of the palm microphone by the responder will not be altered by this modification. The radio interface will contain no field programmable capabilities. It is essentially a cable connecting a USB port on the ruggedized laptop to a standard hand microphone connector that in turn plugs into the P-25 radio.


Source: Battelle

**Figure 4-14. Personal Alarm Safety Subsystem (PASS) Components.**

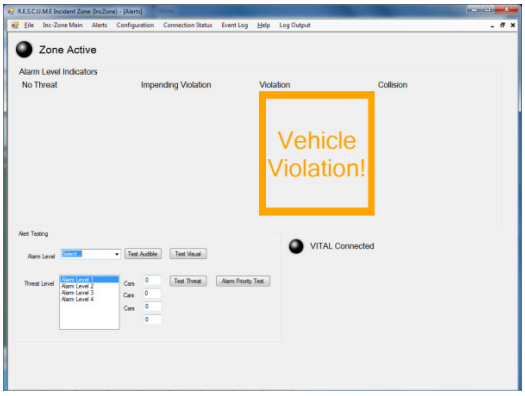
## Responder Vehicle INC-ZONE User Interface Message Examples

Figure 4-15 through Figure 4-19 show screen capture displays of the INC-ZONE Responder Laptop User Interface advisory, alert and warnings of oncoming vehicle threats.



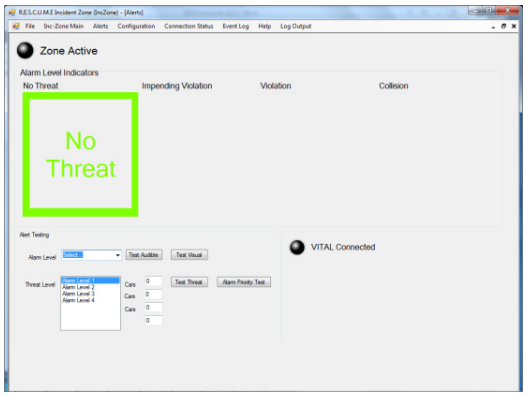

Source: Battelle

**Figure 4-15. INC-ZONE Responder Laptop Application Start Screen.**



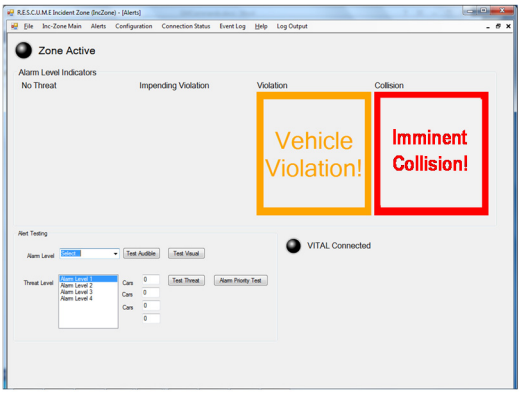

Source: Battelle

**Figure 4-18. INC-ZONE Responder Laptop Application Incident Zone Violation Alert.**



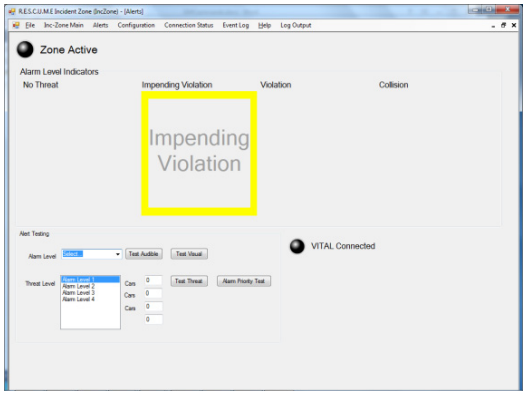

Source: Battelle

**Figure 4-16. INC-ZONE Responder Laptop Application No Threat Display.**




Source: Battelle

**Figure 4-19. INC-ZONE Responder Laptop Application Incident Zone Imminent Collision Warning.**

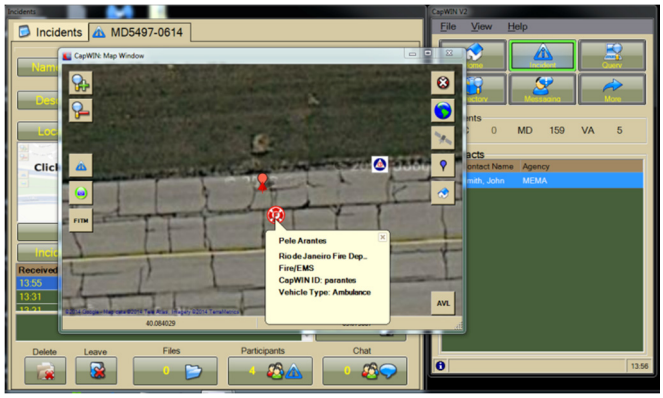



Source: Battelle

**Figure 4-17. INC-ZONE Responder Laptop Application Impending Incident Zone Violation Advisory.**

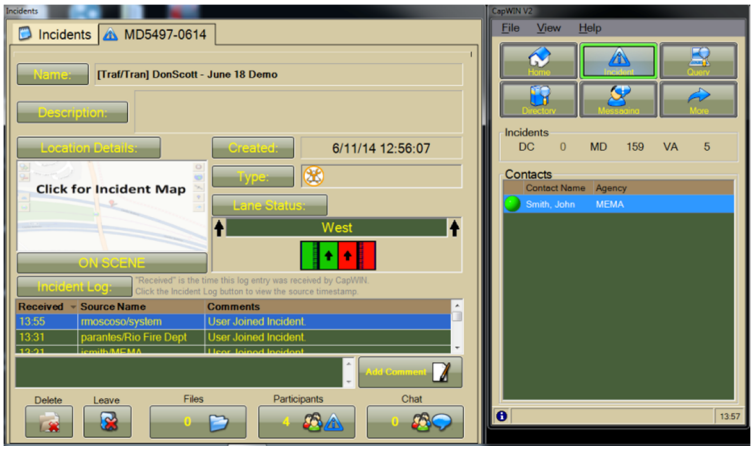
## Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples

Figure 4-20 through Figure 4-23 show screen capture displays of the Responder Vehicle CapWIN Mobile RESP-STG User Interface.



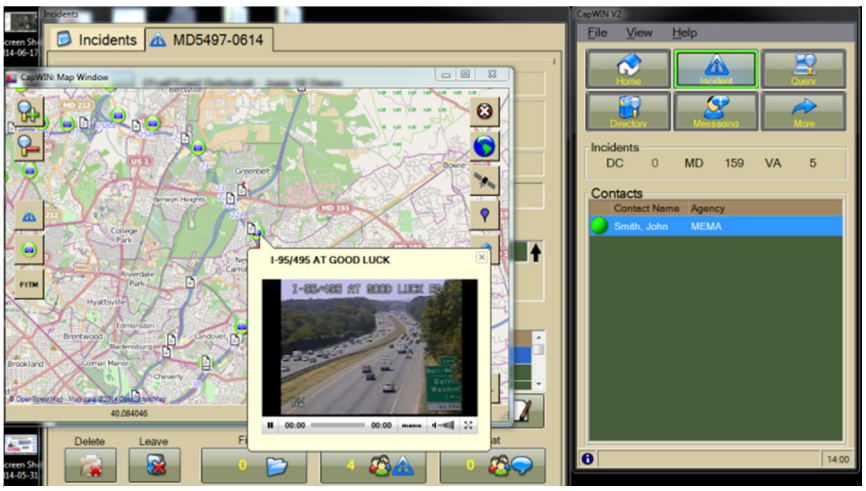

Source: UMD CATT

**Figure 4-20. CapWIN Client – Satellite View of On-Scene Responders (Lane Level) showing Icons and Specific Details.**



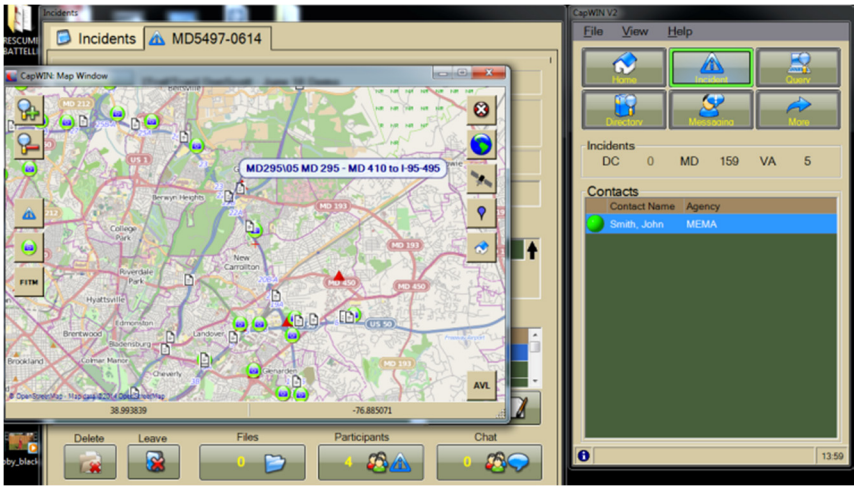

Source: UMD CATT

**Figure 4-21. CapWIN Client Lane Status Screen showing Right Shoulder and Right Lane Closed on Westbound Roadway.**




Source: UMD CATT

**Figure 4-22. CapWIN Client showing Live Video Streaming from Traffic Camera Nearby Incident.**



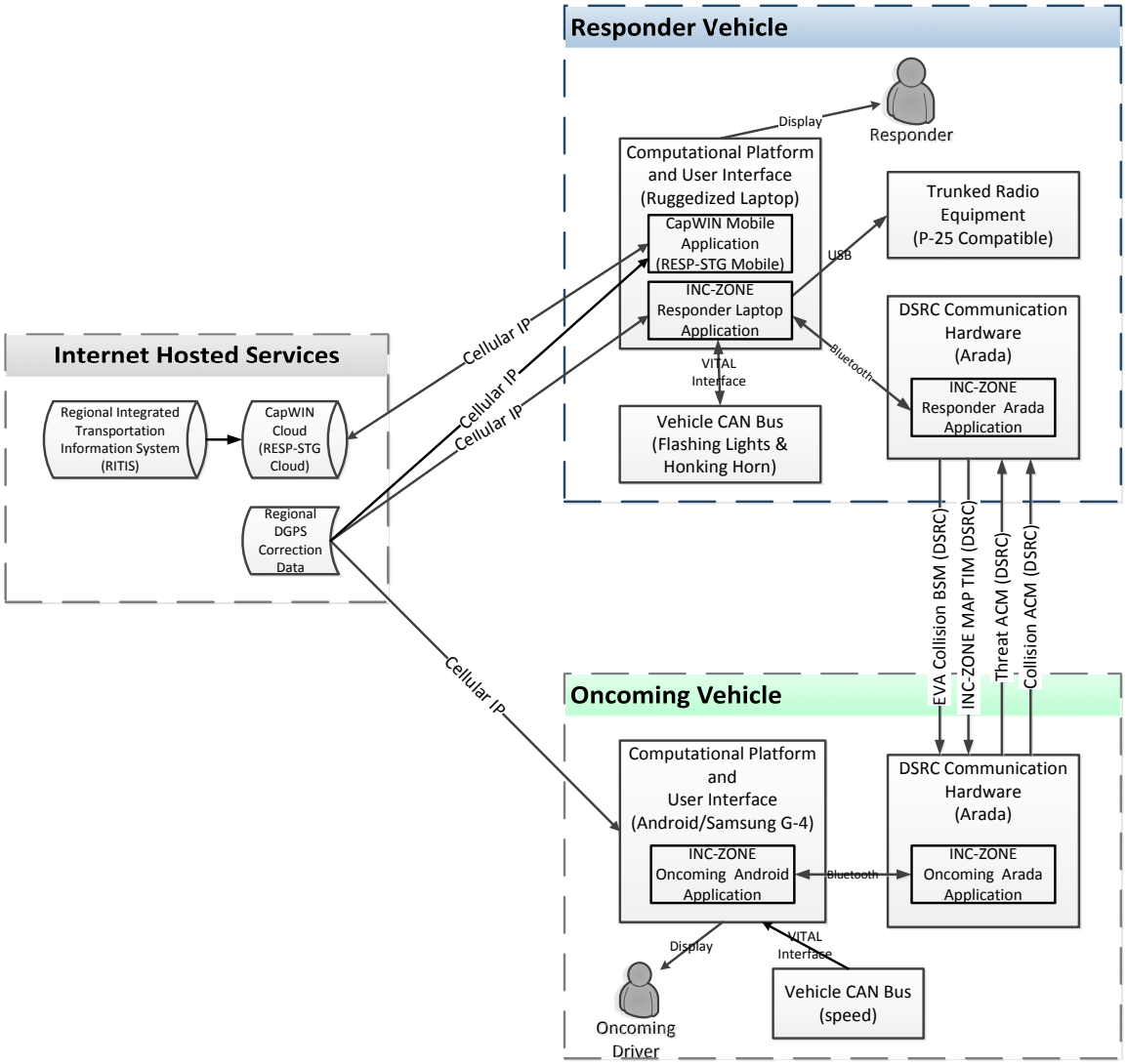

Source: UMD CATT

**Figure 4-23. CapWIN Client Showing Freeway Incident Traffic Management (FITM) Plans Available on Freeway Rerouting Layer from FITM Plans.**

## Internet Hosted Services

As implemented for this demonstration, Internet Hosted Services include the

- RESP-STG Application Cloud Components (CapWIN Cloud)
- Regional DGPS Correction Data




Source: Battelle

## DGPS Correction Network

DGPS is an enhancement to satellite-based GPS systems that uses fixed ground-based reference stations to correct for error and improve location accuracy. DGPS correction data was used to improve the accuracy of the location services within the Arada Systems DSRC Communication Hardware component. An Internet-based, public regional source of correction data from the Ohio Department of Transportation was used in Ohio for the Acceptance Testing. Where this data is not available from public sources, such as Maryland and Virginia, they are available from commercial sources.

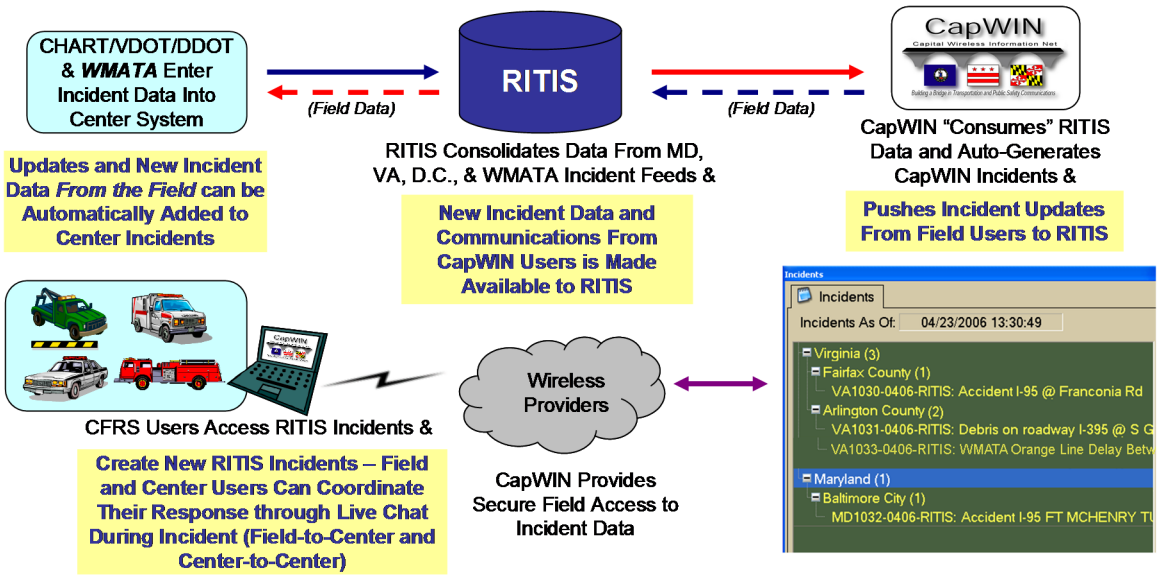
As noted earlier, while DGPS was more accurate than GPS alone, testing during the June demonstration showed that the position could drift as much as a lane over a few hours of time, making it necessary to periodically reset the position of stationary vehicles. For the Field Demonstration, Battelle modified the design to use PPP, a method that performs precise position determination to within a meter using a single receiver. Battelle tests of the PPP system demonstrated much improved accuracy and reduction of drift over time to roughly a meter, without need for an external Internet hosted service.

## CapWIN Cloud Incident Data Feed

The CapWIN system provides a cloud-based XML feed of all incident data collected from all deployed CapWIN clients running on any responder vehicle's ruggedized laptop. The CapWIN system provides lane closure data to the Responder Vehicle INC-ZONE application via cellular IP communications.

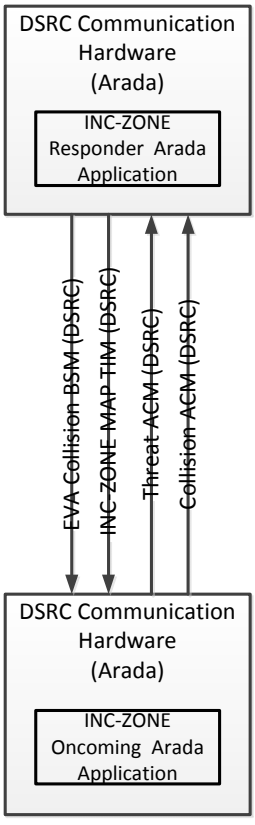
The purpose of the CapWIN XML Feeder is to enable seamless data exchange across multiple systems and user interfaces. Data generated in a center-based system, e.g., the MD CHART system is automatically ingested by the CapWIN Feed Interface (CFI) and presented to CapWIN mobile users in the field environment. User updates made via the CapWIN Mobile Client are then incorporated into the CapWIN Feeder XML which can then be ingested by external consumers, e.g., CHART and RITIS.

Figure 4-24 illustrates the flow of incident data from a center-based system to the CapWIN infrastructure and client, and back again via the CapWIN Feeder.




Source: UMD CATT

**Figure 4-24. CapWIN Cloud Incident Data XML Feeder.**




# DSRC Messages

DSRC messages are exchanged between the oncoming and responder vehicles for the INC-ZONE application to communicate the existence of an incident zone to the oncoming vehicles, and to send threat messages from the oncoming vehicle to the responder vehicle.

All DSRC communications between the DSRC radios in the Arada Systems DSRC Communication Hardware component in both the oncoming and responder vehicles transmit and receive messages conforming to the SAE J2735:2009 specification. The Oncoming Vehicle's DSRC radio receives and processes TIM and EVA messages broadcast by the responder vehicle. The Responder Vehicle's DSRC radio receives and processes ACM messages broadcast by the oncoming vehicle.

The INC-ZONE and RESP-STG Final Prototype Demonstration Report provides examples Log Files collected during testing of each message type in XML format for illustration purposes.

Table 4-1 summarizes the DSRC Messages used in the INC-ZONE application.

**Table 4-1. SAE J2735.2009 Messages used in the INC-ZONE Application.**

| Message | |
|---|---|
| Emergency Vehicle Alert (EVA) | • Transmitted from every responder vehicle's DSRC radio based on the INC-ZONE application.<br>• Received by oncoming vehicles and used by the INC-ZONE application to detect collision threats.<br>• Received by the responder vehicle's DSRC radio and used by the INC-ZONE application to manage incident zone resources, such as which responder vehicle is in the most favorable position to broadcast the INC-ZONE TIM messages. |
| Traveler Information Message (TIM) | • Transmitted from a single responder's DSRC radio based on the INC-ZONE application.<br>• Constructed from data received from the Computational Platform and User Interface, including local map data as well as incident specific lane and speed information.<br>• Received by oncoming vehicles and used by the INC-ZONE application to provide lane and speed guidance. |
| A la Carte (ACM) collision threat[2] | • Generated by the oncoming vehicle from vehicle location data and incident zone descriptions broadcast from the responder vehicle.<br>• Received by the responder vehicle and used by the INC-ZONE application to alert the responder to threats in the incident zone. |

Source: Battelle

# Visualization Tools

## INC-ZONE DSRC Situational Display

The Acceptance Testing and Field Demonstrations used an INC-ZONE DSRC Situational Display, shown in Figure 4-25, as a demonstration and diagnostic aid for geo-locating and visualizing DSRC messages on a map. The hardware consists of an Arada Systems DSRC Radio and an Android tablet with cellular data service. The Arada DSRC radio passively listens for DSRC traffic, receives and decodes the messages in that traffic, and passes an extract of those messages over Bluetooth to the Android tablet, where the message extract is geo-located and displayed on a local map.

The Situational Display utilizes a software library on the Arada Systems radio for decoding all SAE J2735 compliant WAVE traffic. Three message types were decoded, processed, and an extract of those messages were passed on to the tablet for display: the BSM, the EVA and the TIM. The tablet used the geo-location data (latitude and longitude) in the messages and

[2] ACM can contain any of over 200 data elements defined in J2735. As part of this effort Battelle designed one particular type of ACM containing the elements need to enable the required functionality of the application.

displayed distinguishing icons for each on publicly available map extracts pulled from map services on the Internet. Messages were processed and displayed in near real time, allowing the user to track the traversal of DSRC equipped vehicles through zones broadcast by roadside equipment (RSE) or other sources of TIM messages, as it happened.

Since the Situational Display interacted with the DSRC stream using a well-defined library standard for SAE J2735, it is agnostic to the source of the DSRC traffic, be it V2V, V2I, of any vendor.


Source: Battelle

**Figure 4-25. Display of Responder EVA Collision BSM and TIM Message Data showing the Closed Lanes as Red Lines, Reduced Speed Lane as Yellow Lines, the Responder Vehicle Blue Icon, Oncoming Vehicle Green Icon.**

# RESP-STG Component Description

This section identifies the components that make up the RESP-STG application within the R.E.S.C.U.M.E. prototype system as seen both logically and physically.

## Overview

As noted in the R.E.S.C.U.M.E. Concept of Operations, emergency responders do not currently have the capability to factor in all potentially important information that could be modeled to help them arrive and position themselves in a way that best supports the needs of the incident and the objectives of the incident commander. The purpose of RESP-STG is to provide this supplemental information to responders on-scene and en-route in order to improve situational awareness among all participants, including incident commanders and center-based users. In addition, the integration of this information with direct input from first responders in the field to the INC-ZONE Threat Detection and Alerting functions can help to improve the safety of first responders at the incident scene.

The primary components of the RESP-STG solution were realized through specific enhancements to the CapWIN Mobile Client suite of applications and backend server infrastructure. Currently, the CapWIN Mobile Client provides the following capabilities:

- Incident information from transportation center systems via RITIS as well as CapWIN user created incidents. This information includes:
  - Incident Name
  - Incident Type
  - Incident Location (if available)
  - List of users who have "joined" the incident via the CapWIN Mobile Client
  - Incident log of system and CapWIN user updates to the incident information
  - Messaging (one-to-one and group) for incident participants

RESP-STG enhancements to the CapWIN Mobile Client included the following *new* functions:

- Real-Time (automatic vehicle location) AVL display for all responders denoting themselves as "On-Scene" or "En-Route" to the Incident scene, which includes information on the agency and discipline for each responder. The R.E.S.C.U.M.E. team used advanced AVL components providing "hyper accurate" (< 1m resolution) GPS location coordinates (X,Y's) for responders.
- An interface to allow first responders identify the types of vehicles and the vehicles' lane level positions on the incident scene
- Enhanced mapping functions and data, including:
  - New core mapping engine based on Open Street Maps
  - "Lane level" satellite imagery,
  - Hospital Locations
  - Highway Rerouting Plans
  - Live Traffic Data
  - Live Weather Data
  - Dash Cam video (if available).
  - Lane-Level AVL for all Incident Participants, including a visual denotation of each participant's agency, discipline and asset

The CapWIN Mobile Client and supporting database (IBM DB2) were modified to capture information on the type of vehicle ("asset") used by each CapWIN user.

In addition to the enhancements to the CapWIN Mobile Client Suite, significant enhancements were also made to the CapWIN server infrastructure and CapWIN Business Layer (CBL). Specific enhancements included:

- Creation of near real-time NIEM-compliant XML feed of CapWIN incident data, including CapWIN Mobile Client user updates for ingestion into the INC-ZONE Threat Determination and Alerting solution.[3] This new Incident feed included lane

[3] The National Information Exchange Model (NIEM) is an interagency initiative that provides the foundation and building blocks for national-level interoperable information sharing and data exchange. Initiated in February 2005, NIEM was originally a joint venture between the U.S. Departments of Justice (DOJ) and Homeland Security (DHS) with outreach to other Government departments and agencies.

condition status based on user input as well as center updates. The CapWIN XML Feeder is available through a secure connection and can be accessed by other external consumers, including, but not limited to, transportation and emergency management center systems.

- Incorporation of near real-time AVL data from all CapWIN Mobile Client users who have denoted themselves as either on-scene or en-route to an incident scene. This AVL data was not previously captured or distributed by the CapWIN infrastructure and was done in a way to enable the real-time "push" of this location data to CapWIN Mobile Client users as well as to the CapWIN XML Feeder.

## Integration with INC-ZONE

The primary data integration between RESP-STG and INC-ZONE supports the Threat Determination and Alerting function by providing near real-time information on lane status and first responder locations based on AVL data and user input made in the CapWIN Mobile Client. This data was made accessible to INC-ZONE via the CapWIN XML Feeder. This information was algorithmically incorporated as part of the threat determination for alerting purposes.

# Chapter 5 R.E.S.C.U.M.E. Prototype Component, System and Application Acceptance Testing

This chapter summarizes the results of System Acceptance Testing for the R.E.S.C.U.M.E. application bundle, with a focus on the INC-ZONE and RESP-STG applications. It addresses the component, system integration and prototype acceptance testing conducted to verify that the system met its functional and performance requirements. The results of the acceptance tests were used by the U.S. DOT in its decision to conduct follow-on field demonstrations of INC-ZONE and RESP-STG.

## Overview

The principles of system engineering were applied in conducting R.E.S.C.U.M.E. Prototype System Acceptance Testing to verify that the developed prototype met the system requirements defined in Chapters 3 and 6 of the R.E.S.C.U.M.E. Final Functional and Performance Requirements (FHWA-JPO-14-TBD). Specifically, the tests addressed required testing for the following subsystems, as described in the R.E.S.C.U.M.E. Prototype System Architecture (FHWA-JPO-14-TBD), and further refined in the R.E.S.C.U.M.E. Prototype System Design Document (FHWA-JPO-14-TBD):

- Applications Under Test
  - Incident Zone (INC-ZONE)
    - INC-ZONE Oncoming Android Application
    - INC-ZONE Oncoming Arada Application
    - INC-ZONE Responder Laptop Application
    - INC-ZONE Responder Arada Application
  - Response Staging (RESP-STG)
    - RESP-STG Mobile (CapWIN Mobile Application)
    - RESP-STG Cloud (CapWIN Cloud)
- Oncoming Vehicle Subsystem
  - Computational Platform and User Interface (Samsung Galaxy S-4)
  - DSRC Communication Hardware (Arada)
  - Vehicle Data Interface (VITAL™)

- Responder Vehicle Subsystem
  - Computational Platform and User Interface (Ruggedized Laptop)
  - DSRC Communication Hardware (Arada)
  - Vehicle Data Interface (VITAL™)
  - Responder Personal Trunked Radio (PASS)
- Internet Hosted Services
  - DGPS Correction Network
  - CapWIN Incident Data Feed

# Participation

All testing described within this document was conducted by the Team of Battelle and UMD CapWin. Upon completion of the testing, the Battelle Team conducted a demonstration of the key Phase II and Phase III acceptance tests that were witnessed by representatives of the U.S. DOT and selected contractors.

# Security

No testing related to security was planned for this prototype. While Arada has implemented and verified over-the-air-security for DSRC radios as prescribed for the U.S. DOT Safety Pilot Model Deployment in V3.0 of the Roadside Equipment specification, the necessary firmware modifications for the "backpack" form factor used here were still in development at the time this testing was conducted. Over-the-air-security for DSRC radios will be verified prior to further prototype development or enhancements. Communications using cellular and other internet 'standards' used secure-socket layers, and as necessary, virtual private network connections.

# Overview of the R.E.S.C.U.M.E. Prototype Acceptance Testing

The objective of this series of tests was to confirm and to demonstrate to the U.S. DOT that the R.E.S.C.U.M.E. Prototype System was fully functional and sufficiently robust to support refinement and follow-on Field Demonstrations of INC-ZONE and RESP-STG.

## Phase I – Component Level Acceptance Testing

Phase I test cases were tested within the Battelle Team laboratory integration test environment. During this phase the Battelle Team verified each system component against the system requirements using simulated data inputs. Both the functionality of the component and the external interfaces of the component were tested in this phase. This enabled parallel development and testing of each system component to ensure that they each conform to their basic functional requirements.

## Phase II – System Interface Level Acceptance Testing

Phase II test cases integrated the system components to verify the interface performance and functionality of the components as a system. During this phase the Battelle Team verified the integrated systems used by the INC-ZONE application on the oncoming vehicle and the RESP-STG and INC-ZONE applications used by the responder vehicle separately, before verifying the integrated system of both the RESP-STG and INC-ZONE applications together on the responder vehicle.

## Phase III – Prototype System Acceptance Testing

During Phase III test cases, connected vehicle nomadic devices were placed in vehicles and the Battelle Team conducted communication and messaging testing of the system on a closed course test track. The purpose of Phase III was to demonstrate that the system would fully function in on-road environments and be able to support further development and demonstrations.

Upon completion of the testing, the Battelle Team conducted a demonstration of key Phase II and Phase III tests that was witnessed by representatives of the U.S. DOT and selected contractors. The results of this acceptance testing was used by the U.S. DOT to determine support for refinement and follow-on field demonstrations of INC-ZONE and RESP-STG described in the following chapter.

Summaries of all three testing phases are provided in Appendix A.

# Chapter 6 R.E.S.C.U.M.E. Prototype System and Application Field Demonstration

## Scope of the Field Demonstration

Following the successful acceptance testing of the R.E.S.C.U.M.E. INC-ZONE and RESP-STG applications, the U.S. DOT authorized Battelle to proceed with a Field Demonstration of the applications. This demonstration was conducted at the Maryland Police and Correctional Training Commissions Driver Training Facility in Sykesville, Maryland on November 13, 2014. Following is an overview of the demonstration.

The scope of the field demonstration included the INC-ZONE prototype, and the RESP-STG prototype in a limited field test, showing how the elements of these applications could be implemented in roadway incidents. The INC-ZONE application demonstrated providing first responders with real-time alerts of oncoming vehicles that have trajectories or speeds that pose a high risk to their safety. The INC-ZONE application also demonstrated delivering merging and speed guidance around an incident to on-coming vehicles based on the configuration and needs of the incident scene.

The RESP-STG application demonstrated communications, visual display, vehicle equipment and staging, and emergency responder status reporting. RESP-STG functions were shown upon dispatch, while en-route to establish incident scene work zones, upon initial arrival and staging of assets, and afterward where circumstances require additional dispatch and staging.

## Demonstration Participation

All demonstration activities were conducted by the team of Battelle and UMD CATT to be witnessed by representatives of the U.S. DOT and selected support contractors including Booz Allen Hamilton and Noblis. They were supported by:

- Maryland State Police, providing a Patrol Vehicle and Officer
- EMS vehicle and responders from the Sykesville/Freedom Volunteer Fire Company and West Friendship Volunteer Fire Company
- Maryland State Highway Administration providing CHART ERU and staff.
- Maryland Emergency Management Agency (MEMA)

Observers of the Field Demonstration included representatives of the following organizations:

- Federal agencies
  - ITS Joint Program Office
  - Federal Highway Administration
  - National Highway Safety Traffic Administration
  - Federal Motor Carrier Safety Administration
- Other organizations
  - Erie County New York Sheriff's Office
  - Transportation Research Board – Standing Committee on Traffic Law Enforcement (ANB40)
  - Transportation Safety Advancement Group (TSAG)
  - International Association of Chiefs of Police
  - Intelligent Transportation Society of America

## R.E.S.C.U.M.E. Prototype Field Demonstration Overview

The purpose of this demonstration was to show how the R.E.S.C.U.M.E. INC-ZONE and RESP-STG applications can be incorporated into and support mobility and safety during a highway responder incident. This demonstration simulated a roadside medical emergency which is responded to by Maryland State Police, EMS, and ERU vehicles. In particular, the demonstration simulated a medical emergency where a driver pulls to the side of the road and calls 9-1-1. Participants observed the evolution of the incident as a Maryland State Police vehicle, followed by an EMS/Ambulance and an ERU. Participants observed the tools that responders have to establish incident scene work zones both upon initial arrival and staging of assets.

The simulated emergency was broken down into a sequence of steps showing the arrival (and departure) of each responder vehicle, followed by oncoming vehicles approaching safely and approaching unsafely. This sequence highlights the full functionality of the INC-ZONE and RESP-STG applications from three different perspectives including the perspective of the on-coming vehicle driver, the en-route responder, and the on-scene responder. All three aspects were observed during the scenario by a group of observers riding in on-coming vehicles, a second group of observers viewing the incident as if they were an en-route responder or dispatcher, and a third group of observers witnessing the incident as if they were on-scene.

Observers of the demonstration were rotated through each group or station and observed the same scenario from each of the three aspects.

## On-Coming Vehicle Observers

Demonstration Observers rode in an on-coming vehicle with a dedicated driver and the Demonstration Narrator. The Narrator provided a "play-by-play" narration of the scenario as it unfolded as well as explained the various actions, messages, and advisories that the observers encountered. The Demonstration Observers witnessed Advisories, Alerts, and Warnings received by the on-coming vehicle and presented to the driver on a DSRC nomadic device. Multiple "passes" of the incident were made with the first pass being performed as if the on-coming vehicle was driven by a "safe" driver and the subsequent pass being performed by a driver who is approaching the incident scene hazardously.

## En-route First Responder Observers

The RESP-STG application provides situational awareness to and coordination among emergency responders—upon dispatch and while en-route—to establish incident scene work zones both upon initial arrival and staging of assets, and afterward, if circumstances require, additional dispatch and staging. It provides input to responder and dispatcher decisions and actions. A range of data is provided through mobile devices and other types of communication to help support emergency responder vehicle routing, staging, and secondary dispatch decision-making. The project team developed a response staging application through enhancements to the UMD CATT CapWIN program. UMD CATT demonstrated the latest developments in CapWIN RESP-STG in real-time on a large display screen at the demonstration site. This screen replicated the screen that appears on the first-responder's in-vehicle computer. Demonstration Observers witnessed an updated map display with first responders appearing on the map while they were en-route or on-scene, lane closure information, and dash-camera live video feeds.

## On-Scene Observers

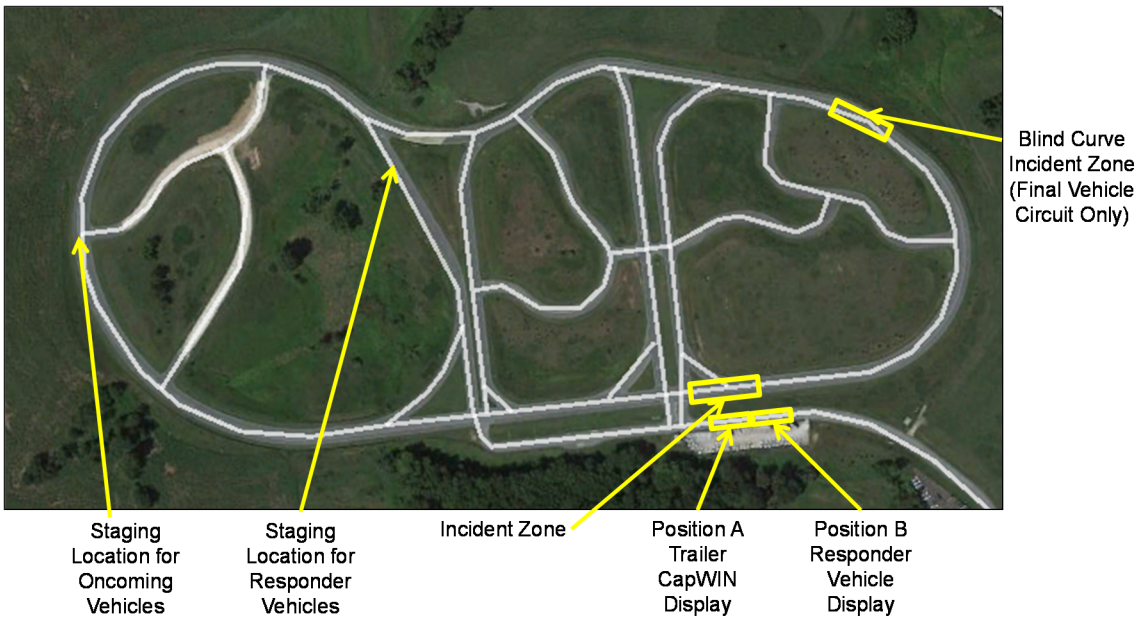
Demonstration Observers also observed the INC-ZONE application's warning system for on-scene workers when a vehicle approaching or in the incident zone is being operated outside of safe parameters for the conditions. Observers were located near the incident and witnessed the warning system at close range without being part of the incident.

## Field Demonstration Facility

The R.E.S.C.U.M.E. INC-ZONE and RESP-STG Field Demonstrations took place at the Maryland Police and Correctional Training Commission Driver Training Track in Sykesville, Maryland. The outer circumference of the track is approximately one mile in length and has two paved lanes with a shoulder. The size and layout of the track supported the responder vehicle configurations and oncoming vehicle speeds needed to safely demonstrate the full functionality and performance of the R.E.S.C.U.M.E. applications.

A satellite view of the driver training facility is shown in Figure 6-1. The figure shows the location of the Primary Incident Zone and three observer positions. Visitors to the demonstration were divided into two groups, to observe events taking place. The visitors rotated among three observer positions to observe the R.E.S.C.U.M.E. applications from three perspectives.

The first position, "Position A," was at an off-track test trailer with a 60 inch display screen on the outside. Observers witnessed the response staging features of CapWIN that were implemented as part of the R.E.S.C.U.M.E. project.




Source: Battelle

**Figure 6-1. Overview of the Maryland Police and Correctional Training Commission Driver Training Track and Demonstration Layout.**

The second location, "Position B," was adjacent to the incident zone and responder vehicles. At this location observers witnessed responders activating the incident zone electronically and adjusting the incident zone as additional responders arrived. They observed the approach and passage of oncoming vehicles, and were able to experience the same warnings received by responders when a vehicle approached in an unsafe or threatening manner.

The final location, "Position C" was in the oncoming vehicles where observers witnessed warnings received by the drivers when approaching and/or passing an incident zone in an unsafe manner.

The demonstration scenario was repeated to ensure that all visitors were able to observe events from each of the three positions shown on the track.

## Participating Responder Vehicles

Three responder vehicles and responders participated in the simulation of a medical emergency:

- Patrol Vehicle and Officer from the Maryland State Police
- EMS Vehicle and responders from the Sykesville/Freedom Volunteer Fire Company and West Friendship Volunteer Fire Company
- CHART ERU from the Maryland State Highway Administration

A fire truck from the Sykesville/Freedom Volunteer Fire Company or the West Friendship Volunteer Fire Company was on location, but was not included in the primary scenario due to weight limitations of the test track.

Oncoming vehicles in the demonstration were large sport utility vehicles (SUVs), either Ford Expeditions or Chevrolet Tahoes.

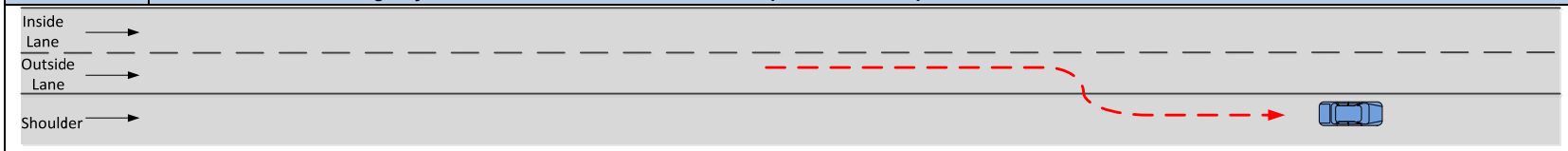
A Chevrolet Cruze was used to simulate a Maryland State Police patrol vehicle in the blind curve demonstration.

## R.E.S.C.U.M.E. Demonstration Scenarios

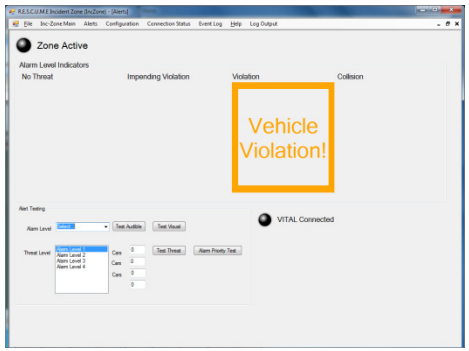
The following tables briefly describe the scenario, along with a graphic showing the location of responder and approaching vehicles. Below those descriptions is a listing of the functionality demonstrated during that scenario.

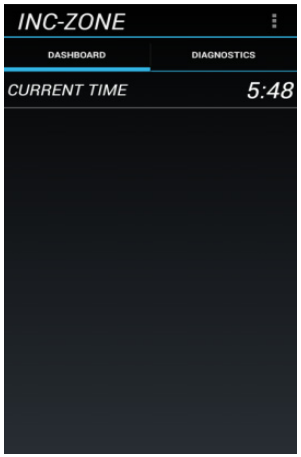
It is important to note that it was not possible to conduct the blind curve demonstration. A range of factors contributed to this, including the overlap of radio communications, and inability to receive maps in a timely manner as the zones were too close in proximity to one another. The Battelle Team recognizes that this is a limitation that would need be addressed prior to the INC-ZONE being placed into an operational environment.

| Scenario | Action and Graphic |
|---|---|
| 1 | **Driver with Medical Emergency Pulls to the Shoulder and Calls 9-1-1, Dispatch Initiates CapWIN Incident** |



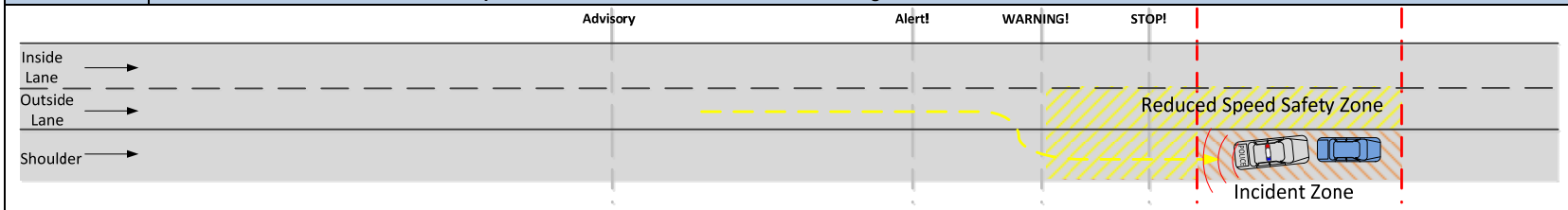

| Position A Trailer CapWIN Display: | Position B Responder Vehicle Display: | Position C Oncoming Vehicle Display: |
|---|---|---|
| - Introduction to CapWIN Response Staging<br>- Initiation of CapWIN Incident<br>- Safety briefing<br>- Demonstrated | - Arrival of Disabled Vehicle<br>- Introduction to Responder Vehicle Displays<br>- Safety briefing<br>- Demonstrated | - Participants board vehicles and proceed to Oncoming Vehicle staging location<br>- Introduction to Oncoming Vehicle Display and Onboard Vehicle System<br>- Safety briefing<br>- Demonstrated |


| Demonstrated Functionality: |
|---|
| - CapWIN: Initiation of an Incident from Central Dispatch **– Demonstrated** |

| Scenario | Action and Graphic |
|---|---|
| 2 | **Patrol Officer is Dispatched, Opens Incident in CapWIN, and Presses "En-route/On Scene" Button**<br>**Patrol Officer Closes Shoulder in CapWIN and activates INC-ZONE DSRC Message broacast** |

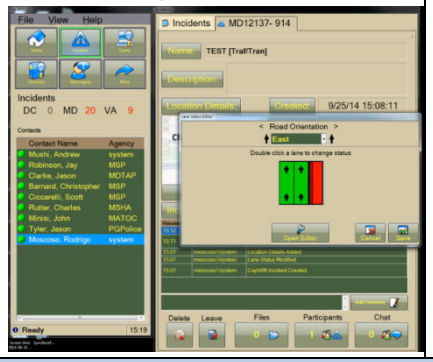



**Position A Trailer CapWIN Display:**

- CapWIN satellite view of AVL tracking of patrol officer progress and arrival
- CapWIN satellite view of on-scene responder locations
- CapWIN Display of Lane Closure Status
- CapWIN Display of Freeway Incident Traffic Management Plan (FITM Plans) from nearby highway location
- Demonstrated

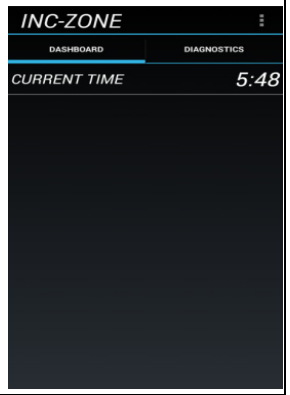
**Position B Responder Vehicle Display:**

- Arrival of patrol vehicle
- CapWIN Closure of shoulder by patrol officer
- Activation of INC-ZONE broadcast by patrol officer
- INC-ZONE situational display of lane closures
- Demonstrated



**Position C Oncoming Vehicles Display:**

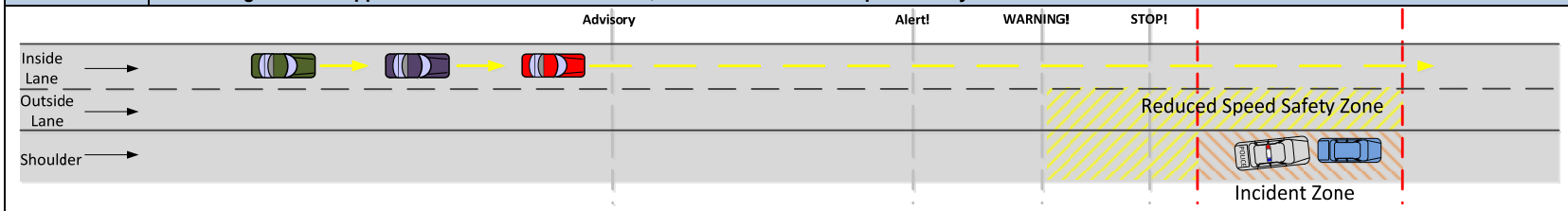
- Holds at Oncoming Vehicle Staging Location
- Description of Oncoming Vehicle Scenarios
- Demonstrated



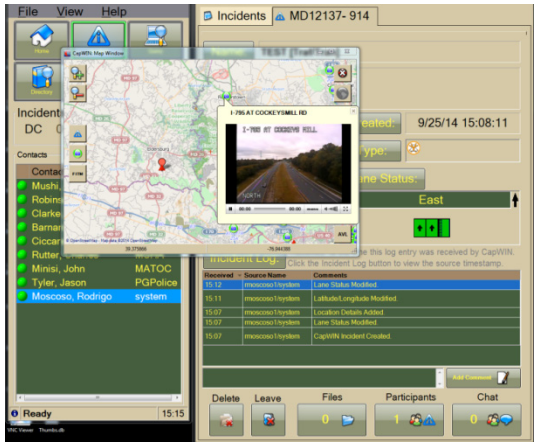

**Demonstrated Functionality:**

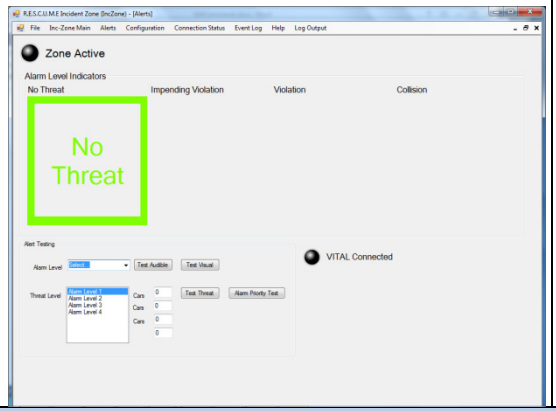
- CapWIN: Satellite view of AVL tracking of patrol officer progress and arrival **– Demonstrated**
- CapWIN: satellite view of on-scene responders to Lane Level Detail **– Demonstrated**
- CapWIN: Closure of the shoulder by patrol officer **– Demonstrated**
- CapWIN: Communication of lane closure to dispatch and en-route vehicles (Position A) **– Demonstrated**
- CapWIN: Freeway Incident Traffic Management Plan (FITM Plans) **– Demonstrated**
- INC-ZONE Responder Vehicle: Initiation of electronic Incident Zone and Reduced Speed Safety Zone **– Demonstrated**
- INC-ZONE Responder Vehicle: Initiation of DSRC broadast of Lane Closure and Reduced Speed Safety Zone **– Demonstrated**

| Scenario | Action and Graphic |
|---|---|
| 3 | **Oncoming Vehicles Approach and Pass on Inside Lane, Outside the Reduced Speed Safety Zone** |




| Position A Trailer CapWIN Display: | Position B Responder Vehicle Display: | Position C Oncoming Vehicles Display: |
|---|---|---|
| - CapWIN display of live video streaming of the incident<br>- Demonstrated | - Observe Oncoming Vehicles approaching on inside lane, outside the safety zone<br>- Observe that no Responder Warnings are issued<br>- Demonstrated | - Oncoming Drivers receive Advisory of closed lane and reduced speed ahead<br>- Observe that no driver alerts or warnings are issued<br>- Demonstrated |

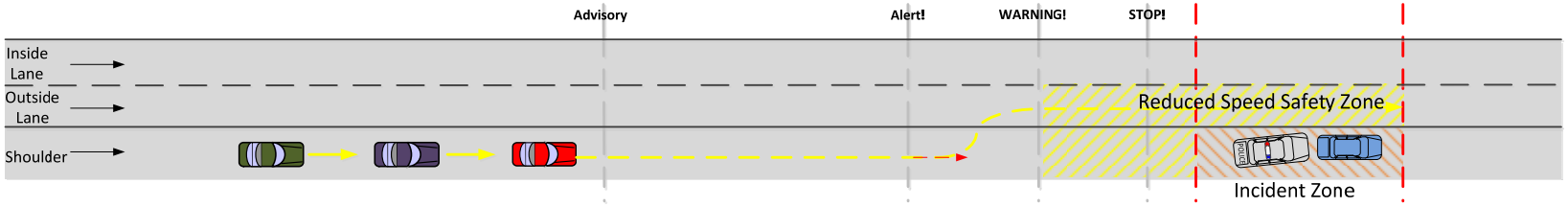




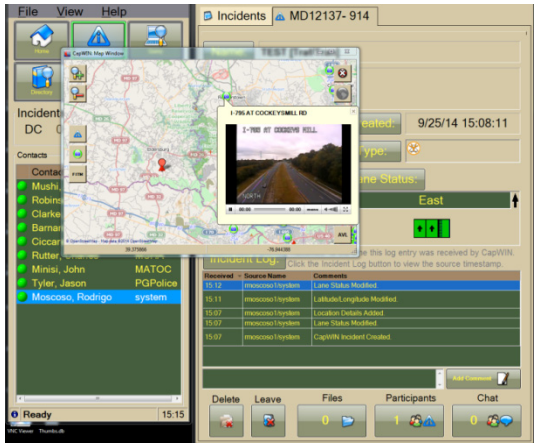
| Demonstrated Functionality: |
|---|
| - INC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Advisory in Oncoming Vehicles **– Demonstrated**<br>- INC-ZONE Oncoming Vehicle: No display of Alerts or Warnings when traveling outside the Safety Zone **– Demonstrated**<br>- INC-ZONE Responder Vehicle: No warnings issued as vehicles did not enter warning zone **– Demonstrated** |

| Scenario | Action and Graphic |
|---|---|
| 4 | **Oncoming Vehicles Approach Incident Zone Safely on Shoulder at (55 mph), Receive Alert, Then Change Lanes And Reduce Speed to Pass** |



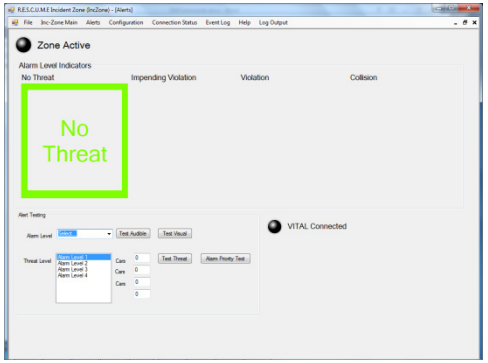

**Position A Trailer CapWIN Display:**

- CapWIN display of live video streaming of the incident
- Demonstrated




**Position B Responder Vehicle Display:**

- Observe Oncoming Vehicles approaching on shoulder, then change lanes and reduce speed
- Observe that no Responder Warnings are issued
- Demonstrated



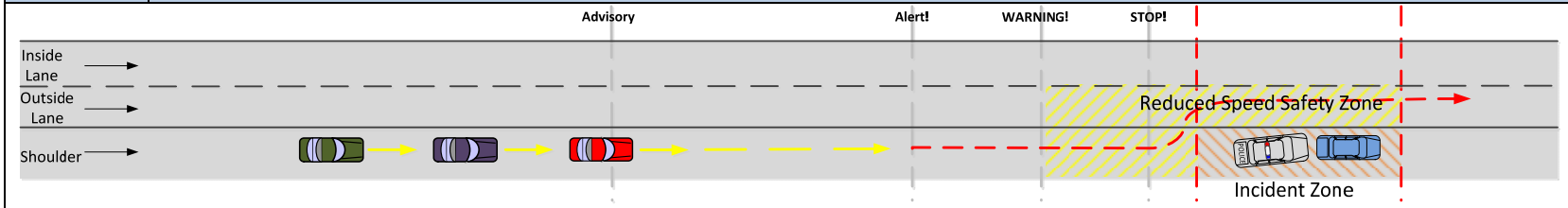

**Position C Oncoming Vehicles Display:**

- Oncoming Drivers receive Lane Closed and Reduce Speed Alerts, Change Lanes and Reduce Speed.
- Observe that no Oncoming Driver Warnings are issued.
- Demonstrated


**Demonstrated Functionality:**

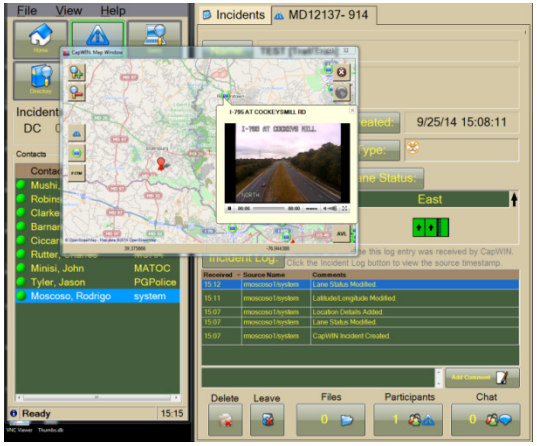
- INC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Advisory **– Demonstrated**
- INC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Alert **– Demonstrated**
- INC-ZONE Oncoming Vehicle: Cease display of Lane Closure and Reduced Speed Alert when vehicle changes lanes and reduces speed **– Demonstrated**
- INC-ZONE Responder Vehicle: No warnings issued as vehicles did not enter warning zone **– Demonstrated**

| Scenario | Action and Graphic |
|---|---|
| 5 | Oncoming Vehicles Approach Incident Zone Unsafely on Shoulder (55 mph), receive Alert, receive Warning, then Change lanes and Maintain Elevated Speed |



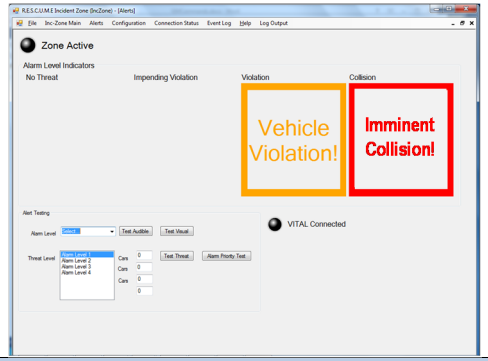

**Position A Trailer CapWIN Display:**

- CapWIN display of live video streaming of the incident
- Demonstrated




**Position B Responder Vehicle Display:**

- Observe Oncoming Vehicles approaching on shoulder, then change lanes and maintain elevated speed through Safety Zone
- Observe Responder Warnings including Radio Signal and patrol vehicle flashing lights and honking horn
- Demonstrated



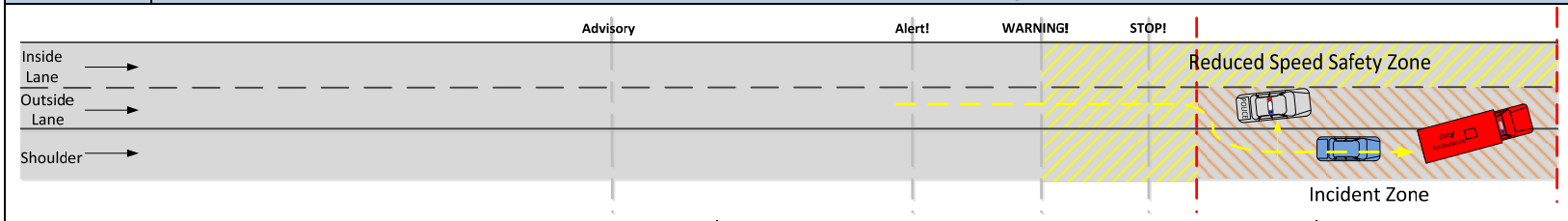

**Position C Oncoming Vehicles Display:**

- Oncoming Drivers receive Lane Closed and Reduce Speed Alerts, Warning, then Imminent Collision Stop
- Observe patrol vehicle flashing lights and honking horn
- Demonstrated


**Demonstrated Functionality:**

- INC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Advisory
- INC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Alert
- INC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Warning
- INC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Imminent Collision Stop
- INC-ZONE Oncoming Vehicle: Display of Reduced Speed Warning on Outside Lane Safety Zone
- INC-ZONE Responder Vehicle: Collision Warnings when vehicles enter enter warning zone

| Scenario | Action and Graphic |
|---|---|
| 6 | **EMS Opens Incident in CapWIN, and Presses "En-route/On Scene" Button then Arrives and positions, Patrol Vehicle repositions**<br>**Patrol Officer Closes Outside Lane in CapWIN, Inside lane is now part of Reduced Speed Safety Zone** |




**Position A Trailer CapWIN Display:**

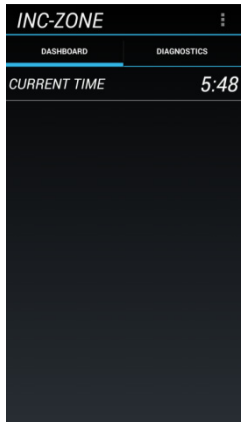
- CapWIN satellite view of AVL tracking of EMS progress and arrival
- CapWIN satellite view of on-scene responders
- CapWIN Display of Lane Closure Status
- Demonstrated

**Position B Responder Vehicle Display:**

- Arrival of EMS vehicle
- Repositioning of patrol vehicle
- CapWIN closure of outside lane and shoulder by by patrol officer
- Update of Incident Zone configuration by patrol officer
- Update of INC-ZONE DSRC message broadcast
- INC-ZONE situational display of lane closures
- Demonstrated

**Position C Oncoming Vehicles Display:**

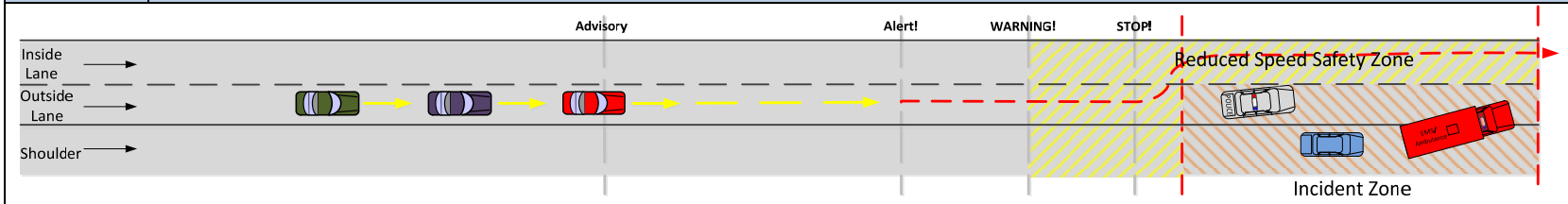
- Holds at Oncoming Vehicle Staging Location
- Description of Oncoming Vehicle Scenarios
- Demonstrated




**Demonstrated Functionality:**

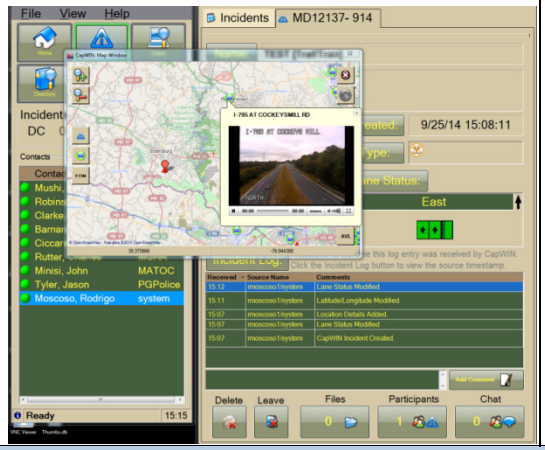
- CapWIN: Satellite view of AVL tracking of EMS progress and arrival **– Demonstrated**
- CapWIN: satellite view of on-scene responders **– Demonstrated**
- CapWIN Closure of the inside lane and shoulder by Patrol Officer **– Demonstrated**
- CapWIN communication of updated lane closures to dispatch and en-route vehicles **– Demonstrated**
- INC-ZONE Responder Vehicle: Update of electronic Incident Zone and Reduced Speed Safety Zone **– Demonstrated**
- INC-ZONE Responder Vehicle: Update of DSRC broadast of Lane Closure and Reduced Speed Safety Zone **– Demonstrated**

| Scenario | Action and Graphic |
|---|---|
| 7 | **Oncoming Vehicles Approach Incident Zone Unsafely on Outside Lane (55 mph), receive Alert, receive Warning, then Change lanes and Maintain Elevated Speed** |



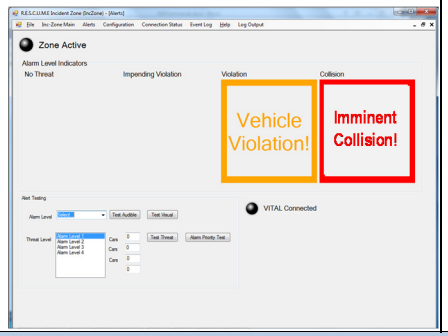

**Position A Trailer CapWIN Display:**

- CapWIN display of live video streaming of the incident
- Demonstrated




**Position B Responder Vehicle Display:**

- Observe Oncoming Vehicles approaching on outside lane, then change lanes and maintain elevated speed through Safety Zone
- Observe Responder Warnings including Radio Signal and patrol vehicle flashing lights and honking horn
- Demonstrated



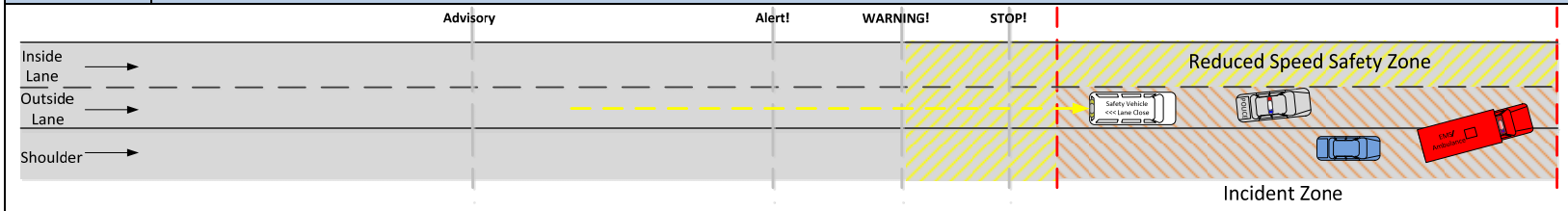

**Position C Oncoming Vehicles Display:**

- Oncoming Drivers receive Lane Closed and Reduce Speed Alerts, Warning, then Imminent Collision Stop
- Observe patrol vehicle flashing lights and honking horn
- Demonstrated


**Demonstrated Functionality:**

- INC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Advisory in Outside Lane **– Demonstrated**
- NC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Alert in Outside Lane **– Demonstrated**
- INC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Warning in Outside Lane **– Demonstrated**
- INC-ZONE Oncoming Vehicle: Display of Lane Closure and Reduced Speed Imminent Collision Stop in Outside Lane **– Demonstrated**
- INC-ZONE Oncoming Vehicle: Display of Reduced Speed Warning on Inside Lane Safety Zone **– Demonstrated**
- INC-ZONE Responder Vehicle: Collision Warnings when Vehicles Enter Enter Warning Zone **– Demonstrated**

| Scenario | Action and Graphic |
|---|---|
| 8 | **Safety Vehicle Opens Incident in CapWIN, and Presses "En-route/On Scene" Button then Arrives and positions upstream, Beginning of Incident Zone is Moved Upstream Officer Updates size of Incident Zone in INC-ZONE** |




**Position A Trailer CapWIN Display:**

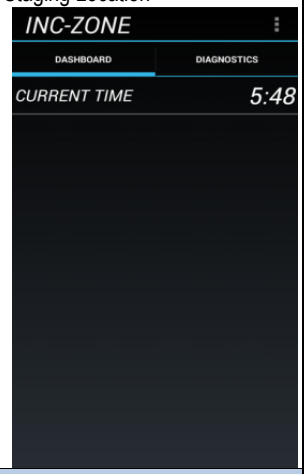
- CapWIN satellite view of AVL tracking of Safety Vehicle progress and arrival
- CapWIN satellite view of on-scene responders
- CapWIN Display of Lane Closure Status
- Demonstrated


**Position B Responder Vehicle Display:**

- Arrival of Safety Vehicle
- Safety Vehicle Activation of "On Scene" in CapWIN
- CapWIN closure of outside lane and shoulder by by patrol officer
- Update of Incident Zone configuration by patrol officer
- Update of INC-ZONE DSRC message broadcast
- INC-ZONE situational display of lane closures
- Demonstrated


**Position C Oncoming Vehicles Display:**

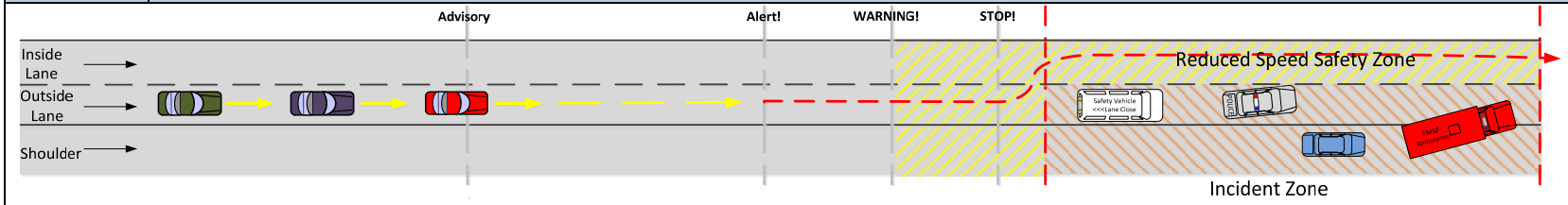
- Holds at Oncoming Vehicle Staging Location
- Description of Oncoming Vehicle Scenarios
- Demonstrated




**Demonstrated Functionality:**

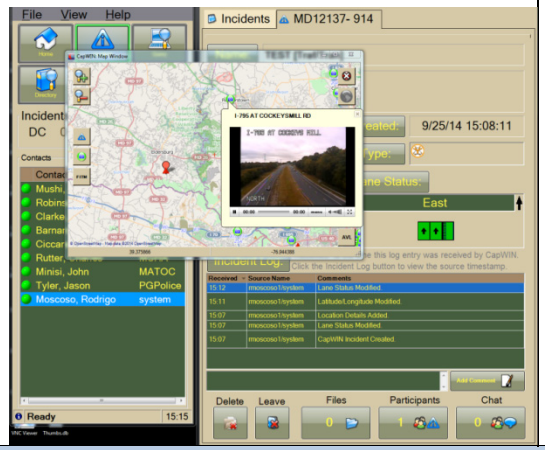
- CapWIN: Satellite view of AVL tracking of Safety Vehicle progress and arrival **– Demonstrated**
- CapWIN: Satellite view of on-scene responders **– Demonstrated**
- CapWIN communication of updated lane closures to dispatch and en-route vehicles **– Demonstrated**
- INC-ZONE Responder Vehicle: Update of electronic Incident Zone and Reduced Speed Safety Zone **– Demonstrated**
- INC-ZONE Responder Vehicle: Update of DSRC broadast of Lane Closure and Reduced Speed Safety Zone **– Demonstrated**

| Scenario | Action and Graphic |
|---|---|
| 9 | **Oncoming Vehicles Approach Incident Zone Unsafely on Outside Lane (55 mph), receive Alert, receive Warning, then Change lanes and Maintain Elevated Speed** |



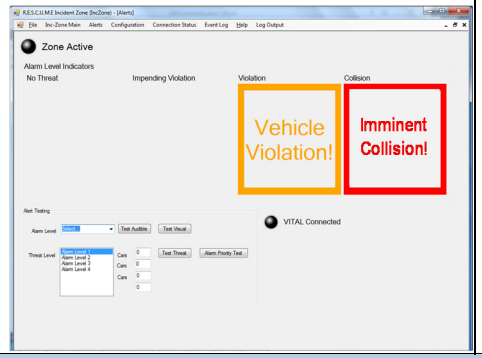

**Position A Trailer CapWIN Display:**

- CapWIN display of live video streaming of the incident
- Demonstrated




**Position B Responder Vehicle Display:**

- Observe Oncoming Vehicles approaching on outside lane, then change lanes and maintain elevated speed through Safety Zone
- Observe Responder Warnings including Radio Signal and patrol vehicle flashing lights and honking horn
- Demonstrated



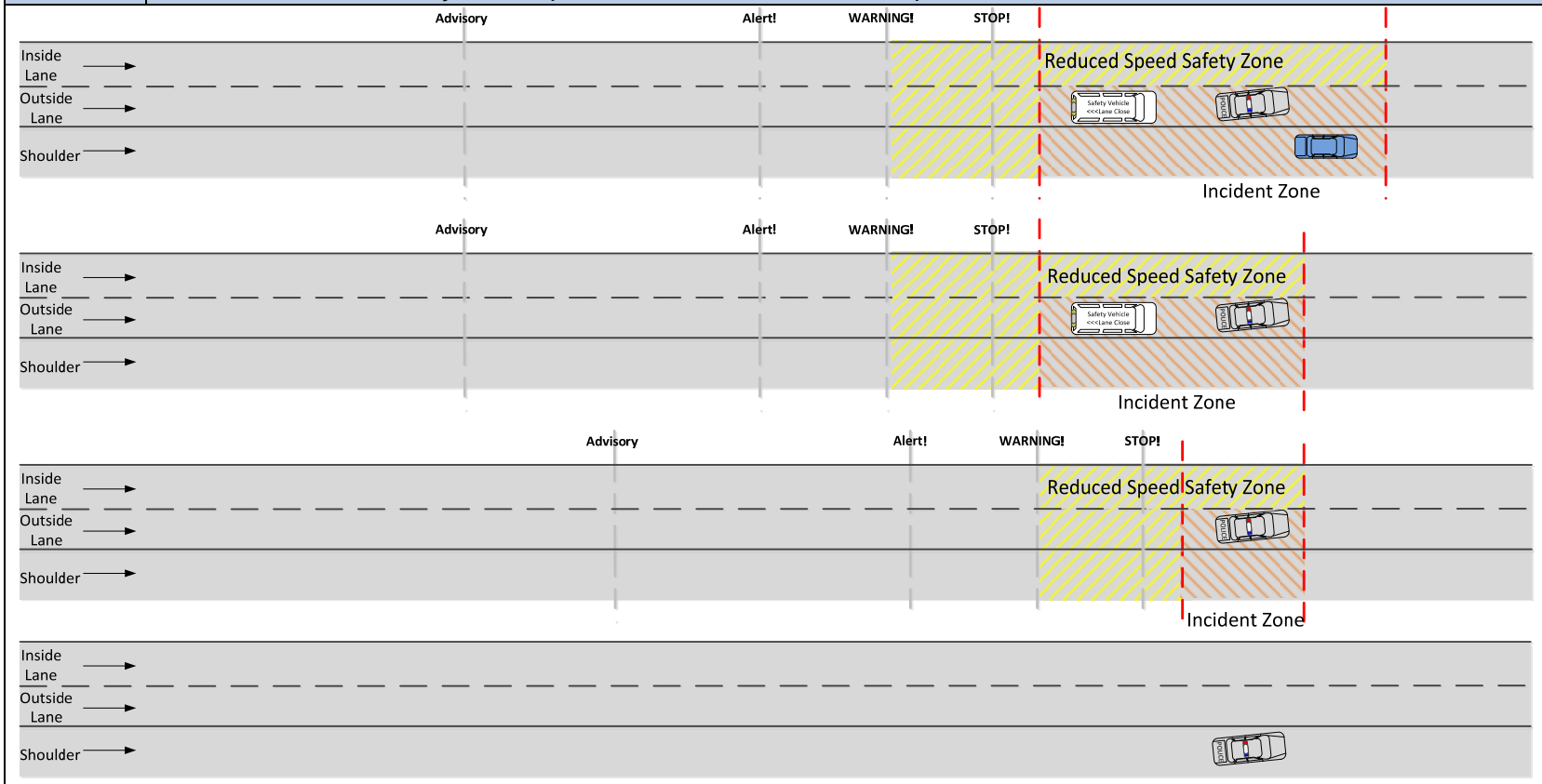

**Position C Oncoming Vehicles Display:**

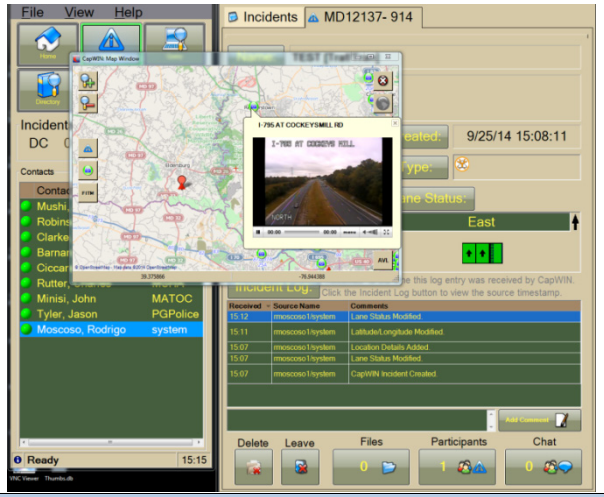
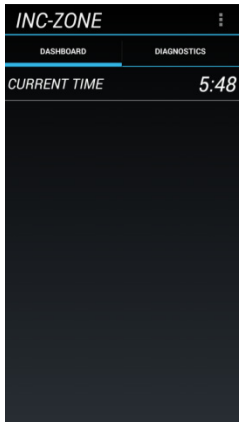
- Oncoming Drivers receive Lane Closed and Reduce Speed Alerts, Warning, then Imminent Collision Stop
- Observe patrol vehicle flashing lights and honking horn
- Passed


**Demonstrated Functionality:**

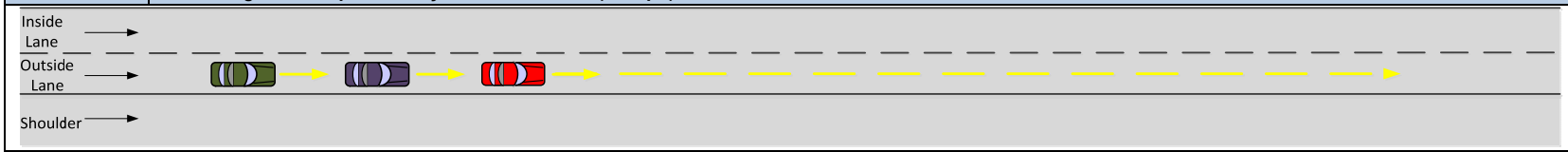
- INC-ZONE Oncoming Vehicle: Revised Position of Display of Lane Closure and Reduced Speed Advisory in Outside Lane **– Demonstrated**
- INC-ZONE Oncoming Vehicle: Revised Position of Display of Lane Closure and Reduced Speed Alert in Outside Lane **– Demonstrated**
- INC-ZONE Oncoming Vehicle: Revised Position of Display of Lane Closure and Reduced Speed Warning in Outside Lane **– Demonstrated**
- INC-ZONE Oncoming Vehicle: Revised Position of Display of Lane Closure and Reduced Speed Imminent Collision Stop in Outside Lane **– Demonstrated**
- INC-ZONE Oncoming Vehicle: Display of Reduced Speed Warning on Inside Lane Safety Zone **– Demonstrated**
- INC-ZONE Responder Vehicle: Revised Position of Collision Warnings when vehicles enter enter warning zone **– Demonstrated**

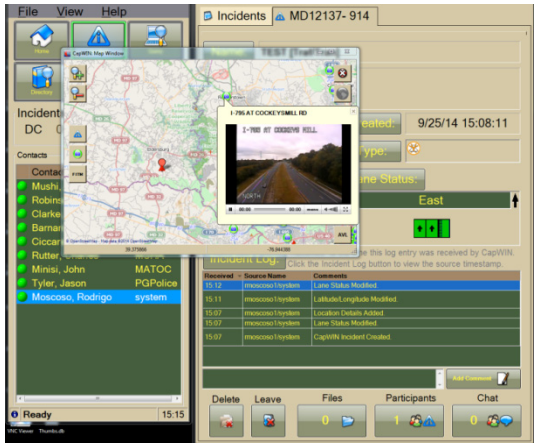
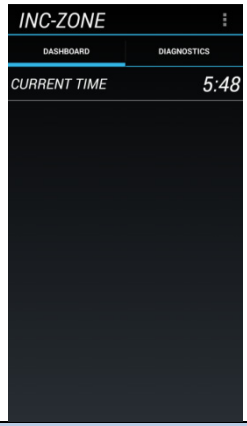
| Scenario | Action and Graphic |
|---|---|
| 10 | EMS, Disabled Vehicle and Safety Vehicle Depart, Patrol Officer closes Incident and Departs |



<table>
<tr><th>Scenario</th><th colspan="3">Action and Graphic</th></tr>
<tr><td>10</td><td colspan="3">EMS, Disabled Vehicle and Safety Vehicle Depart, Patrol Officer closes Incident and Departs</td></tr>
<tr><td>Position A Trailer CapWIN Display:</td><td>Position B Responder Vehicle Display:</td><td colspan="2">Position C Oncoming Vehicles Display:</td></tr>
<tr><td>- CapWIN satellite view of on-scene responders<br>- CapWIN Display of Lane Closure Status<br>- CapWIN display of live video streaming of the incident<br>- Demonstrated<br> 
</td><td>- Departure of EMS, Disabled Vehicle and Safety Vehicles<br>- Patrol Officer closes incident and departs<br>- INC-ZONE situational display of lane reopening<br>- Demonstrated</td><td colspan="2">- Holds at Oncoming Vehicle Staging Location<br>- Description of Oncoming Vehicle Scenarios<br>- Demonstrated<br> 
</td></tr>
<tr><td colspan="4">Demonstrated Functionality:</td></tr>
<tr><td colspan="4">- CapWIN: Satellite view of AVL tracking of vehicle departures – Demonstrated<br>- CapWIN: Satellite view of on-scene responders – Demonstrated<br>- CapWIN: Live Video streaming of incident – Demonstrated</td></tr>
</table>

| Scenario | Action and Graphic |
|---|---|
| 11 | Oncoming vehicles pass Safely on Outside Lane (55 mph) |




| Position A Trailer CapWIN Display: | Position B Responder Vehicle Display: | Position C Oncoming Vehicles Display: |
|---|---|---|
| - CapWIN display of live video streaming of the incident<br>- Demonstrated<br>  | - Observe Oncoming Vehicles approaching on outside lane<br>- INC-ZONE situational display of lanes open<br>- Demonstrated | - Observe that no driver advisories, alerts or warnings are issued<br>- Demonstrated<br>  |





| Demonstrated Functionality: |
|---|
| - INC-ZONE: Termination of warnings after incident closure **– Demonstrated**<br>- CapWIN: Closure of Incident **– Demonstrated**<br>- CapWIN: Live Video streaming of incident **– Demonstrated** |

## Demonstration Event Photos

Figure 6-2 through Figure 6-16 show photographs from the Field Demonstration illustrating events and elements of the applications observed by participants.

Source: Battelle

**Figure 6-2. Introduction and Safety Briefing for Participants prior to Demonstration.**

Source: Battelle

**Figure 6-3. Introduction to CapWIN Response Staging and Initiation of CapWIN Incident in Scenario 1.**


Source: Battelle

**Figure 6-4. Demonstration of CapWIN Response Staging with Satellite and Camera Views of Incident Zone in Scenario 2.**

Source: Battelle

**Figure 6-5. CapWIN Response Staging Monitoring of En-route and On Scene Responder Vehicles in Scenario 8.**


Source: Battelle

**Figure 6-6. Participant Discussion of CapWIN Lane Closure.**

Source: Battelle

**Figure 6-7. Participants Observing Oncoming Vehicles Approach and Pass Responder Vehicles in Scenario 7 (Patrol Vehicle Lights are Flashing and Horn is Honking).**

Source: Battelle

**Figure 6-8. Responder Vehicle in Position for Scenario 9 during Dry Run.**

Source: Battelle

**Figure 6-9. Black SUV with Dash Mounted Camera Collected On Scene Video of Incident that was Displayed on CapWIN Response Staging.**


Source: Battelle

**Figure 6-10. Oncoming Vehicles Approaching and Passing Responder Vehicles in Scenario 9 (Patrol Vehicle Lights are Flashing and Horn is Honking).**

Source: Battelle

**Figure 6-11. Description of Responder In-Vehicle Displays in Position B.**

Source: Battelle

**Figure 6-12. Lane Closure and Reduce Speed Alerts Issued to Oncoming Vehicle Drivers and Passengers (Position C) Approaching Incident in Scenario 9.**

Source: Battelle

**Figure 6-13. Oncoming Vehicles Prepared for Demonstration.**

Source: Battelle

**Figure 6-14. Smart Phone Message Display in Oncoming Vehicles.**

Source: Battelle

**Figure 6-15. DSRC Radio Installed Temporarily in back of Oncoming Vehicles.**

Source: Battelle

**Figure 6-16. Integrated DSRC and GPS Radio Antenna used on All Vehicles.**

# Chapter 7 Small-Scale Implementation of Responder Staging Application

The University of Maryland CapWIN Program has engaged the Maryland State Highway Administration (SHA) to implement a small-scale pilot of enhancements made to the CapWIN Mobile Client software developed as part of the project. This 60-day pilot, which began on March 20, 2015, will test new features designed to improve responder staging and situational awareness among first responders. Seven vehicles were included in the initial deployment.

During the pilot, SHA first responders with the pilot hardware and software will be broadcasting their locations using Automated Vehicle Location (AVL)/GPS technologies to all users via the CapWIN Incident Map. In addition, participating SHA first responders will be using new features of the CapWIN Mobile Client, including the ability to denote themselves as “On Scene” of an incident, correcting and updating incident information, and accessing new mapping features, including roadway rerouting plans.

Specific actions anticipated by SHA participants (whenever feasible and safe to do so) during the pilot include:

- Denoting themselves as “On Scene” When Responding to or supporting specific incidents
- Updating CapWIN incident information, as appropriate, including:
    - Lane Status (if different from what is displayed in the incident)
    - Incident location (if different from what is displayed in the incident)
    - Logging updates relevant to incident, e.g., arrival of additional vehicles or resources not using CapWIN
    - Using the CapWIN incident map to support “Vehicle Staging” or to access other map layers, including satellite imagery, traffic cameras, FITM Plans, etc.
- Using new quick-set features, including “Set Incident Location to My Location” and “Open Closest Incident"

There were only minor difficulties installing the GPS devices in the laptops due to configuration (USB driver) requirements. There were no problems installing the enhanced CapWIN software. It is anticipated that reports from the operators will begin to be collected the week of April 20, 2015.

CapWIN staff will also conduct an evaluation of the Pilot that will include the analysis of reports on those incidents modified by Pilot participants. This information will be provided to the Independent Assessor, Booz Allen Hamilton. In addition, CapWIN staff will regularly collect feedback from participants on the value and usability of the specific Client enhancements.

In order for CapWIN to implement the Pilot, several Mobile Client and backend infrastructure enhancements were made, including:

- Development and installation of a new production-ready AVL user management system
- Incorporation of new AVL/GPS features in the CapWIN Mobile Client software, including:
    - Integration between the GPS technologies and CapWIN's new AVL XMPP "Pub/Sub" backend
    - Ability to update incident information with local client GPS data/coordinates
    - Ability to view incidents based on geographic proximity to a given user's GPS data/coordinates

It is important to note that an independent assessor team from Booz Allen Hamilton has been given data from both prototype demonstrations, and will be using the data to evaluate the benefits of the two applications, and estimate the regional and national impact of the applications. In addition, Booz Allen Hamilton staff conducted interviews on November 13, 2014 following the demonstration to obtain qualitative assessments of the demonstrations from various Federal stakeholders.

Finally, as required as part of this work, Battelle has supplied data from the prototypes to the U.S. DOT Research Data Exchange (RDE), and has supplied code from the prototypes to the Open Source Application Development Portal (OSADP).

# Chapter 8 Summary and Conclusions

This chapter summarizes the programmatic accomplishments from the project, future considerations and the value and benefits of the effort.

## Programmatic Accomplishments

As part of the R.E.S.C.U.M.E. project the Battelle Team successfully developed and demonstrated to the U.S. DOT and invited guests the application of the latest developments in technology to enhance the situational awareness of incident responders and safety of motorists and persons likely to be found in an incident zone, including crash victims, law enforcement, EMS, Fire and Rescue, HAZMAT Response Unit, Towing and Recovery assets, and infrastructure repair workers. The R.E.S.C.U.M.E. bundle of applications seeks to leverage new information that helps to quickly detect and assess incidents and their effects on traffic flow, identify the best available resources and ways to allocate them in the timeliest manner, provide safety alerts and warning to responders and travelers at or near incident work zones, and better coordinate and conduct mass evacuations. Government officials who conduct evacuations will have a better common operational picture, enhanced by greater communication with vehicles and roadside equipment, public safety personnel in the field, and the public itself. Public safety personnel in the field who are increasingly using portable communications devices (such as tablets and smartphones to supplement radios, cell phones, and mobile data terminals) are able to provide real-time information to operations centers and traffic management centers which will improve traffic and route guidance during incidents and evacuations.

Two aspects of the R.E.S.C.U.M.E. applications developed under U.S. DOT support were demonstrated:

- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG) and
- Incident Scene Work Zone Alerts for Drivers and Workers (INC- ZONE)

The RESP-STG application developed and demonstrated in this program provides situational awareness to and coordination among emergency responders—upon dispatch and while en-route—to establish incident scene work zones both upon initial arrival and staging of assets, and afterward, if circumstances require, additional dispatch and staging. The developed application provides valuable input to responder and dispatcher decisions and actions. A range of data is provided through mobile devices and other types of communication to help support emergency responder vehicle routing, staging, and secondary dispatch decision-making. This response staging application was developed through enhancements to the UMD CATT Lab's CapWIN program.

The INC-ZONE application developed and demonstrated in this project improves protection of personnel at incident sites from the threat of oncoming vehicles. The application includes a warning system for on-scene responders when a vehicle approaching or in the incident zone is being operated outside of safe parameters for the conditions. The INC-ZONE application includes an in-vehicle messaging system that provides oncoming drivers with merging and speed guidance around an incident. The INC-ZONE application also provides in-vehicle alerts and warnings to drivers in violation of speed and lane closure restrictions, both for the protection of the drivers and incident zone personnel.

On November 13, 2014 the Battelle Team conducted a small-scale demonstration of the applications at the Maryland Police and Correctional Training Commissions Driver Training Facility in Sykesville, Maryland. That demonstrations simulated a medical emergency where a driver becomes ill, pulls to the side of the road and calls 9-1-1. The U.S. DOT and visitors observed and experienced first-hand:

- The evolution of the incident as a Patrol car arrives, followed by an EMS/Ambulance and a Maryland State Highway Administration CHART ERU vehicle.
- The tools that responders have to establish incident zones both upon initial arrival and staging of assets.
- The establishment of an incident zone and a safety zone that was broadcast to oncoming vehicles.
- The tools for improved situational awareness to and coordination among emergency responders—upon dispatch and while en-route—to establish incident scene work zones both upon initial arrival and staging of assets, and afterward, if circumstances require, additional dispatch and staging.
- The warnings received by responders when oncoming vehicles approached hazardously, breaching the safety zones.
- The Lane Closure, Merging and Reduced Speed Advisories, Alerts, Warnings and Imminent Collision Stop messages that were given to approaching vehicle drivers both for the protection of the drivers and incident zone personnel.
- Application of latest technology advancements by the U.S. DOT to enhanced safety for responders, crash victims, and the traveling public, as well as reducing the impact that incidents have on the normal operations of roadways, whether it be traffic incidents, or routine operations such as an officer issuing a citation.

The responder and driver warnings demonstrated to participants are based upon connected vehicle technology. The vehicles were connected wirelessly, meaning they are continuously communicating their location, speed and heading to each other, using 5.9 GHz DSRC, an enhanced Wi-Fi band specifically dedicated to vehicle safety and mobility. Connected vehicles can deliver warnings to drivers, to help prevent crashes and improve mobility around incidents. The U.S. DOT and auto manufacturers have studied this technology extensively and the NHTSA is considering mandating this technology be installed in all new vehicles in the next few years.

The demonstration was supported by:

- Maryland State Police, providing a Patrol Vehicle and Officer
- EMS vehicle and responders from the Sykesville/Freedom Volunteer Fire Company and West Friendship Volunteer Fire Company
- Maryland State Highway Administration providing CHART ERU and staff.

# Technical Accomplishments

The accomplishments outlined above required a number of key technical accomplishments. These accomplishments required the integration of new connected vehicle technology with existing responder systems to add new capabilities without adding to the burden of responder incident management. The implementation should be transparent to responders. Technical accomplishments in the project include the following:

- Developed the connected vehicle applications which reside on separate vehicles (responder and oncoming) but work together to identify potential threats and collisions and warn drivers and responders in time to take evasive action.
- Implemented DSRC Messaging between responder and oncoming vehicles to support threat and imminent crash warnings
- Implementation of lane level mapping and GPS positioning accuracy system required to support responder and oncoming vehicle imminent crash warnings as well as lane closure alerts and warnings in oncoming vehicles.
- Developed and integrated DSRC, Cellular and Bluetooth communications in both oncoming vehicle and responder vehicle systems using smart phones and DSRC radios for comprehensive communications and efficient installation and operation
- Integration of applications on existing responder portable laptops
- Integration of applications onto existing consumer smart phones
- Integration of responder alerts and warnings in existing systems including
    - Issue of audible alerts and warning through existing responder vehicle and portable radios as well as vehicle honking horns
    - Issue of visible alerts and warnings through patrol and other emergency vehicle flashing headlights, tail lights and change in light bar flashing modes
- Integration of RESP-STG and INC-ZONE for compatibility and coordination
- Integration of Response Staging feature within the UMD CATT CapWIN, including
    - Lane-level satellite view of On-Scene responder positions with detailed descriptions
    - Enhanced simple input of incident level lane closures
    - Live video streaming from nearby traffic cameras
    - Graphic display and access to Freeway Incident Traffic Management Plans

# Value and Benefits of this Work

Highway traffic incidents represent a number of safety and mobility challenges for first responders and the traveling public. Incident zones are dynamic with moving responder vehicles and personnel working in close proximity to vehicles approaching at highway speeds. Approaching drivers don't know what is happening and how to position to safely and efficiently pass the incident. Connected vehicle technology offers substantial safety and mobility benefits for highways by significantly improving drivers' situational awareness and, for incident zones, situational awareness of first responders. This system was developed using DSRC technologies and it is recognized that the full functionality of this DSRC enabled system will not be realized without considerable market penetration of DSRC-enabled vehicles. However, additional research could be conducted to develop a non-DSRC-based threat detection system that could be deployed on a wide scale in the near future. These improvements in situational awareness will support more informed and prepared behavior and response by both incident participants and approaching and passing vehicles.

The work summarized in this report presents the important foundation for capturing the safety and mobility benefits of connected vehicle technology during highway traffic incidents. First, this work demonstrates that connected vehicle technology is fully feasible and that the technology can reliably deliver information, alerts and warnings in sufficient time for responders and the public to take preventive and mitigating measures. Secondly, this work demonstrates *how* connected vehicle technology can be effectively integrated into existing responder and public vehicle "ecosystems" without increasing the cognitive workload or equipment management of either responders or approaching drivers. There is a substantial "ecosystem" of technology currently in use, particularly for first responders, including radio communications and laptops with cellular internet connections. This project has demonstrated how connected vehicle technology can be efficiently and effectively integrated into this existing "communications ecosystem" in order to reap its safety and mobility benefits.

# APPENDIX A. Prototype Component, System and Application Acceptance Testing Summary

## Phase I – Component Level Testing Summary

Phase I of the R.E.S.C.U.M.E. Prototype Acceptance Testing consisted of testing and verifying the functionality and performance of each of the components making up the R.E.S.C.U.M.E. system in the laboratory. This required testing the operational capabilities, data detection, retrieval and transmission capabilities, data logging capabilities and communication capabilities of each of the components. Many of the components used in the development of R.E.S.C.U.M.E. Prototype were used by Battelle and others in the development and implementation of the systems deployed in Safety Pilot Model Deployment in 2012 and 2013 where their functionality and performance had been well established. Furthermore, many of the components were developed, implemented and tested as part of the Intelligent Network Flow Optimization (INFLO) Prototype Acceptance Testing. Consequently, individual component testing was completed quickly and often in conjunction with Phase II – System Integration Acceptance Testing. Furthermore, Phase II System Integration Acceptance Testing provides a more complete verification of the functionality and performance of each component. Consequently, an Acceptance Test Demonstration of the component functionality for the U.S. DOT was performed as an integral part of the Phase II and Phase III Acceptance Test Demonstrations.

The Test Case tables below summarize the component testing conducted in Phase I for each of the following test cases.

| Phase | Test Case |
|---|---|
| **Phase I** | **Component Level Acceptance Test Cases** |
| | • TC-1-01 Oncoming Vehicle Component Functionality – Component Mounting & Installation<br>• TC-1-02A Oncoming Vehicle Computational Platform and User Interface Functionality – Android Platform Functionality<br>• TC-1-02B Oncoming Vehicle Computational Platform and User Interface Functionality – Android Oncoming INC-ZONE Application Functionality<br>• TC-1-02C Oncoming Vehicle Computational Platform and User Interface Functionality – Android Oncoming INC-ZONE Driver Interface Functionally<br>• TC-1-03 Oncoming Vehicle VITAL™ Functionality – CAN Interface Platform Functionality<br>• TC-1-04 Oncoming Vehicle DSRC Arada Functionality – Arada Platform Functionality<br>• TC-1-05 Responder Vehicle Component Functionality – Component Mounting and Installation<br>• TC-1-06A Responder Vehicle Computational Platform and User Interface Functionality – Ruggedized Laptop Platform Functionality<br>• TC-1-06B Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Responder Interface<br>• TC-1-06C Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Application Functionality<br>• TC-1-07 Responder Vehicle VITAL™ Functionality – CAN Interface Platform Functionality<br>• TC-1-08 Responder Vehicle DSRC Arada Radio Functionality – Arada Platform Functionality<br>• TC-1-09A Responder Vehicle /Personal Trunked Radio – Motorola Platform Functionality<br>• TC-1-09B Responder Vehicle/Personal Trunked Radio – Motorola Application Functionality<br>• TC-1-10A (UMD-TC-1.1) Internet Hosted Services Functionality – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User “On Scene”<br>• TC-1-10B (UMD-TC-1.2) Internet Hosted Services Functionality – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident |

Source: Battelle

Each test case summarizes the

- Test Case Number
- Test Case Name
- Test Objective
- Requirements Verified
- Brief Description
- Test Location
- Test Setup and Configuration
- Test Procedures
- Test Results and Remarks
- Pass/Fail
- Test Case Pass/Fail Results

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC-1-01 | | | | |
| **Test Case Name** | TC-1-01 Oncoming Vehicle Component Functionality – Component Mounting & Installation | | | | |
| **Test Objective** | • Verify all components are contained within or mounted upon the vehicle;<br>• Verify mounting is safe and does not require sustain permanent damage to the vehicle;<br>• Verify oncoming vehicles are passenger vehicles. | | | | |
| **Requirements Verified** | PD-4.0-1 PD-4.0-2 PD-4.0-3 PD-4.2-8 | | | | |
| **Brief Description** | Test will inspect the oncoming vehicle and the oncoming vehicle components. Examine the oncoming vehicle, and the devices to make sure they were properly and safely mounted. Expect components to be safely installed in passenger vehicles in a way that will not cause permanent damage. | | | | |
| **Test Location** | Garage Integration Test Environment | | | | |
| **Test Setup and Configuration** | • Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• VITAL™ Oncoming Vehicle CAN Interface | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Inspect oncoming vehicle components as installed for test | Observe that all components are contained within or mounted upon the vehicle; | Inspection | Pass | Verified |
| 1b | | Observe that mounting is safe and does not require sustain permanent damage to the vehicle; | Inspection | Pass | Temporary mounting brackets |
| 1c | | Observe that oncoming vehicles are passenger vehicles. | Inspection | Pass | |
| **Test Results and Remarks** | Verified Oncoming Vehicle Component Functionality – Component Mounting & Installation All test components designed for simple temporary installation in test vehicles. | | | | |
| **Pass/Fail** | Pass | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC-1-02A | | | | |
| **Test Case Name** | TC-1-02A Oncoming Vehicle Computational Platform and User Interface Functionality – Android Platform Functionality | | | | |
| **Test Objective** | • Verify that the component is an Android-based smartphone<br>• Verify ability to communicate via Bluetooth<br>• Verify ability to log information | | | | |
| **Requirements Verified** | PD-4.2-8 PD-4.3-1 PD-4.3-2 PD-4.3-4 | | | | |
| **Brief Description** | Test will inspect and demonstrate the oncoming vehicle computational platform and user interface functionality. Examine the device and component specifications. Send data to device to demonstrate communications capabilities and ability to log information. | | | | |
| **Test Location** | Laboratory Integration Test Environment | | | | |
| **Test Setup and Configuration** | • Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Arada Oncoming INC-ZONE Application Test Code<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• Android INC-ZONE Application Test Code<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• Component Communications Connectivity | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Inspect Oncoming Vehicle Computational Platform and User Interface | Observe component is an Android-based smartphone | Inspection | Pass | Confirmed Android |
| 2 | Pair Android Oncoming Vehicle Computational Platform and User Interface with Arada Oncoming Vehicle DSRC Communication Hardware via Bluetooth | Observe Bluetooth pairing confirmation on Android device | Demonstration | Pass | Bluetooth pairing confirmed on diagnostic screen |

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC-1-02A | | | | |
| **Test Case Name** | TC-1-02A Oncoming Vehicle Computational Platform and User Interface Functionality – Android Platform Functionality | | | | |
| 3 | Initiate Android INC-ZONE Application;<br>Initiate Android INC-ZONE Application Test Code | Observe INC-ZONE Log files stored on Device | Locate and browse Arada and Android INC-ZONE log files. | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration |
| **Test Results and Remarks** | Verified Android Platform Functionality with no exceptions. | | | | |
| **Pass/Fail** | Pass | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC-1-02B | | | | |
| **Test Case Name** | TC-1-02B Oncoming Vehicle Computational Platform and User Interface Functionality – Android Oncoming INC-ZONE Application Functionality | | | | |
| **Test Objective** | • Verify ability to calculate predicted path and timing information<br>• Verify ability to determine oncoming vehicle threat level and message(s) for the incident zone given speed and lane closure restrictions<br>• Verify ability to use collision and threat score for triggering specific messages to display to the driver<br>• Verify ability to log collision and threat scores, and all data items used for their calculation, to persistent memory<br>• Verify that collision and threat detection score is calculated whenever the oncoming vehicle is within the incident zone geographic boundary<br>• Verify that after one alert message is issued that another alert will not be issued for a duration of time that shall be a configurable intervals based upon vehicle speed, distance to the incident, vehicle information, vehicle telematics information, and traffic conditions. | | | | |
| **Requirements Verified** | IZ-14 | IZ-20 | PD-4.3.2-2 | PD-4.3.2-5 | PD-4.3.2-8 |
| | IZ-15 | PD-4.3-3 | PD-4.3.2-3 | PD-4.3.2-6 | PD-4.3.2-9 |
| | IZ-16 | | PD-4.3.2-4 | PD-4.3.2-7 | PD-4.3.2-10 |
| **Brief Description** | Use oncoming vehicle computational platform and user interface, its test code, and simulated oncoming vehicle data. Simulate incident scenario with application to demonstrate application code and ability to issue proper collision and threat for oncoming vehicle. Inspection of output logs and driver display will confirm sufficient capabilities to calculate and issue proper collision and threat information. | | | | |
| **Test Location** | Laboratory Integration Test Environment | | | | |
| **Test Setup and Configuration** | • Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Arada Oncoming INC-ZONE Application Test Code<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• Android INC-ZONE Application Test Code<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Threat GPS Input Data<br>• Simulated Oncoming Vehicle Collision GPS Input Data<br>• Simulated Responder EVA Collision Message Input<br>• Simulated Responder INC-ZONE Map TIM Input<br>• Component Communications Connectivity | | | | |

| **Test Case Number** | TC-1-02B | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-02B Oncoming Vehicle Computational Platform and User Interface Functionality – Android Oncoming INC-ZONE Application Functionality | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Initiate Android INC-ZONE Application<br>Initiate Arada Oncoming INC-ZONE Application<br>Initiate Android INC-ZONE Application Test Code<br>Initiate Simulated Oncoming Vehicle Threat GPS Input Data<br>Initiate Simulated Oncoming Vehicle Collision GPS Input Data | Observe result of predicted path and timing calculations by observing alarm and threat messages in output logs. | Inspect Arada Output Logs for Threat and Collision ACM messages | Pass | See Appendix A for example Alert Output Logs from Prototype Acceptance Test Demonstration |
| 1b | | Observe oncoming vehicle threat level and message(s) for the incident zone given speed and lane closure restrictions | Inspect Arada Output Logs for Threat and Collision ACM messages | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration |
| 1c | | Observe specific messages displayed to the driver | Observation of Android Oncoming Vehicle Driver Messages | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for example message display screens |
| 1d | | Observe logging of collision and threat scores, and all data items used for their calculation, to persistent memory | Inspect Arada Output Logs | Exception | Scores not implemented in the Task 2 Prototype |

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| **Test Case Number** | TC-1-02B | | | | |
| **Test Case Name** | TC-1-02B Oncoming Vehicle Computational Platform and User Interface Functionality – Android Oncoming INC-ZONE Application Functionality | | | | |
| 1e | | Collision and threat detection score is calculated whenever the oncoming vehicle is within the incident zone geographic boundary | Inspect Arada Output Logs for Threat and Collision ACM messages | Partial | Collision and threats are detected within the incident zone, but scores are not implemented in the Task 2 Prototype |
| 1f | | After one alert message is issued that another alert will not be issued for a configurable interval based upon vehicle speed, distance to the incident, vehicle information, vehicle telematics information, and traffic conditions. | Inspect Arada Output Logs for Threat and Collision ACM messages– Observation of Android Oncoming Vehicle Driver Messages | | See Appendix A for example Alert Output Logs from Prototype Acceptance Test Demonstration |
| **Test Results and Remarks** | Verified Android Oncoming INC-ZONE Application Functionality with the exception of collision and threat scores. Application has the foundational capability for refinement and enhancement to implement collision and threat scores. | | | | |
| **Pass/Fail** | Pass | | | | |

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|---|---|
| **Test Case Number** | TC-1-02C |
| **Test Case Name** | TC-1-02C Oncoming Vehicle Computational Platform and User Interface Functionality – Android Oncoming INC-ZONE Driver Interface Functionally |
| **Test Objective** | • Verify ability to display oncoming vehicle threat level and message(s) for the incident zone given speed and lane closure restrictions<br>• Verify ability to provide visual and audio messages to driver when the application is running in the foreground<br>• Verify that visual message appear for 1-10 seconds, and clear from the screen within 60 seconds without user interaction<br>• Verify that device does not enter sleep mode while application is running in the foreground<br>• Verify that audio message lasts ~1 second in duration<br>• Verify ability to present different types of audio and visual messages<br>• Verify availability of different types of messages based on the collision and threat score, vehicle telematics, and incident information |
| **Requirements Verified** | IZ-10, IZ-11, IZ-12, IZ-13, IZ-18, IZ-19, IZ-20, IZ-21, IZ-22, PD-4.3.1-1, PD-4.3.1-2, PD-4.3.1-3, PD-4.3.1-4, PD-4.3.1-5†, PD-4.3.1.6†, PD-4.3.1-7†, PD-4.3.1-8† |
| **Brief Description** | Use oncoming vehicle computational platform and user interface and simulated oncoming vehicle data. Simulate incident scenario with application to properly issue audio and visual messages to oncoming vehicle driver. Audio and visual messages from the user interface will be examined in a demonstration. |
| **Test Location** | Laboratory Integration Test Environment |
| **Test Setup and Configuration** | • Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Arada Oncoming INC-ZONE Application Test Code<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• Android INC-ZONE Application Test Code<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Threat GPS Input Data<br>• Simulated Oncoming Vehicle Collision GPS Input Data<br>• Simulated Responder EVA Collision Message Input<br>• Simulated Responder INC-ZONE Map TIM Input<br>• Component Communications Connectivity |

| **Test Case Number** | TC-1-02C | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-02C Oncoming Vehicle Computational Platform and User Interface Functionality – Android Oncoming INC-ZONE Driver Interface Functionally | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Initiate Android INC-ZONE Application<br>Initiate Arada Oncoming INC-ZONE Application<br>Initiate Android INC-ZONE Application Test Code<br>Initiate Simulated Oncoming Vehicle Threat GPS Input Data<br>Initiate Simulated Oncoming Vehicle Collision GPS Input Data | Observe display of oncoming vehicle threat level and message(s) for the incident zone given speed and lane closure restrictions | Observation of Android Oncoming Vehicle Driver Messages | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for screen capture of Oncoming Vehicle Driver Messages |
| 1b | | Observe visual and audio messages to driver when the application is running in the foreground | Observation of Android Oncoming Vehicle Driver Messages | Pass | Utilizes Android text to speed capability for audio messages |
| 1c | | Visual message appear for 1-10 seconds, and clear from the screen within 60 seconds without user interaction | Observation of Android Oncoming Vehicle Driver Messages | Pass | Verified |
| 1d | | Observe that device does not enter sleep mode while application is running in the foreground | Observation of Android Oncoming Vehicle Driver Messages | Pass | Verified in Laboratory |
| 1e | | Observe that Audio message lasts ~1 second in duration | Observation of Android Oncoming Vehicle Driver Messages | Pass | Utilizes Android text to speed capability for audio messages |
| 1f | | Observe different types of audio and visual messages | Observation of Android Oncoming Vehicle Driver Messages | Pass | Utilizes Android text to speed capability for audio messages |

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|---|---|---|---|---|---|
| **Test Case Number** | TC-1-02C | | | | |
| **Test Case Name** | TC-1-02C Oncoming Vehicle Computational Platform and User Interface Functionality – Android Oncoming INC-ZONE Driver Interface Functionally | | | | |
| 1g | | Observe different types of messages based on the collision and threat score, vehicle telematics, and incident information | Observation of Android Oncoming Vehicle Driver Messages | Partial | Demonstrated different types of messages based upon speed, lane and incident TIM message. Scores not implemented in the Task 2 Prototype. |
| **Test Results and Remarks** | Verified Android Oncoming INC-ZONE Driver Interface Functionally | | | | |
| **Pass/Fail** | Pass | | | | |

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| **Test Case Number** | TC-1-03 |
| **Test Case Name** | TC-1-03 Oncoming Vehicle VITAL™ Functionality – CAN Interface Platform Functionality |
| **Test Objective** | • Verify ability to communicate via Bluetooth<br>• Verify that the oncoming vehicle interface subsystem is the VITAL™ OBD-II module<br>• Verify presence of an OBD-II port to access a vehicle CAN bus<br>• Verify ability to process Bluetooth messages<br>• Verify that VITAL™ does not "drain" vehicle's battery when vehicle is not running<br>• Verify the support of legislated OBD-II protocols required for the prototype |
| **Requirements Verified** | PD-4.2-1 PD-4.2-3 PD-4.2-5 PD-4.2-6 PD-4.2-8<br>PD-4.2-2 PD-4.2-4 |
| **Brief Description** | The oncoming vehicle VITAL™ component and the VITAL™ test code will be used in this test. The installed component will be inspected and the test code will be demonstrated for its ability to process and transmit information and support legislated protocols. |
| **Test Location** | Laboratory Integration Test Environment and test track |
| **Test Setup and Configuration** | • Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• Android INC-ZONE Application Test Code<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• INC-ZONE DSRC Situational Display Test Tool<br>• ECUSIM Vehicle CAN Bus Simulator Test Tool |

| **Test Case Number** | TC-1-03 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-03 Oncoming Vehicle VITAL™ Functionality – CAN Interface Platform Functionality | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Pair VITAL™ Bluetooth with Android Oncoming Vehicle Computational Platform and User Interface; Vary vehicle ECU parameters required by INC-ZONE Applications. | Observe confirmation of Bluetooth pairing on Android Oncoming Vehicle Computational Platform and User Interface; Observe change in vehicle parameters on Android device. | Inspect Android Output Logs to confirm ability to obtain and process Bluetooth messages and support of OBD-II protocols required for the prototype | Pass | Used Android diagnostic screen data to verify pairing and change in engine speed output with change in simulated vehicle input. |
| 2a | Inspect oncoming vehicle components as installed for test | The oncoming vehicle interface subsystem is the VITAL™ OBD-II module | Inspection | Pass | |
| 2b | | Presence of an OBD-II port to access a vehicle CAN bus | Inspection | Pass | |
| | | Verify that VITAL™ does not "drain" vehicle's battery when vehicle is not running | Demonstration | Pass | See VITAL™ Specification Sheet in Appendix B |
| 2c | | Ability to issue commands to vehicle systems using CAN bus protocols | Demonstration | NA | Ability to issue commands to vehicle systems is demonstrated in responder vehicle test cases. This ability is not required for INC-ZONE Application |

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| **Test Case Number** | TC-1-03 |
| **Test Case Name** | TC-1-03 Oncoming Vehicle VITAL™ Functionality – CAN Interface Platform Functionality |
| **Test Results and Remarks** | Verified CAN Interface Platform Functionality required for Oncoming vehicle application. |
| **Pass/Fail** | Pass |

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| **Test Case Number** | TC-1-04 |
| **Test Case Name** | TC-1-04 Oncoming Vehicle DSRC Arada Functionality – Arada Platform Functionality |
| **Test Objective** | • Verify ability to communicate via Bluetooth<br>• Verify ability to transmit J2735 compliant message to Computation and User Interface Platform within one second of receiving it<br>• Verify compliance with U.S. DOT's Connected Vehicle certification<br>• Verify ability to draw power from the vehicle<br>• Verify ability to enter low-power mode when vehicle is not running<br>• Verify ability to transmit and receive J2735 compliant messages independent of user interface |
| **Requirements Verified** | IZ-24 PD-4.1-1 PD-4.1-2 PD-4.1-3 PD-4.1-4 PD-4.1-5 PD-4.1-6 PD-4.1-7 |
| **Brief Description** | The DSRC Arada will be used in this test. The Arada device communications capabilities, power modes, and certification compliance will be demonstrated using the installed component, test code, and certification report. |
| **Test Location** | Laboratory Integration Test Environment |
| **Test Setup and Configuration** | • Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Arada Oncoming INC-ZONE Application Test Code<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• Android INC-ZONE Application Test Code<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Threat GPS Input Data<br>• Simulated Oncoming Vehicle Collision GPS Input Data<br>• Simulated Responder EVA Collision Message Input<br>• Simulated Responder INC-ZONE Map TIM Input<br>• Component Communications Connectivity<br>• INC-ZONE DSRC Situational Display Test Tool<br>• Scantool ECUSIM Vehicle CAN Bus Simulator |

| **Test Case Number** | TC-1-04 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-04 Oncoming Vehicle DSRC Arada Functionality – Arada Platform Functionality | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Pair Arada Oncoming Vehicle DSRC Communication Hardware with Android Oncoming Vehicle Computational Platform and User Interface<br>Initiate Android INC-ZONE Application<br>Initiate Arada Oncoming INC-ZONE Application<br>Initiate Simulated Responder EVA Collision Message Input<br>Initiate Simulated Responder INC-ZONE Map TIM Input | Observe oncoming vehicle data from communications | Inspect Arada Output Logs for Threat and Collision ACM messages<br>Observation of Android Oncoming Vehicle Driver Messages | Pass | Used Android diagnostic screen data to verify pairing. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration |
| 2 | Initiate Simulated Responder EVA Collision Message Input. | Observe evidence of transmission of J2735 compliant message (from Arada to Android) to Computation and User Interface Platform within one second of receiving it by observing Responder Collision message. | Observation of Android Oncoming Vehicle Driver Messages | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. See Appendix A for DSRC Packet Sniffer XML Logs of J2735 compliant messages. |
| 3 | Obtain Arada Certification Report | Compliance with U.S. DOT's Connected Vehicle certification | Inspection | Pass | See http://www.its.dot.gov/safety_pilot/safety_pilot_qpl.htm for Arada research QPL acceptance |
| 4a | Install DSRC Arada device in test vehicle | Observe installation of power cabling from the vehicle | Inspection | Pass | |
| 4b | | Observe log evidence of entering low-power mode when vehicle is not running | Inspect logs to confirm transition to low power mode | Pass | |

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| **Test Case Number** | TC-1-04 | | | | |
| **Test Case Name** | TC-1-04 Oncoming Vehicle DSRC Arada Functionality – Arada Platform Functionality | | | | |
| 5 | Power off the Oncoming Vehicle User Interface | Verify ability to transmit and receive J2735 compliant messages independent of user interface by observing BSM message traffic on the Situational Display after user interface is powered off. | Demonstration | | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. See Appendix A for DSRC Packet Sniffer XML Logs of J2735 compliant messages. |
| **Test Results and Remarks** | Verified Arada Platform Functionality | | | | |
| **Pass/Fail** | Pass | | | | |

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| **Test Case Number** | TC-1-05 | | | | |
| **Test Case Name** | TC-1-05 Responder Vehicle Component Functionality – Component Mounting and Installation | | | | |
| **Test Objective** | • Verify all components are contained within or mounted upon the vehicle<br>• Verify mounting is safe and does not sustain permanent damage to the vehicle | | | | |
| **Requirements Verified** | PD-3.0-1 PD-3.0-2 | | | | |
| **Brief Description** | Test will inspect the responder vehicle and the responder vehicle components. Examine the responder vehicle, and the devices to make sure they were properly and safely mounted. Expect components to be safely installed in responder vehicle in a way that will not cause permanent damage. | | | | |
| **Test Location** | Garage Integration Test Environment | | | | |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• VITAL™ Responder Vehicle CAN Interface<br>• Trunked Radio Equipment<br>• Ruggedized Laptop Radio Interface Cable with LED indicator | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Inspect responder vehicle components as installed for test | All components are contained within or mounted upon the vehicle | Inspection | Pass | |
| 1b | | Mounting is safe and does not sustain permanent damage to the vehicle | Inspection | Pass | Temporary mounting |
| **Test Results and Remarks** | Verified Component Mounting and Installation in Responder Vehicle | | | | |
| **Pass/Fail** | Pass | | | | |

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| **Test Case Number** | TC-1-06A |
| **Test Case Name** | TC-1-06A Responder Vehicle Computational Platform and User Interface Functionality – Ruggedized Laptop Platform Functionality |
| **Test Objective** | • Verify the device has a graphical display per ATIS/CVO guidance<br>• Verify ability to be portable without external power connection and carried by a single person<br>• Verify operation of a currently supported Windows operating system on the ruggedized laptop comprising this component<br>• Verify installation of CapWIN Mobile (Responder-based RESP-STG) (Responder-based RESP-STG) software<br>• Verify Incident Staging and Status element is based upon CapWIN software<br>• Verify ability for independent operation from the Incident Staging and Status subsystem<br>• Verify ability to log information<br>• Verify ability to communicate via Bluetooth<br>• Verify ability to communicate via radio |
| **Requirements Verified** | RS-4, RS-8, PD-3.4-1, PD-3.4-2, PD-3.4-3, PD-3.4-6, PD-3.4-7, PD-3.4.1-1, PD-3.4.2-1, PD-3.4.2-2, PD-3.4.2.1-3 |
| **Brief Description** | Test will inspect and demonstrate the responder vehicle computational platform and user interface functionality. Examine the device and component software. Send data to device to demonstrate communications capabilities and ability to log information. |
| **Test Location** | Laboratory Integration Test Environment |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• Arada Responder INC-ZONE Application Test Code<br>• VITAL™ Responder Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Threat ACM Message Input<br>• Simulated Oncoming Vehicle Collision ACM Message Input<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool |

| **Test Case Number** | TC-1-06A | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-06A Responder Vehicle Computational Platform and User Interface Functionality – Ruggedized Laptop Platform Functionality | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Log into the CapWIN application and display an incident. | Observe that device has a graphical display per ATIS/CVO guidance | Inspection | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN display |
| 1b | Inspect | Observe that the device is portable without external power connection and can be carried by a single person | Inspection | Pass | Ruggedized Laptop |
| 2 | Power up and boot the device. | A currently supported Windows operating system on the ruggedized laptop comprising this component boots up. | Demonstration | Pass | Operates on Windows 7 environment |
| 3a | Locate and click on the CapWIN icon in the Windows startup menu. | CapWIN starts up and the CapWIN login prompt is displayed. | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN display |

| **Test Case Number** | TC-1-06A | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-06A Responder Vehicle Computational Platform and User Interface Functionality – Ruggedized Laptop Platform Functionality | | | | |
| 3b | Create a simulated incident in CapWIN and observe a corresponding TIM message appear on the INC-ZONE DSRC Situational Display. | Incident Staging and Status element is based upon CapWIN software | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN incident display. See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display |
| 3c | Turn off cellular communications | Observe independent operation from the Incident Staging and Status subsystem | Demonstration | Pass | |
| 3d | | Ability to log information | Locate and inspect logs | Pass | |
| 4 | On the INC-ZONE application's Bluetooth Configuration page, pair the INC-ZONE application with the Arada Systems radio;<br>Initiate Simulated Oncoming Vehicle Collision ACM Message Input | Observe INC-ZONE Confirmation of Bluetooth Communications | Demonstration | Pass | Inspected INC-ZONE diagnostics screen to confirm Bluetooth pairing |
| 5 | On the INC-ZONE application's Alarm Configuration page, click on an alarm test button. | Ability to communicate via radio is verified by observing the LED on the Radio Interface Cable illuminating when the test button is clicked. | Demonstration | Pass | Confirmed audible alarm through responder radio when test mode is activated. |

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| **Test Case Number** | TC-1-06A |
| **Test Case Name** | TC-1-06A Responder Vehicle Computational Platform and User Interface Functionality – Ruggedized Laptop Platform Functionality |
| **Test Results and Remarks** | Verified Ruggedized Laptop Platform Functionality |
| **Pass/Fail** | Pass |

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| **Test Case Number** | TC-1-06B | | | | |
| **Test Case Name** | TC-1-06B Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Responder Interface | | | | |
| **Test Objective** | • Verify ability to process, compile, and communicate information<br>• Verify ability to configure oncoming vehicle collision warning issuance<br>• Verify ability to determine and display appropriate oncoming vehicle threat message(s) to the incident zone given oncoming vehicle threat level<br>• Verify ability to initiate and transmit a J2735 compliant message<br>• Verify ability to process received J2735 messages to determine if collision alert should be issued to on-scene responder(s)<br>• Verify ability to configure vehicle collision warning issuance<br>• Verify ability to limit only one collision alert in any rolling 5 second period<br>• Verify that any collision alert includes visual and audible warning not exceeding 2 seconds in duration<br>• Verify ability to issue a comment to the Responder Vehicle Interface Subsystem when an alert is issued to a responder's radio for sounding the vehicle horn and flashing the lights<br>• Verify responder ability to disable/enable vehicle-based messages<br>• Verify responder ability to disable/enable radio-based messages | | | | |
| **Requirements Verified** | IZ-12 | PD-3.4-4 | PD-3.4.2-5 | PD-3.4.2.2-2* | PD-3.4.2.2-8* |
| | IZ-25 | PD-3.4-5 | PD-3.4.2.1-1 | PD-3.4.2.2-3* | PD-3.4.2.2-9* |
| | IZ-26 | PD-3.4.1.2-7 | PD-3.4.2.1-2 | PD-3.4.2.2-6* | |
| | IZ-31 | PD-3.4.2-4 | PD-3.4.2.2-1* | PD-3.4.2.2-7* | |
| **Brief Description** | Use responder vehicle computational platform and user interface and simulated responder vehicle data. Simulate incident scenario with application to verify communications and proper issuance of audio and visual messages to responders. Audio and visual messages from the user interface will be examined in a demonstration. | | | | |
| **Test Location** | Laboratory Integration Test Environment | | | | |

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|---|---|---|---|---|---|
| **Test Case Number** | TC-1-06B | | | | |
| **Test Case Name** | TC-1-06B Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Responder Interface | | | | |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• Arada Responder INC-ZONE Application Test Code<br>• VITAL™ Responder Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Threat ACM Message Input<br>• Simulated Oncoming Vehicle Collision ACM Message Input<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Initiate Android INC-ZONE Application<br>Initiate Arada Oncoming INC-ZONE Application<br>Initiate Simulated Oncoming Vehicle Collision ACM Message Input | Observe ability to process, compile, and communicate information by displaying Responder Collision Message Output | Observation of Ruggedized Laptop Responder Messages | Pass | See Responder Vehicle INC-ZONE User Interface Message Examples for INC-ZONE Responder Laptop Collision Message Displays |

| **Test Case Number** | TC-1-06B | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-06B Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Responder Interface | | | | |
| 1b | | Observe ability to configure oncoming vehicle collision warning issuance by displaying Responder Collision Message on User Interface | Observation of Ruggedized Laptop Responder Messages | Pass | See Responder Vehicle INC-ZONE User Interface Message Examples for INC-ZONE Responder Laptop Application Configuration screens |
| 1c | | Observe ability to determine and display appropriate oncoming vehicle threat message(s) to the incident zone given oncoming vehicle threat level by displaying Responder Collision Message Output and by displaying Responder Threat Message on User Interface | Observation of Ruggedized Laptop Responder Messages | Pass | See Responder Vehicle INC-ZONE User Interface Message Examples for INC-ZONE Responder Laptop Collision Message Displays |

| **Test Case Number** | TC-1-06B | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-06B Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Responder Interface | | | | |
| 1d | | Observe ability to initiate and transmit a J2735 compliant message | Inspect Responder Arada Message Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. See Appendix A for DSRC Packet Sniffer XML Logs of J2735 compliant messages. |
| 1e | | Observe ability to process received J2735 messages to determine if collision alert should be issued to on-scene responder(s) | Inspect Arada Responder Message Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. See Appendix A for DSRC Packet Sniffer XML Logs of J2735 compliant messages. |
| 1f | | Observe configuration of vehicle collision warning issuance | Demonstration | Pass | Observed visual and audible messages |
| 1g | | Observe one collision alert in any rolling 5 second period when multiple collision alerts are generated | Demonstration | Pass | |

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|---|---|---|---|---|---|
| **Test Case Number** | TC-1-06B | | | | |
| **Test Case Name** | TC-1-06B Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Responder Interface | | | | |
| 1h | | Observe that collision alert includes visual and audible warning not exceeding 2 seconds in duration | Demonstration | Pass | |
| 1i | | Observe a comment to the Responder Vehicle Interface Subsystem when an alert is issued to a responder's radio for sounding the vehicle horn and flashing the lights | Demonstration<br>Inspect Ruggedized Laptop Message Logs | Pass | Observed vehicle horn and flashing lights |
| 1j | | Observe disable/enable vehicle-based messages through Responder Interface | Demonstration | | See Responder Vehicle INC-ZONE User Interface Message Examples for INC-ZONE Responder Laptop Application Configuration screens |
| 1k | | Observe disable/enable radio-based messages through Responder Interface | Demonstration | | |
| **Test Results and Remarks** | Verified CapWIN Mobile (Responder-based RESP-STG) Responder Interface | | | | |
| **Pass/Fail** | Pass | | | | |

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| **Test Case Number** | TC-1-06C | | | | | |
| **Test Case Name** | TC-1-06C Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Application Functionality | | | | | |
| **Test Objective** | • Verify ability to develop and display a scalable spatial representation of incident zone<br>• Verify ability to establish and customize multiple displays<br>• Verify ability to add or remove information from the display<br>• Verify ability to provide visual alerts<br>• Verify ability to present multiple sources of information on a single viewing platform<br>• Verify ability to input staging location information via CapWIN Incident Log<br>• Verify ability to relocate responder vehicle locations with lane-level accuracy until incident is closed or responder vehicle has left incident scene<br>• Verify ability to compile incident zone information for transmission Verify ability to determine and display appropriate oncoming vehicle threat message(s) to the incident zone given oncoming vehicle threat level<br>• Verify ability of responder to input information<br>• Verify ability to input lane closure information within 10 seconds | | | | | |
| **Requirements Verified** | RS-4 | RS-13 | RS-29 | IZ-32 | PD-3.4.1.1-2 | PD-3.4.1.2-5 |
| | RS-5 | RS-17 | RS-39 | IZ-33 | PD-3.4.1.1-5 | PD-3.4.1.2-6 |
| | RS-6 | RS-19 | | IZ-34 | PD-3.4.1.1-6 | |
| | RS-7 | RS-20 | | IZ-35 | PD-3.4.1.2-2 | |
| | RS-9 | RS-21 | | IZ-47 | PD-3.4.1.2-3 | |
| **Brief Description** | Use responder vehicle computational platform and user interface and simulated oncoming vehicle data. Simulate incident scenario with application to properly issue audio and visual messages to responder and allow information inputs. | | | | | |
| **Test Location** | Laboratory Integration Test Environment | | | | | |

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| **Test Case Number** | TC-1-06C | | | | |
| **Test Case Name** | TC-1-06C Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Application Functionality | | | | |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• Arada Responder INC-ZONE Application Test Code<br>• VITAL™ Responder Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Threat ACM Message Input<br>• Simulated Oncoming Vehicle Collision ACM Message Input<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/ Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Initiate Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application | Observe display of a scalable spatial representation of incident zone and changes in the display | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for examples of CapWIN displays |

| **Test Case Number** | TC-1-06C | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-06C Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Application Functionality | | | | |
| 1b | | Observe establishment and customization of multiple displays | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for examples of CapWIN displays |
| 1c | | Observing adding or remove information from the display | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for examples of CapWIN displays |
| 1d | Initiate Simulated Oncoming Vehicle Threat ACM Message Input | Observe visual alerts | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for examples of CapWIN displays |

| **Test Case Number** | TC-1-06C | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-06C Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Application Functionality | | | | |
| 1e | | Observe Input from multiple sources of information on a single viewing display | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for examples of CapWIN displays |
| 1f | | Observe input staging location information via CapWIN Incident Log Display | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for examples of CapWIN displays |
| 1g | | Observe responder vehicle locations with lane-level accuracy until incident is closed or responder vehicle has left incident scene | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for examples of CapWIN displays |
| 1h | | Observe incident zone information for transmission | Demonstration | Pass | |

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| **Test Case Number** | TC-1-06C | | | | |
| **Test Case Name** | TC-1-06C Responder Vehicle Computational Platform and User Interface Functionality – CapWIN Mobile (Responder-based RESP-STG) Application Functionality | | | | |
| 1i | | Observe ability to determine and display appropriate oncoming vehicle threat message(s) to the incident zone given oncoming vehicle threat level by observing Oncoming Vehicle Collision ACM Message and Oncoming Vehicle Threat ACM Message | Demonstration | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 1j | | Observe input changes through responder interface | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for examples of CapWIN displays |
| 1k | | Observe input lane closure information on visual display to confirm it displays within 10 seconds | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for examples of CapWIN displays |
| **Test Results and Remarks** | Verified CapWIN Mobile (Responder-based RESP-STG) Application Functionality | | | | |
| **Pass/Fail** | Pass | | | | |

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| **Test Case Number** | TC-1-07 |
| **Test Case Name** | TC-1-07 Responder Vehicle VITAL™ Functionality – CAN Interface Platform Functionality |
| **Test Objective** | • Verify that equipment is the VITAL™ OBD-II module<br>• Verify ability to use low-power setting<br>• Verify ability to communicate via Bluetooth<br>• Verify presence of an OBD-II port to access a vehicle CAN bus<br>• Verify ability to process Bluetooth messages<br>• Verify ability to issue commands to vehicle systems using CAN bus protocols<br>• Verify the support of all legislated OBD-II protocols required for the prototype |
| **Requirements Verified** | PD-3.3-1 PD-3.3-3 PD-3.3-4 PD-3.3-5 PD-3.3-7<br>PD-3.3-2 |
| **Brief Description** | The responder vehicle VITAL™ component and the VITAL™ test code will be used in this test. The installed component will be inspected and the test code will be demonstrated for its ability to process and transmit information and support legislated protocols. |
| **Test Location** | Laboratory Integration Test Environment |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• Arada Responder INC-ZONE Application Test Code<br>• VITAL™ Responder Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Threat ACM Message Input<br>• Simulated Oncoming Vehicle Collision ACM Message Input<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool |

| **Test Case Number** | TC-1-07 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-07 Responder Vehicle VITAL™ Functionality – CAN Interface Platform Functionality | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Pair VITAL™ Bluetooth with Responder Vehicle Computational Platform and User Interface | Observe Responder Vehicle CAN data obtained from VITAL™ Bluetooth connection on Responder Vehicle Interface | Demonstration | Pass | Used Responder Laptop diagnostics screen to confirm pairing |
| 2a | Inspect responder vehicle components as installed for test | Equipment is the VITAL™ OBD-II module | Inspection | Pass | |
| 2b | | Presence of an OBD-II port to access a vehicle CAN bus | Inspection | Pass | |
| 3a | Initiate Responder Vehicle VITAL™ Test Code and ECUSIM Vehicle CAN Bus Simulator | Observe Responder Vehicle CAN data obtained from VITAL™ Bluetooth connection on Responder Vehicle Interface | Demonstration | Pass | Used Responder Laptop diagnostics screen to confirm data receipt |
| 3b | | Observe flashing lights and honking horn on Remote vehicle to demonstrate ability to issue commands to vehicle systems using CAN bus protocols | Demonstration | Pass | Demonstrated activation of flashing lights and honking horn through VITAL™ CAN interface |
| 3c | | The support of legislated OBD-II protocols required for the prototype | Demonstration | Pass | See Appendix B for VITAL™ specification Sheet |
| 4 | Power on VITAL™ equipment | Inspect logs to confirm the ability to use low power setting | Inspection of VITAL™ logs | Pass | See Appendix B for VITAL™ specification Sheet |

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| **Test Case Number** | TC-1-07 |
| **Test Case Name** | TC-1-07 Responder Vehicle VITAL™ Functionality – CAN Interface Platform Functionality |
| **Test Results and Remarks** | Verified CAN Interface Platform Functionality |
| **Pass/Fail** | Pass |

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| **Test Case Number** | TC-1-08 |
| **Test Case Name** | TC-1-08 Responder Vehicle DSRC Arada Radio Functionality – Arada Platform Functionality |
| **Test Objective** | • Verify ability to communicate via Bluetooth<br>• Verify ability to have real-time data transfers of at least 3G<br>• Verify compliance with U.S. DOT's research QPL<br>• Verify ability to log DSRC messages<br>• Verify ability to draw power from the vehicle<br>• Verify ability to enter low-power mode when vehicle is not running<br>• Verify ability to transmit and receive J2735 compliant messages |
| **Requirements Verified** | PD-3.1-2 PD-3.2-2 PD-3.2-4 PD-3.2-6 PD-3.2-8<br>PD-3.2-1 PD-3.2-3 PD-3.2-5 PD-3.2-7 PD-3.4.2-4 |
| **Brief Description** | The DSRC Arada will be used in this test. The Arada device communications capabilities, power modes, and certification compliance will be demonstrated using the installed component, test code, and certification report. |
| **Test Location** | Laboratory Integration Test Environment |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• Arada Responder INC-ZONE Application Test Code<br>• VITAL™ Responder Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Threat ACM Message Input<br>• Simulated Oncoming Vehicle Collision ACM Message Input<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool |

| **Test Case Number** | TC-1-08 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-08 Responder Vehicle DSRC Arada Radio Functionality – Arada Platform Functionality | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/ Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Pair Arada device with Responder Vehicle Computational Platform and User Interface | Observe Responder Vehicle CAN data obtained from VITAL™ Bluetooth connection on Responder Vehicle Interface | Demonstration | Pass | Used Responder Laptop diagnostic screen to confirm pairing |
| 2 | Initiate DSRC Arada Test Code | Ability to have real-time data transfers of at least 3G | Demonstration | Pass | Demonstrated |
| 3 | Obtain Arada Certification Report | Compliance with U.S. DOT's research Qualified Products List (QPL) | Inspection | Pass | See http:// www.its.dot.gov/safety_pilot/ safety_pilot_qpl.htm for Arada research QPL acceptance |
| 4a | Install DSRC Arada device in test vehicle | Observe DSRC log messages | Inspect Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 4b | | Observe device drawing power from the vehicle | Demonstration | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 4c | | Inspect logs to confirm entry to low-power mode when vehicle is not running | Demonstration | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

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| **Test Case Number** | TC-1-08 | | | | |
| **Test Case Name** | TC-1-08 Responder Vehicle DSRC Arada Radio Functionality – Arada Platform Functionality | | | | |
| 5 | Initiate DSRC Arada Test Code | Inspect logs of transmission and receipt of J2735 compliant messages | Demonstration | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. See Appendix A for DSRC Packet Sniffer XML Logs of J2735 compliant messages. |
| **Test Results and Remarks** | Verified Arada Platform Functionality | | | | |
| **Pass/Fail** | Pass | | | | |

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| **Test Case Number** | TC-1-09A | | | | |
| **Test Case Name** | TC-1-09A Responder Vehicle /Personal Trunked Radio –Motorola Platform Functionality | | | | |
| **Test Objective** | • Verify that radio device can be worn by responders<br>• Verify that the PASS system is based on existing responder radio systems | | | | |
| **Requirements Verified** | IZ-27 PD-5.0-1 | | | | |
| **Brief Description** | Visual inspection of radio device to ensure it is based on existing radio systems. An individual will verify that device can be worn. | | | | |
| **Test Location** | Laboratory Integration Test Environment | | | | |
| **Test Setup and Configuration** | Personal Trunked Radio | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Inspect | Radio device can be worn by responders | Inspection | Pass | |
| 1b | Inspect | The PASS system is based on existing responder radio systems | Inspection/ Demonstration | Pass | See Responder Radio Interface for PASS system description |
| **Test Results and Remarks** | Verified Motorola Platform Functionality | | | | |
| **Pass/Fail** | Pass | | | | |

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| **Test Case Number** | TC-1-09B |
| **Test Case Name** | TC-1-09B Responder Vehicle/Personal Trunked Radio –Motorola Application Functionality |
| **Test Objective** | • Verify radio communications capabilities<br>• Verify ability to configure oncoming vehicle collision warning issuance to responder PASS device, including ability to disable/enable<br>• Verify ability to generate variable tactile, audible, and visual notifications without responder interaction<br>• Verify that the alerts do not impact the ability to otherwise utilize the radio<br>• Verify ability to limit only one collision alert in any rolling 5 second period<br>• Verify that any collision alert includes visual and audible warning not exceeding 2 seconds in duration |
| **Requirements Verified** | IZ-28 PD-3.4.2.2-3* PD-3.4.2.2-9* PD-5.0-2 PD-5.0-3<br>IZ-29 |
| **Brief Description** | The personal trunked radio and test code will be examined in this test. A demonstration will ensure device is configurable for issuance and duration of alerts, and can issue audio, visual, and tactile alerts, while not interfering with responder communications. |
| **Test Location** | Laboratory Integration Test Environment |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• Arada Responder INC-ZONE Application Test Code<br>• VITAL™ Responder Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Threat ACM Message Input<br>• Simulated Oncoming Vehicle Collision ACM Message Input<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool |

| **Test Case Number** | TC-1-09B | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-09B Responder Vehicle/Personal Trunked Radio –Motorola Application Functionality | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/ Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Initiate Responder Vehicle Test Code<br>Initiate Simulated Oncoming Vehicle Collision ACM Message Input | Demonstrate radio communications capabilities by observing radio alarms | Demonstration | Pass | Observed audible radio alarms |
| 1b | | Observe configuration of oncoming vehicle collision warning issuance to responder PASS device, including ability to disable/enable | Demonstration | Pass | See Responder Vehicle INC-ZONE User Interface Message Examples for INC_ZONE Responder Laptop configuration screen |
| 1c | | Observe tactile, audible, and visual notifications without responder interaction | Demonstration | Pass | Observed visual notifications on responder laptop and audible radio alarms |
| 2 | Issue alerts while radio is in use | Observe radio communications when the radio receives alerts | Demonstration | Pass | Observed audible radio alarms |
| 3 | Issue multiple alerts within a 5 second period to radio | Observe single collision alert in any rolling 5 second period when multiple alerts are issued | Demonstration | Pass | Observed audible radio alarms |

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| **Test Case Number** | TC-1-09B | | | | |
| **Test Case Name** | TC-1-09B Responder Vehicle/Personal Trunked Radio –Motorola Application Functionality | | | | |
| 4 | Issue alert to radio | Observe that collision alert includes visual and audible warning not exceeding 2 seconds in duration | Demonstration | Pass | Observed visual notifications on responder laptop and audible radio alarms |
| **Test Results and Remarks** | Verified Motorola Application Functionality | | | | |
| **Pass/Fail** | Pass | | | | |

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| **Test Case Number** | TC-1-10A (UMD-TC-1.1) | | | | | |
| **Test Case Name** | TC-1-10A (UMD-TC-1.1) Internet Hosted Services Functionality – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User "On Scene" | | | | | |
| **Test Objective** | • User Arrives at Incident and Denotes Status as "On Scene"<br>• Verify ability to successfully login<br>• Verify ability to view "number of satellites" accessed by CapWIN Mobile (Responder-based RESP-STG) Client<br>• Verify ability of CapWIN Mobile (Responder-based RESP-STG) Client to display user as "joined" in Incident Log and user as "On Scene"<br>• Verify that user sees red icon in CapWIN Incident Map denoting their location | | | | | |
| **Requirements Verified** | RS-7<br>RS-15<br>RS-18<br>RS-19 | RS-20<br>RS-21<br>RS-23<br>RS-27 | RS-29<br>RS-31<br>RS-37 | IZ-1<br>IZ-2<br>IZ-42<br>IZ-45 | PD-3.4.1.1-2<br>PD-3.4.1.1-3<br>PD-3.4.1.1-4<br>PD-3.4.1.1-5 | PD-3.4.1.2-1<br>PD-3.4.1.2-2<br>PD-3.4.1.2-3 |
| **Brief Description** | Demonstrate and verify the capability of a user to denote themselves at the location of an Incident using the CapWIN Mobile (Responder-based RESP-STG) Client | | | | | |
| **Test Location** | Laboratory Integration Test Environment | | | | | |
| **Test Setup and Configuration** | • Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code<br>• RESP-STG Application CapWIN Cloud Components | | | | | |

| **Test Case Number** | TC-1-10A (UMD-TC-1.1) | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-10A (UMD-TC-1.1) Internet Hosted Services Functionality – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User "On Scene" | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Login to CapWIN Mobile (Responder-based RESP-STG) Client prototype application | Successful login | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| 2 | Ensure proper operation of A-GPS device | View "number of satellites" accessed by CapWIN Mobile (Responder-based RESP-STG) Client | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |

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| **Test Case Number** | TC-1-10A (UMD-TC-1.1) | | | | |
| **Test Case Name** | TC-1-10A (UMD-TC-1.1) Internet Hosted Services Functionality – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User "On Scene" | | | | |
| 3 | Upon arrival at incident location, user selects "On Scene" button in CapWIN Mobile (Responder-based RESP-STG) Client | CapWIN Mobile (Responder-based RESP-STG) Client displays user as "joined" in Incident Log and user as "On Scene" | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| 4 | User opens CapWIN Mobile (Responder-based RESP-STG) Client Incident Map and views user location denoted as red icon | User sees red icon in CapWIN Incident Map denoting their location | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| **Test Results and Remarks** | Verified RESP-STG CapWIN Mobile (Responder-based RESP-STG) User "On Scene" | | | | |
| **Pass/Fail** | Pass | | | | |

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| **Test Case Number** | TC-1-10B (UMD-TC-1.2) |
| **Test Case Name** | TC-1-10B (UMD-TC-1.2) Internet Hosted Services Functionality – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident |
| **Test Objective** | • User Updates Incident Location and other Incident Details<br>• Verify ability to successfully login<br>• Verify ability to view "number of satellites" accessed by CapWIN Mobile (Responder-based RESP-STG) Client<br>• Verify ability of CapWIN Mobile (Responder-based RESP-STG) Client to display user as "joined" in Incident Log and user as "On Scene"<br>• Verify that user sees incident location updated to reflect current location<br>• Verify that user notes that they have automatically "Joined" the incident, as denoted in the Incident Log<br>• Verify that user notes corrected Lane Status on CapWIN Incident lane display<br>• Verify that CapWIN XML Incident Feed reflects update to lane status and is successfully ingested by INC-ZONE software<br>• Verify that updates are reflected in CapWIN Incident pane<br>• Verify the availability of external sources feeding RITIS<br>• Verify the availability of RITIS as the Traffic and Incident Database<br>• Verify the availability of CapWIN's emergency responder system as the First Responder Information System<br>• Verify the availability of RITIS traveler information system as the Traveling Public Information System<br>• Verify information from external sources can correspond to demonstration and not "live" scenarios<br>• Verify that prototype data is recognizable as test data and not "live" data<br>• Verify access to GIS, road maps, video cameras, databases of still photos and satellite imagery, type and position of responder vehicles on an incident scene, locations of medical care facilities, and current traffic speeds<br>• Verify the availability of lane closure information in the Traveling Public Information System<br>• Verify ability to update lane closure information within 15 minutes of a status change<br>• Verify ability to receive and transmit information |
| **Requirements Verified** | RS-4<br>RS-5<br>RS-6<br>RS-7<br>RS-9<br>RS-12<br>RS-13<br>RS-15<br>RS-18<br>RS-17<br>RS-18<br>RS-19<br>RS-20<br>RS-21<br>RS-23<br>RS-27<br>RS-29<br>RS-31<br>RS-37<br>RS-39<br>IZ-1<br>IZ-2<br>IZ-42<br>IZ-45<br>PD-1.0-1<br>PD-1.0-2<br>PD-1.0-3<br>PD-2.0-1<br>PD-2.0-2<br>PD-2.0-3<br>PD-3.4.1.1-1<br>PD-3.4.1.1-2<br>PD-3.4.1.1-3<br>PD-3.4.1.1-4<br>PD-3.4.1.1-5PD-3.4.1.2-1<br>PD-3.4.1.2-2<br>PD-3.4.1.2-3<br>PD-3.4.1.2-4<br>PD-3.4.1.2-5<br>PD-3.4.1.2-6 |

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| **Test Case Number** | TC-1-10B (UMD-TC-1.2) | | | | |
| **Test Case Name** | TC-1-10B (UMD-TC-1.2) Internet Hosted Services Functionality – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident | | | | |
| **Brief Description** | Demonstrate and verify the capability for user to update incident data using the CapWIN Mobile (Responder-based RESP-STG) client. | | | | |
| **Test Location** | Laboratory Integration Test Environment | | | | |
| **Test Setup and Configuration** | • Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• RESP-STG Application CapWIN Cloud Components | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/ Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Login to CapWIN Mobile (Responder-based RESP-STG) Client prototype application | Successful login | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |

| **Test Case Number** | TC-1-10B (UMD-TC-1.2) | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-10B (UMD-TC-1.2) Internet Hosted Services Functionality – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident | | | | |
| 2 | Ensure proper operation of A-GPS device | View "number of satellites" accessed by CapWIN Mobile (Responder-based RESP-STG) Client | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| 3 | Upon arrival at incident location, user selects "On Scene" button in CapWIN Mobile (Responder-based RESP-STG) Client | CapWIN Mobile (Responder-based RESP-STG) Client displays user as "joined" in Incident Log and user as "On Scene" | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |

| **Test Case Number** | TC-1-10B (UMD-TC-1.2) | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-1-10B (UMD-TC-1.2) Internet Hosted Services Functionality – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident | | | | |
| 4 | User open's CapWIN Incident map and sets location to current location using "Pin Drop" | User sees incident location updated to reflect current location<br>User notes that they have automatically "Joined" the incident, as denoted in the Incident Log | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| 5 | User opens Lane Status editor in CapWIN Incident pane and changes lane status | User notes corrected Lane Status on CapWIN Incident lane display<br>CapWIN XML Incident Feed reflects update to lane status and is successfully ingested by INC-ZONE software | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC-1-10B (UMD-TC-1.2) | | | | |
| **Test Case Name** | TC-1-10B (UMD-TC-1.2) Internet Hosted Services Functionality – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident | | | | |
| 6 | User updates other Incident details, such as Description, Type, etc. | Updates are reflected in CapWIN Incident pane | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| **Test Results and Remarks** | Verified RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident | | | | |
| **Pass/Fail** | Pass | | | | |

## Phase II – System Interface Level Testing Summary

Phase II testing in this program is focused on laboratory and garage integration of the system components and verifying functionality and performance of the system using simulated oncoming and responder vehicle data. This chapter describes the Phase II laboratory system communications and message acceptance tests which test, verify and demonstrates the functionality of interfaces, communications and transmission of messages between all mobile components.

The Test Case tables below summarize the component testing conducted in Phase II for each of the following test cases.

| Phase | Test Case Type |
|---|---|
| **Phase II** | **Interface Level Acceptance Test Cases** |
| | • TC-2-01A (UMD-TC-1.3) RESP-STG Application Integration – CapWIN Mobile (Responder-based RESP-STG) User Responding to Incident Location<br>• TC-2-01B (UMD-TC-1.4) RESP-STG Application Integration – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Monitors On Scene Responders<br>• TC-2-02A Oncoming Vehicle INC-ZONE Application Integration – Application Functionality<br>• TC-2-02B Oncoming Vehicle INC-ZONE Application Integration – Communications Functionality<br>• TC-2-03 Responder Vehicle and Personal Trunked Radio INC-ZONE Application Integration – Application Functionality<br>• TC-2-04 Integration of RESP-STG and INC-ZONE for Responder Vehicle – Application Functionality |

Each test case summarizes the

- Test Case Number
- Test Case Name
- Test Objective
- Requirements Verified
- Brief Description
- Test Location
- Test Setup and Configuration
- Test Procedures
- Test Results and Remarks
- Pass/Fail
- Test Case Pass/Fail Results

| | | | | | | |
|---|---|---|---|---|---|---|
| **Test Case Number** | TC-2-01A (UMD-TC-1.3) | | | | | |
| **Test Case Name** | TC-2-01A (UMD-TC-1.3) RESP-STG Application Integration –CapWIN Mobile (Responder-based RESP-STG) User Responding to Incident Location | | | | | |
| **Test Objective** | • User Denotes Status as “On Scene” while responding to Incident Location<br>• Verify ability to successfully login<br>• Verify ability to view “number of satellites” accessed by CapWIN Mobile (Responder-based RESP-STG) Client<br>• Verify that CapWIN Mobile (Responder-based RESP-STG) Client displays user as “joined” in Incident Log and user as “On Scene”<br>• Verify that user is now viewable by all other CapWIN users using the CapWIN Incident Map<br>• Verify that user sees themselves on the CapWIN Incident Map as well as the location of other responders who have denoted themselves as “On Scene” in the CapWIN Mobile (Responder-based RESP-STG) Client | | | | | |
| **Requirements Verified** | RS-7 | RS-20 | RS-29 | IZ-1 | PD-3.4.1.1-2 | PD-3.4.1.2-1 |
| | RS-15 | RS-21 | RS-31 | IZ-2 | PD-3.4.1.1-3 | PD-3.4.1.2-2 |
| | RS-18 | RS-23 | RS-37 | IZ-42 | PD-3.4.1.1-4 | PD-3.4.1.2-3 |
| | RS-19 | RS-27 | | IZ-45 | PD-3.4.1.1-5 | |
| **Brief Description** | Demonstrate and verify the capability for user to denote themselves as “On Scene” while en route to an incident scene using the CapWIN Mobile (Responder-based RESP-STG) Client and to interact with the CapWIN Incident Map. | | | | | |
| **Test Location** | Garage Integration Test Environment | | | | | |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code<br>• RESP-STG Application CapWIN Cloud Components | | | | | |

| **Test Case Number** | TC-2-01A (UMD-TC-1.3) | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-2-01A (UMD-TC-1.3) RESP-STG Application Integration –CapWIN Mobile (Responder-based RESP-STG) User Responding to Incident Location | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Login to CapWIN Mobile (Responder-based RESP-STG) Client prototype application | Successful login | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| 2 | Ensure proper operation of A-GPS device | View “number of satellites” accessed by CapWIN Mobile (Responder-based RESP-STG) Client | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC-2-01A (UMD-TC-1.3) | | | | |
| **Test Case Name** | TC-2-01A (UMD-TC-1.3) RESP-STG Application Integration –CapWIN Mobile (Responder-based RESP-STG) User Responding to Incident Location | | | | |
| 3 | Upon determining to respond to an incident where they are not currently located, the user selects "On Scene" button in CapWIN Mobile (Responder-based RESP-STG) Client | CapWIN Mobile (Responder-based RESP-STG) Client displays user as "joined" in Incident Log and user as "On Scene"<br>User is now viewable by all other CapWIN users using the CapWIN Incident Map | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| 4 | User open's CapWIN Incident map and enables "GPS mode" to monitor progress towards the incident and the location of other responders already on scene of the incident | User sees themselves on the CapWIN Incident Map as well as the location of other responders who have denoted themselves as "On Scene" in the CapWIN Mobile (Responder-based RESP-STG) Client | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| **Test Results and Remarks** | Verified CapWIN Mobile (Responder-based RESP-STG) User Responding to Incident Location | | | | |
| **Pass/Fail** | Pass | | | | |

| | |
|---|---|
| **Test Case Number** | TC-2-01B (UMD-TC-1.4) |
| **Test Case Name** | TC-2-01B (UMD-TC-1.4) RESP-STG Application Integration – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Monitors On Scene Responders |
| **Test Objective** | • User monitors status of responders denoted as "On Scene" from multiple AVL sources of Incident using CapWIN Mobile (Responder-based RESP-STG) Client Map, including use of various base map layers (e.g., street maps and satellite views)<br>• Verify ability to successfully login<br>• Verify ability to view "number of satellites" accessed by CapWIN Mobile (Responder-based RESP-STG) Client<br>• Verify ability to view one or more responders on incident map<br>• Verify that on scene responders are visually distinguished as icons representing different disciplines<br>• Verify that mouse-over of images displays first responder name, CapWIN userid and agency<br>• Monitor near real-time changes to responder locations on map based on vehicle movement, if applicable<br>• Verify view of satellite imagery base layer<br>• Verify view of "lane level" detail on Incident Map<br>• Verify view of first responders denoted as "on scene" at lane-level zoom<br>• Verify view of hospital and school locations on CapWIN Incident Map through "scrolling" of map relative to incident location<br>• Verify Responder Vehicle System Elements are operational<br>• Verify ability to display satellite views of the incident with overlays of responder vehicles<br>• Verify ability to provide a visual alerts when either new information or a high priority message is received<br>• Verify ability to refresh information automatically every 20 seconds and also by user<br>• Verify minimal performance reductions due to any application enhancements to CapWIN<br>• Verify ability to display video, including views from dash and infrastructure cameras<br>• Verify RESP-STG Application Cloud Components are operational<br>• Responder-based RESP-STG can input additional and updated incident information<br>• Verify functionality of Responder Vehicle System Elements communications<br>• Verify communications of Internet Hosted Services (RESP-STG Application Cloud Components)<br>• Verify ability to communicate responder input information to and from information broker |

| | |
|---|---|
| **Test Case Number** | TC-2-01B (UMD-TC-1.4) |
| **Test Case Name** | TC-2-01B (UMD-TC-1.4) RESP-STG Application Integration – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Monitors On Scene Responders |
| | • Verify that when a *simulated* incident is created, the following occurs:<br>  ○ Application Cloud-based RESP-STG is fusing and processing available data to facilitate response staging strategies<br>  ○ RESP-STG Application Cloud Components can recommend response staging strategies<br>  ○ Application Cloud-based RESP-STG is receiving real-time incident zone conditions and information from various sources<br>  ○ RESP-STG Application Cloud Components are receiving real-time incident zone conditions and information from the Application Cloud Components<br>  ○ Application Cloud-based RESP-STG is disseminating the strategies to Responder Vehicles<br>  ○ RESP-STG CapWIN Mobile (Responder-based RESP-STG) is receiving incident information from other responder vehicles via the RESP-STG Application Cloud Components<br>• RESP-STG CapWIN Mobile (Responder-based RESP-STG) can communicate incident information to other Responder Vehicles via the RESP-STG Application Cloud Components |
| **Requirements Verified** | RS-7, RS-15, RS-18, RS-19, RS-20, RS-21, RS-23, RS-27, RS-29, RS-31, RS-37, IZ-1, IZ-2, IZ-42, IZ-45, PD-3.4.1.1-2, PD-3.4.1.1-3, PD-3.4.1.1-4, PD-3.4.1.1-5, PD-3.4.1.2-1, PD-3.4.1.2-2, PD-3.4.1.2-3 |
| **Brief Description** | Demonstrate User monitoring of the status and location of responders who are “on scene” or responding to an incident location and to use other mapping features to enhance situational awareness to improve responder staging activities, including from “center/oversight” locations |
| **Test Location** | Garage Integration Test Environment |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code<br>• RESP-STG Application CapWIN Cloud Components |

| **Test Case Number** | TC-2-01B (UMD-TC-1.4) | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-2-01B (UMD-TC-1.4) RESP-STG Application Integration – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Monitors On Scene Responders | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Login to CapWIN Mobile (Responder-based RESP-STG) Client prototype application | Successful login | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| 2 | Ensure proper operation of A-GPS device | View “number of satellites” accessed by CapWIN Mobile (Responder-based RESP-STG) Client | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |

| **Test Case Number** | TC-2-01B (UMD-TC-1.4) | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-2-01B (UMD-TC-1.4) RESP-STG Application Integration – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Monitors On Scene Responders | | | | |
| 3 | Open CapWIN Mobile (Responder-based RESP-STG) Client Incident Map where responders are "on scene" or "on scene/responding" and view information about each responder | View one or more responders on incident map.<br>On scene responders are visually distinguished as icons representing different disciplines.<br>Mouse-over of images displays first responder name, CapWIN userid and agency.<br>Monitor near real-time changes to responder locations on map based on vehicle movement, if applicable. | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| 4 | Zoom to lane-level satellite view to view responder locations | View of satellite imagery base layer.<br>View "lane level" detail on Incident Map.<br>View first responders denoted as "on scene" at lane-level zoom. | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |

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|---|---|---|---|---|---|
| **Test Case Number** | TC-2-01B (UMD-TC-1.4) | | | | |
| **Test Case Name** | TC-2-01B (UMD-TC-1.4) RESP-STG Application Integration – RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Monitors On Scene Responders | | | | |
| 5 | View other data, including hospital and school locations on CapWIN Incident Map using map base layer relative to the incident location | View of hospital and school locations on CapWIN Incident Map through "scrolling" of map relative to incident location | Demonstration | Pass | See Responder Vehicle CapWIN Mobile RESP-STG User Interface Examples for CapWIN Screen captures from Acceptance Test Demonstration |
| **Test Results and Remarks** | Verified RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Monitors On Scene Responders | | | | |
| **Pass/Fail** | Pass | | | | |

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|---|---|---|---|---|---|
| **Test Case Number** | TC-2-02A | | | | |
| **Test Case Name** | TC-2-02A Oncoming Vehicle INC-ZONE Application Integration – Application Functionality | | | | |
| **Test Objective** | **Oncoming Vehicle INC-ZONE Application Integrated** Performance – Data Collection, Assessment, Recommendation, and Display<br>• Verify Oncoming Vehicle System Elements are operational<br>o Verify ability to log vehicle telematics, GPS, and predicted path data elements at 1 second intervals<br>o Verify ability to discard message received when a message is already activated<br>• Verify that when a *simulated* incident is created, the following occurs:<br>o Oncoming Vehicle-based INC-ZONE is fusing and processing available data to generate appropriate speed and/or lane advisory, alert, and/or warning messages<br>o Oncoming Vehicle-based INC-ZONE is fusing and processing available data to generate predicted path information and collision threat determination<br>o Oncoming Vehicle-based INC-ZONE is providing recommendations to the User Interface | | | | |
| **Requirements Verified** | IZ-6 | PD-4.1-6 | PD-4.3.1-2 | PD-4.3.1-8† | PD-4.3.2-5 |
| | IZ-21 | PD-4.2-4 | PD-4.3.1-3 | PD-4.3.1-9† | PD-4.3.2-6 |
| | PD-3.4.2-5 | PD-4.2-6 | PD-4.3.1-4 | PD-4.3.2-1 | PD-4.3.2-7 |
| | PD-3.4.2.1-1 | PD-4.3-3 | PD-4.3.1-5† | PD-4.3.2-2 | PD-4.3.2-9 |
| | PD-3.4.2.1-3 | PD-4.3-4 | PD-4.3.1-6† | PD-4.3.2-3 | PD-4.3.2-10 |
| | PD-4.1-3 | PD-4.3.1-1 | PD-4.3.1-7† | PD-4.3.2-4 | |
| **Brief Description** | Demonstrate and verify the functionality of the Oncoming Vehicle INC-ZONE Application when receiving INC-ZONE messages from Responder Vehicles | | | | |
| **Test Location** | Garage Integration Test Environment | | | | |

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|---|---|---|---|---|---|
| **Test Case Number** | TC-2-02A | | | | |
| **Test Case Name** | TC-2-02A Oncoming Vehicle INC-ZONE Application Integration – Application Functionality | | | | |
| **Test Setup and Configuration** | • Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Arada Oncoming INC-ZONE Application Test Code<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• Android INC-ZONE Application Test Code<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Collision GPS Input Data<br>• Component Communications Connectivity<br>• INC-ZONE DSRC Situational Display Test Tool<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code Generating INC-ZONE MAP and EVA Collision Messages<br>• RESP-STG Application CapWIN Cloud Components | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/ Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Initiate Android INC-ZONE Application<br>Initiate Arada Oncoming INC-ZONE Application<br>Initiate Simulated Incident in CapWIN Mobile (Responder-based RESP-STG)<br>Initiate Ruggedized Laptop INC-ZONE Application<br>Initiate INC-ZONE Application Test Code Generating INC-ZONE MAP and EVA Collision Messages<br>Initiate Simulated Oncoming Vehicle Collision GPS Input Data | Verify oncoming vehicle ability to log vehicle telematics, GPS, and predicted path data elements at 1 second intervals | Inspect Arada Oncoming Vehicle Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC-2-02A | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-2-02A Oncoming Vehicle INC-ZONE Application Integration – Application Functionality | | | | |
| 1b | | Verify ability to discard message received when a message is already activated | Inspect Arada Oncoming Vehicle Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| | | Oncoming Vehicle-based INC-ZONE is fusing and processing available data to generate appropriate speed and/or lane advisory, alert, and/or warning messages | Inspect Arada Oncoming Vehicle Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 1c | | Oncoming Vehicle-based INC-ZONE is fusing and processing available data to generate predicted path information and collision threat determination | Inspect Arada Oncoming Vehicle Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 1d | | Oncoming Vehicle-based INC-ZONE is providing recommendations to the User Interface | Observation of Android Oncoming Vehicle Driver Messages | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for screen capture of Oncoming Vehicle Driver Messages |

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|---|---|
| **Test Case Number** | TC-2-02A |
| **Test Case Name** | TC-2-02A Oncoming Vehicle INC-ZONE Application Integration – Application Functionality |
| **Test Results and Remarks** | |
| **Pass/Fail** | |

| | |
|---|---|
| **Test Case Number** | TC-2-02B |
| **Test Case Name** | TC-2-02B Oncoming Vehicle INC-ZONE Application Integration – Communications Functionality |
| **Test Objective** | Performance – Communication of Information<br>• Verify Oncoming Vehicle System Elements are operational<br>  ○ Verify ability to receive and transmit data between applications and components<br>  ○ Verify ability to accept input information including enhanced basic safety message and vehicle telematics information<br>  ○ Verify VITAL™ receives and processes Bluetooth messages from oncoming vehicle's mobile computational and user interface platform<br>• Verify Responder Vehicle data communications functions are operational<br>• Verify that when a *simulated* incident is created, the following occurs:<br>  ○ Oncoming Vehicle-based INC-ZONE is receiving real-time incident zone speed reduction and lane restriction information from Responder Vehicle<br>  ○ Oncoming Vehicle-based INC-ZONE is receiving real-time vehicle positioning and operating characteristics from various sources<br>  ○ Oncoming Vehicle-based INC-ZONE User Interface is communicating with driver<br>  ○ Oncoming Vehicle-based INC-ZONE is transmitting threat level information to Responder Vehicle |
| **Requirements Verified** | IZ-2, IZ-4, IZ-8, IZ-9, IZ-12, IZ-15, IZ-16, IZ-20, PD-3.4.2-4, PD-4.1-1, PD-4.1-2, PD-4.1-3, PD-4.1-4, PD-4.1-7, PD-4.2-2#, PD-4.2-3, PD-4.2-4, PD-4.2-7 |
| **Brief Description** | Demonstrate and verify the communication functionality of the Oncoming Vehicle INC-ZONE Application when receiving INC-ZONE messages from Responder Vehicles |
| **Test Location** | Garage Integration Test Environment |

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC-2-02B | | | | |
| **Test Case Name** | TC-2-02B Oncoming Vehicle INC-ZONE Application Integration – Communications Functionality | | | | |
| **Test Setup and Configuration** | • Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Arada Oncoming INC-ZONE Application Test Code<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• Android INC-ZONE Application Test Code<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Collision GPS Input Data<br>• Component Communications Connectivity<br>• INC-ZONE DSRC Situational Display Test Tool<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code Generating INC-ZONE MAP and EVA Collision Messages | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Initiate Android INC-ZONE Application<br>Initiate Arada Oncoming INC-ZONE Application<br>Initiate Simulated Incident in CapWIN Mobile (Responder-based RESP-STG)<br>Initiate Ruggedized Laptop INC-ZONE Application<br>Initiate INC-ZONE Application Test Code Generating INC-ZONE MAP and EVA Collision Messages<br>Simulated Oncoming Vehicle Collision GPS Input Data | Observe receipt and transmission of data between applications and components | Inspect Arada Oncoming Vehicle Message Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC-2-02B | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-2-02B Oncoming Vehicle INC-ZONE Application Integration – Communications Functionality | | | | |
| 1b | | Observe acceptance of input information including enhanced basic safety message and vehicle telematics information | Inspect Arada Oncoming Vehicle Message Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 1c | | Observe oncoming Vehicle-based INC-ZONE receipt of real-time incident zone speed reduction and lane restriction information from Responder Vehicle | Inspect Arada Oncoming Vehicle Message Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 1d | | Observe oncoming Vehicle-based INC-ZONE receipt of real-time vehicle positioning and operating characteristics from various sources | Inspect Arada Oncoming Vehicle Message Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 1e | | Observe oncoming Vehicle-based INC-ZONE User Interface is communicating with driver | Observation of Android Oncoming Vehicle Driver Messages | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

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|---|---|---|---|---|---|
| **Test Case Number** | TC-2-02B | | | | |
| **Test Case Name** | TC-2-02B Oncoming Vehicle INC-ZONE Application Integration – Communications Functionality | | | | |
| 1f | | Observe oncoming Vehicle-based INC-ZONE is transmitting threat level information to Responder Vehicle | Inspect Arada Responder Vehicle Message Logs | Pass | See Responder Vehicle INC-ZONE User Interface Message Examples for screen capture of Responder Vehicle Messages |
| **Test Results and Remarks** | Verified Oncoming Vehicle INC-ZONE Application Integration – Communications Functionality | | | | |
| **Pass/Fail** | Pass | | | | |

| | |
|---|---|
| **Test Case Number** | TC-2-03 |
| **Test Case Name** | TC-2-03 Responder Vehicle and Personal Trunked Radio INC-ZONE Application Integration – Application Functionality |
| **Test Objective** | Performance – Data Collection, Assessment, Recommendation, Display, and Broadcast of Advisories, Alerts, and Warnings<br>• Verify Responder Vehicle System Elements are operational<br>  ○ Verify ability to communicate lane closure information and updates such that it is available to oncoming vehicles within 5 seconds of a status change<br>• Verify Responder Vehicle/Personal Trunked Radio System Elements are operational<br>  ○ Verify that all responders within the incident zone receive the collision alert<br>  ○ Verify that responders not within the incident zone do not receive the collision alert<br>  ○ Verify ability of application to trigger flashing lights or siren (i.e., for notification of oncoming vehicle threat) when a command is received to do so)<br>• Verify Internet Hosted Services (RESP-STG Application Cloud Components) are operational<br>• Verify that when a *simulated* incident is created, the following occurs:<br>  ○ Responder Vehicle-based INC-ZONE is transmitting real-time incident zone information to Oncoming Vehicles, including position, speed reductions, and lane restriction information<br>  ○ Responder Vehicle-based INC-ZONE is receiving real-time prediction path and threat determination information from Oncoming Vehicle(s)<br>  ○ Responder Vehicle-based INC-ZONE is receiving real-time incident zone information from various sources<br>  ○ Responder Vehicle-based INC-ZONE is fusing and processing available data to generate appropriate oncoming vehicle threat advisory, alert, and/or warning messages<br>  ○ Responder Vehicle-based INC-ZONE is providing message recommendations to the User Interface which is communicating with responders, including vehicle system activation of horn and/or lights<br>  ○ Responder Vehicle-based INC-ZONE is transmitting threat level information to Personal Trunked Radio which is communicating with responders |
| **Requirements Verified** | IZ-2, IZ-3, IZ-4, IZ-5, IZ-6, IZ-7, IZ-8, IZ-26, IZ-27, IZ-28, IZ-30, IZ-31, PD-3.3-6, PD-3.4-5, PD-3.4-7, PD-3.4.1.2-7, PD-3.4.2-1, PD-3.4.2-3, PD-3.4.2-4, PD-3.4.2-5, PD-3.4.2.1-1, PD-3.4.2.1-2, PD-3.4.2.1-3, PD-3.4.2.1-4, PD-3.4.2.2-1*, PD-3.4.2.2-2*, PD-3.4.2.2-3*, PD-3.4.2.2-4*, PD-3.4.2.2-5*, PD-3.4.2.2-6*, PD-3.4.2.2-7* |
| **Brief Description** | Demonstrate and verify the functionality of the Responder Vehicle INC-ZONE Application when receiving INC-ZONE messages from Oncoming Vehicles |
| **Test Location** | Garage Integration Test Environment |

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC-2-03 | | | | |
| **Test Case Name** | TC-2-03 Responder Vehicle and Personal Trunked Radio INC-ZONE Application Integration – Application Functionality | | | | |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• VITAL™ Responder Vehicle CAN Interface<br>• Simulated Oncoming Vehicle Collision ACM Message Input<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool<br>• RESP-STG Application CapWIN Cloud Components | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/ Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Initiate Android INC-ZONE Application<br>Initiate Arada Oncoming INC-ZONE Application<br>Initiate Simulated Incident in CapWIN Mobile (Responder-based RESP-STG)<br>Initiate Ruggedized Laptop INC-ZONE Application<br>Initiate Arada Responder INC-ZONE Application<br>Initiate Simulated Oncoming Vehicle Collision ACM Message Input | Observe Responder Vehicle System Elements are operational | Inspect Ruggedized Vehicle INC-ZONE function and display<br>Inspect Ruggedized Vehicle INC-ZONE Message Logs | Pass | See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC-2-03 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-2-03 Responder Vehicle and Personal Trunked Radio INC-ZONE Application Integration – Application Functionality | | | | |
| 1b | | Observe communication of lane closure information and updates such that it is available to oncoming vehicles within 5 seconds of a status change | Inspect Ruggedized Vehicle INC-ZONE Message Logs<br>Observe INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display |
| 1c | | Verify Responder Vehicle/Personal Trunked Radio System Elements are operational | Inspect Ruggedized Vehicle INC-ZONE Message Logs | Pass | |
| 1d | | Verify that all responders within the incident zone receive the collision alert | Observation of Trunked Radio Messages and Alarms of Local Responders<br>Observe INC-ZONE DSRC Situational Display | Pass | Observed audible alerts on Responder Radios |
| 1e | | Verify that responders not within the incident zone do not receive the collision alert | Observation of Trunked Radio Messages and Alarms of Non Local Responders | Partial | Collision alerts are delivered to responders on preprogrammed talk groups using existing capabilities. However, do not have access to responders on other talk groups to demonstrate that they do not receive alert. |

| **Test Case Number** | TC-2-03 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-2-03 Responder Vehicle and Personal Trunked Radio INC-ZONE Application Integration – Application Functionality | | | | |
| 1f | | Verify Internet Hosted Services (RESP-STG Application Cloud Components) are operational | Inspect Ruggedized Vehicle INC-ZONE Functionality Indicators and Messages<br>Inspect Ruggedized Vehicle INC-ZONE Message Logs | Pass | |
| 1g | | Responder Vehicle-based INC-ZONE is transmitting real-time incident zone information to Oncoming Vehicles, including position, speed reductions, and lane restriction information | Inspect Arada Oncoming Vehicle Message Logs<br>Observe INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display |
| 1h | | Responder Vehicle-based INC-ZONE is receiving real-time prediction path and threat determination information from Oncoming Vehicle(s) | Inspect Arada Responder Vehicle Message Logs<br>Observe INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC-2-03 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-2-03 Responder Vehicle and Personal Trunked Radio INC-ZONE Application Integration – Application Functionality | | | | |
| 1j | | Responder Vehicle-based INC-ZONE is receiving real-time incident zone information from various sources | Inspect Ruggedized Laptop INC-ZONE Message Logs<br>Inspect Arada Responder Vehicle Message Logs | Pass | See INC-ZONE DSRC Situational Display for example Message Logs from Prototype Acceptance Test Demonstration. |
| 1k | | Responder Vehicle-based INC-ZONE is fusing and processing available data to generate appropriate oncoming vehicle threat advisory, alert, and/or warning messages | Inspect Arada Responder Vehicle Message Logs | Pass | See INC-ZONE DSRC Situational Display for example Message Logs from Prototype Acceptance Test Demonstration. |
| 1L | | Responder Vehicle-based INC-ZONE is providing message recommendations to the User Interface which is communicating with responders, including vehicle system activation of horn and/or lights | Inspect Arada Responder Vehicle Message Logs<br>Observation of Ruggedized Laptop INC-ZONE Responder Message Display<br>Observe INC-ZONE DSRC Situational Display | | Observed audible alerts on Responder Radios and activation of horn and flashing lights. |

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|---|---|---|---|---|---|
| **Test Case Number** | TC-2-03 | | | | |
| **Test Case Name** | TC-2-03 Responder Vehicle and Personal Trunked Radio INC-ZONE Application Integration – Application Functionality | | | | |
| 1m | | Responder Vehicle-based INC-ZONE is transmitting threat level information to Personal Trunked Radio which is communicating with responders | Observation of Trunked Radio Messages and Alarms of Local Responders | | Observed audible alerts on Responder Radios |
| **Test Results and Remarks** | Verified Responder Vehicle and Personal Trunked Radio INC-ZONE Application Functionality | | | | |
| **Pass/Fail** | Pass | | | | |

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|---|---|---|---|---|---|---|
| **Test Case Number** | TC-2-04 | | | | | |
| **Test Case Name** | TC-2-04 Integration of RESP-STG and INC-ZONE for Responder Vehicle – Application Functionality | | | | | |
| **Test Objective** | • Verify RESP-STG Application is transmitting, receiving, processing, and displaying appropriate information, and also:<br>• Verify ability to compile incident zone information for transmission to oncoming vehicles Verify INC-ZONE Application is transmitting, receiving, processing, and displaying appropriate information<br>• Verify that when the RESP-STG and INC-ZONE applications are both generating incident response strategies and messages that the appropriately prioritized warnings and alerts are disseminated to the responders via the user interface and personal trunked radios. | | | | | |
| **Requirements Verified** | RS-1<br>IZ-1<br>IZ-32 | IZ-33<br>IZ-34<br>IZ-35 | IZ-36<br>IZ-37<br>IZ-39 | IZ-40<br>IZ-42<br>IZ-43 | IZ-44<br>IZ-45 | IZ-46<br>IZ-47 |
| **Brief Description** | Use Case 1.0 Demonstrate the ability of the RESP-STG CapWIN and the INC-ZONE Applications to share and exchange data through the RESP-STG Cloud Environment. | | | | | |
| **Test Location** | Garage Integration Test Environment | | | | | |
| **Test Setup and Configuration** | • Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Ruggedized Laptop INC-ZONE Application Test Code<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• VITAL™ Responder Vehicle CAN Interface<br>• Simulated Incident Zone<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool<br>• RESP-STG Application CapWIN Cloud Components | | | | | |

| **Test Case Number** | TC-2-04 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC-2-04 Integration of RESP-STG and INC-ZONE for Responder Vehicle – Application Functionality | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1a | Establish simulated Incident zone coverage in a responder vehicle on scene (as appropriate, refer to test cases TC-2-01A (UMD-TC-1.1), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User "On Scene" and TC-2-01B (UMD-TC-1.2), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident)<br>Initiate Simulated Oncoming Vehicle Collision GPS Input Data | Verify RESP-STG Application is transmitting, receiving, processing, and displaying appropriate information. | Observation of Ruggedized Laptop INC-ZONE Responder Message Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display |
| 1b | | Verify ability to compile incident zone information for transmission to oncoming vehicles Verify INC-ZONE Application is transmitting, receiving, processing, and displaying appropriate information | Observation of Ruggedized Laptop INC-ZONE Responder Message Display | | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display. See Responder Vehicle INC-ZONE User Interface Message Examples for screen capture of Responder Vehicle Messages. |

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|---|---|---|---|---|---|
| **Test Case Number** | TC-2-04 | | | | |
| **Test Case Name** | TC-2-04 Integration of RESP-STG and INC-ZONE for Responder Vehicle – Application Functionality | | | | |
| 1c | | Verify that when the RESP-STG and INC-ZONE applications are both generating incident response strategies and messages that the appropriately prioritized warnings and alerts are disseminated to the responders via the user interface and personal trunked radios | Observation of Ruggedized Laptop INC-ZONE Responder Message Display<br>Observation of Trunked Radio Messages and Alarms of Local Responders | | Observed audible alerts on Responder Radios |
| **Test Results and Remarks** | **Verified the ability of the RESP-STG CapWIN and the INC-ZONE Applications to share and exchange data through the RESP-STG Cloud Environment.** | | | | |
| **Pass/Fail** | Pass | | | | |

## Phase III – Prototype Pilot Acceptance Testing Summary

Phase III testing in this program focused on vehicle-based closed-course testing and verification of functionality and performance of the system. This chapter describes the Phase III onroad system communications and message acceptance tests which test, verify, and demonstrate the functionality of interfaces, communications and transmission of messages between oncoming and responder vehicle subsystems.

The Test Case tables below summarize the component testing conducted in Phase III for each of the following test cases.

| Phase | Test Case Type |
|---|---|
| **Phase III** | **Prototype Pilot Acceptance Test Cases** |
| | • TC-3-01RESP-STG and INC-ZONE Single Responder Traffic Stop Without Oncoming Vehicles<br>• TC-3-02 RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Oncoming Vehicles<br>• TC 3-03a RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat<br>• TC-3-03b RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat<br>• TC-3-03c RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat |

Each test case summarizes the

- Test Case Number
- Test Case Name
- Test Objective
- Requirements Verified
- Brief Description
- Test Location
- Test Setup and Configuration
- Test Procedures
- Test Results and Remarks
- Pass/Fail
- Test Case Pass/Fail Results

| | |
|---|---|
| **Test Case Number** | TC3-01 |
| **Test Case Name** | TC3-01 RESP-STG and INC-ZONE Single Responder Traffic Stop Without Oncoming Vehicles |
| **Test Objective** | Verify that the INC-ZONE application can be accessed and deployed during a routine traffic stop without impeding the responder's ability to perform their primary responsibilities. |
| **Requirements Verified** | RS-1, IZ-4, IZ-7, IZ-8, IZ-9, IZ-11, IZ-18, IZ-19, IZ-12 IZ-15, IZ-16, PD-3.2-3, PD-3.4.2.1-4, PD-4.1-3, PD-4.2-8, PD-4.3.1-3, PD-4.3.2-8 |
| **Brief Description** | Simulated single responder traffic stop on two-lane highway without oncoming vehicles. System automatically establishes incident zone and terminates incident zone without action by the responder. |
| **Test Location** | Test Track |
| **Test Setup and Configuration** | • Single responder traffic stop on two-lane highway without oncoming vehicles.<br>• RESP-STG Application CapWIN Cloud Components<br>• Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• VITAL™ Responder Vehicle CAN Interface<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool |

| **Test Case Number** | TC3-01 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC3-01 RESP-STG and INC-ZONE Single Responder Traffic Stop Without Oncoming Vehicles | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Establish Incident zone coverage in a responder vehicle on scene (as appropriate, refer to test cases TC-2-01A (UMD-TC-1.1), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User "On Scene" and TC-2-01B (UMD-TC-1.2), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident) | The patrol vehicle's DSRC radio commences to broadcast:<br>a. Traveler Information (TIM) messages containing lane closure based on the cloud-based CapWIN incident data and speed advice based on local guidelines, and<br>b. Map data embedded in the TIM messages containing lane configuration and closure data, based on detailed GIS data retrieved from a (local) map repository, centered on the patrol vehicle's current location. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display. See Appendix a for example Message Logs from Prototype Acceptance Test Demonstration. |
| 2 | The incident commander in the responder vehicle uses the CapWin client to close out the incident scene. | The responder vehicle ceases to broadcast the TIM messages. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

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|---|---|
| **Test Case Number** | TC3-01 |
| **Test Case Name** | TC3-01 RESP-STG and INC-ZONE Single Responder Traffic Stop Without Oncoming Vehicles |
| **Test Results and Remarks** | ***Verified RESP-STG and INC-ZONE Single Responder Traffic Stop Without Oncoming Vehicles*** |
| **Pass/Fail** | Pass |

| | |
|---|---|
| **Test Case Number** | TC3-02 |
| **Test Case Name** | TC3-02 RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Oncoming Vehicles |
| **Test Objective** | • Verify that the RESP-STG and INC-ZONE application can be used to provide real-time incident information to on-scene responders and oncoming vehicles.<br>• Verify that INC-ZONE merging and speed messages are transmitted, received, displayed, and acted upon by oncoming vehicle drivers in time to prevent sudden stopping and provide reduced speeds through incident zone, but maintain throughput. |
| **Requirements Verified** | RS-1, IZ-4, IZ-7 IZ-8, IZ-9, IZ-11 IZ-18, IZ-19, IZ-12 IZ-15, IZ-16, PD-3.2-3, PD-3.4.2.1-4, PD-4.1-3 PD-4.2-8, PD-4.3.1-3, PD-4.3.2-8 |
| **Brief Description** | Simulated single responder traffic stop on two-lane highway with oncoming vehicles. Oncoming vehicle receives incident zone information via the TIM and EVA messages being broadcast from the responder vehicle. Oncoming vehicle conforms to the broadcast lane closure and reduced speed advice. |
| **Test Location** | Test Track |
| **Test Setup and Configuration** | • Single responder traffic stop on two-lane highway with oncoming vehicles.<br>• RESP-STG Application CapWIN Cloud Components<br>• Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• Component Communications Connectivity<br>• Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• VITAL™ Responder Vehicle CAN Interface<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool |

| **Test Case Number** | TC3-02 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC3-02 RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Oncoming Vehicles | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/ Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Establish Incident zone coverage in a responder vehicle on scene (as appropriate, refer to test cases TC-2-01A (UMD-TC-1.1), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User "On Scene" and TC-2-01B (UMD-TC-1.2), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident) | Inspect the INC-ZONE DSRC Situational Display and the Arada Responder INC-ZONE Logs to observe that the patrol vehicle's DSRC radio commences to broadcast:<br>a. Traveler Information (TIM) messages containing lane closure based on the cloud-based CapWIN incident data and speed advice based on local guidelines, and<br>b. Map data embedded in the TIM messages containing lane configuration and closure data, based on detailed GIS data retrieved from a (local) map repository, centered on the patrol vehicle's current location. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 2 | Drive an oncoming Connected Vehicle within range of the responder vehicle's DSRC transmissions. | The oncoming vehicle receives incident zone information via the TIM and EVA messages being broadcast from the responder vehicle. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC3-02 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC3-02 RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Oncoming Vehicles | | | | |
| 2a | | Based on the TIM and EVA messages received from the responder vehicle's broadcast, lane closure and reduced speed advice are presented to the driver of the oncoming vehicle. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Responder INC-ZONE log files | Pass | See INC-ZONE DSRC Situational Display for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 3 | Drive the oncoming vehicle through the incident zone, conforming to the broadcast lane closure and reduced speed advice. | Based on the TIM and EVA messages received from the responder vehicle's broadcast, as well as the oncoming vehicle's own telematics, the oncoming vehicle's MCD calculates no warning or threats to the responder vehicles in the incident zone, and hence no warnings or alarms are presented to the oncoming driver as the oncoming vehicle moves through and exits the incident zone. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Responder INC-ZONE log files | Pass | See INC-ZONE DSRC Situational Display for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC3-02 | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC3-02 RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Oncoming Vehicles | | | | |
| 3a | | The responder vehicle's MCD detects no warning or threat messages being broadcast by the oncoming vehicle to the responder vehicles in the incident zone, and hence no warnings or alarms are presented to the responder as the oncoming vehicle moves through and exits the incident zone. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Responder INC-ZONE log files | Pass | See INC-ZONE DSRC Situational Display for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 4 | The incident commander in the responder vehicle uses the CapWin client to close out the incident scene. | Inspect the INC-ZONE DSRC Situational Display and the Arada Responder INC-ZONE Logs to observe that the responder vehicle ceases to broadcast the TIM messages. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| | |
|---|---|
| **Test Case Number** | TC3-02 |
| **Test Case Name** | TC3-02 RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Oncoming Vehicles |
| **Test Results and Remarks** | Verified RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Oncoming Vehicles |
| **Pass/Fail** | Pass |

| | |
|---|---|
| **Test Case Number** | TC 3-03a |
| **Test Case Name** | TC 3-03a RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat |
| **Test Objective** | • Verify that the RESP-STG and INC-ZONE application can be used to provide real-time incident information to on-scene responders and oncoming vehicles.<br>• Verify that oncoming speeding vehicles receive appropriate INC-ZONE messages with sufficient time slow down prior to the incident zone.<br>• Verify that the INC-ZONE warning method is reliable and effective in alerting responders to potential threats. |
| **Requirements Verified** | IZ-6, IZ-10, IZ-13, IZ-14 IZ-20, IZ-21, IZ-22 IZ-24, IZ-25, IZ-26 IZ-27, IZ-28, IZ-29 IZ-30, IZ-31, PD-3.4.2.1-4 PD-3.4.2.2-2, PD-3.4.2.2-3, PD-4.3.1-3 |
| **Brief Description** | Simulated single responder traffic stop on two-lane highway with an oncoming vehicle. Oncoming vehicle receives incident zone information via the TIM and EVA messages being broadcast from the responder vehicle. The oncoming vehicle enters the incident zone at a speed above the advised speed. Oncoming vehicle driver and Responder receive warning messages and alarms. |
| **Test Location** | Test Track |
| **Test Setup and Configuration** | • Simulated single responder traffic stop on two-lane highway with a speeding oncoming vehicle.<br>• RESP-STG Application CapWIN Cloud Components<br>• Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• Component Communications Connectivity<br>• Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• VITAL™ Responder Vehicle CAN Interface<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool |

| **Test Case Number** | TC 3-03a | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03a RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/ Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Establish Incident zone coverage in a responder vehicle on scene (as appropriate, refer to test cases TC-2-01A (UMD-TC-1.1), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User "On Scene" and TC-2-01B (UMD-TC-1.2), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident) | The patrol vehicle's DSRC radio commences to broadcast:<br>a. Traveler Information (TIM) messages containing lane closure based on the cloud-based CapWIN incident data and speed advice based on local guidelines, and<br>b. Map data embedded in the TIM messages containing lane configuration and closure data, based on detailed GIS data retrieved from a (local) map repository, centered on the patrol vehicle's current location. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03a | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03a RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat | | | | |
| 2 | Drive an oncoming Connected Vehicle within range of the responder vehicle's DSRC transmissions. | The oncoming vehicle receives incident zone information via the TIM and EVA messages being broadcast from the responder vehicle. | Inspect Arada Oncoming INC-ZONE Log Files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 2a | | Based on the TIM and EVA messages received from the responder vehicle's broadcast, lane closure and reduced speed advice are presented to the driver of the oncoming vehicle. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Oncoming INC-ZONE Log Files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03a | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03a RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat | | | | |
| 3 | Drive the oncoming vehicle into the incident zone at a speed above the advised speed. | Based on the TIM messages received from the responder vehicle's broadcast and the oncoming vehicle's own telematics, the oncoming vehicle's MCD detects the speed violation, warns the driver of the violation and provides corrective advice to the driver on the oncoming vehicle's MCD to reduce the vehicle's speed. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Oncoming INC-ZONE Log Files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03a | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03a RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat | | | | |
| 3a | | The oncoming vehicle commences to broadcast a threat alert message, indicating an oncoming vehicle is violating the broadcast speed advice. | Inspect Arada Oncoming INC-ZONE Log Files<br>Inspect Arada Responder INC-ZONE Log Files | Pass | See Responder Vehicle INC-ZONE User Interface Message Examples for examples of INC-ZONE Responder Laptop Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 3b | | Based on the oncoming vehicle's threat alert message, the responder vehicle's MCD displays a warning and emits a warning tone to the responder's PASS. | Observation of Responder Vehicle Messages<br>Inspect Arada Responder INC-ZONE Log Files | Pass | Observed Audible Messages from Responders PASS |

| **Test Case Number** | TC 3-03a | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03a RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat | | | | |
| 4 | Reduce oncoming vehicle speed so as to conform to the broadcast speed advice. | Based on the TIM messages received from the responder vehicle's broadcast, as well as the oncoming vehicle's own telematics, the oncoming vehicle's MCD determines that the oncoming vehicle is no longer a threat to the responder vehicles in the incident zone, and removes the corrective advice from the oncoming vehicle's MCD's UI. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Oncoming INC-ZONE Log Files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03a | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03a RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat | | | | |
| 4a | | The threat alert message broadcast by the oncoming vehicle ceases. | Inspect Arada Oncoming INC-ZONE Log Files<br>Inspect Arada Responder INC-ZONE Log Files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03a | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03a RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat | | | | |
| 4b | | Based on the cessation of the oncoming vehicle's threat alert messages, the responder vehicle's MCD determines that the oncoming vehicle is no longer a threat to the responder vehicles in the incident zone, ceases the warning tone on the responder's PASS and removes the warning from the responder vehicle's MCD's UI. | Observation of Responder Vehicle Messages<br>Inspect Arada Responder INC-ZONE Log Files | Pass | See Responder Vehicle INC-ZONE User Interface Message Examples for examples of INC-ZONE Responder Laptop Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 5 | Exit the oncoming vehicle from the incident zone observing speed advice. | No additional warnings or alarms are presented to the oncoming driver. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Oncoming INC-ZONE Log Files | Pass | |
| 5a | | No additional warnings or alarms are presented to the responder. | Observation of Responder Vehicle Messages<br>Inspect Arada Responder INC-ZONE Log Files | Pass | |

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC 3-03a | | | | |
| **Test Case Name** | TC 3-03a RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat | | | | |
| 6 | The incident commander in the responder vehicle uses the CapWin client to close out the incident scene. | The responder vehicle ceases to broadcast the TIM messages. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display. |
| **Test Results and Remarks** | Verified RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with OverSpeed Threat | | | | |
| **Pass/Fail** | Pass | | | | |

| | |
|---|---|
| **Test Case Number** | TC 3-03b |
| **Test Case Name** | TC 3-03b RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat |
| **Test Objective** | • Verify that the RESP-STG and INC-ZONE application can be used to provide real-time incident information to on-scene responders and oncoming vehicles.<br>• Verify that oncoming vehicles approaching a lane closure receive appropriate INC-ZONE messages with sufficient time to change lanes or slow down prior to the incident zone.<br>• Verify that the INC-ZONE warning method is reliable and effective in alerting responders to potential threats. |
| **Requirements Verified** | IZ-6, IZ-10, IZ-13, IZ-14 IZ-20, IZ-21, IZ-22 IZ-24, IZ-25, IZ-26 IZ-27, IZ-28, IZ-29 IZ-30, IZ-31, PD-3.4.2.1-4 PD-3.4.2.2-2, PD-3.4.2.2-3, PD-4.3.1-3 |
| **Brief Description** | Simulated single responder traffic stop on two-lane highway with oncoming vehicle in the closed lane. Oncoming vehicle receives incident zone information via the TIM and EVA messages being broadcast from the responder vehicle. The oncoming vehicle enters the incident zone in the closed lane. Oncoming vehicle driver and responder receive warning messages and alarms. |
| **Test Location** | Test Track |
| **Test Setup and Configuration** | • Simulated single responder traffic stop on two-lane highway with an oncoming vehicle in the closed lane.<br>• RESP-STG Application CapWIN Cloud Components<br>• Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• Component Communications Connectivity<br>• Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• VITAL™ Responder Vehicle CAN Interface<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool |

| **Test Case Number** | TC 3-03b | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03b RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/ Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Establish Incident zone coverage in a responder vehicle on scene (as appropriate, refer to test cases TC-2-01A (UMD-TC-1.1), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User "On Scene" and TC-2-01B (UMD-TC-1.2), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident) | Inspect the INC-ZONE DSRC Situational Display and the Arada Responder INC-ZONE Logs to observe that the patrol vehicle's DSRC radio commences to broadcast:<br>a. Traveler Information (TIM) messages containing lane closure based on the cloud-based CapWIN incident data and speed advice based on local guidelines, and<br>b. Map data embedded in the TIM messages containing lane configuration and closure data, based on detailed GIS data retrieved from a (local) map repository, centered on the patrol vehicle's current location. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03b | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03b RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat | | | | |
| 2 | Drive an oncoming Connected Vehicle within range of the responder vehicle's DSRC transmissions. | The oncoming vehicle receives incident zone information via the TIM and EVA messages being broadcast from the responder vehicle. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03b | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03b RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat | | | | |
| 2a | | Based on the TIM and EVA messages received from the responder vehicle's broadcast, lane closure and reduced speed advice are presented to the driver of the oncoming vehicle. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Responder INC-ZONE log files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03b | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03b RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat | | | | |
| 3 | Drive the oncoming vehicle into the incident zone in a closed lane. | Based on the TIM messages received from the responder vehicle's broadcast and the oncoming vehicle's own telematics, the oncoming vehicle's MCD detects the lane violation, warns the driver of the violation and provides corrective advice to the driver on the oncoming vehicle's MCD to move to an open lane. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Responder INC-ZONE log files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03b | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03b RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat | | | | |
| 3a | | The oncoming vehicle commences to broadcast a threat alert message, indicating an oncoming vehicle is violating the broadcast lane advice. | Inspect Arada Oncoming INC-ZONE Log Files<br>Inspect Arada Responder INC-ZONE Log Files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 3b | | Based on the oncoming vehicle's threat alert message, the responder vehicle's MCD displays a warning and emits a warning tone to the responder's PASS. | Observation of Responder Vehicle Messages<br>Inspect Arada Responder INC-ZONE Log Files | Pass | Observed Audible Messages from Responders PASS |

| **Test Case Number** | TC 3-03b | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03b RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat | | | | |
| 4 | Maneuver the oncoming vehicle to a through lane so as to conform to the broadcast lane advice. | Based on the TIM messages received from the responder vehicle's broadcast, as well as the oncoming vehicle's own telematics, the oncoming vehicle's MCD determines that the oncoming vehicle is no longer a threat to the responder vehicles in the incident zone, and removes the corrective advice from the oncoming vehicle's MCD's UI. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Oncoming INC-ZONE Log Files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03b | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03b RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat | | | | |
| 4a | | The threat alert message broadcast by the oncoming vehicle ceases. | Inspect Arada Oncoming INC-ZONE Log Files<br>Inspect Arada Responder INC-ZONE Log Files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 4b | | Based on the cessation of the oncoming vehicle's threat alert messages, the responder vehicle's MCD determines that the oncoming vehicle is no longer a threat to the responder vehicles in the incident zone, ceases the warning tone on the responder's PASS and removes the warning from the responder vehicle's MCD's UI. | Observation of Responder Vehicle Messages<br>Inspect Arada Responder INC-ZONE Log Files | Pass | |
| 5 | Exit the oncoming vehicle from the incident zone in a through lane. | No additional warnings or alarms are presented to the oncoming driver. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Oncoming INC-ZONE Log Files | Pass | |

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC 3-03b | | | | |
| **Test Case Name** | TC 3-03b RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat | | | | |
| 5a | | No additional warnings or alarms are presented to the responder. | Observation of Responder Vehicle Messages<br>Inspect Arada Responder INC-ZONE Log Files | Pass | |
| 6 | The incident commander in the responder vehicle uses the CapWin client to close out the incident scene. | The responder vehicle ceases to broadcast the TIM messages. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | |
| **Test Results and Remarks** | Verified RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Lane Closure Threat | | | | |
| **Pass/Fail** | Pass | | | | |

| | |
|---|---|
| **Test Case Number** | TC 3-03c |
| **Test Case Name** | TC 3-03c RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat |
| **Test Objective** | • Verify that the RESP-STG and INC-ZONE application can be used to provide real-time incident information to on-scene responders and oncoming vehicles.<br>• Verify that oncoming vehicles on path to strike a responder can accurately and consistently be self-identified with sufficient time to transmit an INC-ZONE message to responder vehicles that can be disseminated in time for responder(s) to take evasive action.<br>• Verify that the INC-ZONE warning method is reliable and effective in alerting responders to potential collisions. |
| **Requirements Verified** | IZ-6, IZ-10, IZ-13, IZ-14, IZ-20, IZ-21, IZ-22, IZ-24, IZ-25, IZ-26, IZ-27, IZ-28, IZ-29, IZ-30, IZ-31, PD-3.4.2.1-4, PD-3.4.2.2-2, PD-3.4.2.2-3, PD-4.3.1-3 |
| **Brief Description** | Simulated single responder traffic stop on two-lane highway with an oncoming vehicle The oncoming vehicle enters the incident zone above the advised speed, headed directly toward the responder vehicle in the incident zone. Oncoming vehicle receives incident zone information via the TIM and EVA messages being broadcast from the responder vehicle. Oncoming vehicle driver and Responder receive warning messages and alarms. |
| **Test Location** | Test Track |

| | |
|---|---|
| **Test Case Number** | TC 3-03c |
| **Test Case Name** | TC 3-03c RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat |
| **Test Setup and Configuration** | • Simulated single responder traffic stop on two-lane highway with a speeding oncoming vehicle on a collision course with a responder vehicle.<br>• RESP-STG Application CapWIN Cloud Components<br>• Oncoming vehicle<br>• Arada Oncoming Vehicle DSRC Communication Hardware<br>• Arada Oncoming INC-ZONE Application<br>• Android Oncoming Vehicle Computational Platform and User Interface Hardware<br>• Android INC-ZONE Application<br>• VITAL™ Oncoming Vehicle CAN Interface<br>• Component Communications Connectivity<br>• Responder Vehicle<br>• Ruggedized Laptop Responder Vehicle Computational Platform and User Interface Hardware<br>• Ruggedized Laptop CapWIN Mobile (Responder-based RESP-STG) Application<br>• Ruggedized Laptop INC-ZONE Application<br>• Arada Responder Vehicle DSRC Communication Hardware<br>• Arada Responder INC-ZONE Application<br>• VITAL™ Responder Vehicle CAN Interface<br>• Trunked Radio Equipment<br>• Personal Trunked Radio<br>• Ruggedized Laptop Radio Interface Cable with LED indicator<br>• INC-ZONE DSRC Situational Display Test Tool |

| **Test Case Number** | TC 3-03c | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03c RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat | | | | |
| **Step** | **Procedure** | **Expected Result** | **Measurement/ Verification Method** | **Pass/ Fail** | **Remarks** |
| 1 | Establish Incident zone coverage in a responder vehicle on scene (as appropriate, refer to test cases TC-2-01A (UMD-TC-1.1), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User "On Scene" and TC-2-01B (UMD-TC-1.2), RESP-STG CapWIN Mobile (Responder-based RESP-STG) User Updates Incident) | Inspect the INC-ZONE DSRC Situational Display and the Arada Responder INC-ZONE Logs to observe that the patrol vehicle's DSRC radio commences to broadcast:<br>a. Traveler Information (TIM) messages containing lane closure based on the cloud-based CapWIN incident data and speed advice based on local guidelines, and<br>b. Map data embedded in the TIM messages containing lane configuration and closure data, based on detailed GIS data retrieved from a (local) map repository, centered on the patrol vehicle's current location. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See INC-ZONE DSRC Situational Display for Examples of DSRC Situational Display. See Responder Vehicle INC-ZONE User Interface Message Examples for examples of INC-ZONE Responder Laptop Messages. |

| **Test Case Number** | TC 3-03c | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03c RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat | | | | |
| 2 | Drive an oncoming Connected Vehicle within range of the responder vehicle's DSRC transmissions. | The oncoming vehicle receives incident zone information via the TIM and EVA messages being broadcast from the responder vehicle. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03c | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03c RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat | | | | |
| 2a | | Based on the TIM and EVA messages received from the responder vehicle's broadcast, lane closure and reduced speed advice are presented to the driver of the oncoming vehicle. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Responder INC-ZONE log files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03c | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03c RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat | | | | |
| 3 | Drive the oncoming vehicle into the incident zone above the advised speed, headed directly toward the responder vehicle in the incident zone. The speed and trajectory of the oncoming vehicle, if unchanged, will result in the oncoming vehicle colliding with the responder vehicle. | Based on the TIM and EVA messages received from the responder vehicle's broadcast and the oncoming vehicle's telematics, the oncoming vehicle's MCD detects the potential for a collision and displays corrective advice to the driver on the vehicle's MCD to prevent the collision. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Responder INC-ZONE log files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |

| **Test Case Number** | TC 3-03c | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03c RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat | | | | |
| 3a | | The oncoming vehicle begins to broadcast a threat alert message, indicating that a collision between the oncoming vehicle and specified responder vehicle is predicted. | Inspect Arada Oncoming INC-ZONE Log Files<br>Inspect Arada Responder INC-ZONE Log Files | Pass | See Responder Vehicle INC-ZONE User Interface Message Examples for examples of INC-ZONE Responder Laptop Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 3b | | Based on the oncoming vehicle's threat alert messages, the responder vehicle's MCD displays a collision warning on the responder vehicle's MCD UI and emits a shrill alarm tone on the responder's PASS. | Observation of Responder Vehicle Messages & Alarms<br>Inspect Arada Responder INC-ZONE Log Files | Pass | Observed Audible Messages from Responders PASS |

| **Test Case Number** | TC 3-03c | | | | |
|---|---|---|---|---|---|
| **Test Case Name** | TC 3-03c RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat | | | | |
| 4 | Reduce the speed of the oncoming vehicle and maneuvers so as to avoid a collision with the responder vehicle. | Based on the TIM and EVA messages received from the responder vehicle's broadcast, as well as the oncoming vehicle's own telematics, the oncoming vehicle's MCD determines that the oncoming vehicle is no longer a collision threat to the responder vehicle, and removes the corrective advice to the driver on the oncoming vehicle's MCD UI. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Oncoming INC-ZONE Log Files | Pass | See Oncoming Vehicle INC-ZONE User Interface Message Examples for Examples of Oncoming Vehicle Driver Messages. See Appendix A for example Message Logs from Prototype Acceptance Test Demonstration. |
| 4a | | The threat alert message broadcast by the oncoming vehicle ceases. | Inspect Arada Oncoming INC-ZONE Log Files<br>Inspect Arada Responder INC-ZONE Log Files | Pass | |
| 4b | | Based on the cessation of the oncoming vehicle's BSM panic messages, the responder vehicle's MCD determines that the oncoming vehicle is no longer a collision threat to the responder vehicle, the collision warning on the responder vehicle's MCD's UI is removed, and the shrill alarm tone on the responder's PASS ceases. | Observation of Responder Vehicle Messages & Alarms<br>Inspect Arada Responder INC-ZONE Log Files | Pass | |

| | | | | | |
|---|---|---|---|---|---|
| **Test Case Number** | TC 3-03c | | | | |
| **Test Case Name** | TC 3-03c RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat | | | | |
| 5 | Exit the oncoming vehicle from the incident zone observing speed and lane advice. | No additional warnings or alarms are presented to the oncoming driver. | Observation of Oncoming Vehicle Driver Messages<br>Inspect Arada Oncoming INC-ZONE Log Files | Pass | |
| 5a | | No additional warnings or alarms are presented to the responder. | Observation of Responder Vehicle Messages<br>Inspect Arada Responder INC-ZONE Log Files | Pass | |
| 6 | The incident commander in the responder vehicle uses the CapWin client to close out the incident scene. | The responder vehicle ceases to broadcast the TIM messages. | Inspect Arada Responder INC-ZONE log files<br>Inspect the INC-ZONE DSRC Situational Display | Pass | |
| **Test Results and Remarks** | RESP-STG and INC-ZONE Single Responder Traffic Stop on Two-lane Highway with Collision Threat | | | | |
| **Pass/Fail** | Pass | | | | |

# APPENDIX B. Acronyms and Abbreviations

| | |
|---|---|
| **ACM** | A la Carte Message |
| **ADD** | Architecture Description Document |
| **API** | Application Programming Interface |
| **ASN** | Abstract Syntax Notation |
| **BSM** | Basic Safety Message |
| **CAN** | Controller Area Network |
| **CBL** | CapWIN Business Logic |
| **CFI** | CapWIN Feed Interface |
| **CHART** | Coordinated Highways Action Response Team |
| **DGPS** | Differential Global Positioning System |
| **DHS** | Department of Homeland Security |
| **DMA** | Dynamic Mobility Applications |
| **DOJ** | Department of Justice |
| **DSRC** | Dedicated Short Range Communications |
| **DVI** | Driver Vehicle Interface |
| **EGNOS** | European Geostationary Navigation Overlay Service |
| **EMS** | Emergency Medical Services |
| **ERU** | Emergency Response Unit |
| **EVA** | Emergency Vehicle Alert |
| **FITIM** | Freeway Incident Traffic Management |
| **GAGAN** | GPS-Aided Geo-Augmented Navigation |
| **GGA** | Global Positioning System Fix Data |
| **GNSS** | Global Navigation Satellite System |
| **GPS** | Global Positioning System |
| **HAZMAT** | Hazardous Materials |
| **HTTPS** | Hypertext Transfer Protocol Secure |
| **I2V** | Infrastructure-to-vehicle |
| **INC-ZONE** | Incident Zone |
| **INFLO** | Intelligent Network Flow Optimization |
| **ITIS** | International Traveler Information Systems |

| | |
|---|---|
| **ITS** | Intelligent Transportation Systems |
| **MAP** | Map Data Message |
| **MDB** | Message Driven Beans |
| **MDT** | Mobile Data Terminal |
| **MEMA** | Maryland Emergency Management Agency |
| **MSAS** | Multi-functional Satellite Augmentation System |
| **MUTCD** | Manual of Uniform Traffic Control Devices |
| **NHTSA** | National Highway Traffic Safety Administration |
| **NIEM** | National Information Exchange Model |
| **NMEA** | National Marine Electronics Association |
| **Ntrip** | Networked Transport of RTCM via Internet Protocol |
| **OBD** | On-board Diagnostics |
| **OBE** | On-Board Equipment |
| **OSADP** | Open Source Application Development Portal |
| **PASS** | Personal Alerting Safety Subsystem |
| **PID** | Parameter IDs |
| **PPP** | Precise Point Positioning |
| **RDE** | Research Data Exchange |
| **R.E.S.C.U.M.E.** | Response, Emergency Staging, Communications, Uniform Management, and Evacuation |
| **RESP-STG** | Response Staging |
| **REST** | Representational State Transfer |
| **RITIS** | Regional Integrated Transportation Information System |
| **RSA** | Road Side Alert |
| **RSE** | Roadside Equipment |
| **RTCM** | Radio Technical Commission for Maritime Services |
| **SAE** | SAE International |
| **SDD** | System Design Document |
| **SDK** | Software Development Kit |
| **TIM** | Traveler Information Message |
| **TSAG** | Transportation Safety Advancement Group |
| **TTC** | Temporary Traffic Control |

| | |
|---|---|
| **UMD CATT** | University of Maryland – Center for Advanced Transportation Technology |
| **U.S. DOT** | United States Department of Transportation |
| **V2I** | Vehicle-to-infrastructure |
| **V2V** | Vehicle-to-vehicle |
| **VITAL™** | Vehicle Initiated Telematics and Logging |
| **WAAS** | Wide Area Augmentation System |
| **WAVE** | Wireless Access in Vehicular Environments |
| **XML** | eXtensible Mark-Up Language |
| **XMPP** | eXtensible Messaging and Presence Protocol |

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