

Connected Vehicle Pilot Deployment Program Independent Evaluation

Stakeholder Acceptance & User Satisfaction Assessment—Wyoming

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16. Abstract This report presents the stakeholder acceptance and user satisfaction evaluation conducted by the Texas A&M Transportation Institute (TTI) Independent Evaluation Team of the Wyoming Connected Vehicle Pilot Deployment (CVPD). The purpose of the evaluation was to assess whether and how the Wyoming CVPD achieved the vision, goals, and desired mobility, environmental, and public agency efficiency impacts. In addition, the information gathered from stakeholders included observations and experiences pertaining to anticipated or potential challenges (e.g., technical, institutional, and financial), adopted solutions, and lessons learned. The results are intended to be of benefit to the long-term sustainability of the connected vehicle (CV)–deployed applications and to other entities seeking to deploy CV applications.					
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Chapter 1. Introduction

The purpose of the stakeholder acceptance and user satisfaction evaluation was to assess whether and how the Wyoming connected vehicles pilot deployment (CVPD) achieved the vision, goals, and desired mobility, environmental, and public agency efficiency (MEP) impacts. In addition, the information gathered from stakeholders included observations and experiences pertaining to anticipated or potential challenges (e.g., technical, institutional, and financial), adopted solutions, and lessons learned. The results are intended to be of benefit to the long-term sustainability of the connected vehicle (CV)–deployed applications and to other entities seeking to deploy CV applications.

The stakeholder acceptance/satisfaction data collection for the Wyoming CV Pilot Deployment (CVPD) included both qualitative and quantitative methods: qualitative interviews, online surveys, and a virtual workshop. The qualitative interviews were well suited for examining and exploring contextual issues for the deployment; perspectives on vision, goals, and desired impacts; and concerns and challenges in advance of the start of the CVPD. The survey allowed for the quantification of outcomes (both desired and not desired) from a broader group of stakeholders. The virtual workshop brought together key stakeholders in Wyoming to review and discuss the findings of the interviews, assess the outcomes of the CVPD, and provide strategic and operational recommendations (and lessons learned) for subsequent activities.

Wyoming Connected Vehicle Pilot Deployment

The Wyoming Department of Transportation’s (WYDOT’s) primary goal for implementing the Wyoming CVPD was to demonstrate the potential and feasibility of using CV technologies to improve safety and mobility along 402 miles of Interstate 80 (I-80) in southern Wyoming. As the lead agency, WYDOT wanted to explore using CV technologies to communicate road and travel information to commercial truck drivers and fleet managers that routinely travel the I-80 corridor. The deployment built upon WYDOT’s extensive road weather and traveler information systems to provide warnings and alerts about road conditions, particularly during severe winter weather and high wind events.⁽¹⁾

At a high level, the scope of deployment included implementing the following:⁽²⁾

- Deploying around 75 roadside units (RSUs) that could receive and broadcast messages using dedicated short-range communications (DSRC) along various sections of I-80.
- Equipping a combination of WYDOT fleet vehicles (e.g., snowplows, highway patrol vehicles, and others) and commercial trucks—all regular users of I-80—with onboard units (OBUs) capable of receiving alerts and broadcasting basic safety messages (BSMs). A portion of the vehicles could also collect and disseminate environmental and road condition information using mobile weather sensors.
- Developing multiple vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) applications that communicate alerts and advisories to drivers about road conditions. The applications were designed to support the in-vehicle dissemination of advisories for avoiding collisions, managing speeds, implementing detours, and alerting drivers to the presence of downstream

work zones and maintenance and emergency vehicles—all based on the vehicle’s location in the network.

- Enabling improvements to WYDOT’s TMC and traveler information practices by using data collected from CVs. Targeted improvements included better activation of WYDOT’s variable speed limit (VSL) and traveler information dissemination systems (i.e., 511, dynamic message signs, and others).

Organization of Report

The TTI CVPD Evaluation Team has organized this report into the following chapters. The titles of each chapter and the major topics contained therein are:

- **Chapter 2. Target Stakeholders**—This chapter describes the target stakeholders engaged throughout the course of the CVPD and subsequent evaluation, including stakeholder type, specific stakeholder entities, and the respondents for the various evaluation efforts documented in this report.
- **Chapter 3. Interviews and Surveys**—This chapter provides the results of the pre- and post-deployment interviews and surveys conducted as part of the evaluation.
- **Chapter 4. Post-Deployment Workshop**—This chapter describes the results of the virtual post-deployment workshop held with the Wyoming CVPD Team.
- **Chapter 5. User Satisfaction Evaluation**—This chapter describes the results of the user satisfaction surveys conducted as part of the Wyoming CVPD.
- **Chapter 6. Summary of Results**—This chapter provides an overall summary of the results for stakeholder acceptance and user satisfaction across all evaluation activities.

Chapter 2. Target Stakeholders

For this evaluation, a *stakeholder* is defined as an entity/agency that is directly responsible for planning, designing, operating, and/or maintaining one or more of the systems or technologies associated with the Wyoming CVPD or that financially or institutionally influence the decision making and sustainability of the deployment. Examples of stakeholders include city and/or state departments of transportation (DOTs), transit agencies, private fleet operators, etc. Stakeholders differ from end users. For this evaluation, *end users* are those individual vehicle operators in whose vehicles the equipment is installed and that receive information from applications that might influence their travel behavior on any given trip. Examples of end users include vehicle operators, pedestrians, transit vehicle operators, etc.

Categories of Stakeholders

Six categories of stakeholders were the target of the acceptance/satisfaction information gathering activities as part of the Wyoming CVPD. ⁽³⁾ These stakeholder groups are:

1. **Deployment managers** are those individuals associated with the lead deployment agency and decision makers for each CVPD. For the Wyoming CVPD, WYDOT Geographic Information Services/Intelligent Transportation Systems group is the lead stakeholder.
2. **Deployment team members** are those individuals/agencies responsible for planning, development, and/or implementation of the applications and technologies. They include private sector technology partners and universities. There are six deployment team entities involved in the Wyoming CVPD.
3. **Operating agencies** are involved in pre-deployment planning and development activities, as well as day-to-day operations of the pilots once started. These include the Wyoming State Highway Patrol and WYDOT traffic management center. They may also include agencies involved in pass-through of funding. The TTI CVPD Evaluation Team has identified six operating agencies involved with the Wyoming CVPD.
4. **Fleet operators** are those agencies that will be installing and operating CV technologies in multiple vehicles. They include WYDOT snowplow operators and commercial freight operators in Wyoming. The Wyoming CVPD Team has listed seven commercial freight stakeholders.
5. **Supporting agencies** may interact with or have their operations impacted by the pilot deployments. These agencies include law enforcement, state and local government, relevant associations, and special interest groups. There are many supporting agencies in each CVPD.
6. **Policy makers** are in a position to have influenced the selection of the pilot site or to make decisions about the deployment in the future. The WYDOT Commission and state legislators are in this stakeholder group.

Table 1 provides descriptions of these stakeholders.

Users of the CV applications are not considered stakeholders. Different data collection methods were used to collect acceptance/satisfaction information from the stakeholder types due to varying roles in the CVPDs.

Table 1. Wyoming CVPD Stakeholders. ⁽³⁾

Stakeholder Category	Agency/Entity
Deployment Manager	<ul style="list-style-type: none"> Wyoming Department of Transportation (WYDOT)
Deployment Team Members	<ul style="list-style-type: none"> ICF Trihydro University of Wyoming McFarland Management Vital Assurance National Center for Atmospheric Research (NCAR)
Operating Agencies	<ul style="list-style-type: none"> WYDOT Highway Patrol WYDOT Traffic Management Center (TMC) WYDOT Geographic Information Systems/Intelligent Transportation System (GIS/ITS) WYDOT Telecomm WYDOT GIS/ITS Contractors WYDOT Maintenance
Fleet Operators	<ul style="list-style-type: none"> WYDOT Snowplow Operators Freight Operators
Supporting Agencies	<ul style="list-style-type: none"> Wyoming Trucking Association County Emergency Management Adjacent State DOTs
Policymakers	<ul style="list-style-type: none"> Transportation Commission State legislators

Source: Texas A&M Transportation Institute, 2022

Wyoming Stakeholder Evaluation Goals and Objectives

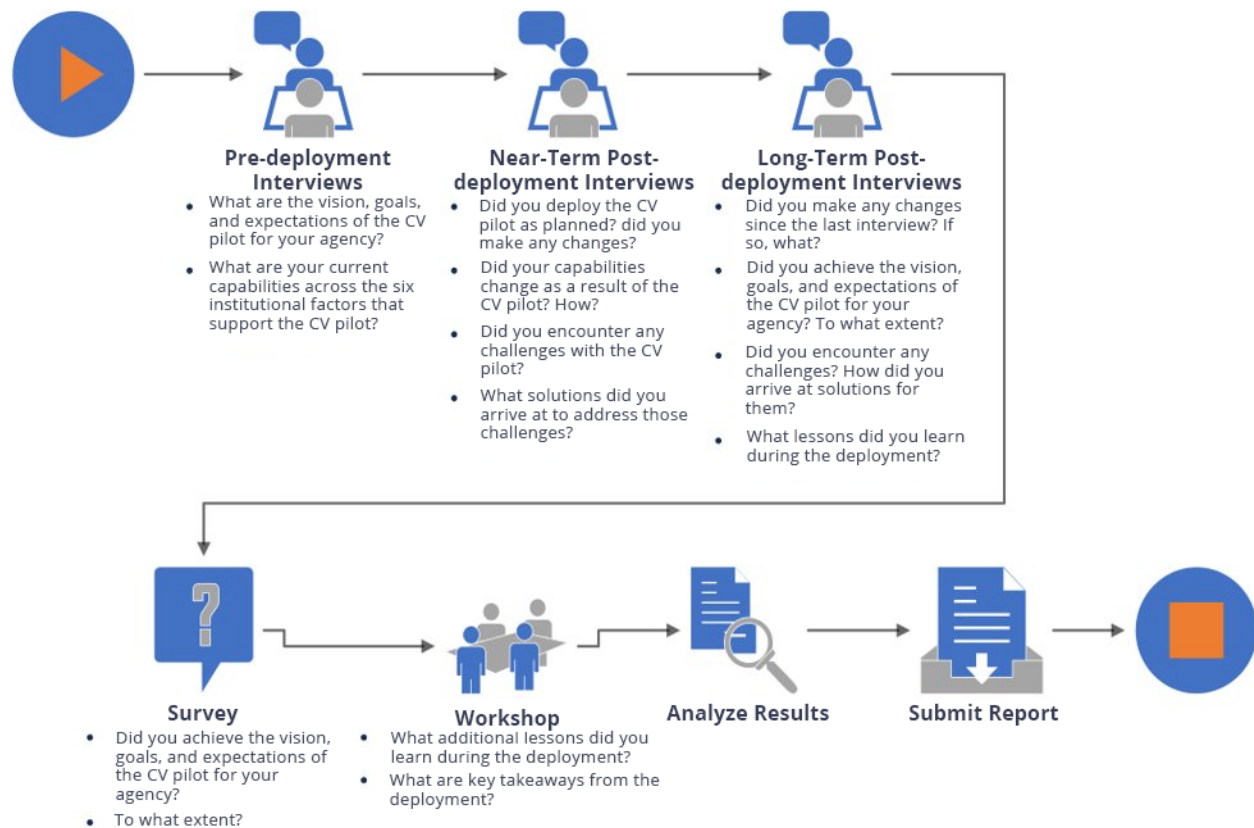
The TTI CVPD Evaluation Team identified the following key stakeholder acceptance and user satisfaction evaluation objectives for the Wyoming pilot deployment: ⁽³⁾

- Reduce the number of truck-related crashes and incidents (including secondary incidents) due to adverse weather conditions along the I-80 corridor to improve safety and reduce incident-related delays
- Improve emergency management on the I-80 corridor through early identification of conditions and improved messaging and communication
- Improve freight driver's ability to locate truck parking locations along the corridor. This objective is safety related as it allows drivers to find safer parking locations in designated areas and to better meet hours of service regulatory requirements

- Improve freight traveler information on construction activities in the corridor. This objective is related to both the safety of the construction zones and the increased efficiency of the freight logistics through improved information for the scheduling of freight movements through the corridor
- Improve mobility for connected trucks and for all traffic while reducing negative environmental impacts along I-80 during adverse weather through reductions in truck-related crashes and incidents by deploying connected vehicles, improved freight traveler information, and weather-responsive variable speed limits
- Improve freight reliability through improved freight traveler information
- Improve decision-making by transportation managers
- Improve customer satisfaction of connected truck drivers.

As illustrated in Figure 1, the stakeholder acceptance analysis assessed the perceptions of the stakeholders regarding whether these objectives were achieved by the deployment throughout its various stages. Through a series of interviews, surveys, and workshops, the TTI Evaluation Team explored how stakeholder acceptance throughout the deployment on a wide variety of topics and issues, such as:

- Changing of evolving goals and objectives for the deployment
- Changing institutional, technological, and agency factors that includes the capabilities implemented in the deployment
- Changing stakeholder perspectives related to challenges, issues, and lessons learned through the various stages of deployment and operations.



Source: Texas A&M Transportation Institute, 2022

Figure 1. Flowchart. Stakeholder acceptance and user satisfaction evaluation process.

Analysis Approach

The Stakeholder Acceptance Evaluation implemented a multipronged approach for the data collection that included qualitative interviews, on-line survey, and a virtual workshop. ⁽⁴⁾ These efforts are described as follows:

- **Qualitative interviews** in the form of one-on-one discussions were conducted with deployment managers, deployment team members, operating agencies, and policy makers. These individuals were interviewed because they are the most invested and involved in the pilots and would be able to provide rich feedback. Policy makers were also interviewed given their status and potential influence on long-term sustainability of the deployments. These interviews were conducted at three points in time: immediately after the planning/design stage (i.e., pre-deployment), shortly after activation of devices (i.e., near-term post-deployment), and toward the end of the deployments (i.e., long-term post-deployment). Pre-deployment interviews were intended to elicit vision, goals, and expectations. Post-deployment interviews served to capture information about deployment experiences, outcomes, and satisfaction.
- **A post-deployment online survey** (rather than in-depth interviews) was administered to fleet operators and supporting agencies because they were less involved in day-to-day pilot planning and execution. The survey gathered information on how well the pilot deployment program fulfilled these stakeholders' goals and objectives.

- **A virtual post-deployment workshop** was held after interviews were completed to foster additional dialog among deployment managers, deployment team members, and operating agencies. The workshop was structured to capture distinct information. The workshop was also used to foster cross-stakeholder dialog and discussion about challenges, solutions, and lessons learned. The workshop confirmed and clarified key findings.

Survey instruments and interview guides for each of these activities are presented in this document in the appendices. These instruments only collected qualitative input from stakeholders on safety impacts because the Volpe National Transportation Systems Center was responsible for conducting the safety evaluation. Table 2 shows the distribution of data collection activities across stakeholder types.

Due to time constraints and delays in getting the deployment operational, the TTI Evaluation Team was unable to perform the on-line survey as planned.

Table 2. Data collection method by stakeholder type.

Stakeholder Type	Pre-deployment Interviews	Post-deployment Interviews—Near Term ¹	Post-deployment Interviews—Long Term ²	Survey	Workshop
Deployment managers	Yes	Yes	Yes	No	Yes
Deployment team	Yes	Yes	Yes	No	Yes
Operating agencies	Yes	No	Yes	No	Yes
Fleet operators	No	No	Yes	No	No
Supporting agencies	No	No	No	No	No
Policy makers	Yes	No	Yes	No	No

Notes

¹ Near-term post-deployment is 2–3 months after activation.

² Longer-term post-deployment is 9–12 months after activation.

Source: Texas A&M Transportation Institute, 2022

Summary of Data Collection Approach

Table 3 summarizes the data collection approach for the stakeholder acceptance evaluation plan for Wyoming.

Table 3. Summary of data collection approach—Wyoming.

Data Collection Activity	Purpose	Timeline	Target Group
Pre-deployment interviews	Vision, goals, and expectations. Gather financial and institutional preparedness.	Prior to activation	<ul style="list-style-type: none"> • Deployment managers • Deployment team members • Operating agencies • Policy makers
Near-term post-deployment interviews	Early deployment experiences, challenges, and solutions.	1–3 months after activation	<ul style="list-style-type: none"> • Deployment managers • Deployment team members
Long-term post-deployment interviews	Vision, goals, and desired MEP impacts achieved. Experiences/ observation pertaining to challenges (e.g., technical, institutional, and financial), adopted solutions, and lessons learned. Satisfaction with pilot outputs/outcomes.	9–12 months after activation	<ul style="list-style-type: none"> • Deployment managers • Operating agencies • Policy makers
Workshop	Cross-stakeholder dialog concerning the lessons learned and major takeaways. Information for financial and institutional assessments.	9–12 months after activation	<ul style="list-style-type: none"> • Deployment managers • Deployment team members • Operating agencies
Survey*	Data from stakeholders who are important but less engaged in day-to-day operations about whether and how the CVPD achieved the vision, goals, and desired MEP impacts.	9–12 months after activation	<ul style="list-style-type: none"> • Fleet operators • Support agencies

*Not performed due to limit time constraints caused by delays in getting the deployment fully operational.

Source: Texas A&M Transportation Institute, 2022

Chapter 3. Stakeholder Interviews

The TTI CVPD Evaluation Team conducted pre- and post-deployment interviews with deployment managers, deployment team members, operating agency staff, and policy makers who were involved in the Wyoming CVPD. ⁽³⁾ The objectives of the pre-deployment interviews were to gather in-depth baseline information on vision, goals, and desired impacts; anticipated or potential challenges; and desired outcomes. The post-deployment interviews were used to assess whether the pilots achieved their vision, goals, and desired impacts as well as to derive lessons learned for future CVPDs. The post-deployment interviews were conducted at two points in time: ⁽³⁾

- Shortly after deployment to get initial feedback (i.e., near term)
- Toward the end of deployment to gather comprehensive information (i.e., long term).

Identification, Selection, and Invitation of Interviewees

The target stakeholders for interviews are deployment managers, deployment team members, operating agencies, and policy makers. The evaluation plan outlined that deployment managers would be interviewed at three points in time, deployment team members at two points in time, operating agencies at two points in time, and policy makers at two points in time. This plan was accomplished except for policy makers (see Table 4). The willingness and availability of stakeholders to be interviewed diminished over time as noted in the table below.

The Wyoming CVPD manager identified the persons to be interviewed in all interviews. The selected individuals were from target stakeholder entities that were especially knowledgeable about or had history with the CVPD.

Table 4. Numbers of Wyoming CVPD stakeholder interviews by type and timepoint.

Stakeholder Type	Pre-deployment	Near-Term Post-deployment	Long-Term Post-deployment
Deployment managers	2	2	2
Deployment teams	6	5	1
Operating agencies	6	Not applicable according to plan	1
Fleet operators	Not applicable according to plan	Not applicable according to plan	1
Policy maker	1	Not applicable according to plan	0
Total interviews	15	7	5

Source: Texas A&M Transportation Institute, 2022

The TTI CVPD Evaluation Team sent email invitations to identified individuals to participate in the interviews. The email contained information about the study purpose, interview method, content, and duration. An informed consent document was attached to the email invitation. The participants who replied in the affirmative to the email invitation were asked to provide their availability, after which a suggested date and time for the interview was communicated. As noted above, stakeholders' compliance with the interview requests diminished over time.

Interview Guide

A semi-structured interview format was used (see Appendix A). In semi-structured interviewing, a guide is followed, with questions and topics that must be covered. An interviewer has some discretion about the order in which questions are asked, but the questions are standardized, and probes are provided to ensure that the researcher covers the correct material. This kind of interview collects detailed information, which is needed for the stakeholder assessment, but in a way that is consistent yet conversational.

The pre- and post-deployment interview questions covered the following topic areas:

- Visions, goals, and objectives
- Pilot effectiveness
- Policy challenges
- Institutional challenges
- Culture
- Collaboration
- Financial issues
- Business processes
- Performance measurement
- Systems and technology
- Workforce development
- Outreach
- User experience/satisfaction.

The pre-deployment and long-term post deployment interview guides were about equal in length, whereas the near-term post-deployment interview guide was shorter. Although the interview guides contained a few of the same questions across the time periods, many of the questions were different across deployment stages. The actual interview guides are presented in Appendix A. It was anticipated that many of the questions were pertinent to all stakeholder types, but to target the interview and to reduce burden on the interviewees, interviewees were advised to answer only those questions for which they felt comfortable and knowledgeable in answering.

Implementation of Interviews and Schedule

All interviews started with an explanation of the evaluation purpose, scope, and sponsors, and a description of the purpose and process for the stakeholder interviews. The confidentiality of the collected

information was highlighted (i.e., responses will not be attributed to specific individuals) and the need for IRB/human subject protection requirements even though the efforts were not determined to be human subject research. Following this introduction, the main body of the interview began.

The first five pre-deployment interviews served as a rolling pilot to test the questions' wordings for clarity and efficacy. A set of evaluative questions were asked of the interviewees after the interview was completed. The following are sample questions:

- How relevant were the questions?
- Were the questions clear and understandable?
- Were there any biased questions?
- What questions should I have asked (i.e., possible missed questions)?

Afterward, no questions were added, but the wording of some questions were tweaked. In addition, two members of the TTI CVPD Evaluation Team participated in the pre-deployment interviews for quality assurance purposes. One individual led the interview, asked the questions, and facilitated the discussion. The second individual took notes. This was not continued for the post-deployment interviews. One person conducted each post-deployment interview.

The questions were sent to the interviewees in advance of the interviews to help facilitate discussions. The durations of the interviews varied, depending on the number and type of questions answered, with an average of about 30 minutes per interview. The following is a breakdown of the interview durations by stage:

- Pre-deployment interviews with deployment managers, deployment team members, operating agencies, and policy makers lasted no more than 45 minutes.
- Near-term post-deployment interviews lasted about 20 minutes.
- Long-term post-deployment interviews lasted no more than 40 minutes.

Upon completion of the interviews, interviewees were asked if they would like the opportunity to review the interview summary. If yes, it was sent to them for review, edit, and approval. About one-third of interviewees asked to review the summary.

According to the Reference (6), the Wyoming CVPD Team pre-deployment period ran from 2018 to mid-2019. The post deployment valuation period ran from late 2019 through early 2022. Table 5 shows the general period for the execution of interviews for each of the points in time.

Table 5. Interview schedule.

Interview Type	Wyoming CVPD Interviews
Pre-deployment	January-February 2019
Near-term post-deployment	November–December 2019
Long-term post-deployment	March 2022

Source: Texas A&M Transportation Institute, 2022

Interview Analysis Methods

Immediately following the interviews, the responses of each stakeholder to every question were summarized. Information was anonymized. The summary reports were organized by topic area and interview question, with a final section asking for concluding thoughts.

Pre-deployment Interviews

The findings in this section represent the results of 15 interviews with deployment managers, deployment team members, and operating agency staff, as well as one policy maker in January-February 2019.

Vision and Goals

The stated goal of the Wyoming CVPD was to use CV technology to reduce crashes on the I-80 corridor by alerting drivers of existing crashes on the road ahead. The primary indicators of success were evidence of reduction of crashes and fatalities. Success was secondarily characterized as proving that the deployed technology worked so that USDOT and OEMs would support further development and adoption of it.

Policy Challenges

A policy challenge was identified, that is whether USDOT would continue funding past the pilot stage. This issue was raised even though USDOT had clearly communicated to CVPD sites that funding ended with the completion of Phase 3 and that each site was responsible for funding continuation of the pilot beyond Phase 3.

Institutional Challenges

One cited institutional challenge was related to a communications networking issue (i.e., the state's network was configured for IPv4 and the CV system required IPv6). To address this, WYDOT needed to work through the State of Wyoming's centralized IT department (not part of WYDOT). WYDOT perceived that this department was not as responsive to its needs as an internal IT department would have been. Another institutional issue was that WYDOT underestimated the staff and time resources that the pilot would require, i.e., the level of ConOps detail required, the number of WYDOT departments that would be involved, the level of training that should have been provided for people working on the pilot.

Culture

All entities involved in the pilot supported its implementation, which helped in ensuring needed support and flexibility when issues such as the longer timeline for the roll-out of the system happened.

Collaboration

All entities brought different priorities to the pilot deployment (e.g., WYDOT, public good; private companies, potential profit) but these different perspectives did not result in lack of collaboration. All

stakeholders had the opportunity to participate in stakeholder meetings and provide input on the decisions made during the design of the CV system.

Financial Issues

The large question was how to attain financial sustainability beyond the pilot period. How it will be funded and who will fund? If successful, WYDOT had indicated a commitment to future funding to maintain and expand the system. However, it was thought that true expansion would require OEM commitment to installing CV devices in new vehicles. At this time, the likelihood of this happening was uncertain.

Business Processes

WYDOT would view the CV system as another tool in their ITS toolbox if proven successful in the pilot. At the time of the interviews, interviewees were still figuring out how to address all the new data being introduced into the TMC environment and whether this data stream would require new business processes for the TMC.

Performance Measures

Several performance measures were developed, including system performance measures, such as decreases in crashes to reduce response time and better management of road closures, and behavioral measures, such as how do drivers respond to the traffic information received. At the time of the interviews, the Wyoming CVPD team was unsure whether the pilot would be able to capture the quality data necessary to populate these types of performance measures.

Systems and Technology

WYDOT was essentially receiving prototypes of the needed CV hardware (OBUs and RSUs) as well as immature software (e.g., unstable firmware) rather than road-hardened technology. Also, the hardware was not adequate to withstand the “wear and tear” of deployment in the harsh Wyoming climate. The immaturity of the SCMS software caused security issues at the start but with a switch in vendors midstream those issues diminished. This situation negatively impacted the project schedule as numerous issues with the technology needed to be worked through during the planning stage.

The Wyoming CVPD was procuring CV technology from smaller start-up companies, so they did not necessarily have the depth of resources to support the iterations of development and testing necessary to develop a refined product.

Troubleshooting of technology issues included: getting power to the RSUs via solar power and microwave technology, figuring out how to install OBUs in Wyoming Highway Patrol vehicles without interfering with other equipment on the patrol cars, and dealing with holes that developed in the roofs of snowplows from intense vibrations of antennas installed on the roofs.

RSUs and OBUs were monitored in real-time via a program called Solar Winds; however, because the system was designed to be anonymous, vehicles could not be intentionally tracked, making maintenance possible but difficult.

Workforce Development

WYDOT made an early decision not to hire new staff due to limited funds. The pilot created more work on top of existing responsibilities. WYDOT hired consultants to fill gaps and acquire expertise.

Outreach

WYDOT conducted a menu of different outreach activities from stakeholder meetings to press releases, magazine articles, academic papers, and webinars.

Initial Deployment Issues and Challenges

The most pressing initial deployment issues were: (1) the fact that procured CV system (i.e., hardware and software) was not deployment ready, and (2) the incongruity between the states IPv4 network and the CV systems IPv6 network. These issues like other ones (i.e., underestimation of staff and time resources, SCMS software provider change mid-stream, and large data streams at the TMC) were dealt with creative troubleshooting. This would not have been possible without the commitment of team to flag and fix issues in a timely manner.

Near-Term Post-deployment Interviews

This section summarizes the information captured during seven telephone interviews with deployment managers and deployment team members in November and December 2019.

Vision and Goals

Goals for the success of the pilot had not changed, although frustrations with the maturity of the technology and related issues had increased. Extensive testing, debugging, maintenance, and fixes delayed the project.

Pilot Effectiveness

It was too early for people to state whether the pilot was meeting its stated goals. The ability to implement the technology as expected did not meet expectations. Stakeholders were waiting for the project to generate data to demonstrate or not whether the pilot is successful.

Institutional Challenges

Several institutional challenges were mentioned across the interviews: (a) delays, coupled with staff shortages, led to competing priorities regarding internal staff availability to work on the pilot, (b) vendors were not forthright about the capabilities of their technology, and (c) WYDOT procurement policies were not aligned with pilot requirements.

One individual raised a concern related to USDOT involvement being limited to management of the deployment at a programmatic level. This individual felt that the pilot would benefit if USDOT was more closely involved with all aspects of the deployment, including the design and manufacturing of the technology, to ensure that deployed CV systems would be marketable after the pilot.

Financial Issues

The lack of field-hardened technology overly burdened the pilot. The Wyoming CVPD team thought that a far more robust financial arrangement than was in place would be needed to address the significant amount of time required to deploy, troubleshoot, test, and update prototypes. There was also the concern that WYDOT, as a first deployer of this technology, would be stuck with outdated technology and would not be in a financial position to implement the next generation.

Performance Measures

At the time of the interviews, the performance measures had not changed, but data had not yet been collected to populate them.

Systems and Technology

The technology was not ready for prime time. Getting over-the-air updates, addressing lane level accuracy, and integrating SCMS software have remained challenging, requiring non-stop testing. The requirement to use the Secure Data Commons was more of a hindrance than a benefit. Because of the “bleeding edge” technology being deployed, keeping up with evolving standards proved challenging for the manufacturers involved. OBUs and RSUs were the weak links and the investment required to conduct necessary R&D to meet standards safety, redundancy, cyber-security, extreme weather environments for a real-world implementation proved more than challenging.

Satisfaction with Pilot Rollout

In early deployment, frustration with the enormity of the problems with the OBUs and RSUs was high. This led to statements of dissatisfaction with the pilot and with disappointment with the vendors. A strong concern was the delayed schedule and uncertainty about moving forward. One individual was more optimistic, indicating “we are the guinea pigs” and they were setting the standard for how agencies can work through the technical issues.

Communication and collaboration among the Wyoming CVPD team was mentioned as a strength of the pilot, complementing WYDOT and ICF in this regard. However, there was less complimentary appraisal of communication between vendors and the team.

Early Deployment Issues and Challenges

The Wyoming CVPD team was still dealing with the negative impacts of immature CV technology in the early deployment. In hindsight, the use of a contract for procurement instead of a purchase order may have allowed for performance requirements from the vendor and potentially could have improved the issues with development.

Long-Term Post-deployment Interviews

This section summarizes the information captured during five telephone interviews conducted in March 2022.

Pilot Effectiveness

There was consensus among the stakeholders that the deployment attained all their performance goals. At the end of the deployment, the Wyoming CVPD team was satisfied with the outcome and felt a sense of accomplishment in being able to get the CV system operational so that better information was disseminated quicker to the drivers on I-80.

One disappointment associated with the deployment was the inability to thoroughly test and utilize the Distress Notification Application. This application required the use of the DSRC units onboard each vehicle to pass information between equipped vehicles. Several stakeholders expected this application to show significant positive benefits to quickly spread information about hazards and events quickly between users. FCC's spectrum-change ruling prevented this application from becoming mature and achieve widescale deployment.

Policy Challenges

The overall perception was that the FCC ruling on not preserving spectrum for DSRC would have long-term negative consequences on the sustainability of the deployment. Satellite communications would not be able to support the CV applications. OEM involvement in providing in-vehicle equipment was critical to the deployment's long-term success.

Institutional Challenges

Institutional challenges arose with the end users of the system (fleet partners) due to incomplete communications. The WYDOT CVPD team underestimated the need to adequately communicate the capabilities and benefits of the deployed technology for end users. Also, as end users expressed concerns, these were not always acted upon in a timely manner.

Culture

Most stakeholders agreed that the culture within WYDOT and between the stakeholders had a positive effect on the deployment. WYDOT was perceived by the stakeholder to be a very progressive organization, particularly as it related with weather traffic management, and that the organization encourages staff to use advance technologies to address operational needs. The deployment reinforced an already existing culture of being progressive and prioritizing safety among WYDOT and stakeholders.

Collaboration

The stakeholders felt like there was consensus and everyone was always on board with the scope and intent of the deployment. More than one stakeholder indicated that the team as a whole were strong advocates for the deployment and worked well together. As the CVPD progressed, the CVPD team pivoted from reliance on formal agreements and to use less-formal collaborations to troubleshoot the various issues as they arose. Several stakeholders mentioned that changes in staffing in some of the supporting stakeholders created continuity issues, but these were resolved as the deployment progressed.

Financial Issues

WYDOT increased its pilot budget due to the unforeseen challenges (i.e., RSU maintenance, equipment not rugged enough for snowplows, commercial vehicle antenna system). The fleet partner cost for equipment installs was higher than anticipated due to lower levels of knowledge about the CV technology. The fleet provider also ended up continuing to pay for in-vehicle satellite services in 17 vehicles after the pilot period ended.

Business Processes

A plan has been formulated for extending the dissemination of traveler information after pilot and expanding it beyond the I-80 corridor. There is a plan to update the RSUs and to secure an out of band channel to disseminate messages to fleet partners. For work zones, a transition is underway from a construction administration system to a more TMC focused approach to facilitate information to a focused set of likely affected drivers. Future deployment related costs will be incorporated into existing WYDOT budgets.

Systems and Technology

WYDOT-Specific Issues

The CV hardware and software were not ready for widespread deployment, so the ConOps evolved over time. The RSUs required frequent maintenance due to extreme weather conditions. Maintenance was time intensive because the long drive times between installed units due to the rural nature of the deployment. However, all maintenance was done in-house with new maintenance procedures now in place by WYDOT. Some fleet partners outsourced their initial equipment installations to a private contractor. In addition, RSUs lacked the necessary coverage and connectivity to provide maximum benefits of the deployed technology. At time, maintaining the deployed equipment placed a strain on maintenance personal, but over time, these issues were resolved. At the same time, one person suggested that the increased “in-house knowledge” gained through the deployment will greatly benefit WYDOT in similar deployments in the future.

In terms of applications, one stakeholder expressed the opinion that the spot weather application was potential mature enough to see widespread deployment, but other applications required additional refinements. For example, the Forward Collision Warning application required significant troubleshooting to get it to work for large trucks. New standards recently developed by the Society of Automotive Engineers for Forward Collision Warning that accounts for commercial vehicle articulation may help this application become more mature.

The equipment installed on the snowplows was not rugged enough for the operating environment.

The initial attempts to use the SCMS provide to the deployment team was insufficient and inadequate for their needs. This cause the deployer to switch to a private vendor for providing security certificates for their devices. Once this switch occurred, the safety and security protocols were deemed adequate with only slight adjustments to SCMS protocols over time.

Fleet Partner Issues

Feedback from fleet partners indicated that they experienced negative issues with system volume, the Work Zone Warning sounding in a timely manner, antenna placement, timeliness of traveler information, and the screens going black when drivers keyed the microphone on the CB radio. Fleet partners were

surprised to learn late in the pilot that WYDOT itself was still learning how to troubleshoot various issues with deployed technology.

Workforce Development

WYDOT deemed their staff to be adequately trained and equipped to handle the deployment. As technology evolves, WYDOT expects that training requirements will need to be upgraded.

Outreach

The outreach over the course of the Wyoming CVPD was significant, including industry stakeholders, interested vendors, the public, internal WYDOT staff, and other state DOTs. Methods included press releases, presentations, YouTube videos, published articles and papers. The Wyoming CVPD team had little knowledge of public awareness / acceptance of the deployment. Policy maker awareness was perceived as high and positive, as was commercial fleet support.

User Experience/Satisfaction

User survey comments speak to the challenges associated with the system and technology over the duration of the Wyoming CVPD. One interviewee described user perception as “not good,” particularly with the equipment installed on the snowplows. Once lost, trust and confidence in the system is difficult to regain.

Ongoing Deployment Issues and Challenges

One piece of advice that a stakeholder had for other deployers is to concentrate on doing what your agency does best and leave the other applications (i.e., the V2V applications) to those entities that are better suited for developing them. For WYDOT, the development and dissemination of road and weather condition travel information is a priority and thus the focus of their deployment. The pilot demonstrated that WYDOT can disseminate these messages using CV technology. A fleet partner commented that no other similar system is commercially available, and it is useful to the industry. They would be disappointed if the deployment were to terminate. Going forward WYDOT will be refining the processes used to get the messages out and the robustness of the devices used to receive the messages.

Summary of Findings of Stakeholder Issues and Perspectives

Table 6 presents a summary of issues and perspectives across time.

Table 6. Summary of findings from stakeholder interviews.

Topic Area	Pre-deployment	Immediate Post-deployment	Final Post-deployment
Vision and goal	<ul style="list-style-type: none"> Primary goal was increasing safety with the use of CV technology to reduce crashes by providing road condition and weather traveler information. 	<ul style="list-style-type: none"> The primary goal did not change even as team was increasingly frustrated by system and technology challenges. 	<ul style="list-style-type: none"> The primary goal did not change, emphasizing that disseminating better information to the travelers on I-80 in a timelier manner would improve safety.
Effectiveness	<ul style="list-style-type: none"> Success was defined as actual reduction in crashes and fatalities, as well as identifying areas along I-80 where communications were difficult and providing solutions, providing better information through the CV system to the TMC. 	<ul style="list-style-type: none"> Early experience with deployment did not alter view of what would constitute success. But a definitive answer was impossible due to the fact system had not yet been deployed. Frustrations with technology and system issues created levels of disappointment. 	<ul style="list-style-type: none"> At the end, CVPD team felt success had been achieved by having deployed technology that could send and receive messages. In addition, per the WYDOT Phase 3 Evaluation Report, "The crash rate per million vehicle miles traveled decreased for all corridor segments except for one corridor between Laramie and Cheyenne."
Policy challenges	<ul style="list-style-type: none"> Funding once the pilot is over. 	Not applicable	<ul style="list-style-type: none"> FCC ruling on DSRC spectrum
Institutional challenges	<ul style="list-style-type: none"> Working with State of Wyoming centralized IT department to address incongruity of IPv4 and CV systems IPv6 networks. Underestimating required time and staff resources. 	<ul style="list-style-type: none"> Procurement policies (i.e., vendor vs. professional services) Vendor misrepresentation of technology readiness Completing staff priorities 	<ul style="list-style-type: none"> Addressing end user expectations of technology capabilities Staffing to maintain RSUs
Culture	<ul style="list-style-type: none"> CVPD team organizations supported the pilot, even with delays in roll-out of the team. 	Not applicable	<ul style="list-style-type: none"> Collaboration and support stayed high through the pilot end. Deployment reinforced existing culture of being progressive.

Topic Area	Pre-deployment	Immediate Post-deployment	Final Post-deployment
Collaboration	<ul style="list-style-type: none"> Consensus existed among various stakeholders as to goals, expectations, and priorities. 	<ul style="list-style-type: none"> Not Applicable 	<ul style="list-style-type: none"> Wyoming CVPD team shared the same commitment to achieving (having achieved) success.
Financial issues	<ul style="list-style-type: none"> How to achieve sustainability beyond the pilot was an important consideration. 	<ul style="list-style-type: none"> Development and testing required to implement did not dull the commitment to deployment. Keeping technology operational was harder than anticipated. Lack of field hardened technology led to unexpected financial burdens. 	<ul style="list-style-type: none"> Pilot budget increased due to unforeseen challenges. Fleet partner costs were also higher than anticipated.
Business processes	<ul style="list-style-type: none"> Significant business process changes were not expected and were minimized to the extent possible. 	<ul style="list-style-type: none"> Not Applicable 	<ul style="list-style-type: none"> Many business process changes resulted from the deployment. Deployment cost incorporated into existing budgets. A plan for extending and expanding the pilot has been formulated.
Performance measures	<ul style="list-style-type: none"> Many performance measures were identified from safety to system performance to driver behavior. 	<ul style="list-style-type: none"> Performance measures not changed but data capture not fully implemented. 	<ul style="list-style-type: none"> Performance measure reporting not finalized at the time of these interviews.
Systems and technology	<ul style="list-style-type: none"> Significant challenges identified were the lack of maturing of the OBUs, RSUs, and software, network issues in remote Wyoming landscape, and installing OBUs in highway patrol cars and on snowplows. Reliance on smaller technology companies contributed to the technology challenges. 	<ul style="list-style-type: none"> Dealing with technology that was not “plug and play” remained challenging. SCMC integration was particularly challenging for vendors. Addressing continuing evolving standards 	<ul style="list-style-type: none"> ConOps evolved over time as technology issues were addressed. While hardware challenges continued through end of pilot, security issues diminished. Fleet partners identified many problems with installed technology which may have decreased driver confidence in the system.

Topic Area	Pre-deployment	Immediate Post-deployment	Final Post-deployment
Workforce development	<ul style="list-style-type: none"> • WYDOT made decision not to hire new staff. • Used consultants to fill gaps and acquire expertise. • A lot of flexibility needed to deal with pilot on top of existing responsibilities. 	<ul style="list-style-type: none"> • Not applicable 	<ul style="list-style-type: none"> • CV responsibilities were effectively integrated into existing operational units and job descriptions.
Outreach	<ul style="list-style-type: none"> • Priority was placed on outreach to stakeholder, public, policy makers, and other transportation agencies 	<ul style="list-style-type: none"> • Outreach continued during early deployment. 	<ul style="list-style-type: none"> • Little knowledge of public awareness and acceptance • Policy maker awareness and support was perceived as high. • Commercial fleet support for deployed system was perceived as high.

Source: Texas A&M Transportation Institute, 2022

Chapter 4. Post-Deployment Workshop

The TTI CVPD Evaluation Team held a virtual post-deployment workshop with the Wyoming CVPD team. The purpose of the workshop was to foster additional dialog concerning the lessons learned and major takeaways from planning and implementing the deployments. ⁽⁴⁾ The common themes identified in the post-deployment interviews were used to frame the group discussion, which explored these and other topics in more detail. The workshop was also used to gather information needed to conduct the financial and institutional assessments, which will be documented in a separate report. The workshop was originally planned as an in-person event but was shifted to a virtual platform.

Workshop Participants

Workshop participants represented the deployment managers, deployment team members, and operating agencies of the Wyoming CVPD Team as well as attendees from USDOT. It was originally expected that 20 Wyoming CVPD stakeholders would participate in the workshops when it was thought to be an in-person event. Some, but not all, were to be individuals who had participated in the interviews. eight individuals from the Wyoming CVPD Team participated in the virtual workshop. The TTI CVPD Evaluation Team coordinated with the deployment managers in identifying persons to be invited to the workshop.

Workshop Format and Schedule

The virtual workshop was held on May 31, 2022, from 3:30 p.m. to 5:00 p.m. Central Time. The TTI evaluation team used the following 90-minute agenda to guide the workshops:

- Self-Introductions – name, affiliation, and role in pilot
- Expectation and Accomplishments
- Final Deployment
 - Deployment Clarification
 - Technical Challenges
 - Institutional and Financial Arrangements
- Lesson Learned and Major Takeaways
- Sustainability and Future Operations.

Appendix B contains the seed questions used in the workshop.

Key Findings

The following sections summarize the results of the discussion that took place during the workshop. The discussion and remarks are those shared by the workshop participants throughout the workshop and do not reflect the opinions of the TTI Evaluation Team.

Expectations and Accomplishments

As happens in complicated pilots, the Wyoming CVPD team had a certain set of expectations in terms of what could be accomplished in the pilot; eventually those expectations were met but not without struggle. The goal of the Wyoming CVPD was to improve driver safety, particularly for commercial vehicle operators, on I-80, which runs the entire length of the southern edge of the state. The highway is susceptible to multivehicle collisions and roadway closures during winter weather due to icy roads and low visibility from blizzard conditions, resulting in fatalities and significant economic loss to commercial fleets. WYDOT expected to use CV technology to share traveler information on weather and road conditions from the Traffic Management Center (TMC), along with roadside alerts and dynamic travel guidance. A specific expectation was the capability to deliver the information in-vehicle to truck drivers on the road so that the information would be received in a timely manner.

The Wyoming CVPD team felt that the deployment was a success. They deployed RSUs in various sections of I-80 that could receive and broadcast messages using DSRC and equipped heavy-duty vehicles that regularly used I-80 with OBUs designed to receive information, alerts and advisories. They also equipped WYDOT snowplows to have the additional capabilities to collect and transmit environmental and road weather conditions information through mobile weather sensors. This new CV ecosystem was integrated with legacy TMC operations. It was done without changing the TMC operations or responsibilities of the TMC operators. In the pilot, the TMC operators were doing the exact same job they have always done--pushing out information. "What we've done as part of this pilot was prove that we can push it to in vehicle systems."

The team faced many technical challenges in doing this but were effective in troubleshooting technical solutions. In addition, they had to address challenges exogenous to the pilot itself. They had to deal with FCC spectrum changes which altered the vendor marketplace. Also, the Covid-19 pandemic negatively affected deployment timelines and equipment availability. The deployment manager suggested that any entity considering implementing something similar "should estimate what they think it's going to take in terms of testing and troubleshooting and then double it."

Manufacturer/Vendor Technical Challenges

RSU's, OBUs, and the applications were not ready for widespread deployment. The technical challenges "were ironed out but they were a struggle." For instance, the Wyoming team eventually did figure out how to pull in the weather data from the mobile weather stations, send it over DSRC to the TMC, and then parse and send it to weather cloud for ingesting into the in-vehicle system. But "the technology needed a lot of work in order for it to be there."

A big challenge was the fact that the Wyoming deployment lost support from an OBU/RSU vendor that exited the DSRC market space after the FCC's spectrum ruling, and the team had to find another communications approach. In addition, once installed the RSUs required frequent maintenance because they were not a stable platform, and maintenance was time intensive because of the required drive time. The team knew of problems with the RSUs and OBUs, but it was "pretty well impossible" to fix them. This led to dissatisfaction among users of the technology.

Installation of Equipment Challenges

The Wyoming CVPD team understood that their fleet partners were less than fully satisfied with the CV technology installed in their vehicles. The team had intended to deliver a technology that was "rock solid and ready for prime time." But the technology needed a lot of development, testing, and troubleshooting.

For example, one member of the technical team acknowledged that there were significant complaints about the screens and the lighting levels. “It took us a long time to come up with a happy medium there.”

The team treated the working out of technical bugs as one would in a pilot – trial and error. But because time is money for the commercial fleets, the commercial fleets wanted “something that would go into their systems with very little changes and work out of the box.” Retrospectively the team acknowledged that “one shouldn’t be exploring solutions as these are deployed in user vehicles. You can’t be generating new interfaces and stuff like that. You get one shot at the user and if the user doesn’t like it, they’ll figure out a way to turn it off.”

Other technical issues identified needed troubleshooting, such as:

- Screens would go black if the drivers keyed the microphone on the CB radio
- Issues with the Work Zone Warning sounding in a timely manner
- Incidents of experiencing route closures without any or late notification
- Issues with volume of the alerts produced by the system
- Issues with antenna placement

Timeliness and accuracy of information, while much improved throughout the pilot process, are ongoing issues with the deployed CV system moving forward.

In hindsight, the Wyoming CVPD team thought that it was probably not a wise idea to put the non-ruggedized technology on WYDOT snowplows for the mobile weather stations. The available equipment that was used in the deployment was not hardy enough for these vehicles and was utterly destroyed often within weeks (sometime days or hours) after installation “The cables were wrecked, the sensors were wrecked, they were not rugged enough to support a snowplow platform.” Keeping the sensor equipment operational became a maintenance burden for WYDOT. “There’s no way that people instrumenting these vehicles have the time or patience or budget to do these [installations] once a week.” One stakeholder suggested that a service life of at least 3 years was thought to be more realistic. Members of the team hypothesized it might have been better to put the technology on supervisor vehicles or even on highway patrol vehicles.

Applications Challenges

The Wyoming CVPD team deployed a total of five V2V and V2I applications. Of these, major problems were experienced with three of them. The Forward Collision Warning required significant work for large trucks. The Work Zone Warning did not sound in a timely manner, if at all. The Spot Weather Warning alerted drivers too close to the event.

As an example, one individual discussed the issues around the work zone application. This application relates to “something that what we would traditionally do in ITS and traffic management. The information goes into a database and you put it on a dynamic message sign. Some human [looking at it] will make sense of it. But once you put that in an OBU, the way things are parsed, [the alert] is either there or not there, and sometimes it may pop up when you’re not expecting it.” The bottom line was that if one really wanted to give accurate road condition information to in-vehicle connected systems, especially for work zones, there needs to be some process changes. In Wyoming, the deployment team had to go back to the construction team and see if they would change the way they report the work zone information. “Our snowplow operators are in contact with the TMC on a very regular basis, but that is not true of

construction employees. They think of things in terms of week-long where the [snowplow] guys know that if weather changes, they've got to get updates quickly.”

Institutional Issues

A big institutional challenge was getting commercial fleet partners to agree to participate in the pilot. Working with the freight companies was hard; they had deadlines. “They've got a business to run and to work with us on this project isn't really in their business models, so that was hard.” The Wyoming CVPD team admitted that it continues to be hard. The Wyoming CVPD team recognizes that the fleet companies have different priorities.

Another institutional challenge raised was the uncertainty related to the spectrum DOTs and others have a place to continue to develop safety applications and mobility applications. “I think that is a huge challenge to institutionally move forward with connected and automated vehicles.” “To what extent does the uncertainty of all that come into play and impact your plans? What does that do from your planning perspective about having kind of this uncertainty about what's going to happen or not?” Migrating from DSRC 9.5 GHz spectrum to cellular V2X isn't easy. It is not just one thing, it's a progression, and looking at the backwards compatibility of different versions of cellular V2X is necessary. “What's available now? What will be available in five years and what be available in 10 years?” This can turn out to be overly burdensome to the DOT's who are trying to find how to cover the cost share.

Workforce Challenges

The need and type of ongoing maintenance of the technology will require certain workforce capabilities. The technicians that are used for this level of maintenance are highly trained. To do this type of work, a technician must be trained in both computer communications networking and electronics. “This makes them highly marketable in the workplace. WYDOT currently has an experienced team of technicians, “so hanging on to those people is critical.”

Lessons Learned

A few important lessons for other departments considering a comparable pilot were learned. “The number one lesson is don't let the expectations get too far ahead of what does can realistically be done.”

Second, it is important to add in the security credential management system from the beginning, when the CV system is being built. There was not a fully developed SCMS available for the Wyoming CVPD team to use so the SCMS security was added after the fact. Testing was done without the security turned on. This made testing the CV system more challenging and slowed down the deployment.

A third lesson learned was to evaluate how diverse types of communications work with heavy-duty vehicles. The out-of-the-box solutions with a single antenna on the rooftop works fine for light duty vehicles, but really did not function well for a heavy-duty vehicle. The Wyoming team spent a lot of time, working with different vendors, figuring out how trucks and trailers work with DSRC. Getting the over-the-air updates well-established, tested, and approved took time. The Wyoming team advised that before a DOT starts thinking about the “nice glitzy applications, get one and two [operational] right.” The team spent a lot of time with the care and feeding of the equipment and applications. “I think that's what most owner operators are going have to focus on going forward.”

WYDOT's expressed a willingness to sit down with other DOTs to walk through their approach (i.e., the system engineering documentation that was produced for this pilot). Key advise was to talk through it and

produce a DOT-specific plan, figuring out how to leverage some of the open-source tools used in this pilot and then build a plan that enables the DOT “crawl and then walk and then run.”

Going Forward

Now that DSRC 9.5 GHz spectrum is being usurped by cellular V2X, WYDOT is facing “a whole new set of issues to work through and work out.” WYDOT is going from a “fairly tried and true” technology in terms of the pilot to cellular V2X that is a “very new technology, very unproven technology.” For instance, “the over-the-air updates are inherent in and part of the DSRC spectrum, it's not with cellular V2X.” The Wyoming team felt “blessed with DSRC.” They warn others that moving into cellular V2X, there will be new issues to address that will be dramatically different from what this team was able to do with the Wyoming pilot.

Strong leadership at the federal level is needed to keep this technology moving forward. The fleet partners liked it. There is no other system that is available commercially to them, and it is very useful for their industry. They like having that information and they want to be with us moving forward.

The Wyoming CVPD team thought that an important positive factor in moving forward was the fact that they tied the system into working with the TMC operators and the way that they do business (i.e., close roads, adjust speed limits, describe weather, fog, or traction, atmospheric conditions, road conditions). “The system that we've built for the Connected Vehicle Pilot is not a data silo; it's actually an integrated system into the Wyoming Travel Information System.” When the team expanded satellite delivery of TMC-generated TIMs, “it wasn't a trivial lift, but it wasn't a monumental lift like deploying RSU's to the rest of the state. Doing it with the integrated system that we had is it was a very solvable problem. We have already pushed to statewide.”

There is no V2V communication between the vehicles with satellite, which is a big loss. But the workshop participants thought that the V2V communication was something that should be the responsibility of the OEMs. “Let the OEMs do the things that they do best, right. And that's the in-vehicle side of things.”

WYDOT is committed to continue with this work. The agency is planning on replacing, at least the 75 RSUs along I-80. The intent is to replace those with cellular V2X devices and make sure that they are integrated into the TMC.

The Wyoming CVPD team is working with Colorado DOT to expand the Wyoming CV system in that state. They are translating the documents that have been put together for the Wyoming CVPD and leveraging a lot of the open source USDOT sponsored tools like the Operational Data Environment. Since it is open source, any agency can do the encoding and decoding as long as the standard protocols are followed. That mean if following a standard protocol, any agency can develop their own traveler information messages, sign them, and then distribute it out over satellite or RSUs.

Final Impressions

In the end, it is not the technology itself that is important. It is that users find the information produced useful. “There's a good reason that people like using Google Maps or whatever because it is useful to them. Truck companies are trying to reduce their costs and improve efficiency and inform the specificity of when their vehicles will actually arrive. So, I think that as long as the data that we're providing is accurate and timely, people will want to acquire that technology.” Success begets success. “So. if we do it right. They'll be clamoring for it. Whether it's a DSRC or cellular V2X platform.”

Chapter 5. User Satisfaction Assessment

The Wyoming CVPD Team, like the other two individual CVPD sites, was responsible for executing user acceptance surveys as part of the evaluation. Users of the CV technology in the Wyoming pilot included WYDOT maintenance vehicles and snowplows, WYDOT Highway Patrol vehicles, and private fleet vehicle operators. However, as the independent evaluator, the TTI CVPD evaluation team, along with the Volpe Center, assisted CUTR in developing the survey instruments, ensuring that questions important to the independent evaluation were included, and assessing the user acceptance survey results. The Volpe National Transportation Systems Center designed the survey in coordination with TTI and provided the draft survey instruments to the Wyoming CVPD Team. The Wyoming CVPD Team was responsible for administering the survey to the users.

WYDOT did not provide any information on user satisfaction as part of their final system performance measurement and evaluation report, ⁽⁵⁾ In fact, the Wyoming CVPD Team had to drop several user satisfaction-related performance measures from their evaluation due to lack of responses from drivers and managers. The performance measures dropped from the Wyoming CVPD Team's evaluation include the following: ⁽⁵⁾

- Commercial vehicle managers [were] satisfied with information provided by the TMC.
- Number of operational changes made by fleet managers due to information from TMC.
- Commercial vehicles drivers' benefits experienced due to CV technology during major incidents and events on I-80.

As reported in their interim evaluation report, WYDOT did have limited success in collecting user satisfaction feedback about the deployment. ⁽⁶⁾ WYDOT conducted four rounds of short surveys (May 26, June 10, July 28, Sept 2) to gauge the level of satisfaction of the drivers and dispatch managers participating in the pilot. Although the participation was low (only 49 responses across all four rounds, with 46 responses coming from drivers and three from managers), WYDOT gathered the following feedback about the performance of the deployment from a user's perspective: ⁽⁶⁾

- The deployment initially struggled to provide cohesive and accurate information, particularly during the first months of the year. This was reflected in the comments received from participants.
- Managers reported not making any additional changes based on the information provided, but one manager did comment that the system helped manage the Journey Management of its drivers.
- Several respondents indicated that it was good to have the advisory information ahead of time, particularly high wind warnings during the summer months.

Additional respondents reported feedback suggesting areas of improvement are as follows: ⁽⁶⁾

- The system needed to improve accuracy and timeliness of warnings. While drivers acknowledged alerts being useful, warnings on weather, speed and work zones seem to be arriving late and in a redundant manner, sometimes with inaccurate information.

- There is also a need to refine the preferences of the drivers when it comes to the alerts and warning they receive. Some drivers found the alerts to be too frequent and even unnecessary at times (e.g., beeping the second the vehicle travels one mile per hour above the speed limit).
- Participants also indicated some hardware problems, such as issues with the screen brightness, contrast and even the install location.

Chapter 6. Summary of Results

Stakeholder Acceptance

Stakeholder acceptance was assessed through a mixed-method approach that facilitated capturing a variety of perspectives at different points in time of the Wyoming CVPD. Qualitative interviews were conducted with the CVPD deployment team prior to deployment, shortly after deployment, and near the end of the pilot deployment. In addition, a workshop was held after the final set of interviews to validate the interview findings, fill information gaps identified during interviews, and better understand the perceived CVPD outcomes.

The following lists the key findings from these research activities:

- The Wyoming CVPD faced many unforeseen challenges; however, with persistence and creative troubleshooting the team was able to deploy a CV system that could receive and broadcast messages using DSRC, and they equipped heavy-duty vehicles that regularly used I-80 with OBUs designed to receive weather and traffic information, alerts and advisories. They also equipped WYDOT snowplows to have the additional capabilities of mobile weather stations. They fully integrated the deployed CV system with the legacy TMC. The Wyoming CVPD team shared the same commitment to achieving success throughout the different phases of the deployment.
- One of the biggest challenges was the fact that the RSU's, OBUs, and the applications were not ready for widespread deployment. RSU vendor also was one of the original OBU vendors. There were two OBU vendors: DSRC only (Lear) and dual-mode (DSRC and satellite (SXM)). Relying on smaller technology vendors, rather than established players, contributed to the challenges. The technical challenges were eventually ironed out but not without a struggle. The FCC ruling on spectrum contributed to the technical challenges in that the RSU vendor backed out due to perceptions of a dying market. Other identified challenges included network issues in remote Wyoming land scale and installing OBUs in on snowplows.
- Unlike the experience of the Wyoming CVPD, future deployments of similar systems should do the testing of CV systems with the SCMS turned on. While it is compelling to do otherwise, it makes testing the CV system more challenging and slows down the deployment. In the case of this pilot, the SCMS was not available at the start of the deployment.
- While business process changes were not expected at the start of the project, through solving technical challenges, many business process changes resulted like re-engineering the process for construction teams to provide information on work zone issues.
- There is strong commitment at WYDOT to keep the system deployed moving forward. But even so there are challenges such as an eventual transition from DSRC to cellular V2X. This means going from a fairly tried and true technology (DSRC) to one that is fairly new (cellular V2X). Still the agency is wanting to stay in the forefront of CV deployment so is planning to replace RSUs along I-80 with cellular V2X devices and make sure that they are integrated into the TMC. Also, it was believed that strong leadership at the federal level is needed to keep this technology moving forward.
- Moving forward and expanding the deployed system to more areas of the state has been and will continue to be facilitated by the facts that the deployed system was integrated into existing TMC

operations and that Sirius XM satellite delivery is replacing RSU delivery. An acknowledged concern is that there is no V2V communication between the vehicles with satellite. However, rectifying this situation was considered to be the responsibility of the OEMs not of infrastructure owner operators.

- Getting commercial fleet partners to agree to participate in the pilot was a heavy lift. More so than owners of passenger vehicles, the commercial fleets have a business to run and participating in a pilot deployment is not a priority. Effective solutions for this situation would need to be more fully explored in any future deployments involving the commercial truck industry.
- Determining the effectiveness of the deployed system through performance measures identified early in the project proved challenging. The necessary data was often not available to populate them.

User Satisfaction and Perceptions

Because of limited responses from fleet operator drivers and managers, WYDOT had only limited success in collecting user satisfaction feedback about the deployment.⁽⁶⁾ WYDOT conducted four rounds of short surveys (May 26, June 10, July 28, Sept 2) to gauge the level of satisfaction of the drivers and dispatch managers participating in the pilot. Responses to surveys were extremely low with only a total of 49 responses across all four rounds, with 46 responses coming from drivers and three from managers). These users provided following feedback about the performance of the deployment:⁽⁶⁾

- The deployment initially struggled to provide cohesive and accurate information, particularly during the first months of the year. This was reflected in the comments received from participants.
- Managers reported not making any additional changes based on the information provided, but one manager did comment that the system helped manage the Journey Management of its drivers.
- Several respondents indicated that it was good to have the advisory information ahead of time, particularly high wind warnings during the summer months.

Additional reported feedback suggesting areas of improvement are as follows:⁽⁶⁾

- The system needed to improve accuracy and timeliness of warnings. While drivers acknowledged alerts being useful, warnings on weather, speed and work zones seem to be arriving late and in a redundant manner, sometimes with inaccurate information.
- There is also a need to refine the preferences of the drivers when it comes to the alerts and warning they receive. Some drivers found the alerts to be too frequent and even unnecessary at times (e.g., beeping the second the vehicle travels one mile per hour above the speed limit).
- Participants also indicated some hardware problems, such as issues with the screen brightness, contrast and even the install location.

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Appendix A. Wyoming Stakeholder Survey/Interview Guide

The TTI CVPD Evaluation Team plans to conduct three types of Interviews:

- **Pre-deployment interviews** — These interviews will elicit vision, goals, and expectations and gather information on financial and institutional preparedness. The TTI CVPD Evaluation Team plans to execute these interviews just before activation of the test CV applications.
- **Near-term post-deployment interviews** — These interviews will capture early deployment experiences, challenges, and solutions. The TTI CVPD Evaluation Team plans to conduct these 1–3 months after activation of the deployment.
- **Long-term post-deployment interviews** — These interviews will gather opinions as to whether the deployments achieved the desired vision, goals, and MEP impacts. The TTI CVPD Evaluation Team also plans to collect observations and experiences about challenges (e.g., technical, institutional, financial), adopted solutions, and lessons learned. The TTI CVPD Evaluation Team will also use these interviews to measure stakeholder levels of satisfaction with pilot outputs/outcomes and the long-term sustainability of the CVPD. The team will conduct these interviews about 9–12 months after activation of the applications.

Information about how the interviews will be implemented can be found in the *Stakeholder Acceptance Evaluation Plan*.⁽³⁾

As noted below, the target stakeholders for the qualitative interviews are deployment managers, deployment team members, operating agencies, and policy makers. The TTI CVPD Evaluation Team will interview at least one but not more than three individuals from each stakeholder group:

- **The TTI CVPD Evaluation Team identifies deployment managers** as the lead deployment agency and decision makers for each CVPD. TTI plans to conduct interviews with individuals from these agencies in the pre-, near-term post-, and long-term post-deployment time periods. Respondents will be executive management or project managers. Deployment managers will have integral roles in planning and implementation, so they are interviewed at all three points in time.
- **The TTI CVPD Evaluation Team identifies deployment team members** as those individual/agencies responsible for planning, development, and implementation of the applications and technologies. The CVPD Evaluation Team plans to interview these individuals in the pre-deployment because they have developed applications and near-term post-deployment time periods because they will have been the ones troubleshooting the applications during the pilot implementation. Respondents will be project managers and key technical leads (operations, development, engineering, and IT) from these team member entities.
- **The TTI CVPD Evaluation Team identifies operating agencies** as those individuals involved in the pre-deployment planning and development activities as well as day-to-day operations of the pilots once started. The TTI CVPD Evaluation Team plans to interview these individuals in the pre-deployment and long-term post-deployment time periods because they will have been involved in setting goals and objectives for the pilots. Respondents will be the key technical leads from these agencies.

- **The TTI CVPD Evaluation Team defines Policymakers** as those individuals in a position to influence the selection of the pilot site or to make decisions about the deployment in the future. The TTI CVPD Evaluation Team will interview policymakers in the pre-deployment and long-term post-deployment time periods for the same reason as above for operation agencies. The respondents will be the champion for the CVPD within the policymaking entity.

The TTI CVPD Evaluation Team will select interview respondents using a purposeful sampling methodology. This methodology involves selecting individuals or groups of individuals from stakeholder groups that have specific knowledge about or a history with the CVPD. Once identified, these individuals will receive an email inviting them to participate in the interviews. The emails will contain the informed consent document as an attachment. To the extent possible, the team will interview the same persons from an organization in across all relevant interview types. If this is not possible, the team will substitute an individual from the same organization who is both knowledgeable and experienced with the CVPD to participate in the post-deployment interviews. If such an individual is not available, then no substitute will be used.

All three types of interviews will have a rolling pilot in which the first five interviews for each pilot site will contain questions to elicit feedback from respondents on the clarity and efficacy of the interview questions. The TTI CVPD Evaluation Team will ask the interviewees these evaluative questions after they have completed the interview. Example questions include the following:

- How relevant were these questions?
- Were the questions clear and understandable?
- Were there any biased questions?
- What questions should I have asked (that is, possibly missed questions)?

Pre-Deployment Interview Guide

This section contains questions that the TTI CVPD Evaluation Team will use when conducting pre-deployment interviews. The projected length of the interview is 45–60 minutes depending on the number of questions asked. The interviewer will send the questions to interviewees in advance to facilitate discussion. Probes in the interview guides will be removed prior to sharing with the interviewees. Individuals performing the interviews will be knowledgeable about the deployment and receive proper training through TTI's IRB.

TTI will assign questions to stakeholder groups based upon assumptions of their knowledge and interest levels. It may be necessary to tweak some words based on who is being interviewed.

Preamble

Good morning (afternoon) and thank you for participating in this interview. I am (name here), a member of the CV Pilot Deployment Independent Evaluation Team. Our job is to assess the mobility, environmental, and public agency efficiencies associated with the CV Pilot Deployments. The USDOT ITS Joint Program Office is sponsoring this evaluation. The purpose of this interview is to gather information on the vision, goals, and expectations for the CV Pilot and to gather information on financial and institutional preparedness before the deployment activation. We are conducting this interview under the human subjects' protection requirements of Texas A&M University's Institutional Review Board. The information that you provide in this interview is confidential, and we will not attribute responses to any specific

individuals. As part of this interview, I will be asking a series of questions that pertain specifically to your perceptions and experiences regarding the planning, development, and upcoming implementation of the CV pilot applications.

Interview Questions

Questions to be asked of deployment managers, deployment team members, operating agencies, and policymakers:

1. What is your agency's role in the CV pilot deployment?
2. What is your role in the CV pilot deployment in Wyoming?
 - Probe if not addressed: In what stage are you most involved? (planning, development, implementation, all)
 - Probe if not addressed: In what specific activities are you most involved?
3. To the best of your knowledge, what are your agency's goals/reasons for participating in the CV pilot?
4. In your opinion, what constitutes success for your pilot deployment?
 - Probe: What are the positive outcomes that your agency is hoping will result?

Policy Challenges

Questions to be asked of deployment managers, deployment team members, operating agencies, and policymakers:

5. Are there specific policies or political issues that had to be addressed to deploy the CV applications?
 - Probe: How were they addressed? [note issue by issue]
 - Probe: What are the gaps in state and local laws? [note issue by issue]
 - Probe: Did you encounter issues related to compliance with standards and regulations? [note issue by issue]
6. Are there any policy issues that your agency still needs to address in the future regarding deployment of this type of technology?

Institutional Challenges

Questions to be asked of deployment managers, deployment team members, operating agencies, and policymakers:

7. Did you encounter institutional issues associated with the public partnership arrangements?
 - If Yes: What issues/concerns arose? [note issue by issue] [do not ask policymakers]
 - Probes: roles and responsibilities, communication patterns, MOUs
8. Are there any specific institutional issues that surfaced during the planning for implementation?
 - Probes: completeness of ConOps, private involvement and related procurement issues, assessment of site design and deployment approach, enforcement/compliance, staff training level

- Probe: What solutions were put forth to address these challenges? [note challenge by challenge] [do not ask policymaker]

Culture

Questions to be asked of deployment managers, deployment team members, operating agencies, and policymakers:

9. Does your organization as a whole support the CV Pilot Deployment?
 - If Yes: In what way has this benefitted the deployment?
 - If No: What kinds of issues/concerns has this created for the deployment?

Collaboration

Questions to be asked of deployment managers, deployment team members, and operating agencies:

10. In your opinion, does consensus exist among the various stakeholders regarding CV goals, expectations, and priorities or is each stakeholder participating in the pilot program according to its priorities?
11. To your knowledge, what types of formal processes have been put in place to facilitate collaborative planning/programming among CV pilot stakeholders?
12. How do key stakeholders participate in the decision process for CV system operations and management?
13. Moving into implementation, what kind of business processes and procedures have you enacted to facilitate your operational decision making?

Financial Issues

Questions asked of deployment managers, deployment team members, and operating agencies:

14. In your opinion, is there a shared commitment among stakeholders as to the financial stability of CV pilot and how to achieve it?
 - If Yes: What are the shared commitments (including cash contributions) from the various stakeholders? How were these shared commitments achieved?
 - If No: Discuss why not.
15. Are you familiar with the long-term plan for funding/financing the CV pilot?
 - If Yes: Please describe.
16. Are you aware of the existence of a business plan or business planning process for the CV pilot?
 - If Yes: Please describe.
17. Have projections for future market participation, revenue, and cost associated with the CV pilot been developed?
 - If Yes: Can you provide detail on that process? Outcomes?
 - If No: Are there plans to do this in the future?

Business Processes

Questions asked of deployment managers, deployment team members, and operating agencies:

18. In a typical DOT-centric manner, the pilots would be organized such that the public sector is expected to assume responsibility for the infrastructure aspects of the system and the private sector the installation of vehicle equipment. Was this general structure followed?
 - If Not: what structure was used?
19. Has the CV pilot program been reflected in the overall multimodal transportation and business plans of all participating public agencies?
 - Probe: Have multiyear budgets been developed for pilot implementation?
 - Probe: Is there a plan for ongoing operation of the CV deployment including actions defined and business models for expansion of the existing pilot and transition to support long-term deployment?
20. To what extent are your business processes changing as a result of deploying the pilot? Can you provide an example?

Performance Measures

Questions to be asked of deployment managers, deployment team members, operating agencies, and policymakers:

21. What impacts do you foresee when you (your agency) decided to participate in the CV pilot?
 - Probe specifically on individual mobility, environmental, and efficiency impacts.
 - If efficiency impacts are expected, ask about availability of data to evaluate resource savings.

Questions to be asked of deployment managers:

22. Your agency identified a number of performance measures to monitoring performance of the deployment. How will these data be used during the pilot deployment?
 - Probe: Directly for after-action debriefings and improvements, displayed in dashboards, only after the fact for overall evaluation purposes.
23. During the deployment period, will these performance measures be reported internally to the deployment team only or externally as well?
24. In what way will performance measures be related to financial stability measures – in other words, used to support business decisions related to future CV pilot activities?

Systems and Technology

Questions to be asked of deployment managers, deployment team members, and operating agencies:

25. What do you think are the most significant technical or technology-related challenges related to the CV pilot?
 - Probe: How has your agency coped with the challenges? What kind of solutions has your agency put forth? [note challenge by challenge]
 - Probe: What kind of issues/challenges to you encounter with standards and specifications?
 - Probe: Do you feel the applications are mature enough for deployment?
 - Probe: If no, what needs to be done to solidify the applications?

- Probe: Do you feel the test plans and procedures are sufficient?
- 26. What kinds of security challenges did you face in planning and implementing your deployment?
 - Probe: Does your system design address hacking and privacy concerns? Please explain.
 - If Yes: Does the CV program include adequate infrastructure to ensure timely issuance of security certificates to participants?

Questions asked of deployment managers and deployment team members:

- 27. Does the system design incorporate maintenance monitoring for both vehicles and field equipment that permits rapid identification of system degradations or failures?
 - If Yes: Is emphasis placed on seamless monitoring across jurisdictional boundaries?
 - If Yes: How will you deal with maintenance issues of equipment installed on vehicles?
 - Probe: Who will maintain the field equipment?
 - Probe: Has your agency developed a maintenance management system that captures maintenance actions, cost, inputs, and outputs for both field equipment and vehicles?

Workforce Development

Questions asked of deployment managers and operating agencies:

- 28. Are sufficient people trained to manage, operate, and maintain the CV system through both in-house work and outsourcing?
 - Probe on any challenges encountered.
- 29. For the in-house staff, were these individuals added on to units with the existing structure and staffing or was a CV-specific operational unit developed?
 - Probe: If added to existing structure: Do you foresee CV responsibilities being consolidated into an operational unit with a manager and defined budget?
- 30. How do you see staffing evolving to meet the demands of future technologies and a mix of modes?

Outreach

Questions asked of deployment managers and operating agencies:

- 31. What outreach activities, if any, has your agency planned to engage other stakeholders, policymakers, or the public in the CV deployment?

Final Question

- 32. Do you have any additional thoughts or concerns to share that may not have come up during the interview?

Near-Term Post Deployment Interview Guide

This section contains questions that the TTI CVPD Evaluation team will use when conducting the near-term post-deployment interview. The TTI CVPD Evaluation Team will conduct these interviews 2–3 months after the initial activation of the applications. This interview serves as a quick-check-in with

deployment managers and deployment team members shortly after activation of the CV applications and should be no longer than about 30 minutes in length. The TTI CVPD Evaluation Team will interview the same individuals from the stakeholder entities interviewed previously. Questions that are identical to the pre-deployment instrument are identified with the code (I) and those that are a follow-up to a question asked in the pre-deployment interview are identified with the code (F). Questions will be sent to interviewees in advance of the interviews to facilitate discussion. Probes in the interview guides will be removed prior to sharing with the interviewees.

TTI will assign questions to stakeholder groups based upon assumptions of their knowledge and interest levels. It may be necessary to tweak some words based on who is being interviewed.

Preamble

Good morning (afternoon) and thank you for participating in another [this] interview. I am (name here), a member of the CV Pilot Deployment Independent Evaluation Team. Our job is to assess the mobility, environmental, and public agency efficiencies associated with the CV Pilot Deployments. The sponsor of this evaluation is the USDOT's ITS Joint Program Office. The purpose of this interview is to gather initial perceptions and experiences relating to the activation of the CV applications. The interview is being conducted under the human subjects' protection requirements of Texas A&M University's Institutional Review Board. The information that you provide in this interview is confidential and responses will not be attributed to any specific individual.

Interview Questions

Role, Vision, Goals

1. If previously interviewed: Can you confirm that your role in the CV pilot deployment was [from the pre-deployment interview]? (F) If not previously interviewed: What was your role in the pre-deployment stage?
2. Has your role in the CV pilot deployment changed in any way from the pre-deployment stage? (F)
 - If Yes: What specific activities are you most involved in now?
3. Have expectations about the positive impacts of the CV applications changed at all during the early activation period? (F)
 - If Yes: What has changed and why?

Pilot Effectiveness

4. In a pre-deployment interview, you stated that your agency's objectives in participating in the pilot were [list]? How well is your experience thus far meeting those stated goals? (F)
5. You also mentioned that [list] would constitute success? Has the early experience in the activation of the applications altered your view of what would constitute success? (F)

Institutional Challenges (Placeholder until Institutional Evaluation Plan Is Finalized)

6. Were there any unforeseen institutional issues that needed to be addressed during initial implementation?

- Probe: What solutions to these challenges were identified? Have they been implemented yet? [note challenge by challenge]
- Probe: Are there any lessons learned so far?

Financial Issues (Placeholder until after Initial Interviews and Financial Evaluation)

7. How has the experience thus far with activation of the CV applications influenced your perceptions of whether or not your agency has the resources to deploy and manage the V2X applications?

Performance Measures

8. A number of performance measures have been developed for your site (have list). How are you using these data during the pilot deployment? (F)
 - If Yes: How are you or your agency using these performance metrics?
 - Probe: Are these performance measures reported internally to the deployment team only or externally as well?
 - Probe: Are the performance measures being used to assess financial stability measures? In other words, are data being compiled or analyzed to support business decisions related to future CV pilot activities?

Systems and Technology

9. What have been the most significant technical or technology-related challenges since the deployment started, X months ago?
 - Probe: Are there solutions to these challenges that have been put forth? [note challenge by challenge]
 - Probe: Are there any lessons learned so far?
10. In your opinion, have appropriate levels of cyber security been incorporated into system design?
 - Probe: Does system design address hacking and privacy concerns? (I)
 - If Yes: Are security certificates being issued to participants in a timely manner? (F)
11. Is the system operating as expected with regards to maintenance monitoring for both vehicles and field equipment to permit rapid identification of system degradations or failures? (I)
 - Probe on: What is working well? What needs some tweaking? Are there any lessons learned so far?

Deployment and Communications Management

12. In general, how satisfied are you with the pilot roll-out so far (i.e., activation of the CV applications)?
 - Probe: What is working well? What needs some tweaking?
 - Probe: Are there any lessons learned so far?
13. From your perspective on the deployment team, how effective is the training for drivers who are users of the CV applications?
 - Probe: What is working well? What needs some tweaking? Are there lessons learned so far?

14. How would you describe the communications among stakeholders implementing the pilot?
 - Probe: What is working well in terms of communication among stakeholders? What needs to be improved?
15. What outreach activities, if any, is your agency conducting with policy makers, the public, or other stakeholders to facilitate a successful pilot deployment? (I)

Final Question

16. Do you have any additional thoughts or concerns to share that may not have come up during the interview? (I)

Long-Term Post Deployment Interview Guide

This section contains questions that the TTI CVPD Evaluation team will use when conducting the long-term post-deployment interview. The TTI CVPD Evaluation Team will conduct these interviews 9–12 months after activation of the applications. This interview will gather information on stakeholder perceptions as to whether and how the pilot deployments achieved their goals and objectives. Using qualitative methods of data collection will provide insight into unintended consequences and lessons learned. The interview respondents are deployment managers, operating agencies, and policy makers. The same individuals from the stakeholder entities should be interviewed as were in previous interviews. Interview lengths should range between 45 minutes for policymakers to 90 minutes for the other two stakeholder groups.

Questions have been assigned to stakeholder groups based upon assumptions of their knowledge and interest levels. It may be necessary to tweak some words based on who is being interviewed. Questions that are identical to the pre-deployment instrument are identified with the code (I) and those that are a follow-up to a question asked in the pre-deployment interview are identified with the code (F).

The questions will be shared with interviewees prior to the interview. Probes in the interview guides will be removed prior to sharing with the interviewees.

Preamble

Good morning (afternoon) and thank you for participating in another [this] interview. I am (name here), a member of the CV Pilot Deployment Independent Evaluation Team. Our job is to assess the mobility, environmental, and public agency efficiencies associated with the CV Pilot Deployments. The USDOT ITS Joint Program Office is sponsoring this evaluation. The purpose of this interview is to gather information on your perceptions of the outcomes of the pilot deployments. The interview is being conducted under the human subjects' protection requirements of Texas A&M University's Institutional Review Board. The information that you provide in this interview is confidential, and responses will not be attributed to specific individuals.

Interview Questions

Role, Vision, Goals

Questions to be asked of deployment managers, operating agencies, and policymakers:

1. Has your role in the CV pilot deployment changed in any way over the past 6 months? (F)
 - If Yes: What specific activities are you most involved in now?
2. What activities were you most involved in prior to the past 6 months? (F)
3. Have expectations about the positive impacts of the CV applications changed at all based on your experiences during the early activation period? (F)
 - If Yes: What has changed and why?

Pilot Effectiveness

Questions to be asked of deployment managers, operating agencies, and policymakers:

4. In your opinion, how successful was your deployment at achieving the goals and objectives initially defined for your deployment, which were [X] based on information collected in previous interviews? (F)
5. You also mentioned that [list] would constitute success? Has your experiences with the applications altered your view of what would constitute success? (F)

Questions to be asked of deployment managers and operating agencies:

6. Your deployment included a number of CV applications [list applications]. Which of those applications achieved the desired outcomes and how? Which fell short and why?
7. How satisfied are you with your pilot deployment experience?
8. Would you do this again given the opportunity?
9. Would you recommend it to other agencies?

Policy Challenges

Questions to be asked of deployment managers, operating agencies, and policymakers:

10. Were there any lingering policy issues that created challenges during the pilot deployment?
11. What policy challenges, if any, will influence the long-term sustainability of the CV program?

Institutional Challenges

Questions to be asked of deployment managers, operating agencies, and policymakers:

12. Previously, you identified some institutional issues that needed to be addressed during implementation [list]. Were these issues addressed and how?
13. Were there unforeseen institutional issues that needed to be addressed during implementation?
 - If Yes: What were these issues and how were they addressed?
 - If Yes: What are lessons learned for future deployments?
14. Were deployment plans sufficient to manage the implementation efficiently?
 - If No: What necessary modifications did you encounter?
15. Thinking about future CV application deployment, what institutional issues, if any, need to be considered to ensure successful implementation?

Culture

Questions to be asked of deployment managers, operating agencies:

16. Does your organization as a whole support the CV pilot? (I)
17. Has your organizational culture changed as a result of your experiences with the deployment? If Yes: please explain.
18. Has senior management solidified a CV business case?
 - Probe: Is this being communicated to policymakers and the public?

Collaboration

Questions to be asked of deployment managers and operating agencies:

19. Was consensus reached among the various stakeholders in terms of CV goals, expectations, and priorities or was each stakeholder participating in the pilot program according to its own priorities? (F)
20. Was the pilot deployment implemented through a formal process for collaborative planning/programming among CV pilot stakeholders? (F)
21. Has a formal agreement been put in place for long-term relationships among stakeholders?
 - Probe to address funding responsibilities, business models, future CV system operation, expansion, and replication.

Financial Issues (Placeholder until after Initial Interviews and Financial Evaluation)

Questions asked of deployment managers and operating agencies:

22. In your opinion, was there a shared commitment among stakeholders to the financial stability of the CV pilot and how to achieve it?
 - If Yes: discuss what the shared commitments are (including cash contributions) from various stakeholders and how the shared responsibility was achieved.
 - If No: discuss why not.
23. What were the lessons learned in terms of equipment costs (vehicle and field) to inform future deployments?
24. Previously you identified [list] as the cost categories that you would include in a cost/benefit analysis of the pilot deployment? Would you now add any others?
25. Do you have the data to provide cost estimates for these categories?

Business Processes

Questions to be asked of deployment managers and operating agencies:

26. Is there a plan among stakeholders for ongoing operation of the CV deployment?
 - Probe: Business model for expansion, transition plan
27. To the best of your knowledge, has CV been included as a formal, visible, sustainable line item in your agency's budget?
 - If No: What are the hurdles in doing so?
28. To what extent have your business processes changed as a result of deploying the pilot? Can you provide an example of how they changed?

- If any change: Were these developed by a single agency or were they done in an integrated way across various agencies? Have these been shared with other stakeholders?
- If No change: Why not?

Performance Measures

Questions to be asked of deployment managers, operating agencies, and policymakers:

29. Previously, you mentioned the following mobility, environment, and public agency efficiency impacts [list] as important in your agency's decision to participate in the pilot. To your knowledge, which were successfully achieved? (F)
- Probe: Specific probes for SMEP impacts if interviewee does not mention them when responding to Q. 3.

Questions to be asked of deployment managers:

30. A number of performance measures have been developed for your site (have list). What was the most efficient use of these data during the pilot deployment?
- Probe on specifics using information gathered in the pre-deployment interview.
31. During the deployment period, will these performance measures only be reported internally to the deployment team or externally as well?
32. Have outcome MEP measures been monetized for cost-benefit analysis and to inform financial sustainability? (Placeholder until Financial Evaluation Plan is finalized)

Systems and Technology

Questions to be asked of deployment managers, operating agencies, and policymakers:

33. What were the most significant technical or technology-related challenges related to the CV pilot?
- Probe: What are the lessons learned from addressing these challenges?
34. Do you think that the current CV applications are mature enough for widespread development?
- Probe: Are you considering or prefer alternatives to CV?

Questions asked of deployment managers and operating agencies:

35. Were the regional ConOps developed for CV system implementation followed as designed or were adjustments to the ConOps made as needed?
- Probe: Can you describe those adjustments and why made?
36. In your opinion, were appropriate levels of cyber security incorporated into system design? (F)
37. Did any hacking and privacy incidents occur? (F)
- If Yes: How were these handled?
38. Did the CV program include adequate infrastructure to ensure timely issuance of security certificates to participants? (I)
- If No: Why not? What was the work around?
39. Did the system design adequately incorporate maintenance monitoring for both vehicles and field equipment to permit rapid identification of system degradations or failures? (I)
- If No: Why not? What adverse outcomes, if any, resulted from not having a maintenance monitoring system?

- If Yes: What lessons were learned for future applications?
- If Yes: Was vehicle maintenance performed on an as-needed basis (firefighting) or was it performed by technicians in the vicinity of the CV applications? Were original equipment manufacturers (OEM) dealerships or service centers involved in vehicle maintenance?
- Probe: Who maintained the field equipment?
- Probe: Was a maintenance management system developed that captures maintenance actions, cost, inputs, and outputs for both field equipment and vehicles?

Workforce Development

Questions asked of deployment managers and operating agencies:

40. In hindsight, were sufficient people trained to manage, operate, and maintain the CV system through both in-house work and outsourcing? (I)
 - Probe on any challenges encountered.
41. Have position descriptions for CV responsibilities been institutionalized to support activities going forward?
42. Are sufficient people trained to manage, operate, and maintain the CV system going forward? (F)
43. Do you foresee CV responsibilities being consolidated into an operational unit with manager and defined budget? (F)
44. Is staffing capable of evolving to meet the demands of future technologies and a mix of modes?

Outreach

Questions asked of deployment managers and operating agencies:

45. What outreach activities, if any, did your agency use to engage other stakeholders, policy makers, or the public in the CV deployment? (I)
 - Probe: Which was most effective?

Appendix B. Workshop Guide

Introduction

The TTI CVPD Evaluation Team will conduct a workshop in each site at the conclusions of deployment period. The purpose of the workshops is to foster additional dialog among the deployment managers, deployment teams, and operating agencies concerning the lessons learned and major takeaways from planning and implementing the deployments. The common themes identified in the post-deployment interviews will be used to frame the group discussion, which will explore these and other topics in more detail. These workshops will also be used to gather information needed to conduct the Financial and Institutional Assessments (see Task C scope of work).

Workshop participants will represent the deployment managers, deployment team members, and operating agencies from each site. It is expected that 15–20 persons will participate in workshops per site. Some, but not all, will be individuals who have participated in the interviews. The TTI CVPD Evaluation Team will coordinate with the deployment managers in identifying persons to be invited to the workshops.

Workshop Format

The proposed format for these workshops is presented below. Core members of the TTI CVPD Evaluation Team will lead these workshops in-person. Other TTI CVPD Evaluation Team members will participate via web conference.

Workshop Questions

Without knowing the information that will result from the post-deployment interviews, the following are types of questions that will be used in the workshop:

Participant Introductions: Name, affiliation, role in pilot (specific activities)

Expectations and Satisfaction

1. What is your agency's objective(s) in participating in the pilot?
2. How well did the CV pilot meet the stated objectives?
3. When initially implemented, how did the pilot meet the stated objectives?
4. How well did the pilot implementation match what was initially proposed?
5. Were there unanticipated changes to scope, cost, schedule, or safety?
6. How were these managed? How well were you or others in your organization involved in the risk identification and mitigation planning?

7. What is your overall assessment of the success of this pilot?
8. Has your view of what constitutes success changed during the deployment and operation of the various projects? If so, in what way and why?
9. In what ways are you satisfied with the outcomes? Any ways in which you are not satisfied?
10. Would you do it again?
11. Would you recommend to other agencies?

Technical Challenges

12. What do you think were the three biggest technical or technology-related challenges in pilot implementation?
13. Were these challenges effectively addressed?
14. How were they addressed?
15. What lessons learned can be drawn from these challenges?

Institutional Arrangements

16. In what ways have the capabilities of your organization (related to CV applications) matured because of the pilot?
17. What were the two biggest institutional challenges?
18. Were these challenges effectively addressed?
19. How were they addressed?
20. What lessons learned can be drawn from these challenges?
21. With what other stakeholders did your organization most collaborate during the pilot?
22. Do you expect continued collaboration with these organizations? For what purposes?

Financial Arrangements

23. What were the biggest financial or cost-related challenges for your organization during deployment? How were these addressed?
24. In what ways has the experience with the CV applications influenced your perceptions of whether or not your agency has the resources to deploy and manage the V2X applications?
25. Have you begun any kind of cost-benefit analysis of the pilot deployment? Describe the cost and benefit categories.
26. What are your preliminary assessments?
27. In your opinion, is there a shared commitment among stakeholders to the financial sustainability of CV pilot and how to achieve it?

Lessons Learned

28. What are the three most important lessons learned? List and compare/contrast.

Sustainability

29. Has your organization developed a strategy for sustainability that you are willing to share here?
30. Do you foresee CV as a formal, visible, sustainable line item in your agency's budget?

Expectations for Future Operations

31. Are sufficient people trained to manage, operate, and maintain the CV system going forward?
32. Do you foresee CV responsibilities being consolidated into an operational unit with a manager and defined budget?
33. Is staffing capable of evolving to meet the demands of future technologies and a mix of modes?
34. Has senior management solidified a CV business case? Is this being communicated to policy makers and the public?
35. What is the level of acceptance of a CV program among policy makers and the public?

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