Connected Vehicle Pilot Deployment Program Phase 4

Comprehensive Acquisition Plan – Wyoming CV Pilot

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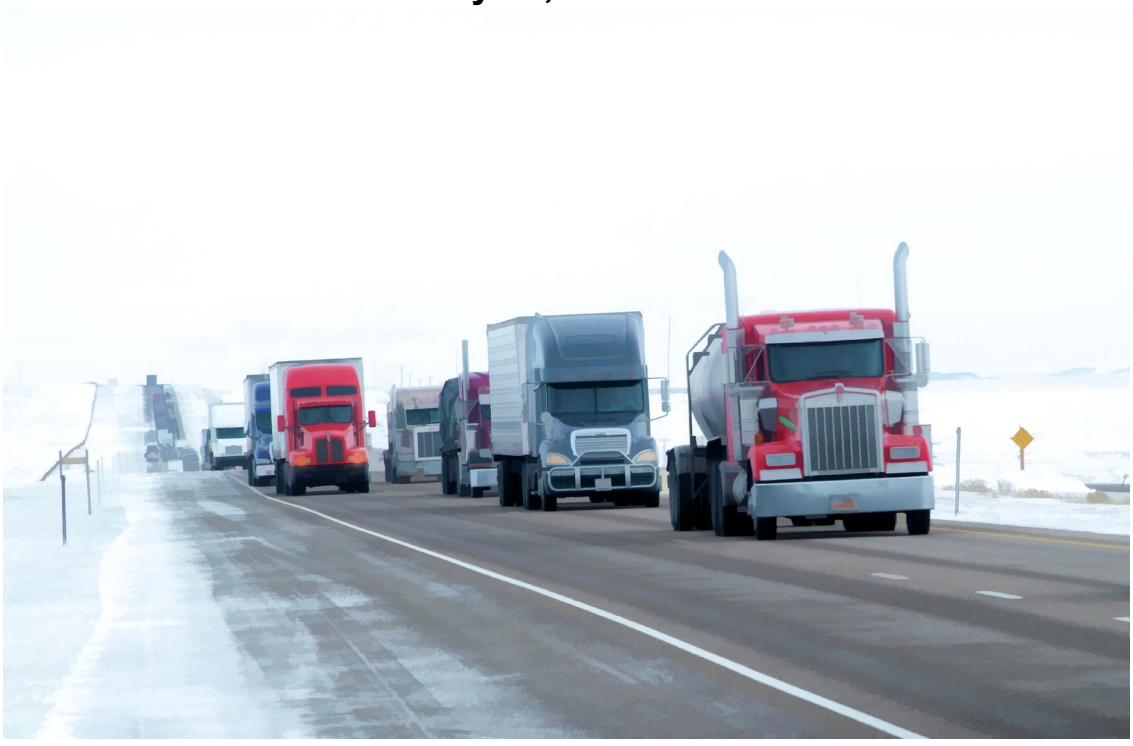
LTE-C2X Phase 4 – January 29, 2024



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Notice

Version History

#	Date	Author	Comment
1	3/10/2017	WYDOT	First draft of the Comprehensive Acquisition Plan
1.1	4/7/2017	WYDOT	Updates based on USDOT/Noblis comments
2	4/30/2017	WYDOT	Updated based on USDOT/Noblis comments
3	6/22/2017	WYDOT	Updated based on USDOT/Noblis comments
4	9/4/2017	WYDOT	Remove Basic Vehicle type and increase qty. of Maint. Vehicles & Integrated Vehicles.
5	10/31/2017	WYDOT	Made requirements in Appendix well-formed. Added details on USDOT approved certification and testing.
6	12/21/2017	WYDOT	Added details on test software for RSU installation kits.
7	1/29/2018	WYDOT	Replace HWP Sharkfin with Lear OBU
8	07/27/2020	WYDOT	As built version of the document.
9	01/2/2024	WYDOT	Updated to support conversion from DSRC to LTE-C2X Phase 4

Technical Report Documentation Page

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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 Phase II document presents the Comprehensive Acquisition Plan for the software, hardware and maintenance for purchases in support of the Concept of Operations document. This version of the document presents the information associated with the as built system.

The January 2024 revised version reflects updating the system from DSRC to LTE-V2X for Phase 4.

17. Key Words Connected Vehicle Technology, I-80 Corridor, Road Weather, Truck Safety, System Architecture, LTE-C2X	**18. Distribution Statement** This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161		
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1 Introduction

The WYDOT Comprehensive Acquisition Plan (CAP) provides an overview of the proposed acquisition approach that includes an assessment of time-to-procure relative to the overall deployment schedule.

The CAP is being updated in January 2024 to reflect converting the existing Wyoming Connected Vehicle project from DSRC to LTE-V2X technology.

The conversion impacts requirements for the Wyoming CV system and its subsystems, namely the roadside units (RSUs), onboard units (OBUs), external interfaces, performance; and requirements traceability. **This CAP aligns with "Connected Vehicle Pilot Deployment Program Phase 4 – System Requirements Specification (SyRS) – WYDOT for LTE-C2X Conversion" (see Table 9-1. References.). Information reflecting as built changes that are no longer applicable will be marked with a "strikethrough" in Phase 3, those requirements and features that will not be part of this Phase 4 effort will be marked with bolded text indicating that they are not part of Phase 4.**

Note to reader: For Phases 2 and 3, WYDOT used a sole source procurement method due to the fact the WYDOT CV Pilot was specifically looking for a vendor that offered satellite radio capability. For Phase 4, WYDOT was no longer seeking an RSU vendor with satellite radio capability; however, WYDOT was seeking an OBU vendor with such capability. Therefore, WYDOT used an open request for proposal (RFP) process to procure and acquire equipment for Phase 4.

1.1 Purpose of the Plan

The purpose of this plan is to document the WYDOT CV Pilot's acquisition plan. This will be useful to demonstrate compliance with both the policies for the State of Wyoming and the Notice of Funding Opportunities (NOFO).

1.2 Organization of the Plan

This section provides a description of how the sections are structured.

- Chapter 2 provides an overview of the WYDOT acquisition approach, schedule, and vendor selection.
- Chapter 3 details the acquisition of vehicle/in-vehicle equipment.
- Chapter 4 details the acquisition of roadside equipment.

- Chapter 5 details the acquisition of mobile devices.
- Chapter 6 details the acquisition of equipment for the data center.
- Chapter 7 details the acquisition of other equipment necessary for the Pilot.
- Chapter 8 describes the terms and acronyms used in this document.
- Chapter 9 lists the references cited in this document.
- Appendix A details the vendor-specific acquisition requirements.

1.3 Wyoming System Overview

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. **With Phase 4 the system is being updated to replace all the DSRC RSUs with LTE-V2X units. Approximately ten LTE-V2X OBUs are being added for testing.**

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 has worked in a planning phase through September 2016. The deployment process happening in the second phase (ending in August 2020), this was followed by a 12-month demonstration period in the third phase. **Phase 4 is a modification in cooperative agreement for 24-months (9/30/2022 through 9/30/2024) in support of replacing the DSRC RSUs with LTE-C2X and incorporating approximately ten LTE-C2X OBUs for testing.** 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. **With Phase 4 these all DSRC RSUs will be removed and replaced with LTE-C2X RSUs.**
- **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) Parts I & II and will include a human-machine interface (HMI) to share alerts and advisories to drivers of these vehicles. **With Phase 4 approximately ten LTE-C2X OBUs will be used in test vehicles. These OBUs will broadcast BSMs, enroll in the SCMS, include an HMI for driver alerts and advisories, and support logging of driver alerts. OBU support for Wi-Fi networking and satellite Traveler Information Message reception will be tested.**

- **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 improvements include better activation of variable speed limits (VSL) and improved road condition dissemination via 511, Dynamic Message Sings (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*. The *Vehicle System* includes five 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 System*s support a variety of V2V and V2I applications. Both systems interface with external systems, including WYDOT, USDOT and the National Weather Service (NWS). **Phase 4 will drop support for the USDOT Research Data Exchange, the USDOT Secure Data Commons, and NWS, to include Pikalert connections.**

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. **Phase 4 will drop support for Distress Notification and Spot Weather Impact Warning.**

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.

Details of the Wyoming CV pilot system are available in the Comprehensive Pilot Deployment Plan (FHWA-JPO-16-297), see Gopalakrishna et al. (2016).

2 Acquisition Overview

The WYDOT CV Pilot acquisition program is in compliance with the NOFO and the State of Wyoming acquisition policies. To ensure full compliance with policies and laws for the State of Wyoming, all purchasing is being done directly through the state's purchasing system. WYDOT has a procurement process that allows the acquisition and tracking of equipment and software for client contracts. The procurement and accounting processes include the following staffing resources: legal/contracts, accounts receivable, accounts payable, inventory tracking, and reporting, and the process involves a subject matter expert to provide the product specifications. WYDOT is using a procurement team that includes WYDOT staff and Neaera. The procurement team will manage the connected vehicle equipment and software acquisitions. The Neaera team will assist WYDOT with equipment and software acquisition. WYDOT will make the acquisitions and Neaera will write the specifications for software and hardware. The Neaera team has former experience with scoping out the specifications, configuring equipment and then installing the equipment on behalf of WYDOT. Vendor specific additional language is included in Appendix A for Lear, SiriusXM and WeatherCloud to cover the CV specific hardware and software needed for this project. **Phase 4 removes Lear, SiriusXM and WeatherCloud Vendor Requirements, and adds Commsignia requirements.**

A detailed description of each of the components is provided in the SDD.

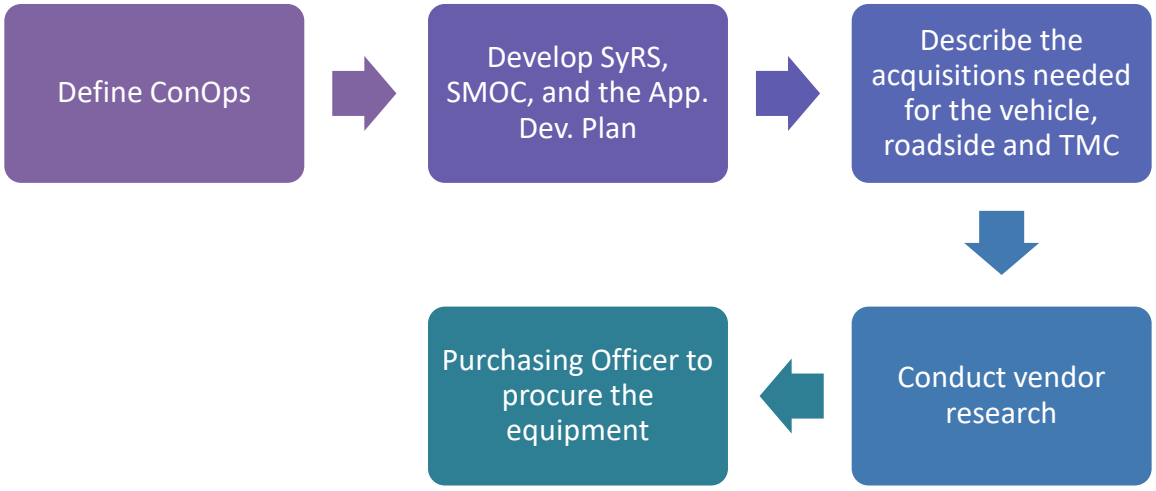
2.1 Acquisition Approach

The approach for acquiring equipment and services is illustrated in Figure 2-1. In summary, the first step is to define the concept of operations (ConOps) based on the identified user needs. This process leads to the system requirements (SyRS), security management operating concept (SMOC), and application development (App. Dev.) plan, all completed in Phase 1. These documents provide enough information to describe the acquisitions needed for the vehicle, roadside and the WYDOT Traffic Management Center (TMC). Based on this, vendor research will be conducted to find vendors knowledgeable in each area that equipment or services are required. The heavy seasonal winter workload of the WYDOT fleet will drive early procurement of some equipment. In some cases, the fleet vehicles and personnel which will install and utilize the equipment are only available for installation and testing during the summer months. Consequently, vendor selection criteria will consider vendor responsiveness for all areas including: software, hardware, support and their ability to deliver on time. Procurement of the equipment will be handled by a purchasing officer within the WYDOT acquisition team. The procurement process will follow these steps:

1. Evaluation of the purchase request by the team including any sole source justifications if necessary.
2. Submittal of a purchase order to the vendor based on the agreed-upon purchase price of the equipment and quantities required.
3. Tracking of the order confirmation and delivery schedule provided by the vendor.

4. Receipt and inventory of the delivery to compare the purchase order and equipment received.

The WYDOT purchasing office will be responsible for tracking and reporting on the equipment budget to the management team.



Source: WYDOT

Figure 2-1. Approach for acquiring equipment and services.

2.2 Acquisition Schedule

The Wyoming Pilot will acquire one type of infrastructure RSU, three mobile types of OBUs, and one type of mobile weather sensor. **In Phase 4 one OBU type will be used and no mobile weather sensors will be used.** This section describes the status of the type of element development, production, and schedule. A summary table of planned equipment purchases is provided in **Table 2-1**.

Table 2-1. Wyoming CV Pilot's Planned Equipment Purchases.

Item	Quantity	Schedule
RSUs	78	Initial set of 10 devices: December 2016. Fulfillment of devices (75 total devices): July 2017
OBU devices capable of bidirectional DSRC communications and receiving Traveler Information Messages (TIM) via satellite – no CAN Bus or environmental sensor support	290	Initial ten devices: June 2017. Remaining devices: Summer/Fall 2020.
OBU devices capable of bidirectional DSRC communications and receiving TIMs via satellite – CAN Bus or environmental sensor would be supported	110	Set of devices will be purchased between December 2016 and April 2018.

Item	Quantity	Schedule
Mobile weather sensors	53	Initial 10 devices: January 2017. Remaining devices: Sept 2017.
Phase 4: LTE-C2X RSUs	**80**	**February, 2023**
Phase 4: LTE-C2X OBUs	**10**	**February, 2023**

2.2.1 Roadside Units

The Wyoming Pilot plans to install 75 RSUs on I-80 and in WYDOT fleet maintenance areas. Additionally, a few will be installed in areas for testing. The goal is to identify successful vendors in November 2016 and purchase an initial set of 10 devices for testing and installation documentation in December 2016, with the fulfillment of devices (78 devices) in July 2017 for the I-80 corridor. The plan is to have all devices installed and tested with initial applications by November 2017 and final, production-tested applications by May 2018.

Phase 4 will migrate all deployed DSRC RSUs to LTE-C2X RSUs. The State of Wyoming issued an RFP for vendor response in December 2022, and final vendor selection was made in January 2023. The initial purchase of 80 LTE-C2X RSU's for testing was made in February 2023.

2.2.2 On-Board Units

The Wyoming Pilot plans to acquire full-featured OBU devices (capable of DSRC bidirectional communications and receiving TIMs via satellite) for the WYDOT maintenance vehicles. Only OBUs that have passed USDOT-approved certification[1] will be considered for acquisition. Currently the pilot has requested proposals from different vendors for these devices. This request includes hardware, software, and installation support for the duration of the pilot, and custom software development is required. This device would be used for the V2V and V2I applications for the pilot and would support CAN Bus and environmental sensors.

The Wyoming Pilot plans to acquire commercial off-the-shelf OBU devices for retrofit commercial vehicles, integrated truck fleet, and the Wyoming Highway Patrol capable of DSRC bidirectional communication and receiving TIMs via satellite. Currently, the pilot is requesting proposals for a complete commercial-off-the-shelf system with an HMI, antennas, and cabling. This request includes hardware, software, and installation support for the duration of the pilot, and a limited amount of custom software development is required. The device would be used for the basic V2V and V2I applications for the pilot but would not support CAN Bus integration or environmental sensors.

[1] USDOT approved certification is not yet available but vendors such as OmniAir are beginning to roll out certification options in Fall of 2017. All of WYDOT's OBU and RSU vendors have communicated their intention to obtain certification when it becomes available and WYDOT is working closely with vendors to drive the schedule to obtain the required certification.

The Wyoming Pilot plans to acquire mobile weather sensors. Currently, the pilot has requested a proposal from vendors for these devices. This request includes hardware, software, and installation support for the duration of the pilot, and custom software development is required.

Phase 4 will acquire 10 LTE-C2X OBUs to validate compatibility and test the functionality and features of the system. The State of Wyoming issued an RFP for vendor response in December 2022, and final vendor selection was made in January 2023. The purchase of 10 LTE-C2X OBU's was completed in February 2023.

2.2.3 Test Gear

In addition to vehicle and roadside equipment, the WYDOT team will purchase test gear for each concurrent deployment of vehicle installation (the team expects 4 sets to include laptop, OBU, wire, tools, and software to be required). One detailed DSRC sniffer will be purchased for detail debugging RF signal and messages.

The TMC will also need hardware for two servers, one storage array, and a switch. This equipment will be used for the operational data environment (ODE), Pikalert, Traffic Management Data Dictionary (TMDD) third party interface, and management software for the RSU's. The data warehouse is in place but will need disk space upgrade as well as security software addition to encrypt and store personally identifiable information (PII).

2.3 Vendor Outreach Plan

During Phase 1 the WYDOT team researched vendors of connected vehicle equipment, discussed with these vendors the pilot's requirements for software, hardware, and services. After discussing with these vendors, the requirements and providing them the ConOps, SMOC, Application Development Plan and SyRS a proposal was requested from qualified vendors. Vendors were invited onsite for a meeting with the WYDOT CV Pilot leadership to discuss and demo equipment. Only RSU/OBUs that have passed USDOT-approved certification will be considered for acquisition. Currently, the pilot is obtaining proposals from vendors to provide turnkey solutions for certified hardware, software, installation support, and warranty support coverage for the roadside and on-board hardware and software for the pilot's duration.

For Phase 4 (migration from DSRC to LTE-C2X) the State of Wyoming issued an RFP for vendor response in December 2022. Four (4) vendors responded to the RFP with bids, one additional vendor provided a no-bid response.

3 Vehicle/In-Vehicle Equipment

The WYDOT CV Pilot has selected five types of connected vehicles that provide different capabilities for the pilot. Each OBU package has its' own subsection below.

Phase 4 (migration from DSRC to LTE-C2X) only supports one type of connected vehicle (Phase 4 Test Vehicle) – all other vehicle types are not included in Phase 4.

3.1 WYDOT Maintenance Vehicles

WYDOT maintenance vehicles will not be included in Phase 4 of the project.

3.1.1 Technical Description/Specification

This Sub-System represents the maintenance fleets operated by WYDOT. These include snowplow 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, the vehicles will be equipped with the full package of sensors and equipment necessary for the CV Pilot. Around 60 maintenance vehicles (snowplows) are expected to be part of this subsystem, which will have the ability to:

- Receive BSM Parts I and II over DSRC
- Broadcast BSM Parts I and II over DSRC
- Receive TIMs via DSRC and Satellite
- Collect weather sensor data. 50 of the snowplows will be outfitted with weather sensors.

3.1.2 Ancillary Equipment

This vehicle category will have the following equipment ordered with the OBU as a single kit.

- Dual DSRC radios
- Global Positioning Systems (GPS)
- Bluetooth
- CPU
- IP Services (over DSRC)
- Wi-Fi
- Sirius XM
- Power Adapter

- Integrated Antenna (GPS and DSRC)
- Sirius XM Antenna
- Three years' hardware and software support

These vehicles will use an Android tablet for the Human Machine Interface (HMI). This device will have a mounting bracket, vehicle power adapter, and rugged case.

These vehicles will use two environmental sensors, one sky sensor and a road sensor with three years of support.

3.1.3 Potential Vendors

For the OBU we engaged with Cohda, Danlaw, eTrans, Lear, Savari, SiriusXM and Commsignia.

For the environmental sensors, we looked at Physical Optics and WeatherCloud.

WYDOT has been using the Samsung TabA for a subset of maintenance vehicles over the past two years to run the Road Condition Reporting application. The pilot will continue the use of these devices.

We used a systematic selection process, derived from the objectives and requirements for the WYDOT CV Pilot system.

3.1.4 Part Numbers and Quantities

Table 3-1 details the number of equipment to be acquired for the WYDOT Maintenance Vehicles.

Table 3-1. Equipment for the WYDOT Maintenance Vehicle

Description	Part Number or Name	Quantity
OBU kit	Lear Locomate Roadstar Premium	110
HMI kit	Samsung SM-T580 and mount	110
Sky Environmental Sensor	Weather Cloud Sky Sensor	53[2]
Road Environmental Sensor	Weather Cloud Road Sensor	53[3]

3.1.5 Associated Software

The WYDOT Maintenance Vehicle hardware will be complemented by the following software:

[2] Count includes 3 spare units for use in lab testing and as potential quick replacements for field units.
[3] Count includes 3 spare units for use in lab testing and as potential quick replacements for field units.

- Weather Cloud Ground Truth App.
- Weather Cloud non-recurring engineering to migrated and test Ground Truth app to Samsung.
- Lear OBU software (including all WYDOT OBU applications).
- Samsung Android 8 software.

3.1.6 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via a sole source purchase order. Vendor evaluations considered the technical maturity of the vendors' existing offerings, the vendors' willingness to update their software and hardware to the industry standards adopted by the Pilot. Our research and vendor interviews have led us to a single vendor for the OBU, HMI, and Environmental Sensor.

3.1.7 Acquisition Schedule

WYDOT Maintenance fleet equipment will be acquired following the dates in **Table 3-2**. The plan is to get a few OBU kits in for proof-of-concept testing with HMI tablets, then get a small proof of concept set of environmental sensors in for testing. Once these devices are validated, the team will purchase the remainder of the devices for the fleet.

Table 3-2. Acquisition schedule for WYDOT Maintenance Vehicle equipment.

Description	Date	Quantity
OBU and HMI PoC kits	December 2016	10
Environmental Sensors	January 2017	10
OBU and HMI kits	April 2018	100
Environmental Sensors	September 2017	43

3.2 WYDOT Highway Patrol Vehicles

WYDOT Highway Patrol vehicles will not be included in Phase 4 of the project.

3.2.1 Technical Description/Specification

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 subsystem, which will have the ability to:

- Receive BSM Parts I and II over DSRC
- Broadcast BSM Parts I and II over DSRC

- Receive TIMs via DSRC and Satellite

3.2.2 Ancillary Equipment

This vehicle category will have the following equipment ordered with the OBU as a single kit:

- Dual DSRC radios
- Global Positioning Systems (GPS)
- CPU
- IP Services (over DSRC)
- Wi-Fi
- Sirius XM
- Power Adapter
- Integrated Antenna (Sirius XM, GPS and DSRC)
- Three years' hardware and software support

These vehicles will use a touch screen or phone for the Human Machine Interface (HMI). This device will have a mounting bracket, vehicle power adapter, and rugged case.

3.2.3 Part Numbers and Quantities

Table 3-3 details the number of equipment to be acquired for the WYDOT Highway Patrol Vehicles.

Table 3-3. Equipment for the WYDOT Highway Patrol Vehicle.

Description	Part Number or Name	Quantity
OBU kit	Sirius XM OBU	50[4]
HMI kit	Touch Screen	50

3.2.4 Associated Software

The WYDOT Highway Patrol Vehicle hardware will be complemented by the following software:

- Sirius XM software.

[4] Count includes 2 spare units for use in lab testing and as potential quick replacements for field units.

3.2.5 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via a sole source purchase order. Vendor evaluations considered the technical maturity of the vendors' existing offerings, the vendors' willingness to update their software and hardware to the industry standards adopted by the Pilot. Our research and vendor interviews have led us to a single vendor for the OBU.

3.2.6 Potential Vendors

For the OBU we engaged with Cohda, Danlaw, eTrans, Lear, Savari, SiriusXM and Commsignia.

We used a systematic selection process, derived from the objectives and requirements for the WYDOT CV Pilot system.

3.2.7 Acquisition Schedule

WYDOT Highway Patrol fleet will be acquired following the schedules in **Table 3-4**.

Table 3-4. Acquisition schedule for WYDOT Highway Patrol Vehicle equipment.

Description	Date	Quantity
OBU kit	Summer/Fall 2020	50
HMI kit	Summer/Fall 2020	50

3.3 Integrated Commercial Vehicles

Integrated Commercial will not be included in Phase 4 of the project.

3.3.1 Technical Description/Specification

This connected trucks Sub-System represents a subset of commercial trucks owned and operated by fleet partners involved in the pilot that can be integrated with the vehicle network. In contrast to the WYDOT Maintenance Vehicles, no external weather sensor data will be collected from these systems (i.e., only data from the vehicle). To summarize, this Sub-System will include the abilities to:

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

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

3.3.2 Ancillary Equipment

This vehicle category will have the following equipment ordered with the OBU as a single kit.

- Dual DSRC radios
- Global Positioning Systems (GPS)
- CPU
- IP Services (over DSRC)
- Wi-Fi
- Sirius XM
- Power Adapter
- Integrated Antenna (Sirius XM Antenna, GPS and DSRC)
- Sirius XM Antenna
- Three years' hardware and software support

These vehicles will use a touch screen for the Human Machine Interface (HMI). This device will have a mounting bracket, vehicle power adapter, and rugged case. The WYDOT pilot team will work with the fleet teams to integrate with existing systems for the HMI.

3.3.3 Part Numbers and Quantities

Table 3-5 details the number of equipment to be acquired for the Integrated Commercial Vehicles.

Table 3-5. Equipment for the Integrated Commercial Vehicles.

Description	Part Number or Name	Quantity
OBU kit	Sirius XM OBU	200[5]
HMI kit	Touch Screen	200

3.3.4 Associated Software

The Integrated Commercial Vehicles hardware will be complemented by the following software:

- Sirius XM software

[5] Count includes 3 spare units for use in lab testing and as potential quick replacements for field units.

3.3.5 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via a sole source purchase order. Vendor evaluations considered the technical maturity of the vendors' existing offerings, the vendors' willingness to update their software and hardware to the industry standards adopted by the Pilot. Our research and vendor interviews have led us to a single vendor for the OBU.

3.3.6 Potential Vendors

For the OBU we engaged with Cohda, Danlaw, eTrans, Lear, Savari, SiriusXM and Commsignia.

We used a systematic selection process, derived from the objectives and requirements for the WYDOT CV Pilot system.

3.3.7 Acquisition Schedule

The plan is to get a few OBU kits in for proof-of-concept testing with HMI tablets. Once these devices are validated, the team will purchase the remainder of the devices for the Integrated Commercial Vehicles based on the schedule presented in **Table 3-6**.

Table 3-6. Acquisition schedule for Integrated Commercial Vehicles.

Description	Date	Quantity
OBU kit	Summer/Fall 2020	200
HMI kit	Summer/Fall 2020	200

3.4 Retrofit Commercial Vehicles

Retrofit Commercial vehicles will not be included in Phase 4 of the project.

3.4.1 Technical Description/Specification

This Sub-System is for trucks and other fleet vehicles that do not include integration with CAN bus data integration. This Sub-System intends to test the interaction between the systems within the WYDOT CV Pilot and external/commercial devices that are not developed as part of this pilot. In this manner, this Sub-System is intended to “simulate” a commercial-off-the-shelf (COTS) system that enables a vehicle to communicate data through DSRC to other connected devices and receive TIMs through DSRC and satellite. These devices will also receive BSM Parts I and II over DSRC. About 50 vehicles are expected in this category.

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

3.4.2 Ancillary Equipment

This vehicle category will have the following equipment ordered with the OBU as a single kit.

- Dual DSRC radios
- Global Positioning Systems (GPS)
- Bluetooth
- CPU
- IP Services (over DSRC)
- Wi-Fi
- Sirius XM
- Power Adapter
- Integrated Antenna (Sirius XM Antenna, GPS and DSRC)
- Sirius XM Antenna with three years' hardware and software support

These vehicles will use a tablet for the Human Machine Interface (HMI). This device will have a mounting bracket, vehicle power adapter, and rugged case.

3.4.3 Part Numbers and Quantities

Table 3-7 details the number of equipment to be acquired for the Retrofit Commercial Vehicles.

Table 3-7. Equipment for the Retrofit Commercial Vehicles

Description	Part Number or Name	Quantity
OBU kit	SiriusXM OBU	50[6]
HMI kit	Touch Screen	50

3.4.4 Associated Software

The Retrofit Commercial Vehicles hardware will be complemented by the following software:

- SiriusXM OBU software (does not include WYDOT custom applications)

[6] Count includes 3 spare units for use in lab testing and as potential quick replacements for field units.

3.4.5 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via a sole source purchase order. Vendor evaluations considered the technical maturity of the vendors' existing offerings, the vendors' willingness to update their software and hardware to the industry standards adopted by the Pilot. Our research and vendor interviews have led us to a single vendor for the OBU.

3.4.6 Potential Vendors

For the OBU we engaged with Cohda, Danlaw, eTrans, Lear, Savari, SiriusXM and Commsignia.

We used a systematic selection process, derived from the objectives and requirements for the WYDOT CV Pilot system.

3.4.7 Acquisition Schedule

The plan is to get a few OBU kits in for proof-of-concept testing with HMI tablets. Once these devices are validated, the team will purchase the remainder of the devices for the Retrofit Commercial Vehicles following the schedule in **Table 3-8**.

Table 3-8. Acquisition schedule for Retrofit Commercial Vehicles

Description	Date	Quantity
OBU kit	June 2017	10
OBU kit	Summer/Fall 2020	40
HMI kit	Summer/Fall 2020	50

3.5 Test Vehicles for Phase 4

3.5.1 Technical Description/Specification

This Sub-System represents the test vehicles to be used during Phase 4. Around 10 vehicles are expected in this subsystem and their abilities include:

- **Receive TIMs via LTE-C2X and test satellite.**
- **Broadcast BSM Parts I and II.**

3.5.2 Ancillary Equipment

This vehicle category will have the following equipment ordered with the OBU as a single kit.

- **Cellular Vehicle to Everything LTE-C2X communication**
- **Global Positioning Systems (GPS)**
- **CPU**

- **Wi-Fi**
- **Sirius XM via USB adapter**
- **Power Adapter**
- **Integrated Antenna (GPS and LTE-C2X)**
- **Sirius XM Antenna**
- **Three years' hardware and software support**

These vehicles will use an Android tablet for the Human Machine Interface (HMI).

3.5.3 Potential Vendors

For the OBU we engaged with Commsignia, Inc., Cohda Wireless America, LLC., Iteris, Inc., T-Mobile, and Yunex, LLC.

3.5.4 Part Numbers and Quantities

Table 3-1 details the number of equipment to be acquired for the Phase 4 Test Vehicles.

Table 3-9. Equipment for the Phase 4 Test Vehicle

Description	Part Number or Name	Quantity
OBU Kit	Commsignia	10

3.5.5 Associated Software

The Phase 4 Test Vehicle hardware will be complemented by the following software:

- **Commsignia OBU software**
- **Android software for HMI**

3.5.6 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via an RFP. Vendor evaluations considered the technical maturity of the vendors' existing offerings, the vendors' willingness to update their software and hardware to the industry standards adopted by the Pilot.

3.5.7 Acquisition Schedule

Phase 4 Test Vehicle equipment will be acquired following the dates in Table 3-2.

Table 3-10. Acquisition schedule for Phase 4 Test Vehicle equipment.

Description	Date	Quantity
OBU kits	February, 2023	10

4 Roadside Equipment

The WYDOT CV Pilot has selected one manufacture for RSUs in Phase 4. Many of the applications built for the OBUs will have an RSU component.

4.1 Roadside Equipment Unit

4.1.1 Technical Description/Specification

This Sub-System describes the physical units for deployment as part of the system along I-80. Roadside Units (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.

Phase 4 will migrate all deployed DSRC RSUs to LTE-C2X RSUs

4.1.2 Ancillary Equipment

The RSU will have the following equipment ordered as a single kit.

- Dual DSRC radios **(replaced with LTE-V2X for Phase 4)**
- GPS
- ~~Bluetooth~~
- CPU
- IP Services (over DSRC) **(replaced with Wi-Fi for Phase 4)**
- Wi-Fi
- Sirius XM
- Power Adapter
- GPS Antenna
- ~~Sirius XM Antenna~~
- Dual DSRC Antennas **(replaced with LTE-V2X for Phase 4)**
- Three years' hardware and software support

These devices will be installed along I-80 as well as rest stops and WYDOT fueling areas. Locations have been selected based on availability for power, high speed back haul, and a mount at 8 meters high. If an RSU is mounted higher than 8 meters, the EIRP must be adjusted to maintain compliance with FCC regulations.[7]

4.1.3 Part Numbers and Quantities

Table 4-1 details the number of equipment to be acquired for the RSU.

Table 4-1. Equipment for the RSU.

Description	Part Number or Name	Quantity
RSU kit	Locomate Roadstar Premium	78[8]
Phase 4: RSU kit	**Commsignia LTE-C2X**	**80**

4.1.4 Associated Software

Lear RSU software (including all WYDOT RSU applications).

Phase 4 removes support for Lear RSU software, and instead includes Commsignia RSU software.

4.1.5 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via an RFP.

4.1.6 Potential Vendors

For the RSU we engaged with Cohda, Lear, Savari, and Commsignia.

For the RSU in Phase 4 we engaged with Commsignia, Inc., Cohda Wireless America, LLC., Iteris, Inc., T-Mobile, and Yunex, LLC.

We used a systematic selection process, derived from the objectives and requirements for the WYDOT CV Pilot system.

[7] https://www.law.cornell.edu/cfr/text/47/90.377

[8] Count includes 3 spare units for use in lab testing and as potential quick replacements for field units.

4.1.7 Acquisition Schedule

The plan is to get a few RSU kits in for proof-of-concept testing of the interactions with other devices in the ecosystem (OBUs, satellite messages, probe data, SNMP, etc.). Once these devices are validated, the team will purchase the remainder of the devices for the pilot based on the schedule presented in **Table 4-2**.

Table 4-2. Acquisition schedule for RSU.

Description	Date	Quantity
RSU kit	December 2016	10
RSU kit	July 2017	68
Phase 4: RSU LTE-C2X kit	**February 2023**	**80**

5 Mobile Devices

The WYDOT CV Pilot will not be purchasing any Mobile Devices.

6 Management Center Equipment

Two servers, a storage array and 24-port 10GBase-T Ethernet switch have been purchased to support the CV Pilot. This infrastructure provides a fault-tolerant computing environment to host the TMDD third party interface, ODE, Pikalert weather simulation and prediction software as well as management software for the RSU's according to the system requirements. This new equipment is located at the WYDOT Transportation Management Center (TMC) data center in Cheyenne.

6.1 Servers

6.1.1 Technical Description/Specification

The TMC will procure two servers to host the TMDD third party interface, ODE, Pikalert weather simulation and prediction software as well as management software for the RSU's. The Third-Party Interface, which publishes TMDD data, the Operational Data Environment and the Pikalert weather software are integral components of the WYDOT Pilot.

Both servers have redundant (RAID-1) boot devices, multi-path IO connections (iSCSI over 10GBase-T) to the Storage Array, redundant Ethernet connections for management and redundant 10GBase-T primary data links to both the public internet and to the existing WYDOT intranet.

Both servers will run Microsoft's Hyper-V 2016 Server edition and applications running on the servers will be hosted in Virtual Machines. All storage for Virtual Machines will be located on the Storage Array. Microsoft Failover Cluster Manager and Microsoft Cluster Shared Volumes will be used to enable live Virtual Machine migration between the servers and together with a regular backup plan will insure quick recovery for either a failed server or virtual machine.

Each server contains two Intel Xeon, 18 Core CPUs and 256 GB of DDR3 memory. The CPUs were selected based on price/performance per core up to the level where incremental price/performance began to diminish. The CPU and memory configurations were selected to maximize performance for virtual machine environments.

6.1.2 Ancillary Equipment

Each server is configured with:

- (2) Intel Xeon CPUs
- 256 GB of DDR memory
- (2) 120 GB Solid State Boot Drives
- Integrated RAID Controller, 2GB Cache

- (2) Intel 10GBASE-T, dual port Ethernet Adapters
- Broadcom 1GB, quad port, Ethernet Card
- iDRAC8 Enterprise, integrated Dell Remote Access Controller
- Four years' hardware and software support

6.1.3 Part Numbers and Quantities

Table 6-1 details the number of equipment to be acquired for the servers.

Table 6-1. Equipment for the servers.

Description	Part Number or Name	Quantity
Dell PowerEdge R730 Server	210-ACXU	2
Intel Xeon 18 Core CPU	E5-2697 v4 2.3GHz	4
120 GB Solid State Drives, 6Gbps SATA	400-AEIB	4
32GB RDIMM, 2400MT/s, DDR	370-ACNS	16
PERC H730P Integrated RAID Controller	405-AAEH	2
Intel Ethernet X540 2-port Adapter	540-BBHZ	4
Broadcom 5720 4-port 1Gb Network	540-BBBW	2
iDRAC8 Enterprise Controller	385-BBHO	2

6.1.4 Associated Software

No additional software is purchased for these servers.

- The BIOS and firmware included with the servers is provided by Dell and covered under the product warranty.
- Both physical servers will run Microsoft Hyper-V Server 2016, which is a stand-alone product that contains only the Windows hypervisor, a Windows Server driver model, and virtualization components. This edition of Microsoft Server 2016 is available free of charge.
- Open-source Linux (Ubuntu & Debian) and existing licenses for Microsoft Windows Server will run on the virtual machines hosted by the servers.

6.1.5 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via a sole source purchase order. Our research and vendor interviews have led us to use a single vendor for the servers, storage and switch for the Management Center Equipment.

6.1.6 Potential Vendors

For the servers, we engaged Dell and Hewlett Packard (HP).

We used a systematic selection process, derived from the objectives and requirements for the WYDOT CV Pilot system.

6.1.7 Acquisition Schedule

The servers will be acquired based on the schedule presented in **Table 6-2**.

Table 6-2. Acquisition schedule for servers.

Description	Date	Quantity
Dell R730 server	12/2016	2

6.2 Storage Array

6.2.1 Technical Description/Specification

The storage array contains (24) 1.2TB SAS HDDs and has a formatted capacity of 19TB. The storage array uses RAID configuration, hot spare disks, and dual redundant controllers to ensure data integrity and fault tolerance. The storage array is connected to both servers using multi-path iSCSI over 10GB Ethernet.

The storage array will host Virtual Machine images for servers hosting the TMDD third party interface, ODE, Pikalert weather simulation and prediction software as well as management software for the RSU's according to the system requirements.

6.2.2 Ancillary Equipment

The storage array is configured with:

- (24) Dell 1.2TB, SAS 12Gb, 10K, 2.5", HDD
- Four years' hardware and software support

6.2.3 Part Numbers and Quantities

Table 6-3 details the number of equipment to be acquired for storage.

Table 6-3. Equipment for storage.

Description	Part Number or Name	Quantity
Dell SCv2020 ISCSI	210-ADRU	1
Dell 1.2TB, SAS 12Gb, 10K, 2.5", HDD	400-AHEB	36

6.2.4 Associated Software

No additional software is purchased for the storage array.

6.2.5 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via a sole source purchase order. Our research and vendor interviews have led us to use a single vendor for the servers, storage and switch for the Management Center Equipment.

6.2.6 Potential Vendors

For the storage array, we engaged with Dell and HP.

We used a systematic selection process, derived from the objectives and requirements for the WYDOT CV Pilot system.

6.2.7 Acquisition Schedule

The storage array will be acquired based on the schedule presented in **Table 6-4**.

Table 6-4. Acquisition schedule for servers.

Description	Date	Quantity
Dell SCv2020 storage array	12/2016	1

6.3 Switch

6.3.1 Technical Description/Specification

The switch has (24) 10GBase-T copper Ethernet ports, redundant power supplies and supports layer-2 and layer-3 capabilities.

The switch serves as the interconnect fabric for the servers and storage array. The switch also connects to the existing WYDOT intranet.

6.3.2 Ancillary Equipment

The following additional items were purchased for the switch:

- Cat6 Ethernet cables
- Four years' hardware and software support

6.3.3 Part Numbers and Quantities

Table 6-5 details the number of equipment to be acquired for the switch.

Table 6-5. Equipment for switch.

Description	Part Number or Name	Quantity
Dell Networking N4032, 24x 10GBaset-T switch	210-ABVS	1
C2G 2t Cat6 Unshielded Ethernet cables	A7523371	21

6.3.4 Associated Software

No additional software is purchased for the switch.

6.3.5 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via a sole source purchase order. Our research and vendor interviews have led us to use a single vendor for the servers, storage and switch for the Management Center Equipment.

6.3.6 Potential Vendors

For the switch, we engaged with Dell, Cisco, and HP.

We used a systematic selection process, derived from the objectives and requirements for the WYDOT CV Pilot system.

6.3.7 Acquisition Schedule

The switch will be acquired based on the schedule presented in **Table 6-6**.

Table 6-6. Acquisition schedule for servers.

Description	Date	Quantity
Dell Networking N4032, 24x 10GBase-T switch	12/2016	1

7 Other Equipment

The WYDOT CV Pilot will purchase installation kits and test gear for OBUs and RSUs. We expect to need four concurrent fleet installations and therefore need four kits. Additionally, we expect to need a DSRC sniffer, and a tool set for RSU maintenance.

Phase 4 (migration from DSRC to LTE-C2X) removes the need for a DSRC sniffer. No additional equipment is anticipated to support Phase 4.

7.1 OBU Installation Kit

7.1.1 Technical Description/Specification

This kit will be borrowed by fleet installers during the installation of OBU equipment. This kit will be better defined after we do the initial installations for Trihydro and WYDOT fleet vehicles.

7.1.2 Ancillary Equipment

Toolbox for storage and organization of cable tools and installation supplies.

7.1.3 Part Numbers and Quantities (all per tool kit)

Table 7-1 details the number of equipment to be acquired for the OBU Installation Kit.

Table 7-1. Equipment for OBU Installation Kit.

Description	Part Number or Name	Quantity
Cabling tools	Crimper, tester, box cable ends	1
Wire	Spool of antenna wire and power wire	1
Soldering equipment	Flux, solder, solder gun, heat gun	1
Tape/Sealant/Zip Ties/ Mounts/Shrink wrap	Automotive tape and sealant	1
Volt/Ohm meter		1
Automotive fuses	Assorted box	1
Laptop	Used to configure and test OBU with scripts	1

7.1.4 Associated Software

Trihydro will create scripts for testing DSRC, GPS, and each application for the OBU. Test scripts will be developed throughout 2020 and will be completed and verified by the end of 2020.
Phase 4 will validate and update existing test scripts to support LTE-C2X.

7.1.5 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via a sole source purchase order.

7.1.6 Potential Vendors

Standard online vendors (e.g., Amazon, Grainger, MSC Direct, Harbor Freight) were also considered.

We used a systematic selection process, derived from the objectives and requirements for the WYDOT CV Pilot system.

7.1.7 Acquisition Schedule

These kits will be acquired during the Spring/Summer of 2020.

7.2 RSU Installation Kit

7.2.1 Technical Description/Specification

This kit will be used by WYDOT to install RSUs and maintain a DSRC fleet with infrastructure. This kit will be better defined after we do the initial installations for the proof-of-concept RSUs.

Phase 4 (migration from DSRC to LTE-C2X) does not anticipate any additional RSU Installation equipment.

7.2.2 Ancillary Equipment

The team will acquire a toolbox for storage and organization of cable tools and installation supplies.

7.2.3 Part Numbers and Quantities (all per tool kit)

Table 7-2 details the number of equipment to be acquired for the RSU Installation Kit.

Table 7-2. Equipment for RSU Installation Kit.

Description	Part Number or Name	Quantity
Cabling tools	Crimper, tester, box cable ends	1
Wire	Spool of exterior grade Ethernet cable	1
Soldering equipment	Flux, solder, solder gun, heat gun	1
Tape/Sealant/Zip Ties/ Mounts/Shrink wrap	Automotive tape and sealant	1
Volt/Ohm meter		1
DSRC Sniffer	2016 standard capable	1
Laptop	Used to configure and test OBU and RSU with scripts	1

7.2.4 Associated Software

Trihydro will create scripts for testing DSRC, GPS, and each application for the OBU and RSU. Test scripts will be developed throughout 2020 and will be completed and verified by the end of 2020.

Phase 4 will validate and update existing test scripts to support LTE-C2X.

7.2.5 Acquisition Method

This equipment will be ordered by the Wyoming Acquisition team via a sole source purchase order.

7.2.6 Potential Vendors

Standard online vendors (Amazon, Grainger, 3M, MSC Direct, Harbor Freight)

7.2.7 Acquisition Schedule

These kits will be acquired during the Spring/Summer of 2020.

8 Glossary

This section provides a glossary of terms and acronyms used in this document.

Table 8-1. Glossary of Terms.

Term	Definition
Basic Safety Message	Connected V2V safety applications are built around the capability to transmit BSMs, following the Society of Automotive Engineers (SAE) J2735 standard. The BSM is transmitted over DSRC over a range of approximately 300 meters. In general, BSMs are broadcast frequently to provide connected vehicles with data content necessary for the different safety-oriented applications. The BSM is divided into two parts: • Part I, transmitted approximately 10 times per second, contains the core data elements: Message Count, Temporary ID, Time (through a Second Mark), Latitude, Longitude, Elevation, Positional Accuracy, Transmission State, Speed, Heading, Steering Wheel Angle, Acceleration, Brake System Status, and Vehicle Size. • Part II, transmitted less frequently, is added to Part I depending on events (e.g., Anti-lock Braking System (ABS) activated) and contains a variable set of data elements drawn from many optional data elements (availability by vehicle model varies)
Broadcast	Sharing data with no specific destination. All broadcast data is sent unencrypted but is signed with a certificate (based on the Institute of Electrical and Electronics Engineers (IEEE) standard 1609.2).
Data	Data is raw (unorganized and unprocessed) digital messages sent between components. From SAE J2735: Representations of static or dynamic entities in a formalized manner suitable for communication, interpretation, or processing by humans or by machines.
Information	Processed data that is organized, structured, or presented in a given context to make it useful
Message	A well-structured set of data elements and data frames that can be sent as a unit between devices to convey some semantic meaning in the context of the applications (adapted from SAE J2735).
On-Board Unit	This represents the package of DSRC radios, computing, sensors and HMI that will be installed on a vehicle. This is similar to the Retrofit Safety Device used in the Safety Pilot Program.
Requirements	Set of information necessary to accomplish one action.
Roadside Units	This represents the package of DSRC radios, computing, communications that will be installed on the roadside on I-80
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 SAE J2945/1.
Transportation Management Center	Center that collects information and informs the public about changing travel conditions.
WGS-84	Latest revision of the standard for use in cartography, geodesy, and navigation including by global positioning systems (GPS).

Table 8-2. Acronym List.

Acronym/ Abbreviation	Definition
ABS	Anti-lock Braking System
App. Dev.	Application Development
BSM	Basic Safety Message
CAN bus	Controller Area Network bus
CAP	Comprehensive Acquisition Plan
ConOps	Concept of Operations
LTE-C2X	Cellular V2X
CV	Connected Vehicle
DMS	Dynamic Message Signs
DN	Distress Notification
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
FCW	Forward Collision Warning
FHWA	Federal Highway Administration
GB	Giga byte
GPS	Global Positioning System
HMI	Human-Machine Interface
I2V	Infrastructure-to-vehicle
I-80	Interstate 80
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transportation System
NOFO	Notice of Funding Opportunities
NWS	National Weather Service
OBU	On-Board Unit
ODE	Operational Data Environment
RSU	Roadside Units
SAE	Society of Automotive Engineers
SDD	System Design Document
SMOC	Security Management Operating Concept
SCMS	Security Credential Management System
SWIW	Spot Weather Impact Warning
SyRS	System Requirements Specification
TBD	To be Determined
TIM	Traveler Information Message
TMC	Transportation Management Center
TMDD	Traffic Management Data Dictionary
V2I	Vehicle-to-infrastructure
V2V	Vehicle-to-vehicle
V2X	Vehicle-to-Everything
VSL	Variable Speed Limit
WYDOT	Wyoming Department of Transportation
WZW	Work Zone Warning

9 References

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

Table 9-1. References.

#	Documents, Sources Referenced
1.	Gopalakrishna, et al. (2023). *Connected Vehicle Pilot Deployment Program Phase 1, Concept of Operations (Phase 4), ICF/Wyoming (FHWA-JPO-23-112)*. U.S. Department of Transportation.
2.	Gopalakrishna, et al. (2023). *Connected Vehicle Pilot Deployment Program Phase 1, System Requirements Specification (Phase 4) – ICF/Wyoming (FHWA-JPO-23-113).* U.S. Department of Transportation.
3.	Gopalakrishna, et al. (2016). *Connected Vehicle Pilot Deployment Program Phase 1, Security Management Operating Concept (version 2), ICF/Wyoming (FHWA-JPO-16-288).* U.S. Department of Transportation.
4.	Gopalakrishna, et al. (2016). *Connected Vehicle Pilot Deployment Program Phase 1, Comprehensive Deployment Plan (version 2), ICF/Wyoming (FHWA-JPO-16-297).* U.S. Department of Transportation.
5.	*English, T., et al., (2023) Connected Vehicle Pilot Deployment Program Phase 2, System Architecture Document (SAD) – Wyoming CV Pilot, FHWA-JPO-23-114. U.S. Department of Transportation.*
6.	*English, T., et al., (2017) Connected Vehicle Pilot Deployment Program Phase 2, Interface Control Document (ICD) – Wyoming CV Pilot, FHWA-JPO-17-468. U.S. Department of Transportation.*

Appendix A. Vendor Requirements

A.1 Lear Requirements for OBU/RSU Acquisition

Lear Requirements for OBU/RSU Acquisition are removed for Phase 4

Additions to the normal WYDOT requirements:

LR-REQ-1 Source Code and Build Instructions – Lear shall place into escrow, all of the source code and build instructions necessary to build the Lear ConnexUS HMI application, the Lear OBU embedded firmware, and the Lear RSU embedded firmware, such that it will become available to WYDOT in conditions of Lear non-responsiveness (greater than 30 days) or insolvency.

LR-REQ-2 SDD Custom Software and Applications – Lear shall provide custom software and applications for the Lear RSU and Lear OBU which implement the functionality as defined in the referenced System Design Document, Sections: 3.1.2, 3.1.4.5, 3.2.1, 3.2.6, and 3.2.7.2 by the end of December 2017.

LR-REQ-3 ICD Custom Software and Applications – Lear shall provide custom software and applications for the Lear RSU and Lear OBU which implement the functionality and interfaces as defined in the included Interface Control Document, Sections: 5.1, 5.2, 5.3, 5.4, 5.9, 5.10, 5.11, 5.13, 5.14, 5.16, 5.17, 5.18 and 5.24 by the end of December 2017.

LR-REQ-4 Support to WYDOT SMOC – Lear shall provide OBU and RSU devices which all support the included WYDOT Security Management Operating Concept by the end of December 2017. Lear shall provide OBUs which all have FIPS 140-2 level 2 capabilities and RSUs which all have FIPS 140-2 level 3 capabilities by the end of December 2017.

LR-REQ-5 System Requirement – Lear shall provide OBU and RSU devices which all meet the included WYDOT System Requirements by the end of December 2017. Specifically, sections 2.2, 2.5.1, 2.6, 2.9, 3.1, 3.2, 4.2, 5.1.1, 5.2, 5.3, Appendix A, and Appendix B. This includes using the 2016 SAE J2735, J2945/1, IEEE 1609, RSU spec 4.1, and the current Security Credential Management System (SCMS) being released in February 2017.

LR-REQ-6 Antennas – Lear shall provide antennas for Lear OBUs which all meet the performance requirements defined in 2945/1, when installed on tractor trailers per vendor's guidance by the end of December 2017. Lear shall supply antennas with all Lear devices for DSRC, GPS, Bluetooth and where applicable, Sirius XM and WiFi by the end of December 2017.

LR-REQ-7 Software and Hardware Support – Lear shall include software and hardware support and repair/replacement for 3 years for all OBU and RSU devices provided by Lear for the WYDOT CV Pilot. WYDOT understands that the SCMS and custom application will be a work in progress through March 2017 and is not currently completely ready for production.

LR-REQ-8 APIs/SDKs – Lear shall provide WYDOT with all of the APIs/SDKs (application programming interfaces/software development kits) necessary to create HMI, OBU, and RSU applications so that WYDOT may assist vendor with troubleshooting or customizations throughout the Pilot as needed.

A.2 SiriusXM Requirements for OBU Acquisition

SirusXM Requirements for OBU Acquisition are removed for Phase 4

Additions to the normal WYDOT requirements:

SXM-REQ-1 Source Code and Build Instructions – SiriusXM shall place into escrow, all of the source code and build instructions necessary to build the SiriusXM HMI application and the SiriusXM OBU embedded firmware, such that it will become available to WYDOT in conditions of SiriusXM non-responsiveness (greater than 30 days) or insolvency.

SXM-REQ-2 SDD Custom Software and Applications – SiriusXM shall provide custom software and applications for the SiriusXM OBU and SiriusXM HMI which implement the functionality as defined in the included System Design Document, Sections: 3.1.4.5, 3.2.6, 3.2.7.2 by the end of December 2017.

SXM-REQ-3 ICD Custom Software and Applications – SiriusXM shall provide custom software and applications for the SiriusXM OBU and HMI which implement the functionality and interfaces as defined in the included Interface Control Document, Sections: 5.1, 5.13, 5.16.1 by the end of December 2017.

SXM-REQ-4 Support to WYDOT SMOC – SiriusXM shall provide OBU and HMI devices which all support the included WYDOT Security Management Operating Concept by the end of December 2017. SiriusXM shall provide OBU devices which all have FIPS 140-2 level 2 capabilities by the end of December 2017.

SXM-REQ-5 System Requirement – SiriusXM shall provide OBU and HMI devices which all meet the included WYDOT System Requirements by the end of December 2017. Specifically, sections 2.2, 2.5.1, 2.6, 2.9, 3.1, 3.2, 4.2, 5.1.1, 5.2, 5.3, Appendix A, and Appendix B. This includes using the 2016 SAE J2735, J2945/1, IEEE 1609, RSU spec 4.1, and the current Security Credential Management System (SCMS) being released in February 2017.

SXM-REQ-6 Antennas – SiriusXM shall provide antennas for SiriusXM OBUs which all meet the performance requirements defined in 2945/1, when installed on tractor trailers per vendor's guidance by the end of December 2017. SiriusXM shall supply antennas with all SiriusXM devices for DSRC, GPS, Bluetooth and where applicable Sirius XM and WiFi by the end of December 2017.

SXM-REQ-7 Software and Hardware Support – SiriusXM shall include software and hardware support and repair/replacement for 3 years for all OBUs and HMIs provided by SiriusXM for the WYDOT CV Pilot. WYDOT understands that the SCMS and custom application will be a work in progress through March 2017 and is not currently completely ready for production.

SXM-REQ-8 APIs/SDKs – SiriusXM shall provide WYDOT with all of the APIs/SDKs (application programming interfaces/software development kits) necessary to create HMI, and OBU applications so that WYDOT may assist vendor with troubleshooting or customizations throughout the Pilot as needed.

A.3 WeatherCloud Requirements for Roadpack/Skypack Acquisition

WeatherCloud Requirements for Roadpack/Skypack Acquisition are removed for Phase 4

Additions to the normal WYDOT requirements:

WC-REQ-1 Source Code and Build Instructions – WeatherCloud shall place into escrow, all of the source code and build instructions necessary to build the WeatherCloud HMI application which is deployed for the WYDOT CV Pilot, such that it will become available to WYDOT in conditions of WeatherCloud non-responsiveness (greater than 30 days) or insolvency.

WC-REQ-1 ICD Custom Software and Applications – WeatherCloud shall provide custom software and application which creates a log file on the Android tablet according to the specifications in the Interface Control Document, Section: 5.5 by the end of December 2017.

A.3 Vendor Requirements for Phase 4 LTE-C2X OBU / RSU Acquisition

Additions to the normal WYDOT requirements:

A.3.1 General RSU Requirements

Phase4-REQ-1.1 - RSU shall use Cellular Vehicle to Everything LTE-C2X communication.

Phase4-REQ-1.2 - RSU should have a Graphical User Interface for programming.

Phase4-REQ-1.3 - RSU shall come with the latest software/firmware at the time of delivery.

Phase4-REQ-1.4 - WYDOT will define the data forwarding endpoint. The data endpoint will be WYDOT's CV ecosystem. Under no circumstance shall any RSU/CV/OBU data be sent to other endpoints without approval and specific guidance from the CV program manager.

Phase4-REQ-1.5 - CV unit should be OmniAir certified (if available) and comply with all elements of ITE Connected Transportation Interoperability (CTI) 4001 v01.01 Roadside Unit Standard (RSU).

Phase4-REQ-1.6 - Message set produced by OBU shall comply with the Society of Automotive Engineers (SAE) J2735 _202007, current version of IEEE 1609.x family (to include 1609.2.1 and 1609.2 with extensions) and the SAE J2945/1_202004 standard.

Phase4-REQ-1.7 - RSU shall have remote management capability supporting firmware updates, configuration management, SNMP management for MIBs defined in CTI 4001 and RSU Spec 4.1 Appendix B completed remotely within WYDOT's CV ecosystem.

Phase4-REQ-1.8 - RSU shall receive and decode the full SAE J2735 Basic Safety Message Part I content.

Phase4-REQ-1.9 - RSU shall receive and decode the full SAE J2735 Basic Safety Message Part II content.

Phase4-REQ-1.10 - RSU should transmit, encode, and sign the full SAE J2735 Probe Data Management message after receiving from the TMC.

Phase4-REQ-1.11 - RSU should receive and decode the full SAE J2735 Probe Vehicle Data message.

Phase4-REQ-1.12 - RSU should transmit, receive, encode, and sign the full SAE J2735 Radio Transmission Correction Message (RTCM).

Phase4-REQ-1.13 - The RSU shall transmit, decode, and sign the SAE J2735 Travelers Information Message (TIM) after receiving from the TMC.

Phase4-REQ-1.14 - The RSU should transmit, encode, and sign the SAE J2735 Signal Phase and Timing (SPaT) message.

Phase4-REQ-1.15 - The RSU should transmit, encode, and sign the SAE J2735 Traffic Signal Status Message (SSM) after received from the signal controller.

Phase4-REQ-1.16 - The RSU should receive, decode, and sign the SAE J2735 Traffic Signal Request Message (SRM) and send to the signal controller.

Phase4-REQ-1.17 - The RSU should send, encode, and sign the SAE J2735 Geographic Information Message (MAP) after received from the TMC.

Phase4-REQ-1.18 - RSU shall support logging and log uploads to the endpoint specified by WYDOT.

Phase4-REQ-1.19 - RSU should support log offloads for OBUs.

Phase4-REQ-1.20 - A connected vehicle device shall continue normal operations regardless of the number, rate, or content of the messages received.

Phase4-REQ-1.21 - RSU shall support log management.

Phase4-REQ-1.22 - RSU shall support OTA updates for OBUs.

Phase4-REQ-1.23 - RSU shall support for IPv6 and IPv4 on wireless and wired interfaces.

Phase4-REQ-1.24 - RSU shall be compliant with CTI 4001 and USDOT RSU v4.1 Specifications or most current specification.

Phase4-REQ-1.25 - Vendor response shall provide information on the frequency bands that the RSU is capable of utilizing.

A.3.2 Security Requirements

Phase4-REQ-2.1 - Access to RSU shall be restricted with login credentials.

Phase4-REQ-2.2 - All communication ports shall have access control e.g. configurable firewalls and Access Control Lists.

Phase4-REQ-2.3 - RSU must be fully compatible with the ISS SCMS and SCMS Manager.

Phase4-REQ-2.4 - RSU must be compatible to integrate with Integrity Security Services (ISS)'s SCMS. This is WYDOT's statewide SCMS provider.

Phase4-REQ-2.5 - RSU SCMS functionality must include: local certificate chain file processing, certificate revocation list processing, spectrum related updates, and misbehavior detection.

Phase4-REQ-2.6 - The RSU host processor and its operating software shall perform an integrity check on boot.

Phase4-REQ-2.7 - The RSU shall provide evidence to detect tampering (e.g. opening of the case) through tamper-evident seals. Unused ports should include plastic caps.

Phase4-REQ-2.8 - Support for CAMP v1.2.2 protocols.

Phase4-REQ-2.9 - JTAG must be disabled on the main CPU and the HSM. If JTAG can be re-enabled, it must use a unique password/key per device and not a global password.

Phase4-REQ-2.10 - RSU must be remotely updateable. Firmware updates must be digitally signed using a cryptosystem no weaker than AES-128/ECCp256.

Phase4-REQ-2.11 - Regarding support for the LCCF, the RSU will need to potentially store multiple certificates for the SCMS components as new certs are issued and distributed before the old certs expire (ICA, ECA, PCA). The RSU will also need to store two enrollment certs.

Phase4-REQ-2.12 - Secure boot should use a cryptosystem no weaker than AES-128/ECCp256.

Phase4-REQ-2.13 - CRL Processing - must support CRL Series 1, 2, 3 and 256.

Phase4-REQ-2.14 - Must support the SCMS Manager requirements outlined here:
https://www.scmsmanager.org/publications/

Including: end-entity certificate re-enrollment specification, ASN.1-for-Misbehavior Reporting, Misbehavior Report and Application Specification, Elector Technical Specification and Elector Policy.

Phase4-REQ-2.15 - VPN connections (SSH, TLS, IPsec) used between the CV ecosystem and the RSU must be configured to use only strong cipher suites.

Phase4-REQ-2.16 - The RSU shall provide contain an HSM for SCMS cryptographic information.

A.3.3 Unit Delivery Requirements

Phase4-REQ-3.1 - Provide detailed schedule of estimated delivery of units.

A.3.4 Other Requirements

Phase4-REQ-4.1 - Vendor should have at least one deployment in United States of America (U.S.A.)

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