Leading in Sustainable Safety with V2X Technology in Oakland County Michigan

Workforce Development Plan

Recipient Name: Road Commission Oakland County (RCOC)

Funding Opportunity Number: DOT-SMART-FY22-01

Period of Performance: August 15, 2023, to February 15, 2025

Organizations Preparing the Prototype Plan: P3Mobility, Brandmotion

Date Submitted: June 28, 2024

Table of Contents

Revision History:

Name:	Revision Description:	Date:
Tom Tracz	Included document section(s: Introduction, Purpose, Scope, Basic Principles of CV.	05/09/2024
Hayden Wheeker	Added document elements based on Jeremy W. and Tom T.'s comments for the drafted sections (through Classroom Training Outline)	5/17/24
Jeremy Ward	Complete Draft V1	6/28/24
Carissa Markel	V2 _Review and updates by RCOC including D. Deneau comments	7/22/24

Glossary of Terms:

Term	Acronym	Definition
Cellular Vehicle to Everything	C-V2X	Communication method to a cellular network for cloud-based services like navigation and information which uses direct links to communication with other vehicles, smart infrastructure, and pedestrians. C-V2X is based on 3GPP's release 14 and builds on the IEEE's 802.11p standard for dedicated short-range communication (DSRC.) C-V2X uses 5.9 GHz ITS spectrum.
On-Board Unit	OBU	A radio is responsible for broadcasting and receiving C-V2X/DSRC messages. The OBU represents the key

Workforce Development Plan

Term	Acronym	Definition
		connected device for the 'Vehicle' user group in a connected vehicle environment.
On-Board Equipment	OBE	Includes all equipment installed by the V2X team and is part of the OBU subsystem.
Vehicle-to-Everything	V2X	An intelligent vehicle communication network that allows vehicles to relay information to and from other vehicles, infrastructure, and devices.
General Purpose Input/Output	GPIO	A general-purpose input/output is an uncommitted connection point pin on an integrated circuit for vehicle signal information. GPIOs have no predefined purpose and are unused by default. The Kapsch GPIO harness has a
Human Machine Interface	HMI	Human-Machine Interface is to display safety and driver-critical alerts from the OBU to the driver. These alerts are driven by the V2X environment and will provide visual and audible cues to the driver for connected vehicle applications.

Term	Acronym	Definition
Road-side Unit	RSU	Is a controller responsible for broadcasting and receiving C-V2X/DSRC messages and is installed on the roadside. The RSU represents the 'Infrastructure' user group in a connected vehicle environment, and these controllers can also be connected to traffic management devices, signalized intersection controllers, and other road-side edge sensing equipment.
Security Credential Management System	SCMS	SCMS provides message security for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. Benefits of the SCMS include: ● Ensuring integrity—Users can trust that the message was not modified between sender and receiver ● Ensuring authenticity—Users can trust that the message originates from a trustworthy and legitimate source ● Ensuring privacy—Users can trust that the message appropriately protects their privacy ● Achieving interoperability—RSUs and OBUs from different suppliers will be able to talk to each other and exchange trusted data without pre-existing agreements

1 Introduction

Project Purpose

The goal of this Stage 1 SMART Grant project is to lay out the plans for the Road Commission for Oakland County (RCOC) to lead an economically sustainable model and deployment of Cellular-Vehicle -to-Everything (C-V2X) technology in Oakland County, Michigan. RCOC recognizes that government funding cannot be the only source of money to support the expansion and operations of its digital infrastructure. This planning grant will create a blueprint for building digital infrastructure that supports private investment and generates the revenue needed to finance ongoing operations and maintenance.

Stage 1 Deliverable(s) include:

- A Business and Financial Model for Deploying Economically Sustainable Safety Technology.
- Data Management Plan
- Evaluation Plan
- A Prototype Demonstration of the technology to inform key stakeholders and influence the County Wide Deployment Plan for Stage 2.
- A Community Engagement Plan will be executed during Stage 2 of the project.
- A Workforce Development Plan which will be executed during Stage 2 of the project. This document intends to lay out that plan.
- Implementation Report

Workforce Development Plan

<u>**Oakland County Stage 1 Prototype Block Diagram:**</u>

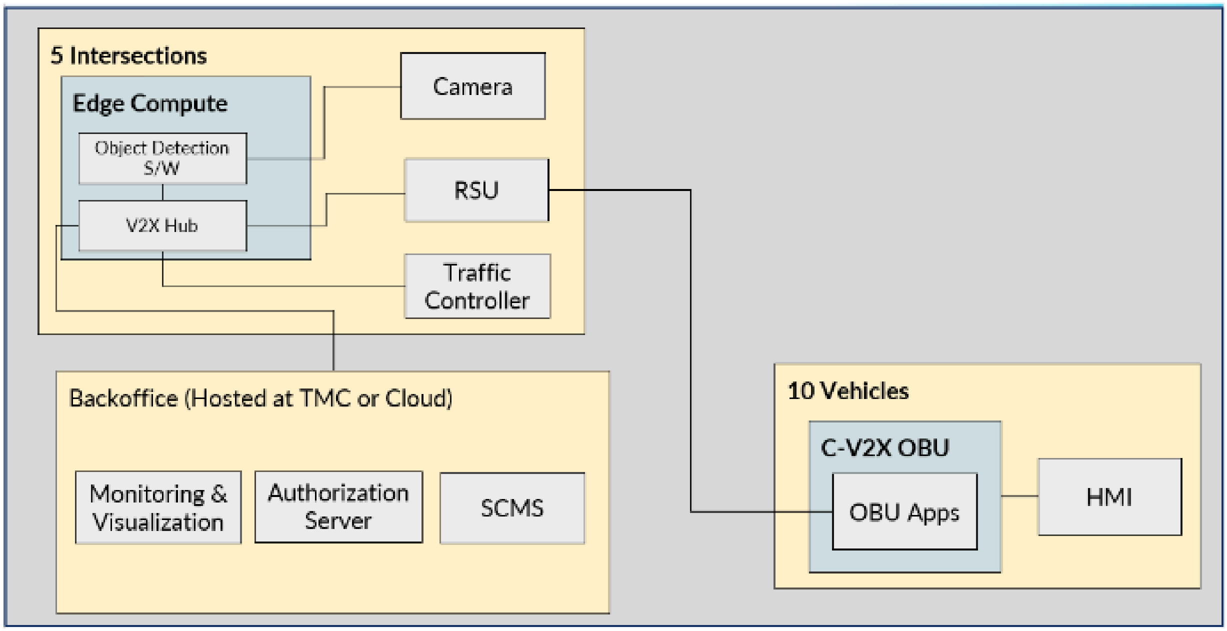


Figure 1

Document Scope and Objectives

This document will identify the plan to educate RCOC and the wider community workforce on deploying and maintaining C-V2X technology for Stage 2. This deliverable will generate qualitative data in the form of recommendations for Stage 2.

The primary topic of workforce development will be V2X vehicle hardware installation and maintenance rather than V2X infrastructure hardware installation and maintenance. This is for several reasons:

1. There will be many times more vehicles will require installation and maintenance than infrastructure sites, so it is more critical for workforce development for vehicles to target a larger audience.
2. Vehicle work can be performed at any location with a garage and the necessary tools, while infrastructure work can only be performed by RCOC or contractors with RCOC approval.

Therefore, planning for the vehicle installation and maintenance is the scope of this document, however much of the strategy and approach below can also be applied to workforce development for any component of the ecosystem.

2 Workforce Development Goals

Developing, funding, and sustaining a V2X workforce development plan is a significant investment. In addition to the efforts required to plan and develop the content, the training process requires employees to spend time away from their normal tasks. This means that the goals and outcomes of the workforce development must offset the investment. The following goals are envisioned for this workforce development effort:

Safety
Investment in training and development has the primary goal of improving worker safety. Understanding the technology and process steps is critical to reducing injuries during installation and maintenance.

Quality
Understanding the technology and process steps is critical to a high-quality installation done right the first time.

Job Satisfaction and Retention
An employee who has the opportunity to continue to learn will feel increased job satisfaction, which has the goal of improving worker retention.

3 Current Workforce Analysis

Industry Need

According to the U.S. Bureau of Labor Statistics, growth in demand for automotive technicians is increasing 2% in 2023.[1] This number is only expected to grow due to a higher average number of employees exiting the industry without a trained workforce to replace them. Many technicians seek careers in traditional automotive repair & service facilities rather than pursuing available opportunities with new technology manufacturers.

[1] https://www.bls.gov/ooh/installation-maintenance-and-repair/automotive-service-technicians-and-mechanics.htm

Also, in addition to the requirement for new automotive technicians to enter the workforce, there is a similar need to re skill in new areas of automotive development.

There is an increase in the number of connected, autonomous, electric and hybrid vehicles currently being produced. These vehicles are equipped with more complex vehicle data and communication systems. These enhancements in power and communication have enabled advancements to ADAS & connected capability. Advanced Driver Assistance Systems (ADAS) are those designed to help a driver avoid a collision based on a sensing capability built into the vehicle. The sensing data can be communicated at extremely high speed for low latency driver alerts using vehicle communication systems such as the Controller Area Network (CAN.)

This trend has pushed new organizations and institutions to be founded for the purpose of increasing the technical knowledge within this industry of skilled laborers. Programs like the Toyota Technician Training Network (T-TEN)[2] highlight this shift of thinking for leading auto manufacturers. This training, along with others, provide a roadmap for training a new class of automotive technicians to learn this emerging class of technology through hands-on, online, and in-person training.

Identifying the Technicians

People with technical product knowledge or experience in installing certain types of technology may find the installation steps for connected vehicle deployments familiar. There is often an overlap in the installation standards between these areas, which can make the process more intuitive for those with relevant experience. Areas of product knowledge that have this natural alignment to the connected vehicle category are:

- Telematics - Telematics systems typically transmit data via cellular networks and are used to enhance vehicle safety, improve fleet management, and offer connected services like roadside assistance and remote vehicle control.
- Asset Management - Involves the systematic process of deploying, operating, maintaining, upgrading, and disposing of vehicles within a fleet to ensure maximum efficiency and cost-effectiveness. There are several new emerging products and connected devices that offer fleet managers a benefit for their asset management, and that need to be installed by technicians who possess this type of installation skillset.
- Connected Devices - Products in the categories of asset management, and telematics may also be called “Connected Devices” and are tools and systems embedded in or attached to vehicles within a fleet that enables communication and data exchange between the vehicles and a central management system.

[2] https://www.forwardontalent.org/stories/toyota/

These devices use various forms of technology, such as GPS, cellular networks, and IoT (Internet of Things) connectivity, to provide real-time information on vehicle status, location, and usage. If a device is categorized as 'connected' that indicates that communication to an external source from the vehicle is implied. There will commonly be a requirement to install an antenna for communication purposes. This is similar to an OBE system. Further alignment for these is that they will require similar power connections. For instance, most vehicles have a 'Battery Constant' circuit, which may allow an OBU to retain some power draw while the vehicle is idle and the key is 'off.' The vehicle / connected device will still communicate location when not in use would be an example of how a constant connection to a vehicle power source could be utilized to improve the device's function.

If a new connected vehicle Technician candidate is considering the benefit of pursuing formal training in connected vehicle technology, it would be a helpful reference if they consider OBUs and their installation requirements in comparison to these other types of technology. If they have a great deal of experience with Telematics or Connected Products, then connected vehicle OBU installation may be a logical next step. Alternatively, if a technician can self-identify that they would not be comfortable making connections to a vehicle for power, then they may want to improve their automotive electrical skillset before pursuing advanced training.

4 Key Stakeholders / Candidates for Training

Primary stakeholders for training are those who already possess an automotive technical skillset and a foundation in electronics. The ideal candidates will be able to understand basic vehicle systems and understand the causality of driving actions for the OBU / Application logic in the scope of CV. Non-technical personnel from any of the stakeholder groups may also receive training, however; the prospective audience will represent the labor force most responsible for increasing the number of traditional 'connected vehicle' devices in and around Oakland County.

RCOC

The jurisdiction leading the project. The Road Commission for Oakland County (RCOC) manages more than 2,700 miles of roads and over 1500 traffic signals in the county and has been on the cutting edge of ITS technologies since the early 1990s. RCOC fleet vehicles range from passenger cars and trucks to heavy-duty road construction equipment and salt trucks.

Other Govt. Agencies with Agency Fleets

Oakland County includes 62 cities, townships, and villages, each with a combination of internal fleet vehicles, fire, police, and emergency first responders, which could all be potential customers for V2X. Both RCOC fleet vehicles and other Oakland County community fleet vehicles are assumed to be in the first wave of V2X deployment.

Students

High school, college, and trade school students are candidates for training in V2X technology. Students interested in STEM subjects provide a solid foundation for understanding V2X systems, while hands-on coursework equips them with practical skills. Training these students aligns with workforce development goals, preparing them for careers in advanced automotive technologies and supporting the adoption of connected vehicle systems for safer, more efficient transportation.

Aftermarket C-V2X Adopter

The challenge with putting in technology in one geographic area is the vehicles that could benefit need to use those corridors and intersections to gain the most benefit. The following categories of aftermarket fleets would be considered in the 2nd wave of V2X aftermarket deployment:

- Freight and Logistics Services
- EMS / Ambulances
- School Buses
- Waste Management
- Consumer Services (HVAC, delivery, plumbing, etc.)

Several organizations may have candidates who fit the mold for the audience to receive training. Organizations that may have technicians capable, as well as a business incentive to do so, may include:

- Last Mile Delivery Providers - USPS, FedEx, UPS.
- Additional Govt. Agencies - SMART, DDOT, MDOT, municipalities, and many more.
- Trade Schools & Professional Dev. Organizations: Oakland Community College, Auto Diesel Institute (Baker College,) and several other public and private institutions for training.

There is a business incentive for these organizations to remain ahead of the deployment of connected vehicle technology. CV controllers and V2X communication are considered to be key steps for achieving greater safety and autonomy for all vehicles. More immediate benefits come from the safety applications already possible with V2X communication, as well as those for specialty vehicles to allow them preemption and priority at some signalized intersections. There are already several commercial vehicle fleets deploying the use of connected vehicle technologies, which are seeing improved route and transit performance of their fleet of vehicles. For many of these businesses whose service is delivery, may stand to gain even greater benefits from a rapid roll-out of this technology.

5 Workforce Development Approach

To deliver the workforce development for an expanded deployment that would take place in Stage 2, the following deliverables are recommended:

- **Full Stakeholder Register** - Document that captures entities that have technician candidates for connected vehicle Technology.
- **Stakeholder Interviews** - Documented notes for stakeholders to suggest the format and best types of training with additional details for their organization's needs.
- **Needs Register** - Collaborative document that will capture identified needs from stakeholder interviews.
- **Training Requirements** - Document output from all information gathered during the needs discovery process. Includes training execution requirements and suggested metrics for measuring outputs from training. Metrics for training may include: number of trained technicians, aptitude tests, number of training modules completed, number of certifications issued.
- **Training Implementation Plan** - Documents the steps required to deliver the workforce development.
- **Schedule & Execution Plan** - Document that serves as an itinerary for any in-person / classroom training. It will identify the location, time, date, and audience to receive training as well as a final outline that will be provided as a reference prior to training for new candidates.
- **Training Execution Report** - Document detailing the performance evaluation of final delivered training. It uses the metrics identified in the requirements of training and summarizes how the requirements were met.

6 Anticipated Skills and Competencies

For a full program focused on implementing and maintaining connected vehicle projects in an operational state training for Connected 'Vehicle' installation technicians would cover the installation topics:

Taking Automotive Power Readings:

Taking measurements of vehicle power in Volts, taking current readings, and checking resistance. This will be a quick review and may serve as a re-familiarization for the audience.

Basics of Troubleshooting:

As the most important element of training as identified by the Brandmotion team of Master Technician staff, it was agreed that having a basic understanding of issue/resolution steps is important before beginning any new installation. They recommend covering the following steps for best practices.

1. Identify the problem.
2. Establish a theory of probable cause.
3. Test the theory to determine the cause.
4. Establish a plan of action to resolve the problem and implement the solution.
5. Verify full system functionality and if applicable implement preventative measures.
6. Document findings, actions, and outcomes.

Vehicle Signal Systems:

An important element of connected vehicle OBU installation is to have a familiarity with vehicle control and accessory systems. These are likely connection points to GPIO wires for common models of OBU. A training would impart details of vehicle control system possible locations, functions, and how to connect for:

- Chassis Controller
- Motor Position Sensor
- Throttle Position Sensor
- HVAC Sensor
- Steering Sensor
- Body Control Module BCM
- CAN BUS

Interpreting Wire Schematics:

This is a basic review of the CAD file / schematic drawing symbols and their meaning. This will ensure that if presented with an electrical schematic from a vehicle that they are asked to install on, they will have a basic understanding of where to locate and connect for the OBUs proper function.

Vehicle Connections for OBE:

This will be the final module of a class / E-learning delivered training and will cover in greater detail the typical connection requirements for C-V2X project OBUs. This will include installation practices for the installation of the OBU, Main Harness, V2X Antenna, LTE/Bluetooth/Wi-Fi Antenna(s), and HMI. Beyond the installation of the equipment, there are best practices for integrating the equipment into a vehicle. This includes the use of fuses to prevent electrical shorts, and diodes to protect against back feed on voltage-sensitive systems.

7 Proposed Training Method

7.1 Program Overview

Objective: Equip lead technicians with the necessary skills and knowledge to train other technicians on the installation and maintenance of connected vehicle OBUs.

Target Audience: Lead automotive technicians, senior technicians, and technical supervisors.

Duration: 4 weeks (divided into multiple sessions).

7.2 Curriculum Design

Elements of training that would be proposed for future training implementation are included in the left-hand column of the design table below. Methods of implementing those training elements are included in the center column. In the right-hand column are the author’s notes for when a certain training method may be used.

Training Element	Method(s)	Author's Notes
Training Best Practices	• Effective training methods and learning principles. • Hands-on demonstration and practical exercises. • Evaluating Trainee Understanding	• Hands-on training may include the installation of OBUs in a project deployment. • Evaluating trainees is important to ensure a new connected vehicle trainee is capable of safely interfacing with the OBU and not compromising its function.
Practical Application	• Test / Validate with real-world installation scenarios. • Group exercises and workshops. • Field training sessions with actual fleet vehicles.	• For Gov't Technician trainees there is an added benefit to training on the vehicles in the agency's fleet. • For field Engineers and other professional service trainees, this type of workshop may include bench testing the OBU and demonstrating the basics of the new configuration in a controlled environment.

<table>
<tr><th><u>Training Element</u></th><th><u>Method(s)</u></th><th><u>Author's Notes</u></th></tr>
<tr><td>Training Materials</td><td>Comprehensive training manual and installation guide.
Step-by-step video tutorials.
Troubleshooting and maintenance checklists.
Assessment quizzes and feedback forms.
Installation kits and tools.</td><td>In some cases, training is provided in a video format. Videos showing the steps of installation can also be embedded into a Learning Management System (LMS), E-Learning module for remote training.
An element of training can also be to create these during a class setting, where a trainer can suggest preventative maintenance tasks and the trainees can suggest a method and cadence for checks.
For data collection a quiz, survey, or exam given to trainees. This will ensure that there is a quantitative measure of the training. It will also give an idea of any training modules that may require regular updates to be provided post-training.
Some data cables & adapter cables are commonly used to perform configuration steps with an OBU. In an advanced training setting, these cables could be provided to new trainees. Otherwise, they are commonly available at electronics stores.</td></tr>
</table>

Training Element	Method(s)	Author's Notes
Training Methodology	• Instructor-Led Sessions • Hands-On Workshops • E-Learning Modules • Field Training	• Instructor-led sessions work in a formal class setting or a group meeting space at a maintenance facility. • Hands-on training are interactive workshops for real-time practice and skill application. Can occur in, ○ Lab Setting ○ Garage/Vehicle Bay Setting • E-learning can be developed in coordination with training institutions in Oakland County. If planned with a formal training body, it could be added as a formal certification or new curriculum for a degree program. • Field Training can occur on-site training with actual fleet vehicles for real-world experience
Assessment and Certification	• Knowledge Assessment • Practical Assessment • Certification	• Quizzes and written tests work as a knowledge check to evaluate understanding of theoretical concepts. • Practical assessments should be performed to evaluate a new trainee's technical proficiency. • Certification is awarded to trainers upon successful completion of the program

Table 1

8 Proposed Training Modules

The audience to receive training will be introduced to connected vehicle technology for elements of its function & methods of communication. A proposed outline for training in a classroom setting that covers these topics is shown below.

8.1 Classroom Training Outline

1) History of connected vehicle deployments and technology.
    a) U.S. Department of Transportation Mandate
    b) NHTSA Support of CV initiatives.
    c) IEEE; SAE; ITSA - Early organizations to adopt CV initiatives for support.

2) Legacy Communication - Dedicated Short Range Radio (Old Method.) 5.9GHz spectrum, and the first DOT sponsored deployments (NYC, WY, FL.)
    a) Outcomes - Speak to the results, and white paper findings as a result of these initial CV Deployments.
    b) Cover key developments in the time since the new deployment of CV technology began.
    c) Provide a qualitative current status of the National Landscape of CV technology and its readiness at scale.
        i) This will be delivered in the context of training and would have the objective of enhancing the audience's understanding of their own benefit for learning CV technology installation & maintenance required skills.

3) V2V - Cover the means of V2V communication, sensor & controller technology for vehicles.
    a) Components of On-Board Equipment (OBE).
        i) On-Board Unit (OBU)
        ii) Human Machine Interface (Tablet, Monitor, Other Display / Speakers)
        iii) Glonass antenna with BT, Wi-Fi, and Radio receiver & transmitting nodes.
        iv) LTE Antenna
        v) Harness for Power connections to vehicles.
        vi) Data harness(s): Harness from the OBU to vehicle I/O input sources, and Ethernet / RJ45 Connector for tablet OBU data transfer.

4) Vehicle to Vehicle (V2V) Message Types

   a) Basic Safety Messages (BSMs)
      i) App Alerts for Collision Alert, Hard Brake Event, etc.…
   b) Traveler Information Messages (TIMs)
      i) App Alerts for Wrong Way Driver / Intersection alerts from connected vehicles.
   c) Cover several V2V applications in more detail to provide a description of the logic flow included in a few representative applications.
      i) Include additional context that will allow a trainee to derive how safety applications need the data from these controllers in order to work properly.
         (1) Share details of the vehicle data required to be communicated for various applications.

5) Vehicle to Infrastructure (V2I) Message Types
   a) Signal Request Messages (SRMs)
      i) Foundational message type for applications that have priority.
   b) Signal Safety Messages (SSMs)
      i) From the Road-Side Unit to the On-Board Unit. This is an example of back-and-forth communication between infrastructure and vehicles.
      ii) Has critical importance for the audience's understanding of the connected vehicle required elements, and a sense of what must be in place for a CV environment to scale.

6) Other Developed Applications & Message Types
   a) Foundations Vulnerable Road User (VRU) safety applications.
   b) Review existing applications.
   c) Describe some unique use cases of CV communication for non-traditional safety applications. I.e. rail, marine, pedestrian, and other non-motor vehicles that may have CV controllers for other functions.

7) Basics of Secure Communication
   a) Briefly cover various vehicle classifications identified by SAE connected vehicle operation standards.
   b) Provide current methodology for secure communication. Also, provide additional context by reviewing and showing SCMS provider material for their security layer in the scope of connected vehicle deployments.

8) Sensor Technology & Other CV Enhancements

a) Cover the use of infrastructure sensors to provide more accurate safety data and more possible applications & alerts in concert with the signal controllers and traffic management systems.
   i) Intersection Sensor Types -
      (1) Lidar
      (2) Smart Camera
      (3) Radar
   ii) In-Vehicle Sensor Types -
      (1) CAN BUS
      (2) Accessory Analog Connections to OBU I/Os
      (3) Aftermarket Accessory Systems.

The training on foundational communication requirements for connected vehicle / connected intersection operation will be delivered technically. The ideal audience will have some basic understanding of wireless communication, and how by leveraging space/connections to a vehicle, there is available data that other devices can use to transmit actionable intelligent alerts for other drivers for enhanced safety.

It is a finding from past training that this is a good point of delivery of information to ask that the audience provide some representative example intersections/use cases for connected vehicle technology in Oakland County. This can also be used as a basic check for understanding what the audience may have retained from the delivered information.

8.2 Hands-On Training: Vehicle Subassembly

Once the principles of connected vehicle technology are covered in a classroom setting, it is recommended to provide the opportunity for trainees to transition to a hands-on setting for instruction. This should be in a lab, or a garage bay space working with a vehicle. During this hands-on portion of the training instruction, the following elements of the on-board equipment (OBE) should be reviewed and trained on processes of installation:

- On Board Unit (OBU) - radio transceiver that allows 2-way communication to the intersection and other cars equipped with V2X. Includes antennas that are connected for improved reception of the target V2X frequencies

- Human Machine Interface (HMI) - a tablet that shares safety alerts with the driver. Includes a secure mount to the vehicle.
- V2X Antenna - Roof-mounted three (3) channel antenna with nodes for Radio (DSRC), C-V2X, and GNSS.
- LTE Antenna - Adjustable mounted antenna that provides LTE reception and transmission capability from several models of OBU. This is for the C-V2X project utilizing LTE for communication rather than the 5.0gHZ dedicated safety radio spectrum.
- Vehicle Interface Harness - this is the power, and GPIO harness provided with the OBU and is used to connect the OBU to the vehicle source for power, and for various vehicle signals required by the OBU and project applications.
- Wireless Modem - For event logging, or regular security credential management and top-off the OBU may be interconnected to a 3rd part LTE-enabled device. Review the data connection of an RJ45 ethernet cable when an OBU is used that may accompany an installation if there is a modem or similar device included.

Figure 2

Example: Cohda OBU Kit Showing Base Kit Components

All the components mentioned for training under the "*Vehicle Subassembly"* category are included and will be required to be installed under various installation 'types.' During the portion of hands-on instruction, trainees should be coached on the various types of connected vehicle installations that are requested by fleets and agencies interested in deploying connected vehicle technology.

8.3 Determine Types of Installation for Training

Vehicle operators and fleets who are interested in deploying connected vehicle technology have various use cases in mind for the OBE that they select. All OBUs have a similar hardware 'form-factor' and can usually be described as a module with ports. The module will drive alerts based on the sensors and connections to the ports on the OBU, but the OBU itself shouldn't be visible to the driver under any installation scenario. Knowing that the OBU is not important for the driver for regular interface while driving, then we must consider best practices for securing the OBU out-of-site from the driver, and in a position where it can still be connected to the other OBE components of the system. That is the general starting criteria for the aftermarket installation of connected vehicle devices. From there we can ask further questions to determine more steps of the install and how to complete them.

Permanent Installation

This is the most commonly requested 'type' of installation. This provides the OBE subsystem with the longest useful life. A permanent installation is meant to ensure longevity and does not account for a time later when the OBU would need to be removed. For a permanent installation, the following sub-components and installation practices may be used:

1) Drill Through V2X Antenna
    a) The Drill Through form of V2X antenna has a threaded stud on the flat mounting side of the roof antenna. It allows a hole to be drilled for the stud to pass through into the vehicle headliner, and then the antenna to be secured using more traditional mounting hardware for attachment.
        i) Example of a drill-through antenna with stud showing on the flat mounting side. Antenna cables can be passed directly into the vehicle headliner under this type of installation.

Figure 3

ii) Example of drill-through antenna with wires passed into vehicle roof.

Figure 4

iii) Example of the drill-through antenna with split-nut securing the antenna to the roof (view from the interior of vehicle between headliner and roof.)

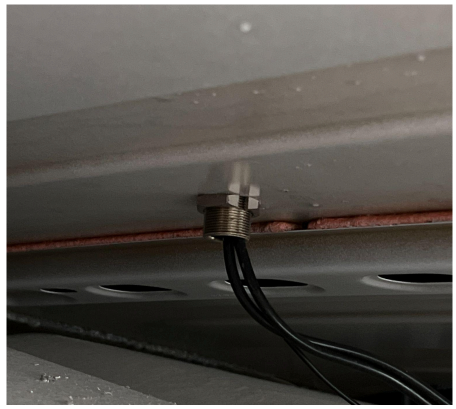


Figure 5

b) Sika-Flex 221 is a high-strength commercial adhesive and sealant that can be used in a permanent installation. The Sika-Flex provides a strong adherence of the antenna to the vehicle roof. It cannot be removed once it has had time to set and will allow almost any vehicle to operate under any use case with the OBE installed. This includes weather operation in adverse weather conditions, going through a high-strength vehicle wash, and use in commercial applications where durability is a requirement.

   i) Example of the Sika-Flex 221 loaded into an applicator gun.

Firugre 6

ii) Example of Sika-Flex 221 being applied to vehicle roof in a permanent mount scenario.

Figure 7

2) Permanent OBU Mounting
    a) Hardware Fasteners (e.g. Screws, Bolts, Nuts, etc.) in a permanent installation scenario, installation technicians are empowered to use more permanent attachment methods. In many cases, this includes the use of screws or bolts through a permanent fixture of the vehicle. Holes used to attach the OBU using hardware cannot be repaired in many cases, this is why it is a practice for mounting that we reserve for when a fleet/vehicle owner requests the permanent type of installation.
        i) Fasteners include screws, nuts, bolts, and other mechanical attachments. Example:

Figure 8

        ii) For attachment in a permanent installation where the driver may be asked to interface with the OBU and may need to remove it for routine checks it may be a useful practice to use hardware with features for hand-tightening and removal.

Figure 9

b) Mounting the OBU behind vehicle panels is another element of a permanent installation that should be covered. This is often the best area in a vehicle to ensure that the installed equipment cannot be interfered with by other drivers or vehicle conditions that may be present.

i) Luggage compartment wall panels often have room behind them with space to contain the OBU and that will not interfere with other connections that are needed.

Figure 10

OBU in the image is from another manufacturer but shows the OBU installed using mechanical fasteners on the interior of a luggage compartment panel.

ii) A flat wall behind the plastic panel of the vehicle will provide a metal surface for mounting. The attachment hardware often has the best results for mounting when attached to a metal surface.

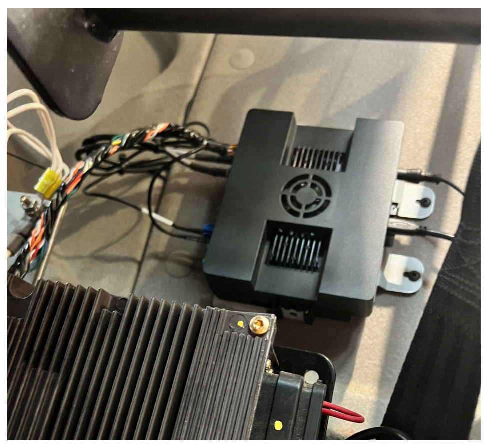


Figure 11

The OBU in the image is from another manufacturer but shows the OBU installed against a flat wall for mounting and using permanent fasteners as the attachment method.

Semi-Permanent Installation

Semi-permanent installation is categorized using components and installation processes that can be removed and restored at a later date when the CV equipment is no longer needed to achieve the goals of the connected vehicle deployment. This could be in a 'pilot' scenario wherein the Vehicle Owner of the Fleet is testing the equipment in a subset of their vehicles to determine the value of a full rollout. The common reason a Fleet / Vehicle Owner would opt for a semi-permanent installation is that it would allow the vehicle to be fully restored to the condition it was in prior to receiving the OBE, the OBE can then be reused in another vehicle for testing, and the vehicle could be returned to the dealer or sold. Semi-permanent installations have unique sub-components that can be used for the desired effect of being able to remove them later:

1. Magnetic Mounted V2X (Roof) Antenna
    a. The V2X antenna on the roof can create the most irreparable modification to the vehicle when a ‘drill-through’ antenna is used. For this reason, there is a magnetic option for the V2X antenna. It has magnetic ‘discs’ on the flat mounting side of the antenna that will create magnetism for attachment to a metal roof surface.
        i. Example of a magnetic mount V2X antenna with the magnetic discs on the flat mounting surface exposed.

Figure 12

        ii. To mount the magnetic antenna to the roof’s surface it is recommended to add extra adhesive measures. These commonly include double-sided VHB automotive adhesive tape, applied to the bottom of the antenna. As well as vinyl tape applied to the length of the antenna cable on the exterior of the vehicle.

Figure 13

Example of a magnetically mounted antenna on a pickup truck roof and showing the vinyl tape applied to the antenna cable on the exterior of the vehicle.

iii. The antenna cables in the mag-mount scenario can be routed into the vehicle underneath. There are more available pass-through points into the vehicle from the underside of the body. Using a rubber grommet that a technician can locate the hole can be widened to accept the antenna cable passing into the vehicle. The grommet can be sealed with some commercial waterproofing sealer, and upon removal, the full grommet can be replaced to restore the vehicle to 'like new' condition.

Figure 14

The red arrow is pointed to the area where the antenna cable is sealed using vinyl tape to the vehicle exterior.

Portable OBU Sub-System

In some cases, it is requested that the OBU not be installed into the vehicle before use. This is most commonly requested when a single OBU is going to be used by multiple individuals for testing & validation. These OBUs are built into a 'portable' case configuration that can be easily transported and used by a single individual. These cases contain all elements of the OBU subsystem and all connections are contained within the case. The only connection to the vehicle that should be needed to use the OBU is a connection to an auxiliary power jack. Vehicle auxiliary power ports are commonly referred to as a 'cigarette lighter' and all portable OBUs are provided with a male power cable to connect to a port like these.

Elements of a 'Portable OBU' that enable its function without more vehicle connections and steps of integration are:

1. Portable Case

Workforce Development Plan

a. The portable case is a 'pelican case' style of heavy-duty case that will protect the OBU against shock from drops or falls at height. This will also have ports and pass-through positions into the interior of the case for any wiring to be connected to the OBU.
   i. An example of a case with an HMI showing a GPS status alert is provided as an example:

Figure 15

b. All wiring is contained in the portable case. This may include relays, diodes, CPT boards, and two-position switches to achieve the wiring required to trigger applications and simulate vehicle signal trigger sources.

Figure 16

The example shown is not of the OBU for this project. The example shows the OBU wired for all connections to power and accessory signals for the proper deployment of V2X applications from the OBU.

2. Adjustable V2X Antenna
    a. For portable OBUs, there is still a requirement for a roof-mounted antenna. This must be placed on the roof by the driver before using the portable OBU sub-system.

Figure 17

The example of the V2X antenna on the portable case above shows the metal plate that is incorporated into the case for use with a magnetic antenna. The metal plate allows the antenna to be secured during transport outside of the vehicle, and storage when not in use.

3. Adjustable HMI
    a. For portable OBUs that use a human-machine interface to display or provide driver alerts, this must be included in the portable case.

Figure 18

The example of an HMI integrated into a portable OBU is shown above. This is for a 'heads-up-display' HMI and this would be placed on the dash before each drive using a portable OBU.

b. A tablet is another common display HMI that is used in a portable configuration. The tablet has the benefit of more features of interfacing with the OBU from the tablet. It can be used to calibrate and configure the OBU more than other HMIs. The most common way for mounting a tablet into a portable OBU configuration is to use a 'ball & socket' arm with a tablet case for attachment.

Figure 19

4. Driver Operated I/O Trigger Input
    a. For many OBU applications, there is a requirement to get a vehicle signal 'status' input. This input may be for the status of a vehicle accessory system that would trigger a V2X application alert or message. Examples include Light Bar activation for EVP.

Figure 20

A common I/O trigger for a portable case would use a latching switch to provide voltage to a GPIO harness wire for the OBU. This would use the power input to the case but not require any further connections outside the vehicle.

5. LTE Modem or Router
    a. For security and logging requirements of the OBUs, there is sometimes the requirement to connect a data cable between a wireless modem and the OBU. This can be achieved in a portable OBU case also. The key limitation to consider when installing an OBU and a modem into a single portable case is, what interior dimension is required to leave space for air circulation. Can the OBU and the Modem fit together, or is a larger case needed to accommodate both items?

Figure 21

Use Case Requirements for Installation

For each of the described 'types' of OBU system that can be provided, there are several advantages to each. The role of a connected vehicle stakeholder team will be to coach the Vehicle Owner or Fleet Operator on which is best suited for their vehicles based on their goals for the outcome from the deployment of connected vehicle deployment.

For trainees who are receiving instruction that will allow them to provide a recommendation for the type of installation to be performed, it is helpful to know the Classes / Types of vehicles commonly operated by Fleets that could benefit from the C-V2X technology for their vehicles:

Vehicle Type / Class	Example of This Type of Vehicle
Class 1 - Light Duty	Ex: Police Patrol Car (sedan)

Class 2 - Light Duty	Ex: Police Patrol Car (SUV or Pickup)
Class 3 - Light Duty	Ex: Ambulance or Emergency Response Truck
Class 4 - Medium Duty	Ex: Local Delivery Van or Sign Truck
Class 5 - Medium Duty	Ex: School Bus
Class 6 - Medium Duty	Ex: Single Axle City Maintenance (snowplow)
Class 7 - Heavy Duty	Ex: City Bus
Class 8 - Heavy Duty	Ex: Fire Truck

Table 2

Based on these various Classes, we can assume some conditions for their regular use cases. For instance, a Fire Truck has a plethora of additional equipment and in-vehicle electronics. Also, these vehicles are used in any condition, so all processes of installation must account for operation in a harsh environment. For this reason, it would be recommended that a Fire Department strongly consider a permanent installation for their OBUs. This will have the longest useful life for the equipment in this type of vehicle.

A representative decision tree with basic factors for providing a recommendation is included as an example of possible guidance to be provided to technicians:

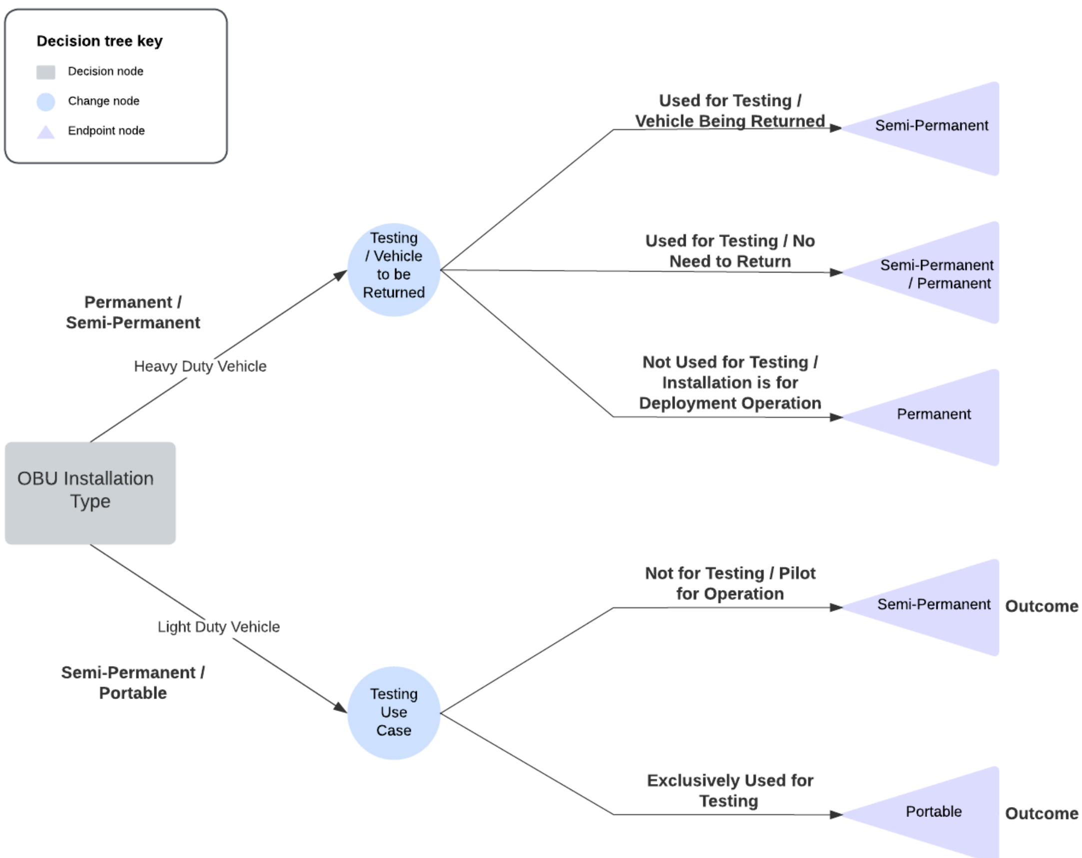


Figure 22

Data Connections

For larger vehicles that are not in the ‘light’ or ‘medium’ duty category - these will have a different requirement when connecting to a vehicle source for CAN Bus data. The two common port types when connecting the OBU to a source for vehicle CAN, are:

- J1939
- OBDII

The connectors will appear different and have a different set of standard pins that provide different elements of the CAN Bus data stream from the vehicle's OEM computer sensor system.

J1939 & OBDII Standard Connector Pins

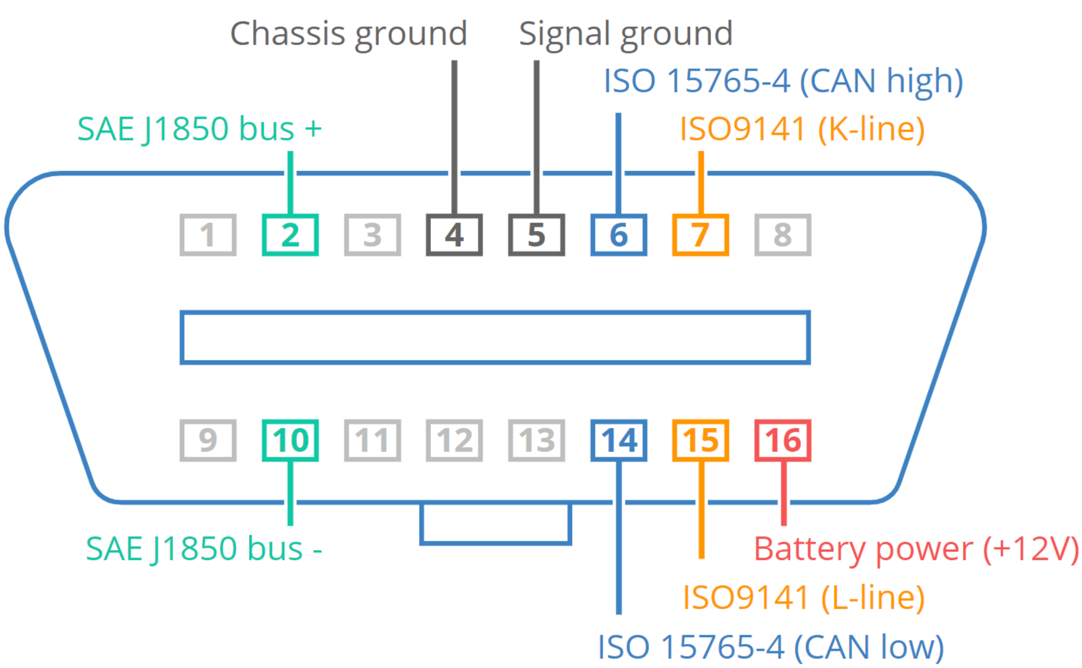
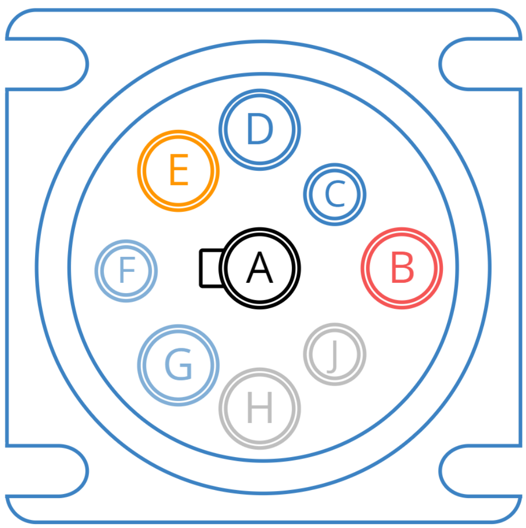


Figure 23

For Light-Duty model vehicles this is the OBDII data connector port with pin positions and labels. This is a standard connector type used in the automotive industry as a diagnostic port.

Workforce Development Plan

ROAD COMMISSION for OAKLAND COUNTY



A Ground
B Battery power
C CAN 1 H
D CAN 1 L
E CAN shield
F J1708 (+) / CAN 2 H
G J1708 (-) / CAN 2 L
H OEM specific
J OEM specific

Type 1 (black): CAN 1 = 250K
Type 2 (green): CAN 1 = 500K

Figure 24

Heavy-duty model vehicles are more likely to contain the J1939 type of data port for connection. This may have a ‘Green’ plastic portion of the connector, which may help identify its location when performing an installation. Installing the OBU Vehicle interface harness may require separating the CAN wires from other wires of the harness, and then routing them separately to the data connection point in the vehicle. CAN wires are also in a ‘twisted pair’ which means that wires are tightly twisted together, and this is a critical feature for these wires to transmit data properly. Any twisted pair wires in the vehicle interface harness should be routed together and remain twisted until the point where they are connected to the vehicle data port.

Most commonly, technicians will be instructed to connect to the data port using a connector for the interface. This will ensure that none of the vehicle’s factory wires are damaged. When a data wire is damaged during a step of installation it can cause missed data transmission and the failure of critical driving and safety systems. Since there is no ‘standard’ CAN connector, very few OBU manufacturers supply a supplemental component for connection to CAN. As a step of installation, new connected vehicle technicians will be taught how to use a separate data harness to connect the OBU to these sources for vehicle inputs.

Figure 25

Splitters are commonly used for a connection to a vehicle's data port without a requirement to modify vehicle factory wiring.

Figure 26

For using a splitter to connect we can splice into the raw wires of the splitter for connection. This will prevent the need to cut / splice wires after the vehicle's OBD II or J1939 port position.

8.4 Maintenance Training

For all OBU installed into a vehicle, there should be a plan to perform regular health and system checks. This can commonly be incorporated into existing checklists that are performed by maintenance technicians, or vehicle Drivers. For all items included in the OBE, trainees would learn how to perform and document the following preventative maintenance checks:

- Visual Inspection - Check the on-board unit 'status lights' upon power up.

Description
Beth - BroadR-Reach Ethernet
Cell - Cellular
CV2X
DSRC
GNSS
WLAN - WiFi / Bluetooth
SYS - OBU status

Figure 27

For the Cohda MK6 OBU, seven (7) LED lights on the OBU can provide a status indication for the connectivity of the unit to the required inputs. Inputs are for both the power ('SYS') as well as for communication ('C-V2X'; 'DSRC'; 'Cell') If any of the lights are not showing their expected color or light pattern following the operation of the vehicle, it should be noted on a preventative maintenance checklist as this may impact the OBUs ability to function.

- HMI Visual Indicator - Upon power-up, check that the HMI is providing any manufacturer-programmed 'splash-screen' or other visual representation that there is a video feed being driven by the OBU. This is an indication that the OBU is working as expected.

- GPS Status Check - Upon power up, check that the 'GNSS' light is showing a solid green status light.

- System Log Review - Once the vehicle has been in operation for several days in the connected environment there should be a 'log' or record of alerts, and message transmissions from the OBU / RSU. Reviewing these will give a confirmation of proper function.

- ITS System Log or SCMS Log Review - *SCMS* or Security Credential Management System is another stored log that may provide further details for whether an OBU is working once installed. The SCMS platform provides 'certificates' to individual OBUs for their secure messaging. By checking the SCMS platform it can be seen which have active security credentials and should be working properly.

8.5 Certification

Certification is awarded to trainers upon successful completion of the program.

- For certifications to be given during training it is important to establish in the early phases of planning:
    - Who is issuing the certification?
    - What are they certifying the trainee for?
    - Does it have a material impact, or is it an acknowledgment of their effort? It is important to distinguish.
    - What burden of retraining may be associated with the certification?
    - How many people should have this certification?
    - Who are the right people to have this certification?
    - Who will manage the list of certified trainees, and ensure that records are maintained?
- Trainer Support and Resources
    - Ongoing technical support from subject matter experts.
    - Access to a knowledge base and technical documentation.

- Regular updates on new technologies and best practices.
- A community forum for trainers to share experiences and solutions.

9 Partnerships and Collaborations

The successful execution of the Workforce Development Training Plan hinges on robust partnerships and collaborations with key stakeholders within the automotive and connected vehicle ecosystem. These partnerships will be critical in ensuring the deployment of connected vehicle technology is sustainable, scalable, and meets the industry standards for safety, quality, and job satisfaction. The following entities have been identified as strategic partners for workforce development activities:

Automotive Industry Partners

- Original Equipment Manufacturers (OEMs): Collaboration with OEMs such as Ford, General Motors, and Stellantis will provide insights into the integration of CV technology with new vehicle models. OEMs will also offer support in terms of technical expertise and access to the latest vehicle technology.
- Tier 1 Suppliers: Partnerships with Tier 1 suppliers like Bosch, Harman, and Continental will ensure the availability of necessary components and technical support for CV technology deployment.

Educational Institutions

- Oakland Community College, Lawrence Tech University, Oakland University: Partnering with local educational institutions to develop and deliver training programs tailored to CV technology. These institutions can provide facilities for hands-on training and workshops.
- Trade Schools and Professional Development Organizations: Collaborations with entities such as the Auto Diesel Institute (Baker College) will help in training new technicians and reskilling existing ones to meet the demands of CV technology.

Government and Public Sector

- Road Commission of Oakland County (RCOC): As the lead jurisdiction for the project, RCOC will play a crucial role in facilitating training for its own fleet.
- Other agency fleets within Oakland County: Other local agencies would rely initially on the project partner performing vehicle installation for initial training.

- Other Government Agencies: Engagement with agencies such as SMART, DDOT, and MDOT will be essential for extending training to their respective fleets and ensuring a unified approach to CV technology deployment.

Industry Associations and Standards Organizations

- SAE International and IEEE: Collaborations with these organizations will ensure that the training programs adhere to industry standards and best practices. Their resources will also help in staying updated with the latest advancements in CV technology.

Private Sector and Aftermarket Adopters

- Freight and Logistics Companies: Engaging with companies like FedEx, UPS, and local delivery services to train their technicians on CV technology, thereby promoting widespread adoption of the technology.
- Consumer Service Providers: Collaboration with businesses in sectors like HVAC, plumbing, and waste management to integrate CV technology into their fleet operations.

10 Performance Metrics and Evaluation

A comprehensive set of performance metrics and evaluation criteria will be established to ensure the effectiveness of the Workforce Development Training Plan. These metrics will provide quantitative and qualitative data to measure the success of the training initiatives and identify areas for improvement.

10.1 Key Performance Indicators (KPIs)

1. Training Completion Rate: The percentage of enrolled technicians who complete the training program.
2. Certification Rate: The number of trainees who achieve certification upon completing the training, indicating their readiness to deploy and maintain CV technology.
3. Job Placement Rate: The percentage of trained technicians who secure employment in roles related to CV technology within six months of completing the training.

4. Retention Rate: The rate at which trained technicians remain in their positions, reflecting job satisfaction and the effectiveness of the training in preparing them for their roles.
5. Quality of Installation: Evaluation of the quality and accuracy of CV technology installations performed by trained technicians, measured through post-installation audits and customer feedback.

Evaluation Methods

- Surveys and Feedback Forms: Collecting feedback from trainees and employers to assess the effectiveness of the training content, delivery methods, and overall satisfaction.
- Practical Assessments: Hands-on evaluations during and after the training to ensure technicians can apply the learned skills in real-world scenarios.
- Follow-up Interviews: Conduct interviews with trainees and their employers at regular intervals to gauge the long-term impact of the training on job performance and career development.
- Regular Review of Training Materials: Updating training content to reflect the latest advancements in CV technology and industry best practices.
- Stakeholder Workshops: Hold periodic workshops with stakeholders to review performance metrics, share insights, and identify opportunities for improvement in the training program.

11 Implementation Plan

The implementation plan outlines the steps and timeline for executing the Workforce Development Training Plan, ensuring a structured approach to achieve the training objectives and deliverables.

Phase 1: Planning and Preparation

- Establish Training Partnerships: Formalize agreements with key partners, including OEMs, educational institutions, and industry associations.
- Develop Training Curriculum: Create a comprehensive curriculum that includes theoretical knowledge, hands-on training, and practical assessments.
- Identify Training Facilities: Secure locations for conducting training sessions, including classrooms, workshops, and field training sites.

Phase 2: Training Program Rollout

- Pilot Training Sessions: Conduct initial training sessions with a small group of participants to validate the curriculum and gather feedback.
- Full-Scale Training Deployment: Roll out the training program to a broader audience, targeting technicians from RCOC, local government fleets, and private sector partners.
- Certification Process: Implement the certification process for trainees who successfully complete the program, ensuring they are recognized for their expertise in CV technology.

Phase 3: Monitoring and Evaluation

- Track Performance Metrics: Collect data on key performance indicators to measure the success of the training program.
- Conduct Evaluations: Regularly evaluate the effectiveness of the training through surveys, practical assessments, and follow-up interviews.
- Adjust Training Methods: Use the collected data to refine and improve the training program, ensuring it meets the evolving needs of the industry.

Phase 4: Scaling and Sustainability

- Expand Training Partnerships: Engage additional partners to expand the reach of the training program and accommodate more trainees.
- Develop E-Learning Modules: Create online training modules to complement in-person sessions and provide flexible learning options.
- Sustainability Plan: Establish a long-term plan to ensure the training program remains relevant and sustainable, including securing funding and resources for ongoing training needs.

Proposed Timeline for Stage 2 Vehicle Workforce Development

	YEAR 1				YEAR 2				YR. 3	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Phase 1										

Phase 2										
Phase 3										
Phase 4										

Table 3

12 Conclusion

The Workforce Development Training Plan is designed to equip technicians with the skills and knowledge required to successfully deploy and maintain connected vehicle technology. By leveraging strong partnerships, rigorous performance metrics, and a structured implementation plan, RCOC will be well-positioned to lead the nation in connected vehicle technology deployment, ensuring a safer, more efficient transportation system for all.