

Connected Vehicle Pilot Deployment Program Phase 1

System Requirements Specification (SyRS) – WYDOT

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7	02/16/2018	WYDOT	Updated version based on latest architecture and system design.
8	03/16/2018	WYDOT	Updated version with added requirements for testing.
9	05/11/2018	WYDOT	Updated version base on latest architecture and system design, which now includes the Hardware Security Module (HSM) and Secure Data Commons (SDC).
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16. Abstract The Wyoming Department of Transportation's (WYDOT) Connected Vehicle (CV) Pilot Deployment Program is intended to develop a suite of applications that utilize vehicle to infrastructure (V2I) and vehicle to vehicle (V2V) communication technology to reduce the impact of adverse weather on truck travel in the I-80 corridor. These applications support a flexible range of services from advisories, roadside alerts, parking notifications and dynamic travel guidance. Information from these applications are made available directly to the equipped fleets or through data connections to fleet management centers (who will then communicate it to their trucks using their own systems). The pilot will be conducted in three Phases. Phase I includes the planning for the CV pilot including the concept of operations development. Phase II is the design, development, and testing phase. Phase III includes a real-world demonstration of the applications developed as part of this pilot. This document presents the high-level Systems Requirement Specifications (SyRS) for the physical objects and applications identified in the Concept of Operations document. The SyRS provides testable requirements based on the user needs identified by the pilot site and will be used as the basis for system design activities. The SYRS also supports the pilot site's partnership and vendor selection process by setting clear expectations of various physical objects and applications that will be procured, integrated and demonstrated as part of the pilot. This 2020 revised version reflects the as built system.					
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1 Introduction

1.1 Purpose of the Document

This document is the System Requirements Specification (SyRS) of The Wyoming Connected Vehicle Pilot project for the United States Department of Transportation's (USDOT) connected vehicle program. This is document number: FHWA-JPO-16-291.

1.2 Project Scope

Wyoming Department of Transportation (WYDOT) is one of the first wave of Connected Vehicle (CV) Pilot sites selected to showcase the value of and spur the adoption of Connected Vehicle Technology in the United States. Connected Vehicle Technology is a broad term to describe the applications and the systems that take advantage of dedicated short-range communications (DSRC) between vehicle to vehicle (V2V), vehicle to infrastructure (V2I) and infrastructure to vehicle (I2V) to improve safety, mobility and productivity of the users of the nation's transportation system.

As one of the three selected pilots, WYDOT is focusing on improving safety and mobility by creating new ways to communicate road and travel information to commercial truck drivers and fleet managers along the 402 miles of Interstate 80 (I-80 henceforth) in the State. For the pilot project, WYDOT worked in a planning phase through September 2016. The deployment process will happen in the second phase (ending in August 2020) followed by a 12-month demonstration period in the third phase. At a very high level, the pilot scope includes the following implementation elements:

- **Deployment of about 75 roadside units (RSU)** that can receive and broadcast messages using DSRC along various sections on I-80.
- **Equip around 400 vehicles, a combination of fleet vehicles and commercial trucks, with on-board units (OBU).** Of the 400 vehicles, at least 75 would be heavy trucks. All vehicles are expected to be regular users of I-80. Several types of OBU are being procured as part of the pilot and differ based on their communication capabilities, ability to integrate with the in-vehicle network, and connectivity to ancillary devices and sensors. All OBUs will have the functionality to broadcast Basic Safety Messages (BSM) and will include a human-machine interface (HMI) to share alerts and advisories to drivers of these vehicles.
- **Develop several V2V and V2I (and I2V) applications** that will enable communication with drivers for alerts and advisories regarding various road conditions. These applications include support for in-vehicle dissemination of advisories for collision avoidance, speed management, detours, parking, and presence of work zones and maintenance and emergency vehicles downstream of their current location.
- **Enable overall improvements in WYDOT's traffic management and traveler information practices** by using data collected from connected vehicles. Targeted

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improvements include better activation of variable speed limits (VSL) and improved road condition dissemination via 511, Dynamic Message Signs (DMS) and other WYDOT sources.

Systems and applications developed in the pilot will enable drivers of connected vehicles to have awareness of hazards and situations they cannot even see. The CV Pilot is considered a System of Systems, with two systems of interest: The *Vehicle System* and the *Wyoming CV System*, see Figure 1-1. The *Vehicle System* includes four Sub-Systems that represent the various vehicle and equipment types to be used in the pilot. These Sub-Systems vary in their data collection and sharing capabilities. The *Wyoming CV System* includes the infrastructure used in the pilot and back-office systems in charge of the various processes that lead to the generation and distribution of advisories and alerts. Together, the Vehicle and *Wyoming CV Systems* support a variety of V2V and V2I applications. Both systems interface with external systems, including WYDOT, USDOT and the National Weather Service (NWS).

The CV Pilot Project will, at its core, provide key information to the drivers through five on-board applications: i) Forward Collision Warning (FCW); ii) I2V Situational Awareness (SA); iii) Distress Notification (DN); iv) Work Zone Warning (WZW); and v) Spot Weather Impact Warning (SWIW). In addition, the CV Pilot project will support overall traffic management and traveler information services offered by WYDOT.

Through these applications and functions, WYDOT hopes to improve operations on the corridor especially during periods of adverse weather and when work zones are present. By means of the anticipated outcomes of the pilot, fleet managers will be able to make better decisions regarding their freight operations on I-80, truckers will be made aware of downstream conditions and provided guidance on parking options as they travel the corridor, and automobile travelers will receive improved road condition and incident information through various existing, improved and new information outlets.

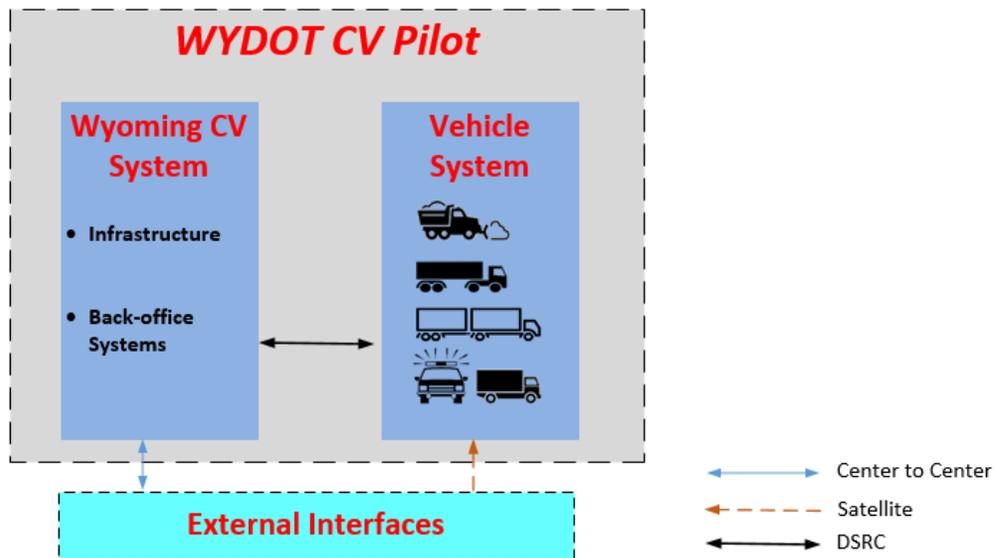


Figure 1-1 Wyoming CV Pilot System of Systems (Source: WYDOT)

1.3 Definition, Acronyms, and Abbreviations

Table 1-1 Glossary of Terms.

Term	Definition
Advanced Automatic Crash Notification Relay	An application that provides the capability for a vehicle to automatically transmit an emergency message when the vehicle has been involved in a crash or other distress situation.
Basic Safety Message	<p>Connected V2V safety applications are built around the SAE J2735 BSM, which has two parts</p> <p>BSM Part I:</p> <p>Contains the core data elements (vehicle size, position, speed, heading, acceleration)</p> <p>Transmitted approximately 10x per second</p> <p>BSM Part II:</p> <p>Added to Part I depending upon events (e.g., ABS activated)</p> <p>Contains a variable set of data elements drawn from many optional data elements (availability by vehicle model varies)</p> <p>Transmitted less frequently</p> <p>The BSM is transmitted over DSRC (range of between at least 2 and 300 meters). The BSM is tailored for low latency, localized broadcast required by V2V safety applications</p>
Broadcast	Sharing data with no specific destination. All broadcasted data is sent unencrypted but is signed with a certificate (based on 1609.2).
Commercial Vehicle Operator Portal	Provides forecasted road condition information on common commercial vehicle routes.
Freight-Specific Dynamic Travel Planning	An application that provides both pre-trip and enroute travel planning, routing, and commercial vehicle related traveler information, which includes information such as truck parking locations and current status.
Host Vehicle	A connected vehicle that receives messages from a remote vehicle. In this document, the host vehicle is also used to describe the originator of a vehicular transmission of information to the RSU.
Data Ingest	Obtaining and importing data for use or storage.
Mandatory Requirements	Minimum set of information necessary to accomplish one action/requirement.
Receive Data	A connected device accepts a data package broadcasted or transmitted by another connected device.
Remote Vehicle	A connected vehicle that periodically and dynamically broadcasts a message about its general situation to a host vehicle.
Road Weather Information for Freight Carriers	An application that is a special case of the Road Weather Advisories and Warnings for Motorists application focuses on Freight Carrier users.
WYDOT Road Segment	A road segment is defined as a link in TMDD v3.03c as Link: A link is defined as a roadway or transit right-of-way between two nodes.

Term	Definition
	WYDOT has implemented road segments to fully cover I-80 in each direction.
Segment Alert	TIMs that provide information related to Weather, Road Condition, Construction, Incident and Truck Parking, or a combination of, that is linked to a specific spatial area that is describe following Section 6.30 Data Frame: DF_GeographicalPath of J2735.
Situational Awareness	An application that determines if the road conditions measured by other vehicles represent a potential safety hazard for the vehicle containing the application.
Spot Weather Impact Warning	An application that will alert drivers to unsafe conditions or road closure at specific points on the downstream roadway as a result of weather-related impacts.
Transmit	Sharing data directed to a specific receiver. In the case of transmission between Systems, all transmitted data is signed and encrypted where required based on 2945/1.
Transportation Management Center	Center that collects information and informs the public about changing travel conditions.
Warnings about Upcoming Work Zone	An application that provides information about the conditions that exist in a work zone to vehicles that are approaching the work zone.
WGS-84	Latest revision of the standard for use in cartography, geodesy, and navigation including by GPS.
Yaw rate	Angular velocity of rotation or rate of change of heading angle when horizontal.

Table 1-2. Acronym List.

Acronym/Abbreviation	Definition
ABS	Anti-lock Braking System
BSM	Basic Safety Message
DB	Data Broker
DNM	Distress Notification Message
DW	Data Warehouse
CA and ConAdmin	Construction Administration
CAN bus	Controller Area Network bus
ConOps	Concept of Operations
CV	Connected Vehicle
CVOP	Commercial vehicle operator portal
DMS	Dynamic Message Signs
DSRC	Dedicated Short Range Communications
FHWA	Federal Highway Administration
HAR	Highway Advisory Radio
HMI	Human Machine Interface
HSM	Hardware Security Module
I-80	Interstate 80
IC	Incident Console

Acronym/Abbreviation	Definition
IEEE	Institute of Electrical and Electronics Engineers
ISP	Information Service Provider
ITS	Intelligent Transportation System
LTS	Location and Time Service
NWS	National Weather Service
OBU	On-board Unit. This represents the package of DSRC radios, computing, sensors and human-machine interface that will be installed on a vehicle. This is similar to the Retrofit Safety Devices (RSD) used in the Safety Pilot Program.
ODE	Operational Data Environment
OTA	Over the Air
PA	Pikalert System
PSID	Provider Service Identifier
RCRS	Road Condition Reporting System
RF	Radio Frequency
RDE	Research Data Exchange
RSU	Roadside Unit. This represents the package of DSRC radios, computing, communications that will be installed on the roadside on I-80
RWIS	Road Weather Information System
SCMS	Security Credential Management System
SCP	Secure Copy
SDC	Secure Data Commons
SDX	Situation Data Exchange
SHH	Secure Shell
TIM	Traveler Information Message
TMC	Transportation Management Center
TPI	Third-Party Information Service Providers
TRAC	Transportation Reports and Action Console
V2I	Vehicle to infrastructure
V2V	Vehicle to vehicle
VSL	Variable Speed Limit
WHP	Wyoming Highway Patrol
WYDOT	Wyoming Department of Transportation
WTI	Wyoming Traveler Information system

1.4 References

The following table lists the documents, sources and tools used to develop the concepts in this document.

Table 1-3. References.

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1.5 Document Overview

This document follows the sequential logic illustrated in Figure 1-2. An example is also provided to illustrate how identified User Needs drove the development of the requirements at the System, Interface and Sub-System level—in other words, how a detailed Sub-System Requirement can be traced back to a particular User Need.

The remainder of this document is organized as follows:

- Section 2 provides a general description of the system, explaining the different systems of interest, their capabilities and applications that will be developed through this pilot project.
- Section 3 details the requirements with external interfaces to the systems of interest.
- Section 4 details the System level requirements for the CV Pilot Systems.
- Section 5 details the Sub-System level requirements for the CV Pilot Sub-Systems.
- Section 6 details the performance requirements for the different Sub-systems.
- Section 7 provides the traceability of the different components of the system of systems to the user needs.
- Appendices A and B lists the requirements for the OBU and RSU, respectively.

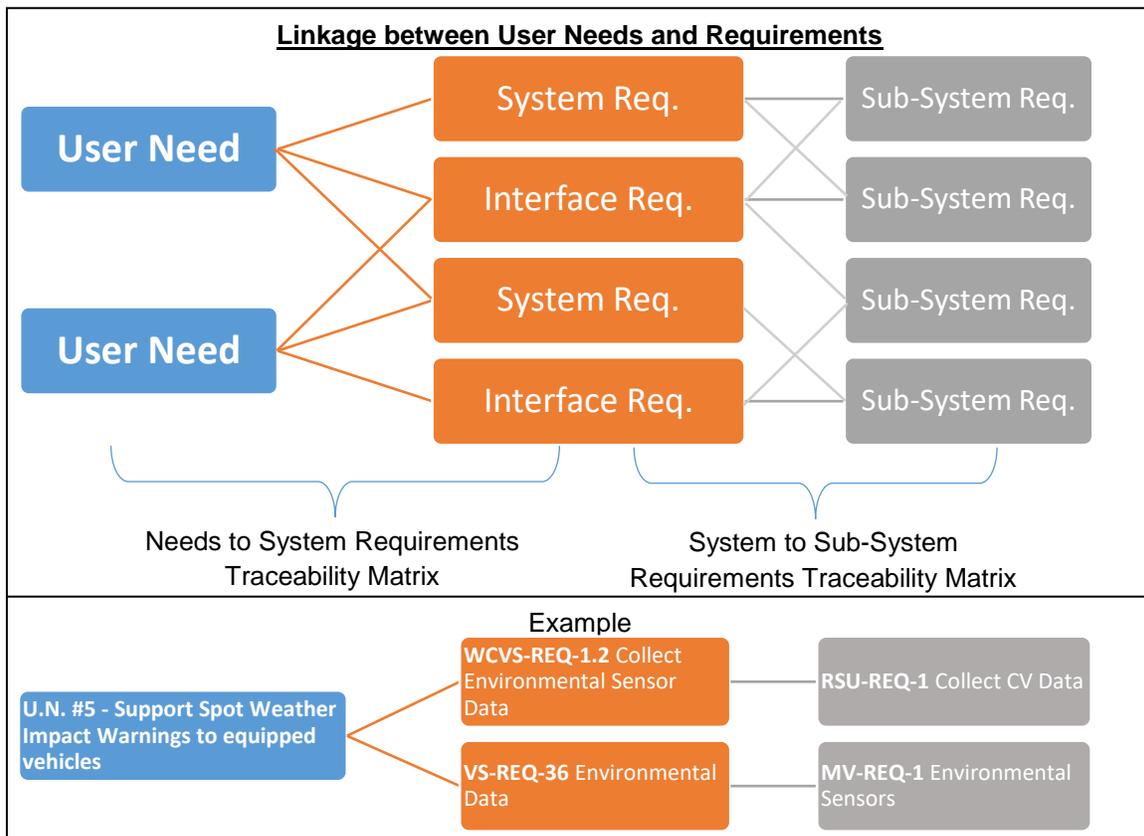


Figure 1-2. Illustration of the Sequential Logic of the System Requirements (Source: WYDOT)

2 General System Description

2.1 System Context

This project will develop systems that make relevant information directly available to, and shared among, equipped fleets. Information is also shared through linkages with fleet management centers (who will then communicate it to their trucks using their own communication systems) and other external agencies and partners.

Supporting the applications and the CV environment of roadside, vehicle and back-office infrastructure are core services that allow safe, secure, reliable operations of the system. The main project objectives of the pilot to be accomplished and demonstrated are as follows:

- Deploy and operate a set of vehicles that are equipped with on-board units (OBU) with DSRC connectivity. These vehicles will be a combination of snow plows, fleet vehicles, emergency vehicles and private trucks that will broadcast a basic safety message, collect vehicle, weather and road condition data, and provide it remotely to the WYDOT Transportation Management Center. These vehicles will also receive in-vehicle alerts through the infrastructure and wirelessly from various applications developed as part of the pilot through a human-machine interface (HMI).
- Deploy roadside units (RSUs) with DSRC connectivity that are able to transmit advisories and alerts to equipped vehicles along I-80.
- Leverage the data provided from the equipped vehicles to develop and demonstrate a suite of V2V and V2I applications. As part of the pilot, several applications will be developed to support wide-area travel advisories, variable speed limit postings, forecast road condition information, spot-specific warnings, work zones, distress notifications, and parking notifications.

A detailed explanation of the Wyoming CV Pilot project can be found in *Connected Vehicle Pilot Deployment Program Phase I, Concept of Operations (ConOps)* (Gopalakrishna, et al., 2015). The context diagram shown in Figure 1-1 highlights the different communication types between the systems of interest, which will be through WYDOT-owned telecom (such as WYDOT's communication backhaul or WYOLINK radio system) or other remote telecommunications (cellular or satellite) shown in the figure.

2.2 System Capabilities

This section describes functions to be performed by the *Vehicle System* and the *Wyoming CV System*. The *Vehicle System* will perform eight functions:

1. Collect CV Data – Connected vehicles wirelessly receive BSMs from other connected vehicles.
2. Collect TIMs – Wirelessly receives packets containing traveler information from the *Wyoming CV System* and distress information from other connected vehicles.

3. Manage and Process Information for Applications – Manages and processes information for the five on-board applications.
4. Provide In-Vehicle Application Alerts – Provides prioritized alerts and advisories for the Vehicle Operator.
5. Broadcast Vehicle Data – Broadcasts, at a predefined rate, vehicle information (BSMs and DNs) to other connected devices and to the *Wyoming CV System*.
6. Transmit Environmental and Log Data – Transmits environmental data and management logs to the *Wyoming CV System*.
7. Store Data – Locally stores selected data collected and generated (both from the field and the applications) until they are transferred to the *Wyoming CV System*.
8. OBU Management – Logs availability and operational capability, including validating and obtaining certificates, time and location accuracy, logging system information, and routine wellness check.

The *Wyoming CV System* performs six functions:

1. Collect CV Information – Collects data from the *Vehicle System*. Data collected includes BSMs, event logs, weather sensor data, and distress messages.
2. Generate Road Weather Alerts and Advisories – Generates segment-level advisories and alerts of both current and forecast road and weather conditions based on customizable thresholds.
3. Support Information Brokerage – Distributes Road Weather Alerts and Advisories to the WYDOT's interfaces.
4. Distribute TIMs – Distributes the TIM to the *Vehicle System* and the Situation Data Exchange (SDX).
5. Store Data – Data generated are stored by the system.
6. Manage and Maintain System – The WYDOT Maintenance team monitors the system for availability and operational capabilities.

In addition to on-board vehicle applications, information generated by the *Wyoming CV System* is expected to be used to support WYDOT traffic management and traveler information. WYDOT expects to use the information from the pilot for the following purposes:

- **Setting and removing VSL along the I-80 corridor** – VSLs will be managed through the Wyoming Traveler Information (WTI) interface. When segment-level alerts and advisories are received from the *Wyoming CV System* in WTI, the TMC operator will have the option to reduce speed according to the normal operation protocols. Similarly, when speed limits are reduced due to information available from the TMC, this information will be communicated with the *Wyoming CV System* and shared as part of the TIM. The VSL zones utilize changeable yet enforceable speed limits in 143 miles along four (4) segments – 23 miles around Evanston, 25 miles around Green River, 57 miles along Elk Mountain and 47 miles between Cheyenne and Laramie.
- **Supporting 511 and other traveler information** – Road weather collected by the *Wyoming CV System* will be ingested into and processed by the Pikalert system for dissemination to the public. In addition, incident information collected by the CV system will be used to directly update the WTI. The WTI system, upon database saves, has the integrated logic to automatically update the 511 systems (web, phone, email/text messages, app) in near real time.

- **Supporting road weather advisories and freight-specific travel guidance through CVOP** – Information from the *Wyoming CV System* will update the CVOP system to provide freight-specific information to subscribed fleet partners. Currently, more than 800 firms subscribe to CVOP.

The functional architecture view describes the abstract functional elements or processes and their logical interactions via data flows that satisfy the system requirements. Figure 2-1 depicts the functional diagram of the Systems of Interest along with the external interfaces that interact with the CV Systems. Section 2.4 describes in more detail the internal and external interactions of each system.

2.3 Wyoming System

The *Wyoming CV System* includes the infrastructure used in the pilot and the back-office systems in charge of the various processes that lead to the generation and distribution of advisories and alerts for CV Pilot vehicles. The *Wyoming CV System* will be located at the WYDOT TMC. Additionally, this system provides external interfaces to share the advisories and alerts with the public and commercial vehicle operators.

The *Wyoming CV System* is composed of five Sub-Systems:

- Roadside Units (RSU)
- Operational Data Environment (ODE)
- Hardware Security Module (HSM)
- Pikalert System
- Data Broker (DB)
- Data Warehouse (DW)

2.3.1 Roadside Units

This Sub-System describes the physical units for deployment as part of the system along I-80. RSUs include DSRC connectivity, application support, data storage, and other support services to enable CV applications, such as necessary certificates. WYDOT RSUs can be either fixed or portable equipment depending on the use. In general, RSUs serve as a two-way communication portal between connected vehicles that provide information through DSRC and the ODE. About 75 RSUs are planned to be deployed in the pilot.

2.3.2 Operational Data Environment

The WYDOT ODE Sub-System receives information collected with connected devices, checks its quality, and then shares it with other Sub-Systems in charge of analyzing and distributing the information. The ODE also exports data to the SDX for USDOT-related activities. The ODE will be hosted at WYDOT TMC and uses the same codebase as the USDOT ODE. High-level requirements for the ODE are contained within the *Task 4 ODE ConOps from the Southeast Michigan Test Bed Advanced Data Capture Field Testing*. These include requirements for Validation, Integration, Sanitization, and Aggregation (VISA), which are combined in this document with the description of ODE processed data.

2.3.3 Hardware Security Module

The Wyoming CV Pilot uses the IIS/GHS¹ rented, black box hardware security module (HSM) in the Cheyenne TMC. In essence, the HSM will manage the Wyoming CV System's certifications. It has a Representational State Transfer (RESTful)² endpoint that receives an unsigned TIM and outputs a signed TIM. The HSM also has a link to the ISS/GHS Certificate Management System (CMS) to get updated certifications. It should be noted that its internal workings are a black box that is proprietary code, and therefore WYDOT will not have access to it. WYDOT will physically have two 1U rack³ units that each have dual power supplies and are fail over in capability. The units also have a gig Ethernet connection with IPv4 and IPv6.

2.3.4 Pikalert System

The Pikalert System supports the integration and fusion of CV and non-CV weather data to develop alerts and advisories regarding adverse weather conditions along I-80. CV data are received from the ODE, while non-CV data derive from weather sources and the WYDOT DB. To generate the alerts and advisories, the Pikalert System assigns CV and non-CV data to 1-mile segments on I80 every 5 minutes. The CV data is quality checked, then passed to the Road Weather Hazard module (RWH). The RWH uses these data to produce the alerts and advisories for adverse weather and for a 72-hour forecast of road weather conditions and hazards. The generated information is then shared with the DB for further distribution.

2.3.5 WYDOT Data Broker

WYDOT DB receives information from the ODE, Pikalert and some external systems, analyzes them, and shares them with the corresponding system or service including other sources. The DB supports the information brokerage of road weather alerts and advisories to WYDOT's Third-Party Interface (TPI), TRAC, WTI, Road Condition Reporting System (RCRS), and CVOP. Additionally, this system takes in incident information from the Incident Console (IC), work zone data from the Construction Administrator and parking availability information from the 511 Application. The DB also sends the information back to the ODE to support the dissemination of TIM to the RSUs and can also access historical data stored at the DW if needed.

2.3.6 WYDOT Data Warehouse

The WYDOT DW stores various TMC- and CV-related data. The DW includes timestamped and geotagged logs of CV and non-CV data—information collected, generated and shared within the *Wyoming CV System*—that will be used for performance measurement.

¹ IIS/GHS is the company hosting the pilot's certificate management system (i.e., INTEGRITY Software Services/Green Hills Software).

² https://en.wikipedia.org/wiki/Representational_state_transfer

³ Rack height unit 1.75" (https://en.wikipedia.org/wiki/Rack_unit)

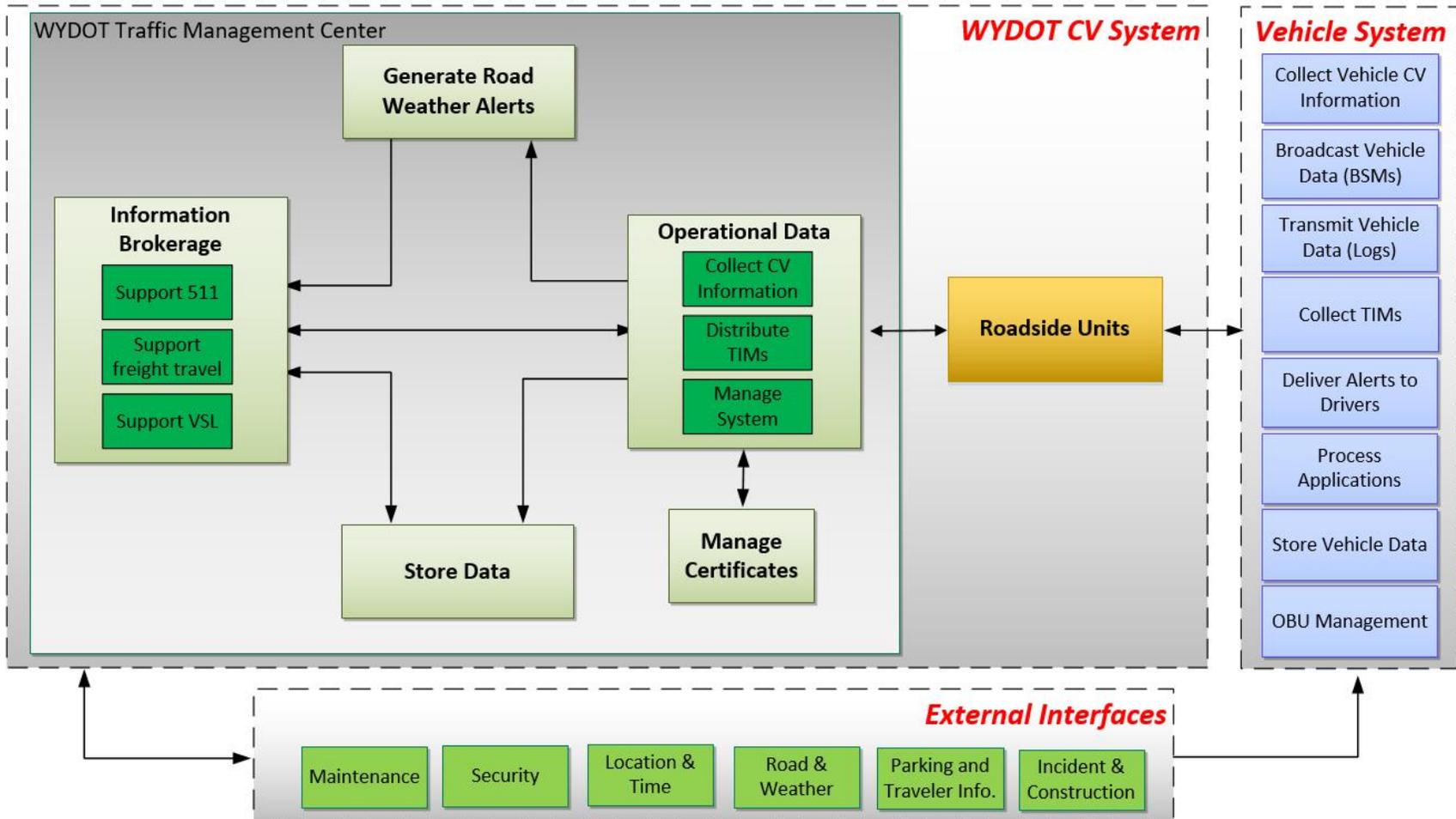


Figure 2-1. Functions of the Wyoming CV System and the Vehicle System. (Source: WYDOT)

2.4 Wyoming CV System External Interfaces

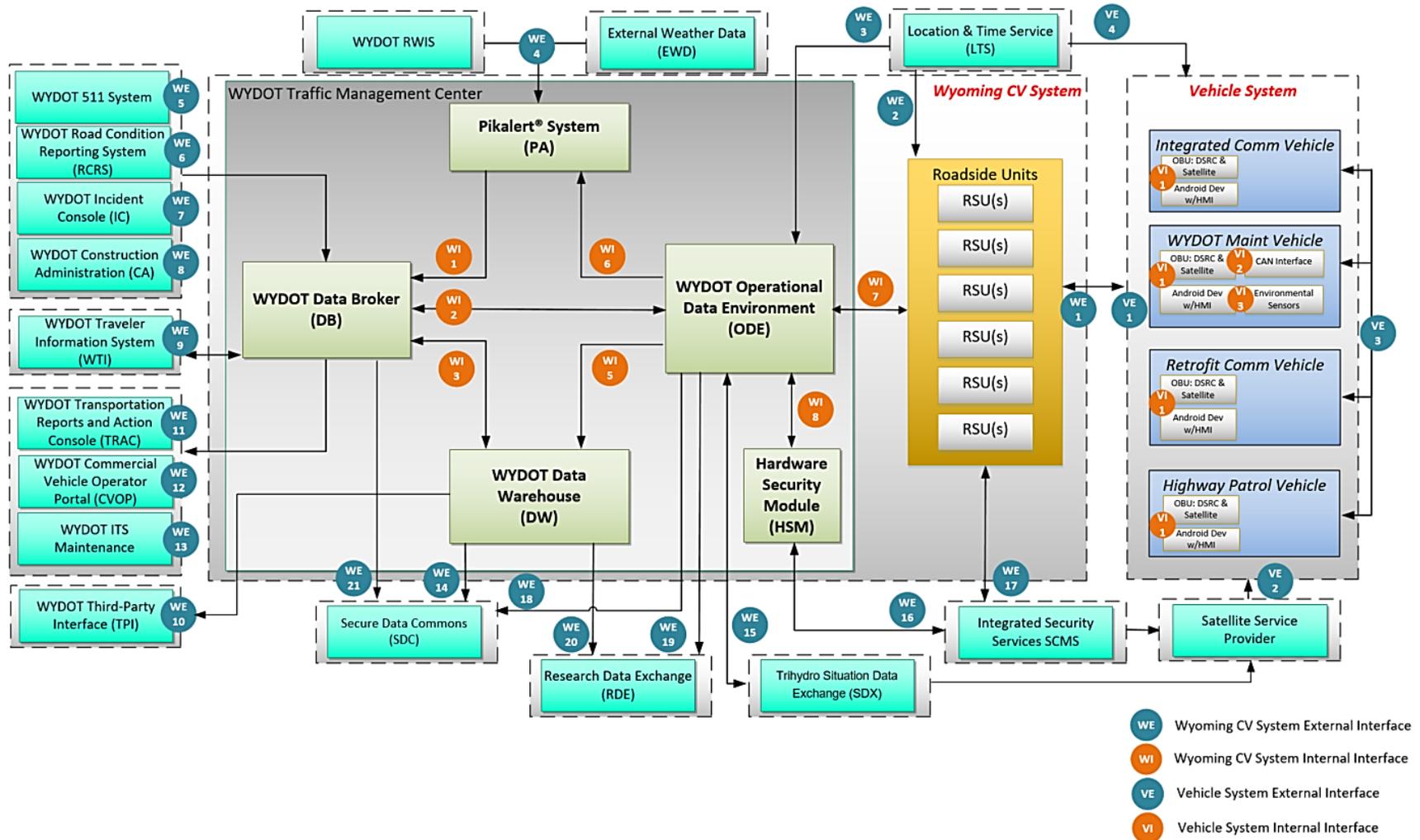
Figure 2-2 shows the physical architecture with interfaces numbered for reference and discussion here and in following sections. The Wyoming CV System includes the following external interfaces for exchanging data and information with external WYDOT and USDOT systems.

- **I2V DSRC Communications Interface** (Interface WE1 and VE1) Wireless DSRC interface provides communication between Wyoming CV System and Vehicle System through exchange of messages conforming to SAE J2735 and SAE J2945/1.
- **Location and Time Service (LTS)** (Interfaces WE2 and WE 3) – Provides location and time information, which is later used to geotag and timestamp all information produced by the systems of interest.⁴
- **EWD and RWIS** (Interface WE4) – EWD provides regional weather data shared through data sources outside of WYDOT, such as the National Oceanic and Atmospheric Administration’s Meteorological Assimilation Data Ingest System and USDOT. **RWIS** provides atmospheric and pavement condition information collected through Environmental Sensor Stations (ESS) deployed as part of the WYDOT RWIS network in the field.
- **WYDOT 511 Application** (Interface WE5) – Provides information to the public regarding I-80’s road weather and traffic conditions (e.g., road closure). The application is currently being updated to also share crowdsourced truck parking information with the CV Pilot.
- **WYDOT RCRS** (Interface WE6) – An Android tablet-based application that resides in WYDOT snow plows which enables field personnel (e.g., snowplow operators) to report weather and roadway pavement conditions following WYDOT’s 8 Code (roadway condition), 9 Code (atmospheric) and 10 Code (other road condition) system.
- **WYDOT IC** (Interface WE7) – Provides timestamped and geotagged incident information on incidents along I-80 obtained from the WHP and other sources (e.g., maintenance).
- **WYDOT Construction Administration (CA)** (Interface WE8) – Provides timestamped and geotagged information of WYDOT’s scheduled and unscheduled work-zone activities along I-80.
- **WTI** (Interface WE9) – Supports traveler information services to the public and to fleet management centers via various means (website, 511, 511 App, text, email, and alerts).
- **WYDOT TPI** (Interface WE10) – A standardized interface based on the TMDD standard that can be used to support delivery of traveler information to external centers and information service providers.
- **WYDOT TRAC** (Interface WE11) – An operator console used in the TMC to monitor and manage planned, ongoing, and forecast events and actions on facilities monitored by the TMC. The TRAC provides a tabular list of currently ongoing events that require operator attention. These events may be entered manually and can be reported based on other systems like RCRS, radio communications with field personnel and citizen reports.
- **WYDOT CVOP** (Interface WE12) – A subscription-based website created by WYDOT for providing advanced notification of forecasted conditions to commercial travelers and fleet

⁴ The location is obtained from a GPS using WGS-84 coordinates system, and time is provided using UTC from GPS time.

managers. Currently there are over 800 companies subscribed to the CVOP. As part of the CV Pilot System, the CVOP will be enhanced to include current weather information for segments on I-80.

- **WYDOT ITS Maintenance** (Interface WE13) – Provides a mechanism to report service outages and resumption of services of WYDOT's ITS equipment.
- **Secure Data Commons (SDC) / Research Data Exchange (RDE)** (Interfaces WE14, WE18, WE19, WE20, and WE21) – Provides WYDOT CV Pilot data to the independent evaluators and the RDE for use in independent analysis and impact evaluation across multiple CV pilots.
- **Trihydro Situation Data Exchange (SDX)** (Interface WE15) – A service based on the original USDOT Situation Data Warehouse (SDW), operated by Trihydro that stores near real-time data and shares them with the remote users and developers for further distribution. As shown, this interface also supports communication of messages through **Satellite Service Provider (SSP)** satellites, allowing the system to transmit traveler-related information.
- **USDOT SCMS** (Interfaces WE16 and WE17) – Generates security certificates to manage messages securely from connected devices. As shown, this interface also supports communication of messages through **SSP** satellites, allowing the system to SCMS-related information.



NOTE: The Wyoming CV System Interface WI4 (PA→DW) and VI2 (OBU-CAN Bus) were not implemented in the final system design.

Figure 2-2. Physical View of WYDOT CV Pilot System Architecture with Numbered Interfaces. (Source: WYDOT)

2.5 Vehicle System

The *Vehicle System* represents the deployment of on-board equipment, sensors, and an HMI that will support CV applications. All vehicles that are part of the *Vehicle System* will have the following core capabilities:

- Ability to share and receive information via DSRC communication from other connected devices (vehicles and RSUs).
- Ability to broadcast BSM.
- An HMI that allows alerts and advisories to be communicated with the driver.

Additionally, several vehicles that are part of the *Vehicle System* have further capability. Based on this, the *Vehicle System* is divided into four Sub-Systems, which define the various vehicle types for this pilot based on their data collection, communication capabilities and fleet/vehicle type. Each Sub-System and its rationale are described below.

2.5.1 WYDOT Maintenance Vehicles

This Sub-System represents the maintenance fleets operated by WYDOT. This includes, but is not limited to, snow plow vehicles assigned to the I-80 corridor. These vehicles represent a set of vehicles over which WYDOT has full control as part of their operations. As such, some of the vehicles will be equipped with the full package of environmental sensors and equipment necessary to support the CV Pilot applications.

Around 60 vehicles are expected to be part of this sub-system, but not all with the same capabilities. All vehicles will have the ability to:

- Receive TIMs via DSRC and Satellite.
- Broadcast BSM Parts I and II.

Whereas 50 of them are expected to be able to:

- Collect weather sensor data.

While vehicles within this subsystem will have the capability to integrate its network via a Controller Area Network (CAN bus) connection, no vehicle within this subsystem will provide Can Bus integration in this pilot.

2.5.2 WYDOT Highway Patrol Vehicles

This Sub-system represents the highway patrol fleet assigned to the I-80 corridor. While also operated by WYDOT, these vehicles represent a set over which WYDOT has less flexibility given the nature of their operations. Around 50 highway patrol vehicles are expected to be part of this sub-system, which will have the ability to:

- Receive TIMs via DSRC and Satellite.
- Broadcast BSM Parts I and II.

2.5.3 Integrated Commercial Vehicles

This connected trucks Sub-System represents a subset of commercial trucks owned and operated by fleet partners involved in the pilot. Similar to Highway Patrol Vehicles, no external

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weather sensor data will be collected from these systems (i.e., only data from the vehicle) and there is no CAN Bus integration. To summarize, this Sub-system will include the abilities to:

- Receive TIMs via DSRC and Satellite (or other remote communication methods).
- Broadcast BSM Parts I and II.

In essence, these vehicles represent the capability to use vehicle data collected from trucks in the pilot. WYDOT anticipates that about 200 trucks will have these functionalities.

2.5.4 Retrofit Commercial Vehicle

This Sub-system is intended to simulate a commercial-off-the-shelf system—which is different from the one installed on the integrated commercial vehicles—that enables a vehicle to communicate data through DSRC to other connected devices and receive TIMs through DSRC or satellite. About 50 vehicles are expected in this category and their abilities include:

- Receive TIMs via DSRC and Satellite (or other remote communication methods).
- Broadcast BSM Parts I and II.

2.6 Pilot On-Board Applications

The WYDOT CV Pilot will develop five on-board applications that will provide key information to the drivers of equipped vehicles. In addition to on-board applications, information generated by the *Wyoming CV System* is planned to support ongoing WYDOT traffic management and traveler information services. WYDOT expects to use the information from the pilot for:

- Setting and removing VSLs along the I-80 corridor.
- Supporting 511 and other traveler information.
- Supporting road weather advisories and freight-specific travel guidance through WYDOT's CVOP.

The following subsections provide a view of the applications to be developed as for this Pilot.

2.6.1 Forward Collision Warning (FCW)

FCW is a V2V communication-based safety feature that issues a warning to the driver of the connected host vehicle in case of an impending front-end collision with a connected vehicle ahead in traffic in the same lane and direction of travel on both straight and curved geometry roadways as illustrated in Figure 2-3. FCW will help drivers avoid or mitigate front-to-rear vehicle collisions in the forward path of travel. This application is critically important for safety along I-80 in conditions when snow plows are moving slower than following traffic and/or when visibility may be limited due to adverse weather. The application does not attempt to control the host vehicle to avoid an impending collision. This application will follow the description from standard SAE J2945/1 March 2016 Section 4.2.4.

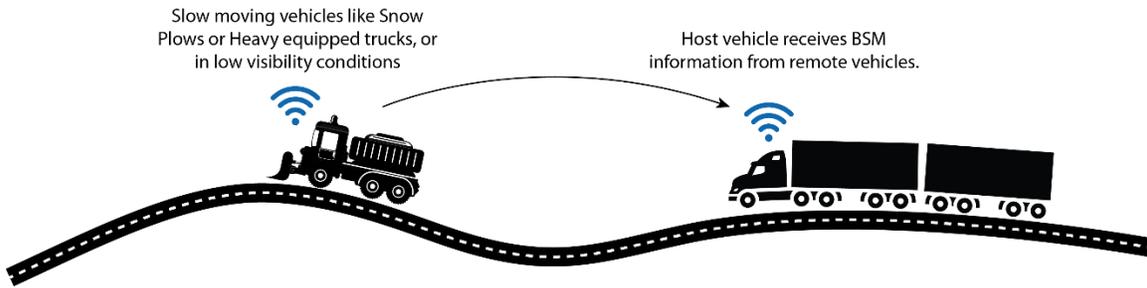


Figure 2-3. Forward Collision Warning Concept Diagram. (Source: WYDOT)

2.6.2 Infrastructure-to-Vehicle (I2V) Situational Awareness

One of the important promises of Connected Vehicle technology is the delivery of up-to-date travel information to drivers that impact their safety and mobility. The WYDOT CV Pilot will implement an I2V Situational Awareness application that assembles important travel information from back-office systems and communications that directly to drivers through both DSRC and satellite communications. This application enables delivery of relevant downstream road condition information to drivers along I-80 in Wyoming, including: Weather alerts, Speed restrictions, Vehicle restrictions, Road conditions, Incidents ahead, Truck parking⁵, and Road closures.

This information is expected to enhance both safety and traveler mobility along the corridor. The generic application is illustrated in Figure 2-4. It should be noted that the 402 miles of Wyoming I-80 is too long to provide cost effective DSRC communications coverage. Accordingly, the WYDOT CV Pilot will implement satellite-based communications to send situational awareness road condition information directly to satellite enabled connected vehicles along the entire length of Wyoming I-80, when out of range of DSRC communications. This application will follow the description from SAE J3067 August 2014 Section 2.9.3.6.

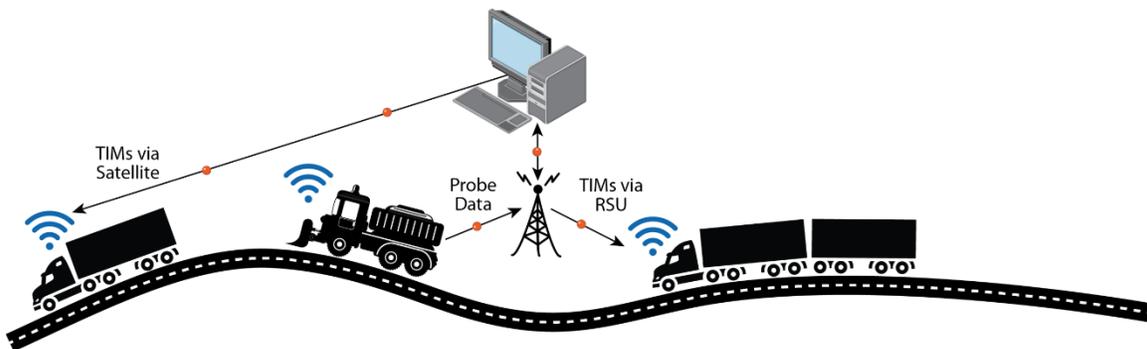


Figure 2-4. I2V Situational Awareness Concept Diagram. (Source: WYDOT)

2.6.3 Distress Notification (DN)

This application enables connected vehicles to communicate a distress status back to Wyoming CV System when the vehicle’s sensors detect an event that might require assistance from others (e.g., air bag deployed, vehicle disabled) or the vehicle’s operator manually initiates a distress

⁵ As part of this project, the WYDOT CV Pilot team will update the WYDOT 511 Application for personal information devices (e.g. smartphones) to capture crowdsourced truck parking information and to share that with commercial vehicle drivers, particularly during inclement road weather conditions

status. The vehicle generates and broadcasts a DN (e.g., Mayday) to the nearest RSU. The DN will include the location, time of message, distress message explanation, and vehicle category. The RSU forwards it on to the *Wyoming CV System* for notification of system operators and first responders.

Recognizing that this CV Pilot cannot provide continuous coverage of I-80 by RSUs, this application includes a V2V relay of DNs, illustrated in Figure 2-5. When a distressed vehicle (#1) is not within communication range of an RSU, the message is received by nearby connected vehicles (#2) traveling in the same and/or in opposite directions. These vehicles relay the Notification to the nearest RSU, whether upstream or downstream, which forwards it on to the *Wyoming CV System*. The relay function also enables vehicles traveling the opposite direction (#2), to inform vehicles upstream (#3), traveling in the same direction as the distressed vehicle, of the need for caution ahead.

Although this application is loosely based on the Mayday application description from SAE J3067 Section 3.5.9.2.1, it is built on a higher priority TIM communication using SAE J2735 March 2016, Section 5.16, Part 3, Integrated Transport Information System (ITIS) advisory elements.

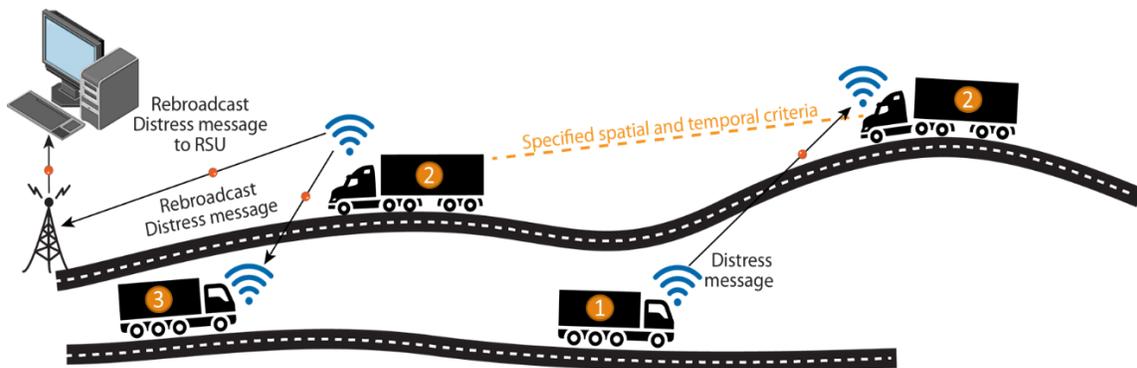


Figure 2-5. Distress Notification concept diagram (Source: WYDOT)

2.6.4 Work Zone Warning (WZW)

The WZW Application provides information about the conditions that exist in a work zone which the host vehicle is approaching (illustrated in Figure 2-6). This capability provides approaching vehicles with information about work zone activities that could present unsafe conditions for the workers or the host vehicle, such as obstructions in the vehicle’s travel lane, lane closures, lane shifts, speed reductions or vehicles entering/exiting the work zone. This application will follow the TIM WZW described in SAE J2735 March 2016 Part 3 in Section 6.142.

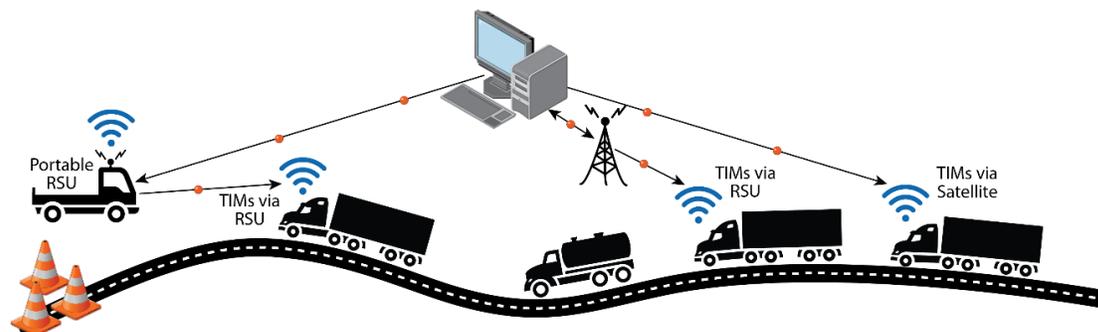


Figure 2-6. Work Zone Warning Concept Diagram. (Source: WYDOT)

2.6.5 Spot Weather Impact Warning (SWIW)

SWIW is a special case of I2V Situational Awareness that enables hazardous road condition information due to weather, such as fog or icy roads, to be broadcast from a RSU and received by the connected host vehicles (see Figure 2-7). This application, however, is distinct from other I2V Situational Awareness applications in that it provides more localized information (i.e., at the segment level instead of area wide or region wide). This application will follow the TIM advisory content from part 3 defined in SAE J2735 Section 6.142 for ITIS data elements 6.54 for weather conditions and 6.55 for winds defined in SAE J2540_2.

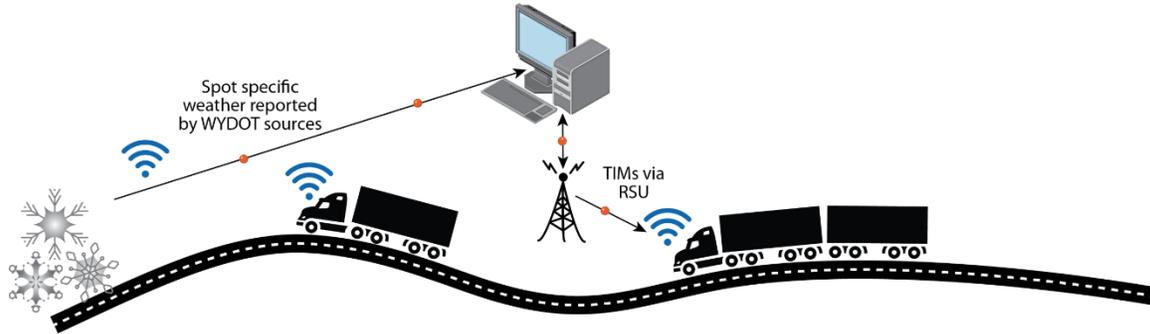


Figure 2-7. Spot Weather Impact Warning concept diagram (Source: WYDOT)

2.7 System Modes and States

This section describes the following modes of operation for the proposed system.

2.7.1.1 Normal Operations

During normal operations, the full suite of CV applications, described in Section 2.6 and 2.7, are available. Objects in the CV environment are being monitored by the WYDOT TMC and are functioning normally.

2.7.1.2 Degraded Mode

In a degraded mode, some of the vehicle or infrastructure objects in the CV environment are not functioning as intended. Depending on the nature of the degradation, different functions and processes are available. For example, *Vehicle System* malfunctions would limit the availability of on-board applications. Operations are limited to wide area advisories via 511 and the use of traditional ITS (DMS and HAR) for roadside communications through existing WYDOT interfaces. On the other hand, failure of specific RSUs in the proposed system can be managed with redundancy in RSU deployment and wide area communications (such as satellite).

2.7.1.3 Back-up Mode

In a back-up mode, some of the *Wyoming CV System* Sub-systems like the ODE, Pikalert, DB are not functioning as intended. Due to the risk associated with malfunctioning center system, all CV-related use-cases would be suspended and the proposed system would revert back to pre-CV state of operations.

2.8 Major System Constraints

The following constraints were identified during the conceptualization of the system and are considered as part of the system design:

- Vehicle to vehicle interactions are limited by the presence of connected vehicles in vicinity of each other during conditions of interest.
- Minimizing distraction to truck drivers is critical to any advisories and alerts issued by the system. Any in-vehicle advisory needs to be balanced with the demands of the driving tasks required of the truck driver during stressful conditions.
- Many important highway locations lack reliable, cost effective commercial power and communications services.
- The use of DSRC technology in the pilot will be guided by the IEEE 1609.2, 1609.3, and 1609.4 standards for Security, Network Services and Multi-Channel Operation (IEEE, 2016a, IEEE, 2016b; IEEE, 2016c), the SAE J2735 Message Set Dictionary (SAE, 2016b), and the recently released SAE J2945/1 Communication Minimum Performance Requirements standard (SAE, 2016a). As standards change and evolve, system requirements will continue to evolve.

2.9 User Characteristics

The following sections represent the user classes and other involved personnel in the proposed system.

2.9.1 Stakeholders

The following are the stakeholders, in no particular order, for the proposed system:

- U.S Department of Transportation
- WYDOT – Traffic, Construction, Maintenance, GIS/ITS, IT, Telecom Programs
- Wyoming Highway Patrol (WHP)
- Fleet Managers
- Wyoming Trucking Association
- Adjacent State DOTs
- Third party application developers
- System integrators and vendors

2.9.2 User Profiles

The following user profiles are directly impacted by the system.

Table 2-1. User Profiles in the Proposed System

User Group	Owner	Short Description	Changes to responsibilities and interaction with the system
1. Traffic Management Center - Operators	WYDOT	Traffic Management Operators responsible for managing advisory, control strategies from the TMC in	Personnel will have to factor new sources of data and information into their decision making. Their primary interface will be through the TRAC system which will

User Group	Owner	Short Description	Changes to responsibilities and interaction with the system
		Cheyenne. Responsible for VSL, DMS, Traffic Incident Management etc.	include information from the CV environment.
2. Highway Patrol - Dispatch	WYDOT	Personnel providing the dispatch and center capability for highway patrol on I-80. Includes port of entry operations. For the purpose of user needs, this group also includes State homeland security systems and personnel who are involved in emergency response when event-scale warrants emergency operations protocol. This group also manages the port-of entries and are responsible for commercial vehicle safety enforcement.	Will see increased communication about road conditions and incident notifications from the TMC as a result of the notifications from CV Pilot. No direct engagement with <i>Wyoming CV System</i>
3. ITS Maintenance	WYDOT	WYDOT maintenance staff specifically for Intelligent Transportation System (ITS) devices	ITS maintenance will be responsible for a new set of devices that need to be maintained as per the performance requirements
4. Fleet Management Centers	Various	Personnel and systems at participating fleet management centers who will receive information only from the CVOP.	These management centers will see new capabilities realized though improvements in the CVOP.
5. Snow Plow Operators	WYDOT	Operators of snow plow vehicles who are on the frontlines of weather event response. Personnel are also responsible for providing road condition updates and situational awareness of travel conditions on I-80.	Snow plow operators will see additional in-vehicle advisories and alerts on their human-machine interface. They will also continue their road condition updates
6. Highway Patrol – Field	WYDOT	Operators of highway patrol cars on I-80 who are on the frontlines for incident response, traffic control and enforcement on I-80. From a user needs perspective, this group also includes local police, fire and medical crews that provide first responder capability along the I-80 corridor. This group also manages the port-of entries and are responsible for commercial vehicle safety enforcement.	Field patrol officers will see additional in-vehicle advisories and alerts. They will also be responsible for setting up portable RSUs around incidents and work zones.
7. Commercial Truck Drivers	Various	Commercial truck drivers who travel the I-80 corridor as part of their freight movement with OBUs installed in their vehicles	<p>Drivers of Connected trucks will see a significant change to their driving environment including in- vehicle alerts and advisories through a new interface.</p> <p>Drivers may also see an increased amount of communication with their fleet managers and more location-specific information communicated to them.</p>

2.9.3 Interactions among user classes

A greater degree of interaction between the WYDOT TMC user groups and fleet management centers is expected to occur in the proposed system. Similarly, a greater degree of communication is required between WYDOT field personnel (snow plow and highway patrol) and the TMC to support truck advisories and warnings.

2.9.4 Other involved personnel

The following personnel are also involved in the operations of the proposed system:

- USDOT SCMS Operators – Personnel responsible for operating the SCMS.
- USDOT Impact Evaluation Contractor – Personnel involved in USDOT-sponsored impact evaluation.
- Third party application developers – Application developers with interest in using data products created by the proposed system.
- System vendors and integrators – Private sector system vendors and integrators involved in the development and operation of the proposed system.
- WYDOT 511 App Users – WYDOT 511 App users provide valuable information on road conditions and parking availability that will be used by the system to notify truckers.

2.9.5 User Needs

Through the process of identifying user needs, the team has identified what the project stakeholders want from the intended system. Three main groups of stakeholder needs include:

- i) Centers’ Needs, such as TMC, highway patrol (dispatch), and fleet management centers, truck facility operators, amongst others.
- ii) Field Needs, related to commercial truck drivers, personal auto travelers, maintenance supervisors, snow plow operators, and highway patrol (in the field).
- iii) Wide Area Needs, namely 511 phone, application and website consumers and media.

A detailed description of the stakeholder needs is provided in the *Connected Vehicle Pilot Deployment Program Phase I, Concept of Operations (ConOps)* Document (Gopalakrishna et al., 2015).

These stakeholder needs, which overlap with each other were combined and analyzed to develop the needs for the system. The following list of needs were identified for the system (Table 2-2). A traceability matrix that highlights the mapping between our system requirements and the needs provided in Section 6.

Table 2-2. User Needs for CV Pilot System

UN #	List of User Needs
1	Support warnings of impending forward collision in a host vehicle based on information received from a remote vehicle.
2	Support ability to provide situational awareness of road conditions on the corridor to an equipped vehicle
3	Support notification of distress conditions to and from equipped vehicles
4	Support notification of warnings about work zones to equipped vehicles
5	Support Spot Weather Impact Warnings to equipped vehicles
6	Support WYDOT Corridor Management & Traditional Traveler Information Program Services

UN #	List of User Needs
7	Need capability to monitor and update CV Pilot field devices system health (up-time, communication strength, device status) remotely during normal and adverse weather conditions
8	Need to develop human machine interface that minimizes the distraction and does not pose a burden on the work load of the driver.
9	Need capability through the pilot of logging time-stamped data for various pilot elements
10	Need a capability to collect, manage, store data collected from equipped fleets as part of the pilot
11	Need to be able to share data to/from vehicles to field, and back-office systems in both real-time and non-real time for various CV applications.
12	Need to ensure that data transfer is secure. Non-reputable, signed, and secured data sent and received by vehicles in this pilot
13	Need to be able to share mobile data at required latency for various pilot applications.

2.10 Dependencies and Assumptions

Some key assumptions and constraints are made in defining the features for the proposed system. The V2I requirements were built with SAE J3067 August 2014. The user needs were used with the operation scenarios from the Concept of Operations (Gopalakrishna et al., 2015) to identify and define the functional requirements from Section 3 onwards.

While some of the V2V requirements were used from J3067, in all cases where SAE J2945™/1 March 2016 had related V2V applications, the newer J2945/1 was used.

The current standard for basic safety messages within J2945/1 is for light vehicles and does not address heavy trucks or tractor-trailers. The CV pilot developers plan to extend the current specification to include trailer-related standards. For this, the CV pilot team will watch for an outcome in the form of a standard based on the NHTSA research project “V2V Basic Safety Message for Truck/CV Trailers.”

Additionally, SAE J2735™ March 2016 is used to update the outdated parts of the J3067 based on the new message set dictionary for DSRC. This document retains the original J3067’s system requirements numbers and descriptions in order to ensure compatibility with other CV projects and to provide clarity for future standards.

In cases where conflicting information is defined between the J2945/1, J2735, and J3067, J2945/1 will take initial precedence, followed by J2735 and finally J3067. The reason for this is J2945/1 is most specific and up to date for V2V safety communications and is there for most relevant to our pilot. J2735 is the second order of precedence because it has many updates to the message set that were not available when J3067 was written. J3067, while somewhat outdated is still relevant because it covers V2I communications and additional applications that are relevant to the Wyoming Pilot.

As J2945/2 and J2945/x become available the Wyoming Pilot will implement the standard interfaces and messages for Situation Awareness – Weather Condition Application, Situational Awareness Suboptimal Road Segment Conditions Applications and RWINFO for Freight Use Case if applicable and the pilot is not too far into implementation.

As for the assumptions, these include the following:

- During the pilot design and demonstration, the number of connected vehicles is expected to be a fraction of the I-80 truck traffic. However, as the rate of connectivity grows, the

system needs to be able to work with new on-board units on vehicles as they come on board. This necessitates a strong adherence to standards so that vehicles equipped with DSRC and on-board units are able to receive information from the infrastructure.

- Road weather forecasts by segment still will likely rely on a human meteorologist who is able to assimilate disparate datasets to generate a travel advisory. This does not apply for current observations or short-term alerts of impending conditions which may be based on reported conditions by connected vehicles directly.
- Cost-effective real-time monitoring of truck parking availability across the state of Wyoming can be accomplished through crowdsourcing interface in the WYDOT 511 App to support CV Pilot objectives. Due to budget constraints and project scope, equipping parking facilities with availability monitoring systems was not considered.
- USDOT-developed Security Certificate Management System (SCMS) can support secure communications as part of a larger security management framework developed for the proposed system. Evaluation is ongoing to select the PoC SCMS from CAMP or a commercial SCMS that will provide continued availability after the end of Phase 3.
- The USDOT developed ODE software is compatible with the 2016 version of J2735 and J2945/1 as well as the current version of the SCMS and the current version of the RSU specification. Additionally, the ODE is adequately scalable to support a 400-vehicle pilot.
- The USDOT developed Situational Data Clearinghouse is compatible with the 2016 version of J2735 and J2945/1 as well as the current version of the SCMS and the current version of the RSU specification. Additionally, the clearinghouse is adequately scalable to support the Wyoming pilot of about 400 additional vehicles.
- CAN Bus information is notoriously difficult to acquire due vehicle manufactures using different and proprietary codes sets. As such, this pilot will not attempt to use the standard CAN bus information (e.g., steering wheel angle, brake status, air bag deployment, traction control, antilock brake status and transmission status). While this information is helpful, it is not required.

An important constraint to note is the dependency on external standards and WYDOT documents that are currently being developed or have not been published yet.

3 External Interface Requirements

The CV Pilot System relies heavily on interfaces between various ongoing USDOT systems as well as existing WYDOT systems within the TMC. An additional interface is also defined to the weather enterprise which collects weather data from various external sources like NWS, NOAA, and Weather Data Environment (WDE) to support weather forecasting. The following interfaces are identified in this section:

- USDOT Interfaces
 - Security Credential Management System
 - Situation Data Exchange
 - Secure Data Commons
 - Research Data Exchange
- Location and Time Source Interface
- WYDOT Interfaces
 - 511 App
 - Third Party Interface
 - Transportation Reports and Action Console
 - Road Condition Reporting System
 - Wyoming Traveler Information
 - Commercial Vehicle Operator Portal
 - Incident Console
 - Construction Admin
 - WYDOT ITS Maintenance
- Weather Interface
 - External Data – NWS, NOAA Radar, WDE, others.
 - Fixed Data – RWIS

3.1 USDOT Interfaces

The following requirements apply to USDOT systems that will play a role in the CV Pilot. Several of these systems are undergoing modifications and updates to support future pilot activities. As their requirements change, the following requirements might be modified as well.

3.1.1 Security Credential Management System (SCMS)

SCMS-REQ-1 Wyoming CV System (WCVS) SCMS Use – The *Wyoming CV System* shall interface with the USDOT SCMS based on the requirements in the current version of the Security Credential Management System Proof-of-Concept Implementation EE Requirements and Specifications Supporting SCMS Software (available at <https://wiki.campllc.org/display/SCP/SCMS+CV+Pilots+Documentation>).

SCMS-REQ-1.1 SCMS Wyoming CV System Certificates – The *Wyoming CV System* shall download certificates from the USDOT SCMS.

SCMS-REQ-1.2 SCMS Wyoming CV System Misbehavior Reporting – The *Wyoming CV System* shall send misbehavior reports after they are published to the USDOT SCMS within 24 hours.

SCMS-REQ-1.3 SCMS Wyoming CV System Certificates Revocation List (CRL) – The *Wyoming CV System* shall download the CRL from the USDOT SCMS.

SCMS-REQ-1.4 SCMS Wyoming CV System Rejection – The *Wyoming CV System* shall reject messages received from any vehicles on the current CRL.

SCMS-REQ-2 Vehicle System SCMS Use – The *Vehicle System* used in the Wyoming Pilot shall be certified from a USDOT authorized testing facility based on the current version of the Security Credential Management System Proof-of-Concept Implementation EE Requirements and Specifications Supporting SCMS Software (available at <https://wiki.campllc.org/display/SCP/SCMS+CV+Pilots+Documentation>).

SCMS-REQ-2.1 SCMS Vehicle System Certificates – The *Vehicle System* shall download certificates from the USDOT SCMS.

SCMS-REQ-2.2 SCMS Vehicle System Misbehavior Reporting – The *Vehicle System* shall send misbehavior reports after they are defined to the USDOT SCMS.

SCMS-REQ-2.3 SCMS Vehicle System Certificates Revocation List (CRL) – The *Vehicle System* shall download and utilize the CRL from the USDOT SCMS.

SCMS-REQ-2.4 SCMS Vehicle System Rejection – The *Vehicle System* shall reject messages received from any vehicles on the current CRL.

3.1.2 Situation Data Exchange (SDX)

The SDX is a warehouse maintained currently by Tryhydro and may not be available going forward. This requirement is for general compliance with the national communication of TIMs and is one way that the Wyoming pilot can get TIMs to third parties for broader distribution. If the SDX becomes unavailable, the pilot can directly send TIMs to the third parties for distribution. The SDX is not required for the Wyoming pilot.

SDX-REQ-1 Data Provided to the SDX – The *Wyoming CV System* shall transmit traveler information messages (TIMs) generated by the system to the SDX within five minutes of generation. TIMs are formatted as defined in J2735 – 5.16 Message: MSG_TravelerInformation Message (TIM).

SDX-REQ-2 Distribute TIM to VS – The Situation Data Exchange shall distribute TIMs to the *Vehicle System* through satellite, as defined in WCVS-REQ-10.2 Distribute TIM to SDX.

3.1.3 Secure Data Commons (SDC)

SDC-REQ-1 Data Provided to the SDC – The *Wyoming CV System* shall transmit information to the Secure Data Commons.

3.1.4 Research Data Exchange (RDE)

RDE-REQ-1 Data Provided to the RDE – The *Wyoming CV System* shall transmit information to the Research Data Exchange.

3.2 Location and Time Source (LTS)

Location and time are obtained in accordance with J2945/1 and J2735.

LTS-REQ-1 WCVS Time – The *Wyoming CV System* shall acquire time as specified below.

LTS-REQ-1.1 WCVS LTS Time – The *Wyoming CV System* shall acquire time from the LTS interface in accordance with Section 5.10.1 of the ICD.

LTS-REQ-1.2 WCVS Time Synchronization – The *Wyoming CV System* shall receive time synchronization information from a Stratum 2 NTP source, as described in Section 5.12.1 of the ICD.

LTS-REQ-2 WCVS LTS Time Standard – The *Wyoming CV System* shall use Coordinated Universal Time (UTC) time for logged data (e.g., events logs and environmental data) based on the format defined in J2735 section 6.19 and epoch of January 1st 1970.

LTS-REQ-3 WCVS LTS Location – The *Wyoming CV System* shall acquire location from the LTS interface in accordance with J2945/1 section 6.2.1.

LTS-REQ-4 VS LTS Time – The *Vehicle System* shall acquire time from the LTS interface in accordance with Section 5.3.1 of the ICD.

LTS-REQ-5 VS LTS Time Standard – The *Vehicle System* shall use Coordinated Universal Time (UTC) time for logged data (e.g., events logs and environmental data) based on the format defined in J2735 section 6.19 and epoch of January 1st 1970.

LTS-REQ-6 VS LTS Location – The *Vehicle System* shall acquire location from the LTS interface in accordance with J2945/1 section 6.2.1.

3.3 WYDOT Interfaces

The following requirements are identified for existing WYDOT systems as they interact with the *Wyoming CV System*.

3.3.1 WYDOT 511 Application (511App)

The 511App will be used for collecting parking information from users of the App along I-80. Users will have the opportunity to enter parking availability for facilities along the corridor as part of the 511App interface, which will share the information with the *Wyoming CV System*.

511-REQ-1 511App Parking Data Collection – The *Wyoming CV System* shall receive parking status data from Wyoming 511 App.

511-REQ-1.1 Availability – The *Wyoming CV System* shall categorize parking availability for the facility of interest as follows: i) Full – No parking availability, ii) Spaces available, or iii) Only a few spaces available.

511-REQ-1.2 Default – The *Wyoming CV System* shall set parking availability default to available if not provided.

511-REQ-1.3 Time – The *Wyoming CV System* shall timestamp parking availability reports.

511-REQ-1.4 Location – The *Wyoming CV System* shall associate parking availability with a parking facility on I-80.

511-REQ-1.5 Protocol – The *Wyoming CV System* shall receive information, based on HTTP protocol, from the 511App.

511-REQ-1.6 Schema – The *Wyoming CV System* shall receive information based on the parking schema defined by WYDOT (WYDOT Truck Parking Map – as of 07/2016⁶).

511-REQ-2 Timeframe – The *Wyoming CV System* shall receive Parking availability data from the WYDOT 511 application within thirty minutes of generation.

3.3.2 WYDOT Third Party Interface (TPI)

As part of ongoing approaches to improve traveler information, WYDOT is creating a standardized interface that is based on the Traffic Management Data Dictionary (TMDD) standard that can be used to support delivery of traveler information to external centers and information service providers. The current approved TMDD standard (v3.03c) is being used to develop the interface. From the pilot perspective, the interface includes the following relevant TMDD user needs that will drive a specification based on the Needs to Requirements Traceability Matrix (NRTM) in the standard:

- 2.3.1 Need for Connection Management
- 2.3.2 Need to Provide Information on Organizations, Centers, and Contacts
- 2.3.3 Need to Share Event Information
- 2.3.4 Need to Provide Roadway Network Data
- 2.3.5.5 Need to Share Environment Sensor Data
- 2.3.5.6 Need to Share Lane Closure Gate Control

TPI-REQ-1 TPI Data – The *Wyoming CV System* shall transmit traffic condition information to the WYDOT TPI, as described in Section 5.36.1 of the ICD.

3.3.3 WYDOT Transportation Reports and Action Console (TRAC)

The TRAC is an operator console used in the TMC to monitor and manage planned, ongoing, and forecast events and actions on facilities monitored by the TMC. The TRAC provides a tabular list of actions that require operator attention. As events progress, operators mark actions as complete. The TRAC receives information from various sources available to the TMC (e.g., citizen reports, 511 App, RCRS, field reports) but can also include operator inputs. The TRAC interface is the primary interface for communicating information to the operators in the TMC.

TRAC-REQ-1 TRAC Updates – The *Wyoming CV System* shall transmit CV pilot events to the TRAC. CV-Pilot events are those generated by the *Wyoming CV System* that require operator attention as defined in the following requirements.

TRAC-REQ-1.1 Distress Notification – The *Wyoming CV System* shall transmit received distress notifications to TRAC. Distress notifications are defined in WCVS-REQ-1.3.

TRAC-REQ-1.1.1 Transmission Time – The *Wyoming CV System* shall transmit distress notifications to TRAC within five minutes of its generation in the system.

⁶<http://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Public%20Affairs/Maps/Truck%20parking%20map.pdf>

TRAC-REQ-1.2 Segment Alerts – The *Wyoming CV System* shall transmit segment-level alerts, defined in WCVS-REQ-4, to TRAC.

TRAC-REQ-1.2.1 Transmission Time – The *Wyoming CV System* shall transmit alerts to TRAC within five minutes of its generation in the system.

TRAC-REQ-1.2.2 Segment Alerts-Pikalert – The *Wyoming CV System* shall transmit Pikalert segment-level alerts, defined in WCVS-REQ-4, to TRAC.

3.3.4 WYDOT Road Condition Reporting (RCRS)

The RCRS is an Android-based app that is installed on snowplows. Snowplow operators input road and atmospheric condition based on their observations while on the road. This information is transmitted wirelessly back to the TMC. This information is used by the pilot system to improve road weather condition reporting and forecasting. The information is also used to make adjustments to speed limits and determine a maintenance response.

RCRS-REQ-1 RCRS Data Sharing – The *Wyoming CV System* shall receive road condition information from the RCRS.

RCRS-REQ-1.1 Road Condition – The *Wyoming CV System* shall receive road condition information from the RCRS following the 8 Code System. The 8 Code includes:

- 8-1 Dry Road
- 8-2 Wet Road
- 8-3 Slick
- 8-4 Slick Spots
- 8-5 Drifted Snow
- Black Ice
- Freezing Temps

RCRS-REQ-1.2 Weather – The *Wyoming CV System* shall receive atmospheric information from the RCRS following the 9 Code System. The 9 Code includes:

- 9-1 Favorable
- 9-2 Snowing
- 9-3 Raining
- 9-4 Strong Winds
- 9-5 Fog
- 9-6 Blowing Snow
- 9-7 Reduced Visibility

RCRS-REQ-1.3 Other Road Condition – The *Wyoming CV System* shall receive other road information from RCRS following the 10 Code System. The 10 Code includes:

- 10-7 Out of Service
- 10-45 Animal Carcass
- 10-46 Citizen Assist
- 10-50 Crash
- 10-54 Livestock
- Total Blockage
- Partial Blockage
- Slide Off
- Detour Available

RCRS-REQ-1.4 Report Time – The *Wyoming CV System* shall receive reports from RCRS containing a timestamp of when the operator entered the information into the app.

RCRS-REQ-1.5 Location – The *Wyoming CV System* shall receive reports from RCRS containing a location reference of when the operator entered the information into the app.

RCRS-REQ-1.6 Transmit Time – The *Wyoming CV System* shall receive reports from RCRS containing a timestamp of when the report was transmitted to the TMC. The transmitting timestamp may be different from the reporting time.

3.3.5 WYDOT Wyoming Traveler Information (WTI)

The WTI is a system that assembles information for various WYDOT traveler information resources. These resources include the 511App, 511 Phone System, website and text/email alert services.

WTI-REQ-1 WTI Inputs – The *Wyoming CV System* shall transmit CV Pilot event information to the WTI. CV-Pilot events are those generated by the *Wyoming CV System* as defined in the following requirements.

WTI-REQ-1.1 Current Segment Alerts – The *Wyoming CV System* shall transmit current segment-specific alerts, defined in WCVS-REQ-4, to the WTI.

WTI-REQ-1.1.1 Transmission Time – The *Wyoming CV System* shall transmit alerts within five minutes of its generation in the system to the WTI.

WTI-REQ-1.2 Forecast Segment Alerts – The *Wyoming CV System* shall transmit forecast segment-specific alerts, defined in WCVS-REQ-5, to the WTI.

WTI-REQ-1.2.1 Forecast Time – The *Wyoming CV System* shall transmit forecast reports to WTI for pre-specified forecast windows determined by WYDOT (6, 12, 24, 48, 72 hours).

WTI-REQ-1.2.2 Forecast Update – The *Wyoming CV System* shall update its forecast reports in WTI at WYDOT-determined intervals (every 12 hours for example).

WTI-REQ-2 WTI Outputs – The *Wyoming CV System* shall receive the current information for corridor roadway segments available from the WTI within five minutes of generation. Roadway segments are defined by WYDOT as sections of roadway between variable mileposts. Corridor information is defined by the following requirements.

WTI-REQ-2.1 Posted Speed – The *Wyoming CV System* shall receive notification that current posted speed for a segment is changed. This is applicable for only those segments on I-80 where variable speed limits are in operation. The notification includes the new posted speed.

WTI-REQ-2.2 Vehicle Restrictions – The *Wyoming CV System* shall receive the notification of vehicle restrictions that have been set for a roadway segment.

WTI-REQ-2.2.1 Restriction Information – The *Wyoming CV System* shall receive details on the restriction in effect for affected segments. Restrictions can consist of one or more of the following:

- Width restriction
- Height restriction
- Weight restrictions

- High-Profile restrictions
- Chain Law Level 1
- Chain Law Level 2

WTI-REQ-2.2.2 Restriction Start Time – The *Wyoming CV System* shall receive the start time of restrictions in effect for segments.

WTI-REQ-2.3 Posted Messages – The *Wyoming CV System* shall receive the notification of DMS messages that have been set in the corridor.

WTI-REQ-2.3.1 Message Information - The *Wyoming CV System* shall receive the content of the posted DMS message.

WTI-REQ-2.4 Posted Closures - The *Wyoming CV System* shall receive the notification of closures that have been set for a roadway segment.

WTI-REQ-2.4.1 Closure Beginning – The *Wyoming CV System* shall receive notification of the beginning point of the closure. Beginning point of the closure will be identified by the exit number on I-80.

WTI-REQ-2.4.2 Closure End – The *Wyoming CV System* shall receive notification of the ending point of the closure. Ending point of the closure will be identified by the exit number on I-80.

WTI-REQ-2.4.3 Closure Start Time – The *Wyoming CV System* shall receive notification of the starting time of the closure.

3.3.6 WYDOT Commercial Vehicle Operator Portal (CVOP)

The CVOP is a subscription-based website created by WYDOT for providing advanced notification for commercial travelers and fleet managers. Currently there are over 800 companies subscribed to the CVOP. The CVOP today is restricted to providing forecasted weather information for segments on I-80. Planned enhancements to the CVOP include providing current information from the CV Pilot system.

CVOP-REQ-1 CVOP Inputs – The *Wyoming CV System* shall transmit CV Pilot event information to the CVOP. CV-Pilot events are those generated by the *Wyoming CV System* as defined in the following requirements.

CVOP-REQ-1.1 Current Segment Alerts – The *Wyoming CV System* shall transmit current segment-specific alerts, defined in WCVS-REQ-4, to the CVOP.

CVOP-REQ-1.1.1 Transmission Time – The *Wyoming CV System* shall transmit alerts within five minutes of its generation in the system to the CVOP.

CVOP-REQ-1.2 Forecast Segment Alerts – The *Wyoming CV System* shall transmit forecast segment-specific alerts, defined in WCVS-REQ-5, to the CVOP.

CVOP-REQ-1.2.1 Forecast Time – The *Wyoming CV System* shall transmit forecast reports to the CVOP for pre-specified forecast windows determined by WYDOT (6, 12, 24, 48, 72 hours).

CVOP-REQ-1.2.2 Forecast Update – The *Wyoming CV System* shall update its forecast reports in CVOP at WYDOT-determined intervals (every 12 hours for example).

3.3.7 WYDOT Incident Console (IC)

WYDOT Incident Console is an operator system that is used to record incidents on the corridor. Incidents can be reported by various methods including field reports from highway patrols, visual inspection, and maintenance field personnel. This information needs to be communicated with the CV Pilot system.

IC-REQ-1 IC Data Sharing – The *Wyoming CV System* shall receive timestamped incident information from the IC.

IC-REQ-2 Protocol – The *Wyoming CV System* shall receive incident information, based on HTTP protocol, from the IC. The HTTP protocol used will be based on the six part specifications RFC 7230-RFC 7235.

IC-REQ-3 Schema – The *Wyoming CV System* shall receive incident information from WYDOT IC, as described in Section 5.31.1 of the ICD.

IC-REQ-4 Transmission – The *Wyoming CV System* shall receive Road Incident data from WYDOT Incident Console within five minutes of generation.

3.3.8 WYDOT Construction Administration (CA)

WYDOT Construction Administration (CA), also known as ConAdmin, is an operator-based system that logs various planned work zone related activities on the I-80 corridor.

CA-REQ-1 CA Data Sharing – The *Wyoming CV System* shall receive timestamped work zone information from the CA.

CA-REQ-2 Protocol – The *Wyoming CV System* shall receive work zone information, based on HTTP protocol, from the CA.

CA-REQ-3 Schema – The *Wyoming CV System* shall receive work zone information from WYDOT CA, as described in Section 5.32.1 of the ICD.

CA-REQ-4 Transmission – The *Wyoming CV System* shall receive work zone data from WYDOT Construction Administrator within thirty minutes of generation.

3.3.9 WYDOT ITS Maintenance

WYDOT ITS Maintenance is an interface to the team deployed to repair ITS gear in the field and the TMC based on alerts from monitoring systems defined in Section 4.1.6 of the SyRS.

ITSM-REQ-1 WYDOT ITS Alerts – The *Wyoming CV System* shall send alerts, defined in *WCVS-REQ-16*, to the WYDOT ITS Maintenance team within five minutes of a system becoming unavailable.

3.4 Weather Interface (WI)

WI-REQ-1 External Data Acquisition – The *Wyoming CV System* shall collect weather information from external sources, as defined in the Section 4.1 - Data Ingest Module Requirements of the *Motorist Alert and Warning Application* (NCAR, 2014). The external weather information may consist of one or more of the following sources:

- NWS watches and warnings, including county-based and polygon-based data.
- NWS storm reports, including hail, wind, and tornado data.

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- NWS radar data.
- Weather model data
 - Global Forecast System (GFS),
 - North American Mesoscale Forecast System (NAM)
 - High-Resolution Rapid Refresh (HRRR).
- NOAA remote sensing data.
- NOAA single polarization radar data.
- NOAA satellite data.
- USDOT Weather Data Environment

WI-REQ-2 Fixed Data Acquisition – The *Wyoming CV System* shall receive road weather information system (RWIS) data from the WYDOT RWIS Server as defined in Section 4.1 – Data Ingest Module Requirements of the Motorist Alert and Warning Application (NCAR, 2014).

4 System Requirements

The following sections provide the system and Sub-system requirements for the CV pilot.

4.1 Wyoming CV System (WCVS) Requirements

The *Wyoming CV System* includes the infrastructure used in the pilot and back-office systems in charge of the various processes that lead to the generation and distribution of advisories and alerts to the *Vehicle System*. The *Wyoming CV System* will be located at the WYDOT TMC.

4.1.1 Collect CV Information

The following set of requirements pertain to the ability to collect data from the *Vehicle System*.

WCVS-REQ-1 Collect CV Data – The *Wyoming CV System* shall collect data from the *Vehicle System*.

WCVS-REQ-1.1 Collect BSM Data – The *Wyoming CV System* shall collect Basic Safety Message Parts I and II (as defined in J2945/1) from the *Vehicle System* consistent with Section 6.3.8 (BSM Scheduling and Congestion Control) of J2945/1.

WCVS-REQ-1.2 Collect Environmental Sensor Data – The *Wyoming CV System* shall collect environment sensor data using secure copy (SCP) from the *Vehicle System* consistent with secure shell (SSH).

WCVS-REQ-1.3 Collect Distress Messages – The *Wyoming CV System* shall collect distress messages using the Traveler Information Message (as defined in section 5.16 of J2735) from the *Vehicle System* consistent with Section 3.5.8 (Traveler Information Requirements) of J3067.

WCVS-REQ-2 Validate Data – The *Wyoming CV System* shall provide validation- and sanitization-related functions of CV Data as defined in Section 3.1.4.1 of the SDD.

4.1.2 Generate Alerts and Advisories

The following set of requirements pertain to the ability of the system to generate current and forecast road condition information based on the inputs received. Segment-level alerts are contained within TIMs and provide information related to Weather, Road Condition, Construction, Incident and Truck Parking, or a combination of, that is linked to a specific spatial area that is described following Section 6.30 Data Frame: DF_GeographicalPath of J2735.

WCVS-REQ-3 Ingest Data for Road Weather information – The *Wyoming CV System* shall use one or more of the following sources of data to generate road weather information:

- Collected CV Information defined in WCVS-REQ-1.
- Segment road and weather conditions from the WYDOT RCRS in RCRS-REQ-1.
- Weather conditions from weather interfaces defined in WI-REQ-1 and WI-REQ-2.

WCVS-REQ-4 Contents of Alerts and Advisories – The *Wyoming CV System* shall generate alerts and advisories of roadway hazard conditions as defined in the following requirements:

WCVS-REQ-4.1 Precipitation Hazard – The *Wyoming CV System* shall generate a precipitation type and intensity report every 5 minutes, as specified in Section 3.1.4.2 of the SDD.

WCVS-REQ-4.2 Road Condition Hazard – The *Wyoming CV System* shall generate a pavement state and slickness flag report every 5 minutes, depending on input data, as specified in Section 3.1.4.2 of the SDD.

WCVS-REQ-4.3 Visibility Hazard – The *Wyoming CV System* shall generate a visibility report, along with the condition causing it, every 5 minutes, as specified in Section 3.1.4.2 of the SDD.

WCVS-REQ-4.4 Work Zone Hazard – The *Wyoming CV System* shall generate a work zone report within 5 minutes of receiving work zone information from the Construction Administration (defined in CA-REQ-1), as specified in Section 3.1.5.4 of the SDD.

WCVS-REQ-4.5 Incident Hazard – The *Wyoming CV System* shall generate an incident report within 5 minutes of receiving incident notifications from the Incident Console (defined in IC-REQ-1), as specified in Section 3.1.4.3 of the SDD.

WCVS-REQ-4.6 Parking – The *Wyoming CV System* shall generate a parking report within 5 minutes of receiving parking availability notification, as specified in Section 3.1.4.3 of the SDD.

WCVS-REQ-5 Forecast Conditions – The *Wyoming CV System* shall generate forecasts of conditions as defined in the following requirements:

WCVS-REQ-5.1 Atmospheric Forecasts – The *Wyoming CV System* shall produce atmospheric weather forecasts, at a minimum, for (a) atmospheric temperature, (b) probability of precipitation, (c) wind speed, and (d) wind direction.

WCVS-REQ-5.2 Road Weather Forecasts – The *Wyoming CV System* shall produce road weather forecasts, at a minimum, for (a) pavement temperature, and (b) subsurface temperature.

WCVS-REQ-5.3 Forecast Time – The *Wyoming CV System* shall generate forecast reports for customizable forecast windows. The windows of interest will be determined by WYDOT (6, 12, 24, 48 hours for example).

WCVS-REQ-5.4 Forecast Update – The *Wyoming CV System* shall generate forecast updates for customizable intervals. The update frequency will be determined by WYDOT and may vary based on time of year (every 3 hours for example in winter to 12 hours during summer).

WCVS-REQ-6 Associate Alerts and Forecast to Segments – The *Wyoming CV System* shall associate each alert and forecast to one or more road segments on I-80. Roadway segments are defined by WYDOT as sections of roadway between variable mileposts.

4.1.3 Support Information Brokerage

The following set of requirements pertain to how the information in the Wyoming CV system will be brokered between various external interfaces.

WCVS-REQ-7 External Brokerage with WYDOT Interfaces – The *Wyoming CV System* shall transfer data with WYDOT systems as defined in WCVS-REQ-7.1 and WCVS-REQ-7.2.

WCVS-REQ-7.1 Receive from WYDOT External Interfaces – The *Wyoming CV System* shall receive data from WYDOT systems as defined in 511-REQ-1, RCRS-REQ-1, WTI-REQ-2, IC-REQ-1, and CA-REQ-1.

WCVS-REQ-7.2 Distribute to WYDOT External Interfaces – The *Wyoming CV System* shall distribute information to WYDOT systems as defined in TPI-REQ-1, TRAC-REQ-1, WTI-REQ-1, CVOP-REQ-1, and ITSM-REQ-1.

WCVS-REQ-8 Internal Brokerage – The *Wyoming CV System* shall support internal brokerage of data as defined in RSU-REQ-1, RSU-REQ-2, ODE-REQ-1, ODE-REQ-3, PA-REQ-2, PA-REQ-4, DB-REQ-4, DB-REQ-5, DB-REQ-6, DB-REQ-7, DW-REQ-1, DW-REQ-2, DW-REQ-4, HSM-REQ-1, HSM-REQ-2, HSM-REQ-3, and HSM-REQ-4.

4.1.4 Distribute TIMs

The following set of requirements pertain to the development and distribution of the TIM from the *Wyoming CV System* to the *Vehicle System* and the Situation Data Exchange (SDX)

WCVS-REQ-9 Create TIM – The *Wyoming CV System* shall create a Traveler Information Message (TIM) formatted as defined in J2735 – 5.16 Message: MSG_TravelerInformation Message (TIM). The TIM is used to send various types of information (advisory and road sign types) to equipped devices. It makes heavy use of the ITIS encoding system to send well known phrases, but allows limited text for local place names. The supported message types specify several sub-dialects of ITIS phrase patterns to further reduce the number of octets to be sent. The expressed messages are active at a precise start and duration period, which can be specified to a resolution of a minute. The affected local area can be expressed using either a radius system or one of the systems of short defined regions, similar to the way roadway geometry is defined in the MAP messages

WCVS-REQ-10 Distribute TIM – The *Wyoming CV System* shall distribute signed TIMs to the *Vehicle System* and the Situation Data Exchange (SDX).

WCVS-REQ-10.1 Distribute TIM to VS – The *Wyoming CV System* shall distribute signed TIM to the *Vehicle System* consistent with Section 3.5.8 (Traveler Information Requirements) of J3067.

WCVS-REQ-10.2 Distribute TIM to SDX – The *Wyoming CV System* shall distribute signed TIM to the SDX consistent with Section 3.5.8 (Traveler Information Requirements) of J3067. The SDX may not be available going forward. This requirement is for general compliance with the national communication of TIMs and is one way that the Wyoming pilot can get TIMs to third parties for broader distribution. If the SDX becomes unavailable, the pilot can directly send TIMs to the third parties for distribution. The SDX is not required for the Wyoming pilot.

4.1.5 Store Data

The following requirements pertain to the storage of data in the *Wyoming CV System*.

WCVS-REQ-11 Store VS Data – The *Wyoming CV System* shall store processed data collected by the *Vehicle Systems* and retain it for the duration of the CV Pilot. Data Processing is defined in ODE-REQ-2.

WCVS-REQ-11.1 Store BSM – The *Wyoming CV System* shall store processed BSM Parts I and II data received from the *Vehicle System*. As the BSM will be previously validated, only core data elements will be stored (defined in sections 6.8, 6.147, 6.128, and 6.133 of J2735).

WCVS-REQ-11.2 Store Environment Sensor Data – The *Wyoming CV System* shall store processed environment sensor data consistent with Section 5.19.2 of the ICD.

WCVS-REQ-11.3 Store Distress Messages – The *Wyoming CV System* shall store processed distress messages using the Traveler Information Message (as defined in section 5.16 of J2735) received from the *Vehicle System* consistent with Section 3.5.8 (Traveler Information Requirements) of J3067. As the distress message will be previously validated, only core data will be stored (defined in sections 5.16, and 6.142 of J2735).

WCVS-REQ-12 Store Generated Alerts/Advisories – The *Wyoming CV System* shall store generated road weather alerts and advisories (defined WCVS-REQ-4) and retained for the duration CV Pilot.

WCVS-REQ-13 Store TIM – The *Wyoming CV System* shall store TIMs distributed to the *Vehicle System* and the Situation Data Exchange (SDX) and retain it for the duration of the CV Pilot.

WCVS-REQ-14 Store System Monitoring Data – The *Wyoming CV System* shall store system monitoring data, as defined by WCVS-REQ-16 Monitored Functions, and retain it for the duration of the CV Pilot.

4.1.6 Manage and Maintain System

WCVS-REQ-15 Notifications – The *Wyoming CV System* shall notify designated personnel within five minutes of a monitored function becoming unavailable.

WCVS-REQ-16 Monitored Functions – The *Wyoming CV System* shall monitor the functions described in WCVS-REQ-16.1 through WCVS-REQ-16.4.

WCVS-REQ-16.1 Sub-System Availability – The *Wyoming CV System* shall monitor the Sub-systems for availability of ping services running. The WYDOT maintenance team will be sent a notification after a device, web service or running service is non-responsive for five minutes.

WCVS-REQ-16.2 Sub-System Performance – The *Wyoming CV System* shall monitor the system's ability to transmit information in a timely manner. This will be done by monitoring message input queues age of oldest entry not processed. If the messages are not processed within five minutes the WYDOT maintenance team will be notified.

WCVS-REQ-16.3 Availability for Interfaces – The *Wyoming CV System* shall monitor the external interfaces for availability of ping services running. The WYDOT maintenance team will be sent a notification after a device, web service or running service is non-responsive for five minutes.

WCVS-REQ-16.4 Availability for Data Storage – The *Wyoming CV System* shall monitor available data storage of ping services running. The WYDOT maintenance team will be sent a notification after a device, web service or running service is non-responsive for five minutes. Notification will also be sent for disk space under 10% availability.

WCVS-REQ-17 Archive Data – The *Wyoming CV System* shall provide the TMC administrator the ability to archive data used by the CV pilot by writing CV data to the WYDOT Data

Warehouse, data written to the Data Warehouse is automatically archived per existing TMC best practices.

WCVS-REQ-18 Management and Performance Policy – The *Wyoming CV System*'s infrastructure-related elements shall manage the policy for data collection and performance data following requirements defined in *Appendix B.4 RSU Performance Data* of the SyRS.

~~**WCVS-REQ-19 Manage Architecture** – The *Wyoming CV System*'s infrastructure-related elements shall conform to the core architecture requirements defined in *Appendix A* of the SyRS. This requirement no longer applies to this system.~~

WCVS-REQ-20 Manage Safe Communications – The *Wyoming CV System*'s infrastructure-related elements shall conform to the core safety communications requirements defined in *Appendix B.2 V2I Core Safety Communication Requirements* of the SyRS.

WCVS-REQ-21 Manage CV Equipment – The *Wyoming CV System* shall provide the TMC administrator the ability to add/edit/delete equipment from the internal inventory list.

WCVS-REQ-22 Test WCVS Equipment – The *Wyoming CV System* shall provide the TMC administrator the ability to test the RSUs by allowing a series of Python testing scripts to be run on an RSU and results of the test returned to the user.

WCVS-REQ-23 Track WCVS Equipment – The *Wyoming CV System* shall provide the TMC administrator the geolocation of RSUs.

WCVS-REQ-24 Update WCVS Equipment – The *Wyoming CV System* shall provide the TMC administrator the ability to push out updates to the RSU firmware.

WCVS-REQ-25 Update VS Equipment – The *Wyoming CV System* shall provide the TMC administrator the ability to push out OTA updates to the OBU firmware.

4.2 Vehicle System (VS) Requirements

The *Vehicle System* represents the deployment of on-board units, sensors, and a human-machine interface that will support CV applications. The following set of requirements provide the system-level requirements for the vehicle systems

4.2.1 Receive CV Information

VS-REQ-1 Receive BSM – The *Vehicle System* shall receive Basic Safety Message (as defined in SAE J2945/1) over DSRC from other connected vehicles consistent with Section 6.3.8 of SAE J2945/1 (BSM Scheduling and Congestion Control).

4.2.2 Receive TIMs

VS-REQ-2 Receive TIM – The *Vehicle System* shall wirelessly receive a packet containing traveler information from the *Wyoming CV System*. Each packet may contain one or more individual traveler information message as defined in Section 5.16 of SAE J2735.

VS-REQ-2.1 Receive TIM through DSRC – The *Vehicle System* shall wirelessly receive a packet containing traveler information from the *Wyoming CV System* through DSRC.

VS-REQ-2.2 Receive TIM through Satellite – The *Vehicle System* shall wirelessly receive a packet containing traveler information from the *Wyoming CV System* (via the Situation Data Exchange) through satellite.

VS-REQ-3 Receive Distress Information – The *Vehicle System* shall wirelessly receive a packet containing distress information from other connected vehicles over DSRC. Distress information is a high priority messages based on the received distress broadcast (defined in J3067 3.5.9.2.1), but has the content of the TIM (defined in J2735 5.16 Part III advisory ITIS data elements 6.1 from J2540-2 Accidents and Incidents).

4.2.3 Collect Vehicle and Environmental Data

VS-REQ-4 Collect Vehicle Data – The *Vehicle System* shall have the capability to collect vehicle information from the host vehicle and the driver as stated below.

VS-REQ-4.1 Collect Vehicle Status Data – The *Vehicle System* shall have the capability to collect vehicle status information from the host vehicle, as stated in Section 5.4.2 of the ICD.

VS-REQ-4.2 Collect Dimension Data – The *Vehicle System* shall have the capability to collect information from the host vehicle driver. The VS will maintain these values across power cycles and OTA updates. The data will be included in BSMs broadcasted by the Vehicle System. The list of fields are shown in Table 7-1 of the ICD, where column #1 contains the value "yes/driver".

VS-REQ-4.2.1 Vehicle Dimension Data – The *Vehicle System* shall have the capability to collect vehicle dimension from the host vehicle driver through the Human Machine Interface.

VS-REQ-4.2.2 Vehicle Trailer Data – The *Vehicle System* shall have the capability to collect information from the host vehicle driver regarding the dimensions of attached trailers, including capability to indicate that no trailer is present, through the Human Machine Interface.

VS-REQ-5 External Environment Sensor Data – The *Vehicle System* shall collect additional environmental sensor data from host vehicles equipped with external environmental sensors. Additional data collected from external environmental sensors is shown in Table 7-4 of the Interface Control Document.

VS-REQ-5.1 External Environment Sensor Data Configuration – The collection of sensor data by the *Vehicle System* shall be configurable as specified in Section 3.2.5.1 of the SDD.

VS-REQ-5.2 External Environment Sensor Data Management– The application shall support a data management mechanism, specified in Section 3.2.5.1 of the SDD.

4.2.4 Manage and Process Information for On-Board Applications

The following five applications are included in the *Vehicle System*.

4.2.4.1 Forward Collision Warning (FCW)

Forward Collision Warning is a vehicle-to-vehicle (V2V) communication-based safety feature that issues a warning to the driver of the connected host vehicle in case of an impending front-end collision with a connected vehicle ahead in traffic in the same lane and direction of travel on both

straight and curved geometry roadways. This application will follow the description from J2945/1 March 2016 Section 4.2.4.

VS-REQ-6 FCW Stopped Vehicles – The *Vehicle System* shall ingest BSM Parts I and II data received from remote vehicles to identify stopped remote vehicles directly ahead in the same lane and direction of travel (defined in J2945/1 section 4.2.4.2 (a)). Data ingest is defined as obtaining and importing data for use or storage.

VS-REQ-7 FCW Decelerating/Slow Moving Vehicles – The *Vehicle System* shall ingest BSM Parts I and II data received from remote vehicles to identify decelerating or slower moving remote vehicles directly ahead in the same lane and direction of travel (defined in J2945/1 section 4.2.4.2 (c)). Data ingest is defined as obtaining and importing data for use or storage

VS-REQ-8 FCW Stopped and Obstructed Vehicles – The *Vehicle System* shall ingest BSM Parts I and II data received from remote vehicles to identify stopped and obstructed remote vehicles directly ahead in the same lane and direction of travel (defined in J2945/1 section 4.2.4.2 (d)). Data ingest is defined as obtaining and importing data for use or storage

VS-REQ-9 FCW Rear-End Crash – The *Vehicle System* shall ingest BSM Parts I and II data received from remote vehicles to identify imminent danger of a rear-end crash with a remote vehicle in its lane of travel (defined in J2945/1 section 4.2.4.3). Data ingest is defined as obtaining and importing data for use or storage.

VS-REQ-9.1 Rear-End Crash in Straight Road – The *Vehicle System* shall identify imminent danger of a rear-end crash with a remote vehicle in its lane of travel in a straight roadway geometry.

VS-REQ-9.2 Rear-End Crash in Curved Road – The *Vehicle System* shall identify imminent danger of a rear-end crash with a remote vehicle in its lane of travel in a curved roadway geometry.

VS-REQ-10 FCW No Warning – The *Vehicle System* shall ingest BSM Parts I and II data received from remote vehicles to identify when there is no need to display a warning on the HMI of the host vehicle. Data ingest is defined as obtaining and importing data for use or storage.

VS-REQ-10.1 Safely Following a Vehicle – The *Vehicle System* shall identify when no imminent danger of a rear-end crash is present with a remote vehicle in its lane of travel in common roadway geometries.

VS-REQ-10.2 Passing a Stopped Vehicle – The *Vehicle System* shall identify when no imminent danger of a rear-end crash is present with a remote vehicle that is stopped and not in its lane of travel in common roadway geometries.

4.2.4.2 I2V Situational Awareness (SA)

This application enables relevant downstream road condition information including weather alerts, speed restrictions, vehicle restrictions, road conditions, incidents, parking, and road closures to be broadcast from a roadside unit and received by the connected host vehicle. Such information is useful to connected host vehicles that are not fully equipped with weather sensors or to connected host vehicles in paths toward or entering areas with hazardous conditions. The Wyoming pilot will extend this application to use full coverage of the I-80 corridor with satellite communications to send road condition information directly to selected connected vehicles. This step is important for mitigating the short range and sparse placement of RSUs along the corridor. This application will follow the description from J3067 August 2014 Section 2.9.3.6.

VS-REQ-11 SA TIM-Advisories – The *Vehicle System* shall ingest received TIMs to identify advisories (Part III content choice ITIS.ITIScodesAndText defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage

VS-REQ-12 SA TIM-Speed Limit – The *Vehicle System* shall ingest received TIMs to identify speed limits (Part III content choice speedLimit defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage

VS-REQ-13 SA TIM-Exit Services – The *Vehicle System* shall ingest received TIMs to identify Exit Services (Part III content choice exitService defined in J2735 section 6.142). This is used to provide parking information if necessary. Data ingest is defined as obtaining and importing data for use or storage

VS-REQ-14 SA TIM-Region – The *Vehicle System* shall ingest received TIMs to identify the applicable regions of use geographical path (Part II defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage

4.2.4.3 Distress Notification (DN)

Distress Notification provides the capability for the vehicle system to broadcast and transmit an emergency message when either the host or a remote vehicle has been involved in a crash or other distress situation. Distress notification application will not be available on all Vehicle Systems (see RFV-REQ-5)

VS-REQ-15 Distress Notification ID – The *Vehicle System* shall identify received distress notifications. Distress information is a high priority messages loosely based on the mayday broadcast (defined in J3067 3.5.9.2.1), but has the content of the TIM (defined in J2735 5.16 Part III advisory ITIS data elements 6.1 from J2540_2 Accidents and Incidents).

VS-REQ-15.1 Log – The *Vehicle System* shall log received distress notifications to include the DNM.

VS-REQ-16 Create Distress Notification – The *Vehicle System* shall have the ability to generate a distress notification.

~~**VS-REQ-16.1 System-Generated Distress Notification** – The *Vehicle System* shall have the ability to self-generate a distress notification when the vehicle Event Status reports airbag deployment or disabled vehicle code. Vehicle Status data is specified in Section 5.4.2 of the IGD. This requirement no longer applies to this Pilot.~~

VS-REQ-16.2 Driver-Generated Distress Notification – The *Vehicle System* shall have the ability to generate a distress notification when the vehicle operator selects the distress notification activation alternative in the HMI.

VS-REQ-17 DNM-Region – The *Vehicle System* shall ingest received DNMs to identify the applicable regions of use geographical path (Part II defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage.

VS-REQ-18 DN PSID – The *Vehicle System* shall use a unique high priority Provider Service Identifier (PSID) for the distress notification application as per IEEE 1609.12.

4.2.4.4 Work Zone Warning (WZW)

Work Zone Warnings provides information about the conditions that exist in a work zone to vehicles that are approaching the work zone.

VS-REQ-19 WZW TIM – The *Vehicle System* shall ingest received TIMs to identify work zone warnings (Part III content choice workZone defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage.

VS-REQ-20 WZW TIM-Region – The *Vehicle System* shall ingest received TIMs to identify the applicable regions of use geographical path (Part II defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage.

4.2.4.5 Spot Weather Impact Warning (SWIW)

Spot Weather Impact Warning will alert drivers to unsafe conditions or road closure at specific points on the downstream roadway as a result of weather-related impacts (e.g., high winds, flood conditions, ice, and fog).

VS-REQ-21 SWIW TIM – The *Vehicle System* shall ingest received TIMs to identify advisories for wind and weather conditions (Part III content choice advisories defined in J2735 section 6.142 for ITIS - data elements 6.54 Weather Conditions and 6.55 Winds defined in J2540_2). Data ingest is defined as obtaining and importing data for use or storage.

VS-REQ-22 SWIW TIM-Region – The *Vehicle System* shall ingest received TIMs to identify the applicable regions of use geographical path (Part II defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage.

4.2.5 Provide In-Vehicle Application Alerts (IVAA)

The following requirements pertain to providing in-vehicle application alerts.

VS-REQ-23 IVAA Rank – The *Vehicle System* shall provide prioritized in-vehicle alerts based on the rank order presented in Table 4-1 of the SyRS, with the highest rank on top.

Table 4-1. Rank order of in-vehicle alerts.

Message	Details
Forward Collision Warning	Specified in Section 4.2.4 SAE J2945/1
Distress Message	Distressed vehicle ahead within five miles
TIM	Spot Weather
TIM	Work Zone Warning
TIM	Variable Speed Limit

VS-REQ-24 IVAA Level – The *Vehicle System* shall have three levels of alert, as described in Table 4-2 of the SyRS.

Table 4-2. Levels of alert of the *Vehicle System*.

Alert Level	Description
None	No alert to issue
Inform message	Inform vehicle operator about upcoming alerts or advisories (one low volume beep followed by an HMI message)
Warning 1	Early warning for a dangerous situation (medium volume beep followed by an HMI message)
Warning 2	Urgent warning to take immediate action (three loud volume beeps followed by an HMI message)

VS-REQ-25 IVAA Priority Alert – The *Vehicle System* shall provide only the highest priority alert to the vehicle operator when more than one alert is currently active.

VS-REQ-26 IVAA FCW – The *Vehicle System* shall alert the vehicle operator for forward collision warning based on the warning distance calculation algorithm in Section 3.1 of the “Connected Commercial Vehicles—Retrofit Safety Device Kit Project, Safety Applications and Development Plan” (FHWA-JPO-14-106) and guidance for FCW Time-to Collision, Advisories and Alerts provided in SyRS Section 6.1.1 This could be an inform message, warning 1 or warning 2 based on the calculated deceleration rate required. During the design phase a deceleration rate will be selected for a warning 1 and for warning 2 based on vehicle type and weight.

VS-REQ-27 IVAA DN – The *Vehicle System* shall alert the vehicle operator for a distress message when the direction of travel of the host vehicle moving toward the distressed vehicle and is within five miles of the location of a distressed vehicle using an inform message. Distress Notification functionality is described in Section 2.6.3 of the SyRS.

VS-REQ-28 IVAA SA-Advisory – The *Vehicle System* shall alert the vehicle operator for a situational awareness advisory using an inform message when the host vehicle is traveling towards the segment where the situational awareness applies.

VS-REQ-29 IVAA SA-VSL – The *Vehicle System* shall inform the vehicle operator of the current speed limit of the variable speed limit zone. The current speed limit and the variable speed limit zone are provided by the TIM.

VS-REQ-30 IVAA SWIW – The *Vehicle System* shall alert the vehicle operator of a spot weather incident when the host vehicle is traveling toward the incident’s location using an inform message (Spot Weather functionality is described in Section 2.6.5 of the SyRS).

VS-REQ-31 IVAA WZW – The *Vehicle System* shall alert the vehicle operator of a work zone, based on the information defined in requirement CA-REQ-3, when host vehicle is traveling towards the location of a work zone using an inform message (Work Zone Warning functionality is described in Section 2.6.4 of the SyRS).

4.2.6 Human-Machine Interface

All Vehicle Sub-systems will provide information to and receive information from the driver of the host vehicle through a Human-Machine Interface (HMI). HMIs can be either mounted in the vehicle as new equipment (e.g., tablet or touch panel) or installed in existing ones (e.g., tablets or smartphones).

VS-REQ-32 HMI Characteristics – All Vehicle Sub-systems shall contain an HMI that conforms to the following characteristics.

VS-REQ-32.1 HMI-Location – The location where the devices will be mounted/installed shall be selected so that they do not obstruct the line of sight of the driver nor distract the driver from the primary task of driving.

VS-REQ-32.2 HMI-Distraction –The HMI shall minimize the ‘eyes off the road’ time when presenting information for an application.

VS-REQ-32.3 HMI-Readability – The HMI shall provide messages that can be read from the driver’s normal seating position.

VS-REQ-32.4 Visual and Auditory Interface – The HMI shall include both a visual and auditory interface for sharing traveler information.

VS-REQ-32.4.1 Visual Consistency – The HMI shall maintain a consistent structure across applications with respect to presenting information to drivers and inputs to the system.

VS-REQ-32.4.2 Audio Signals – Auditory signals shall be loud enough to overcome masking sounds from road noise, the cab environment, and other equipment.

VS-REQ-32.5 Customizations – HMI characteristics shall be customizable to reflect driver preferences. Preferences that may be customizable are:

- Volume
- Brightness
- Contrast text size
- Display contrast
- Mounting eye position

VS-REQ-32.6 System Status – The HMI shall provide system status information to drivers.

VS-REQ-32.6.1 Power Status – The HMI shall notify the driver of the power status of device with the screen graphics (i.e., off, powering up and online).

VS-REQ-32.6.2 System Settings – The HMI shall allow the driver to see the system settings of the device with screen graphics. (i.e., version, brightness, volume font size).

VS-REQ-32.6.3 Application Availability – The HMI shall allow the driver to see application availability with screen graphics (i.e., failed, operating, disabled).

VS-REQ-32.6.4 Pending Update Status – The HMI shall allow the driver see pending updates for the device with screen graphics (i.e., applications, firmware, operating system).

VS-REQ-32.7 Distress Notification – The HMI shall include a distress button to allow a driver to notify the Vehicle System that the driver has initiated a distress condition (Distress Notification functionality is described in Section 2.6.3 of the SyRS).

VS-REQ-32.8 Non-Distress Information – The HMI shall allow the driver to input data, as defined in VS-REQ-4.2.

4.2.7 Broadcast Vehicle Information (BCVI)

VS-REQ-33 BCVI Messages – The *Vehicle System* shall wirelessly broadcast over DSRC a basic safety message (BSM) to other connected devices.

VS-REQ-34 BCVI Distress – The *Vehicle System* shall wirelessly broadcast distress messages to other connected devices. Distress information is a high priority messages based on the mayday broadcast (defined in J3067 3.5.9.2.1), but has the content of the TIM (defined in J2735 5.16 Part III advisory ITIS data elements 6.1 from J2540 2 Accidents and Incidents).

VS-REQ-34.1 Received Distress – The *Vehicle System* shall broadcast distress notifications (over DSRC), received from remote vehicles, for five miles from the location where the distressed vehicle is located.

VS-REQ-34.2 Generated Distress - The *Vehicle System*, in distress (described in Section 2.6 of the SyRS), shall broadcast generated distress notifications over DSRC, until the vehicle event code that triggered the distress notification is reset or power is lost (whichever comes first).

VS-REQ-35 BCVI General Broadcast Requirements – The *Vehicle System* shall use the general broadcast requirements defined in Appendix A.4 Broadcast Traveler Information of the SyRS.

4.2.8 Transmit Information (TI)

VS-REQ-36 Transmit Data – The *Vehicle System* shall transmit data over DSRC.

VS-REQ-36.1 Transmit Environmental Data – The *Vehicle System* shall transmit over DSRC environmental data, defined in Table 7-4 of the SDD, to the *Wyoming CV System* when available from a vehicle Sub-system

VS-REQ-36.2 TVI Data Management-Log – The *Vehicle System* shall transmit log files via secure copy (SCP) to the *Wyoming CV System* over DSRC that contain event logs data defined in VS-REQ-41.

4.2.9 Communication Performance

~~**VS-REQ-37 Communication Performance** – All Vehicle Sub-systems shall follow all core communication requirements defined in Appendix A.6 of the SyRS. *This requirement no longer applies to this system.*~~

4.2.10 Store Local Data (SLD)

VS-REQ-38 SLD Information – The *Vehicle System* shall store information generated by the host vehicle on local storage. Information to be stored is detailed in Table 4-3 of the SyRS.

Table 4-3. Information to be stored on local storage.

Messages	Details
Vehicle Data	Desired Vehicle Status data is specified in VS-REQ-4 Collect Vehicle Data
Distress Notification	Application message is based on high priority TIM in J2735
Environmental data	Defined in VS-REQ-5 External Environment Sensor Data

VS-REQ-39 SLD Rolling Log – The *Vehicle System* shall maintain rolling logs for in vehicle generated CV data for 10 seconds. Table 4-4 of the SyRS lists one or more sources of the rolling logs that may be available in a vehicle Sub-system.

Table 4-4. Data types that need a rolling log.

Data type	Description of what is logged
BSM broadcast	Parts I and II (defined in Section 7.1.1 of the ICD)
Vehicle Status Data	Specified in VS-REQ-4.1

VS-REQ-40 SLD Log Format – The event log format shall contain UTC time stamped text.

VS-REQ-41 SLD Log Data – The *Vehicle System* shall create event logs for all interactions with the *Wyoming CV System* or *Vehicle System* that is retained until it is sent to the *Wyoming CV System* or is older than seven (7) days. An interaction is defined as a received message from the *Wyoming CV System* or the *Vehicle System*. Each log should contain the information in Table 4-5 of the SyRS.

Table 4-5. Data for event log.

Data type	Description
In vehicle data from rolling log	Data from 10 seconds before interaction, data throughout interaction, data from 10 seconds after interaction.
Time based BSM log	Every 30 seconds log a BSM.
External CV data	Data received from the <i>Wyoming CV System</i> to include core data from TIMs and SCMS. The core data is the message elements listed in J2735.
External CV data	Data received from the <i>Vehicle System</i> outside of the in vehicle generated data to include core data from received BSM parts I and II, TIM, and distress messages. The core data is the message elements listed in J2735.

4.2.11 Vehicle System Management (VSM)

VS-REQ-42 VSM SCMS – The *Vehicle System* shall use the USDOT SCMS Certificates in accordance with the security and privacy requirements in Section 6.5 of J2945/1.

VS-REQ-43 VSM SCMS Encryption – The *Vehicle System* shall use the USDOT SCMS Certificates to sign and encrypt messages transmitted. The approved encryption algorithms are defined in IEEE 1609.2 and explained in [USDOT SCMS CAMP Wiki Cryptography](#).⁷

VS-REQ-44 VSM SCMS Sign – The *Vehicle System* shall use the USDOT SCMS Certificates to sign, but not encrypt, all broadcasted messages.

VS-REQ-45 VSM SCMS Encryption-Log – The *Vehicle System* shall use the USDOT SCMS Certificates to encrypt log files stored locally using the Public Key Encryption defined in [USDOT SCMS CAMP Wiki Cryptography](#). Password protection is also allowable protection for log files.

VS-REQ-46 VSM SCMS Sign-Log – The *Vehicle System* shall use the USDOT SCMS Certificates to sign log files stored locally. Password protection is also allowable for in place of signing log files.

REQ-47 VSM App Availability Log – The *Vehicle System* shall log local application availability to the local event logs by vehicle type. This will contain application restarts and availability based on application availability testing defined in FHWA-JPO-16-292 Connected Vehicle Pilot Deployment Program Phase 1, Application Deployment Plan.

VS-REQ-48 VSM Updates – The *Vehicle System* shall support Over-the-Air (OTA) software updates from the *Wyoming CV System* based on WAVE Service Announcements (WSA).

4.2.12 Vehicle System Core Architecture Requirements

VS-REQ-49 Architectural –Vehicle Sub-systems shall follow all core architectural requirements defined in Appendix A.2 OBU Core Architecture Requirements of the SyRS.

VS-REQ-50 Safety Communication –Vehicle Sub-systems shall follow all core safety communication requirements defined in Appendix A.3 V2V Core Safety Communication Requirements of the SyRS.

VS-REQ-51 VS Equipment –Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.

⁷ Available at <https://wiki.campllc.org/display/SCP/Approved+Cryptographic+Algorithms>

5 Sub-System Requirements

This chapter presents the Sub-system requirements that are decomposed from the top-level system requirements.

5.1 Wyoming CV System’s Sub-System Requirements

The Wyoming Connected *Vehicle Systems* is composed of five Sub-systems that provide the capabilities of receiving CV and non-CV data, processing it, generating alerts and advisories, distributing the generated information to relevant destinations, and storing all information for further analysis—as explained in Section 2 of this document. The Sub-system figure is reproduced here from Section 2.

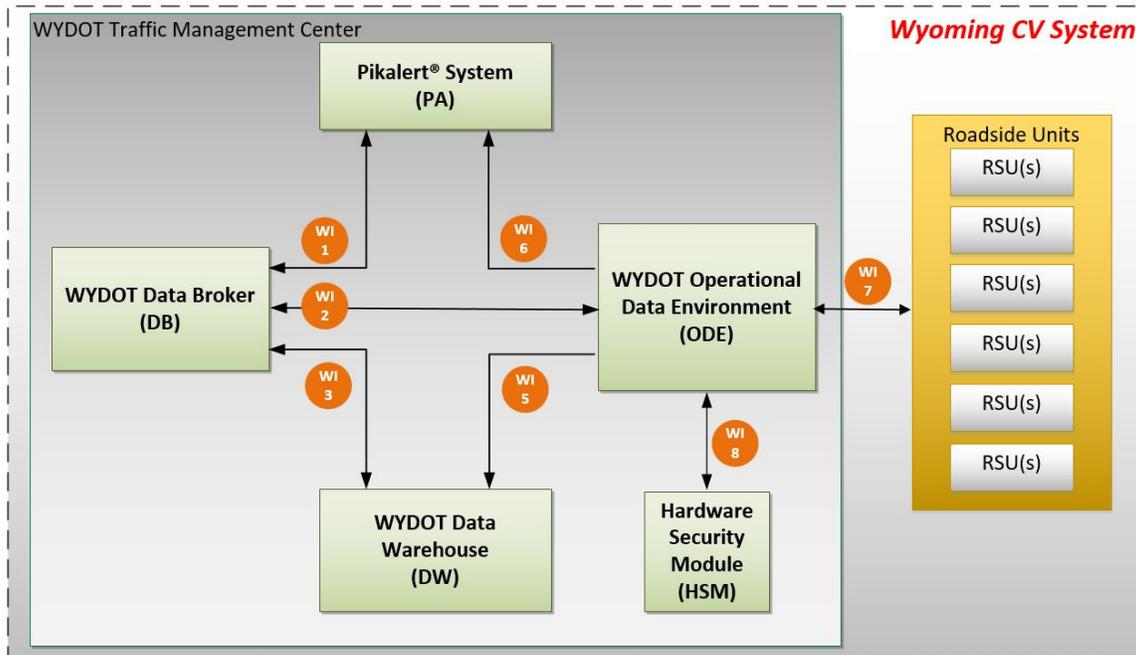


Figure 5-1. Wyoming CV System Sub-System (Source: WYDOT)

Table 5-1 maps out the system requirements identified in Section 4.1 of this document to the Sub-systems. A detail trace of Sub-system requirements to System and Interface requirements is provided in Section 7 (Table 7-2) of the SyRS.

Table 5-1. Mapping of System Requirements to the Wyoming CV Sub-Systems.

System Requirement	RSU	ODE	PA	DB	DW	HSM
USDOT Interfaces						
SCMS-REQ-1 WCVS SCMS Use	X	X				X
SCMS-REQ-1.1 SCMS WCVS Certificates	X	X				X

Section 5. Sub-System Requirements

System Requirement	RSU	ODE	PA	DB	DW	HSM
SCMS-REQ-1.2 SCMS WCVS Misbehavior Reporting	X	X				X
SCMS-REQ-1.3 SCMS WCVS Certificates Revocation List (CRL)	X	X				X
SCMS-REQ-1.4 SCMS WCVS Rejection	X	X				X
SDX-REQ-1 ODE Data Provided to the SDX		X				X
SDX-REQ-2 Distribute TIM to VS		X				
SDC-REQ-1 Data Provided to the SDC		X				
RDE-REQ-1 Data Provided to the RDE		X				
External Interfaces						
LTS-REQ-1 WCVS Time	X	X				
LTS-REQ-1.1 WCVS LTS Time	X	X				
LTS-REQ-1.2 WCVS Time Synchronization		X				
LTS-REQ-2 WCVS LTS Time Standard	X	X				
LTS-REQ-3 WCVS LTS Location	X	X				
WYDOT Interfaces						
511-REQ-1 511App Parking Data Collection				X		
511-REQ-1.1 Availability				X		
511-REQ-1.2 Default				X		
511-REQ-1.3 Time				X		
511-REQ-1.4 Location				X		
511-REQ-1.5 Protocol				X		
511-REQ-1.6 Schema				X		
511-REQ-2 Timeframe				X		
TPI-REQ-1 TPI Data				X		
TRAC-REQ-1 TRAC Updates				X		
TRAC-REQ-1.1 Distress Notification				X		
TRAC-REQ-1.1.1 Transmission Time				X		
TRAC-REQ-1.2 Segment Alerts				X		
TRAC-REQ-1.2.1 Transmission Time				X		
TRAC-REQ-1.2.2 Segment Alerts-Pikalert				X		
RCRS-REQ-1 RCRS Data Sharing				X		
RCRS-REQ-1.1 Road Condition				X		
RCRS-REQ-1.2 Weather				X		
RCRS-REQ-1.3 Other Road Condition				X		
RCRS-REQ-1.4 Report Time				X		
RCRS-REQ-1.5 Location				X		
RCRS-REQ-1.6 Transmit Time				X		
WTI-REQ-1 WTI Inputs				X		
WTI-REQ-1.1 Current Segment Alerts				X		
WTI-REQ-1.1.1 Transmission Time				X		
WTI-REQ-1.2 Forecast Segment Alerts				X		

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System Requirement	RSU	ODE	PA	DB	DW	HSM
WTI-REQ-1.2.1 Forecast Time				X		
WTI-REQ-1.2.2 Forecast Update				X		
WTI-REQ-2 WTI Outputs				X		
WTI-REQ-2.1 Posted Speed				X		
WTI-REQ-2.2 Vehicle Restrictions				X		
WTI-REQ-2.2.1 Restriction Information				X		
WTI-REQ-2.2.2 Restriction Start Time				X		
WTI-REQ-2.3 Posted Messages				X		
WTI-REQ-2.3.1 Message Information				X		
WTI-REQ-2.4 Posted Closures				X		
WTI-REQ-2.4.1 Closure Beginning				X		
WTI-REQ-2.4.2 Closure End				X		
WTI-REQ-2.4.3 Closure Start Time				X		
CVOP-REQ-1 CVOP Inputs				X		
CVOP-REQ-1.1 Current Segment Alerts				X		
CVOP-REQ-1.1.1 Transmission Time				X		
CVOP-REQ-1.2 Forecast Segment Alerts				X		
CVOP-REQ-1.2.1 Forecast Time				X		
CVOP-REQ-1.2.2 Forecast Update				X		
IC-REQ-1 IC Data Sharing				X		
IC-REQ-2 Protocol				X		
IC-REQ-3 Schema				X		
IC-REQ-4 Transmission				X		
CA-REQ-1 CA Data Sharing				X		
CA-REQ-2 Protocol				X		
CA-REQ-3 Schema				X		
CA-REQ-4 Transmission				X		
ITSM-REQ-1 WYDOT ITS Alerts				X		
Weather Interfaces						
WI-REQ-1 External Data Acquisition			X			
WI-REQ-2 Fixed Data Acquisition			X			
Wyoming CV System (WCVS)						
WCVS-REQ-1 Collect CV Data	X	X				
WCVS-REQ-1.1 Collect BSM Data	X	X				
WCVS-REQ-1.2 Collect Environmental Sensor Data	X	X				
WCVS-REQ-1.3 Collect Distress Messages	X	X				
WCVS-REQ-2 Validate Data		X				
WCVS-REQ-3 Ingest Data for Road Weather Information		X	X	X		
WCVS-REQ-4 Contents of Alerts and Advisories			X			
WCVS-REQ-4.1 Precipitation Hazard			X			

Section 5. Sub-System Requirements

System Requirement	RSU	ODE	PA	DB	DW	HSM
WCVS-REQ-4.2 Road Condition Hazard			X			
WCVS-REQ-4.3 Visibility Hazard			X			
WCVS-REQ-4.4 Work Zone Hazard				X		
WCVS-REQ-4.5 Incident Hazard				X		
WCVS-REQ-4.6 Parking				X		
WCVS-REQ-5 Forecast Conditions			X			
WCVS-REQ-5.1 Atmospheric Forecasts			X			
WCVS-REQ-5.2 Road Weather Forecasts			X			
WCVS-REQ-5.3 Forecast Time			X			
WCVS-REQ-5.4 Forecast Update			X			
WCVS-REQ-6 Associate Alerts and Forecast to Segments			X			
WCVS-REQ-7 External Brokerage with WYDOT Interfaces				X		
WCVS-REQ-7.1 Receive from WYDO External Interfaces				X		
WCVS-REQ-7.2 Distribute to WYDOT External Interfaces				X		
WCVS-REQ-8 Internal Brokerage	X	X	X	X	X	
WCVS-REQ-9 Create TIM				X		
WCVS-REQ-10 Distribute TIM	X	X				X
WCVS-REQ-10.1 Distribute TIM to VS	X	X				X
WCVS-REQ-10.2 Distribute TIM to SDX		X				X
WCVS-REQ-11 Store VS Data					X	
WCVS-REQ-11.1 Store BSM					X	
WCVS-REQ-11.2 Store Environment Sensor Data					X	
WCVS-REQ-11.3 Store Distress Messages					X	
WCVS-REQ-12 Store Generated Alerts/Advisories					X	
WCVS-REQ-13 Store TIM					X	
WCVS-REQ-14 Store System Monitoring Data					X	
WCVS-REQ-15 Notifications	X	X	X	X	X	
WCVS-REQ-16 Monitored Functions	X	X	X	X	X	
WCVS-REQ-16.1 Sub-System Availability	X	X	X	X	X	
WCVS-REQ-16.2 Sub-System Performance	X	X	X	X	X	
WCVS-REQ-16.3 Availability for Interfaces	X	X	X	X	X	
WCVS-REQ-16.4 Availability for Data Storage	X	X	X	X	X	
WCVS-REQ-17 Archive Data					X	
WCVS-REQ-18 Management and Performance Policy	X					
WCVS-REQ-19 Manage Architecture						
WCVS-REQ-20 Manage Safe Communications	X					
WCVS-REQ-21 Manage CV Equipment	X				X	

System Requirement	RSU	ODE	PA	DB	DW	HSM
WCVS-REQ-22 Test WCVS Equipment	X	X				
WCVS-REQ-23 Track WCVS Equipment	X	X			X	
WCVS-REQ-24 Update WCVS Equipment	X	X				
WCVS-REQ-25 Update VS Equipment	X	X				

5.1.1 Roadside Units (RSU)

RSUs include DSRC connectivity, application support, data storage, and other support services to enable CV applications, such as necessary certificates. In general, RSUs serve as a two-way communication portal between connected vehicles that provide information through DSRC and the Operational Data Environment.

RSU-REQ-1 Collect CV Data – The Roadside Units shall collect data from the *Vehicle System*, as defined in WCVS-REQ-1.

RSU-REQ-2 Distribute TIM to VS – The Roadside Units shall distribute TIMs received from the ODE to the *Vehicle System*, as defined in WCVS-REQ-10.

RSU-REQ-3 SCMS – The Roadside Units shall interface with the USDOT SCMS, as defined in SCMS-REQ-1.

RSU-REQ-4 LTS – The Roadside Units shall interface with the USDOT LTS, as defined in LTS-REQ-1.

~~**RSU-REQ-5 Architectural** – The Roadside Units shall follow all core architectural requirements defined in Appendix B2 of the SyRS. This requirement no longer applies to this system.~~

RSU-REQ-6 Safety Communication – The Roadside Units shall follow all core safety communication requirements defined in Appendix B.2 V2I Core Safety Communication Requirements of the SyRS.

RSU-REQ-7 Broadcast – The Roadside Units shall broadcast information following all requirements defined in Appendix B.3 RSU Broadcast Traveler Information of the SyRS.

~~**RSU-REQ-8 Transmit** – The Roadside Units shall transmit information following all requirements defined in Appendix B5-B.4 of the SyRS. This requirement no longer applies to this system.~~

~~**RSU-REQ-9 Receive from VS** – The Roadside Units shall receive information following all requirements defined in Appendix B6 of the SyRS. This requirement no longer applies to this system.~~

RSU-REQ-10 Management and Performance – The Roadside Units shall manage the policy for data collection and performance data following all requirements defined in Appendix RSU Performance Data of the SyRS.

RSU-REQ-11 Distribute to ODE – The Roadside Units shall transmit all collected information to the Operational Data Environment, as described in Section 5.18.1 of the ICD.

RSU-REQ-12 Receive Update – The Roadside Units shall receive firmware updates from the TMC administrator.

RSU-REQ-13 RSU Equipment – Roadside Unit equipment shall conform to the characteristics described in Appendix A of the CAP.

5.1.2 Operational Data Environment (ODE)

The WYDOT ODE is a Sub-system that ingests CV-data from the connected devices field and shares it with various other Sub-systems. The ODE also disseminates data back to connected devices and the Situation Data Exchange, and interfaces with the SCMS. The ODE code has been developed by USDOT and will be used in the pilot. Functional requirements for the ODE are being currently defined by USDOT.

ODE-REQ-1 Collect CV Data – The Operational Data Environment shall collect *Vehicle System* data, defined in WCVS-REQ-1, from the RSU and/or the Vehicle System.

ODE-REQ-2 Data Processing – The Operational Data Environment shall provide the VISA-related functions of CV Data as defined in Section 3.1.4.1 of the SDD.

ODE-REQ-3 Distribute Data – The Operational Data Environment shall distribute processed CV information to other External Interfaces, Systems, and Sub-systems.

ODE-REQ-3.1 Distribute TIM to RSU – The Operational Data Environment shall distribute TIMs to the RSU, to be later transmitted to the *Vehicle System*, as defined WCVS-REQ-10.1.

ODE-REQ-3.2 Distribute TIM to SDX – The Operational Data Environment shall distribute TIMs to the Situation Data Exchange, as defined in WCVS-REQ-10.2.

ODE-REQ-3.3 Distribute to Pikalert – The Operational Data Environment shall distribute Environmental Data to the Pikalert System, as described in Section 5.19 of the ICD.

ODE-REQ-3.4 Distribute to Data Warehouse – The Operational Data Environment shall distribute all collected and processed information to the Data Warehouse, as described in Section 5.20 of the ICD.

ODE-REQ-3.4.1 Distribute to Data Warehouse-BSM – The Operational Data Environment shall distribute all collected and processed BSM information to the Data Warehouse, as described in Section 5.20 of the ICD.

ODE-REQ-3.4.2 Distribute to Data Warehouse-DNM – The Operational Data Environment shall distribute all collected and processed DNM information to the Data Warehouse, as described in Section 5.20 of the ICD.

ODE-REQ-3.4.3 Distribute to Data Warehouse-ES – The Operational Data Environment shall distribute all collected and processed Environmental Sensor information to the Data Warehouse, as described in Section 5.20 of the ICD.

ODE-REQ-3.5 Distribute to Data Broker – The Operational Data Environment shall distribute distress information to the Data Broker, as described in Section 5.21.1 of the ICD.

ODE-REQ-3.6 Distribute to SDC – The Operational Data Environment shall distribute CV data to the Secure Data Commons, as defined in Section 5.37.1 of the ICD.

ODE-REQ-3.7 Distribute to RDE – The Operational Data Environment shall distribute CV data to the Research Data Exchange, as defined in Section 5.40.1 of the ICD.

ODE-REQ-4 SCMS – The Operational Data Environment shall interface with the USDOT SCMS, as defined in SCMS-REQ-1.

ODE-REQ-5 LTS – The Operational Data Environment shall interface with the USDOT LTS, as defined in LTS-REQ-1.

ODE-REQ-6 OBU Updates – The Operational Data Environment shall send OTA firmware updates to the OBU.

ODE-REQ-7 Receive Data from DB – The Operational Data Environment shall receive information from the Data Broker, as defined in Section 5.21.2 of the ICD.

ODE-REQ-8 Generate TIM for Connected Vehicles – The ODE shall generate traveler information messages (TIMs), as defined in J2735 (5.16 Message: MSG_Traveler Information Message (TIM)).

5.1.3 Pikalert System (PA)

The Pikalert Sub-system, developed by NCAR, ingests CV-data, fuses it with other weather data sources and generate alerts and advisories for I-80.

PA-REQ-1 External Weather Data – The Pikalert System shall receive weather information, as defined in WI-REQ-1 and WI-REQ-2.

PA-REQ-2 Wyoming CV Sub-Systems Data – The Pikalert System shall receive information from other Wyoming CV Sub-systems.

PA-REQ-2.1 ODE Data – The Pikalert System shall receive CV data from the Operational Data Environment as defined in ODE-REQ-3.3.

PA-REQ-2.2 TMC Data – The Pikalert System shall receive camera imagery from the TMC File Transfer Protocol (FTP) server as described in Section 5.26.1 of the ICD.

PA-REQ-3 Generate Alerts/Advisories and Forecasts – The Pikalert System shall generate alerts, advisories and forecasts, defined in WCVS-REQ-4. Detailed requirements for how the Pikalert System generates alerts are in the reference document “Motorist Alert and Warning Application, Detailed System Requirements, Final Report — Feb 28, 2014”, developed by NCAR for FHWA.

PA-REQ-4 Distribute Alerts/Advisories and Forecasts – The Pikalert System shall distribute alerts, defined in WCVS-REQ-4 to other Sub-systems.

PA-REQ-4.1 Distribute to DB – The Pikalert System shall transmit generated information to the Data Broker, as described in Section 5.27 of the ICD.

PA-REQ-4.2 Distribute to DW – ~~The Pikalert System shall transmit generated information to the Data Warehouse within five minutes of generation of the alert, as described in Sections 5.27.1.3.1 and 5.27.2.3.1 of the ICD. This requirement no longer applies to this system.~~

5.1.4 WYDOT Data Broker (DB)

The WYDOT Data Broker (DB) is a Sub-system that moves data between various Sub-systems and external interfaces.

DB-REQ-1 Receive from External Interfaces – The Data Broker shall receive data from WYDOT system as defined in the external interface requirements as defined in 511-REQ-1, RCRS-REQ-1, WTI-REQ-2, IC-REQ-1, and CA-REQ-1.

DB-REQ-2 Distribute to External Interfaces – The Data Broker shall distribute information to WYDOT systems as defined in TRAC-REQ-1, TPI-REQ-1, WTI-REQ-1, CVOP-REQ-1, and ITSM-REQ-1.

~~DB-REQ-3 Generate TIM for Connected Vehicles~~ – The DB shall generate traveler information messages (TIMs), as defined in J2735 (5.16 Message: MSG_Traveler Information Message (TIM)). This requirement no longer applies to this system.

DB-REQ-4 Receive from Pikalert – The DB shall receive all generated segment-level information from Pikalert.

DB-REQ-4.1 Receive Alerts and Advisories – The DB shall receive all generated segment-level alerts and advisories from Pikalert, as described in Section 5.27.1 of the ICD.

DB-REQ-4.2 Receive Forecast – The DB shall receive all generated segment-level forecast information from Pikalert, as described in Section 5.27.2 of the ICD.

DB-REQ-5 Distribute to ODE – The DB shall transmit TIM information to the ODE, as defined in Section 5.21.2 of the ICD.

DB-REQ-6 Receive from ODE – The DB shall receive distress information from the ODE, as defined in Section 5.21.1 of the ICD.

DB-REQ-7 Distribute to Data Warehouse – The DB shall transmit information to the Data Warehouse as defined in Table 5-2 of the SyRS.

Table 5-2. Information shared with the Data Warehouse.

Data type	Description	Defined in the ICD
TIM	All TIMs generated by the ODE shall be transmitted to the DW	Section 5.35.1.3.1
Distress Notifications	All Distress Notifications received by the DB shall be transmitted to the DW	Section 5.21.1.3.1 sequence diagram message [30]
Alerts and Advisories	All Alerts and Advisories received by the DB shall be transmitted to the DW	Section 5.27.1.3.1 sequence diagram message [30]
Forecast	All forecasts received by the DB shall be transmitted to the DW	Section 5.27.2.3.1 sequence diagram message [30]

DB-REQ-8 Receive Data from DW– The DB shall receive current TIM information from the DW. Current TIM information is defined in DB-REQ-7.

DB-REQ-9 Distribute to SDC – The DB shall manually upload data to the SDC as defined in ICD Section 5.39.1.

5.1.5 WYDOT Data Warehouse (DW)

WYDOT Data Warehouse is the central repository of both CV and non-CV data at the TMC. The Data Warehouse also provides incident information and planned work zone information to the WYDOT data broker.

DW-REQ-1 Store Data – The Data Warehouse shall store all data collected and generated by the *Wyoming CV System*, as defined in DW-REQ-1.1, DW-REQ-1.2, DW-REQ-1.3, and DW-REQ-1.4.

DW-REQ-1.1 Store Alerts/Advisories and Forecasts – The Data Warehouse shall store all generated alerts, advisories and forecasts, as defined in WCVS-REQ-12.

DW-REQ-1.1.1 Store Alerts/Advisories-Precipitation Hazard – The Data Warehouse shall store all generated precipitation hazard alerts, advisories and forecasts, as defined in WCVS-REQ-12.

DW-REQ-1.1.2 Store Alerts/Advisories- Road Condition Hazard – The Data Warehouse shall store all generated road condition hazard alerts, advisories and forecasts, as defined in WCVS-REQ-12.

DW-REQ-1.1.3 Store Alerts/Advisories-Visibility Hazard – The Data Warehouse shall store all generated visibility hazard alerts, advisories and forecasts, as defined in WCVS-REQ-12.

DW-REQ-1.1.4 Store Alerts/Advisories-Work Zone Hazard – The Data Warehouse shall store all generated work zone hazard alerts and advisories, as defined in WCVS-REQ-12.

DW-REQ-1.1.5 Store Alerts/Advisories-Incident Hazard – The Data Warehouse shall store all generated incident hazard alerts and advisories, as defined in WCVS-REQ-12.

DW-REQ-1.1.6 Store Alerts/Advisories-Parking – The Data Warehouse shall store all generated parking alerts and advisories, as defined in WCVS-REQ-12.

DW-REQ-1.2 Store Vehicle System Data – The Data Warehouse shall store all data collected by the *Vehicle Systems*, as defined in WCVS-REQ-11.

DW-REQ-1.3 Store TIM – The Data Warehouse shall store all TIMs distributed to the *Vehicle System* and the Situation Data Exchange, as defined in WCVS-REQ-13.

DW-REQ-1.4 Store System Monitoring Data – The Data Warehouse shall store all system monitoring data, as defined in WCVS-REQ-14.

DW-REQ-2 Share Data – The Data Warehouse shall provide access to stored information to Wyoming CV Sub-Systems and External Interfaces defined in DW-REQ-2.1, DW-REQ-2.2, DW-REQ-2.3 and DW-REQ-2.4.

DW-REQ-2.1 Share Data with TPI – The Data Warehouse shall transmit information to the TPI, as defined in Section 5.36.1 of the ICD.

DW-REQ-2.2 Share Data with SDC – The Data Warehouse shall transmit information to the SDC, as defined in Section 5.38.1 of the ICD.

DW-REQ-2.3 Share Data with RDE – The Data Warehouse shall transmit information to the RDE, as defined in Section 5.41.1 of the ICD.

DW-REQ-2.4 Share Data with DB – The DW shall share current TIM information, including starting and stopping milepost, TIM ID, active RSU ID, and RSU TIM index, with the DB. The DW receives TIM information from the DB, as defined in DB-REQ-7.

DW-REQ-3 Data Storage Administration – This requirement addresses administration of data storage. The DW shall perform the following administrative functions:

- Maintain System Data Tables
- Manage Data Storage Security
- Manage Data System
- Manage Archive

DW-REQ-3.1 Maintain System Data Tables – The DW shall maintain (i.e., update data columns for additional data fields as necessary, build views for authorized audiences needing to interact with the data) tables of data coming from connected vehicles and other sources used by the connected vehicle pilot. The views built will be based on requests made by the Performance Management and IE team that are not currently defined.

DW-REQ-3.1.1 CVE Data – The DW shall maintain the tables for CVE Data. This includes space for data from BSM related application data, driver/fleet related data, and performance management data.

DW-REQ-3.2 Manage Data Storage Security – The Data Warehouse shall have a designated TMC data storage administrator who will maintain security for data collected by the CV pilot within compliance of Sections 7(D), 7(E), 7(F), 7(G) and Appendix 11 – SMOC (Section 6.2) of the Institutional Review Board (University of Wyoming, 2016).

DW-REQ-3.2.1 User Access – The DW shall be implemented to control granular access to the CV data storage at the column to the table space resolution to people with a need to know and that have been approved by the WYDOT program manager.

DW-REQ-3.2.2 Unauthorized Access – The DW shall be implemented to notify the TMC administrator of attempted access by unauthorized personnel to the CV data storage to all users that have not been specifically approved by the WYDOT program manager.

DW-REQ-3.3 Manage Data System – The Data Warehouse shall have a designated TMC data storage administrator who will manage the data systems for the CV pilot. The following three requirements address data system management at the TMC and the cloud databases used by the CV pilot.

DW-REQ-3.3.1 System Back-ups – The DW shall provide the TMC administrator the ability to back up the data, provided by the WYDOT CV System, using WYDOT best practices for data protection, as stated in Section 2.5 of the Data Management Plan (FHWA-JPO-17-470) (Kitchener et al., 2017). This will be done for the development, test, quality assurance and production environments.

DW-REQ-3.3.2 Import/Export – The DW shall provide the TMC administrator the ability to perform import/export operation as needed for the CV pilot data.

DW-REQ-3.3.3 Version Control – The DW shall provide the TMC administrator the ability to maintain version control for the data systems in use by the CV pilot.

DW-REQ-3.4 Manage Data Archive – The DW shall provide the TMC administrator the ability to archive data used by the CV pilot data to be retained using WYDOT best practices for data archival, as stated in Section 2.5 of the Data Management Plan (FHWA-JPO-17-470) (Kitchener et al., 2017).

DW-REQ-4 Receive Data – The Data warehouse shall receive information sent from other Sub-systems.

5.1.6 Hardware Secure Module

The hardware security module (HSM) will manage the Wyoming CV System's certifications.

HSM-REQ-1 Receive from ODE – The HSM shall receive unsigned TIMs from the ODE as defined in Section 3.1.4.1 of the SDD.

HSM-REQ-2 Share with ODE – The HSM shall provide signed TIMs to the ODE as defined in Section 3.1.4.1 of the SDD.

HSM-REQ-3 Receive from SCMS – The HSM shall receive updated certificates from the SCMS as defined in Section 3.1.3 of the SDD.

HSM-REQ-4 Share with SCMS – The HSM shall shares authentication data with the SCMS as defined in Section 3.1.3 of the SDD.

5.2 Vehicle Sub-System Requirements

The *Vehicle Systems* is composed of four Sub-systems that provide the capabilities of collecting, receiving and sharing data, processing it, presenting alerts and advisories to drivers, and storing information for a limited time—as described in Section 2.2 of the SyRS. Table 5-3 maps out the system requirements identified in Section 4.2 to the Sub-systems. A detail trace of Sub-system requirements to System and Interface requirements is provided in Section 7 (Table 7-3) of the SyRS.

Table 5-3. Mapping of System Requirements to the Vehicle Sub-Systems.

System Requirement		MV	HPV	IT	RFV
Vehicle System					
VS-REQ-1	Receive BSM	X	X	X	X
VS-REQ-2	Receive TIM	X	X	X	X
VS-REQ-2.1	Receive TIM through DSRC	X	X	X	X
VS-REQ-2.2	Receive TIM Through Satellite	X	X	X	X
VS-REQ-3	Receive Distress Information	X	X	X	
VS-REQ-4	Collect Vehicle Data	X	X	X	X
VS-REQ-4.1	Collect Vehicle Status Data	X			
VS-REQ-4.2	Collect Dimension Data	X	X	X	X
VS-REQ-4.2.1	Vehicle Dimension Data	X	X	X	X
VS-REQ-4.2.2	Vehicle Trailer Data	X	X	X	X
VS-REQ-5	External Environment Sensor Data	X			
VS-REQ-5.1	External Environment Sensor Data Configuration	X			
VS-REQ-5.2	External Environment Sensor Data Management	X			
VS-REQ-6	FCW Stopped Vehicles	X	X	X	X
VS-REQ-7	FCW Decelerating/Slow Moving Vehicles	X	X	X	X
VS-REQ-8	FCW Stopped and Obstructed Vehicles	X	X	X	X
VS-REQ-9	FCW Rear-End Crash	X	X	X	X
VS-REQ-9.1	Rear-End Crash in Straight Road	X	X	X	X
VS-REQ-9.2	Rear-End Crash in Curved Road	X	X	X	X
VS-REQ-10	FCW No Warning	X	X	X	X
VS-REQ-10.1	Safely Following a Vehicle	X	X	X	X
VS-REQ-10.2	Passing a Stopped Vehicle	X	X	X	X
VS-REQ-11	SA TIM-Advisories	X	X	X	X
VS-REQ-12	SA TIM-Speed Limit	X	X	X	X
VS-REQ-13	SA TIM-Exit Services	X	X	X	X
VS-REQ-14	SA TIM-Region	X	X	X	X
VS-REQ-15	Distress Notification ID	X	X	X	
VS-REQ-15.1	Log	X	X	X	
VS-REQ-16	Create Distress Notification	X	X	X	
VS-REQ-16.1	System-Generated Distress Notification	X	X	X	
VS-REQ-16.2	Driver-Generated Distress Notification	X	X	X	
VS-REQ-17	DNM-Region	X	X	X	
VS-REQ-18	DN PSID	X	X	X	
VS-REQ-19	WZW TIM	X	X	X	X
VS-REQ-20	WZW TIM-Region	X	X	X	X
VS-REQ-21	SWIW TIM	X	X	X	X

Section 5. Sub-System Requirements

System Requirement		MV	HPV	IT	RFV
VS-REQ-22	SWIW TIM-Region	X	X	X	X
VS-REQ-23	IVAA Rank	X	X	X	X
VS-REQ-24	IVAA Level	X	X	X	X
VS-REQ-25	IVAA Priority Alert	X	X	X	X
VS-REQ-26	IVAA FCW	X	X	X	X
VS-REQ-27	IVAA DN	X	X	X	
VS-REQ-28	IVAA SA-Advisory	X	X	X	X
VS-REQ-29	IVAA SA-VSL	X	X	X	X
VS-REQ-30	IVAA SWIW	X	X	X	X
VS-REQ-31	IVAA WZW	X	X	X	X
VS-REQ-32	HMI Characteristics	X	X	X	X
VS-REQ-32.1	HMI-Location	X	X	X	X
VS-REQ-32.2	HMI-Distraction	X	X	X	X
VS-REQ-32.3	HMI-Readability	X	X	X	X
VS-REQ-32.4	Visual and Auditory Interface	X	X	X	X
VS-REQ-32.4.1	Visual Consistency	X	X	X	X
VS-REQ-32.4.2	Audio Signals	X	X	X	X
VS-REQ-32.5	Customizations	X	X	X	X
VS-REQ-32.6	System Status	X	X	X	X
VS-REQ-32.6.1	Power Status	X	X	X	X
VS-REQ-32.6.2	System Settings	X	X	X	X
VS-REQ-32.6.3	Application Availability	X	X	X	X
VS-REQ-32.6.4	Pending Update Status	X	X	X	X
VS-REQ-32.7	Distress Notification	X	X	X	
VS-REQ-32.8	Non-Distress Information	X	X	X	X
VS-REQ-33	BCVI Messages	X	X	X	X
VS-REQ-34	BCVI Distress	X	X	X	
VS-REQ-34.1	Received Distress	X	X	X	
VS-REQ-34.2	Generated Distress	X	X	X	
VS-REQ-35	BCVI General Broadcast Requirements	X	X	X	X
VS-REQ-36	Transmit Data	X	X	X	X
VS-REQ-36.1	Transmit Environmental Data	X			
VS-REQ-36.2	TVI Data Management-Log	X	X	X	X
VS-REQ-37	Communication Performance				
VS-REQ-38	SLD Information	X	X	X	X
VS-REQ-39	SLD Rolling Log	X	X	X	X
VS-REQ-40	SLD Log Format	X	X	X	X
VS-REQ-41	SLD Log Data	X	X	X	X
VS-REQ-42	VSM SCMS	X	X	X	X
VS-REQ-43	VSM SCMS Encryption	X	X	X	X
VS-REQ-44	VSM SCMS Sign	X	X	X	X
VS-REQ-45	VSM SCMS Encryption-Log	X	X	X	X
VS-REQ-46	VSM SCMS Sign-Log	X	X	X	X
VS-REQ-47	VSM App Availability Log	X	X	X	X
VS-REQ-48	VSM Updates	X	X	X	X
VS-REQ-49	Architectural	X	X	X	X
VS-REQ-50	Safety Communication	X	X	X	X
VS-REQ-51	VS Equipment	X	X	X	X
External Interfaces					
LTS-REQ-4	VS LTS Time	X	X	X	X
LTS-REQ-5	VS LTS Time Standard	X	X	X	X
LTS-REQ-6	VS LTS Location	X	X	X	X

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System Requirement		MV	HPV	IT	RFV
USDOT Interfaces					
SCMS-REQ-2	Vehicle System SCMS Use	X	X	X	X
SCMS-REQ-2.1	SCMS Vehicle System Certificates	X	X	X	X
SCMS-REQ-2.2	SCMS Vehicle System Misbehavior Reporting	X	X	X	X
SCMS-REQ-2.3	SCMS Vehicle System Certificates Revocation List (CRL)	X	X	X	X
SCMS-REQ-2.4	SCMS Vehicle System Rejection	X	X	X	X

5.2.1 WYDOT Maintenance Vehicle (MV)

The following unique requirements are identified.

MV-REQ-1 Environmental Sensors – WYDOT Maintenance Vehicles shall transmit environment information collected through equipped external environmental sensors to the *Wyoming CV system*. External environmental sensors will provide the information detailed in Table 7-4 of the ICD.

MV-REQ-1.1 Environmental Sensors Equipment – Environmental Sensor equipment shall conform to the characteristics described in Appendix A of the CAP.

~~**MV-REQ-2 Can Bus** – WYDOT Maintenance Vehicles shall provide connection to the Can Bus as part of the Vehicle System. The information extracted from the Can Bus is detailed in Table 7-1 of the ICD, where column #1 contains the value "yes/CAN."~~ *This requirement no longer applies to this system.*

MV-REQ-3 Static Identifier – WYDOT Maintenance Vehicles' DSRC communications shall have a static identifier.

MV-REQ-4 Receive TIM over DSRC – WYDOT Maintenance Vehicles shall receive a packet containing traveler information from the *Wyoming CV System* over DSRC. Each packet may contain one or more individual traveler information message as defined in Section 5.16 of SAE J2735.

MV-REQ-5 Receive TIM over Satellite – WYDOT Maintenance Vehicles shall receive a packet containing traveler information from the *Wyoming CV System* (via the Situation Data Exchange) over Satellite communication. Each packet may contain one or more individual traveler information message as defined in Section 5.16 (SAE J2735).

MV-REQ-6 OTA Updates – WYDOT Maintenance Vehicles shall receive software updates OTA, as defined in Section 5.16.2 of the ICD.

MV-REQ-7 Time – WYDOT Maintenance Vehicles shall obtain time as defined in LTS-REQ-4.

MV-REQ-8 Location – WYDOT Maintenance Vehicles shall obtain location as defined in LTS-REQ-6.

MV-REQ-9 General – All vehicle system requirements identified in Section 4.2 of the SyRS shall apply to this Sub-system.

MV-REQ-10 OBU Equipment – MV OBU equipment shall conform to the characteristics described in Appendix A of the CAP.

5.2.2 Highway Patrol Vehicle

HP-REQ-1 General – All vehicle system requirements identified in Section 4.2 of the SyRS shall apply to this Sub-system except:

- VS-REQ-4.2 Collect Dimension Data
- VS-REQ-5 External Environment Sensor Data
- VS-REQ-5.1 External Environment Sensor Data Configuration
- VS-REQ-5.2 External Environment Sensor Data Management
- VS-REQ-36.1 Transmit Environmental Data

HP-REQ-2 Receive TIM over DSRC – Highway Patrol vehicles shall receive traveler information from the *Wyoming CV System* over DSRC. Traveler information may contain one or more packets of traveler information as defined in Section 5.16 (SAE J2735).

HP-REQ-3 Time – Highway Patrol vehicles shall obtain time as defined in LTS-REQ-4.

HP-REQ-4 Location – Highway Patrol vehicles shall obtain location as defined in LTS-REQ-6.

HP-REQ-5 OBU Equipment – Highway Patrol OBU equipment shall conform to the characteristics described in Appendix A of the CAP.

HP-REQ-6 Receive TIM over Satellite – Highway Patrol vehicles shall receive a packet containing traveler information from the *Wyoming CV System* (via the Situation Data Exchange) over Satellite communication. Each packet may contain one or more individual traveler information message as defined in Section 5.16 (SAE J2735).

HP-REQ-7 OTA Updates – Highway Patrol vehicles shall receive software updates OTA, as defined in Section 5.16.2 of the ICD.

5.2.3 Integrated Truck (IT)

The following unique requirements are identified.

IT-REQ-1 Receive TIM over DSRC – Integrated Truck Fleet vehicles shall receive a packet containing traveler information from the *Wyoming CV System* over DSRC. Each packet may contain one or more individual traveler information message as defined in Section 5.16 (SAE J2735).

IT-REQ-2 Receive TIM over Satellite – Integrated Truck Fleet vehicles shall receive a packet containing traveler information from the *Wyoming CV System* (via the Situation Data Exchange) over Satellite communication. Each packet may contain one or more individual traveler information message as defined in Section 5.16 (SAE J2735).

IT-REQ-3 OTA Updates – Integrated Truck Fleet vehicles shall receive software updates OTA, as defined in Section 5.16.2 of the ICD.

IT-REQ-4 Time – Integrated Truck Fleet vehicles shall obtain time as defined in LTS-REQ-4.

IT-REQ-5 Location – Integrated Truck Fleet vehicles shall obtain location as defined in LTS-REQ-6.

IT-REQ-6 General – All vehicle system requirements identified in Section 4.2 of the SyRS shall apply to this Sub-system except:

- VS-REQ-5 External Environment Sensor Data
- VS-REQ-5.1 External Environment Sensor Data Configuration

- VS-REQ-5.2 External Environment Sensor Data Management
- VS-REQ-36.1 Transmit Environmental Data

IT-REQ-7 OBU Equipment – Integrated Truck OBU equipment shall conform to the characteristics described in Appendix A of the CAP.

IT-REQ-8 Can Bus – ~~Integrated Truck Fleet vehicles shall provide connection to the Can Bus as part of the Vehicle System. The information extracted from the Can Bus is detailed in Table 7-1 of the ICD, where column #1 contains the value "yes/CAN."~~ This requirement no longer applies to this subsystem.

5.2.4 Retrofit Vehicles (RFV)

The following unique requirements are identified for this Sub-system.

RFV-REQ-1 Receive TIM over DSRC – Retrofit Fleet vehicles shall receive traveler information from the *Wyoming CV System* over DSRC. Traveler information may contain one or more packets of traveler information as defined in Section 5.16 (SAE J2735).

RFV-REQ-2 Receive TIM over Satellite – Retrofit Fleet vehicles shall receive a packet containing traveler information from the *Wyoming CV System* (via the Situation Data Exchange) over Satellite communication. Each packet may contain one or more individual traveler information message as defined in Section 5.16 (SAE J2735).

RFV-REQ-3 Time – Retrofit Fleet vehicles shall obtain time as defined in LTS-REQ-4.

RFV-REQ-4 Location – Retrofit Fleet vehicles shall obtain location as defined in LTS-REQ-6.

RFV-REQ-5 General – All vehicle system requirements identified in Section 4.2 of the SyRS shall apply to this Sub-system except the following requirements pertaining to distress notifications and updates:

- VS-REQ-3 Receive Distress Information
- VS-REQ-4.1 Collect Vehicle Status Data
- VS-REQ-5 External Environment Sensor Data
- VS-REQ-5.1 External Environment Sensor Data Configuration
- VS-REQ-5.2 External Environment Sensor Data Management
- VS-REQ-15 Distress Notification ID
- VS-REQ-15.1 Log
- VS-REQ-16 Create Distress Notification
- ~~VS-REQ-16.1 System-Generated Distress Notification~~
- VS-REQ-16.2 Driver-Generated Distress Notification
- VS-REQ-17 DNM-Region
- VS-REQ-18 DN PSID
- VS-REQ-27 IVAA DN
- VS-REQ-32.5 Customizations
- VS-REQ-32.7 Distress Notification
- VS-REQ-34 BCVI Distress
- VS-REQ-34.1 Received Distress
- VS-REQ-34.2 Generated Distress
- VS-REQ-35 BCVI General Broadcast Requirements
- VS-REQ-36.1 Transmit Environmental Data

RFV-REQ-6 OBU Equipment – RFV OBU equipment shall conform to the characteristics described in Appendix A of the CAP.

RFV-REQ-7 OTA Updates – Retrofit Fleet vehicles shall receive software updates OTA, as defined in Section 5.16.2 of the ICD

5.3 Sub-System Internal Interfaces

Sub-systems have interaction(s) with others within their respective System through internal and external interfaces. At the *Wyoming CV System* level, the following internal interfaces exists:

1. ODE – RSU: This interface defines the information exchanged between the ODE and the RSU.
2. ODE – Pikalert: This interface defines the information exchanged between the ODE and Pikalert.
3. ODE – Data Broker: This interface defines the information exchanged between the ODE and the Data Broker.
4. ODE – Data Warehouse: This interface defines the information exchanged between the ODE and the Data Warehouse.
5. ODE – Hardware Secure Module: This interface defines the information and certificate exchange between the ODE and the HSM.
6. Pikalert – Data Warehouse: This interface defines the information exchanged between the ODE and the Data Warehouse.
7. Pikalert – Data Broker: This interface defines the information exchanged between the ODE and the Data Broker.
8. Data Warehouse – Data Broker: This interface defines the information exchanged between the Data Warehouse and the Data Broker.

At the *Vehicle System* level, the following internal interfaces exists (all related to V2V communications):

1. WYDOT Maintenance Vehicles to other vehicle Sub-systems
2. Highway Patrol Vehicles to other vehicle Sub-systems
3. Integrated Trucks to other vehicle Sub-systems
4. Retrofit Trucks to other vehicle Sub-systems

These interfaces are described in detail in the Interface Control Document, which complements this System Requirement Specification document.

6 Performance Requirements

This section provides a list of requirements that detail the performance of the different components of the Wyoming CV Pilot System. Figure 6-1 illustrates how these performance requirements are linked to the overall systems requirements of the Pilot, and consequently to the sub-systems requirements as well. It should be noted that most of these performance requirements are focused on the Vehicle System, as this is largely the “new” component that is introduced within the Pilot. The performance of the Wyoming CV System, and its sub-systems, will mainly follow WYDOT TMC’s established guidelines of performance.

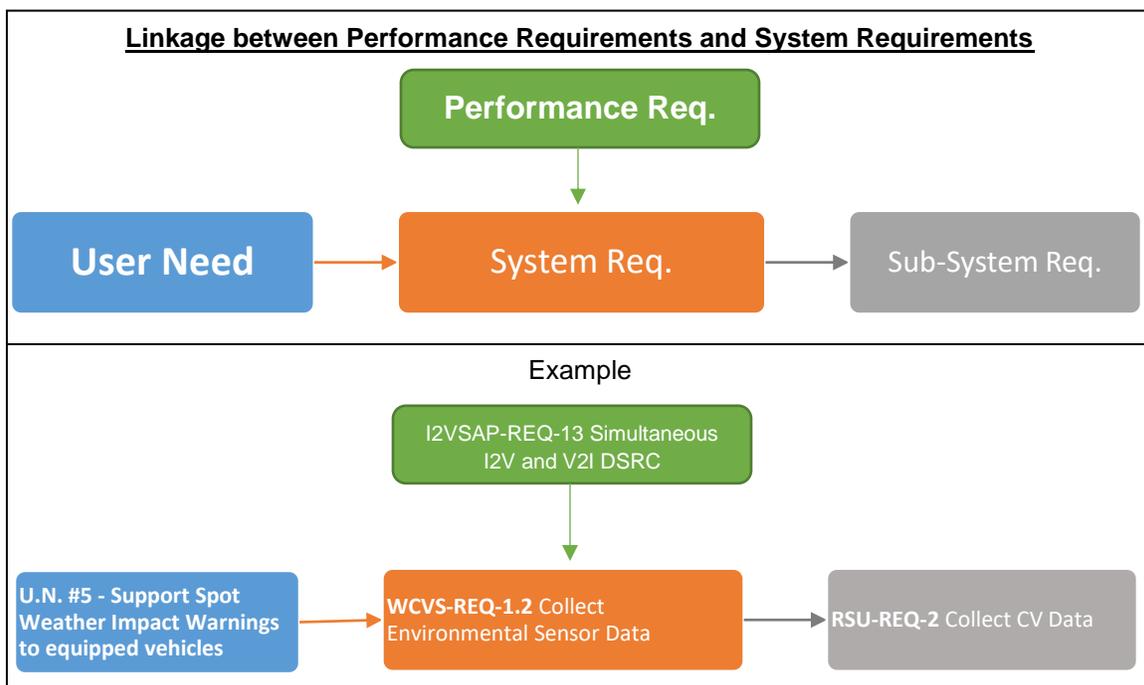


Figure 6-1. Illustration of the Sequential Logic of the System Requirements (Source: WYDOT)

A complete trace of these performance requirements to the system-level requirements is provided in Table 7-4 of the SyRS.

6.1 Performance of Forward Collision Warning

Note: For all FCWP requirements, the FCW application developer is responsible for verifying the functionality of the application over the range of vehicle speeds the application is specified to cover.

FCWP-REQ-1 FCW Advisory Alert Performance – The Vehicle System shall issue an advisory FCW alert when the Time-to-Collision is below a configurable threshold for advising the driver of

potential for collision with a stopped vehicle ahead in the same lane of travel. Guidance for FCW Time-to Collision, Advisories and Alerts is provided in SyRS Section 6.1.1.

FCWP-REQ-2 FCW Imminent Alert Performance – The Vehicle System shall issue an imminent FCW alert when the Time-to-Collision is below a configurable threshold for alerting the driver that there is an imminent threat of forward collision with a stopped vehicle ahead in the same lane of travel and immediate action is required from the driver to avoid the collision. Guidance for FCW Time-to Collision, Advisories and Alerts is provided in SyRS Section 6.1.1.

FCWP-REQ-3 Passing a Stopped Vehicle Performance – The Vehicle System shall not issue an FCW advisory or alert when passing a stopped vehicle in an adjacent lane.

FCWP-REQ-4 Following a Vehicle Performance – The Vehicle System shall not issue an imminent FCW alert when following a remote vehicle traveling at a constant speed above 30 mph.

FCWP-REQ-5 Decelerating Vehicle Performance – The Vehicle System shall issue an imminent FCW alert when the Time-to-Collision is below a configurable threshold for alerting the driver that there is an imminent threat of forward collision with a decelerating vehicle ahead in the same lane of travel and immediate action is required from the driver to avoid the collision. Guidance for FCW Time-to Collision, Advisories and Alerts is provided in SyRS Section 6.1.1.

FCWP-REQ-6 FCW Advisory Alert in a Curve Performance – The Vehicle System shall issue an advisory FCW alert when the Time-to-Collision is below a configurable threshold for advising the driver of potential for collision with a stopped vehicle ahead in the same lane of travel in a curve. Guidance for FCW Time-to Collision, Advisories and Alerts is provided in SyRS Section 6.1.1.

FCWP-REQ-7 FCW Imminent Alert in a Curve Performance – The Vehicle System shall issue an imminent FCW alert when the Time-to-Collision is below a configurable threshold for alerting the driver that there is an imminent threat of forward collision with a stopped vehicle ahead in the same lane of travel in a curve and immediate action is required from the driver to avoid the collision. Guidance for FCW Time-to Collision, Advisories and Alerts is provided in SyRS Section 6.1.1.

FCWP-REQ-8 Passing a Stopped Vehicle in a Curve Performance – The Vehicle System shall not issue an FCW advisory or alert when passing a stopped vehicle in an adjacent lane in a curve.

FCWP-REQ-9 Slow Moving Vehicle Advisory Alert in a Curve Performance – The Vehicle System shall issue an advisory FCW alert when the Time-to-Collision is below a configurable threshold for advising the driver of potential for collision with a moving vehicle ahead in the same lane of travel in a curve. Guidance for FCW Time-to Collision, Advisories and Alerts is provided in SyRS Section 6.1.1.

FCWP-REQ-10 Slow Moving Vehicle Imminent Alert in a Curve Performance – The Vehicle System shall issue an imminent FCW alert when the Time-to-Collision is below a configurable threshold for alerting the driver that there is an imminent threat of forward collision with a moving vehicle ahead in the same lane of travel in a curve and immediate action is required from the driver to avoid the collision. Guidance for FCW Time-to Collision, Advisories and Alerts is provided in SyRS Section 6.1.1.

6.1.1 FCW Time-to-Collision, Advisories, and Alerts Background and Rationale

Typically, FCW advisories and alerts must be tuned for each class of vehicles (because of their different stopping distances and stopping times) while avoiding the need to alert the driver so frequently that they become a nuisance. The threshold values for issuing advisories and alerts are based upon empirical testing and human factors and engineering judgement. Threshold values for issuing advisories and alerts are based on Time-to-Collision (TTC). Total TTC is the sum of the Driver Brake Reaction Time and the Vehicle Response Time. Driver Response Time includes Driver Mental Processing Time (Sensation + Perception + Response Selection & Preparation) plus movement time. Following is background information references for assistance in estimating TTC and in configuring FCW advisories and alerts.

- For estimating the Driver Brake Reaction Time, Campbell (2016) notes that "values from research [2] indicate that a primed (expectant of the cue) driver under optimal conditions may have a brake reaction time of under 1 s, while analysis of naturalistic data [7] suggest that brake reaction time could range from 1.5 s to 2.5 s (and occasionally greater depending on driver state, such as distraction)."
- As for Vehicle Response Time, this is the vehicle's braking or deceleration capacity for its given weight. NHTSA FMVSS specifies a maximum stopping distance of 250 ft. to safely stop a fully loaded (new) tractor trailer from 60 mph, equivalent to a 0.48g uniform deceleration rate and a 5.67 seconds vehicle response (stopping) time. NHTSA FMVSS 135 specifies a maximum stopping distance of 230 ft. to safely stop a passenger vehicle from 62.1 mpg, equivalent to a 0.56g uniform deceleration rate and a 5.06 seconds vehicle response (stopping) time.
- Furthermore, *Vehicle Response Only Time to Collision (TTC) = t - (1/(2v)) * a * t^2* where *t* is the time prior to impact when braking is initiated, *v* is vehicle speed when braking is initiated, and *a* is the constant braking deceleration (Kusano & Gabler, 2011).
- The AASHTO "Policy on Geometric Design of Highways and Streets" indicates that most drivers decelerate at a rate that is greater than 14.8 ft/s² (4.5 m/s²) (0.46g) when there is a sudden need to stop for an unexpected object in the roadway, while 90 percent of drivers decelerate at a rate over 11.2 ft/s² (3.4 m/s²) (0.35g). These deceleration rates account for the comfort level of drivers, the ability of the driver to maintain steering control on wet surfaces in tandem with tire-pavement friction levels, and vehicle braking systems capabilities.
- Bogard and LeBlanc (2014) uses a Total TTC criterion of 6.5 ± 1.0 s for imminent FCW alert for an unloaded commercial vehicle stopping behind a passenger vehicle.
- Industry guidelines and/or local policy should provide guidance on deceleration rates for specific circumstances.

6.2 Performance of Distress Notification

DNP-REQ-1 Distress Notification OBU DSRC Performance 1 – Remote vehicles shall receive distress notification via DSRC between at least 2 and 300 meters from the distressed vehicle.

DNP-REQ-2 Distress Notification OBU DSRC Performance 2 – Remote vehicles shall receive distress notification from other remote "relay" vehicles via DSRC between at least 2 and 300 meters from the other remote vehicle.

DNP-REQ-3 Distress Notification RSU DSRC Performance – ODE shall receive Distress Notification Messages (through RSU) from distressed vehicle or remote "relay" vehicles via DSRC from a distance between at least 2 and 300 meters between vehicles and RSU.

DNP-REQ-4 Distress Notification Driver Display Performance – Distress Notification Caution shall be issued to the driver of the receiving vehicle at least at a configurable distance from the distressed vehicle. Note: the configurable distance is to be determined empirically by system engineers during development and testing.

DNP-REQ-5 Distressed Vehicle Distance – Distress Notification Cautions shall indicate the approximate distance to the distressed vehicle.

DNP-REQ-6 Distressed Vehicle Direction of Travel – Distress Notification Cautions shall indicate if the distressed vehicle is in the same direction of travel as the receiving vehicle.

DNP-REQ-7 Distressed Vehicle Roadway – Distress Notification Cautions shall be issued to drivers approaching the distressed vehicle on the same roadway.

DNP-REQ-8 Distress Vehicle Passing – Distress Notification Cautions shall not be issued to drivers after passing the distressed vehicle.

DNP-REQ-9 Remote Vehicle Distress Notification Distance 1 – Remote Vehicles receiving the broadcast DNM shall continue to broadcast it for a configurable distance and configurable time. Note: Initially this distance would be set to 5 miles.

DNP-REQ-10 Remote Vehicle Distress Notification Distance 2 – After broadcasting for the configurable distance or configurable time, a remote Relay Vehicle shall stop broadcasting the DNM and go silent until it receives an RSU WSA broadcast for the ODE server's IPv6 address.

DNP-REQ-11 Remote Vehicle Distress Notification Upload to ODE – When a remote Relay Vehicle receives an RSU WSA broadcast for the ODE server's IPv6 address, the OBU shall copy a log for the DNM to the ODE server.

DNP-REQ-12 Remote Vehicle Distress Notification Upload Termination – When a remote Relay Vehicle OBU completes copying a log for the DNM to the ODE server, the Relay Vehicle shall stop further broadcasting the DNM and will stop copying it to RSUs to the ODE.

6.3 Performance of I2V Situational Awareness

Note: 16 meters is the distance traveled in 1 second at 35 mph and the distance traveled in 500 milliseconds at 70 mph. Design processing speed for message processing and display of alerts and advisories to driver is 500 milliseconds (Bogard 2014).

I2VSAP-REQ-1 Message Display in Travel Lanes – Situational Awareness Message(s) shall display in vehicles traveling in all travel lanes of the roadway in the direction specified in the I2V SA TIM.

I2VSAP-REQ-2 Message Display in Shoulder Lanes – Situational Awareness Message(s) shall display in vehicles traveling on shoulders of the roadway in the direction specified in the I2V SA TIM.

I2VSAP-REQ-3 Message Display in Acceleration Lane – Situational Awareness Message(s) shall display in vehicles in entrance acceleration lane of the roadway in the direction specified in the I2V SA TIM.

I2VSAP-REQ-4 Message Display Geofence Beginning – Situational Awareness Message(s) shall display within 8 meters, at a speed of 35 miles per hour, of beginning of geofence specified in the I2V SA TIM.

I2VSAP-REQ-5 Message Display Geofence Ending – Situational Awareness Message(s) shall cease display within 8 meters, at a speed of 35 miles per hour, of end of geofence specified in the I2V SA TIM.

I2VSAP-REQ-6 Message Display in Opposing Travel Lanes – Situational Awareness Message(s) shall not display in vehicles traveling in a direction other than that specified in the I2V SA TIM.

I2VSAP-REQ-7 Message Display on Adjacent Service Road – Situational Awareness Message(s) shall not display in vehicles on roadways adjacent to that specified in the I2V SA TIM.

I2VSAP-REQ-8 Message Display in Perpendicular to Travel Lanes – Situational Awareness Message(s) shall not display in vehicles on roadways intersecting that specified in the I2V SA TIM.

I2VSAP-REQ-9 Message Display Start Time – Situational Awareness Message(s) shall begin display within 1 second of the time specified in the I2V SA TIM.

I2VSAP-REQ-10 Message Display Stop Time – Situational Awareness Message(s) shall cease display within 1 second of the time specified in the I2V SA TIM.

I2VSAP-REQ-11 Verify I-80 Map and Geofences – Vehicle Systems shall be capable of displaying Situational Awareness Message(s) in vehicles traveling in all travel lanes anywhere on I-80 across Wyoming.

I2VSAP-REQ-12 Satellite TIM Coverage – Vehicle Systems shall be capable of receiving I2V SA TIMs via satellite in vehicles traveling on I-80 across Wyoming.

I2VSAP-REQ-13 Simultaneous I2V and V2I DSRC Communications – The WYDOT CV Pilot System shall support simultaneous capture of vehicle system BSMs, capture of vehicle system log files, and broadcast of I2V SA TIMs via DSRC.

I2VSAP-REQ-14 Simultaneous DSRC and Satellite TIM Processing – Vehicle Systems shall support processing of identical I2V SA TIMs received via DSRC and satellite without conflict or error.

6.4 Performance of Message Communication

MCP-REQ-1 V2V Exchange of BSMs – Host vehicles shall receive BSM from remote vehicles via DSRC from between at least 2 and 300 meters distance.

MCP-REQ-2 V2I & End-to-end Communication of BSMs – RSUs shall receive BSM from Remote Vehicles via DSRC from between at least 2 and 300 meters distance.

MCP-REQ-3 OBU Shakedown – The WYDOT CV Pilot System shall support periodic testing to verify functionality and DSRC range performance of WYDOT controlled Pilot vehicles.

MCP-REQ-4 RSU and Backhaul Communications Shakedown 1 – The WYDOT CV Pilot System shall support periodic testing to verify functionality and DSRC range performance of RSUs.

MCP-REQ-5 RSU and Backhaul Communications Shakedown 2– The WYDOT CV Pilot System shall support periodic testing to verify functionality and DSRC range performance of RSUs after major storm events.

MCP-REQ-6 OBU Installation Robustness – WYDOT CV Pilot OBUs shall maintain functionality and DSRC communications range performance after up to five installations and removal.

MCP-REQ-7 RSU Installation Robustness – WYDOT CV Pilot RSUs shall maintain functionality and DSRC communications range performance after up to three installations and removal.

7 Traceability to User Needs and System-level Requirements

This section provides a series of tables that links the user needs to the System, Sub-system and Performance requirements, following the structure depicted in Figure 1-2 and Figure 6-1. A total of four (4) tables are presented here:

- Table 7-1 links the system-level requirements to the 13 user needs identified for this pilot.
- Table 7-2 links the Wyoming CV System requirements to its Sub-systems.
- Table 7-3 links the Vehicle System requirements to its Sub-systems.
- Table 7-4 links the performance requirements to their respective system-level requirement.

Table 7-2 and Table 7-3 identify the “parent” and “child” requirement relationships to be used as guidance for requirement traceability. However, it should be noted that this relationship may be different from the parent-child relationships that are identified for requirement verification procedures—these ones can be found in the Operational Readiness Plan – WYDOT CV Pilot, Attachment B - Operational Readiness Test Plan (FHWA-JPO-17-472B).

The following table maps the user needs identified for the pilot with the system- and interface-level requirement.

Table 7-1. Needs to System Requirements Traceability Matrix

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
1) Support warnings of impeding forward collision in a host vehicle based on information received from a remote vehicle.			
Vehicle System (VS)	VS-REQ-1	Receive BSM	The Vehicle System shall receive Basic Safety Message (as defined in SAE J2945/1) over DSRC from other connected vehicles consistent with Section 6.3.8 of SAE J2945/1 (BSM Scheduling and Congestion Control).
Vehicle System (VS)	VS-REQ-4	Collect Vehicle Data	The Vehicle System shall have the capability to collect vehicle information from the host vehicle and the driver as stated below
Vehicle System (VS)	VS-REQ-4.1	Collect Vehicle Status Data	The Vehicle System shall have the capability to collect vehicle status information from the host vehicle, as stated in Section 5.4.2 of the ICD.
Vehicle System (VS)	VS-REQ-4.2	Collect Dimension Data	The Vehicle System shall have the capability to collect information from the host vehicle driver. The VS will maintain these values across power cycles and OTA updates. The data will be included in BSMs

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
			broadcasted by the Vehicle System. The list of fields are shown in Table 7-1 of the ICD, where column #1 contains the value "yes/driver".
Vehicle System (VS)	VS-REQ-4.2.1	Vehicle Dimension Data	The Vehicle System shall have the capability to collect vehicle dimension from the host vehicle driver through the Human Machine Interface.
Vehicle System (VS)	VS-REQ-4.2.2	Vehicle Trailer Data	The Vehicle System shall have the capability to collect information from the host vehicle driver regarding the dimensions of attached trailers, including capability to indicate that no trailer is present, through the Human Machine Interface.
Vehicle System (VS)	VS-REQ-6	FCW Stopped Vehicles	The Vehicle System shall ingest BSM Parts I and II data received from remote vehicles to identify stopped remote vehicles directly ahead in the same lane and direction of travel (defined in J2945/1 section 4.2.4.2 (a)). Data ingest is defined as obtaining and importing data for use or storage.
Vehicle System (VS)	VS-REQ-7	FCW Decelerating/Slow Moving Vehicles	The Vehicle System shall ingest BSM Parts I and II data received from remote vehicles to identify decelerating or slower moving remote vehicles directly ahead in the same lane and direction of travel (defined in J2945/1 section 4.2.4.2 (c)). Data ingest is defined as obtaining and importing data for use or storage
Vehicle System (VS)	VS-REQ-8	FCW Stopped and Obstructed Vehicles	The Vehicle System shall ingest BSM Parts I and II data received from remote vehicles to identify stopped and obstructed remote vehicles directly ahead in the same lane and direction of travel (defined in J2945/1 section 4.2.4.2 (d)). Data ingest is defined as obtaining and importing data for use or storage
Vehicle System (VS)	VS-REQ-9	FCW Rear-End Crash	The Vehicle System shall ingest BSM Parts I and II data received from remote vehicles to identify imminent danger of a rear-end crash with a remote vehicle in its lane of travel (defined in J2945/1 section 4.2.4.3). Data ingest is defined as obtaining and importing data for use or storage.
Vehicle System (VS)	VS-REQ-9.1	Rear-End Crash in Straight Road	The Vehicle System shall identify imminent danger of a rear-end crash with a remote vehicle lead vehicle in its lane of travel in a straight roadway geometry.
Vehicle System (VS)	VS-REQ-9.2	Rear-End Crash in Curved Road	The Vehicle System shall identify imminent danger of a rear-end crash with a remote vehicle lead vehicle in its lane of travel in a curved roadway geometry.
Vehicle System (VS)	VS-REQ-10	FCW No Warning	The Vehicle System shall ingest BSM Parts I and II data received from remote vehicles to identify when there is no need to display a warning on the HMI of the host vehicle. Data ingest is defined as obtaining and importing data for use or storage.
Vehicle System (VS)	VS-REQ-10.1	Safely Following a Vehicle	The Vehicle System shall identify when no imminent danger of a rear-end crash is present with a remote vehicle in its lane of travel in common roadway geometries.
Vehicle System (VS)	VS-REQ-10.2	Passing a Stopped Vehicle	The Vehicle System shall identify when no imminent danger of a rear-end crash is present with a remote vehicle that is stopped and not in its lane of travel in common roadway geometries.
Vehicle System (VS)	VS-REQ-23	IVAA Rank	The Vehicle System shall provide prioritized in-vehicle alerts based on the rank order presented in Table 4-1 of the SyRS, with the highest rank on top.
Vehicle System (VS)	VS-REQ-24	IVAA Level	The Vehicle System shall have three levels of alert, as described in Table 4-2 of the SyRS.
Vehicle System (VS)	VS-REQ-25	IVAA Priority Alert	The Vehicle System shall provide only the highest priority alert to the vehicle operator when more than one alert is currently active

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Vehicle System (VS)	VS-REQ-26	IVAA FCW	The Vehicle System shall alert the vehicle operator for forward collision warning based on the warning distance calculation algorithm in section 3.1 of the Connected Commercial Vehicles—Retrofit Safety Device Kit Project Safety Applications and Development Plan (FHWA-JPO-14-106) and guidance for FCW Time-to-Collision, Advisories and Alerts provided in SyRS Section 6.1.1. This could be an inform message, warning 1 or warning 2 based on the calculated deceleration rate required. During the design phase a deceleration rate will be selected for a warning 1 and for warning 2 based on vehicle type and weight.
Vehicle System (VS)	VS-REQ-35	BCVI General Broadcast Requirements	The Vehicle System shall use the general broadcast requirements defined in Appendix A.4 Broadcast Traveler Information of the SyRS.
Vehicle System (VS)	VS-REQ-51	VS Equipment	All Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.
2) Support ability to provide situational awareness of road conditions on the corridor to an equipped vehicle			
Situation Data Exchange (SDX)	SDX-REQ-1	Data Provided to the SDX	The Wyoming CV System shall transmit traveler information messages (TIMs) generated by the system to the SDX within five minutes of generation. TIMs are formatted as defined in J2735 – 5.16 Message: MSG_TravelerInformation Message (TIM).
Situation Data Exchange (SDX)	SDX-REQ-2	Distribute TIM to VS	The Situation Data Exchange shall distribute TIMs to the <i>Vehicle System</i> through satellite, as defined in WCVS-REQ-10.2 Distribute TIM to SDX.
WYDOT 511 Application (511App)	511-REQ-1	511App Parking Data Collection	The Wyoming CV System shall receive parking status data from Wyoming 511 App.
WYDOT 511 Application (511App)	511-REQ-1.1	Availability	The Wyoming CV System shall categorize parking availability for the facility of interest as follows: i) Full – No parking availability, ii) Spaces available, or iii) Only a few spaces available.
WYDOT 511 Application (511App)	511-REQ-1.2	Default	The Wyoming CV System shall set parking availability default to available if not provided.
WYDOT 511 Application (511App)	511-REQ-1.3	Time	The Wyoming CV System shall timestamp parking availability reports.
WYDOT 511 Application (511App)	511-REQ-1.4	Location	The Wyoming CV System shall associate parking availability with a parking facility on I-80.
WYDOT 511 Application (511App)	511-REQ-1.5	Protocol	The Wyoming CV System shall receive information, based on HTTP protocol, from the 511App.
WYDOT 511 Application (511App)	511-REQ-1.6	Schema	The Wyoming CV System shall receive information based on the parking schema defined by WYDOT (WYDOT Truck Parking Map – as of 07/2016).
WYDOT 511 Application (511App)	511-REQ-2	Timeframe	The Wyoming CV System shall receive Parking availability data from the WYDOT 511 application within thirty minutes of generation.
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1	RCRS Data Sharing	The Wyoming CV System shall receive road condition information from the RCRS.
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.1	Road Condition	The Wyoming CV System shall receive road condition information from the RCRS following the 8 Code System.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.2	Weather	The Wyoming CV System shall receive atmospheric information from the RCRS following the 9 Code System.
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.3	Other Road Condition	The Wyoming CV System shall receive other road information from RCRS following the 10 Code System.
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.4	Report Time	The Wyoming CV System shall receive reports from RCRS containing a timestamp of when the operator entered the information into the app.
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.5	Location	The Wyoming CV System shall receive reports from RCRS containing a location reference of when the operator entered the information into the app
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.6	Transmit Time	The Wyoming CV System shall receive reports from RCRS containing a timestamp of when the report was transmitted to the TMC. The transmitting timestamp may be different from the reporting time
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2	WTI Outputs	The Wyoming CV System shall receive the current information for corridor roadway segments available from the WTI within five minutes of generation. Roadway segments are defined by WYDOT as sections of roadway between variable mileposts.
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2.1	Posted Speed	The Wyoming CV System shall receive notification that current posted speed for a segment is changed
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2.2	Vehicle Restrictions	The Wyoming CV System shall receive the notification of vehicle restrictions that have been set for a roadway segment
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2.2.1	Restriction Information	The Wyoming CV System shall receive details on the restriction in effect for affected segments. Restrictions can consist of one or more of the following: • Width restriction, • Height restriction, • Weight restrictions, • High-Profile restrictions, • Chain Law Level 1, • Chain Law Level 2
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2.2.2	Restriction Start Time	Wyoming CV System shall receive the start time of restrictions in effect for segments.
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2.3	Posted Messages	The Wyoming CV System shall receive the notification of DMS messages that have been set in the corridor
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2.3.1	Message Information	Wyoming CV System shall receive the content of the posted DMS message
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2.4	Posted Closures	The Wyoming CV System shall receive the notification of closures that have been set for a roadway segment
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2.4.1	Closure Beginning	The Wyoming CV System shall receive notification of the beginning point of the closure.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2.4.2	Closure End	The Wyoming CV System shall receive notification of the ending point of the closure.
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-2.4.3	Closure Start Time	The Wyoming CV System shall receive notification of the starting time of the closure.
WYDOT Incident Console (IC)	IC-REQ-1	IC Data Sharing	The Wyoming CV System shall receive timestamped incident information from the IC.
WYDOT Incident Console (IC)	IC-REQ-2	Protocol	The Wyoming CV System shall receive incident information, based on HTTP protocol, from the IC. The HTTP protocol used will be based on the six part specifications RFC 7230-RFC 7235.
WYDOT Incident Console (IC)	IC-REQ-3	Schema	The Wyoming CV System shall receive incident information from WYDOT IC, as described in Section 5.31.1 of the ICD.
WYDOT Incident Console (IC)	IC-REQ-4	Transmission	The Wyoming CV System shall receive Road Incident data from WYDOT Incident Console within five minutes of generation
Weather Interface (WI)	WI-REQ-1	External Data Acquisition	The Wyoming CV System shall collect weather information from external sources, as defined in the Section 4.1 - Data Ingest Module Requirements of the Motorist Alert and Warning Application (NCAR, 2014)
Weather Interface (WI)	WI-REQ-2	Fixed Data Acquisition	The Wyoming CV System shall receive road weather information system (RWIS) data from the WYDOT RWIS Server as defined in Section 4.1 – Data Ingest Module Requirements of the Motorist Alert and Warning Application (NCAR 2014).
Wyoming CV System (WCVS)	WCVS-REQ-1	Collect CV Data	The Wyoming CV System shall collect data from the Vehicle System.
Wyoming CV System (WCVS)	WCVS-REQ-1.2	Collect Environmental Sensor Data	The Wyoming CV System shall collect environment sensor data using secure copy (SCP) from the Vehicle System consistent with secure shell (SSH).
Wyoming CV System (WCVS)	WCVS-REQ-3	Ingest Data for Road Weather information	The Wyoming CV System shall use one or more of the following sources of data to generate road weather information: <ul style="list-style-type: none"> • Collected CV Information defined in WCVS-REQ-1. • Segment road and weather conditions from the WYDOT RCRS in RCRS-REQ-1. • Weather conditions from weather interfaces defined in WI-REQ-1 and WI-REQ-2.
Wyoming CV System (WCVS)	WCVS-REQ-4	Contents of Alerts and Advisories	The Wyoming CV System shall generate alerts and advisories of roadway hazard conditions as defined in the following requirements.
Wyoming CV System (WCVS)	WCVS-REQ-4.1	Precipitation Hazard	The Wyoming CV System shall generate a precipitation type and intensity report every 5 minutes, as specified in Section 3.1.4.2 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.2	Road Condition Hazard	The Wyoming CV System shall generate a pavement state and slickness flag report every 5 minutes, depending on input data, as specified in Section 3.1.4.2 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.3	Visibility Hazard	The Wyoming CV System shall generate a visibility report, along with the condition causing it, every 5 minutes, as specified in Section 3.1.4.2 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.4	Work Zone Hazard	The Wyoming CV System shall generate a work zone report within 5 minutes of receiving work zone information from the Construction Administration (defined in CA-REQ-1), as specified in Section 3.1.5.4 of the SDD.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Wyoming CV System (WCVS)	WCVS-REQ-4.5	Incident Hazard	The Wyoming CV System shall generate an incident report within 5 minutes of receiving incident notifications from the Incident Console (defined in IC-REQ-1), as specified in Section 3.1.4.3 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.6	Parking	The Wyoming CV System shall generate a parking report within 5 minutes of receiving parking availability notification, as specified in Section 3.1.4.3 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-5	Forecast Conditions	The Wyoming CV System shall generate forecasts of conditions as defined in the following requirements
Wyoming CV System (WCVS)	WCVS-REQ-5.1	Atmospheric Forecasts	The Wyoming CV System shall produce atmospheric weather forecasts, at a minimum, for (a) atmospheric temperature, (b) probability of precipitation, (c) wind speed, and (d) wind direction
Wyoming CV System (WCVS)	WCVS-REQ-5.2	Road Weather Forecasts	The Wyoming CV System shall produce road weather forecasts, at a minimum, for (a) pavement temperature, and (b) subsurface temperature
Wyoming CV System (WCVS)	WCVS-REQ-5.3	Forecast Time	The Wyoming CV System shall generate forecast reports for customizable forecast windows. The windows of interest will be determined by WYDOT (6, 12, 24, 48 hours for example).
Wyoming CV System (WCVS)	WCVS-REQ-5.4	Forecast Update	The Wyoming CV System shall generate forecast updates for customizable intervals. The update frequency will be determined by WYDOT and may vary based on time of year (every 3 hours for example in winter to 12 hours during summer).
Wyoming CV System (WCVS)	WCVS-REQ-6	Associate Alerts and Forecast to Segments	The Wyoming CV System shall associate each alert and forecast to one or more road segments on I-80. Roadway segments are defined by WYDOT as sections of roadway between variable mileposts.
Wyoming CV System (WCVS)	WCVS-REQ-9	Create TIM	The Wyoming CV System shall create a Traveler Information Message (TIM) formatted as defined in J2735 – 5.16 Message: MSG_TravelerInformation Message (TIM).
Wyoming CV System (WCVS)	WCVS-REQ-10	Distribute TIM	The Wyoming CV System shall distribute signed TIMs to the Vehicle System and the Situation Data Exchange (SDX).
Wyoming CV System (WCVS)	WCVS-REQ-10.1	Distribute TIM to VS	The Wyoming CV System shall distribute signed TIM to the Vehicle System consistent with Section 3.5.8 (Traveler Information Requirements) of J3067
Wyoming CV System (WCVS)	WCVS-REQ-10.2	Distribute TIM to SDX	The Wyoming CV System shall distribute signed TIM to the SDX consistent with Section 3.5.8 (Traveler Information Requirements) of J3067. The SDX may not be available going forward. This requirement is for general compliance with the national communication of TIMs and is one way that the Wyoming pilot can get TIMs to third parties for broader distribution. If the SDX becomes unavailable, the pilot can directly send TIMs to the third parties for distribution. The SDX is not required for the Wyoming pilot.
Vehicle System (VS)	VS-REQ-2	Receive TIM	VS-REQ-2 Receive TIM – The Vehicle System shall wirelessly receive a packet containing traveler information from the Wyoming CV System. Each packet may contain one or more individual traveler information message as defined in Section 5.16 of SAE J2735.
Vehicle System (VS)	VS-REQ-2.1	Receive TIM through DSRC	The Vehicle System shall wirelessly receive a packet containing traveler information from the Wyoming CV System through DSRC
Vehicle System (VS)	VS-REQ-2.2	Receive TIM through Satellite	The Vehicle System shall wirelessly receive a packet containing traveler information from the Wyoming CV System (via the Situation Data Exchange) through satellite.
Vehicle System (VS)	VS-REQ-4	Collect Vehicle Data	The Vehicle System shall have the capability to collect vehicle information from the host vehicle and the driver as stated below
Vehicle System (VS)	VS-REQ-4.1	Collect Vehicle Status Data	The Vehicle System shall have the capability to collect vehicle status information from the host vehicle, as stated in Section 5.4.2 of the ICD.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Vehicle System (VS)	VS-REQ-11	SA TIM-Advisories	The Vehicle System shall ingest received TIMs to identify advisories (Part III content choice ITIS.ITISCodesAndText defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage
Vehicle System (VS)	VS-REQ-12	SA TIM-Speed Limit	The Vehicle System shall ingest received TIMs to identify speed limits (Part III content choice speedLimit defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage
Vehicle System (VS)	VS-REQ-13	SA TIM-Exit Services	The Vehicle System shall ingest received TIMs to identify Exit Services (Part III content choice exitService defined in J2735 section 6.142). This is used to provide parking information if necessary. Data ingest is defined as obtaining and importing data for use or storage
Vehicle System (VS)	VS-REQ-14	SA TIM-Region	The Vehicle System shall ingest received TIMs to identify the applicable regions of use geographical path (Part II defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage
Vehicle System (VS)	VS-REQ-23	IVAA Rank	The Vehicle System shall provide prioritized in-vehicle alerts based on the rank order presented in Table 4-1 of the SyRS, with the highest rank on top.
Vehicle System (VS)	VS-REQ-24	IVAA Level	The Vehicle System shall have three levels of alert, as described in Table 4-2 of the SyRS.
Vehicle System (VS)	VS-REQ-25	IVAA Priority Alert	The Vehicle System shall provide only the highest priority alert to the vehicle operator when more than one alert is currently active
Vehicle System (VS)	VS-REQ-28	IVAA SA-Advisory	The Vehicle System shall alert the vehicle operator for a situational awareness advisory using an inform message when the host vehicle is traveling towards the segment where the situational awareness applies.
Vehicle System (VS)	VS-REQ-29	IVAA SA-VSL	The Vehicle System shall inform the vehicle operator of the current speed limit of the variable speed limit zone the vehicle is within using an inform message.
Vehicle System (VS)	VS-REQ-51	VS Equipment	All Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.
3) Support notification of distress conditions to and from equipped vehicles			
WYDOT Transportation Reports and Action Console (TRAC)	TRAC-REQ-1	TRAC Updates	The Wyoming CV System shall transmit CV pilot events to the TRAC.
WYDOT Transportation Reports and Action Console (TRAC)	TRAC-REQ-1.1	Distress Notification	The Wyoming CV System shall transmit received distress notifications to TRAC. Distress notifications are defined in WCVS-REQ-1.3.
WYDOT Transportation Reports and Action Console (TRAC)	TRAC-REQ-1.1.1	Transmission Time	The Wyoming CV System shall transmit distress notifications to TRAC within five minutes of its generation in the system.
Wyoming CV System (WCVS)	WCVS-REQ-1	Collect CV Data	The Wyoming CV System shall collect data from the Vehicle System.
Wyoming CV System (WCVS)	WCVS-REQ-1.3	Collect Distress Messages	The Wyoming CV System shall collect distress messages using the Traveler Information Message (as defined in section 5.16 of J2735) from the Vehicle System consistent with Section 3.5.8 (Traveler Information Requirements) of J3067

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Wyoming CV System (WCVS)	WCVS-REQ-2	Validate Data	The Wyoming CV System shall provide validation- and sanitization-related functions of CV Data as defined in Section 3.1.4.1 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-11	Store VS Data	The Wyoming CV System shall store processed data collected by the Vehicle Systems and retain it for the duration of the CV Pilot. Data Processing is defined in ODE-REQ-2.
Wyoming CV System (WCVS)	WCVS-REQ-11.3	Store Distress Messages	The Wyoming CV System shall store processed distress messages using the Traveler Information Message (as defined in section 5.16 of J2735) received from the Vehicle System consistent with Section 3.5.8 (Traveler Information Requirements) of J3067. As the distress message will be previously validated, only core data will be stored (defined in sections 5.16, and 6.142 of J2735).
Vehicle System (VS)	VS-REQ-3	Receive Distress Information	The Vehicle System shall wirelessly receive a packet containing distress information from other connected vehicles over DSRC. Distress information is a high priority messages based on the received distress broadcast (defined in J3067 3.5.9.2.1), but has the content of the TIM (defined in J2735 5.16 Part III advisory ITIS data elements 6.1 from J2540-2 Accidents and Incidents).
Vehicle System (VS)	VS-REQ-4	Collect Vehicle Data	The Vehicle System shall have the capability to collect vehicle information from the host vehicle and the driver as stated below
Vehicle System (VS)	VS-REQ-4.1	Collect Vehicle Status Data	The Vehicle System shall have the capability to collect vehicle status information from the host vehicle, as stated in Section 5.4.2 of the ICD.
Vehicle System (VS)	VS-REQ-15	Distress Notification ID	The Vehicle System shall identify received distress notifications. Distress information is a high priority messages loosely based on the mayday broadcast (defined in J3067 3.5.9.2.1), but has the content of the TIM (defined in J2735 5.16 Part III advisory ITIS data elements 6.1 from J2540_2 Accidents and Incidents).
Vehicle System (VS)	VS-REQ-15.1	Log	The Vehicle System shall log received distress notifications to include the DNM.
Vehicle System (VS)	VS-REQ-16	Create Distress Notification	The Vehicle System shall have the ability to generate a distress notification.
Vehicle System (VS)	VS-REQ-16.1	System-Generated Distress Notification	The Vehicle System shall have the ability to self-generate a distress notification when the vehicle Event Status reports airbag deployment or disabled vehicle code. Vehicle Status data is specified in Section 5.4.2 of the ICD.
Vehicle System (VS)	VS-REQ-16.2	Driver-Generated Distress Notification	The Vehicle System shall have the ability to generate a distress notification when the vehicle operator selects the distress notification activation alternative in the HMI.
Vehicle System (VS)	VS-REQ-17	DNM-Region	The Vehicle System shall ingest received DNMs to identify the applicable regions of use geographical path (Part II defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage.
Vehicle System (VS)	VS-REQ-18	DN PSID	The Vehicle System shall use a unique high priority Provider Service Identifier (PSID) for the distress notification application as per IEEE 1609.12.
Vehicle System (VS)	VS-REQ-23	IVAA Rank	The Vehicle System shall provide prioritized in-vehicle alerts based on the rank order presented in Table 4-1 of the SyRS, with the highest rank on top.
Vehicle System (VS)	VS-REQ-24	IVAA Level	The Vehicle System shall have three levels of alert, as described in Table 4-2 of the SyRS.
Vehicle System (VS)	VS-REQ-25	IVAA Priority Alert	The Vehicle System shall provide only the highest priority alert to the vehicle operator when more than one alert is currently active

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Vehicle System (VS)	VS-REQ-27	IVAA DN	The Vehicle System shall alert the vehicle operator for a distress message when the direction of travel of the host vehicle moving toward the distressed vehicle and is within five miles of the location of a distressed vehicle using an inform message. Distress Notification functionality is described in Section 2.6.3 of the SyRS.
Vehicle System (VS)	VS-REQ-32	HMI Characteristics	All Vehicle Sub-Systems shall contain a HMI that conforms to the following characteristics.
Vehicle System (VS)	VS-REQ-32.7	Distress Notification	The HMI shall include a distress button to allow a driver to notify the Vehicle System that the driver has initiated a distress condition. This button enables the distress notification application as defined in section 2.6.3 of the SyRS.
Vehicle System (VS)	VS-REQ-34	BCVI Distress	The Vehicle System shall wirelessly broadcast distress messages to other connected devices.
Vehicle System (VS)	VS-REQ-34.1	Received Distress	The Vehicle System shall broadcast distress notifications (over DSRC), received from remote vehicles, for five miles from the location where the distressed vehicle is located.
Vehicle System (VS)	VS-REQ-34.2	Generated Distress	The Vehicle System, in distress (described in Section 2.6 of the SyRS), shall broadcast distress notifications over DSRC, until the vehicle event code that triggered the distress notification is reset or power is lost (whichever comes first).
Vehicle System (VS)	VS-REQ-35	BCVI General Broadcast Requirements	The Vehicle System shall use the general broadcast requirements defined in Appendix A.4 Broadcast Traveler Information of the SyRS.
Vehicle System (VS)	VS-REQ-51	VS Equipment	All Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.
4) Support notification of warnings about work zones to equipped vehicles			
Situation Data Exchange (SDX)	SDX-REQ-1	Data Provided to the SDX	The Wyoming CV System shall transmit traveler information messages (TIMs) generated by the system to the SDX within five minutes of generation. TIMs are formatted as defined in J2735 – 5.16 Message: MSG_TravelerInformation Message (TIM).
Situation Data Exchange (SDX)	SDX-REQ-2	Distribute TIM to VS	The Situation Data Exchange shall distribute TIMs to the <i>Vehicle System</i> through satellite, as defined in WCVS-REQ-10.2 Distribute TIM to SDX.
WYDOT Construction Administration (CA)	CA-REQ-1	CA Data Sharing	The Wyoming CV System shall receive timestamped work zone information from the CA.
WYDOT Construction Administration (CA)	CA-REQ-2	Protocol	The Wyoming CV System shall receive work zone information, based on HTTP protocol, from the CA.
WYDOT Construction Administration (CA)	CA-REQ-3	Schema	The Wyoming CV System shall receive work zone information from WYDOT CA, as described in Section 5.32.1 of the ICD.
WYDOT Construction Administration (CA)	CA-REQ-4	Transmission	The Wyoming CV System shall receive work zone data from WYDOT Construction Administrator within thirty minutes of generation.
Wyoming CV System (WCVS)	WCVS-REQ-9	Create TIM	The Wyoming CV System shall create a Traveler Information Message (TIM) formatted as defined in J2735 – 5.16 Message: MSG_TravelerInformation Message (TIM).
Wyoming CV System (WCVS)	WCVS-REQ-10	Distribute TIM	The Wyoming CV System shall distribute signed TIMs to the Vehicle System and the Situation Data Exchange (SDX).

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Wyoming CV System (WCVS)	WCVS-REQ-10.1	Distribute TIM to VS	The Wyoming CV System shall distribute signed TIM to the Vehicle System consistent with Section 3.5.8 (Traveler Information Requirements) of J3067
Wyoming CV System (WCVS)	WCVS-REQ-10.2	Distribute TIM to SDX	The Wyoming CV System shall distribute signed TIM to the SDX consistent with Section 3.5.8 (Traveler Information Requirements) of J3067. The SDX may not be available going forward. This requirement is for general compliance with the national communication of TIMs and is one way that the Wyoming pilot can get TIMs to third parties for broader distribution. If the SDX becomes unavailable, the pilot can directly send TIMs to the third parties for distribution. The SDX is not required for the Wyoming pilot.
Vehicle System (VS)	VS-REQ-2	Receive TIM	VS-REQ-2 Receive TIM – The Vehicle System shall wirelessly receive a packet containing traveler information from the Wyoming CV System. Each packet may contain one or more individual traveler information message as defined in Section 5.16 of SAE J2735.
Vehicle System (VS)	VS-REQ-19	WZW TIM	The Vehicle System shall ingest received TIMs to identify work zone warnings (Part III content choice workZone defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage.
Vehicle System (VS)	VS-REQ-20	WZW TIM-Region	The Vehicle System shall ingest received TIMs to identify the applicable regions of use geographical path (Part II defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage.
Vehicle System (VS)	VS-REQ-23	IVAA Rank	The Vehicle System shall provide prioritized in-vehicle alerts based on the rank order presented in Table 4-1 of the SyRS, with the highest rank on top.
Vehicle System (VS)	VS-REQ-24	IVAA Level	The Vehicle System shall have three levels of alert, as described in Table 4-2 of the SyRS.
Vehicle System (VS)	VS-REQ-25	IVAA Priority Alert	The Vehicle System shall provide only the highest priority alert to the vehicle operator when more than one alert is currently active
Vehicle System (VS)	VS-REQ-31	IVAA WZW	The Vehicle System shall alert the vehicle operator of a work zone, based on the information defined in requirement CA-REQ-3, when host vehicle is traveling towards and within two miles of the location of a work zone using an inform message as defined in Section 2.6.4 of the SyRS.
Vehicle System (VS)	VS-REQ-51	VS Equipment	All Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.
5) Support Spot Weather Impact Warnings to equipped vehicles			
Situation Data Exchange (SDX)	SDX-REQ-1	Data Provided to the SDX	The Wyoming CV System shall transmit traveler information messages (TIMs) generated by the system to the SDX within five minutes of generation. TIMs are formatted as defined in J2735 – 5.16 Message: MSG_TravelerInformation Message (TIM).
Situation Data Exchange (SDX)	SDX-REQ-2	Distribute TIM to VS	The Situation Data Exchange shall distribute TIMs to the <i>Vehicle System</i> through satellite, as defined in WCVS-REQ-10.2 Distribute TIM to SDX.
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.1	Road Condition	The Wyoming CV System shall receive road condition information from the RCRS following the 8 Code System.
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.2	Weather	The Wyoming CV System shall receive atmospheric information from the RCRS following the 9 Code System.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.3	Other Road Condition	The Wyoming CV System shall receive other road information from RCRS following the 10 Code System.
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.4	Report Time	The Wyoming CV System shall receive reports from RCRS containing a timestamp of when the operator entered the information into the app.
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.5	Location	The Wyoming CV System shall receive reports from RCRS containing a location reference of when the operator entered the information into the app
WYDOT Road Condition Reporting (RCRS)	RCRS-REQ-1.6	Transmit Time	The Wyoming CV System shall receive reports from RCRS containing a timestamp of when the report was transmitted to the TMC. The transmitting timestamp may be different from the reporting time
Wyoming CV System (WCVS)	WCVS-REQ-1	Collect CV Data	The Wyoming CV System shall collect data from the Vehicle System.
Wyoming CV System (WCVS)	WCVS-REQ-1.2	Collect Environmental Sensor Data	The Wyoming CV System shall collect environment sensor data using secure copy (SCP) from the Vehicle System consistent with secure shell (SSH).
Wyoming CV System (WCVS)	WCVS-REQ-3	Ingest Data for Road Weather information	The Wyoming CV System shall use one or more of the following Wyoming sources of data to generate road weather information: <ul style="list-style-type: none"> • Collected CV Information defined in WCVS-REQ-1. • Segment road and weather conditions from the WYDOT RCRS in RCRS-REQ-1. • Weather conditions from weather interfaces defined in WI-REQ-1 and WI-REQ-2.
Wyoming CV System (WCVS)	WCVS-REQ-4	Contents of Alerts and Advisories	The Wyoming CV System shall generate alerts and advisories of roadway hazard conditions as defined in the following requirements.
Wyoming CV System (WCVS)	WCVS-REQ-4.1	Precipitation Hazard	The Wyoming CV System shall generate a precipitation type and intensity report every 5 minutes, as specified in Section 3.1.4.2 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.2	Road Condition Hazard	The Wyoming CV System shall generate a pavement state and slickness flag report every 5 minutes, depending on input data, as specified in Section 3.1.4.2 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.3	Visibility Hazard	The Wyoming CV System shall generate a visibility report, along with the condition causing it, every 5 minutes, as specified in Section 3.1.4.2 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-5	Forecast Conditions	The Wyoming CV System shall generate forecasts of conditions as defined in the following requirements
Wyoming CV System (WCVS)	WCVS-REQ-5.1	Atmospheric Forecasts	The Wyoming CV System shall produce atmospheric weather forecasts, at a minimum, for (a) atmospheric temperature, (b) probability of precipitation, (c) wind speed, and (d) wind direction
Wyoming CV System (WCVS)	WCVS-REQ-5.2	Road Weather Forecasts	The Wyoming CV System shall produce road weather forecasts, at a minimum, for (a) pavement temperature, and (b) subsurface temperature
Wyoming CV System (WCVS)	WCVS-REQ-5.3	Forecast Time	The Wyoming CV System shall generate forecast reports for customizable forecast windows. The windows of interest will be determined by WYDOT (6, 12, 24, 48 hours for example).
Wyoming CV System (WCVS)	WCVS-REQ-5.4	Forecast Update	The Wyoming CV System shall generate forecast updates for customizable intervals. The update frequency will be determined by WYDOT and may vary based on time of year (every 3 hours for example in winter to 12 hours during summer).

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Wyoming CV System (WCVS)	WCVS-REQ-6	Associate Alerts and Forecast to Segments	The Wyoming CV System shall associate each alert and forecast to one or more road segments on I-80. Roadway segments are defined by WYDOT as sections of roadway between variable mileposts.
Wyoming CV System (WCVS)	WCVS-REQ-9	Create TIM	The Wyoming CV System shall create a Traveler Information Message (TIM) formatted as defined in J2735 – 5.16 Message: MSG_TravelerInformation Message (TIM).
Wyoming CV System (WCVS)	WCVS-REQ-10	Distribute TIM	The Wyoming CV System shall distribute signed TIMs to the Vehicle System and the Situation Data Exchange (SDX).
Wyoming CV System (WCVS)	WCVS-REQ-10.1	Distribute TIM to VS	The Wyoming CV System shall distribute signed TIM to the Vehicle System consistent with Section 3.5.8 (Traveler Information Requirements) of J3067
Wyoming CV System (WCVS)	WCVS-REQ-10.2	Distribute TIM to SDX	The Wyoming CV System shall distribute signed TIM to the SDX consistent with Section 3.5.8 (Traveler Information Requirements) of J3067. The SDX may not be available going forward. This requirement is for general compliance with the national communication of TIMs and is one way that the Wyoming pilot can get TIMs to third parties for broader distribution. If the SDX becomes unavailable, the pilot can directly send TIMs to the third parties for distribution. The SDX is not required for the Wyoming pilot.
Vehicle System (VS)	VS-REQ-2	Receive TIM	VS-REQ-2 Receive TIM – The Vehicle System shall wirelessly receive a packet containing traveler information from the Wyoming CV System. Each packet may contain one or more individual traveler information message as defined in Section 5.16 of SAE J2735.
Vehicle System (VS)	VS-REQ-2.1	Receive TIM through DSRC	The Vehicle System shall wirelessly receive a packet containing traveler information from the Wyoming CV System through DSRC
Vehicle System (VS)	VS-REQ-2.2	Receive TIM through Satellite	The Vehicle System shall wirelessly receive a packet containing traveler information from the Wyoming CV System (via the Situation Data Exchange) through satellite.
Vehicle System (VS)	VS-REQ-4	Collect Vehicle Data	The Vehicle System shall have the capability to collect vehicle information from the host vehicle and the driver as stated below
Vehicle System (VS)	VS-REQ-4.1	Collect Vehicle Status Data	The Vehicle System shall have the capability to collect vehicle status information from the host vehicle, as stated in Section 5.4.2 of the ICD.
Vehicle System (VS)	VS-REQ-5	External Environment Sensor Data	The Vehicle System shall collect additional environmental sensor data from host vehicles equipped with external environmental sensors. Additional data collected from external environmental sensors is shown in Table 7-4 of the Interface Control Document.
Vehicle System (VS)	VS-REQ-5.1	External Environment Sensor Data Configuration	The collection of sensor data by the Vehicle System shall be configurable as specified in Section 3.2.5.1 of the SDD.
Vehicle System (VS)	VS-REQ-5.2	External Environment Sensor Data Management	The application shall support a data management mechanism, specified in Section 3.2.5.1 of the SDD.
Vehicle System (VS)	VS-REQ-21	SWIW TIM	The Vehicle System shall ingest received TIMs to identify advisories for wind and weather conditions (Part III content choice advisories defined in J2735 section 6.142 for ITIS - data elements 6.54 Weather Conditions and 6.55 Winds defined in J2540_2). Data ingest is defined as obtaining and importing data for use or storage.
Vehicle System (VS)	VS-REQ-22	SWIW TIM-Region	The Vehicle System shall ingest received TIMs to identify the applicable regions of use geographical path (Part II defined in J2735 section 6.142). Data ingest is defined as obtaining and importing data for use or storage.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Vehicle System (VS)	VS-REQ-23	IVAA Rank	The Vehicle System shall provide prioritized in-vehicle alerts based on the rank order presented in Table 4-1 of the SyRS, with the highest rank on top.
Vehicle System (VS)	VS-REQ-24	IVAA Level	The Vehicle System shall have three levels of alert, as described in Table 4-2 of the SyRS.
Vehicle System (VS)	VS-REQ-25	IVAA Priority Alert	The Vehicle System shall provide only the highest priority alert to the vehicle operator when more than one alert is currently active
Vehicle System (VS)	VS-REQ-30	IVAA SWIW	The Vehicle System shall alert the vehicle operator of a spot weather incident when the host vehicle is traveling toward and within five miles of the incident's location using an inform message as defined in Section 2.6.5 of the SyRS.
Vehicle System (VS)	VS-REQ-36	Transmit Data	The Vehicle System shall transmit data over DSRC.
Vehicle System (VS)	VS-REQ-36.1	Transmit Environmental Data	The Vehicle System shall transmit over DSRC environmental data, defined in Table 7-4 of the SDD, to the Wyoming CV System when available from a vehicle Sub-System.
Vehicle System (VS)	VS-REQ-51	VS Equipment	All Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.
6) Support WYDOT Corridor Management & Traditional Traveler Information Program Services			
WYDOT 511 Application (511App)	511-REQ-1	511App Parking Data Collection	The Wyoming CV System shall receive parking status data from Wyoming 511 App.
WYDOT 511 Application (511App)	511-REQ-1.1	Availability	The Wyoming CV System shall categorize parking availability for the facility of interest as follows: i) Full – No parking availability, ii) Spaces available, or iii) Only a few spaces available.
WYDOT 511 Application (511App)	511-REQ-1.2	Default	The Wyoming CV System shall set parking availability default to available if not provided.
WYDOT 511 Application (511App)	511-REQ-1.3	Time	The Wyoming CV System shall timestamp parking availability reports.
WYDOT 511 Application (511App)	511-REQ-1.4	Location	The Wyoming CV System shall associate parking availability with a parking facility on I-80.
WYDOT 511 Application (511App)	511-REQ-1.5	Protocol	The Wyoming CV System shall receive information, based on HTTP protocol, from the 511App.
WYDOT 511 Application (511App)	511-REQ-1.6	Schema	The Wyoming CV System shall receive information based on the parking schema defined by WYDOT (WYDOT Truck Parking Map – as of 07/2016).
WYDOT 511 Application (511App)	511-REQ-2	Timeframe	The Wyoming CV System shall receive Parking availability data from the WYDOT 511 application within thirty minutes of generation.
WYDOT Third Party Interface (TPI)	TPI-REQ-1	TPI Data	The Wyoming CV System shall transmit traffic condition information to the WYDOT TPI, as described in Section 5.36.1 of the ICD.
WYDOT Transportation Reports and Action Console (TRAC)	TRAC-REQ-1	TRAC Updates	The Wyoming CV System shall transmit CV pilot events to the TRAC.
WYDOT Transportation Reports and Action Console (TRAC)	TRAC-REQ-1.1	Distress Notification	The Wyoming CV System shall transmit received distress notifications to TRAC. Distress notifications are defined in WCVS-REQ-1.3.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
WYDOT Transportation Reports and Action Console (TRAC)	TRAC-REQ-1.1.1	Transmission Time	The Wyoming CV System shall transmit distress notifications to TRAC within five minutes of its generation in the system.
WYDOT Transportation Reports and Action Console (TRAC)	TRAC-REQ-1.2	Segment Alerts	The Wyoming CV System shall transmit segment-level alerts, defined in WCVS-REQ-4, to TRAC.
WYDOT Transportation Reports and Action Console (TRAC)	TRAC-REQ-1.2.1	Transmission Time	The Wyoming CV System shall transmit alerts to TRAC within five minutes of its generation in the system.
WYDOT Transportation Reports and Action Console (TRAC)	TRAC-REQ-1.2.2	Segment Alerts-Pikalert	The Wyoming CV System shall transmit Pikalert segment-level alerts, defined in WCVS-REQ-4, to TRAC
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-1	WTI Inputs	The Wyoming CV System shall transmit CV Pilot event information to the WTI.
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-1.1	Current Segment Alerts	The Wyoming CV System shall transmit current segment-specific alerts, defined in WCVS-REQ-4, to the WTI.
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-1.1.1	Transmission Time	The Wyoming CV System shall transmit alerts within five minutes of its generation in the system to the WTI.
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-1.2	Forecast Segment Alerts	The Wyoming CV System shall transmit forecast segment-specific alerts, defined in WCVS-REQ-5, to the WTI.
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-1.2.1	Forecast Time	The Wyoming CV System shall transmit forecast reports to WTI for pre-specified forecast windows determined by WYDOT (6, 12, 24, 48, 72 hours).
WYDOT Wyoming Traveler Information (WTI)	WTI-REQ-1.2.2	Forecast Update	The Wyoming CV System shall update its forecast reports in WTI at WYDOT-determined intervals (every 12 hours for example).
WYDOT Commercial Vehicle Operator Portal (CVOP)	CVOP-REQ-1	CVOP Inputs	The Wyoming CV System shall transmit CV Pilot event information to the CVOP.
WYDOT Commercial Vehicle Operator Portal (CVOP)	CVOP-REQ-1.1	Current Segment Alerts	The Wyoming CV System shall transmit current segment-specific alerts, defined in WCVS-REQ-4, to the CVOP.
WYDOT Commercial Vehicle Operator Portal (CVOP)	CVOP-REQ-1.1.1	Transmission Time	The Wyoming CV System shall transmit alerts within five minutes of its generation in the system to the CVOP.
WYDOT Commercial Vehicle Operator Portal (CVOP)	CVOP-REQ-1.2	Forecast Segment Alerts	The Wyoming CV System shall transmit forecast segment-specific alerts, defined in WCVS-REQ-5, to the CVOP.

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(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
WYDOT Commercial Vehicle Operator Portal (CVOP)	CVOP-REQ-1.2.1	Forecast Time	The Wyoming CV System shall transmit forecast reports to the CVOP for pre-specified forecast windows determined by WYDOT (6, 12, 24, 48, 72 hours).
WYDOT Commercial Vehicle Operator Portal (CVOP)	CVOP-REQ-1.2.2	Forecast Update	The Wyoming CV System shall update its forecast reports in CVOP at WYDOT-determined intervals (every 12 hours for example).
Wyoming CV System (WCVS)	WCVS-REQ-3	Ingest Data for Road Weather information	The Wyoming CV System shall use one or more of the following sources of data to generate road weather information: <ul style="list-style-type: none"> • Collected CV Information defined in WCVS-REQ-1. • Segment road and weather conditions from the WYDOT RCRS in RCRS-REQ-1. • Weather conditions from weather interfaces defined in WI-REQ-1 and WI-REQ-2.
Wyoming CV System (WCVS)	WCVS-REQ-4	Contents of Alerts and Advisories	The Wyoming CV System shall generate alerts and advisories of roadway hazard conditions as defined in the following requirements.
Wyoming CV System (WCVS)	WCVS-REQ-4.1	Precipitation Hazard	The Wyoming CV System shall generate a precipitation type and intensity report every 5 minutes, as specified in Section 3.1.4.2 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.2	Road Condition Hazard	The Wyoming CV System shall generate a pavement state and slickness flag report every 5 minutes, depending on input data, as specified in Section 3.1.4.2 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.3	Visibility Hazard	The Wyoming CV System shall generate a visibility report, along with the condition causing it, every 5 minutes, as specified in Section 3.1.4.2 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.4	Work Zone Hazard	The Wyoming CV System shall generate a work zone report within 5 minutes of receiving work zone information from the Construction Administration (defined in CA-REQ-1), as specified in Section 3.1.5.4 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.5	Incident Hazard	The Wyoming CV System shall generate an incident report within 5 minutes of receiving incident notifications from the Incident Console (defined in IC-REQ-1), as specified in Section 3.1.4.3 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-4.6	Parking	The Wyoming CV System shall generate a parking report within 5 minutes of receiving parking availability notification, as specified in Section 3.1.4.3 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-5	Forecast Conditions	The Wyoming CV System shall generate forecasts of conditions as defined in the following requirements
Wyoming CV System (WCVS)	WCVS-REQ-5.1	Atmospheric Forecasts	The Wyoming CV System shall produce atmospheric weather forecasts, at a minimum, for (a) atmospheric temperature, (b) probability of precipitation, (c) wind speed, and (d) wind direction
Wyoming CV System (WCVS)	WCVS-REQ-5.2	Road Weather Forecasts	The Wyoming CV System shall produce road weather forecasts, at a minimum, for (a) pavement temperature, and (b) subsurface temperature
Wyoming CV System (WCVS)	WCVS-REQ-5.3	Forecast Time	The Wyoming CV System shall generate forecast reports for customizable forecast windows. The windows of interest will be determined by WYDOT (6, 12, 24, 48 hours for example).
Wyoming CV System (WCVS)	WCVS-REQ-5.4	Forecast Update	The Wyoming CV System shall generate forecast updates for customizable intervals. The update frequency will be determined by WYDOT and may vary based on time of year (every 3 hours for example in winter to 12 hours during summer).
Wyoming CV System (WCVS)	WCVS-REQ-6	Associate Alerts and Forecast to Segments	The Wyoming CV System shall associate each alert and forecast to one or more road segments on I-80. Roadway segments are defined by WYDOT as sections of roadway between variable mileposts.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Wyoming CV System (WCVS)	WCVS-REQ-7	External Brokerage with WYDOT Interfaces	The Wyoming CV System shall transfer data with WYDOT systems as defined in WCVS-REQ-7.1 and WCVS-REQ-7.2.
Wyoming CV System (WCVS)	WCVS-REQ-7.2	Distribute to WYDOT External Interfaces	The Wyoming CV System shall distribute information to WYDOT systems as defined in TPI-REQ-1, TRAC-REQ-1, WTI-REQ-1, CVOP-REQ-1, and ITSM-REQ-1.
Wyoming CV System (WCVS)	WCVS-REQ-8	Internal Brokerage	The Wyoming CV System shall support internal brokerage of data as defined in RSU-REQ-1, RSU-REQ-2, ODE-REQ-1, ODE-REQ-3, PA-REQ-2, PA-REQ-4, DB-REQ-4, DB-REQ-5, DB-REQ-6, DB-REQ-7, DW-REQ-1, DW-REQ-2, DW-REQ-4, HSM-REQ-1, HSM-REQ-2, HSM-REQ-3, and HSM-REQ-4.
Wyoming CV System (WCVS)	WCVS-REQ-18	Management and Performance Policy	The Wyoming CV System's infrastructure-related elements shall manage the policy for data collection and performance data following requirements defined in Appendix B.4 RSU Performance Data of the SyRS.
7) Need capability to monitor and update CV Pilot field devices system health (up-time, communication strength, device status) remotely during normal and adverse weather conditions			
WYDOT ITS Maintenance (ITSM)	ITSM-REQ-1	WYDOT ITS Alerts	The Wyoming CV System shall send alerts, defined in WCVS-REQ-16, to the WYDOT ITS Maintenance team within five minutes of a system becoming unavailable.
Wyoming CV System (WCVS)	WCVS-REQ-15	Notifications	The Wyoming CV System shall notify designated personnel within five minutes of a monitored function becoming unavailable
Wyoming CV System (WCVS)	WCVS-REQ-16	Monitored Functions	The Wyoming CV System shall monitor the functions described in WCVS-REQ-16.1 through WCVS-REQ-16.4.
Wyoming CV System (WCVS)	WCVS-REQ-16.1	Sub-System Availability	The Wyoming CV System shall monitor the Sub-systems for availability of ping services running. The WYDOT maintenance team will be sent a notification after a device, web service or running service is non-responsive for five minutes.
Wyoming CV System (WCVS)	WCVS-REQ-16.2	Sus-System Performance	The Wyoming CV System shall monitor the system's ability to transmit information in a timely manner. This will be done by monitoring message input queues age of oldest entry not processed. If the messages are not processed within five minutes the WYDOT maintenance team will be notified.
Wyoming CV System (WCVS)	WCVS-REQ-16.3	Availability for Interfaces	The Wyoming CV System shall monitor the external interfaces for availability of ping services running. The WYDOT maintenance team will be sent a notification after a device, web service or running service is non-responsive for five minutes.
Wyoming CV System (WCVS)	WCVS-REQ-16.4	Availability for Data Storage	The Wyoming CV System shall monitor available data storage of ping services running. The WYDOT maintenance team will be sent a notification after a device, web service or running service is non-responsive for five minutes. Notification will also be sent for disk space under 10% availability.
Wyoming CV System (WCVS)	WCVS-REQ-18	Management and Performance Policy	The Wyoming CV System's infrastructure-related elements shall manage the policy for data collection and performance data following requirements defined in Appendix B.4 RSU Performance Data of the SyRS.
Wyoming CV System (WCVS)	WCVS-REQ-21	Manage CV Equipment	The Wyoming CV System shall provide the TMC administrator the ability to add/edit/delete equipment from the internal inventory list
Wyoming CV System (WCVS)	WCVS-REQ-22	Test WCVS Equipment	The Wyoming CV System shall provide the TMC administrator the ability to test the RSUs by allowing a series of Python testing scripts to be run on an RSU and results of the test returned to the user.
Wyoming CV System (WCVS)	WCVS-REQ-23	Track WCVS Equipment	The Wyoming CV System shall provide the TMC administrator the geolocation of RSUs.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Wyoming CV System (WCVS)	WCVS-REQ-24	Update WCVS Equipment	The Wyoming CV System shall provide the TMC administrator the ability to push out updates to the RSU firmware.
Wyoming CV System (WCVS)	WCVS-REQ-25	Update VS Equipment	The Wyoming CV System shall provide the TMC administrator the ability to push out OTA updates to the OBU firmware.
Vehicle System (VS)	VS-REQ-48	VSM Updates	The Vehicle System shall support Over-the-Air (OTA) software updates from the Wyoming CV System based on WAVE Service Announcements (WSA).
Vehicle System (VS)	VS-REQ-51	VS Equipment	All Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.
8) Need to develop human machine interface that minimizes the distraction and does not pose a burden on the work load of the driver.			
Vehicle System (VS)	VS-REQ-32	HMI Characteristics	All Vehicle Sub-Systems shall contain a HMI that conforms to the following characteristics.
Vehicle System (VS)	VS-REQ-32.1	HMI-Location	The location where the devices will be mounted/installed shall be selected so that they do not obstruct the line of sight of the driver nor distract the driver from the primary task of driving.
Vehicle System (VS)	VS-REQ-32.2	HMI-Distraction	The HMI shall minimize the 'eyes off the road' time when presenting information for an application
Vehicle System (VS)	VS-REQ-32.3	HMI-Readability	The HMI shall provide messages that can be read from the driver's normal seating position
Vehicle System (VS)	VS-REQ-32.4	Visual and Auditory Interface	The HMI shall include both a visual and auditory interface for sharing traveler information
Vehicle System (VS)	VS-REQ-32.4.1	Visual Consistency	The HMI shall maintain a consistent structure across applications with respect to presenting information to drivers and inputs to the system.
Vehicle System (VS)	VS-REQ-32.4.2	Audio Signals	Auditory signals shall be loud enough to overcome masking sounds from road noise, the cab environment, and other equipment.
Vehicle System (VS)	VS-REQ-32.5	Customizations	HMI characteristics shall be customizable to reflect driver preferences. Preferences that shall be customizable are: <ul style="list-style-type: none"> • Volume • Brightness • Contrast text size • Display contrast • Mounting eye position
Vehicle System (VS)	VS-REQ-32.6	System Status	The HMI shall provide system status information to drivers. Information included in the system status includes power status, system settings, status of applications availability, and pending update status
Vehicle System (VS)	VS-REQ-32.6.1	Power Status	The HMI shall notify the driver of the power status of device with the screen graphics (e.g., off, powering up and online).
Vehicle System (VS)	VS-REQ-32.6.2	System Settings	The HMI shall allow the driver to see the system settings of the device with screen graphics. (e.g., version, brightness, volume font size).
Vehicle System (VS)	VS-REQ-32.6.3	Application Availability	The HMI shall allow the driver to see application availability with screen graphics (e.g., failed, operating, disabled).
Vehicle System (VS)	VS-REQ-32.6.4	Pending Update Status	The HMI shall allow the driver see pending updates for the device with screen graphics (e.g., applications, firmware, operating system).

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Vehicle System (VS)	VS-REQ-32.7	Distress Notification	The HMI shall include a distress button to allow a driver to notify the Vehicle System that the driver has initiated a distress condition. This button enables the distress notification application as defined in section 2.6.3 of the SyRS.
Vehicle System (VS)	VS-REQ-32.8	Non-Distress Information	The HMI shall allow the driver to input data, as defined in VS-REQ-4.2
9) Need capability through the pilot of logging time-stamped data for various pilot elements			
Location and Time Source (LTS)	LTS-REQ-1	WCVS Time	The Wyoming CV System shall acquire time as specified below.
Location and Time Source (LTS)	LTS-REQ-1.1	WCVS LTS Time	The Wyoming CV System shall acquire time from the LTS interface in accordance with Section 5.10.1 of the ICD.
Location and Time Source (LTS)	LTS-REQ-1.2	WCVS Time Synchronization	The Wyoming CV System shall receive time synchronization information from a Stratum 2 NTP source, as described in Section 5.12.1 of the ICD.
Location and Time Source (LTS)	LTS-REQ-2	WCVS LTS Time Standard	The Wyoming CV System shall use Coordinated Universal Time (UTC) time for logged data (e.g., events logs and environmental data) based on the format defined in J2735 section 6.19 and epoch of January 1st 1970.
Location and Time Source (LTS)	LTS-REQ-3	WCVS LTS Location	The Wyoming CV System shall acquire location from the LTS interface in accordance with J2945/1 section 6.2.1.
Location and Time Source (LTS)	LTS-REQ-4	VS LTS Time	The Vehicle System shall acquire time from the LTS interface in accordance with Section 5.3.1 of the ICD.
Location and Time Source (LTS)	LTS-REQ-5	VS LTS Time Standard	The Vehicle System shall use Coordinated Universal Time (UTC) time for logged data (e.g., events logs and environmental data) based on the format defined in J2735 section 6.19 and epoch of January 1st 1970.
Location and Time Source (LTS)	LTS-REQ-6	VS LTS Location	The Vehicle System shall acquire location from the LTS interface in accordance with J2945/1 section 6.2.1.
10) Need a capability to collect, manage, store data collected from equipped fleets as part of the pilot			
Wyoming CV System (WCVS)	WCVS-REQ-1	Collect CV Data	The Wyoming CV System shall collect data from the Vehicle System.
Wyoming CV System (WCVS)	WCVS-REQ-1.1	Collect BSM Data	The Wyoming CV System shall collect Basic Safety Message Parts I and II (as defined in J2945/1) from the Vehicle System consistent with Section 6.3.8 (BSM Scheduling and Congestion Control) of J2945/1
Wyoming CV System (WCVS)	WCVS-REQ-1.2	Collect Environmental Sensor Data	The Wyoming CV System shall collect environment sensor data using secure copy (SCP) from the Vehicle System consistent with secure shell (SSH).
Wyoming CV System (WCVS)	WCVS-REQ-1.3	Collect Distress Messages	The Wyoming CV System shall collect distress messages using the Traveler Information Message (as defined in section 5.16 of J2735) from the Vehicle System consistent with Section 3.5.8 (Traveler Information Requirements) of J3067
Wyoming CV System (WCVS)	WCVS-REQ-2	Validate Data	The Wyoming CV System shall provide validation- and sanitization-related functions of CV Data as defined in Section 3.1.4.1 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-8	Internal Brokerage	The Wyoming CV System shall support internal brokerage of data as defined in RSU-REQ-1, RSU-REQ-2, ODE-REQ-1, ODE-REQ-3, PA-REQ-2, PA-REQ-4, DB-REQ-4, DB-REQ-5, DB-REQ-6, DB-REQ-7, DW-REQ-1, DW-REQ-2, DW-REQ-4, HSM-REQ-1, HSM-REQ-2, HSM-REQ-3, and HSM-REQ-4.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Wyoming CV System (WCVS)	WCVS-REQ-11	Store VS Data	The Wyoming CV System shall store processed data collected by the Vehicle Systems and retain it for the duration of the CV Pilot. Data Processing is defined in ODE-REQ-2.
Wyoming CV System (WCVS)	WCVS-REQ-11.1	Store BSM	The Wyoming CV System shall store processed BSM Parts I and II data received from the Vehicle System. As the BSM will be previously validated, only core data elements will be stored (defined in sections 6.8, 6.147, 6.128, and 6.133 of J2735).
Wyoming CV System (WCVS)	WCVS-REQ-11.2	Store Environment Sensor Data	The Wyoming CV System shall store processed environment sensor data consistent with Section 5.19.2 of the ICD.
Wyoming CV System (WCVS)	WCVS-REQ-11.3	Store Distress Messages	The Wyoming CV System shall store processed distress messages using the Traveler Information Message (as defined in section 5.16 of J2735) received from the Vehicle System consistent with Section 3.5.8 (Traveler Information Requirements) of J3067. As the distress message will be previously validated, only core data will be stored (defined in sections 5.16, and 6.142 of J2735).
Wyoming CV System (WCVS)	WCVS-REQ-12	Store Generated Alerts/Advisories	The Wyoming CV System shall store generated road weather alerts and advisories (defined WCVS-REQ-4) and retained for the duration of the CV Pilot.
Wyoming CV System (WCVS)	WCVS-REQ-13	Store TIM	The Wyoming CV System shall store TIMs distributed to the Vehicle System and the Situation Data Exchange (SDX) and retain it for the duration of the CV Pilot.
Wyoming CV System (WCVS)	WCVS-REQ-14	Store System Monitoring Data	The Wyoming CV System shall store system monitoring data, as defined by WCVS-REQ-16 Monitored Functions, and retain it for the duration of the CV Pilot.
Wyoming CV System (WCVS)	WCVS-REQ-17	Archive Data	The Wyoming CV System shall provide the TMC administrator the ability to archive data used by the CV pilot by writing CV data to the WYDOT Data Warehouse, data written to the Data Warehouse is automatically archived per existing TMC best practices.
Vehicle System (VS)	VS-REQ-4	Collect Vehicle Data	The Vehicle System shall have the capability to collect vehicle information from the host vehicle and the driver as stated below
Vehicle System (VS)	VS-REQ-4.1	Collect Vehicle Status Data	The Vehicle System shall have the capability to collect vehicle status information from the host vehicle, as stated in Section 5.4.2 of the ICD.
Vehicle System (VS)	VS-REQ-4.2	Collect Dimension Data	The Vehicle System shall have the capability to collect information from the host vehicle driver. The VS will maintain these values across power cycles and OTA updates. The data will be included in BSMs broadcasted by the Vehicle System. The list of fields are shown in Table 7-1 of the ICD, where column #1 contains the value "yes/driver".
Vehicle System (VS)	VS-REQ-4.2.1	Vehicle Dimension Data	The Vehicle System shall have the capability to collect vehicle dimension from the host vehicle driver through the Human Machine Interface.
Vehicle System (VS)	VS-REQ-4.2.2	Vehicle Trailer Data	The Vehicle System shall have the capability to collect information from the host vehicle driver regarding the dimensions of attached trailers, including capability to indicate that no trailer is present, through the Human Machine Interface.
Vehicle System (VS)	VS-REQ-5	External Environment Sensor Data	The Vehicle System shall collect additional environmental sensor data from host vehicles equipped with external environmental sensors. Additional data collected from external environmental sensors is shown in Table 7-4 of the Interface Control Document.
Vehicle System (VS)	VS-REQ-5.1	External Environment Sensor Data Configuration	The collection of sensor data by the Vehicle System shall be configurable as specified in Section 3.2.5.1 of the SDD.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Vehicle System (VS)	VS-REQ-5.2	External Environment Sensor Data Management	The application shall support a data management mechanism, specified in Section 3.2.5.1 of the SDD.
Vehicle System (VS)	VS-REQ-36	Transmit Data	The Vehicle System shall transmit data over DSRC.
Vehicle System (VS)	VS-REQ-36.1	Transmit Environmental Data	The Vehicle System shall transmit over DSRC environmental data, defined in Table 7-4 of the SDD, to the Wyoming CV System when available from a vehicle Sub-System.
Vehicle System (VS)	VS-REQ-36.2	TVI Data Management-Log	The Vehicle System shall transmit log files via secure copy (SCP) to the Wyoming CV System over DSRC that contain event logs data defined in VS-REQ-41.
Vehicle System (VS)	VS-REQ-38	SLD Information	The Vehicle System shall store information generated by the host vehicle on local storage. Information to be stored is detailed in Table 4-3 of the SyRS.
Vehicle System (VS)	VS-REQ-39	SLD Rolling Log	The Vehicle System shall maintain rolling logs for in vehicle generated CV data for 10 seconds. Table 4-4 of the SyRS lists one or more sources of the rolling logs that may be available in a vehicle Sub-System.
Vehicle System (VS)	VS-REQ-40	SLD Log Format	The event log format shall contain UTC time stamped text or binary data.
Vehicle System (VS)	VS-REQ-41	SLD Log Data	The Vehicle System shall create event logs for all interactions with the Wyoming CV System or Vehicle System that is retained until it is sent to the Wyoming CV System or is older than seven (7) days. An interaction is defined as a received message from the Wyoming CV System or the Vehicle System. Each log should contain the information in Table 4-5 of the SyRS.
Vehicle System (VS)	VS-REQ-42	VSM SCMS	The Vehicle System shall use the USDOT SCMS Certificates in accordance with the security and privacy requirements in Section 6.5 of J2945/1
Vehicle System (VS)	VS-REQ-48	VSM Updates	The Vehicle System shall support Over-the-Air (OTA) software updates from the Wyoming CV System based on WAVE Service Announcements (WSA).
Vehicle System (VS)	VS-REQ-51	VS Equipment	All Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.
11) Need to be able to share data to/from vehicles from/to field, and back-office systems in both real-time and non-real time for various CV applications.			
Wyoming CV System (WCVS)	SDC-REQ-1	Data Provided to the SDC	The Wyoming CV System shall transmit information to the Secure Data Commons.
Wyoming CV System (WCVS)	RDE-REQ-1	Data Provided to the RDE	The Wyoming CV System shall transmit information to the Research Data Exchange.
Wyoming CV System (WCVS)	WCVS-REQ-7	External Brokerage with WYDOT Interfaces	The Wyoming CV System shall transfer data with WYDOT systems as defined in WCVS-REQ-7.1 and WCVS-REQ-7.2.
Wyoming CV System (WCVS)	WCVS-REQ-7.1	Receive from WYDOT External Interfaces	The Wyoming CV System shall receive data from WYDOT systems as defined in 511-REQ-1, RCRS-REQ-1, WTI-REQ-2, IC-REQ-1, and CA-REQ-1.
Wyoming CV System (WCVS)	WCVS-REQ-7.2	Distribute to WYDOT External Interfaces	The Wyoming CV System shall distribute information to WYDOT systems as defined in TPI-REQ-1, TRAC-REQ-1, WTI-REQ-1, CVOP-REQ-1, and ITSM-REQ-1.
Wyoming CV System (WCVS)	WCVS-REQ-10	Distribute TIM	The Wyoming CV System shall distribute signed TIMs to the Vehicle System and the Situation Data Exchange (SDX).

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Wyoming CV System (WCVS)	WCVS-REQ-10.1	Distribute TIM to VS	The Wyoming CV System shall distribute signed TIM to the Vehicle System consistent with Section 3.5.8 (Traveler Information Requirements) of J3067
Wyoming CV System (WCVS)	WCVS-REQ-10.2	Distribute TIM to SDX	The Wyoming CV System shall distribute signed TIM to the SDX consistent with Section 3.5.8 (Traveler Information Requirements) of J3067. The SDX may not be available going forward. This requirement is for general compliance with the national communication of TIMs and is one way that the Wyoming pilot can get TIMs to third parties for broader distribution. If the SDX becomes unavailable, the pilot can directly send TIMs to the third parties for distribution. The SDX is not required for the Wyoming pilot.
Vehicle System (VS)	VS-REQ-2	Receive TIM	VS-REQ-2 Receive TIM – The Vehicle System shall wirelessly receive a packet containing traveler information from the Wyoming CV System. Each packet may contain one or more individual traveler information message as defined in Section 5.16 of SAE J2735.
Vehicle System (VS)	VS-REQ-3	Receive Distress Information	The Vehicle System shall wirelessly receive a packet containing distress information from other connected vehicles over DSRC. Distress information is a high priority messages based on the received distress broadcast (defined in J3067 3.5.9.2.1), but has the content of the TIM (defined in J2735 5.16 Part III advisory ITIS data elements 6.1 from J2540-2 Accidents and Incidents).
Vehicle System (VS)	VS-REQ-33	BCVI Messages	The Vehicle System shall wirelessly broadcast over DSRC a basic safety message (BSM) to other connected devices.
Vehicle System (VS)	VS-REQ-34	BCVI Distress	The Vehicle System shall wirelessly broadcast distress messages to other connected devices.
Vehicle System (VS)	VS-REQ-35	BCVI General Broadcast Requirements	The Vehicle System shall use the general broadcast requirements defined in Appendix A.4 Broadcast Traveler Information of the SyRS.
Vehicle System (VS)	VS-REQ-36	Transmit Data	The Vehicle System shall transmit data over DSRC.
Vehicle System (VS)	VS-REQ-36.1	Transmit Environmental Data	The Vehicle System shall transmit over DSRC environmental data, defined in Table 7-4 of the SDD, to the Wyoming CV System when available from a vehicle Sub-System.
Vehicle System (VS)	VS-REQ-38	SLD Information	The Vehicle System shall store information generated by the host vehicle on local storage. Information to be stored is detailed in Table 4-3 of the SyRS.
Vehicle System (VS)	VS-REQ-47	VSM App Availability Log	The Vehicle System shall log local application availability to the local event logs by vehicle type.
Vehicle System (VS)	VS-REQ-51	VS Equipment	All Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.
12) Need to ensure that data transfer is secure. Non-reputable, signed, and secured data sent and received by vehicles in this pilot			
Security Credential Management System (SCMS)	SCMS-REQ-1	Wyoming CV System (WCVS) SCMS Use	The Wyoming CV System shall interface with the USDOT SCMS based on the requirements in the current version of the Security Credential Management System Proof-of-Concept Implementation EE Requirements and Specifications Supporting SCMS Software (available at https://wiki.campllc.org/display/SCP/SCMS+CV+Pilots+Documentation).
Security Credential Management System (SCMS)	SCMS-REQ-1.1	SCMS Wyoming CV System Certificates	The Wyoming CV System shall download certificates from the USDOT SCMS.
Security Credential Management System (SCMS)	SCMS-REQ-1.2	SCMS Wyoming CV System Misbehavior Reporting	The Wyoming CV System shall send misbehavior reports after they are published to the USDOT SCMS within 24 hours.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Security Credential Management System (SCMS)	SCMS-REQ-1.3	SCMS Wyoming CV System Certificates Revocation List (CRL)	The Wyoming CV System shall download the CRL from the USDOT SCMS.
Security Credential Management System (SCMS)	SCMS-REQ-1.4	SCMS Wyoming CV System Rejection	The Wyoming CV System shall reject messages received from any vehicles on the current CRL.
Security Credential Management System (SCMS)	SCMS-REQ-2	Vehicle System SCMS Use	The Vehicle System used in the Wyoming Pilot shall be certified from a USDOT authorized testing facility based on the current version of the Security Credential Management System Proof-of-Concept Implementation EE Requirements and Specifications Supporting SCMS Software (available at https://wiki.campllc.org/display/SCP/SCMS+CV+Pilots+Documentation).
Security Credential Management System (SCMS)	SCMS-REQ-2.1	SCMS Vehicle System Certificates	The Vehicle System shall download certificates from the USDOT SCMS.
Security Credential Management System (SCMS)	SCMS-REQ-2.2	SCMS Vehicle System Misbehavior Reporting	The Vehicle System shall send misbehavior reports after they are defined to the USDOT SCMS
Security Credential Management System (SCMS)	SCMS-REQ-2.3	SCMS Vehicle System Certificates Revocation List (CRL)	The Vehicle System shall download and utilize the CRL from the USDOT SCMS.
Security Credential Management System (SCMS)	SCMS-REQ-2.4	SCMS Vehicle System Rejection	The Vehicle System shall reject messages received from any vehicles on the current CRL
Wyoming CV System (WCVS)	WCVS-REQ-2	Validate Data	The Wyoming CV System shall provide validation- and sanitization-related functions of CV Data as defined in Section 3.1.4.1 of the SDD.
Wyoming CV System (WCVS)	WCVS-REQ-20	Manage Safe Communications	The Wyoming CV System's infrastructure-related elements shall conform to the core safety communications requirements defined in Appendix B.2 V2I Core Safety Communication Requirements of the SyRS.
Wyoming CV System (WCVS)	WCVS-REQ-21	Manage CV Equipment	The Wyoming CV System shall provide the TMC administrator the ability to add/edit/delete equipment from the internal inventory list
Wyoming CV System (WCVS)	WCVS-REQ-22	Test WCVS Equipment	The Wyoming CV System shall provide the TMC administrator the ability to test the RSUs by allowing a series of Python testing scripts to be run on an RSU and results of the test returned to the user.
Wyoming CV System (WCVS)	WCVS-REQ-23	Track WCVS Equipment	The Wyoming CV System shall provide the TMC administrator the geolocation of RSUs.
Wyoming CV System (WCVS)	WCVS-REQ-24	Update WCVS Equipment	The Wyoming CV System shall provide the TMC administrator the ability to push out updates to the RSU firmware.
Wyoming CV System (WCVS)	WCVS-REQ-25	Update VS Equipment	The Wyoming CV System shall provide the TMC administrator the ability to push out OTA updates to the OBU firmware.
Vehicle System (VS)	VS-REQ-42	VSM SCMS	The Vehicle System shall use the USDOT SCMS Certificates in accordance with the security and privacy requirements in Section 6.5 of J2945/1

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Vehicle System (VS)	VS-REQ-43	VSM SCMS Encryption	The Vehicle System shall use the USDOT SCMS Certificates to sign and encrypt messages transmitted. The approved encryption algorithms are defined in IEEE 1609.2 and explained in USDOT SCMS CAMP Wiki Cryptography.
Vehicle System (VS)	VS-REQ-44	VSM SCMS Sign	The Vehicle System shall use the USDOT SCMS Certificates to sign, but not encrypt, all broadcasted messages.
Vehicle System (VS)	VS-REQ-45	VSM SCMS Encryption-Log	The Vehicle System shall use the USDOT SCMS Certificates to encrypt log files stored locally using the Public Key Encryption defined in USDOT SCMS CAMP Wiki Cryptography. Password protection is also allowable protection for log files.
Vehicle System (VS)	VS-REQ-46	VSM SCMS Sign-Log	The Vehicle System shall use the USDOT SCMS Certificates to sign log files stored locally. Password protection is also allowable for in place of signing log files.
Vehicle System (VS)	VS-REQ-47	VSM App Availability Log	The Vehicle System shall log local application availability to the local event logs by vehicle type.
Vehicle System (VS)	VS-REQ-48	VSM Updates	The Vehicle System shall support Over-the-Air (OTA) software updates from the Wyoming CV System based on WAVE Service Announcements (WSA).
Vehicle System (VS)	VS-REQ-49	Architectural	All Vehicle Sub-systems shall follow all core architectural requirements defined in Appendix A.2 OBU Core Architecture Requirements of the SyRS.
Vehicle System (VS)	VS-REQ-50	Safety Communication	All Vehicle Sub-systems shall follow all core safety communication requirements defined in Appendix A.3 V2V Core Safety Communication Requirements of the SyRS.
Vehicle System (VS)	VS-REQ-51	VS Equipment	All Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.
13) Need to be able to share mobile data at required latency for various pilot applications			
Wyoming CV System (WCVS)	WCVS-REQ-10	Distribute TIM	The Wyoming CV System shall distribute signed TIMs to the Vehicle System and the Situation Data Exchange (SDX).
Wyoming CV System (WCVS)	WCVS-REQ-10.1	Distribute TIM to VS	The Wyoming CV System shall distribute signed TIM to the Vehicle System consistent with Section 3.5.8 (Traveler Information Requirements) of J3067
Vehicle System (VS)	VS-REQ-33	BCVI Messages	The Vehicle System shall wirelessly broadcast over DSRC a basic safety message (BSM) to other connected devices.
Vehicle System (VS)	VS-REQ-34	BCVI Distress	The Vehicle System shall wirelessly broadcast distress messages to other connected devices.
Vehicle System (VS)	VS-REQ-35	BCVI General Broadcast Requirements	The Vehicle System shall use the general broadcast requirements defined in Appendix A.4 Broadcast Traveler Information of the SyRS.
Vehicle System (VS)	VS-REQ-36	Transmit Data	The Vehicle System shall transmit data over DSRC.
Vehicle System (VS)	VS-REQ-36.1	Transmit Environmental Data	The Vehicle System shall transmit over DSRC environmental data, defined in Table 7-4 of the SDD, to the Wyoming CV System when available from a vehicle Sub-System.
Vehicle System (VS)	VS-REQ-38	SLD Information	The Vehicle System shall store information generated by the host vehicle on local storage. Information to be stored is detailed in Table 4-3 of the SyRS.
Vehicle System (VS)	VS-REQ-50	Safety Communication	All Vehicle Sub-systems shall follow all core safety communication requirements defined in Appendix A.3 V2V Core Safety Communication Requirements of the SyRS.

(Sub-) System/Interface	Req. Number	Requirement Title	Requirement Description
Vehicle System (VS)	VS-REQ-51	VS Equipment	All Vehicle System equipment shall conform to the characteristics described in Appendix A of the CAP.

The following table traces the Sub-System requirements to applicable System- and Interface-level requirements.

Table 7-2. Wyoming CV System Requirements to Sub-System Requirements Mapping Matrix.

System Req. ID	System Req. Title	Sub-System Req. ID	System Req. Title
WCVS-REQ-1	Collect CV Data	RSU-REQ-1	Collect CV Data
		RSU-REQ-13	RSU Equipment
		ODE-REQ-1	Collect CV Data
WCVS-REQ-1.1	Collect BSM Data	RSU-REQ-1	Collect CV Data
		RSU-REQ-13	RSU Equipment
		ODE-REQ-1	Collect CV Data
WCVS-REQ-1.2	Collect Environmental Sensor Data	ODE-REQ-1	Collect CV Data
WCVS-REQ-1.3	Collect Distress Messages	RSU-REQ-1	Collect CV Data
		RSU-REQ-13	RSU Equipment
		ODE-REQ-1	Collect CV Data
WCVS-REQ-2	Validate Data	ODE-REQ-2	Data Processing
WCVS-REQ-3	Ingest Data for Road Weather information	ODE-REQ-1	Collect CV Data
		PA-REQ-1	External Weather Data
		PA-REQ-2	Wyoming CV Sub-Systems Data
		PA-REQ-2.1	ODE Data
		PA-REQ-2.2	TMC Data
		DB-REQ-1	Receive from External Interfaces
WCVS-REQ-4	Contents of Alerts and Advisories	PA-REQ-3	Generate Alerts/Advisories and Forecasts

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System Req. ID	System Req. Title	Sub-System Req. ID	System Req. Title
WCVS-REQ-4.1	Precipitation Hazard	PA-REQ-3	Generate Alerts/Advisories and Forecasts
WCVS-REQ-4.2	Road Condition Hazard	PA-REQ-3	Generate Alerts/Advisories and Forecasts
WCVS-REQ-4.3	Visibility Hazard	PA-REQ-3	Generate Alerts/Advisories and Forecasts
WCVS-REQ-4.4	Work Zone Hazard	DB-REQ-5	Distribute to ODE
WCVS-REQ-4.5	Incident Hazard	DB-REQ-5	Distribute to ODE
WCVS-REQ-4.6	Parking	DB-REQ-5	Distribute to ODE
WCVS-REQ-5	Forecast Conditions	PA-REQ-3	Generate Alerts/Advisories and Forecasts
WCVS-REQ-5.1	Atmospheric Forecasts	PA-REQ-3	Generate Alerts/Advisories and Forecasts
WCVS-REQ-5.2	Road Weather Forecasts	PA-REQ-3	Generate Alerts/Advisories and Forecasts
WCVS-REQ-5.3	Forecast Time	PA-REQ-3	Generate Alerts/Advisories and Forecasts
WCVS-REQ-5.4	Forecast Update	PA-REQ-3	Generate Alerts/Advisories and Forecasts
WCVS-REQ-6	Associate Alerts and Forecast to Segments	PA-REQ-3	Generate Alerts/Advisories and Forecasts
WCVS-REQ-7	External Brokerage with WYDOT Interfaces	DB-REQ-1	Receive from External Interfaces
		DB-REQ-2	Distribute to External Interfaces
		PA-REQ-1	External Weather Data
WCVS-REQ-7.1	Receive from WYDOT External Interfaces	DB-REQ-1	Receive from External Interfaces
		PA-REQ-1	External Weather Data
WCVS-REQ-7.2	Distribute to WYDOT External Interfaces	DB-REQ-2	Distribute to External Interfaces
WCVS-REQ-8	Internal Brokerage	RSU-REQ-11	Distribute to ODE
		ODE-REQ-3	Distribute Data
		ODE-REQ-3.1	Distribute TIM to RSU
		ODE-REQ-3.3	Distribute to Pikalert
		ODE-REQ-3.4	Distribute to Data Warehouse
		ODE-REQ-3.4.1	Distribute to Data Warehouse-BSM
		ODE-REQ-3.4.2	Distribute to Data Warehouse-DNM

System Req. ID	System Req. Title	Sub-System Req. ID	System Req. Title
		ODE-REQ-3.4.3	Distribute to Data Warehouse-ES
		ODE-REQ-3.5	Distribute to Data Broker
		ODE-REQ-7	Receive from Data Broker
		PA-REQ-2	Wyoming CV Sub-Systems Data
		PA-REQ-2.1	ODE Data
		PA-REQ-2.2	TMC Data
		PA-REQ-4	Distribute Alerts/Advisories and Forecasts
		PA-REQ-4.1	Distribute to DB
		DB-REQ-4	Receive from Pikalert
		DB-REQ-4.1	Receive Alerts and Advisories
		DB-REQ-4.2	Receive Forecast
		DB-REQ-5	Distribute to ODE
		DB-REQ-6	Receive from ODE
		DB-REQ-7	Distribute to Data Warehouse
		DB-REQ-8	Receive Data from DW
		DW-REQ-2	Share Data
		DW-REQ-2.1	Share Data with TPI
		DW-REQ-2.4	Share Data with DB
		DW-REQ-4	Receive Data
WCVS-REQ-9	Create TIM	ODE-REQ8	Generate TIMs for Connected Vehicles
WCVS-REQ-10	Distribute TIM	RSU-REQ-2	Distribute TIM to VS
		RSU-REQ-7	Broadcast
		ODE-REQ-3	Distribute Data
		ODE-REQ-3.1	Distribute TIM to RSU
		ODE-REQ-3.2	Distribute TIM to SDX

System Req. ID	System Req. Title	Sub-System Req. ID	System Req. Title
		HSM-REQ-1	Receive from ODE
		HSM-REQ-2	Share with ODE
		HSM-REQ-3	Receive from SCMS
		HSM-REQ-4	Share with SCMS
WCVS-REQ-10.1	Distribute TIM to VS	RSU-REQ-2	Distribute TIM to VS
		RSU-REQ-7	Broadcast
		HSM-REQ-2	Share with ODE
		ODE-REQ-3.1	Distribute TIM to RSU
WCVS-REQ-10.2	Distribute TIM to SDX	ODE-REQ-3.2	Distribute TIM to SDX
		HSM-REQ-2	Share with ODE
WCVS-REQ-11	Store VS Data	DW-REQ-1	Store Data
		DW-REQ-1.2	Store Vehicle System Data
WCVS-REQ-11.1	Store BSM	DW-REQ-1.2	Store Vehicle System Data
WCVS-REQ-11.2	Store Environment Sensor Data	DW-REQ-1.2	Store Vehicle System Data
WCVS-REQ-11.3	Store Distress Messages	DW-REQ-1.2	Store Vehicle System Data
WCVS-REQ-12	Store Generated Alerts/Advisories	DW-REQ-1.1	Store Alerts/Advisories
		DW-REQ-1.1.1	Store Alerts/Advisories-Precipitation Hazard
		DW-REQ-1.1.2	Store Alerts/Advisories-Road Condition Hazard
		DW-REQ-1.1.3	Store Alerts/Advisories-Visibility Hazard
		DW-REQ-1.1.4	Store Alerts/Advisories-Work Zone Hazard
		DW-REQ-1.1.5	Store Alerts/Advisories-Incident Hazard
		DW-REQ-1.1.6	Store Alerts/Advisories-Parking
WCVS-REQ-13	Store TIM	DW-REQ-1.3	Store TIM
WCVS-REQ-14	Store System Monitoring Data	DW-REQ-1.4	Store System Monitoring Data
		DW-REQ-3	Data Storage Administration

System Req. ID	System Req. Title	Sub-System Req. ID	System Req. Title
		DW-REQ-3.1	Maintain System Data Tables
		DW-REQ-3.1.1	CVE Data
		DW-REQ-3.2	Manage Data Storage Security
		DW-REQ-3.2.1	User Access
		DW-REQ-3.2.2	Unauthorized Access
		DW-REQ-3.3	Manage Data System
		DW-REQ-3.3.1	System Back-ups
		DW-REQ-3.3.2	Import/Export
		DW-REQ-3.3.3	Version Control
WCVS-REQ-15	Notifications	System-level Req.	System-level Req.
WCVS-REQ-16	Monitored Functions	System-level Req.	System-level Req.
WCVS-REQ-16.1	Sub-System Availability	System-level Req.	System-level Req.
WCVS-REQ-16.2	Sub-System Performance	System-level Req.	System-level Req.
WCVS-REQ-16.3	Availability for Interfaces	System-level Req.	System-level Req.
WCVS-REQ-16.4	Availability for Data Storage	System-level Req.	System-level Req.
WCVS-REQ-17	Archive Data	DW-REQ-3.4	Manage Data Archive
WCVS-REQ-18	Management and Performance Policy	RSU-REQ-10	Management and Performance
WCVS-REQ-19	Manage Architecture		
WCVS-REQ-20	Manage Safe Communications	RSU-REQ-6	Safety Communication
WCVS-REQ-21	Manage CV Equipment	System-level Req.	System-level Req.
WCVS-REQ-22	Test WCVS Equipment	System-level Req.	System-level Req.
WCVS-REQ-23	Track WCVS Equipment	System-level Req.	System-level Req.
WCVS-REQ-24	Update WCVS Equipment	RSU-REQ-12	Receive Update
WCVS-REQ-25	Update VS Equipment	ODE-REQ-6	OBU Update
SCMS-REQ-1	WCVS SCMS Use	RSU-REQ-3	SCMS

System Req. ID	System Req. Title	Sub-System Req. ID	System Req. Title
		ODE-REQ-4	SCMS
		HSM-REQ-3	Receive from SCMS
		HSM-REQ-4	Share with SCMS
SCMS-REQ-1.1	SCMS WCVS Certificates	RSU-REQ-3	SCMS
		ODE-REQ-4	SCMS
SCMS-REQ-1.2	SCMS WCVS Misbehavior Reporting	RSU-REQ-3	SCMS
		ODE-REQ-4	SCMS
SCMS-REQ-1.3	SCMS WCVS Certificates Revocation List (CRL)	RSU-REQ-3	SCMS
		ODE-REQ-4	SCMS
SCMS-REQ-1.4	SCMS WCVS Rejection	RSU-REQ-3	SCMS
		ODE-REQ-4	SCMS
SDX-REQ-1	Data Provided to the SDX	ODE-REQ-3.2	Distribute TIM to SDX
SDX-REQ-2	Distribute TIM to VS	ODE-REQ-3.2	Distribute TIM to SDX
SDC-REQ-1	Data Provided to the SDC	ODE-REQ-3.6	Distribute to SDC
		DW-REQ-2.2	Share Data with SDC
RDE-REQ-1	Data Provided to the RDE	ODE-REQ-3.7	Distribute to RDE
		DW-REQ-2.3	Share Data with RDE
LTS-REQ-1	WCVS Time	RSU-REQ-4	LTS
		ODE-REQ-5	LTS
LTS-REQ-1.1	WCVS LTS Time	RSU-REQ-4	LTS
		ODE-REQ-5	LTS
LTS-REQ-1.2	WCVS Time Synchronization	RSU-REQ-4	LTS
		ODE-REQ-5	LTS
LTS-REQ-2	WCVS LTS Time Standard	RSU-REQ-4	LTS
		ODE-REQ-5	LTS

System Req. ID	System Req. Title	Sub-System Req. ID	System Req. Title
LTS-REQ-3	WCVS LTS Location	RSU-REQ-4	LTS
		ODE-REQ-5	LTS
511-REQ-1	511App Parking Data Collection	DB-REQ-1	Receive from External Interfaces
511-REQ-1.1	Availability	DB-REQ-1	Receive from External Interfaces
511-REQ-1.2	Default	DB-REQ-1	Receive from External Interfaces
511-REQ-1.3	Time	DB-REQ-1	Receive from External Interfaces
511-REQ-1.4	Location	DB-REQ-1	Receive from External Interfaces
511-REQ-1.5	Protocol	DB-REQ-1	Receive from External Interfaces
511-REQ-1.6	Schema	DB-REQ-1	Receive from External Interfaces
511-REQ-2	Timeframe	DB-REQ-1	Receive from External Interfaces
TPI-REQ-1	TPI Data	DB-REQ-2	Distribute to External Interfaces
TRAC-REQ-1	TRAC Updates	DB-REQ-2	Distribute to External Interfaces
TRAC-REQ-1.1	Distress Notification	DB-REQ-2	Distribute to External Interfaces
TRAC -REQ-1.1.1	Transmission Time	DB-REQ-2	Distribute to External Interfaces
TRAC-REQ-1.2	Segment Alerts	DB-REQ-2	Distribute to External Interfaces
TRAC-REQ-1.2.1	Transmission Time	DB-REQ-2	Distribute to External Interfaces
TRAC-REQ-1.2.2	Segment Alerts-Pikalert	DB-REQ-2	Distribute to External Interfaces
RCRS-REQ-1	RCRS Data Sharing	DB-REQ-1	Receive from External Interfaces
RCRS-REQ-1.1	Road Condition	DB-REQ-1	Receive from External Interfaces
RCRS-REQ-1.2	Weather	DB-REQ-1	Receive from External Interfaces
RCRS-REQ-1.3	Other Road Condition	DB-REQ-1	Receive from External Interfaces
RCRS-REQ-1.4	Report Time	DB-REQ-1	Receive from External Interfaces
RCRS-REQ-1.5	Location	DB-REQ-1	Receive from External Interfaces
RCRS-REQ-1.6	Transmit Time	DB-REQ-1	Receive from External Interfaces
WTI-REQ-1	WTI Inputs	DB-REQ-2	Distribute to External Interfaces

System Req. ID	System Req. Title	Sub-System Req. ID	System Req. Title
WTI-REQ-1.1	Current Segment Alerts	DB-REQ-2	Distribute to External Interfaces
WTI-REQ-1.1.1	Transmission Time	DB-REQ-2	Distribute to External Interfaces
WTI-REQ-1.2	Forecast Segment Alerts	DB-REQ-2	Distribute to External Interfaces
WTI-REQ-1.2.1	Forecast Time	DB-REQ-2	Distribute to External Interfaces
WTI-REQ-1.2.2	Forecast Update	DB-REQ-2	Distribute to External Interfaces
WTI-REQ-2	WTI Inputs	DB-REQ-1	Receive from External Interfaces
WTI-REQ-2.1	Posted Speed	DB-REQ-1	Receive from External Interfaces
WTI-REQ-2.2	Vehicle Restrictions	DB-REQ-1	Receive from External Interfaces
WTI-REQ-2.2.1	Restriction Information	DB-REQ-1	Receive from External Interfaces
WTI-REQ-2.2.2	Restriction Start Time	DB-REQ-1	Receive from External Interfaces
WTI-REQ-2.3	Posted Messages	DB-REQ-1	Receive from External Interfaces
WTI-REQ-2.3.1	Message Information	DB-REQ-1	Receive from External Interfaces
WTI-REQ-2.4	Posted Closures	DB-REQ-1	Receive from External Interfaces
WTI-REQ-2.4.1	Closure Beginning	DB-REQ-1	Receive from External Interfaces
WTI-REQ-2.4.2	Closure End	DB-REQ-1	Receive from External Interfaces
WTI-REQ-2.4.3	Closure Start Time	DB-REQ-1	Receive from External Interfaces
CVOP-REQ-1	CVOP Outputs	DB-REQ-2	Distribute to External Interfaces
CVOP-REQ-1.1	Current Segment Alerts	DB-REQ-2	Distribute to External Interfaces
CVOP-REQ-1.1.1	Transmission Time	DB-REQ-2	Distribute to External Interfaces
CVOP-REQ-1.2	Forecast Segment Alerts	DB-REQ-2	Distribute to External Interfaces
CVOP-REQ-1.2.1	Forecast Time	DB-REQ-2	Distribute to External Interfaces
CVOP-REQ-1.2.2	Forecast Update	DB-REQ-2	Distribute to External Interfaces
IC-REQ-1	IC Data Sharing	DB-REQ-1	Receive from External Interfaces
IC-REQ-2	Protocol	DB-REQ-1	Receive from External Interfaces
IC-REQ-3	Schema	DB-REQ-1	Receive from External Interfaces

System Req. ID	System Req. Title	Sub-System Req. ID	System Req. Title
IC-REQ-4	Transmission	DB-REQ-1	Receive from External Interfaces
CA-REQ-1	CA Data Sharing	DB-REQ-1	Receive from External Interfaces
CA-REQ-2	Protocol	DB-REQ-1	Receive from External Interfaces
CA-REQ-3	Schema	DB-REQ-1	Receive from External Interfaces
CA-REQ-4	Transmission	DB-REQ-1	Receive from External Interfaces
ITSM-REQ-1	WYDOT ITS Alerts	DB-REQ-2	Distribute to External Interfaces
WI-REQ-1	External Data Acquisition	PA-REQ-1	External Weather Data
WI-REQ-2	Fixed Data Acquisition	PA-REQ-1	External Weather Data

Table 7-3. Vehicle System Requirements to Sub-System Requirements Mapping Matrix.

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
VS-REQ-1	Receive BSM	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-2	Receive TIM	MV-REQ-4	Receive TIM over DSRC
		MV-REQ-5	Receive TIM over Satellite
		IT-REQ-2	Receive TIM over Satellite
		IT-REQ-1	Receive TIM over DSRC
		RFV-REQ-1	Receive TIM over DSRC
		RFV-REQ-2	Receive TIM over Satellite
		HP-REQ-2	Receive TIM over DSRC
VS-REQ-2.1	Receive TIM through DSRC	MV-REQ-4	Receive TIM over DSRC
		IT-REQ-1	Receive TIM over DSRC

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		RFV-REQ-1	Receive TIM over DSRC
		HP-REQ-2	Receive TIM over DSRC
VS-REQ-2.2	Receive TIM through Satellite	MV-REQ-5	Receive TIM over Satellite
		IT-REQ-2	Receive TIM over Satellite
		RFV-REQ-2	Receive TIM over Satellite
		HP-REQ-6	Receive TIM over Satellite
VS-REQ-3	Receive Distress Information	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-4	Collect Vehicle Data	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-4.1	Collect Vehicle Status Data	MV-REQ-2	Can Bus
		MV-REQ-9	General
VS-REQ-4.2	Collect Dimension Data	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-4.2.1	Vehicle Dimension Data	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-4.2.2	Vehicle Trailer Data	MV-REQ-9	General
		IT-REQ-6	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-5	External Environment Sensor Data	MV-REQ-1	Environmental Sensors
VS-REQ-5.1	External Environment Sensor Data Configuration	MV-REQ-1	Environmental Sensors
VS-REQ-5.2	External Environment Sensor Data Management	MV-REQ-1	Environmental Sensors
VS-REQ-6	FCW Stopped Vehicles	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-7	FCW Decelerating/Slow Moving Vehicles	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-8	FCW Stopped and Obstructed Vehicles	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-9	FCW Rear-End Crash	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-9.1	Rear-End Crash in Straight Road	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
VS-REQ-9.2	Rear-End Crash in Curved Road	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-10	FCW No Warnings	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-10.1	Safely Following a Vehicle	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-10.2	Passing a Stopped Vehicle	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-11	SA TIM-Advisories	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-12	SA TIM-Speed Limit	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-13	SA TIM-Exit Services	MV-REQ-9	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-14	SA TIM-Region	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-15	Distress Notification ID	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-15.1	Log	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-16	Create Distress Notification	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-16.1	System-Generated Distress Notification	MV-REQ-9	General
		IT-REQ-6	General
VS-REQ-16.2	Driver-Generated Distress Notification	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-17	DNM-Region	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-18	DN PSID	MV-REQ-9	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-19	WZW TIM	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-20	WZW TIM-Region	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-21	SWIW TIM	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-22	SWIW TIM-Region	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-23	IVAA Rank	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-24	IVAA Level	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		HP-REQ-1	General
VS-REQ-25	IVAA Priority Alert	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-26	IVAA FCW	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-27	IVAA DN	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-28	IVAA SA-Advisory	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-29	IVAA SA-VSL	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-30	IVAA SWIW	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-31	IVAA WZW	MV-REQ-9	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32	HMI Characteristics	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.1	HMI-Location	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.2	HMI-Distracton	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.3	HMI-Readability	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.4	Visual and Auditory Interface	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.4.1	Visual Consistency	MV-REQ-9	General
		IT-REQ-6	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.4.2	Audio Signals	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.5	Customizations	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-32.6	System Status	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.6.1	Power Status	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.6.2	System Settings	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.6.3	Application Availability	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
VS-REQ-32.6.4	Pending Update Status	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-32.7	Distress Notification	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-32.8	Non-Distress Information	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-33	BCVI Messages	MV-REQ-3	Static Identifier
		MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-34	BCVI Distress	MV-REQ-3	Static Identifier
		MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-34.1	Received Distress	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-34.2	Generated Distress	MV-REQ-9	General
		IT-REQ-6	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		HP-REQ-1	General
VS-REQ-35	BCVI General Broadcast Requirements	MV-REQ-9	General
		IT-REQ-6	General
		HP-REQ-1	General
VS-REQ-36	Transmit Data	MV-REQ-3	Static Identifier
		MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-36.1	Transmit Environmental Data	MV-REQ-9	General
VS-REQ-36.2	TVI Data Management-Log	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-37	Communication Performance		
VS-REQ-38	SLD Information	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-39	SLD Rolling Log	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-40	SLD Log Format	MV-REQ-9	General
		IT-REQ-6	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-41	SLD Log Data	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-42	VSM SCMS	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-43	VSM SCMS Encryption	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-44	VSM SCMS Sign	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-45	VSM SCMS Encryption-Log	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-46	VSM SCMS Sign-Log	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		HP-REQ-1	General
VS-REQ-47	VSM App Availability Log	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-48	VSM Updates	MV-REQ-6	OTA Updates
		HP-REQ-7	OTA Updates
		IT-REQ-3	OTA Updates
		RFV-REQ-7	OTA Updates
VS-REQ-49	Architectural	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-50	Safety Communication	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
VS-REQ-51	VS Equipment	MV-REQ-1.1	Environmental Sensor Equipment
		MV-REQ-10	OBU Equipment
		IT-REQ-7	OBU Equipment
		RFV-REQ-6	OBU Equipment
		HP-REQ-5	OBU Equipment
LTS-REQ-4	VS LTS Time	MV-REQ-7	Time
		IT-REQ-4	Time
		RFV-REQ-3	Time

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
		HP-REQ-3	Time
LTS-REQ-5	VS LTS Time Standard	MV-REQ-7	Time
		IT-REQ-4	Time
		RFV-REQ-3	Time
		HP-REQ-3	Time
LTS-REQ-6	VS LTS Location	MV-REQ-8	Location
		IT-REQ-5	Location
		RFV-REQ-4	Location
		HP-REQ-4	Location
SCMS-REQ-2	Vehicle System SCMS Use	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
SCMS-REQ-2.1	SCMS Vehicle System Certificates	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
SCMS-REQ-2.2	SCMS Vehicle System Misbehavior Reporting	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General
SCMS-REQ-2.3	SCMS Vehicle System Certificates Revocation List (CRL)	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General

System Req.	System Req. Title	Sub-System Req.	Sub-System Req. Title
SCMS-REQ-2.4	SCMS Vehicle System Rejection	MV-REQ-9	General
		IT-REQ-6	General
		RFV-REQ-5	General
		HP-REQ-1	General

The following table traces the performance requirements to applicable system-level requirements.

Table 7-4. Trace of Performance Requirements to System Requirements

Performance Req. ID	Performance Req. Title	System Req. ID	System Req. Title
FCWP-REQ-1	FCW Advisory Alert Performance	VS-REQ-6	FCW Stopped Vehicles
		VS-REQ-7	FCW Decelerating/Slow Moving Vehicles
		VS-REQ-8	FCW Stopped and Obstructed Vehicles
		VS-REQ-9	FCW Rear-End Crash
		VS-REQ-9.1	Rear-End Crash in Straight Road
FCWP-REQ-2	FCW Imminent Alert Performance	VS-REQ-6	FCW Stopped Vehicles
		VS-REQ-7	FCW Decelerating/Slow Moving Vehicles
		VS-REQ-8	FCW Stopped and Obstructed Vehicles
		VS-REQ-9	FCW Rear-End Crash
		VS-REQ-9.1	Rear-End Crash in Straight Road
FCWP-REQ-3	Passing a Stopped Vehicle Performance	VS-REQ-10	FCW No Warning
		VS-REQ-10.2	Passing a Stopped Vehicle
FCWP-REQ-4	Following a Vehicle Performance	VS-REQ-10	FCW No Warning
		VS-REQ-10.1	Safely Following a Vehicle
FCWP-REQ-5	Decelerating Vehicle Performance	VS-REQ-7	FCW Decelerating/Slow Moving Vehicles
		VS-REQ-9	FCW Rear-End Crash

Performance Req. ID	Performance Req. Title	System Req. ID	System Req. Title
		VS-REQ-9.1	Rear-End Crash in Straight Road
FCWP-REQ-6	FCW Advisory Alert in a Curve Performance	VS-REQ-6	FCW Stopped Vehicles
		VS-REQ-7	FCW Decelerating/Slow Moving Vehicles
		VS-REQ-8	FCW Stopped and Obstructed Vehicles
		VS-REQ-9	FCW Rear-End Crash
		VS-REQ-9.2	Rear-End Crash in Curved Road
FCWP-REQ-7	FCW Imminent Alert in a Curve Performance	VS-REQ-6	FCW Stopped Vehicles
		VS-REQ-7	FCW Decelerating/Slow Moving Vehicles
		VS-REQ-8	FCW Stopped and Obstructed Vehicles
		VS-REQ-9	FCW Rear-End Crash
		VS-REQ-9.2	Rear-End Crash in Curved Road
FCWP-REQ-8	Passing a Stopped Vehicle in a Curve Performance	VS-REQ-6	FCW Stopped Vehicles
		VS-REQ-10	FCW No Warning
		VS-REQ-10.2	Passing a Stopped Vehicle
FCWP-REQ-9	Slow Moving Vehicle Advisory Alert in a Curve Performance	VS-REQ-7	FCW Decelerating/Slow Moving Vehicles
		VS-REQ-9	FCW Rear-End Crash
		VS-REQ-9.2	Rear-End Crash in Curved Road
FCWP-REQ-10	Slow Moving Vehicle Imminent Alert in a Curve Performance	VS-REQ-7	FCW Decelerating/Slow Moving Vehicles
		VS-REQ-9	FCW Rear-End Crash
		VS-REQ-9.2	Rear-End Crash in Curved Road
DNP-REQ-1	Distress Notification OBU DSRC Performance 1	VS-REQ-3	Receive Distress Information
DNP-REQ-2	Distress Notification OBU DSRC Performance 2	VS-REQ-3	Receive Distress Information
DNP-REQ-3	Distress Notification RSU DSRC Performance	WCVS-REQ-1	Collect CV Data
		WCVS-REQ-1.3	Collect Distress Messages

Performance Req. ID	Performance Req. Title	System Req. ID	System Req. Title
DNP-REQ-4	Distress Notification Driver Display Performance	VS-REQ-23	IVAA Rank
		VS-REQ-24	IVAA Level
		VS-REQ-25	IVAA Priority Alert
		VS-REQ-27	IVAA DN
DNP-REQ-5	Distressed Vehicle Distance	VS-REQ-27	IVAA DN
DNP-REQ-6	Distressed Vehicle Direction of Travel	VS-REQ-27	IVAA DN
DNP-REQ-7	Distressed Vehicle Roadway	VS-REQ-27	IVAA DN
DNP-REQ-8	Distress Vehicle Passing	VS-REQ-27	IVAA DN
DNP-REQ-9	Remote Vehicle Distress Notification Distance 1	VS-REQ-34	BCVI Distress
		VS-REQ-34.1	Received Distress
DNP-REQ-10	Remote Vehicle Distress Notification Distance 2	VS-REQ-34	BCVI Distress
		VS-REQ-34.1	Received Distress
DNP-REQ-11	Remote Vehicle Distress Notification Upload to ODE	VS-REQ-36	Transmit Data
		VS-REQ-36.2	TVI Data Management-Log
DNP-REQ-12	Remote Vehicle Distress Notification Upload Termination	VS-REQ-34	BCVI Distress
		VS-REQ-34.1	Received Distress
I2VSAP-REQ-1	Message Display in Travel Lanes	VS-REQ-14	SA TIM-Region
		VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL
I2VSAP-REQ-2	Message Display in Shoulder Lanes	VS-REQ-14	SA TIM-Region
		VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL
I2VSAP-REQ-3	Message Display in Acceleration Lane	VS-REQ-14	SA TIM-Region
		VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL

Performance Req. ID	Performance Req. Title	System Req. ID	System Req. Title
I2VSAP-REQ-4	Message Display Geofence Beginning	VS-REQ-14	SA TIM-Region
		VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL
I2VSAP-REQ-5	Message Display Geofence Ending	VS-REQ-14	SA TIM-Region
		VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL
I2VSAP-REQ-6	Message Display Geofence Ending	VS-REQ-14	SA TIM-Region
		VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL
I2VSAP-REQ-7	Message Display on Adjacent Service Road	VS-REQ-14	SA TIM-Region
		VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL
I2VSAP-REQ-8	Message Display in Perpendicular to Travel Lanes	VS-REQ-14	SA TIM-Region
		VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL
I2VSAP-REQ-9	Message Display Start Time	VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL
I2VSAP-REQ-10	Message Display Stop Time	VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL
I2VSAP-REQ-11	Verify I-80 Map and Geofences	VS-REQ-14	SA TIM-Region
		VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL
I2VSAP-REQ-12	Message Display in Travel Lanes	VS-REQ-14	SA TIM-Region
		VS-REQ-28	IVAA SA-Advisory
		VS-REQ-29	IVAA SA-VSL

Performance Req. ID	Performance Req. Title	System Req. ID	System Req. Title
I2VSAP-REQ-13	Simultaneous I2V and V2I DSRC Communications	WCVS-REQ-1	Collect CV Data
		WCVS-REQ-1.1	Collect BSM Data
		WCVS-REQ-1.2	Collect Environmental Sensor Data
		WCVS-REQ-1.3	Collect Distress Messages
		WCVS-REQ-2	Validate Data
		WCVS-REQ-10	Distribute TIM
		WCVS-REQ-10.1	Distribute TIM to VS
I2VSAP-REQ-14	Simultaneous DSRC and Satellite TIM Processing	VS-REQ-2	Receive TIM
		VS-REQ-2.1	Receive TIM through DSRC
		VS-REQ-2.2	Receive TIM through Satellite
MCP-REQ-1	V2V Exchange of BSMs	VS-REQ-1	Receive BSM
MCP-REQ-2	V2I & End-to-end Communication of BSMs	WCVS-REQ-1	Collect CV Data
		WCVS-REQ-1.1	Collect BSM Data
MCP-REQ-3	OBU Shakedown	N/A	
MCP-REQ-4	RSU and Backhaul Communications Shakedown 1	WCVS-REQ-22	Test WCVS Equipment
MCP-REQ-5	RSU and Backhaul Communications Shakedown 2	WCVS-REQ-22	Test WCVS Equipment
MCP-REQ-6	OBU Installation Robustness	N/A	
MCP-REQ-7	RSU Installation Robustness	N/A	

Appendix A. On-Board Unit Core Requirements

A.1 Introduction

The system requirements for On-Board Units (OBUs) are based on SAE J2945™/1 March 2016 (J2945/1 henceforth) for Vehicle to Vehicle (V2V) safety communications where applicable in the Wyoming Pilot. The Wyoming Pilot will require OBU manufactures to obtain certification from a USDOT approved testing facility for OBUs, so the relevant requirements from J2945/1 will only be referenced and will not be re-tested or verified in the pilot. For Vehicle to Infrastructure (V2I) SAE J3067 August 2014 (J3067 henceforth) is used for applicable applications. Additionally, SAE J2735™ March 2016 is used to update the outdated parts of the J3067 based on the new message set dictionary for DSRC. Here, the original J3067's system requirements numbers and descriptions are kept in order to ensure compatibility with other CV projects and to provide clarity for future standards. The current standard for basic safety messages within J2945/1 is for light vehicles and does not address trailers. The CV pilot developers plan to extend the current specification to include trailer-related standards. For this, the CV pilot team will watch for an outcome in the form of a standard based on the NHTSA research project "V2V Basic Safety Message for Truck/CV Trailers". Operational scenarios are detailed in the Concept of Operations (FHWA-JPO-16-287) Chapter 6. User classes and other involved personnel are described in detail in Section 5.5 of the ConOps. This includes stakeholders, user profiles, responsibilities and interactions with the system, interactions among user classes and the user support environment.

In cases where conflicting information is defined between the J2945/1, J2735, and J3067, J2945/1 will take initial precedence, followed by J2735 and finally J3067. The reason for this is J2945/1 is most specific and up to date for V2V safety communications and is there for most relevant to our pilot. J2735 is the second order of precedence because it has many updates to the message set that were not available when J3067 was written. J3067, while somewhat outdated is still relevant because it covers V2I communications and additional applications that are relevant to the Wyoming Pilot.

As J2945/2 and J2945/x become available the Wyoming Pilot will implement the standard interfaces and messages for Situation Awareness- Weather Condition Application, Situational Awareness Suboptimal Road Segment Conditions Applications and RWINFO for Freight Use Case if applicable.

This appendix is organized as follows

1. Section A.1 is intentionally skipped
2. Section A.2 highlights common architecture-related requirements
3. Section A.3 summarizes the requirements V2V core safety communications used for all OBUs in the pilot.
4. Section A.4 contains the broadcast OBU requirements

A.2 OBU Core Architecture Requirements

The following list of architectural requirements have been identified as being common to all the OBUs used in this pilot.

ARQ-REQ-1 Architectural Requirements -- Connected Device Dialogs (Source: J3067, 3.4.3)

– A connected device shall be able to establish a private wireless connection with another specific connected device that mutually agrees.

A.3 V2V Core Safety Communication Requirements

CSC-REQ-1 OBU SCMS Use – All OBUs used in the Wyoming Pilot shall be certified from a US DOT authorized testing facility based on the SCMS current version CAMP Wiki: Requirements and Specifications.

- Common Requirements
 - [Cryptography](#)
 - [Hardware, Software and OS Security Requirements](#)
 - A HSM that requires low confidentiality and medium integrity shall store keys in tamper-evident hardware equivalent to FIPS 140-2 level 2.
 - [EE-RA Communications – General Guidance](#)
 - Download requests for GPF, LPG, GCCF, LCCF, OBE pseudonym certificate batch file, OBE identification certificate files.
- Requirements by Use Case
 - [Use Case 2: OBE Bootstrapping \(Manual\)](#)
 - [Use Case 3: OBE Pseudonym Certificates Provisioning](#)
 - [Step 3.1: Request for Pseudonym Certificates](#)
 - OBU downloads Local Policy File and Local Certificate Chain and adopts any changes in the new files before making request.
 - [Step 3.3: Initial Download of Pseudonym Certificates](#)
 - OBU downloads Local Policy File and Local Certificate Chain and adopts any changes in the new files before downloading certificates.
 - [Step 3.5: Top-off Pseudonym Certificates](#)
 - [Use Case 6: CRL Download](#)
 - [Use Case 8: OBE Pseudonym Certificate Revocation](#)
 - [Step 8.4: OBE CRL Check](#)
 - [Use Case 19: OBE Identification Certificate Provisioning](#)
 - [Step 19.1: Request for OBE Identification Certificates](#)
 - [Step 19.3: Initial Download of OBE Identification Certificates](#)
 - [Step 19.5: Top-off OBE Identification Certificates](#)
 - [Use Case 20: EE Re-Enrollment \(currently a preliminary concept, support when defined\)](#)
 - [Step 20.1: EE Enrollment Certificate Rollover](#)

CSC-REQ-2 OBU Certification - All OBUs used in the Wyoming Pilot shall be certified from a USDOT authorized testing facility based on J2945/1. At a minimum, the following applications interfaces and requirements from J2945/1 will be included in the certification testing. If no certification is available, OBU vendors will self-certify and provide documentation of tests.

- Applications
 - Forward Collision Warning
- Interfaces
 - 5.1 V2V Over-the-Air Data Description
 - 5.1.1 Basic Safety Message Exchange
 - 5.1.2 Positioning
 - 5.1.3 Security and Privacy
 - 5.1.3.1 Signing and Verification Algorithm
 - 5.1.3.2 BSM Signature Certificate Transmission
 - 5.1.3.3 BSM Verification
 - 5.1.3.4 SCMS
 - 5.1.3.5 Privacy
 - 5.1.4 Startup and Shutdown
 - 5.1.5 Mapping to the V2V Over-the-Air Data
 - 5.2 System Interfaces
 - 5.2.1 Vehicle to Vehicle Communications Interface
 - 5.2.2 System to SCMS Communication Interface
 - 5.2.3 System to Positioning Sub-System Interface
- Minimum Requirements
 - 6.1 Standard Profiles
 - 6.1.1 IEEE 802.11
 - 6.1.2 IEEE 1609.2
 - 6.1.2.1 PICS Proforma
 - 6.1.2.2 BSM Security Profile Proforma
 - 6.1.2.2.1 IEEE 1609.2 Security Profile Identification
 - 6.1.2.2.2 Sending
 - 6.1.2.2.3 Receiving
 - 6.1.2.2.5 Other
 - 6.1.3 IEEE 1609.3
 - 6.1.4 IEEE 1609.4
 - 6.1.5 IEEE 1609.12
 - 6.1.6 SAE J2735 (2016)
 - 6.1.7 FCC 47 CFR, Parts 0, 1, 2, and 95
 - 6.2 Positioning and Timing Requirements
 - 6.2.1 Position Determination
 - 6.2.2 Wide Area Augmentation
 - 6.2.3 Coordinate System and Reference
 - 6.2.4 System Time Coordination
 - 6.3 BSM Transmission Requirements on Channel vChannelNumber
 - 6.3.1 BSM Contents
 - 6.3.2 Channel and Data Rate
 - 6.3.3 Generation of the First BSM after System Device Startup and Generation Timing
 - 6.3.4 User Priority and EDCA Setting
 - 6.3.5 Minimum Transmission Criteria
 - 6.3.6 Data Element (DE) Accuracy
 - 6.3.6.1 DE_DSRC_MessageID
 - 6.3.6.2 DE_MesCount
 - 6.3.6.3 DE_TemporaryID
 - 6.3.6.4 DE_DSecond

- 6.3.6.5 DE_Latitude & DE_Longitude
- 6.3.6.6 DE_Elevation
- 6.3.6.7 DF_PositionalAccuracy
- 6.3.6.8 DE_Speed
- 6.3.6.9 DE_TransmissionSpeed
- 6.3.6.10 DE_Heading
- 6.3.6.11 DE_SteeringWheelAngle
- 6.3.6.12 DF_AccelerationSet4Way
- 6.3.6.13 DF_BrakeSystemStatus
- 6.3.6.14 DF_VehicleSize
- 6.3.6.15 DE_VehicleEventFlags
- 6.3.6.16 DF_PathHistory
- 6.3.6.17 DF_PathPrediction
- 6.3.6.18 DE_ExteriorLights
- 6.3.6.19 Additional Data Elements
- 6.3.7 Data Persistency
 - 6.3.7.1 Heading
 - 6.3.7.2 Path History
- 6.3.8 BSM Scheduling and Congestion Control
 - 6.3.8.1 Inputs
 - 6.3.8.2 Calculate Tracking Error
 - 6.3.8.3 Calculate Transmission Probability
 - 6.3.8.4 Calculate Maximum Inter-Transmit Time
 - 6.3.8.5 Transmission Decision
 - 6.3.8.6 Schedule Transmission
 - 6.3.8.7 Calculate Radiated Power
 - 6.3.8.8 Generate BSM and Schedule Next BSM Generation
- 6.4 RF Performance Requirements
 - 6.4.1 DSRC Radiated Power and Transmit Power Accuracy
 - 6.4.1.1 Transmit Power Accuracy
 - 6.4.2 DSRC Receiver Sensitivity
 - 6.4.28 Psid Ssp Application Permission
- 6.5 Security and Privacy Requirements
 - 6.5.1 Identification Randomization
 - 6.5.2 BSM Signing
 - 6.5.3 Certificate Change
 - 6.5.4 BSM Cryptographic Verification
 - 6.5.5 Certificate Revocation
- 6.6 Security Management
 - 6.6.1 Bootstrap: Initialization and Enrollment Processing
 - 6.6.1.1 Initialization Processing
 - 6.6.1.2 Enrollment Processing
 - 6.6.2 Certificate Loading
 - 6.6.3 Certificate Storage
 - 6.6.4 Certificate Revocation List Loading
 - 6.6.5 Secure Hardware
- Parameter Settings

A.4 Broadcast Traveler Information

The following requirements relate to the “broadcast” capability of the OBU, which is used for the Distress Notification application.

BC-REQ-1 Traveler Information Requirements (Source: J3067, 3.5.8). Traveler information is used to provide connected devices with travel advisories and information.

BC-REQ-1.1 Broadcast Traveler Information (Source: J3067, 3.5.8.1). A connected device shall broadcast a packet containing traveler information to connected devices. Each packet may contain one or more individual traveler information messages.

BC-REQ-1.2 Broadcast Traveler Information - Mandatory Requirements (Source: J3067, 3.5.8.2). The following are the minimum requirements for a connected device to broadcast traveler information to connected devices.

BC-REQ-1.2.1 Broadcast Traveler Information - Packet Identifier (Source: J3067, 3.5.8.2.1). A connected device shall include a packet identifier for the traveler information packet broadcasted to connected devices.

BC-REQ-1.2.2 Broadcast Traveler Information - Message Identifier Requirements (Source: J3067, 3.5.8.2.2). For each traveler information message in a traveler information packet, a connected device needs to identify each message transmitted as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.2.2.1 Broadcast Traveler Advisories - Message Identifier (Source: J3067, 3.5.8.2.2.1). For traveler advisories, a connected device shall include a message identifier for each traveler advisory message as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3 Broadcast Traveler Information (Source: J3067, 3.5.8.3). The following are the requirements for a connected device to broadcast traveler information to connected devices.

BC-REQ-1.3.1 Broadcast Traveler Information - Validity Duration (Source: J3067, 3.5.8.3.4). For each traveler information message in a traveler information packet, a connected device shall include the duration from the start time that the traveler message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.2 Broadcast Traveler Information – Importance (Source: J3067, 3.5.8.3.5). For each traveler information message in a traveler information packet, a connected device shall include the importance of the message relative to other traveler information messages being broadcasted as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3 Broadcast Traveler Information - Presentation Requirements (Source: J3067, 3.5.8.3.6). Agencies may need to present traveler information messages only to specific travelers, such as travelers within specific geographic (spatial) regions or a direction of travel.

BC-REQ-1.3.3.1 Broadcast Traveler Information - Default Anchor Point Position (Source: J3067, 3.5.8.3.6.1). For each traveler information message in a traveler information packet, a connected device shall include the geographic location

(latitude, longitude, elevation) of the default anchor point for which valid regions are determined as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.2 Broadcast Traveler Information - Heading Slice (Source: J3067, 3.5.8.3.6.2). For each traveler information message in a traveler information packet, a connected device shall include the direction of motion (of the connected device) that the message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.3 Broadcast Traveler Information - Circular Valid Region Requirements (Source: J3067, 3.5.8.3.6.3). A spatial region for which a traveler information message is valid for may be a circular region around an anchor point. The connected device should be located within the circular region for the traveler information message to be presented to the traveler.

BC-REQ-1.3.3.3.1 Broadcast Traveler Information - Circular Region – Radius (Source: J3067, 3.5.8.3.6.3.1). For each traveler information message in a traveler information packet, a connected device shall include the radius for the circular region defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.3.2 Broadcast Traveler Information - Circular Region - Anchor Point (Source: J3067, 3.5.8.3.6.3.2). For each traveler information message in a traveler information packet, a connected device shall include the geographic location (latitude, longitude, elevation) of the anchor point for the circular region of travel defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.4 Broadcast Traveler Information - Polygon Valid Region Requirements (Source: J3067, 3.5.8.3.6.4). A spatial region for which a traveler information message is valid for may be a polygon, which may represent the jurisdictional boundaries of a specific transportation agency or a work zone. The connected device should be located within this polygon region for the traveler information message to be presented to the traveler.

BC-REQ-1.3.3.4.1 Broadcast Traveler Information - Polygon Region – Offsets (Source: J3067, 3.5.8.3.6.4.1). For each traveler information message in a traveler information packet, a connected device shall include the area of travel defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.4.2 Broadcast Traveler Information - Polygon Region - Anchor Point (Source: J3067, 3.5.8.3.6.4.2). For each traveler information message in a traveler information packet, a connected device shall include the geographic location (latitude, longitude, elevation) of the anchor point for the area of travel defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.5 Broadcast Traveler Information - Valid Shape Point Set Region Requirements (Source: J3067, 3.5.8.3.6.5). A spatial region for which a traveler information message is valid for may be a shape point set, which allows a spline-like

representation of a geographic area such as a road segment. A connected device should be located within the shape point set region for the traveler information message to be presented to the traveler.

BC-REQ-1.3.3.5.1 Broadcast Traveler Information - Shape Point Set - Default Direction (Source: J3067, 3.5.8.3.6.5.1). For each traveler information message in a traveler information packet, a connected device shall include the default direction of travel along the shape point set as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.5.2 Broadcast Traveler Information - Shape Point Set - Default Width (Source: J3067, 3.5.8.3.6.5.2). For each traveler information message in a traveler information packet, a connected device shall include the default width of the shape point set as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.5.3 Broadcast Traveler Information - Shape Point Set – Offsets (Source: J3067, 3.5.8.3.6.5.3). For each traveler information message in a traveler information packet, a connected device shall include the shape point set defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.5.4 Broadcast Traveler Information - Shape Point Set – Direction (Source: J3067, 3.5.8.3.6.5.4). For each shape point set in a traveler information message, a connected device shall include the allowed direction of travel along the shape point set as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.5.5 Broadcast Traveler Information - Shape Point Set – Width (Source: J3067, 3.5.8.3.6.5.5). For a shape point set in a traveler information message, a connected device shall include the width for the shape point set as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.5.6 Broadcast Traveler Information - Shape Point Set - Node Width (Source: J3067, 3.5.8.3.6.5.6). For a shape point offset in a traveler information message, a connected device shall include the width of the geographic area at that node as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.3.5.7 Broadcast Traveler Information - Shape Point Set - Anchor Point (Source: J3067, 3.5.8.3.6.5.7). For each shape point set in a traveler information message, a connected device shall include the geographic location (latitude, longitude, elevation) of the anchor point for the shape point set defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.4 Broadcast Traveler Advisories – Content (Source: J3067, 3.5.8.3.7). For traveler advisory message in a traveler information packet, a connected device shall include the contents of the travel advisory information as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.5 Broadcast Road Sign – Content (Source: J3067, 3.5.8.3.8). For each road sign message in a traveler information packet, a connected device shall include the

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road sign information as part of a traveler information packet broadcasted to connected devices

BC-REQ-1.3.6 Broadcast Traveler Information - Uniform Resource Locator (Source: J3067, 3.5.8.3.9). For each traveler information message in a traveler information packet, an OBU shall include a uniform resource locator (URL) for the traveler information message as part of a traveler information packet broadcasted to connected devices.

BC-REQ-1.3.7 Broadcast Traveler Information - Valid Vehicle Type (Source: J3067, 3.5.8.3.10). For each traveler information message, a connected device shall include the vehicle types that the traveler advisory or road sign is valid for as part of a traveler information message broadcasted to connected vehicles.

Appendix B. Roadside Unit Core Requirements

B.1 Introduction

Some of the system requirements for Road-Side Units (RSUs) are included in SAE J2945™/1 March 2016 (J2945/1 henceforth), while this is designed for Vehicle to Vehicle (V2V) safety communications, it has applicable components for RSUs related to the Wyoming Pilot. The Wyoming Pilot will require RSU manufacturers to obtain certification from a USDOT approved testing facility for RSUs (based on the current version of the USDOT DSRC Roadside Unit Specifications Document). Additionally, the relevant requirements from J2945/1 will only be referenced and will not be re-tested or verified in the pilot. For Vehicle to Infrastructure (V2I) SAE J3067 August 2014 (J3067 henceforth) is used for applicable applications. Additionally, SAE J2735™ March 2016 is used to update the outdated parts of the J3067 based on the new message set dictionary appendix or DSRC. Here, the original J3067's system requirements numbers and descriptions are kept in order to ensure compatibility with other CV projects and to provide clarity for future standards. Operational scenarios are detailed in the Concept of Operations (FHWA-JPO-16-287) Chapter 6. User classes and other involved personnel are described in detail in Section 5.5 of the Concept of Operations (FHWA-JPO-16-287). This includes stakeholders, user profiles, responsibilities and interactions with the system, interactions among user classes and the user support environment.

In cases where conflicting information is defined between the J2945/1, J2735, and J3067, J2945/1 will take initial precedence, followed by J2735 and finally J3067. The reason for this is J2945/1 is most specific and up to date for V2V safety communications and is therefore most relevant to our pilot. J2735 is the second order of precedence because it has many updates to the message set that were not available when J3067 was written. J3067, while somewhat outdated is still relevant because it covers V2I communications and additional applications that are relevant to the Wyoming Pilot.

As J2945/2 and J2945/x become available the Wyoming Pilot will implement the standard interfaces and messages for Situation Awareness- Weather Condition Application, Situational Awareness Suboptimal Road Segment Conditions Applications and RWINFO for Freight Use Case if applicable.

This appendix is organized as follows

1. Section B.1 is intentionally skipped
2. Section B.2 summarizes the requirements from J2945 relevant for RSUs in the pilot.
3. Section B.3 contains the broadcast RSU requirements
4. Section 4 contains the RSU performance requirements

B.2 V2I Core Safety Communication Requirements

CSC-REQ-3 RSU SCMS Use - All RSUs used in the Wyoming Pilot shall be certified from a US DOT authorized testing facility based on the [SCMS current version CAMP Wiki: Requirements and Specifications](#).

- Common Requirements
 - [Cryptography](#)
 - [Hardware, Software and OS Security Requirements](#)
 - A HSM that requires medium confidentiality and medium integrity shall store keys in tamper-evident hardware equivalent to FIPS 140-2 level 3.
 - [EE-RA Communications – General Guidance](#)
 - Download requests for GPF, LPG, GCCF, LCCF, RSE Application certificate files.
- Requirements by Use Case
 - [Use Case 6: CRL Download](#)
 - [Use Case 12: RSE Bootstrapping \(Manual\)](#)
 - [Use Case 13: RSE Application Certificate Provisioning](#)
 - [Step 13.1: Request RSE Application Certificate](#)
 - RSU downloads Local Policy File and Local Certificate Chain and adopts any changes in the new files before making request.
 - [Step 13.3: Download RSE Application Certificate](#)
 - RSU downloads Local Policy File and Local Certificate Chain and adopts any changes in the new files before downloading certificate.
 - [Use Case 16: RSE Application and OBE Identification Certificate Revocation](#)
 - [Step 16.4: RSE CRL Check](#)
 - [Use Case 20: EE Re-Enrollment](#)
 - [Step 20.1: EE Enrollment Certificate Rollover](#)

CSC-REQ-4 RSU Certification - All RSUs used in the Wyoming Pilot shall be certified from a US DOT authorized testing facility based on J2945/1. The following interfaces and requirements from J2945/1, at a minimum, will be included in the certification testing.

- Interfaces
 - 5.1 V2V Over-the-Air Data Description
 - 5.1.1 Basic Safety Message Exchange
 - 5.1.2 Positioning
 - 5.1.3 Security and Privacy
 - 5.1.3.1 Signing and Verification Algorithm
 - 5.1.3.3 BSM Verification
 - 5.1.3.4 SCMS
 - 5.1.3.5 Privacy
 - 5.1.4 Startup and Shutdown
 - 5.1.5 Mapping to the V2V Over-the-Air Data
 - 5.2 System Interfaces
 - 5.2.2 System to SCMS Communication Interface
 - 5.2.3 System to Positioning Sub-System Interface
- Minimum Requirements

- 6.1 Standard Profiles
 - 6.1.1 IEEE 802.11
 - 6.1.2 IEEE 1609.2
 - 6.1.2.1 PICS Proforma
 - 6.1.2.2 BSM Security Profile Proforma
 - 6.1.2.2.1 IEEE 1609.2 Security Profile Identification
 - 6.1.2.2.3 Receiving
 - 6.1.2.2.5 Other
 - 6.1.3 IEEE 1609.3
 - 6.1.4 IEEE 1609.4
 - 6.1.5 IEEE 1609.12
 - 6.1.6 SAE J2735 (2016)
 - 6.1.7 FCC 47 CFR, Parts 0, 1, 2, and 95
- 6.2 Positioning and Timing Requirements
 - 6.2.1 Position Determination
 - 6.2.2 Wide Area Augmentation
 - 6.2.3 Coordinate System and Reference
 - 6.2.4 System Time Coordination
- 6.3 BSM Transmission Requirements on Channel vChannelNumber
 - 6.3.1 BSM Contents
 - 6.3.2 Channel and Data Rate
 - 6.3.4 User Priority and EDCA Setting
 - 6.3.5 Minimum Transmission Criteria
 - 6.3.6 Data Element Accuracy
 - 6.3.6.1 DE_DSRC_MessageID
 - 6.3.6.2 DE_MesCount
 - 6.3.6.3 DE_TemporaryID
 - 6.3.6.4 DE_DSecond
 - 6.3.6.5 DE_Latitude & DE_Longitude
 - 6.3.6.6 DE_Elevation
 - 6.3.6.7 DF_PositionalAccuracy
 - 6.3.6.8 DE_Speed
 - 6.3.6.9 DE_TransmissionSpeed
 - 6.3.6.10 DE_Heading
 - 6.3.6.11 DE_SteeringWheelAngle
 - 6.3.6.12 DF_AccelerationSet4Way
 - 6.3.6.13 DF_BrakeSystemStatus
 - 6.3.6.14 DF_VehicleSize
 - 6.3.6.15 DE_VehicleEventFlags
 - 6.3.6.16 DF_PathHistory
 - 6.3.6.17 DF_PathPrediction
 - 6.3.6.18 DE_ExteriorLights
 - 6.3.6.19 Additional Data Elements
 - 6.3.7 Data Persistency
 - 6.3.7.1 Heading
 - 6.3.7.2 Path History
- 6.4 RF Performance Requirements
 - 6.4.1 DSRC Radiated Power and Transmit Power Accuracy
 - 6.4.1.1 Transmit Power Accuracy

- 6.4.2 DSRC Receiver Sensitivity
- 6.5 Security and Privacy Requirements
 - 6.5.1 Identification Randomization
 - 6.5.3 Certificate Change
 - 6.5.4 BSM Cryptographic Verification
 - 6.5.5 Certificate Revocation
- 6.6 Security Management
 - 6.6.1 Bootstrap: Initialization and Enrollment Processing
 - 6.6.1.1 Initialization Processing
 - 6.6.1.2 Enrollment Processing
 - 6.6.2 Certificate Loading
 - 6.6.3 Certificate Storage
 - 6.6.4 Certificate Revocation List Loading
 - 6.6.5 Secure Hardware
- Parameter Settings

CSC-REQ-5 RSU Specification - All RSUs used in the Wyoming Pilot shall be compliant with the following interfaces and requirements from DSRC Roadside Unit (RSU) Specifications Document v4.1.

- Minimum Requirements
 - 3.4 Functional Requirements
 - USDOT_RSU-Req_513-v003 System Time: GPS primary
 - 3.4.8 Security
 - USDOT_RSU-Req_442-v002 Data Protection: NTP Secondary Time
 - 3.7.1.2 IEEE 1609.2
 - USDOT_RSU-Req_579-v001 Secure Storage: HSM

B.3 RSU Broadcast Traveler Information

The following requirements describe the “broadcast” function of the RSU

BC-REQ-3 Traveler Information Requirements (Source: J3067, 3.5.8). Traveler information is used to provide connected devices with travel advisories and information.

BC-REQ-3.1 Broadcast Traveler Information (Source: J3067, 3.5.8.1). A connected device shall broadcast a packet containing traveler information to connected devices. Each packet may contain one or more individual traveler information messages.

BC-REQ-3.2 Broadcast Traveler Information - Mandatory Requirements (Source: J3067, 3.5.8.2). The following are the minimum requirements for a connected device to broadcast traveler information to connected devices.

BC-REQ-3.2.1 Broadcast Traveler Information - Packet Identifier (Source: J3067, 3.5.8.2.1). A connected device shall include a packet identifier for the traveler information packet broadcasted to connected devices.

BC-REQ-3.2.2 Broadcast Traveler Information - Message Identifier Requirements (Source: J3067, 3.5.8.2.2). For each traveler information message in a traveler information packet, a connected device needs to identify each message transmitted as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.2.2.1 Broadcast Traveler Advisories - Message Identifier (Source: J3067, 3.5.8.2.2.1). For traveler advisories, a connected device shall include a message identifier for each traveler advisory message as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.2.2.2 Broadcast Road Sign - Message Identifier (Source: J3067, 3.5.8.2.2.2). For road sign messages, the message identifier is determined by its geographic location and its viewing angle. Thus, for each road sign message, a connected device shall include the geographic location (latitude, longitude, elevation), based on the WGS-84 coordinate system, and the viewing angle of the road sign as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3 Broadcast Traveler Information (Source: J3067, 3.5.8.3). The following are the requirements for a connected device to broadcast traveler information to connected devices.

BC-REQ-3.3.1 Broadcast Traveler Information - Validity Duration (Source: J3067, 3.5.8.3.4). For each traveler information message in a traveler information packet, a connected device shall include the duration from the start time that the traveler message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.2 Broadcast Traveler Information – Importance (Source: J3067, 3.5.8.3.5). For each traveler information message in a traveler information packet, a connected device shall include the importance of the message relative to other traveler information messages being broadcasted as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3 Broadcast Traveler Information - Presentation Requirements (Source: J3067, 3.5.8.3.6). Agencies may need to present traveler information messages only to specific travelers, such as travelers within specific geographic (spatial) regions or a direction of travel.

BC-REQ-3.3.3.1 Broadcast Traveler Information - Default Anchor Point Position (Source: J3067, 3.5.8.3.6.1). For each traveler information message in a traveler information packet, a connected device shall include the geographic location (latitude, longitude, elevation) of the default anchor point for which valid regions are determined as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.2 Broadcast Traveler Information - Heading Slice (Source: J3067, 3.5.8.3.6.2). For each traveler information message in a traveler information packet, a connected device shall include the direction of motion (of the connected device) that the message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.3 Broadcast Traveler Information - Circular Valid Region Requirements (Source: J3067, 3.5.8.3.6.3). A spatial region for which a traveler information message is valid for may be a circular region around an anchor point. The connected device should be located within the circular region for the traveler information message to be presented to the traveler.

BC-REQ-3.3.3.3.1 Broadcast Traveler Information - Circular Region – Radius (Source: J3067, 3.5.8.3.6.3.1). For each traveler information message in

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a traveler information packet, a connected device shall include the radius for the circular region defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.3.2 Broadcast Traveler Information - Circular Region - Anchor Point (Source: J3067, 3.5.8.3.6.3.2). For each traveler information message in a traveler information packet, a connected device shall include the geographic location (latitude, longitude, elevation) of the anchor point for the circular region of travel defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.4 Broadcast Traveler Information - Polygon Valid Region Requirements (Source: J3067, 3.5.8.3.6.4). A spatial region for which a traveler information message is valid for may be a polygon, which may represent the jurisdictional boundaries of a specific transportation agency or a work zone. The connected device should be located within this polygon region for the traveler information message to be presented to the traveler.

BC-REQ-3.3.3.4.1 Broadcast Traveler Information - Polygon Region – Offsets (Source: J3067, 3.5.8.3.6.4.1). For each traveler information message in a traveler information packet, a connected device shall include the area of travel defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.4.2 Broadcast Traveler Information - Polygon Region - Anchor Point (Source: J3067, 3.5.8.3.6.4.2). For each traveler information message in a traveler information packet, a connected device shall include the geographic location (latitude, longitude, elevation) of the anchor point for the area of travel defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.5 Broadcast Traveler Information - Valid Shape Point Set Region Requirements (Source: J3067, 3.5.8.3.6.5). A spatial region for which a traveler information message is valid for may be a shape point set, which allows a spline-like representation of a geographic area such as a road segment. A connected device should be located within the shape point set region for the traveler information message to be presented to the traveler.

BC-REQ-3.3.3.5.1 Broadcast Traveler Information - Shape Point Set - Default Direction (Source: J3067, 3.5.8.3.6.5.1). For each traveler information message in a traveler information packet, a connected device shall include the default direction of travel along the shape point set as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.5.2 Broadcast Traveler Information - Shape Point Set - Default Width (Source: J3067, 3.5.8.3.6.5.2). For each traveler information message in a traveler information packet, a connected device shall include the default width of the shape point set as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.5.3 Broadcast Traveler Information - Shape Point Set – Offsets (Source: J3067, 3.5.8.3.6.5.3). For each traveler information message in

a traveler information packet, a connected device shall include the shape point set defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.5.4 Broadcast Traveler Information - Shape Point Set – Direction (Source: J3067, 3.5.8.3.6.5.4). For each shape point set in a traveler information message, a connected device shall include the allowed direction of travel along the shape point set as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.5.5 Broadcast Traveler Information - Shape Point Set – Width (Source: J3067, 3.5.8.3.6.5.5). For a shape point set in a traveler information message, a connected device shall include the width for the shape point set as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.5.6 Broadcast Traveler Information - Shape Point Set - Node Width (Source: J3067, 3.5.8.3.6.5.6). For a shape point offset in a traveler information message, a connected device shall include the width of the geographic area at that node as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.3.5.7 Broadcast Traveler Information - Shape Point Set - Anchor Point (Source: J3067, 3.5.8.3.6.5.7). For each shape point set in a traveler information message, a connected device shall include the geographic location (latitude, longitude, elevation) of the anchor point for the shape point set defining where the traveler information message is valid for as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.4 Broadcast Traveler Advisories – Content (Source: J3067, 3.5.8.3.7). For traveler advisory message in a traveler information packet, a connected device shall include the contents of the travel advisory information as part of a traveler information packet broadcasted to connected devices.

BC-REQ-3.3.5 Broadcast Road Sign – Content (Source: J3067, 3.5.8.3.8). For each road sign message in a traveler information packet, a connected device shall include the road sign information as part of a traveler information packet broadcasted to connected devices

BC-REQ-3.3.6 Broadcast Traveler Information - Valid Vehicle Type (Source: J3067, 3.5.8.3.10). For each traveler information message, a connected device shall include the vehicle types that the traveler advisory or road sign is valid for as part of a traveler information message broadcasted to connected vehicles.

B.4 RSU Performance Data

MNG-REQ-1 Performance Requirements – Message Transmission Rates (Source: J3067, G.2). This section defines the range of allowable time intervals between consecutive transmissions of the same message between connected devices.

MNG-REQ-1.6 Transmission Rate Requirements - Broadcast Traveler Information

(Source: J3067, G.2.11). The detailed transmission rate requirements for an RSU to broadcast traveler information to connected devices are as follows.

MNG-REQ-1.6.1 Maximum Transmission Rate - Broadcast Traveler Information

(Source: J3067, G.2.11.1). An RSU shall broadcast a traveler information message to connected devices no more than once per second.

MNG-REQ-1.6.2 Default Transmission Rate - Broadcast Traveler Information

(Source: J3067, G.2.11.2). If the specification does not indicate a default transmission rate, the suggested default transmission rate for an RSU to broadcast a traveler information message to connected devices once per second. If there is no need for an RSU to broadcast a message, then it is recommended that no messages be transmitted from the RSU to minimize traffic, i.e., congestion. Otherwise, it is recommended that an RSU transmit a broadcast message frequently enough to ensure that the connected device for which the message is intended, traveling at the expected percentile speed would be within the transmission zone for at least three or four broadcasts.

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