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

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

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**15. Supplementary Notes**

**16. Abstract**

This document provides the high-level system architecture for the Prototype Development and Demonstration of a R.E.S.C.U.M.E. system. The requirements addressed in this document are based upon those that can be found in previous R.E.S.C.U.M.E. reports, particularly the R.E.S.C.U.M.E. Concept of Operations ( Final Report — November 19, 2012; FHWA-JPO-13-063) and The Report on Functional and Performance Requirements, and High-Level Data and Communication Needs (Final Report — February 7, 2013; FHWA-JPO-13-064) both prepared previously by Battelle. As such, this document implies the use of the system requirements and associated definitions from these prior documents as the basis for the tailored requirements associated with this next phase of the R.E.S.C.U.M.E. project as contained herein. This document defines the system architecture for implementing the prototype development and demonstration.

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# Table of Contents

## List of Figures



## List of Tables

# 1.0 Document Overview

This document presents the system architecture of the R.E.S.C.U.M.E. Prototype Demonstration, emphasizing the portions of the architecture that require significant hardware and/or software development. The role and interactions with existing commercial-off-the-shelf (COTS) and government-off-the-shelf (GOTS) components used within the Prototype Demonstration are described. However, although the associated COTS/GOTS components are key to the functioning of the overall system, their architecture is not within the scope of this document, thus is not described.

This document builds on the previously submitted software requirements for the R.E.S.C.U.M.E. Prototype Demonstration[1]. It outlines the architecture that implements the functions included for the INC-ZONE and RESP-STG applications, as well as the interfaces among the Oncoming Vehicles, Responder Vehicles, and the various cloud services, especially the Information Broker services. The document is organized as follows:

Section 2.0: R.E.S.C.U.M.E. Prototype Architecture reviews the INC-ZONE and RESP-STG applications in the R.E.S.C.U.M.E. Prototype bundle, defines the relationships among the various components that make up the Prototype architecture, and introduces each of these functional components. This section also describes a number of design considerations concerning the implementation of the Prototype bundle.

Section 3.0: INC-ZONE Application Software Architecture identifies the software subsystems residing in the emergency responder vehicles and the oncoming vehicles needed to orchestrate the detection and communication of threats to on-scene responders required for the INC-ZONE application.

Section 4.0: RESP-STG Application Software Architecture focuses on modifications to the existing GOTS application (CapWIN) in support of the RESP-STG application.

Section 5.0: A crosswalk of architecture components and system requirements is provided.

[1] Prototype Development and Demonstration for Response, Emergency Staging, Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.): Draft Functional and Performance Requirements, submitted by Battelle to US DOT, October 25, 2013.

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

This section contains the description of the proposed applications within the R.E.S.C.U.M.E. bundle as originally documented in the Concept of Operations (CONOPS)[2] and as adapted to reflect the specific prototype applications that will be demonstrated as part the R.E.S.C.U.M.E Prototype Demonstration. This information is included to facilitate understanding and provide a perspective of the requirements addressed without requiring the reader to refer back to other documents. However, the reader should understand that a much more thorough and detailed description of the R.E.S.C.U.M.E. bundle and applications is provided in referenced documents.

## 2.1 Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)

The Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (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 will be provided through mobile devices and other types of communication to help support emergency responder vehicle routing, staging, and secondary dispatch decision-making.

## 2.2 Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)

Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE) is a communication approach that improves protection of incident sites where there have been crashes, accidents, or other events impacting traffic such as stalled vehicles or vehicles pulled over for moving violations. Although there are similarities such as the possible need for lane closures, construction work zones and accident incident 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, HAZMAT Response Unit, Towing and Recovery assets, and roadway/infrastructure repair workers. The INC-ZONE application features an in-vehicle messaging

[2] Prototype Development and Demonstration for Response, Emergency Staging, Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.): Concept of Operations, submitted by Battelle to US DOT, November 19, 2012.

system that provides oncoming drivers with merging and speed guidance around an incident. The INC-ZONE application also provides in-vehicle incident scene alerts to drivers, both for the protection of the drivers as well as 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.

Figure 2-1 illustrates the five subsystems of the R.E.S.C.U.M.E. Prototype Demonstration architecture that implement the RESP-STG and INC-ZONE applications. Physical hardware modules are represented by gray rectangles in the diagram, while software components are represented by gray rectangles with the upper left corner removed. Major subsystems are color coded rectangles, in order to facilitate the identification of corresponding system elements in diagrams presented in later sections.

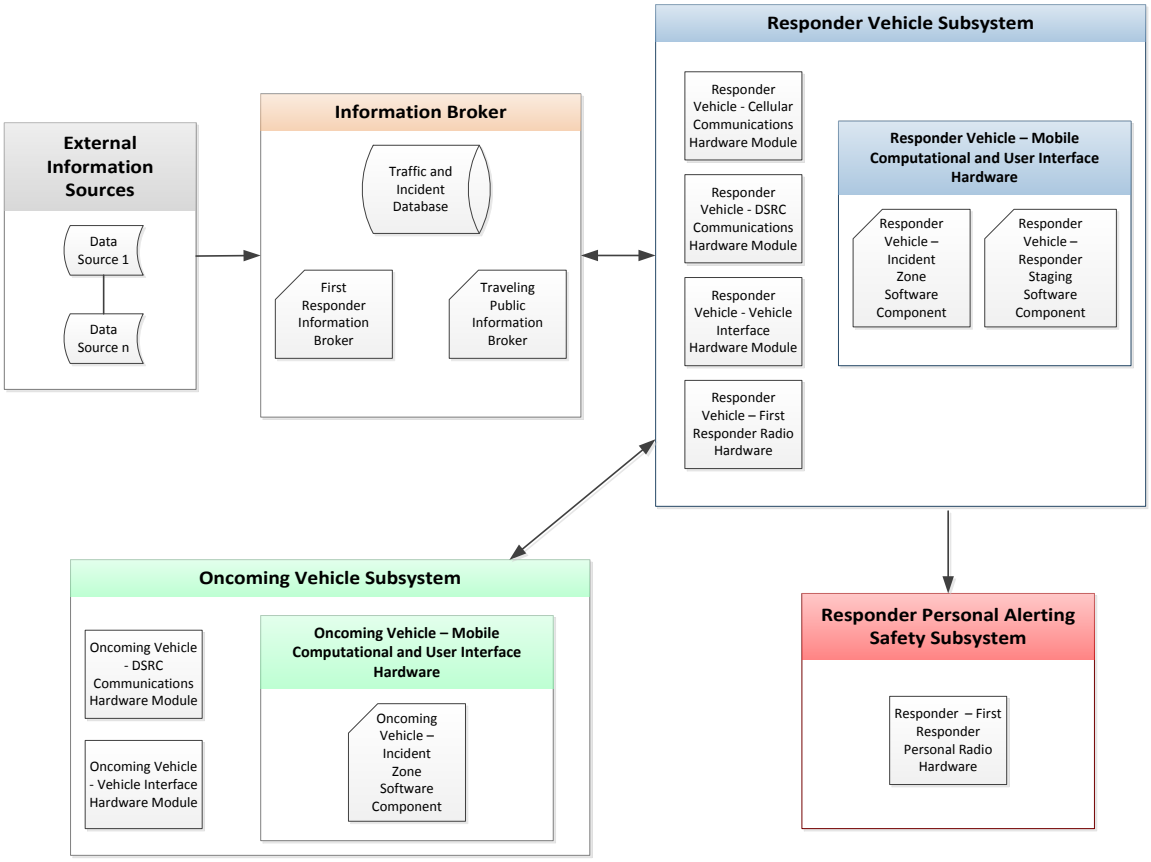


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**Figure 2-1. R.E.S.C.U.M.E. Prototype Architecture**

The function of each of the R.E.S.C.U.M.E. Prototype Demonstration architectural elements is described briefly below.

## 2.3 External Information Sources

This system element represents a host of existing information sources capable of providing useful information to the Information Broker (see Section 2.4), including such entities as Traffic Management Centers, the Traveling Public, and other Dynamic Mobility Application (DMA) bundles. Data provided by these sources serve to support a number of functions, including emergency responder vehicle routing and staging, as well as secondary dispatch decision-making. These data include satellite imagery; GIS map graphics, camera images, current weather data, traffic conditions, and sensor readings. This information flows from these sources to the Information Broker through a number of mechanisms, but primarily through secure Internet protocols.

The data sources included in this component are existing entities currently in wide service, which feed data to the Information Broker through a number of existing data paths. No change to these data feeds is anticipated for the Prototype Demonstration, thus no further description of the details of these data feeds is provided in this document.

## 2.4 Information Broker

The Information Broker is the system component that serves as the primary source for holding and distributing incident-related information and disseminating those data to the RESP-STG and INC-ZONE DMA applications. The primary role of the Information Broker is to serve as an information processor and router.

As with the External Information Sources described in the previous section, the components of the Information Broker are all existing entities currently in wide use. No changes to the structure or interactions among the subsystems within the Information Broker are anticipated for the Prototype demonstration, thus only a broad description of these components is provided below.

The Information Broker incorporates the functionalities currently provided by entities such as Emergency Communications Centers (ECCs, part of which is a public safety answering point, or PSAP), Traffic Management Centers (TMCs), and State Level Emergency Operation Centers (EOCs). This includes processing the received information and determining the entities that need to be informed, as well as providing other decisions on routing of information and data based upon the breadth of the information available throughout the incident. The Information Broker is responsible for both providing information and facilitating the routing and transfer of information among both internal and external entities. A key aspect of the Information Broker is to rapidly sift through the multitudes of input data; interpret, de-conflict, and correlate the data; and through implementation of algorithms and procedures make decisions on the relevance of data to a particular incident and application and then communicate this information to the appropriate entity. Figure 2-2 summarizes the flow of information and the functional architecture of the Information Broker.

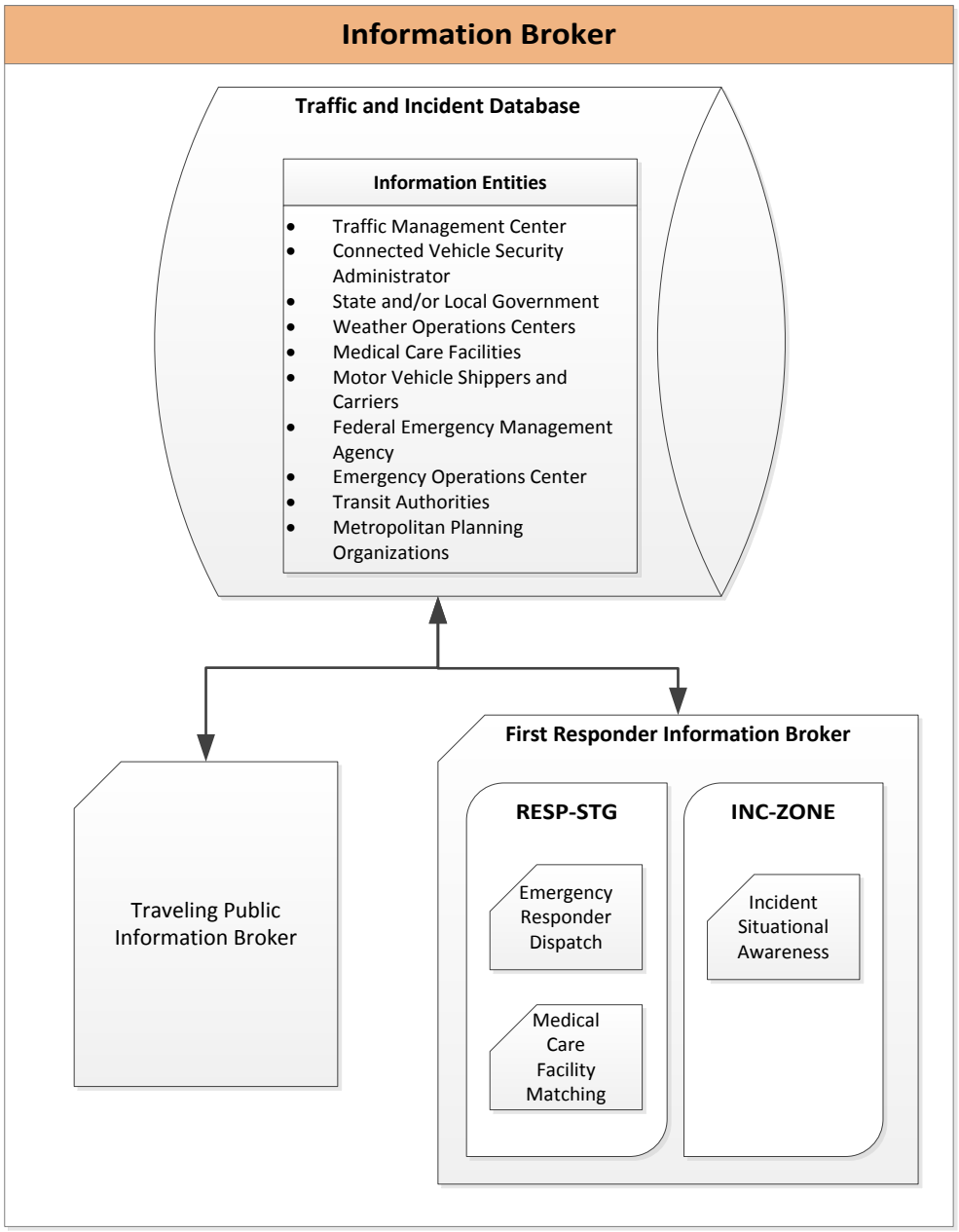


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**Figure 2-2. The Information Broker**

As illustrated in Figure 2-2, the Information Broker consists of three sub-system elements.

The functional elements of the processing are described below for each of the R.E.S.C.U.M.E. Bundle Applications.

### 2.4.1 Traffic and Incident Database

The Traffic and Incident Database serves as the central repository for data on incidents, traffic, and other transportation-related information for the demonstration area. Information from the R.E.S.C.U.M.E. Bundle Applications, as well as information from other organizational entities, is stored in this repository. Once the information is received, it is processed and distributed to both the First Responder Information Broker and the Traveler Public Information Broker.

Inputs to the Traffic and Incident Database come from a variety of external sources, as well as the First Responder Information Broker. Data are disseminated to the Traveling Public Information Broker, providing public awareness of incidents. Data shared with the First Responder Information Broker act to improve situational awareness of ongoing incidents for the Incident Commander.

### 2.4.2 First Responder Information Broker

The First Responder Information Broker is the interface between the Traffic and Incident Database and the Responder Staging Software Component in the Responder Vehicle (described below). This element is responsible for pulling relevant information from the database and delivering it to the responder in a timely and cogent manner, as well as gathering current incident status from the Responder Staging Software Component, storing it in the Traffic and Incident Database, and sharing the incident status with other responders on-scene.

### 2.4.3 Traveling Public Information Broker

The Traveling Public Information Broker is a web-enabled service accessible from the public Internet that provides advance notification to travelers regarding traffic incidents. Data for this public-facing portal are extracted from the Traffic and Incident Database. It provides the traveler with a variety of data services, including weather and road conditions, in addition to incident reports and associated road closure advisories.

## 2.5 Responder Vehicle Subsystem

The Responder Vehicle Subsystem consists of five distinct hardware elements:

1. Cellular Communications Hardware Module – enables communication over the Internet to web-enabled Information Broker resources.
2. DSRC Communications Hardware Module – enables communication with both oncoming connected vehicles and other responder vehicles on-scene.
3. Vehicle Interface Hardware Module – equipment enabling the DMA applications to interact with the emergency vehicle itself, for the purpose of issuing warnings (e.g., by activating the vehicle lights and/or horn).
4. First Responder Radio Hardware Module – communicates with the responder's Personal Alerting Safety Subsystem worn by the responder enabling threat alarms to be instantly communicated to a responder.
5. Mobile Computational and User Interface Module – the emergency responder's primary means of interacting with the INC-ZONE and RESP-STG applications, also containing several key processing components for those applications.

Each of these elements is described below.

### 2.5.1 Responder Vehicle – Cellular Communications Hardware Module

The Cellular Communications Hardware enables the DMA application software components to communicate wirelessly with the resources in the Information Broker, over public cellular networks.

### 2.5.2 Responder Vehicle – DSRC Communications Hardware Module

The Dedicated Short Range Communications (DSRC) Communications Hardware Module is a standardized radio for connected vehicles. It allows similarly equipped vehicles to interact with each other over relatively short distances (line of sight, approximately 300 meters) using either broadcast or subscription-based communication mechanisms, with latency times suitable for DMA applications.

This sub-system element uses a Connected Vehicle DSRC 5.9 GHz radio that can broadcast and receive connected vehicle messages under the J2735:2009 message set. It is the intention of this effort, and mandated by contract, to use existing message definitions within the J2735:2009 standard. Deviations and additions to the standard will be considered during detailed design, as the demands of the application require. Communication between the Mobile Computational and User Interface Hardware and the DSRC Communications Hardware Module is accomplished using a wireless protocol.

### 2.5.3 Responder Vehicle – Vehicle Interface Hardware Module

The Vehicle Interface Hardware Module utilizes the vehicle's OBD-II port to trigger vehicle-based alerts (e.g., flashing lights and horn). Vehicle telematics can be stored within the device's onboard memory, or provided wirelessly to support analysis and processing on the vehicle's Mobile Computational and User Interface Hardware.

### 2.5.4 Responder Vehicle – First Responder Radio Hardware

This Responder Vehicle component is responsible for communicating with the Responder Personal Alerting Safety Subsystem. Activation and messaging of this component are initiated from the Incident Zone Software Component residing on the Responder Vehicle's Mobile Computational and User Interface Hardware.

### 2.5.5 Responder Vehicle – Mobile Computational and User Interface Hardware

The Mobile Computational and User Interface Hardware is a processing unit in the responder vehicle that performs all local processing required of the dynamic mobility applications, and also serves as the primary user interface allowing a responder to interact with the RESP-STG and INC-ZONE applications.

#### *2.5.5.1 Responder Vehicle – Responder Staging Software Component*

This component is a software application residing on the Mobile Computational and User Interface Hardware that performs the software functions and user interface functions for the RESP-STG application. This software also is responsible for disseminating lane guidance (e.g., lane closures), either entered by a responder or relayed to the application from the First Responder Information Broker, to the Incident Zone Software Component (see below). A more detailed discussion of this architecture component is provided in Section 4.0.

#### *2.5.5.2 Responder Vehicle – Incident Zone Software Component*

This element is an embedded application on the Mobile Computational and User Interface Hardware, co-resident with the Responder Staging Software Component. It contains the software components required to compose and broadcast messages that define the incident zone to oncoming vehicles, receive imminent threat messages from the oncoming vehicles, and issue corresponding threat alerts to the involved emergency vehicles and responder radios, via the On-coming Vehicle Subsystem and Responder Personal Alerting Safety Subsystem, respectively. A more detailed discussion of this architecture component is provided in Section 3.0.

## 2.6 Oncoming Vehicle Subsystem

This subsystem is consistent with US DOT's Aftermarket Safety Device (ASD) in that it obtains telematics information from the vehicle, sends and receives DSRC messages, and provides calculations and alerts to the driver. However, for the R.E.S.C.U.M.E. Prototype Demonstration, this subsystem consists of additional elements beyond the ASD. Components of the Oncoming Vehicle Subsystem include:

1. DSRC Communications Hardware Module – enables communication with other connected vehicles, in particular, responder vehicles on-scene.
2. Vehicle Interface Hardware Module – equipment enabling the DMA applications to interact with the vehicle, for the purpose of reading various vehicle telematics.
3. Mobile Computational and User Interface Module – the traveler's sole means of interacting with the INC-ZONE application, also containing key processing components for that application.

Each of these elements is described below.

### 2.6.1 Oncoming Vehicle – DSRC Communications Hardware Module

The DSRC Communications Hardware Module is a standardized radio for connected vehicles, essentially the same component found on the responder vehicle (described in Section 2.5.2).

Similar to the DSRC Module in the responder vehicle, it is the intention of this effort to use existing message definitions within the J2735:2009 standard, unless design constraints force a deviation.

### 2.6.2 Oncoming Vehicle – Vehicle Interface Hardware Module

This is essentially the same component found on the emergency vehicle (described in Section 2.5.3); however in this case, vehicle data such as steering wheel position, vehicle speed, and braking status, are captured from the vehicle's sensor platform to provide additional information with the potential to enhance predicted path calculations and driver intent in relation to the lane guidance and incident zone descriptions provided to it.

### 2.6.3 Oncoming Vehicle – Mobile Computational and User Interface Hardware

This component is the computing element for the INC-ZONE application residing in the oncoming vehicle. It also is the physical user interface device between the driver and the INC-ZONE application.

Software residing on this component is responsible for recognizing threats to responders in the incident zone, based on the incident zone descriptions, and managing the broadcast of those messages through the DSRC radio.

#### *2.6.3.1 Oncoming Vehicle – Incident Zone Software Component*

The software residing on the Oncoming Vehicle's Mobile Computational and User Interface Hardware is the key component for calculating warnings and threats to first responders in the incident zone. The architecture of this software component is described in Section 3.0.

## 2.7 Responder Personal Alerting Safety Subsystem

This component essentially consists of the responder's normal operational radio system for the R.E.S.C.U.M.E. Prototype Demonstration.

## 2.8 Major Subsystem Message Sets

The communication paths and general content of the data exchanged between the five major components of the R.E.S.C.U.M.E. Prototype Demonstration are shown in Figure 2-3.

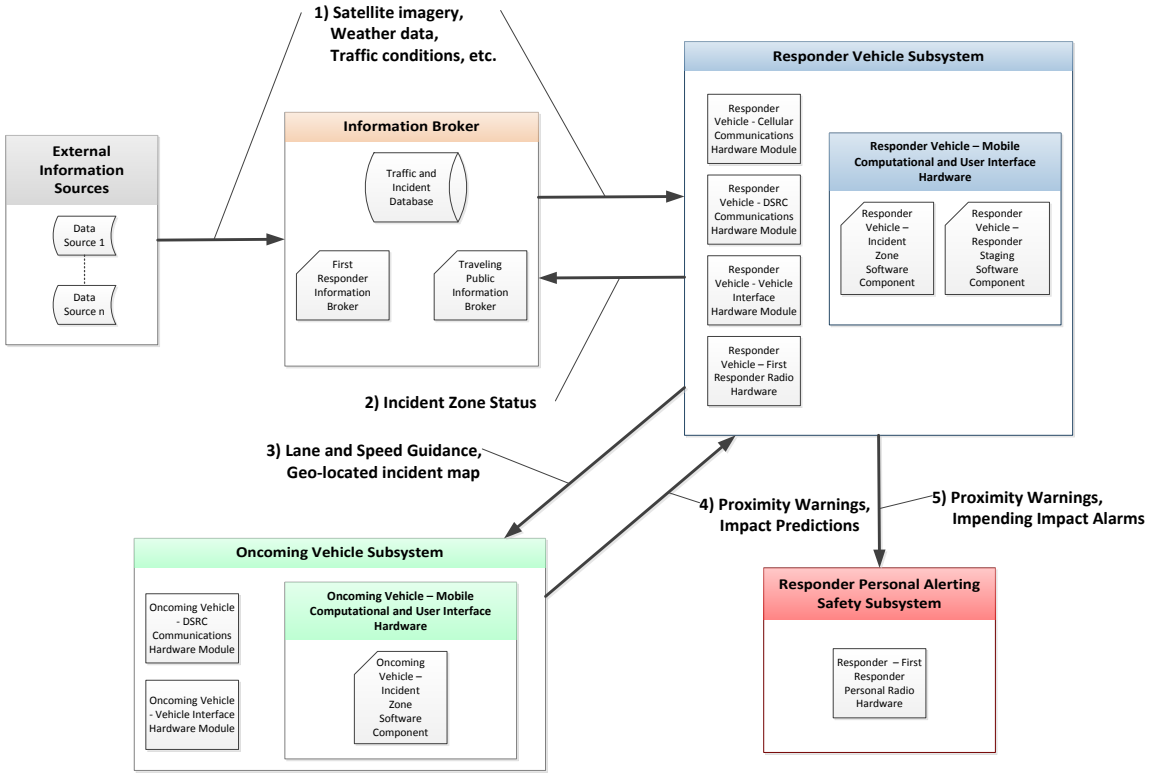


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**Figure 2-3. R.E.S.C.U.M.E. Prototype Data Exchanges**

## 2.8.1 Satellite Imagery, Weather Data, Traffic Conditions

Data provided by the various external sources fed into the Information Broker help support emergency responder vehicle routing, staging, as well as secondary dispatch decision-making. These data include satellite imagery, GIS map graphics, camera images, current weather data, traffic conditions, and sensor readings. Data from these external systems arrive at the Information Broker over a variety of protocols and timeframes, are processed and filtered to suit the incident, and are passed on to the responder vehicle to better inform the responder's situational awareness of the incident.

## 2.8.2 Incident Zone Status

Incident zone status, such as emergency vehicles en-route and on-scene, number of vehicles involved, injuries reported, lane closures, etc., is coordinated across on-scene emergency vehicles via communications between the Responder Staging Software Component located on the Responder Vehicle, and the Information Broker, located in a web-service on the Internet. The transport mechanism for this data is the cellular connection between the Responder Vehicle and the Internet-based Information Broker. In addition, individual responder vehicles automatically share their on-scene geo-location data with each other via DSRC. Lane guidance and a detailed, geo-located incident map are processed into a single, consistent description of the incident zone.

### 2.8.3 Lane and Speed Guidance, Geo-located Incident Map

Lane guidance and a geo-located incident map are broadcast to oncoming vehicles over the DSRC radio. The guidance and map determine the operating parameters that an oncoming vehicle should abide by for safe passage through the incident zone. Each oncoming vehicle subsequently processes the incident zone data, calculates the vehicle's predicted path, and determines whether its trajectory, combined with the parameters of the lane guidance and incident map, implies any threat to the on-scene responders.

These DSRC messages will conform to the J2735:2009 standard to the extent possible.

### 2.8.4 Proximity Warnings, Impact Predictions

Proximity warnings and impact predictions based on the oncoming vehicle's predicted path are broadcast via DSRC back to the responder vehicles.

As with other communications between the oncoming connected vehicle and the responder vehicle over DSRC, these messages are expected to conform to the J2735:2009 standard, to the extent possible.

### 2.8.5 Proximity Warnings, Impending Impact Alarms

Proximity warnings and impending impact alarms are subsequently relayed by the responder vehicles as appropriate to the first responder's personal alerting safety subsystem, providing responders with real-time alerts of oncoming vehicles that have trajectories or speeds that pose a high risk to their safety.

## 2.9 Design Considerations

A number of design details of the R.E.S.C.U.M.E. Prototype, although not strictly considered part of an architectural description, are readily apparent from previously submitted software requirements, CONOPS, and other documents and discussions, and are worthy of mention here. Although these items do not change the intent of any of the elements previously described, their specification here does provide a clearer, more concrete understanding of the architecture and its eventual operation.

Design details of major system elements of the system follow, where such details are apparent:

- ***Information Broker.***
    - ***Traffic and Incident Database.*** This functionality is provided by the Regional Integrated Transportation Information System (RITIS), which already provides a central repository for incidents, traffic, and other transportation related information for the demonstration area.
    - ***First Responder Information System.*** For the R.E.S.C.U.M.E. Prototype Demonstration, this sub-element consists of CapWIN's existing system.
    - ***Traveling Public Information System.*** For the R.E.S.C.U.M.E. Prototype Demonstration, this sub-system element will be the RITIS traveler information application.

- ***Responder Vehicle Subsystem.***
  - ***Cellular Communications Hardware Module.*** All CapWIN users have in-vehicle systems that have embedded cellular connectivity. For the R.E.S.C.U.M.E. Prototype Demonstration, this is accomplished through an aftermarket cellular card.
  - ***DSRC Communications Hardware Module.*** A Connected Vehicle DSRC 5.9 GHz radio that can broadcast and receive connected vehicle messages under the J2735:2009 message set will be used. Wireless communication to the Mobile Computational and User Interface Hardware is accomplished using Bluetooth protocols.
  - ***Vehicle Interface Hardware Module.*** This component in the Responder Vehicle is Battelle's VITAL OBD-II Module, enabling the DMA applications to interact with the responder vehicle for the purpose of providing warnings (e.g., by activating the vehicle lights and/or horn). Furthermore, communication between the Mobile Computational and User Interface Module and the Vehicle Interface is accomplished through Bluetooth protocols.
  - ***Responder Staging Software Component.*** This functionality is handled by CapWIN, an existing software package already in field use by a number of public safety agencies. This item drives a number of design decisions, including the choice the Responder Vehicle Mobile Computational and User Interface Hardware.
  - ***Responder Vehicle Mobile Computational and User Interface Hardware***. For the R.E.S.C.U.M.E. Prototype Demonstration, this platform will be a ruggedized Toughbook running Windows XP, SP1, as required by the CapWin application. This computer will have the CapWin system application installed, providing the mechanism for *Responder Staging Software Component*. A separate application, the Incident Zone Safety Module, operates in concert with, but independently from the CapWIN application, to perform *Threat Detection and Warning*. Communication between these two applications is performed through use of Dynamic Link Libraries.

- ***Oncoming Vehicle Subsystem.***
  - ***Vehicle Interface Hardware Module.*** The Oncoming Vehicle's Hardware Interface Module is Battelle's VITAL OBD-II Module, enabling the DMA applications to interact with the vehicle for the purpose of reading various vehicle telematics. Furthermore, communication between the Mobile Computational and User Interface Module and the Vehicle Interface is accomplished through Bluetooth protocols.
  - ***Mobile Computational and User Interface Hardware Module.*** For the R.E.S.C.U.M.E. Prototype Demonstration, this device is an Android-based smartphone. Communication between the smartphone and other hardware elements in the oncoming vehicle is handled through Bluetooth protocols.

- ***Responder Personal Alerting Safety Subsystem***
  - For the R.E.S.C.U.M.E. Prototype Demonstration, this component essentially consists of the responder's normal operational radio.

# 3.0 INC-ZONE Application Software Architecture

The key INC-ZONE functionality depends on the interaction of software components on two different mobile platforms: the Incident Zone Safety Software Component residing on the Responder Vehicle's ruggedized laptop, and the Oncoming Vehicle's Incident Zone Software Component, running on the Oncoming Vehicle's Mobile Computing and User Interface Hardware. This section describes the major features of these two software subsystems.

Careful management of limited resources, communication bandwidth, and computational processing is key to the ability of the system to accurately and efficiently detect and respond to threats. Two features of the R.E.S.C.U.M.E Prototype's INC-ZONE software architecture support this:

1. A single, consistent, description of the incident zone, using elements of the J2735 message set for representing GIS and other descriptive data, is broadcast from one emergency vehicle on-scene to oncoming vehicles. On-scene emergency vehicles each augment the incident zone description with their own location; however the single message broadcast from a single source reduces the amount of DSRC traffic to be processed by the oncoming vehicles, also reducing the workload required of the oncoming vehicles' threat detection process by eliminating the need to prioritize potentially conflicting messages that would otherwise come from multiple vehicles in the incident zone.
2. Threat assessment is calculated in both the oncoming and the responder vehicles. For the oncoming vehicle, the availability of vehicle telematics increases the accuracy of threat prediction, and makes the results of that prediction immediately available to the driver. Including the threat assessment in the responder vehicle allows for identifying threats from not only connected oncoming vehicles included in the prototype demonstration, but also addresses the possibility of extending the architecture to vehicle awareness device equipped vehicles. With the addition of radar equipment, even vehicles without DSRC could be included in the threat detection process.

The features of the software and system components that enable this functionality are described in the two following subsections, one describing the software components in the Responder Vehicle, and the other describing the software components found in the Oncoming Vehicle.

## 3.1 Responder Vehicle – Incident Zone Software Component

This module is an embedded Windows application on the Responder Vehicle's Mobile Computational and User Interface Hardware containing all of the software required to communicate with the Responder Staging Software Component, compose and broadcast the messages that define the incident zone to incoming vehicles, receive imminent alarm messages from the oncoming vehicles, and issue corresponding alerts to the involved emergency vehicles and responder radios, via the Vehicle Interface Hardware Module and the DSRC Communications Hardware Module, respectively.

The modules that achieve this functionality, as shown in Figure 3-1, are described below.

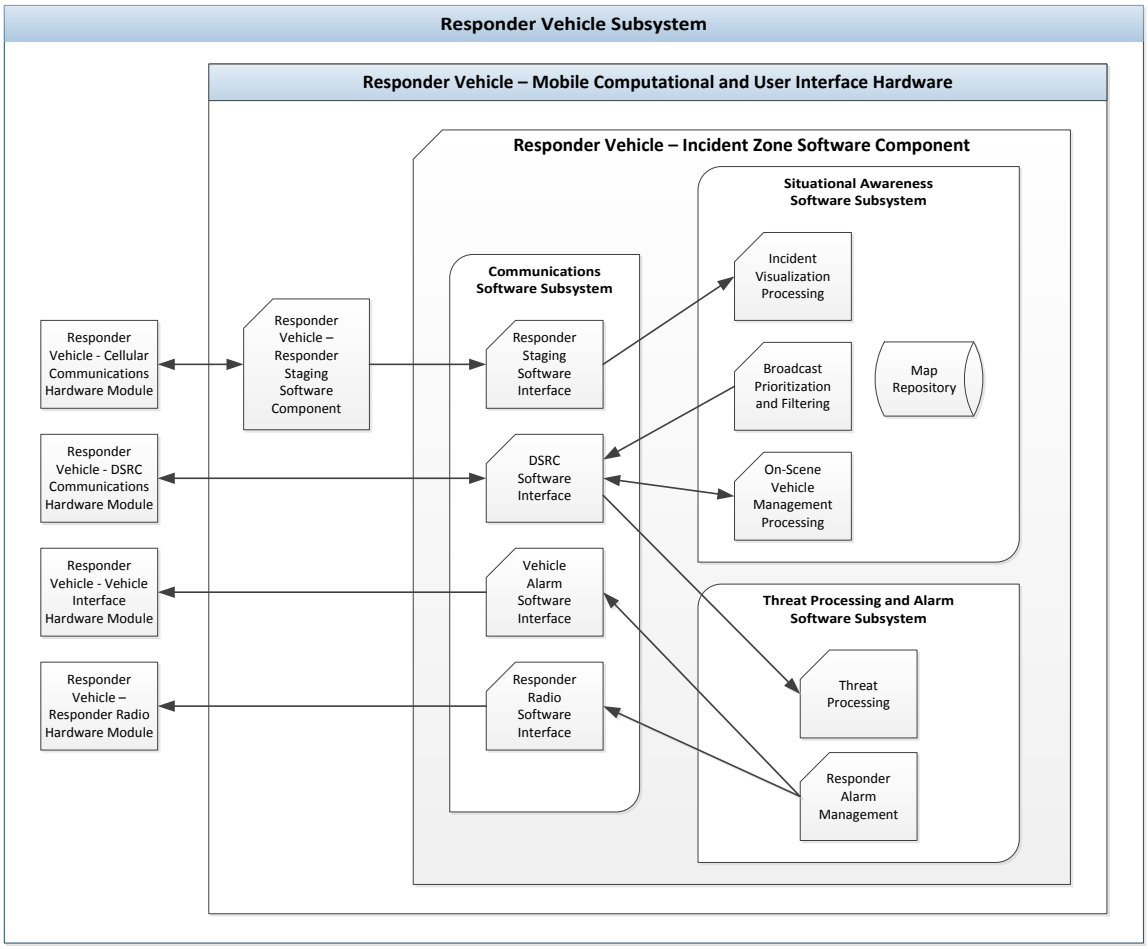


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**Figure 3-1. Incident Zone Safety Module**

## 3.1.1 Communication Software Subsystem

The modules contained in this package are the interfaces that control the various external devices that comprise the system. All other subsystems interact with the real world through the modules in this package. These modules are the system "drivers."

### *3.1.1.1 Responder Staging Software Interface*

This module extracts the list of on-scene emergency vehicles and lane advice from the Responder Staging Software Component.

### *3.1.1.2 DSRC Software Interface*

This component is responsible for interfacing to and controlling the DSRC radio. It converts the internal scene representation into valid elements of the J2735-2009 message set for transmission via the DSRC radio. Only a small set of messages are likely to be required by the INC-ZONE application, including:

- Basic Safety Message (BSM) and Basic Safety Message part II, for communicating location and trajectory of incoming vehicles
- Map Data (MAP) for lane definitions in the incident zone
- Emergency Vehicle Alerts (EMA) for indicating the presence of emergency vehicles and vehicle details
- Traveler Information Message (TIM) for informing the oncoming vehicle of various conditions and alerts about the incident zone

This list may change as the detailed design progresses.

#### *3.1.1.3 Vehicle Alarm Software Interface*

This component is responsible for interfacing to and activating the emergency vehicle's alarm (i.e., flashing the vehicle's lights and/or activating the horn).

#### *3.1.1.4 Responder Radio Software Interface*

This component activates a responder's personal alarm via messages sent over the Responder Personal Alerting Safety Subsystem.

### 3.1.2 Situational Awareness Software Subsystem

The Situational Awareness Software Subsystem is responsible for synthesizing and maintaining a consolidated description of the incident zone and managing the broadcast of that message to oncoming vehicles.

#### *3.1.2.1 On-Scene Vehicle Management Processing*

This component is responsible for creating and maintaining a list of all on-scene emergency vehicles and their current geo-locations. The location of an emergency vehicle is read from its DSRC Module and broadcast over DSRC when a responder notifies the incident commander through the Responder Staging Software Component that the emergency vehicle has arrived on-scene.

When only a single emergency vehicle is on-scene, that vehicle is solely responsible for broadcasting status to oncoming vehicles.

On-scene location messages are subsequently received from each emergency vehicle arriving on-scene and consolidated as they are received into a list of on-scene emergency vehicles. These data are a key component of maintaining a current situational awareness of the incident zone.

#### *3.1.2.2 Map Repository*

The map repository contains the detailed lane definitions known to the system, indexed by geographic location. A subset of these data are selected based on the locations of the on scene emergency vehicles, annotated with relevant information describing the current incident zone status, and broadcast to oncoming vehicles.

#### *3.1.2.3 Incident Visualization Processing*

This component generates the view of the incident zone based on the current location of all on-scene emergency vehicles and lane advice as described from the Responder Staging Software Component

and the Map Repository of GID map data. This integrated view is subsequently encoded into appropriate J2735 DSRC messages and broadcast to oncoming vehicles.

#### *3.1.2.4 Broadcast Prioritization and Filtering*

The communication of information about the incident zone to an oncoming vehicle is essential to the ability of the driver to respond appropriately to the situation. This component determines the on-scene emergency vehicle responsible for broadcasting both the incident zone map and lane and speed guidance messages to the oncoming traffic, based on considerations such as the geometry of the incident zone and the location of the emergency vehicles on scene within the incident zone, in order to provide the best possible conditions for communication between the responder and oncoming vehicles.

The list of on-scene emergency vehicles is prioritized using the emergency vehicle's location within the incident zone and a detailed map of the incident zone pulled from the map repository to determine the most appropriate candidate vehicle. The location of the vehicle in the incident zone in the most favorable line-of-sight position to broadcast to oncoming vehicles is a primary concern in selecting a broadcast master vehicle.

A backup to the broadcast master can also be selected using the same criteria as the master. The backup vehicle monitors the incident zone DSRC traffic to ensure the broadcast master is performing correctly, and takes corrective action if the broadcast master fails to perform. In the event the designated primary vehicle does not broadcast the necessary DSRC messages, the backup vehicle designates and activates a new broadcast vehicle as needed.

### 3.1.3 Threat Processing and Alarm Software Subsystem

The Threat Processing and Alarm Software Subsystem is responsible for handling DSRC traffic from oncoming vehicles indicating a threat condition has been detected by a vehicle. The subsystem consists of two components: one to record the incoming threat messages, and a second that prioritizes those messages and manages activation of the various means of alerting the on-scene responders.

#### *3.1.3.1 Threat Processing*

This element consists of a set of algorithms that run on the responder vehicle’s mobile computational and user interface device to assimilate the trajectory of the oncoming vehicles, GPS location, and other input to determine a risk score for vehicles in the incident zone. Information about those oncoming vehicles which are determined to be a threat is forwarded to the alarm management software module.

#### *3.1.3.2 Responder Alarm Management*

This component determines whether an oncoming vehicle's alarm should be forwarded to the emergency vehicle's alarm interface, the responder radio interface, or both.

## 3.2 Oncoming Vehicle Incident Zone Software Component

This software component contains the software residing on the oncoming vehicle's Mobile Computational and User Interface Hardware. This software is responsible for receiving and interpreting the incident zone descriptions broadcast by the Responder Vehicle Subsystem, as well as informing the driver of lane advice as the oncoming vehicle travels through the incident zone.

The software modules comprise the software in the Oncoming Vehicle Incident Zone Safety Module are shown in Figure 3-2, and are described following section.

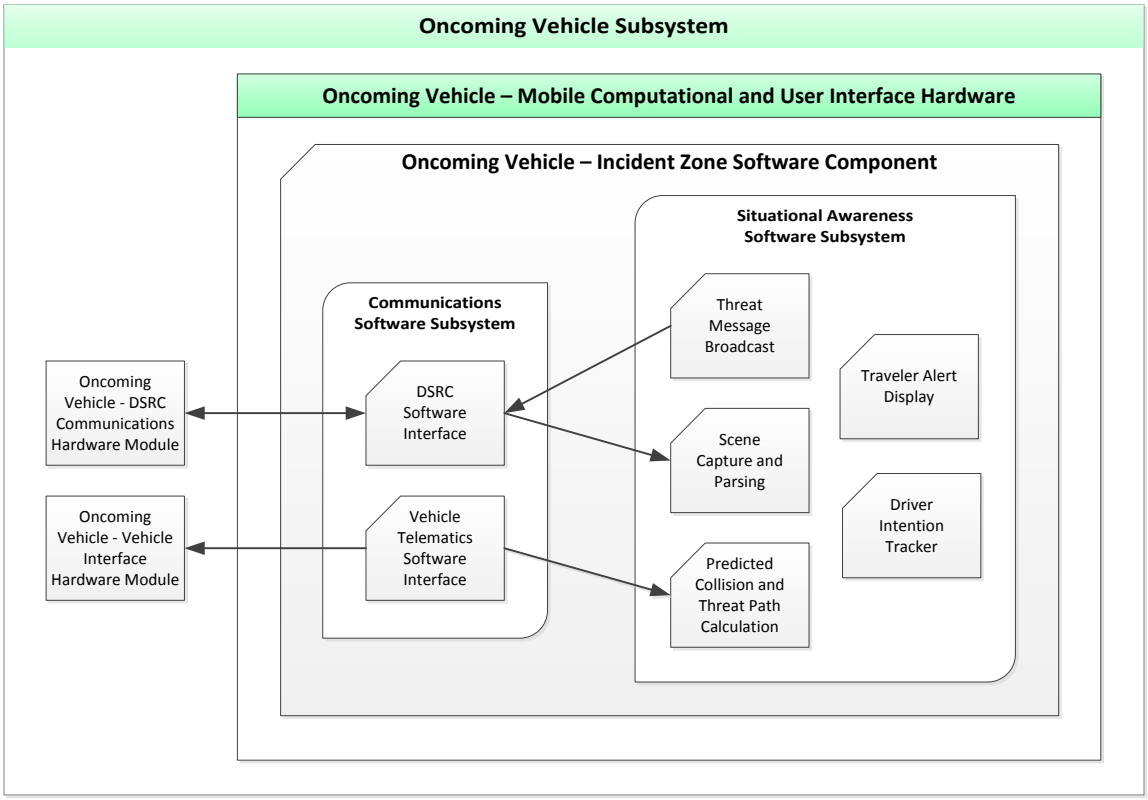


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**Figure 3-2. Oncoming Vehicle Subsystem**

## 3.2.1 Communications Software Subsystem

This Communications Software Subsystem is responsible for interfacing to and controlling the hardware modules in the oncoming vehicle, including both the DSRC radio and the vehicle's telematics hardware module.

#### *3.2.1.1 DSRC Software Interface*

This software component is responsible for interfacing to and controlling the DSRC radio within the oncoming vehicle.

#### *3.2.1.2 Vehicle Telematics Software Interface*

This module is responsible for communication with the Vehicle Interface Hardware Module.

## 3.2.2 Situational Awareness Software Subsystem

This module parses the incoming scene descriptions into internal representations for more effective, efficient threat determination.

#### *3.2.2.1 Threat Message Broadcast*

The software elements formats threat messages and subsequently broadcasts them via DSRC.

#### *3.2.2.2 Scene Capture and Parsing*

This software element parses the incoming scene descriptions broadcast from the responder vehicle and received by the Oncoming Vehicle's DSRC radio into internal representations for more effective, efficient threat determination.

#### *3.2.2.3 Predicted Collision and Threat Path Calculation*

As the heart of the INC-ZONE application, this element consists of a set of algorithms that run in the mobile computational and user interface module to assimilate the vehicle telematics, GPS location, and input from existing threat path algorithms with the DSRC to determine a risk score for the vehicle entering the incident zone.

#### *3.2.2.4 Traveler Alert Display*

This software module uses the smartphone screen and sound system to alert the driver of an incident and provide additional alerts if the vehicle is on a path to enter the incident zone.

#### *3.2.2.5 Driver Intention Tracker*

This software module monitors vehicle telematics over time to develop a model for the traveler's driving behavior and characteristics. This model of the driver's recent history is used to help better predict the driver's immediate driving intentions and is used as an additional input to improve the results of the Predicted Collision and Threat Path Calculation.

# 4.0 RESP-STG Application Software Architecture

As previously indicated (Section 2.9), the role of the Responder Staging Software Component residing on the Responder Vehicle's Mobile Computational and User Interface Hardware will be fulfilled by a modified version of the CapWIN application. The CapWIN application is a proprietary, Government Off-the-Shelf (GOTS) software package, and as such there is no attempt within this document to illustrate the internal architecture of the system.

The existing CapWIN application has been enhanced to provide the responder with additional functionality to support the RESP-STG application. In addition to an overview of the CapWin capabilities that follows, a mockup of the principle user interface screen illustrating the proposed enhancements is shown in Figure 4-5.

The Capital Wireless Information Net (CapWIN) is a program located in the University of Maryland's Center for Advanced Transportation Technology (CATT) that was created by, and continues to operate under the direction of a coalition of law enforcement, fire/EMS, and transportation agencies in Maryland, Virginia, and the District of Columbia to advance data communications across agency, jurisdiction, government, and discipline boundaries. The coalition directs CapWIN through a Board of Directors representing local, state, and federal agencies operating in all three jurisdictions, and drawn from law enforcement, fire/EMS, and transportation.

To advance its mission, CapWIN has implemented an operating system that delivers data to personnel in the field across disciplines and agency boundaries. It has created a set of software products and services that supports field operations of law enforcement, fire/EMS, and transportation agencies. The CapWIN Software Solution Suite is a set of GOTS standards-based solutions that gives users access to multiple data sources (e.g., law enforcement systems (CJIS) in the three states, Maryland driver's license photos, and regional transportation incident data). Two mobile client applications—one for laptops and one for handheld devices—support field access to law enforcement and other data sources, secure instant messaging, and incident coordination tools.

CapWIN's technical infrastructure was designed by a coalition of representatives from public safety and transportation agencies across Maryland, Virginia and the District of Columbia. Based on national data exchange standards, the CapWIN system uses standard web services components that can be easily adapted to evolving mobile communication technologies, and to the requirements for compatibility with legacy agency infrastructures.

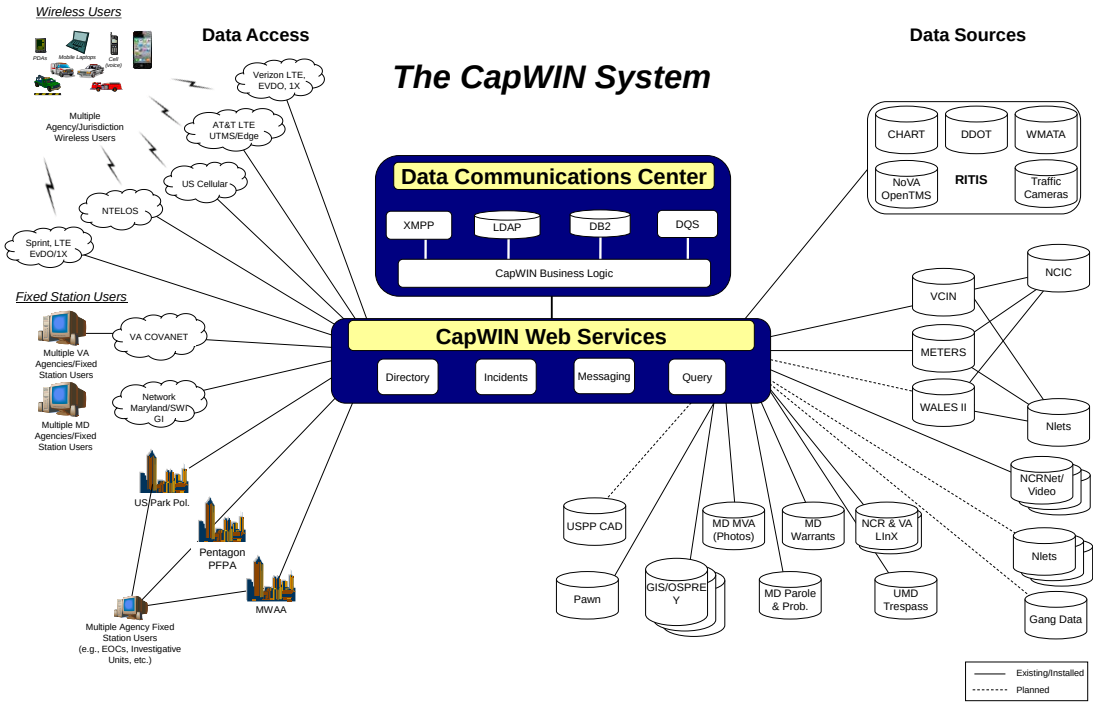


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**Figure 4-1. The CapWIN System**

Following are key elements of the CapWIN design.

- Web Services based client and infrastructure designed for wireless environments (low and high bandwidth);
- Java/J2EE components running on high performance AIX and Linux servers;
- Jabber XMPP messaging supporting “push” technology;
- Custom software developed by the University of Maryland accesses multiple law enforcement databases and establishes FIPS 140-2 secure connections to field users;
- Database services uses DB/2 servers along with standard lightweight directory access protocol (LDAP) software;
- Dedicated connections and VPN’s connect to participating agency’s networks and wireless service providers;
- Redundant configurations ensure operations during hardware, software or power failure.

CapWIN’s Mobile Clients are designed for maximum performance in wireless, field environments. By utilizing a web services-based interface, CapWIN Clients minimize bandwidth needs while maximizing field performance and capabilities. CapWIN Clients incorporate auto-updating capabilities, resulting in “zero touch” upgrades. CapWIN Clients enable:

- Local queuing of law enforcement queries – even in no-connectivity environments
- Persistent “store and forward” messaging – never miss an incident update or alert

- Local rendering of GIS maps supporting location-based services
- User-Customizable application and network linking

CapWIN's data infrastructure also supports agencies using different mobile clients. For example, several jurisdictions in Maryland use CapWIN Web Services to access and deliver driver's license photos to law enforcement officers in the field through their own mobile data client.

## 4.1 RESP-STG Enhancements to CapWIN

CapWIN already includes a sophisticated situational awareness tool called "CapWIN Global View + GIS," which provides first responders with a visual representation of the location of the incident geographically on an interactive display (Figure 4-2). This tool can be used to provide guidance to responders on alternative routes or detours for the public based upon a visual inspection of the map and identifying roadways/routes, as well as the location of other accidents. However, what this module currently does not do, which will be done as part of the RESP-STG application, is link this geospatial incident information to current traffic conditions, available capacity of alternative routes for vehicle throughput, and provide recommendations for diverting traffic should roadways need to be closed or become congested. A representative display of the CapWIN map window illustrating these anticipated features is show in Figure 4-3.


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**Figure 4-2. CapWIN Incident Map**

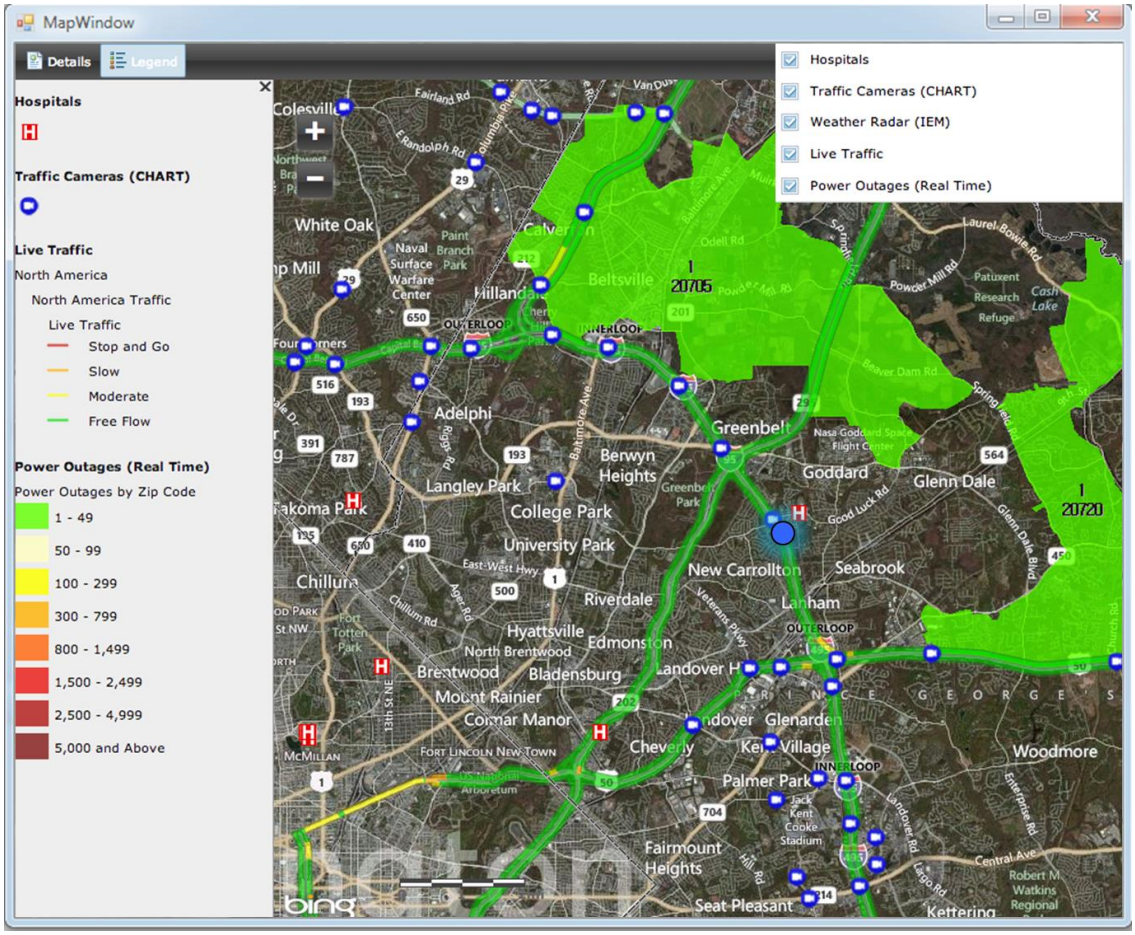


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**Figure 4-3. CapWIN Map Display: Information Layers**

The most significant change is the ability for the first responder to display graphically (and modify) the position of the responding vehicles on-scene. Figure 4-4 illustrates a representative high resolution map display indicating the locations of various responding vehicles in a hypothetical incident. Current

on-scene vehicle locations are automatically displayed to all responding vehicles with no operator intervention required.

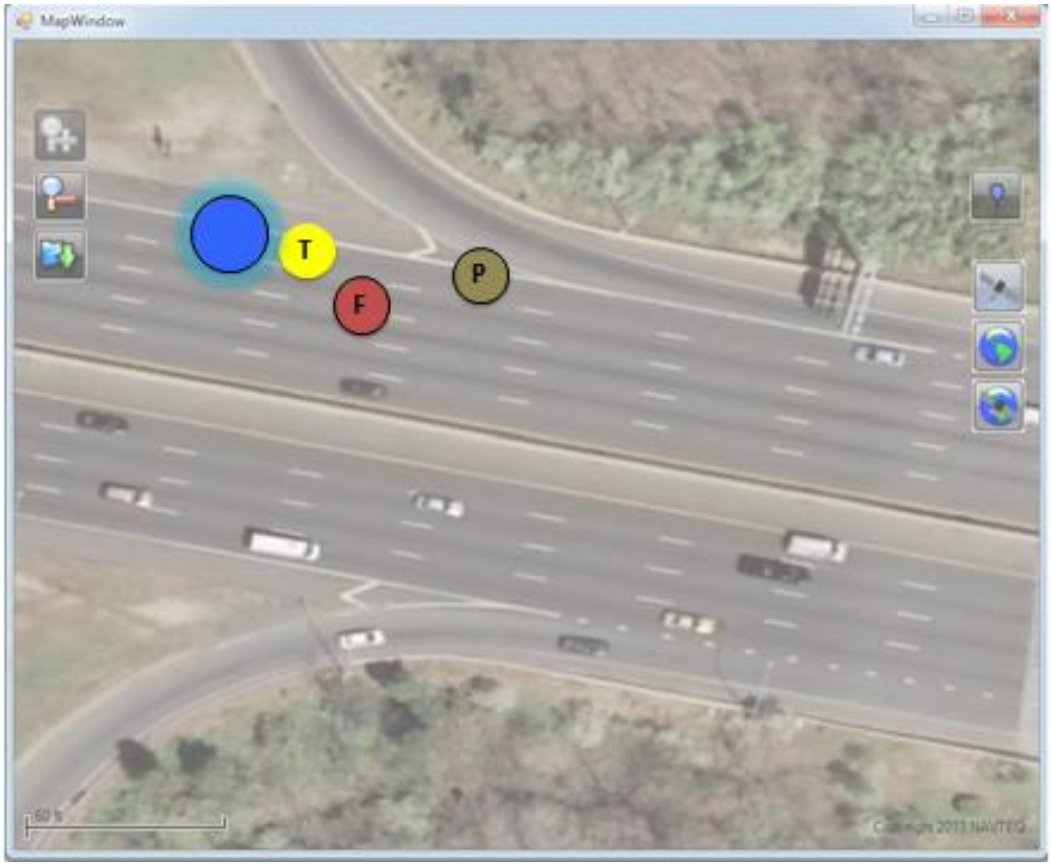


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**Figure 4-4. CapWIN Map Display: High Resolution Imagery and Vehicle Location**

Additional modifications to the CapWIN application enable data to be shared with modules external to CapWIN, including the Incident Zone Safety Module that co-resides on the ruggedized laptop. Of key

importance is the lane closure descriptions shown in Figure 4-5 that are used by the Incident Zone Safety Module to create J2735 compliant DSRC messages broadcast to oncoming vehicles.

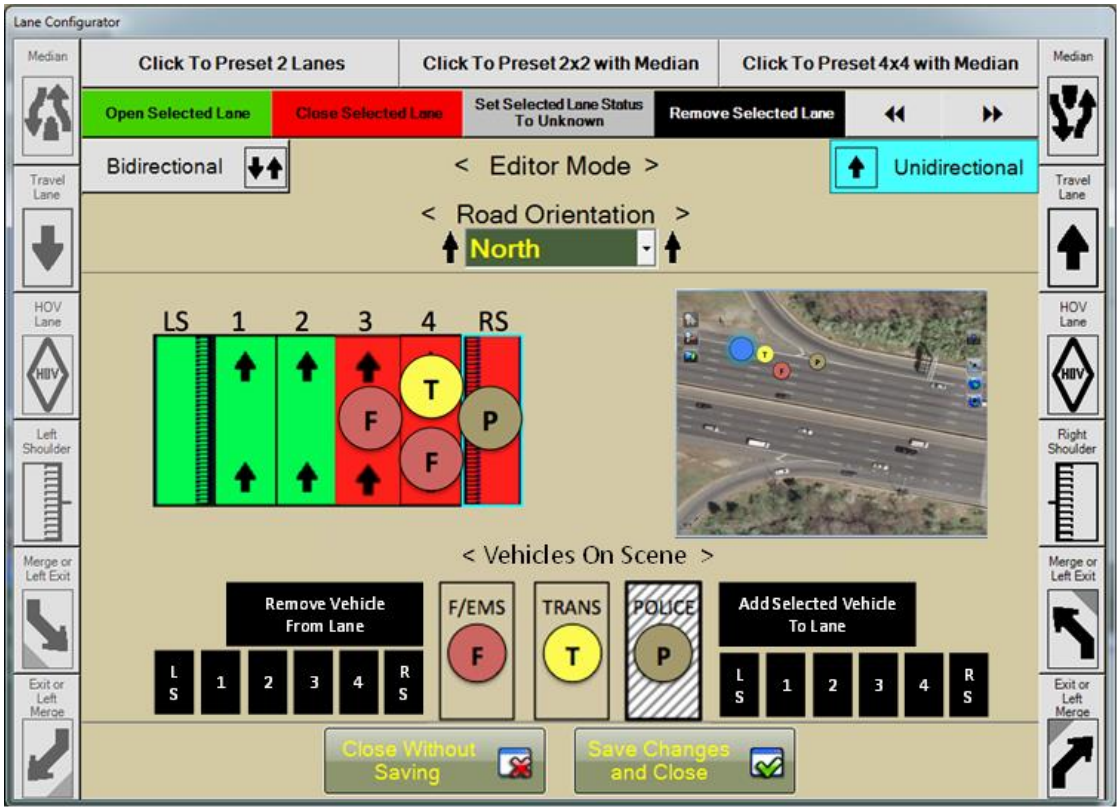


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**Figure 4-5. CapWIN Lane Configuration Screen**

# 5.0 Requirements Crosswalk

The following tables are a traceability matrix between the R.E.S.C.U.M.E. Prototype Demonstration architectural elements described in this document and the requirements for both the INC-ZONE and RESP-STG applications, and the Prototype Demonstration requirements as defined in the previously published R.E.S.C.U.M.E. Prototype Demonstration requirements document.

The first table lists each of the architectural elements along with the list of requirements addressed for each element. This table gives evidence that there are no superfluous elements in the proposed architecture.

The second table lists the same relationship between architectural elements and requirements, but inverts the presentation, listing, for each requirement, the architectural elements that address the requirement. This table provides evidence that the proposed architecture indeed satisfies every one of the documented requirements.

Requirements are identified by the Req. ID found in the R.E.S.C.U.M.E. Prototype Demonstration requirements document. The prefixes for the requirements are defined in Table 5-1 below.

**Table 5-1. Requirement Prefixes**

| Applicability | Prefix |
|---|---|
| **RESP-STG Application** | RS |
| **INC-ZONE Application** | IZ |
| **Prototype Demonstration** | PD |

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Architectural components are identified by the section number in this document where the element is defined.

**Table 5-2. Requirements Addressed by Each Architectural Element**

| Section | Component | Requirements |
|---|---|---|
| 2.3 | Data Source 1_n | PD-1.0-1, PD-1.0-2, PD-2.0-1 |
| 2.4.1 | Traffic and Incident Database | IZ-2 |
| 2.4.2 | First Responder Information Broker | IZ-2, IZ-43, IZ-44, IZ-45, IZ-46, PD-2.0-3 |
| 2.4.3 | Traveling Public Information Broker | PD-2.0-3, IZ-2 |
| 2.5.1 | Cellular Communications Hardware Module | IZ-2, PD-3.1-1, IZ-4 |
| 2.5.2 | DSRC Communications Hardware Module | IZ-4, IZ-5, IZ-6, IZ-7, IZ-8, PD-3.2-1, PD-3.2-2, PD-3.2-3, PD-3.2-4, PD-3.2-5, PD-3.2-6, PD-3.2-7, IZ-28 |
| 2.5.3 | Vehicle Interface Hardware Module | IZ-28, IZ-30, IZ-31, PD-3.3-1, PD-3.3-2, PD-3.3-3, PD-3.3-4, PD-3.3-5, PD-3.3-6, IZ-3 |
| 2.5.4 | Responder Radio Hardware | IZ-3, RS-8 |
| 2.5.5 | Mobile Computational and User Interface Hardware | RS-8, PD-3.4-1, PD-3.4-2, PD-3.4-3, PD-3.4-4, PD-3.4-5, PD-3.4-6, PD-3.4-7, RS-1 |
| 2.5.5.1 | Responder Staging Software | RS-1, IZ-7, IZ-8, PD-4.1-1, PD-4.1-2, PD-4.1-3, PD-4.1-4, PD-4.1-5, PD-4.1-6, IZ-6 |
| 2.6.1 | DSRC Communications Hardware Module | IZ-6, PD-3.0-2, PD-4.0-3, PD-4.2-1, PD-4.2-2, PD-4.2-3, PD-4.2-4, PD-4.2-5, PD-4.2-6, PD-4.2-7, PD-3.0-1 |
| 2.6.2 | Vehicle Interface Hardware Module | PD-3.0-1, PD-4.0-2, PD-4.0-1 |
| 2.6.3 | Mobile Computational and User Interface Hardware | PD-4.0-1, PD-5.0-1, PD-5.0-2, IZ-27 |
| 2.7 | First Responder Personal Radio Hardware | IZ-27, IZ-32, IZ-33, IZ-34, IZ-36, IZ-37, IZ-38, IZ-43 |
| 2.8.2 | Incident Zone Status | IZ-43, IZ-5, IZ-6, IZ-7, IZ-8, PD-3.2-1, PD-3.2-3, PD-3.2-7, IZ-11 |
| 2.8.3 | Lane Guidance and Geo-located Incident Map | IZ-11, PD-3.4.2.2-6, PD-3.4.2.2-7, IZ-8 |
| 2.8.4 | Proximity Warnings, Impact Predictions | IZ-8, 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, IZ-25 |
| 2.8.5 | Proximity Warnings, Impending Impact Alarms | IZ-1 |
| 3.1.1.1 | Responder Staging Software Interface | IZ-1, IZ-19, IZ-20, IZ-4 |
| 3.1.1.2 | DSRC Software Interface | IZ-4, PD-3.4.1.2-1, PD-3.4.1.2-2, PD-3.4.1.2-3, PD-3.4.1.2-4, PD-3.4.1.2-5, PD-3.4.1.2-6, IZ-28 |
| 3.1.1.3 | Vehicle Alarm Software Interface | IZ-28, IZ-27 |

**Table 5 2. Requirements Addressed by Each Architectural Element (Continued)**

| Section | Component | Requirements |
|---|---|---|
| 3.1.1.4 | Responder Radio Software Interface | IZ-27, PD-3.4.2-3, PD-3.4.2.1-1, PD-3.4.2.1-3, PD-3.4.1.1-1 |
| 3.1.2.1 | On-Scene Vehicle Management Processing | PD-3.4.1.1-1, IZ-26, IZ-28, IZ-29, IZ-30, PD-3.4.2-4, IZ-11 |
| 3.1.2.2 | Map Repository | IZ-11, IZ-7, IZ-8, PD-4.1-3, PD-4.1-7, PD-4.3-2, PD-3.4.1.1-5 |
| 3.1.2.3 | Incident Visualization Processing | PD-3.4.1.1-5, PD-4.2-3, PD-4.2-8, PD-4.3-2, IZ-6 |
| 3.1.2.4 | Broadcast Prioritization and Filtering | IZ-6, IZ-9, IZ-10, IZ-24, PD-3.4.2-5, PD-3.4.2-1 |
| 3.1.3 | Threat Processing and Alarm Software | PD-3.4.2-1, IZ-6 |
| 3.1.3.1 | Threat Processing | IZ-6, IZ-13, IZ-14, IZ-15, IZ-16, IZ-20, IZ-22, IZ-24, PD-4.3.2-1, PD-4.3.2-2, PD-4.3.2-3, PD-4.3.2-4, PD-4.3.2-5, PD-4.3.2-6, PD-4.3.2-7, PD-4.3.2-8, PD-4.3.2-9, IZ-25 |
| 3.1.3.2 | Responder Alarm Management | IZ-25, IZ-13, IZ-18, IZ-20, IZ-21, 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, IZ-6 |
| 3.2.1 | DSRC Software Interface | IZ-6, RS-2, RS-3, RS-4, RS-5, RS-6, RS-7, RS-9, RS-12, RS-13, RS-14, RS-15, RS-16, RS-17, RS-18, RS-19, RS-20, RS-21, RS-23, RS-24, RS-27, RS-29, RS-31, RS-32, RS-34, RS-35, RS-36, RS-37, RS-38, RS-39, IZ-2, IZ-32, IZ-33, IZ-34, IZ-35, IZ-36, IZ-37, IZ-39, IZ-42, IZ-43, IZ-44, IZ-45, IZ-46, IZ-47, IZ-16 |
| 3.2.2 | Vehicle Telematics Software Interface | IZ-16, IZ-9, IZ-10, IZ-8 |
| 3.2.3 | Threat Message Broadcast | IZ-8, IZ-19, IZ-20, PD-4.3.2-1 |
| 3.2.4 | Scene Capture and Parsing | PD-4.3.2-1, IZ-6 |
| 3.2.5 | Predicted Collision and Threat Path Calculation | IZ-6, IZ-44, IZ-45, IZ-12 |
| 3.2.6 | Traveler Display Alert | IZ-12, RS-33 |

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**Table 5-3. Architectural Elements Addressing Each Requirement**

| Req # | Components |
|---|---|
| RS-1 | 2.5.5.1 |
| RS-2 | 2.5.5.1 |
| RS-3 | 2.5.5.1 |
| RS-4 | 2.5.5.1 |
| RS-5 | 2.5.5.1 |
| RS-6 | 2.5.5.1 |
| RS-7 | 2.5.5.1 |
| RS-8 | 2.5.5 |
| RS-9 | 2.5.5.1 |
| RS-10 | Requirement not included in Prototype |
| RS-11 | Requirement not included in Prototype |
| RS-12 | 2.5.5.1 |
| RS-13 | 2.5.5.1 |
| RS-14 | 2.5.5.1 |
| RS-15 | 2.5.5.1 |
| RS-16 | 2.5.5.1 |
| RS-17 | 2.5.5.1 |
| RS-18 | 2.5.5.1 |
| RS-19 | 2.5.5.1 |
| RS-20 | 2.5.5.1 |
| RS-21 | 2.5.5.1 |
| RS-22 | Requirement not included in Prototype |
| RS-23 | 2.5.5.1 |
| RS-24 | 2.5.5.1 |
| RS-25 | Requirement not included in Prototype |
| RS-26 | Requirement not included in Prototype |
| RS-27 | 2.5.5.1 |
| RS-28 | Requirement not included in Prototype |
| RS-29 | 2.5.5.1 |
| RS-30 | Requirement not included in Prototype |
| RS-31 | 2.5.5.1 |
| RS-32 | 2.5.5.1 |
| RS-33 | Requirement not included in Prototype |
| RS-34 | 2.5.5.1 |
| RS-35 | 2.5.5.1 |

**Table 5 3. Architectural Elements Addressing Each Requirement (Continued)**

| Req # | Components |
|---|---|
| RS-36 | 2.5.5.1 |
| RS-37 | 2.5.5.1 |
| RS-38 | 2.5.5.1 |
| RS-39 | 2.5.5.1 |
| IZ-1 | 3.1.1.1 |
| IZ-2 | 2.4.2, 2.5.1, 2.5.5.1 |
| IZ-3 | 2.5.4 |
| IZ-4 | 2.5.2, 3.1.1.2 |
| IZ-5 | 2.5.2, 3.1.1.2 |
| IZ-6 | 2.5.2, 2.6.1, 3.1.1.2, 3.1.2.4, 3.1.3.1, 3.2.1, 3.2.5 |
| IZ-7 | 2.5.2, 2.6.1, 3.1.1.2, 3.2.1 |
| IZ-8 | 2.5.2, 2.6.1, 3.1.1.2, 3.2.1, 3.2.3, 2.8.4 |
| IZ-9 | 3.2.3, 2.8.4 |
| IZ-10 | 3.2.3, 2.8.4 |
| IZ-11 | 3.1.2.2, 2.8.3 |
| IZ-12 | 3.2.6 |
| IZ-13 | 3.2.5, 3.2.6 |
| IZ-14 | 3.2.5 |
| IZ-15 | 3.2.5 |
| IZ-16 | 3.2.2, 3.2.5 |
| IZ-17 | Requirement not included in Prototype |
| IZ-18 | 3.2.6 |
| IZ-19 | 3.1.2.2, 2.8.3 |
| IZ-20 | 3.1.2.2, 3.2.5, 3.2.6, 2.8.3 |
| IZ-21 | 3.2.6 |
| IZ-22 | 3.1.2.2, 3.2.5, 2.8.3 |
| IZ-23 | Requirement not included in Prototype |
| IZ-24 | 3.1.2.4, 3.2.3, 3.2.5, 2.8.4 |
| IZ-25 | 3.1.3.2, 2.8.5 |
| IZ-26 | 3.1.3.2 |
| IZ-27 | 2.5.4, 2.7, 3.1.1.4, 2.8.5 |
| IZ-28 | 2.5.3, 3.1.1.3, 3.1.3.2 |
| IZ-29 | 3.1.3.2 |
| IZ-30 | 2.5.3, 3.1.3.2 |
| IZ-31 | 2.5.3 |
| IZ-32 | 3.1.1.1, 2.5.5.1 |

**Table 5 3. Architectural Elements Addressing Each Requirement (Continued)**

| Req # | Components |
|---|---|
| IZ-33 | 3.1.1.1, 2.5.5.1 |
| IZ-34 | 3.1.1.1, 2.5.5.1 |
| IZ-35 | 2.5.5.1 |
| IZ-36 | 3.1.1.1, 2.5.5.1 |
| IZ-37 | 3.1.1.1, 2.5.5.1 |
| IZ-38 | Requirement not included in Prototype |
| IZ-39 | 3.1.1.1, 2.5.5.1 |
| IZ-40 | Requirement not included in Prototype |
| IZ-41 | Requirement not included in Prototype |
| IZ-42 | 2.5.5.1 |
| IZ-43 | 2.4.2, 2.5.5.1, 2.8.2 |
| IZ-44 | 2.4.2, 2.5.5.1, 2.8.2 |
| IZ-45 | 2.4.2, 2.5.5.1, 2.8.2 |
| IZ-46 | 2.4.2, 2.5.5.1, 2.8.2 |
| IZ-47 | 2.5.5.1 |
| PD-1.0-1 | 2.3 |
| PD-1.0-2 | 2.3 |
| PD-1.0-3 | 2.3 |
| PD-2.0-1 | 2.4.1 |
| PD-2.0-2 | 2.4.2 |
| PD-2.0-3 | 2.4.3 |
| PD-2.0-4 | 2.4.3 |
| PD-3.0-1 | 2.6.2 |
| PD-3.0-2 | 2.6.2 |
| PD-3.1-1 | 2.5.1 |
| PD-3.1-2 | 2.5.1 |
| PD-3.2-1 | 2.5.2, 3.1.1.2 |
| PD-3.2-2 | 2.5.2 |
| PD-3.2-3 | 2.5.2, 3.1.1.2 |
| PD-3.2-4 | 2.5.2 |
| PD-3.2-5 | 2.5.2 |
| PD-3.2-6 | 2.5.2 |
| PD-3.2-7 | 2.5.2, 3.1.1.2 |
| PD-3.2-8 | 2.5.2, 3.1.1.2 |
| PD-3.3-1 | 2.5.3 |
| PD-3.3-2 | 2.5.3 |

**Table 5 3. Architectural Elements Addressing Each Requirement (Continued)**

| Req # | Components |
|---|---|
| PD-3.3-3 | 2.5.3 |
| PD-3.3-4 | 2.5.3 |
| PD-3.3-5 | 2.5.3 |
| PD-3.3-6 | 2.5.3 |
| PD-3.3-7 | 2.5.3 |
| PD-3.4-1 | 2.5.5 |
| PD-3.4-2 | 2.5.5 |
| PD-3.4-3 | 2.5.5 |
| PD-3.4-4 | 2.5.5 |
| PD-3.4-5 | 2.5.5 |
| PD-3.4-6 | 2.5.5 |
| PD-3.4-7 | 2.5.5 |
| PD-3.4-8 | 2.5.5 |
| PD-3.4.1-1 | 2.5.5.1 |
| PD-3.4.1.1-1 | 3.1.2.1 |
| PD-3.4.1.1-5 | 3.1.2.3 |
| PD-3.4.1.2-1 | 3.1.2.3 |
| PD-3.4.1.2-2 | 3.1.2.3 |
| PD-3.4.1.2-3 | 3.1.2.3 |
| PD-3.4.1.2-4 | 3.1.2.3 |
| PD-3.4.1.2-5 | 3.1.2.3 |
| PD-3.4.1.2-6 | 3.1.2.3 |
| PD-3.4.1.2-7 | 3.1.2.3 |
| PD-3.4.2-1 | 3.1.3 |
| PD-3.4.2-2 | 3.1.3 |
| PD-3.4.2-3 | 3.1.3.1 |
| PD-3.4.2-4 | 3.1.3.2 |
| PD-3.4.2-5 | 3.2.3 |
| PD-3.4.2.1-1 | 3.1.3.1 |
| PD-3.4.2.1-2 | 3.1.3.2 |
| PD-3.4.2.1-3 | 3.1.3.1 |
| PD-3.4.2.1-4 | 3.1.3.1 |
| PD-3.4.2.2-1 | 3.1.1.4 |
| PD-3.4.2.2-2 | 3.1.1.4 |
| PD-3.4.2.2-3 | 3.1.1.4 |
| PD-3.4.2.2-4 | 3.1.1.4 |

**Table 5 3. Architectural Elements Addressing Each Requirement (Continued)**

| Req # | Components |
|---|---|
| PD-3.4.2.2-5 | 3.1.1.4 |
| PD-3.4.2.2-6 | 3.1.1.3, 3.1.1.4 |
| PD-3.4.2.2-7 | 3.1.1.3, 3.1.1.4 |
| PD-3.4.2.2-8 | 3.1.1.3 |
| PD-3.4.2.2-9 | 3.1.1.4 |
| PD-4.0-1 | 2.6.3 |
| PD-4.0-2 | 2.6.3 |
| PD-4.0-3 | 2.6.2 |
| PD-4.1-1 | 2.6.1 |
| PD-4.1-2 | 2.6.1 |
| PD-4.1-3 | 2.6.1, 3.2.1 |
| PD-4.1-4 | 2.6.1 |
| PD-4.1-5 | 2.6.1 |
| PD-4.1-6 | 2.6.1 |
| PD-4.1-7 | 2.6.1, 3.2.1 |
| PD-4.2-1 | 2.6.2 |
| PD-4.2-2 | 2.6.2 |
| PD-4.2-3 | 2.6.2, 3.2.2 |
| PD-4.2-4 | 2.6.2 |
| PD-4.2-5 | 2.6.2 |
| PD-4.2-6 | 2.6.2 |
| PD-4.2-7 | 2.6.2 |
| PD-4.2-8 | 2.6.2, 3.2.2 |
| PD-4.3-1 | 2.6.3 |
| PD-4.3-2 | 3.2.1, 3.2.2 |
| PD-4.3-3 | 3.2.2 |
| PD-4.3-4 | 3.2.1 |
| PD-4.3.1-1 | 3.2.6 |
| PD-4.3.1-2 | 3.2.6 |
| PD-4.3.1-3 | 3.2.6 |
| PD-4.3.1-4 | 3.2.6 |
| PD-4.3.1-5 | 3.2.6 |
| PD-4.3.1-6 | 3.2.6 |
| PD-4.3.1-7 | 3.2.6 |
| PD-4.3.1-8 | 3.2.6 |
| PD-4.3.1-9 | 3.2.6 |

**Table 5 3. Architectural Elements Addressing Each Requirement (Continued)**

| Req # | Components |
|---|---|
| PD-4.3.2-1 | 3.2.4, 3.2.5 |
| PD-4.3.2-2 | 3.2.4, 3.2.5 |
| PD-4.3.2-3 | 3.2.5 |
| PD-4.3.2-4 | 3.2.5 |
| PD-4.3.2-5 | 3.2.3, 3.2.5 |
| PD-4.3.2-6 | 3.2.5 |
| PD-4.3.2-7 | 3.2.5 |
| PD-4.3.2-8 | 3.2.5 |
| PD-4.3.2-9 | 3.2.5 |
| PD-4.3.2-10 | 3.2.5 |
| PD-5.0-1 | 2.7 |
| PD-5.0-2 | 2.7 |
| PD-5.0-3 | 2.7, |

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# APPENDIX A. List of Acronyms

| *Acronym* | *Definition* |
|---|---|
| **ASD** | Aftermarket Safety Device |
| **CapWIN** | The Capital Wireless Information Net, a proprietary, GOTS software package |
| **CATT** | Center for Advanced Transportation Technology |
| **CJIS** | Criminal Justice Information Service |
| **ConOps** | Concept of Operations |
| **COTS** | Commercial-off-the-shelf |
| **CV** | Connected Vehicle |
| **DMA** | Dynamic Mobility Applications |
| **DMS** | Dynamic Message Sign |
| **DOT** | Department of Transportation |
| **DSRC** | Dedicated Short-Range Communications |
| **EAS** | (National) Emergency Alert System |
| **ECC** | Emergency Communications Center |
| **EMS** | Emergency Medical Services |
| **EOC** | Emergency Operations Center |
| **ETO** | Emergency Transportation Operations |
| **EVAC** | Emergency Communications and Evacuation (a R.E.S.C.U.M.E. application) |
| **FHWA** | Federal Highway Administration |
| **GIS** | Geographic Information System |
| **GOTS** | Government-off-the-shelf |
| **GPS** | Global Positioning System |
| **HAZMAT** | Hazardous Materials |
| **I2V** | Infrastructure-to-Vehicle |
| **INC-ZONE** | Incident Scene Work Zone Alerts for Drivers and Workers (a R.E.S.C.U.M.E. application) |
| **J2735-2009** | A standard for messages for DSRC communications |
| **NHTSA** | National Highway Traffic Safety Administration |
| **ODB-II** | On-Board Diagnostic, a vehicle standard specifying a type of diagnostic connector and pin out, electrical signaling protocols, and messaging format. |
| **PASS** | Personal Alerting Safety Subsystem |
| **PSAP** | Public Safety Answering Point |
| **R.E.S.C.U.M.E.** | Response, Emergency Staging, Communications, Uniform Management, and Evacuation (a DMA bundle) |
| **RESP-STG** | Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (a R.E.S.C.U.M.E. application) |
| **RFID** | Radio Frequency Identification |
| **RITA** | Research and Innovative Technology Administration |
| **RITIS** | Regional Integrated Transportation Information System |
| **TMC** | Traffic Management Center |
| **U.S. DOT** | United States Department of Transportation |
| **V2I** | Vehicle-to-Infrastructure |
| **V2V** | Vehicle-to-Vehicle |
| **V2X** | Vehicle-to-Infrastructure or -Vehicle |

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