Connected Vehicle Pilot Deployment Program Phase 1

Deployment Readiness Summary – ICF/Wyoming

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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 1 includes the planning for the CV pilot including the concept of operations development. Phase 2 is the design, development, and testing phase. Phase 3 includes a real-world demonstration of the applications developed as part of this pilot.

This document presents the Deployment Readiness Summary, which: i) provides a status of all Phase 1 deliverables and a specific punch list of ongoing activities to complete the outstanding deliverables; ii) establishes that the Wyoming CV Pilot team have met all the required elements in the CV Program Phase 1 Broad Area Announcement (BAA); and iii) describes the Wyoming CV Pilot team's level of readiness to immediately initiate Phase 2 activities. The work accomplished in Phase 1 lays an important foundation from which to perform Phase 2 and 3 activities to design, build, test, and demonstrate the CV technologies.

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1 Introduction

1.1 Deployment Overview

The Wyoming CV Pilot project is well documented in the recently completed ***Wyoming CV Pilot Comprehensive Deployment Plan***. A brief overview is provided here for context. The reader is referred to the Task 12 Deployment Plan for further details.

The state of Wyoming is positioned as an important freight corridor utilizing Interstate 80 (I-80) as the primary east-west route. The 402 miles of I-80 in Wyoming exists at high elevations (6,000 to 8,640 feet) and experiences extreme weather conditions, very high truck volumes, and catastrophic vehicle crashes. The goal of this project is to develop systems that support the use of Connected Vehicle (CV) Technology along the 402 miles of Interstate 80 (I-80) in Wyoming to better communicate travel advisories and alerts and reduce related multi-vehicle crashes.

The pilot will develop applications that use vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and its counterpart infrastructure-to-vehicle (I2V), connectivity to support a flexible range of services such as advisories, roadside alerts, and dynamic travel guidance. Information from these applications is made available directly to the equipped fleets or through WYDOT's existing traveler information sources. Key to WYDOT's deployment vision is integration of CV technology with existing Transportation Management Center (TMC) operations. Data collected from the equipped vehicles not only support in-vehicle applications but also enable better traffic and incident management along the I-80 corridor. For example, conditions reported from connected vehicles will enable better setting of variable speed limits along the corridor. On the other hand, integration with existing TMC resources like construction, parking, and road condition reporting enable transmission of timely situational awareness alerts to the equipped vehicle. By relying heavily on standards, especially in defining message sets, WYDOT's vision is focused on the future. As more and more vehicles equipped with DSRC connectivity become available, the true vision of WYDOT is that any connected vehicle on I-80 could benefit from the applications developed as part of the pilot, regardless of the make and model of the vehicle or the on-board unit.

At a very high level, the pilot scope includes the following implementation elements and their locations:

- **Deployment of about 75 roadside units (RSU)** that can receive and broadcast messages using DSRC along various sections on I-80. RSUs will be installed at various locations along the interstate based on a statistically driven approach to identify hotspots and subsequently target RSU locations upstream of that location. It is anticipated that two RSUs will be placed at every selected location. Two reasons for this: 1) for the notification to be early enough in each direction; and 2) because I-80 is a divided highway with a very large distance between East and West bound at many places, which may not be covered by a single RSU.
- **Equip around 400 vehicles, a combination of fleet vehicles and commercial trucks, with on-board units (OBU).** Of the 400 vehicles, at least 150 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) Part I and will include a human-machine interface (HMI) to share alerts and advisories to drivers of these vehicles. A portion of the equipped vehicles will have additional capabilities, such as transmitting BSM Part II and collecting environmental data through mobile weather sensors. The approximately 400 equipped vehicles are based in a variety of locations. Specifically, WYDOT fleet vehicles are located along I-80 in various cities, with Cheyenne and Laramie being the cities of critical interest. Vehicles belonging to several of our fleet partners are based in Wyoming as well, but some vehicles from our fleet partners could be based in other states. Nonetheless, all vehicles involved in the pilot are frequent travelers of I-80 in Wyoming.

- **Develop several V2V and V2I 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 improvements include better activation of variable speed limits (VSL) and improved road condition dissemination via 511, Dynamic Message Sings (DMS) and other WYDOT sources. All back-office functionality and systems will be managed from WYDOT's Geographic Information System (GIS) and Intelligent Transportation System (ITS) Program (GIS/ITS), located in Cheyenne, Wyoming and co-located at the Transportation Management Center (TMC).

In addition, the scope includes support for the performance management and evaluation, outreach, training, systems engineering and program management necessary for delivering the CV Pilot elements.

The CV Pilot is considered a System of Systems, with two of interest: The *Vehicle System* and the *Wyoming CV System* (see Figure 1-1). The *Vehicle System* includes four subsystems that represent the various vehicle and equipment types to be used in the pilot. These subsystems 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.

The *Vehicle System* represents the deployment of on-board equipment, sensors, and a human-machine interface that will support CV applications. All vehicles that are part of the *Vehicle System* will have the following core capabilities (i.e., common capabilities that all sub-systems will be able to perform):

- Ability to share and receive information via DSRC from other connected devices (vehicles and RSUs)
- Ability to broadcast Basic Safety Message Part I
- Ability to receive Basic Safety Message Part I
- Ability to receive Traveler Information Messages (TIM)
- A human-machine interface that allows alerts and advisories to be communicated with the driver.

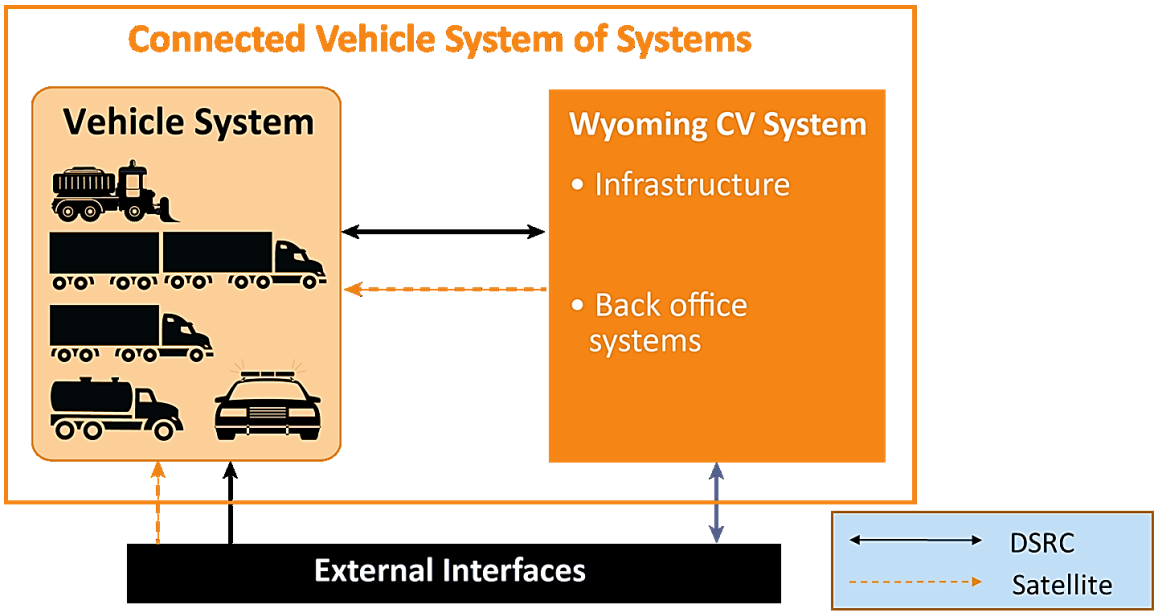

Figure 1-1. Wyoming CV Pilot System of Systems (Source: ICF).

It should be noted that several vehicles that are part of the *Vehicle System* have additional capability. As such, the *Vehicle System* is broken down four subsystems, which define the various vehicle types for this pilot based on their data collection and communication capabilities. For vehicles identified as using Basic Safety Message Part II, this will be done in compliance with J2735 Trailer Data, Probe Data and Vehicle Status Data. For all OBU installed in trucks, antennas will be specified with low loss cabling to compensate for the additional length needed for larger vehicles. No installations of equipment will be on trailers, only on power units. Figure 1-2 illustrates the subsystems and their components.

The *Wyoming CV System* includes the infrastructure used in the pilot and back-office systems, located at the WYDOT TMC, in charge of the various processes that lead to the generation and distribution of advisories and alerts to the Vehicle Systems. This system will have some data that is personally identifiable. The pilot is being built under the design principle of security by design. This means that from the initial planning phase of this pilot, and at each following stage, the privacy of users and data is the foundation of the plan rather than an after-thought. Additionally, this system provides external interfaces to share the advisories and alerts with the public and commercial vehicle operators. The *Wyoming CV System,* and its five subsystems, is shown in Figure 1-3.

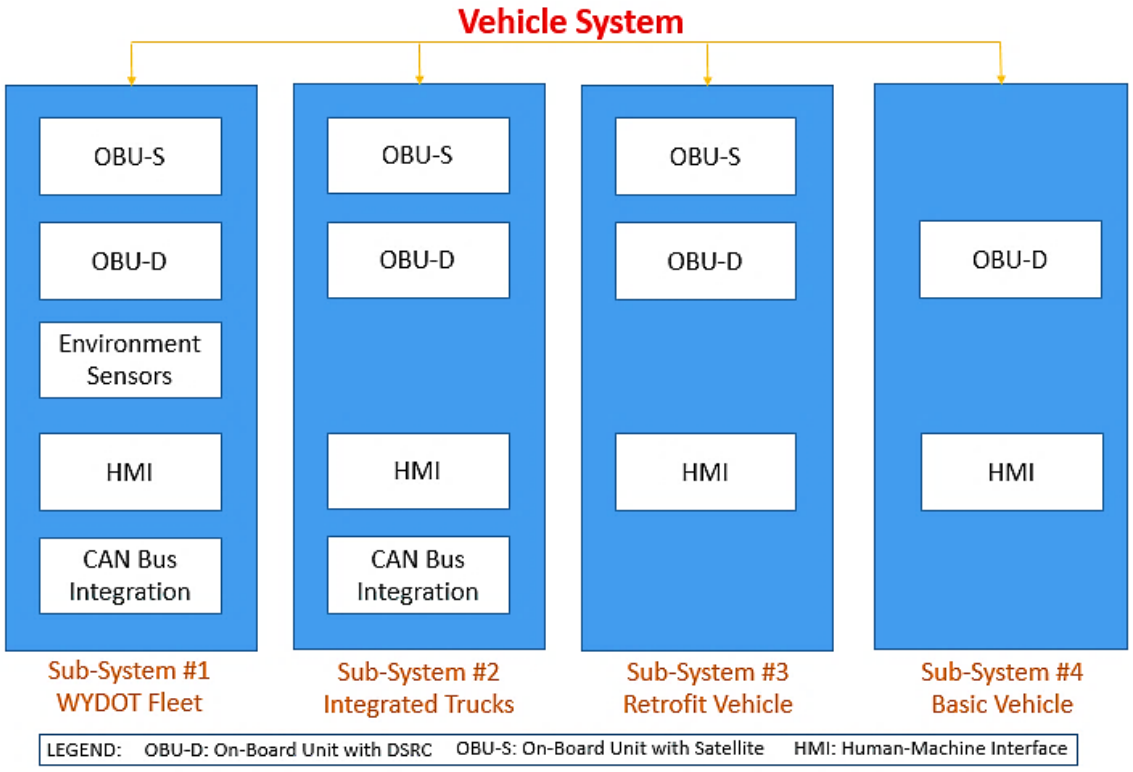

Figure 1-2. Wyoming CV Pilot Vehicle System (Source: ICF).

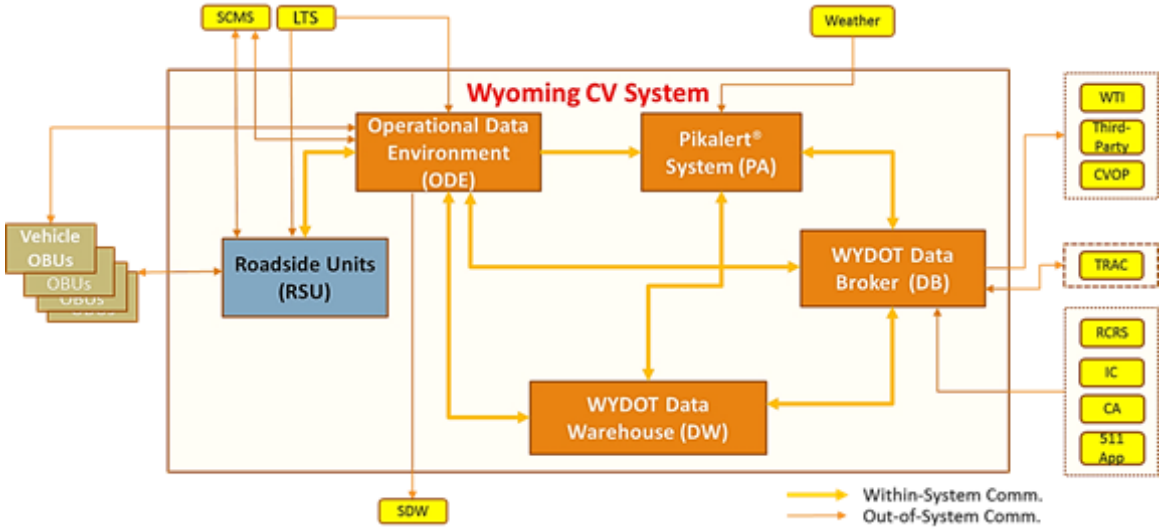

Figure 1-3. Wyoming CV System (Source: ICF).

Additional details are available in the ***Wyoming CV Pilot Comprehensive Deployment Plan***, including specific connected vehicle technology vehicle (on-board) and TMC operations applications.

1.2 Purpose of the Report

The purpose of this report, ***Wyoming CV Pilot Deployment Readiness Summary***, is three-fold:

1. Provide a status of all Phase 1 deliverables and a specific punch list of ongoing activities to complete the outstanding deliverables. It should be noted that all deliverables from Phase 1 will be updated to reflect the Phase 1 end state as part of Task 2-B.
2. Establish that the Wyoming CV Pilot team have met all the required elements in the CV Program Phase 1 Broad Area Announcement (BAA).
3. Describe the Wyoming CV Pilot team's level of readiness to immediately initiate Phase 2 activities. The work accomplished in Phase 1 lays an important foundation from which to perform Phase 2 and 3 activities to design, build, test, and demonstrate the CV technologies.

1.3 Organization of the Report

The remainder of this document is organized as follow:

- Section 2 describes the Phase 1 deliverables status including any punch list items still outstanding to complete all deliverables.
- Section 3 identifies each of the required items contained in the CV Program Phase 1 BAA and how the Wyoming CV Pilot has accomplished them.
- Section 4 details the Wyoming CV Pilot partnership framework and status including how WYDOT will incorporate freight partners, vendors, stakeholders, and subcontractors to successfully execute Phases 2 and 3.
- Section 5 describes the Wyoming CV Pilot deployment scope and level of readiness to accomplish each task.
- Section 6 identifies specific project risks and planned mitigation approaches.
- Section 7 summarizes the Phase 1 lessons learned primarily directed toward other agencies who may be interested in Connected Vehicle deployment endeavors.
- Section 8 lists the references used in this document.

2 Phase 1 Deliverables

This section provides a status of each Wyoming CV Pilot Phase 1 deliverable, and if not yet complete, also provides a punch list of activities underway to complete all deliverables and publish the appropriate documents. Table 2-1 provides a status of all Wyoming CV Pilot Phase 1 deliverables with their corresponding status and related dates. Status options include:

- Not submitted.
- Submitted draft version (date) – The draft version is submitted to USDOT. The pilot site is waiting for COR review or is revising the draft.
- Submitted revised version (date) – The revised version is submitted to USDOT with edits in response to comments. The pilot site is waiting for COR review or is finalizing the deliverable.
- Final deliverable approved (date) – The final version of the deliverable is approved by USDOT. The pilot site is working on the 508 format of the final deliverable.
- Submitted 508 version (date) – The 508 version of the final deliverable is submitted. The pilot site is waiting for the 508 review by USDOT publication staff.
- Published (date) – The final deliverable has been published online.

Not all deliverables were expected to be published and therefore are not to be put into the 508 format. Therefore, some of the deliverable statuses indicate (in the table) “Final deliverable approved (note 1),” and in those cases are considered complete.

Most of the deliverables are complete and either are published (if appropriate) or the 508 version has been submitted.

A few deliverables are still being completed, but are on schedule. The Wyoming CV Pilot team expects that all deliverables will be completed by the end of Phase 1 (September 30, 2016). For those deliverables that are still in some form of completion (indicated by an “*” in the Task column, a punch list of ongoing activities is provided in the next section.

Table 2-1 Wyoming CV Pilot Phase 1 Deliverables Status

Task	Phase 1 Deliverable	Status	Date
1	Kickoff Briefing	Final deliverable approved (note 1)	9/30/2015
	Draft PMP	Final deliverable approved (note 1)	10/9/2015
	Final PMP	Final deliverable approved (note 1)	10/22/15
	Monthly Reports	Final deliverable approved (note 1)	By 15th of each month
2	ConOps Review Panel Roster	Final deliverable approved (note 1)	11/23/2015
	Needs Summary	Final deliverable approved (note 1)	11/25/2015
	Draft ConOps	Final deliverable approved (note 1)	12/15/2015
	Walkthrough Briefing Deck	Final deliverable approved (note 1)	2/1/2016
	ConOps Resolution Report	Final deliverable approved (note 1)	1/19/2016
	Final ConOps	Submitted 508 version	2/11/2016
	ConOps Webinar	Final deliverable approved (note 1)	12/30/2015
3	Security Management Operational Concept	Submitted 508 version	3/28/2016
4	Safety Management Plan	Submitted 508 version	3/28/2016
5	PM and Evaluation Support Plan	Submitted 508 version	8/1/2016
	PM and Evaluation Support Webinar	Final deliverable approved (note 1)	6/6/2016
6	System Requirements Review Panel	Final deliverable approved (note 1)	3/21/2016
	Draft System Requirements	Submitted revised versions	5/23/2016
	SyRs Walkthough Workbook	Final deliverable approved (note 1)	4/19/2016
	SyRs Resolution Report	Final deliverable approved (note 1)	9/7/2016
*	Final SyRs	Final deliverable approved	9/7/2016
7	Application Deployment Plan	Submitted 508 version	7/1/2016
8	IRB Proposal	Final deliverable approved (note 1)	4/21/2016
	Human Use Plan	Submitted 508 version	7/27/2016
9	Training and Education Plan	Submitted 508 version	7/1/2016
10	Partnership Status Summary	Submitted 508 version	8/26/2016
11	Outreach Plan	Submitted 508 version	7/1/2016
12	Comprehensive Deployment Plan	Submitted 508 version	8/19/2016
	CPD Webinar	Final deliverable approved (note 1)	8/22/2016
13*	Deployment Readiness Briefing	Submitted draft version	9/21/2016
*	Deployment Readiness Summary	Submitted revised version	9/16/2016

Note (1): Not published; 508 formatted version not required; deliverable considered “complete”

2.1 Deliverable Punch List

Table 2-2 describes punch list activities to complete the deliverables. The Wyoming CV Pilot team does not see any showstoppers and believes that all deliverables will be complete by the end of Phase 1.

Table 2-2 Wyoming CV Pilot Deliverables Punch List

Task	Phase 1 Deliverable	Punch List Activities	Expected Status	Expected Date
6	Final SyRs	• Wyoming prepares 508 version	Submitted 508 version	9/30/16
13	Deployment Readiness Briefing	• USDOT Approval	Final deliverable approved (note 1)	9/30/16
13	Deployment Readiness Summary	• USDOT Approval • Wyoming prepares 508 version	Submitted 508 version	9/30/16

3 Required Elements

The Connected Vehicle Pilot Deployment Program Phase 1 Broad Area Announcement (BAA – page 68) required the following eight fundamental elements be included in the selected sites:

A. *Include at least one USDOT-developed application in the pilot deployment. (Please see www.its.dot.gov/pilots for a list of the applications.)*

B. *Include two or more applications with clear synergy to either reduce costs or increase benefits, or both.*

C. *Identify some appropriate role for DSRC communications; thoughtful integration of non-DSRC communications technologies are also encouraged.*

D. *Utilize the SCMS as a tool to support general deployment security. In addition, the proposed pilot must utilize the SCMS for at least one of the proposed applications, and all applications where utilizing the SCMS is deemed appropriate (e.g., applications where trust and security are essential).*

E. *Agree to share data and open source code with the broader deployment community*

F. *Agree to interface with national SCMS.*

G. *Utilize CVRIA and use SET-IT tools as appropriate unless site provides compelling reasons otherwise.*

H. *Define team framework with single lead organizational entity with clear programmatic control, with identified single individual responsible for overall pilot deployment leadership.*

The Wyoming CV Pilot achieves all of these required fundamental elements. Each element is discussed below with details of how Wyoming was able to effectively incorporate them in our concept of operation and system architecture.

3.1 Element A: At Least One USDOT-Developed Application

The USDOT Connected Vehicle Program has identified a set of 57 CV Applications in seven categories that represent examples of possible project deployments. A complete list of CV Applications can be found at: http://www.its.dot.gov/pilots/cv_pilot_apps.htm.

As the Wyoming CV Pilot team's concept was evolving, these applications were referenced to ensure our final solution appropriately included the relevant applications. Eight USDOT CV Applications are included in the Wyoming Pilot concept. Some of the Applications were consolidated and a final list of six Wyoming CV Pilot Applications were generated (5 vehicle on-board applications and 1 TMC Operations application). The six Wyoming Pilot Applications include:

Forward Collision Warning (FCW) – This application 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. FCW will help drivers avoid or mitigate front-to-rear vehicle collisions in the forward path of travel. The system does not attempt to control the host vehicle to avoid an impending collision.

Infrastructure-to-vehicle (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.

Distress Notification (DN) – This application enables connected vehicles to communicate a distress status when the vehicle's sensors detect an event that might require assistance from others or the vehicle's operator manually initiates a distress status. The vehicle generates and broadcasts a distress message (e.g., Mayday) to the nearest RSU. When an RSU is not within communication range, the message is received by connected vehicles that are in the vicinity and forwarded to an RSU that forwards it to the *Wyoming CV System*. The Distress Message will include the location, time of message, distress message explanation (e.g., air bag deployed, vehicle disabled, operator initiated), and vehicle make and model. Additionally, the distress notification received by nearby connected vehicles is broadcast to notify oncoming vehicles that a distressed vehicle is ahead.

Work Zone Warning (WZW) – This application provides information about the conditions that exist in a work zone toward which the vehicle is approaching. This capability provides approaching vehicles with information about work zone activities that could present unsafe conditions for the vehicle, such as obstructions in the vehicle's travel lane, lane closures, lane shifts, speed reductions or vehicles entering/exiting the work zone.

Spot Weather Impact Warning (SWIW) – Similar to situational awareness, this application enables relevant road condition information, such as fog or icy roads, to be broadcast from a roadside unit and received by the connected host vehicle. This application, however, is distinct from situational awareness in that it provides more localized information (i.e., at the segment level instead of area wide or region wide).

TMC Operations – Information generated by the *Wyoming CV System* is expected to be used to support ongoing WYDOT traffic management and traveler information services. WYDOT expects to use the information from the pilot to set variable speed limits along I-80, update 511 and other traveler information systems, Support road weather advisories and freight-specific travel guidance through CVOP, and enable 3rd party interfaces to expand information dissemination.

A relationship mapping of USDOT CV Applications to Wyoming CV Pilot Applications is shown in Figure 3-1 below. The figure illustrates how several of the applications support the I2V Situational Awareness and TMC Operations applications. It also shows that the Distress Notification application does not currently have a matching USDOT application.

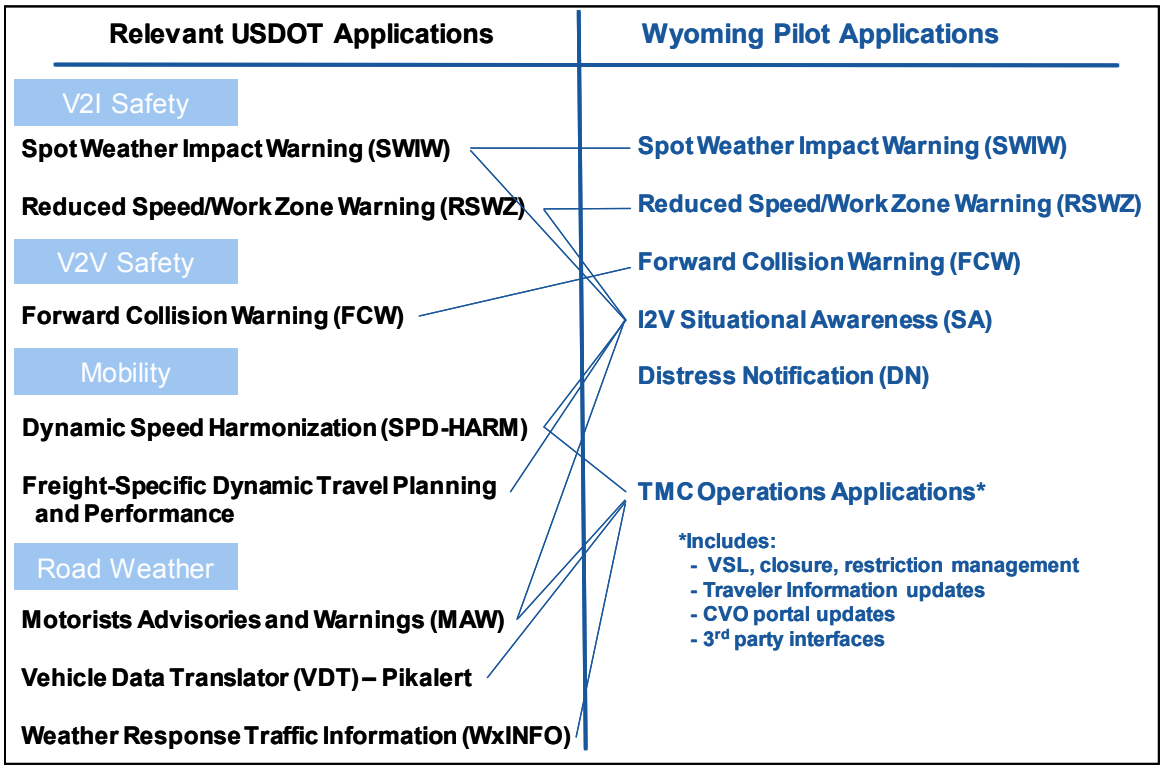

Figure 3-1. Relationship Mapping of USDOT CV Applications to Wyoming CV Pilot Applications (Source: ICF).

3.2 Element B: Two or More Applications with Clear Synergy

As can be seen in Figure 3-1, several of Wyoming's CV applications are working synergistically with each other. The Wyoming CV application that most significantly embodies that approach is the I2V Situational Awareness application (described above). The Wyoming CV Pilot Situational Awareness (SA) application encompasses elements from the following USDOT CV Applications:

- Spot Weather Impact Warning (SWIW)
- Reduced Speed/Work Zone Warning (RSWZ)
- Dynamic Speed Harmonization (SPD-HARM)
- Freight-Specific Dynamic Travel Planning and Performance
- Motorists Advisories and Warnings (MAW)

3.3 Element C: Appropriate Role for DSRC Communications

The Wyoming CV Pilot concept utilizes DSRC communication as a foundational technology. DSRC equipment is planned on-board roughly 400 connected vehicles and incorporated into approximately 75 roadside devices. DSRC will enable important data elements be transferred to and from the Wyoming TMC and other CV systems via V2I/I2V and V2V including, but not limited to, road condition reports, BSMs, TIM messages, incidents, and a variety of other advisories and alerts.

The Distress Notification (DN) Application provides the best example of the role of DSRC in the Wyoming CV Pilot (see Figure 3-2) for both V2V and V2I communications. In this example DSRC communications will be used to transmit Mayday messages from a connected vehicle to a RSU or another connected vehicle that will relay it to a RSU, and to another connected vehicle that could relay it other connected vehicles traveling in other directions that may benefit from knowing of an incident ahead or possibly to render assistance.

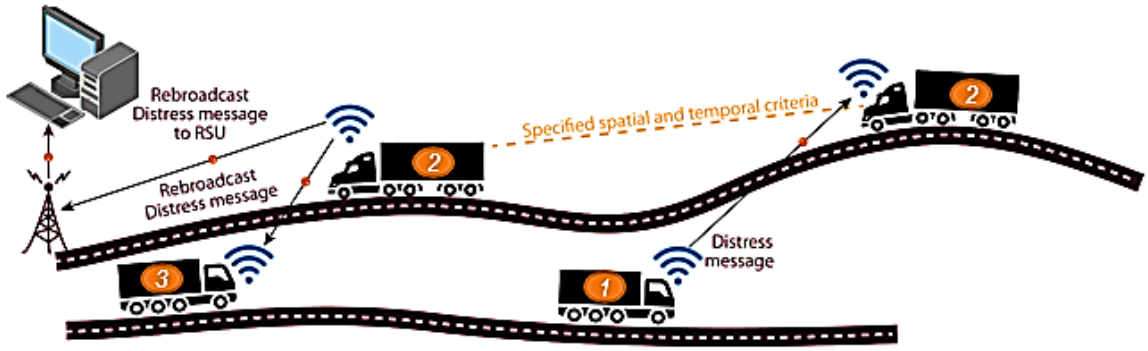

Figure 3-2. Wyoming CV Pilot Distress Notification Application Depiction Illustrating the Use of DSRC (Source: ICF).

3.4 Element D: Utilizing the SCMS

Use of the Security Credential Management System (SCMS) is at the core of the Wyoming CV Pilot. The SCMS system has as its function to provision information, enroll participants, authorize users, and revoke privileges if necessary. The Wyoming CV Pilot plans to use the SCMS in the following applications:

- OBU application data send/receive
    - The SCMS will be used for issuing pseudonym certificate for the OBU. Additionally, the SCMS will be used for issuing application certificates for each OBU application. These certificates will be used for message encryption and/or signing of probe data, event logs, BSMs, and TIMs. They will also be used for validation and decryption of received messages.
    - The SCMS will also be used for sending misbehavior reports and receiving certificate revocation lists.

- RSU application data send/receive
    - The RSU will use the SCMS for the items listed for the OBU and also be used to setup the tunnel from the OBU to the SCMS servers.
- Operational data exchange
    - The ODE will use the SCMS for certificates for applications as well as for signing and encryption.

The Wyoming CV Pilot will interface with the National SCMS system to obtain and log user certifications (see Figure 3-3).

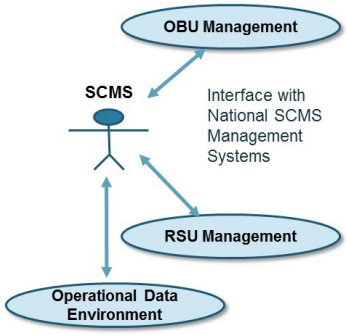

Figure 3-3. Utilizing SCMS (Source: ICF).

3.5 Element E: Sharing Data and Open Source Code

3.5.1 Data Sharing

The Wyoming CV Pilot intends to share project data with USDOT and the Independent Evaluator (IE) in support of performance measurement activities, as defined in the Performance Measurement and Evaluation Support Plan (PMESP). The PMESP describes the data elements, sharing framework, and frequency of data sharing. Data will be shared via the Research Data Exchange and directly with the IE.

Data elements will include system data, non-system data, interview/survey data, and simulator/ modeling/simulation data. Dashboards will be generated and used to communicate key performance measures. The majority of the data will be stored and shared through the Wyoming Data Warehouse. Appropriate interfaces and automated tools will be developed to facilitate data sharing. As other USDOT tools are made available, Wyoming will evaluate their use to ensure efficiency of data sharing.

Wyoming CV Pilot will ensure the security of the data, including personally identifiable information (PII).

3.5.2 Open Source Code

All code developed for the WYDOT CV project and directly paid for (e.g., not included with hardware or software from vendors) will be posted on the Open Source Application Development Portal. Expected applications will be the crowd sourced parking application used in the 511 Application on Android and iPhone, all ODE code developed (data warehouse connections, GIS interface to ODE collected data, SCMS additions, and SDW additions), all code developed for the WYDOT data broker used for CV applications, and the Rest Service development for the third party TMDD interface. Non CV pilot funded code will not be uploaded to the OSADP, this includes code included with hardware purchases, bundled with software purchases, and any code not customized for the CV pilot.

3.6 Element F: Interfacing with National SCMS

As stated above, the Wyoming CV Pilot intends to interface with the National SCMS System.

3.7 Element G: Utilizing CVRIA/SET-IT Tools

The Wyoming team used CVRIA in Phase 1 to organize the system architecture and identify specific applications. The SET-IT tool was initially used to document the concept of operations, but found it to be too technical to tell the project story. The team will use CVRIA applications and the SET-IT tool in Phases 2 and 3 in developing detailed design documents for all OBU and RSU applications. The SET-IT tool will be used for physical and communications flows for the CV applications listed in Section 3.2.

3.8 Element H: Single Lead Organizational Entity

The Wyoming CV Pilot Phase 2 and 3 activities will be led by Wyoming Department of Transportation. They will be supported by freight partners, vendors, subcontractors, and other stakeholders. Subcontract support will include program and technical support, systems development and integration, and human use and training.

A framework has been established and formal arrangements (and contracts) with the partners is under development. The partner framework and project organization is described in Section 4 that follows.

4 Partnership Framework

The Wyoming DOT will lead the Phase 2 and 3 activities with assistance from various subcontractors, vendors, freight partners and other stakeholders. This Wyoming CV Pilot partnership was carefully crafted to incorporate the strengths of each member to ensure the success of the CV project design, build and demonstrate. The partnership framework, organization, and status is described below.

4.1 Partnership Framework

Figure 4-1 illustrates the partners and their key contributions.

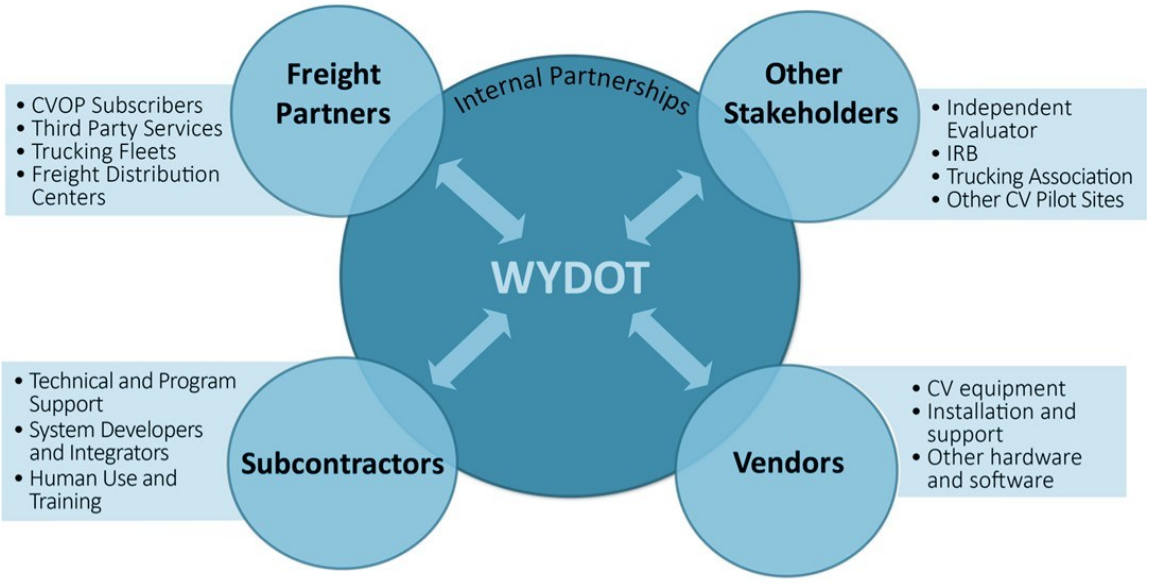

Figure 4-1. Wyoming CV Pilot Phase 2 and 3 Partnership Framework (Source: ICF).

The team for Phase 2 and 3 is composed of staff from the following organizations:

- **Wyoming Department of Transportation (WYDOT)** – WYDOT is the United States DOT (USDOT) Connected Vehicle (CV) Pilot Grant Recipient for Phase 2 and Phase 3 of this project. WYDOT is a strong committed State DOT partner that is a leader in rural intelligent transportation systems (ITS) and CVs. Led by the WYDOT geographic information system (GIS)/ITS group, WYDOT expects several of their departments to be heavily involved in the pilot including:
    - WYDOT Traffic Management Center Personnel
    - WYDOT Telecommunications
    - Wyoming Highway Patrol
    - WYDOT Maintenance

  - WYDOT GIS/ITS
  - WYDOT IT
  - WYDOT Contracts/Procurement
  - WYDOT Public Affairs Office

  WYDOT staff includes State employees and existing GIS/ITS Contractors who currently support various systems development activities.
- **ICF** – ICF's staff bring deep expertise in road weather management, systems engineering, application development, and stakeholder outreach and coordination for this effort. ICF will provide overall program management support, support to various systems engineering tasks, and lead the outreach activities. As the overall program management lead, ICF will provide support to the performance management activities (as will other contracts: University of Wyoming and Trihydro) and ensure schedule, quality and scope adherence of all performance management activities and deliverables. The ICF team includes the firm:
  - **Vital Assurance** - A new addition to the team, Vital Assurance is a group of consultants that includes Dr. Denny Stephens, a national expert in systems development for connected vehicle deployment and a strong truck technology background. Dr. Stephens will play an important role in adequately defining the system architecture, system design and testing approaches for the pilot in Phase 2.
- **Trihydro** – Leads the systems engineering and integration work for the Pilot. An engineering and systems development firm based in Wyoming, with a 118-vehicle fleet that supports WYDOT as well as the oil and gas industry in Wyoming. Trihydro staff, led by our systems integration lead will be responsible for system design, application development, testing during Phase 2 and monitoring the operations of the system in Phase 3. Trihydro's team will include one additional firm:
  - **National Center for Atmospheric Research (NCAR)** – NCAR will help develop the weather-related application portions for the CV Pilot including integration of the Pikalert® system with the overall CV pilot.
- **University of Wyoming (UW)** – A research institution that brings a fully-equipped driving simulator and sophisticated modeling expertise in the areas of road weather management. UW will act as the Institutional Review Board (IRB) of record and will support continued human use approvals and trainings, including amendments to the IRB and support the testing and training of CV pilot elements using the university truck and car simulators. The university will also support the performance management and evaluation of the CV Pilot system in Phase 2 and Phase 3.
- **McFarland Management** - will provide technical leadership and coordination for all performance management and evaluation activities during the pilot.

From a contractual standpoint, WYDOT is the grant recipient and ICF, Trihydro, McFarland Management and UW have separate contracts with WYDOT.

4.2 Partnership Organization

This project requires expertise in a broad range of subject matters and a strong management team to guide the development, deployment, testing, maintenance, and performance measurement of this pilot. To accomplish Phase 2 and 3 within 38 months, the teams on this pilot are organized under one site leader and three main management leads. The Project Site Lead is the main pilot site project lead and is supported by the three other management leads – Project Management Lead, Systems Development Lead, and Human Use and Training Lead. Figure 4-2 shows the organization of this leadership structure.

The top tier leadership structure (the five leads) are supported by a strong team of key supporting technical area leads with experience on a variety of topics. These key supporting technical area leads will coordinate closely with the leadership structure and will provide guidance to the broader team. Table 4-1 lists each of the key supporting technical area leads and their specific area(s) of support during this pilot.

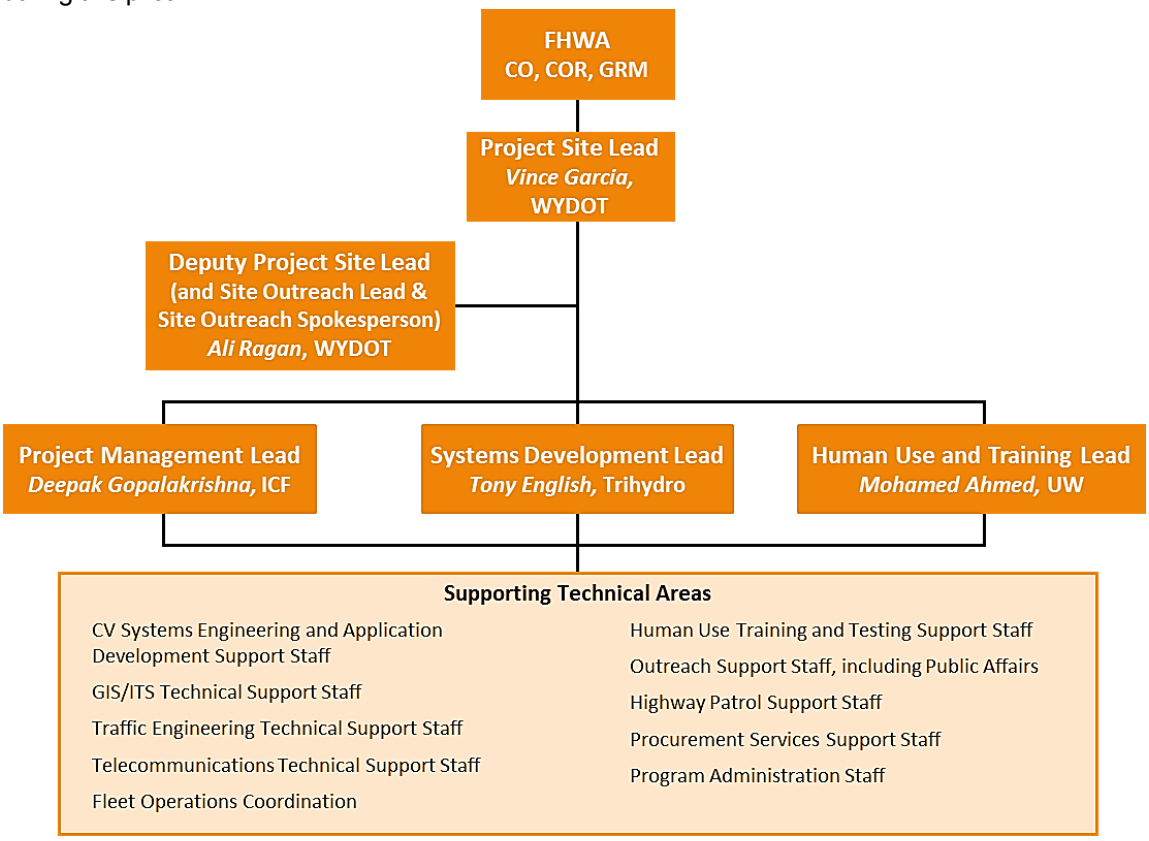

Figure 4-2. Project Organization Chart (Source: ICF).

Table 4-1. Key Supporting Technical Area Leads

Key Supporting Technical Area Leads		
CV Systems Engineering and Application Development Support Leads • Denny Stephens, Vital Assurance – Engineering Lead • Josh Dorrell, Trihydro – Technology Services and Solutions Lead • Shane Zumpf, Trihydro – Software Development Lead • Ivan Yourshaw, WYDOT GIS/ITS Contractor, Neaera Consulting – User Experience Development Lead	**Traffic Engineering Technical Support Leads** • Joel Meena, WYDOT – Traffic Engineering Integration Lead **Telecommunications Technical Support Leads** • Larry Sheridan, WYDOT – Telecommunications Integration Lead	**Human Use Training and Testing Support Leads** • Dr. Mohamed Ahmed, University of Wyoming • Dr. Nayel Urena Serulle, ICF – Technical User Training Integration Lead • Eva Hsu, ICF – User Testing Development Lead

Weather and CV Leads • Amanda Anderson, NCAR • Gerry Weiner, NCAR **GIS/ITS Technical Support Leads** • Jim Vanderweide, Trihydro – GIS Lead • Brian Peel, WYDOT – WYDOT GIS Lead • David Rush, WYDOT GIS/ITS Contractor, DAR Consulting – Technical Integration Lead	**Fleet Operations Coordination** • Tony English • Ali Ragan **Performance Management Leads** • Fred Kitchener, McFarland Management – Evaluation Lead Rhonda Young, UW – Safety Analysis Lead	**Outreach Support Leads** • Ali Ragan, WYDOT - Site Outreach Lead and Site Outreach Spokesperson • Kate Brangaccio, ICF – Collateral Development Lead • Eva Hsu, ICF – Outreach Activities Lead **Program Administration Leads** • Cindy Peck, ICF, Program Management Reporting

4.3 Agreements

The Wyoming CV Pilot team has established relationships with all partners and is ready to engage them formally once Phase 2 is contracted. Formal agreements, as appropriate, will be prepared early in Phase 2 with partners. These agreements will be in various forms depending on partner role. For instance, MOUs are planned with commercial vehicle fleet and freight partners; while subcontract agreements with WYDOT and the subcontractors are planned. The status of arrangements with each partner group is shown in Table 4-2 below.

Phase 2 and 3 will be conducted with Federal and Wyoming State funds. Long term financial commitments beyond the Pilot will be determined near the conclusion of Phase 3 activities, and will likely be funded by WYDOT.

Table 4-2. Wyoming CV Pilot Partnership Arrangement Status

Partnership Category	Status
Fleet and Freight Partners	Letters of support obtained from several fleet partners already. Transitioning them to MOUs in Phase 2. Expected to be non-financial agreements.
Internal WYDOT Partnerships	WYDOT has identified internal needs for Phase 2 and 3 across the department. No agreements are necessary and WYDOT is committed to ensuring its resources are fully available to support the pilot.
Subcontracts	WYDOT developed and executed individual scopes of work and contracts with all subcontractors. The contracts also include financial commitments to execute the defined scopes of work.
Vendors	Initial quotes for equipment obtained. Have discussed scheduling of equipment purchases and ability of vendors to deliver required number of products. Agreements with vendors will include compensation for equipment and services.
Other Stakeholders	Continue to obtain letters of support from other stakeholders. Engagement with other CV pilot sites and IRB is ongoing. Engage with Independent Evaluator when selected by USDOT.

4.3.1 Governance Agreements

The Wyoming Department of Transportation (WYDOT), as the grant recipient for the pilot is the overall lead and responsible for the governance of the Phase 2 and Phase 3 of the pilot. The Wyoming GIS/ITS program will be responsible for delivering the scope of work identified in the grant award. WYDOT will be supported by a contractor team and partners to deliver the pilot per the agreement between USDOT and WYDOT. WYDOT will use their approved contracting and procurement methods and other processes will be defined in the agreements. WYDOT will be supported by fleet partners who will sign a memorandum of understanding (MoU) identifying roles and responsibilities for the pilot.

With an eye towards the post-pilot operations, Wyoming DOT is intending to set up a new CV-Pilot Freight Advisory Council (FAC) to provide advisory support for the pilot. The freight advisory council will consist of representatives from WYDOT, fleet partners who are participating in the pilot, local freight stakeholders who use CVOP, Transportation Safety Council, and the Wyoming Trucking Association (WTA). Wyoming DOT anticipates that the freight advisory council will meet quarterly starting in the middle of Phase 2 (1st Qtr of 2017). The freight advisory council is a sounding board for WYDOT to discuss pilot development in Phase 2 and Phase 3. As the project progresses, the advisory council will support WYDOT in the post pilot transition planning assisting in setting priorities for application updates, and supporting growth in number of fleets that have access to this technology.

4.3.2 Financial Agreements

Financial Arrangements are specified in the Grant Agreement and describe the Federal and Wyoming Cost Share. The total project cost is $5,755,972, which includes $4,439,493 in federal share. Of WYDOT's cost share, $1,193,873 is in cash and $122,606 is an in-kind match.

For contractors, WYDOT will create individual scopes of work that provide clear deliverables and milestones for each contractor as per WYDOT contract regulations.

For fleet partners, financial arrangements, if any, will be included as part of the MoUs. As part of the participation in the pilot, WYDOT will procure the on-board equipment that will be installed on fleet partner vehicles. Fleet partners are expected to support the installation by providing access to their vehicles at their site. Installation will either be done by WYDOT team or by the fleet partner depending on the location of the partner. Regardless, WYDOT will provide the installation guides necessary for the fleet partner. WYDOT also has included a budget for incentives/ reimbursements for drivers when they are taken out of their daily operations for pilot operations (for installation, training, survey/feedback/demonstrations, etc.). However, support from the fleet partners is voluntary, as such, they are not expected to be contractual partners for the pilot.

WYDOT will procure all equipment for the pilot using State of Wyoming procurement standards and in compliance with the USDOT oversight and requirements based on the Phase 2/Phase 3 contracts.

5 Deployment Scope and Readiness

The Wyoming CV Pilot team is ready to begin Phase 2 and 3. The team will rely heavily on the Phase 1 planning documents and has the capability and the capacity to ensure a successful Wyoming Pilot. Phase 2 will complete system design, develop systems and software applications, and test system operation and data collection to support performance measurement (first winter 2017-2018). Phase 3 will demonstrate the operational system, conduct the performance measurement activities (second winter 2018-2019), and document the results.

The Wyoming CV Pilot system is described in Section 1, including geographic boundaries, number of vehicles, devices and roadside equipment. Additionally, Section 1 describes how various vehicles and fleets will be instrumented to demonstrate different types of deployments. This Section focuses on the Wyoming team's level of readiness to "hit the ground running" upon receipt of Phase 2 funding. Readiness highlights include:

WYDOT-led management structure is in place – Strong internal support from the highest levels of WYDOT management exists. Funding is secured. Scopes of work for all contractors have been completed and contracts are in place.

New capabilities added to the team – Vital Assurance will provide new connected vehicle system engineering capability. New software development personnel from WYDOT staff and TriHydro employees have been added to the team. Additional ICF staff have been added to support outreach tasks.

Begun work on formalizing partnerships – specifically with freight and fleet companies.

Strong project management capabilities in place – a detailed Work Breakdown Structure (WBS) and project schedule has been prepared and will be used to guide Phase 2 and 3 tasks.

Dedicated human use lead identified for maintaining IRB compliance – University of Wyoming will perform this function and by the IRB of record.

Truck fleets currently available for deployment and testing – including WYDOT snowplows and highway patrol fleets, and TriHydro truck fleets.

5.1 Wyoming Scope Tasks and Readiness

During Phase 1, the Wyoming CV Pilot team prepared important planning documents that will guide our phase 2 system design and development efforts. But more than that, the team focused on readiness activities to ensure success through building a strong stakeholder group, engaging commercial trucking fleet partners and obtaining several commitments to participate, establishing an integrated system architecture and detailed system requirements, developing data collection and sharing procedures in support of performance measurement.

Table 5-1 identifies each task and the readiness activities that have been conducted in preparation to initiate and successfully accomplish that task.

Table 5-1. Wyoming CV Pilot Task Readiness Description.

Deployment Task	Readiness Preparations
2A – Program Management	• New WYDOT led management structure in place, • Phase 2 PMP initiated in Task 12 & 13. • Detailed WBS schedule being prepared • Continuation of project management lead from Phase 1 • Establishing procedures for invoicing and progress reporting to meet U.S DOT requirements with WYDOT grant administration staff • Began early discussion with WYDOT procurement staff to ensure that CV equipment procurement is in line with WYDOT and U.S DOT regulations • Draft Memorandum of Understanding (MoUs) starting to be prepared with for fleet partners
2B – System Architecture and Design	• Core Phase 1 deliverables lay the groundwork for system architecture refinement and system designs. • Additional systems engineering staff added to the team with experience in documenting CV-related architectures (Dr. Denny Stephens, Rachel Klein, Polly Okuneiff) • System Architecture Development will follow the guidelines laid out in Standard IEEE 42010-2011 • System Design Development will follow the guidelines laid out in IEEE 1016-2009 recommended practice • Updating all Phase I deliverables in this task to create a consistent set of documents to guide architecture and design
2C – Data Management Planning	• Identified initial list of data elements to be shared, prepared privacy and human use plans, initial data sharing framework. • Dedicated human use lead who will facilitate the coordination of IRB amendments and maintain IRB approval for the study • Team is preparing for baseline data collection as early as winter of 2016 • WYDOT is looking at state-level requirements for privacy • WYDOT and partners are signing agreements with University of Wyoming IRB
2D – Acquisition and Installation Planning	• Initial Phase 1 planning and Phase 2 & 3 application development will help begin this task. • Phase 1 activities included early engagement with potential vendors for demonstrations, system requirement discussion, standards, software, customization and certification needs • Available WYDOT ITS specifications for installation planning of RSUs (site analysis, electrical, communications, structures) • WYDOT has started to define specification package, evaluation criteria and procurement timeline
2E – Application Development	• Phase 1 Application Deployment Plan will guide this task, which details the level of effort and process schedule for development. • As part of the NOFA response, the team developed a critical path analysis of applications with a goal of working software early in the deployment process for testing • Support from Technical Writer to help document all of the applications that are being developed or updated by the pilot
2F – Participation and Staff Training	• Phase 1 Participant Training and Education Plan identified stakeholders the necessary training materials. • No additional readiness activities initiated as this time.
2G – Operational Readiness Test and Demonstration Planning	• Include new staff with experience in operational testing for CVs and trucks who will lead our testing and demonstration planning in Phase 2.

2H – Installation and Operational Readiness Testing	• See above
2I – Maintenance and Operations Planning	• WYDOT is looking to add service level agreements for RSU maintenance • No other readiness activities at this stage
2J – Stakeholder Outreach	• Phase 1 Outreach Plan will guide this effort. • Additional staff and resources included as part of our NOFA submittal and the team is ready to begin the outreach process with the onset of Phase 2. • No readiness activities at this stage
2K – Performance Measurement and Independent Evaluation Support	• Prepared PMES Plan and preliminary schedule, established 22 separate performance measures, identified baseline data elements and collection/sharing procedures. • Baseline data collection activities will begin winter of 2016. Our Performance Management leads are working closely with WYDOT to start gathering important safety data this year.
2L – Participation in Standards Development	• Identified relevant standards, plan to participate in working groups to share our experience and knowledge. Our systems lead is actively engaged with the other pilot sites and SAE standards development activities. • No other readiness activities at this stage.
3A – Program Management	• Phase 2 experience will guide this task and inform updated documents.
3B – System Operations and Maintenance	• Testing in Phase 2 would allow for a good transition to Phase 3 in 2018 • Phase 2 experience will guide this task and inform updated documents.
3C – Stakeholder Outreach	• Phase 2 experience will guide this task and inform updated documents.
3D – Performance Measurement and Independent Evaluation Support	• Phase 2 updated PMES Plan, revised PMES schedule, refined DMP and data sharing framework/details.
3E – Post-Pilot Deployment Transition Planning	• Plans to increase number of fleet partners and use of third-party interfaces to deepen and expand partnerships.
3F – Participation in Standards Development	• Phase 2 experience will guide future participation and sharing of knowledge.

6 Risk Assessment

This section describes key technical and key institutional risks associated with Phases 2 and 3. An assessment of risks is not provided in the section. The Phase 2 Program Management Plan will develop the risk management plan and risk register for the project. The risk management plan will document the policies and procedures that will be used to manage conditions and changes (known and unknown) that could have a positive or negative effect on the project objectives if they occur. The risk management plan includes the approach, the roles and responsibilities, process for identifying and analyzing risk, development of a risk register, response planning and control.

6.1 Technical Risks

To date, the following technical risks are identified:

- **Equipment risks**:
  - Procurement delays for vendor equipment
    - CV vendors unable to timely integrate equipment with current standards
    - CV vendors are not able to adequately build applications to documented system requirements
  - Installation procedures for OBUs still unknown
    - Bluetooth range and reliably for environmental sensors is untested in WYDOT's snow plows
    - Wireless or Bluetooth reliability is untested for HMIs
    - Wiring plans and power management is still to be determined for various vehicle platforms
  - Ideal RSU Locations require significant structural elements exceeding our planned cost of installation for field equipment
  - Team runs into DSRC licensing problems with FCC
- **Application development/deployment risks:**
  - External dependencies of pilot are not ready (SCMS/ODE/SDW)
  - Still evolving vehicle mix (makes, model years) complicate integration with CAN data
  - V2I standards are still in development stages as are the certification approaches for the equipment—making procuring these systems a challenge
  - Application development takes longer than expected
- **Verification, Testing, Demonstration Risks**
  - USDOT walkthroughs/documentation requirements take more time and iterations than planned
  - Applications do not work as planned in an operational setting (e.g., incorrect alerts or no alerts when expected)
    - Distress Notification development process takes longer or has hidden complexities
  - Our messages are not inter-operable with other CV Pilot sites

- **Operation risks:**
  - Performance of procured and developed applications in a real-world setting
  - Integration of CV Pilot elements into existing TMC software is more difficult than anticipated
  - More than anticipated number of on-board equipment failures
  - Drivers find warnings a distraction or do not understand them properly
  - Penetration rate of vehicles is too low for significant V2V interactions
  - Failure of external systems cause degradation in CV Pilot performance
  - Cyber Attack of the TMC, RSU or OBU
  - Wyoming extreme weather, along with its drastic changes, could affect the operation and lifecycle of DSRC equipment.
- **Partnership Engagement.**
  - Inability to sign MoUs with a diverse group of fleet partners
  - Freight partners could pull out of the project. Users of the system may also lose trust if too many incorrect weather alerts are shared with the public—one failure could discredit the system.
  - The Pilot might not be enough to get driver buy-in, limiting the expansion (and even retention) of the system, and as such, failing to meet expectations.
- **Evaluation and Performance Measurement**
  - DSRC bandwidth overload for V2I (Event Logs/Probe Data/Software Updates) leading to inability to collect data
  - Although all alerts will be designed and composed in a manner to avoid, to the extent possible, any safety risk, driver behavior following an in-vehicle alert is untested.
  - Conflicts in alerts between CV Pilot and other sources can cause confusion for end users and aggravation from the other sources (e.g., television weather anchor says roads are fine and CV Pilot system has slick road alerts).

6.2 Key Institutional Risks

From an institutional perspective, the following risks were identified:

- **Change in State Budget** could lead to a funding shortfall, which could lead to downsized operations and burdensome maintenance efforts.
- **New Governor in 2018** could bring potential change in priorities.
- **Federal priorities and regulatory environment** could also change, limiting the expansion of the system.
- **Internal Conflict.** Internal WYDOT perception that other tasks/corridors are not being given appropriate priority with CV Pilot taking up significant resources
- **Staffing turnover.** Departure of key management leads and contract leads can cause delays and technical challenges to the pilot deployment
- **Winter operations taking priority –** WYDOT staff are focused on the primary mission of safety and their availability for CV pilot project may be compromised by their daily job functions especially during winter months.

7 Lessons Learned

This section shares the Wyoming CV Pilot team's key lessons that were learned during Phase 1 planning activities. These are shared with USDOT and other agencies that may be endeavoring to initiate a connected vehicle related project. The lessons learned described below combine both technical and institutional elements that challenged the team the most in their efforts to plan for and develop a CV Pilot deployment.

Be Prepared for Concept Evolution – Must Meet Actual Needs! Identifying project needs early from discussions with stakeholders and partners form the basis of a project concept. Developing the concept into an implementable project takes time and several iterations with the team. The final concept needs to balance several elements: meet defined project goals, technically feasible and consistent with national standards, be implementable, integrate with legacy systems, fit within operational constraints, identify adjustments to processes/procedures, clearly define how outputs will be received and used by stakeholders, capable to providing needed data for performance measurement.

Leverage local stakeholders and champions. Engage leadership early. The Wyoming CV Pilot team learned a lot from engaging the local project stakeholders early in Phase 1 that directly guided the development of the concept of operations and system architecture development. Additionally, the input helped the team to understand the operational constraints and concerns of the potential system users that we needed to consider to ensure the concept reflected reality. Also, the local knowledge gained from the stakeholders helped to understand the potential project benefits which led to initial performance measures identification.

Performance Measurement Development Takes Time and Thought. Identifying performance measures should begin by understanding the project benefits to your various stakeholders and knowing how inputs and outputs will be generated and used. The measures themselves need to be straightforward, explainable, attempt to quantify the project benefits, and be achievable given data availability. They should be prepared with your project team, not in a vacuum, and affirmed by the project technical staff to ensure data collection is planned and feasible. Along with the measures, thought should be focused on how the measures will be evaluated and specific evaluation designs established with data needs.

Development of Verifiable System Requirements is challenging. The process of developing verifiable System Requirements with evolving standards has been a learning experience. The critical part of this process has been to have a solid set of User Needs and well-formed Concept of Operations. Developing a good understanding of what is available from the SCMS and vendors for RSU/OBU device capabilities and software integration has been important to develop a system of systems that is possible to build and develop verifiable tests. As the ODE and SET-IT tools continue to evolve into production tools this process will become better defined. Additionally, the publishing of the SAE standards for J2735 and J2945/1 have been instrumental to this pilot. Future standards that update V2I integration will be critical for use as J3067 has become outdated.

Develop an approach to integrate CV pilot with existing transportation systems management and operations. Integration with existing legacy systems at the TMC enables the CV environment to become part of the overall management framework for WYDOT. By developing the interfaces to the TMC systems, the CV pilot elements exchange information with the traditional ITS systems reducing operator burdens to monitor another silo-ed technology element as part of their regular job function.

Address commercial operator's priorities and concerns (privacy, liability, flexibility). As part of Phase I, the project development team carefully considered the commercial vehicle operator priorities and factored them early into our security and privacy concept and ultimately our system requirements. Flexibility to address the diversity of fleet operations and trucking companies is critical. By providing flexibility with the on-board equipment, WYDOT and the team were able to allow the fleet operators several options for them to be engaged in the pilot.

Plan with post-pilot operation in mind. WYDOT fully expects the CV Pilot to result in an operational system that will continue to be used beyond Phase 3. As part of Phase 1 ConOps and system planning, WYDOT has carefully considered the financial and partnership requirements beyond the pilot demonstration. Throughout the transition period, WYDOT will work in close collaboration with the Freight Advisory Council (FAC) to analyze all aspects of the project in order to ensure continuous operation and potential growth of the CV network. The following elements are critical to WYDOT's transition concept:

- A significant population of WYDOT-owned fleets are part of the CV-Pilot
- The CV-Pilot system is conceived to be fully integrated with WYDOT TMC operations
- A reliance on standards and protocols to ensure that applications are broadly available to a diversity of on-board unit**s**

Formalized agreements with private partners take time. Start with initial letters of support. With commercial partners, the level of detail required for a memorandum of understanding may not be ready in the early planning stages. Early engagement and obtaining a letter of support allowed the project team to collaboratively identify the areas of concern and work towards a MoU that will be mutually agreeable in Phase 2.

Engage procurement and contracting personnel early. With the amount of procurement necessary, WYDOT engaged their procurement and contracting personnel early in Phase I. For procurement, questions like management of inventory for on-board equipment need to be resolved early, especially when non-agency fleets are involved.

Research vs. Real-Life Deployment Requires Different Approaches. Early connected vehicle research projects provided invaluable information about what was possible in the real-life deployments. Those early activities have supported the development of and enabled the Pilot Deployment projects. The owners of those research projects had the benefit of absolute control over the participants, vehicles and data which allowed for analysis to be conducted and yielded important results. The Wyoming CV Pilot team came to understand the challenges associated with a different landscape – one that involved private companies that may or may not be willing to share all their data. Our concept had to adapt to this reality – after all our mission is to demonstrate a CV Pilot in real-life conditions. Our concept includes various trucking types (DOT fleets, partner fleets, and commercial truck fleet operators) with different levels of instrumentation as a means of balancing real-life conditions with the need for performance measurement data collection.

Balancing Data Needs is Important. The Wyoming CV Pilot must ensure the security and privacy of the participants, including personally identifiable information (PII). There was no flexibility in meeting

this important premise and requirement. The Pilot also has a need for data to support performance measurement. Sometimes these two important project success factors came into conflict when planning how we could obtain vehicle information and driver behavior to fully evaluate the success of the Pilot. The team carefully assessed what data was available and how to obtain needed data to support the performance measurement activities, all the time ensuring privacy and security of the participants. The balancing sometimes resulted in limited data collection to support evaluation.

8 References

The following is a lists the references used in this document.

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