Connected Vehicle Pilot Deployment Program Phase 1

Lessons Learned

www.its.dot.gov/index.htm
Final Report — January 2017
Publication Number: FHWA-JPO-17-504

U.S. Department of Transportation

Produced by Noblis, Inc.
U.S. Department of Transportation
ITS Joint Program Office

Notice

Technical Report Documentation Page

1. Report No. **FHWA-JPO-17-504**	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle **Connected Vehicle Pilot Deployment Program Phase 1 Lessons Learned**		**5. Report Date** **January 30, 2017** **6. Performing Organization Code**
7. Author(s) **Taylor Deurbrouck and Kathy Thompson**		**8. Performing Organization Report No.**
9. Performing Organization Name And Address Noblis 600 Maryland Ave., SW, Suite 755 Washington, DC 20024		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** **DTFH6116F00019**
12. Sponsoring Agency Name and Address ITS-Joint Program Office 1200 New Jersey Avenue, S.E. Washington, DC 20590		**13. Type of Report and Period Covered** Final Report **14. Sponsoring Agency Code** **HOIT-1**
15. Supplementary Notes		

16. Abstract

The Connected Vehicle Pilot Deployment (CV Pilots) Program seeks to spur innovation among early adopters of connected vehicle application concepts. Pilot deployment awards were given to three sites, New York City, Wyoming, and Tampa, FL. The CV pilot sites are expected to integrate connected vehicle research concepts into practical and effective elements, enhancing current operational capabilities. Each pilot deployment site is expected to be developed in three distinct phases: Phase 1 Concept Development, Phase 2 Design/Build/Test, and Phase 3 Operate and Maintain.

This document covers lessons learned from the USDOT, its technical support team, and the pilot deployment sites during Phase 1 of the CV Pilot Program. The objective of concept development in Phase 1 was to set the stage for a connected vehicle pilot deployment that had an observable measureable near-term impact, deployed on-time and within budget. Overall the three pilot deployment sites were awarded contracts to continue their work in Phases 2 and 3.

Given the promising future of connected vehicle deployments and the growing early deployer community, Noblis conducted a study to gather observations and insights from the CV Pilot team including both federal and pilot deployment site team members. This report represents an organized collection of those lessons learned across all stages of the CV Pilot Phase 1 Program. Observations include lessons learned and recommendations for both future USDOT and early deployer projects and efforts.

17. Key Words Connected vehicle, pilot deployment, ITS, lessons learned	**18. Distribution Statement**		
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 43	**22. Price**

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

Acknowledgements

Noblis conducted over 20 interviews to gather raw observations that could be processed and synthesized into lessons learned that would be useful to both the USDOT and the early deployer community. As such, we would like to thank all of those members of the Connected Vehicle Pilot Deployment Program team that participated in the interviews and provided insights, feedback and recommendations including the federal team members, Noblis team members, and pilot site team members listed below.

Table A- 1: List of Interview Participants

USDOT Team Members	Noblis Technical Support Team Members	Pilot Site Team Members
• Carl Andersen • Deborah Curtis • Walter During • Ed Fok • Joseph Fusari • Ariel Gold • John Halkias • Kate Hartman • Gene McHale • Steve Mortensen • Jon Obenberger • Mike Pina • Bob Rupert • Steve Sill • Jim Sturrock • Govind Vadakpat • Jonathan Walker	• Justin Anderson • Sampson Asare • Blake Christie • Taylor Deurbrouck • Rick Glassco • Bill Hyman • Cory Krause • LaMont McAliley • Mike McGurrin • James O'Hara • Barbara Staples • Kathy Thompson • Meenakshy Vasudevan • Peiwei Wang • Karl Wunderlich	New York City Deployment Team • David Benevelli • Bob Rausch • Mohamed Talas Tampa Deployment Team • Bob Frey • Steven Johnson • Stephen Novosad • Stephen Reich • Dave Miller • Dave McNamara Wyoming Deployment Team • Tony English • Vince Garcia • Deepak Gopalakrishna • Ali Ragan

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Executive Summary

The Connected Vehicle Pilot Deployment (CVPD) Program seeks to spur innovation among early adopters of connected vehicle application concepts. In September 2015, pilot deployment awards were made to three sites, New York City, Wyoming, and Tampa, FL. The pilot sites are expected to integrate connected vehicle research concepts into practical and effective elements, enhancing current operational capabilities.

The overall goals of these pilot deployments include:

- Encourage partnerships of multiple stakeholders (e.g., private companies, state and local agencies, transit agencies, commercial vehicle operators, and freight shippers)
- Deploy applications utilizing data captured from multiple sources (e.g., vehicles, mobile devices, and infrastructure) across all elements of the surface transportation system (i.e., transit, freeway, arterial, parking facilities, and tolled roadways)
- Support improved system performance and enhanced performance-based management.

This report is not intended to cover the entire CVPD Program as it only covers lessons learned from the USDOT, its technical support team, and the pilot deployment sites during Concept Development, Phase 1. The program objective in Phase 1 was to set the stage for a connected vehicle pilot deployment that had an observable measureable near-term impact, deployed on-time and within budget. Based on the quality and timeliness of Phase 1 deliverables, as well as the quality of submitted applications for funding in following phases, the three pilot deployment sites were awarded cooperative agreements to continue deployment activity in September 2016.

The methodology used to develop lessons and recommendations from Phase 1 included a combination of in-person and phone interviews as well as a review of program documentation. Interviews were conducted with 17 federal staff and three pilot site leadership teams. Additional lessons learned were collected from the Noblis technical support team supporting the USDOT. Some of the most common lessons learned reported by the federal team, pilot sites, and technical support include:

- Conduct consistent federal team meetings with clearly communicated agendas and outreach plans. Such meetings are helpful in keeping everyone in the loop and necessary for the pace of the project.
- Provide additional information upfront in the solicitation regarding data ownership and subpoenas.
- Be as frank and transparent as possible regarding technological maturity of deployment-related systems and resources.
- Don’t underestimate the level of effort required to deal with privacy issues. Maintaining user privacy is a critical issue for stakeholders and is far more complex than the sites and USDOT first realized.
- Leverage local stakeholders and leadership early. A lot was learned from engaging the local project stakeholders early in Phase 1 that directly guided the development of the concept of operations and system architecture development.

1 Introduction

1.1 Background

The Connected Vehicle Pilot Deployment (CVPD) Program seeks to spur innovation among early adopters of connected vehicle application concepts. In September 2015, Pilot deployment awards were made to three sites, New York City, Wyoming, and Tampa, FL. The pilot sites are expected to integrate connected vehicle research concepts into practical and effective elements, enhancing current operational capabilities.

The overall goals of these pilot deployments include:

- Encourage partnerships of multiple stakeholders (e.g., private companies, state and local agencies, transit agencies, commercial vehicle operators, and freight shippers)
- Deploy applications utilizing data captured from multiple sources (e.g., vehicles, mobile devices, and infrastructure) across all elements of the surface transportation system (i.e., transit, freeway, arterial, parking facilities, and tolled roadways)
- Support improved system performance and enhanced performance-based management.

Pilot sites must identify key safety, mobility and environmental issues and create an integrated concept to resolve or mitigate these critical problems. Further, each site must establish a set of key quantitative performance measures and develop a deployed system that supports continuous monitoring of observed data capable of quantifying these measures. Pilot deployment sites are also expected to support an independent evaluation effort conducting a comprehensive assessment of cost-benefit, user acceptance/satisfaction, and lessons learned. Finally, pilot deployments are expected to become part of a permanent connected vehicle capability that is fully integrated into routine operational practice in the pilot site – and create a foundation for expanded and enhanced deployments. The CVPD Program seeks institutional and financial models that enable long-term sustainment of successful elements of pilot deployments without dedicated federal funding.

Each pilot deployment site will be developed in three distinct phases:

- Phase 1: Concept Development – Phase 1 award to 12 months. In this phase the preliminary proposed idea is developed into a structured concept that is suitable for further design, building, testing, and operation. The structured concept will include identifying specific performance measures, targets, and capabilities associated with performance monitoring and performance management.
- Phase 2: Design/Build/Test – Phase 2 award to 20 months. In this phase, the pilot deployment concept is designed in detail, built, and tested prior to operation.
- Phase 3: Operate and Maintain – Phase 3 award to 18 months. In this phase, the tested pilot deployment applications and technologies are placed into operational practice. The impact of the deployment on a set of key performance measures will be monitored and reported on a daily, weekly, and monthly basis. Further, performance and other data

supporting a comprehensive assessment of deployment impacts are to be shared with a USDOT-identified independent evaluator.

1.2 Purpose of the Report

This document covers lessons learned from the U.S. Department of Transportation (USDOT), technical support team, and pilot deployment sites during Phase 1 of the Connected Vehicle Pilot Deployment (CVPD) Program. The objective of concept development in Phase 1 was to set the stage for a connected vehicle pilot deployment that had an observable measureable near-term impact, deployed on-time and within budget. Overall, the three pilot deployment sites met this objective, and were awarded cooperative agreements to continue deployment activity in Phases 2 and 3.

Given the promising future of connected vehicle deployments and the growing early deployer community, Noblis conducted a study to gather observations and insights from the CVPD team including both federal and pilot deployment site team members. This report represents an organized collection of those lessons learned across all stages of Phase 1. Observations include lessons learned and recommendations for both future USDOT and early deployer projects and efforts.

1.3 Methodology

The methodology used to develop lessons and recommendations from Phase 1 included a combination of in-person and phone interviews as well as a review of program documentation. For example, connected vehicle (CV) pilot sites were asked to provide explicit lessons learned as a part of both the Task 12 Comprehensive Deployment Plan document as well as the Task 13 Deployment Readiness Assessment document. There were 17 interviews conducted with the USDOT federal CVPD team and one interview with each of the three CV pilot site leadership teams. Lessons learned were also collected from the Noblis technical support team supporting the USDOT in Phase 1.

Lessons learned are organized into tables with the original author attributed to either the USDOT Federal/Technical Support Team or the CV Pilot Sites as noted in Table 1-1. Lessons learned that were addressed well by actions of the CV Pilots team are noted with a description of the observed result and a green checkmark. If the lesson learned was not adequately addressed then what follows is a description of the predicted result if action had been taken and an open circle with an account of the effect caused by not properly addressing the lesson learned.

Table 1-1: Key for Lessons Learned Tables

Lesson Learned Key
Fed/Tech – USDOT Federal and Technical Support Team
Sites – CV Pilot Sites
✓ – Action taken to achieve lesson learned
o – Effect of not addressing lesson learned

1.4 Organization of the Report

This report is organized into ten chapters. The first chapter is this introduction. The next two chapters are focused on overall program management and technical assistance across the entire Phase 1 project as experienced from the perspective of the USDOT and intended for USDOT reference only. The remaining chapters cover the topics related to the tasks of the CVPD combining insights from all interviews and site-provided lessons learned documentation.

This document is organized into ten chapters, namely:

- Chapter 1 Introduction
- Chapter 2 Program Management
- Chapter 3 USDOT Technical Assistance
- Chapter 4 Security and Privacy
- Chapter 5 System Engineering
- Chapter 6 Performance Measurement and Evaluation Support
- Chapter 7 Data Governance and Sharing
- Chapter 8 Human Use Approval and Participant Training
- Chapter 9 Institutional Issues, Financial Sustainability, Partnerships and Outreach
- Chapter 10 Deployment Readiness

2 Program Management

This chapter addresses lessons learned regarding the overall program management of the CVPD Program. It is divided into two subchapters:

- **Program Planning** – This subchapter focuses on the structure of the acquisition strategy leading to the solicitation including outreach efforts and program structure.
- **Program Communications** – This subchapter focuses on the methods of communication utilized by the USDOT to manage and coordinate the CVPD Program.

2.1 Program Planning

This section covers the program planning phase of Phase 1, primarily from a USDOT perspective.

2.1.1 Acquisition Strategy and Outreach

The acquisition process conducted by the USDOT involved a significant amount of time and effort. The entire acquisition team met biweekly for over a year to discuss the needs and requirements for CVPD. At the same time, a focused outreach effort was conducted aimed at the Intelligent Transportation Systems (ITS) community through news releases, social media posts, web-site content, and a coordinated set of webinars regarding the planned nature and intent of the program. For example, in February 2015, a series of webinars on existing Dynamic Mobility Application (DMA) projects were conducted to increase awareness and knowledge of then-current mobility-related prototype applications available to potential deployment proposers. Program-specific webinars and workshops were held in a 12-month period leading up to the expected procurement release date to both inform potential deployers regarding the objectives of the program and to gather feedback from potential deployers regarding the feasibility of mounting a deployment-focused program in the projected time frame.

Table 2-1: Lessons Learned about Acquisition Strategy and Outreach

Lessons Learned – Acquisition Strategy and Outreach
Conduct consistent and organized meetings with the entire acquisition team (federal technical team plus federal contracting team plus support contractors) over 6+ months [Fed/Tech] OBSERVED RESULT: High team cohesion and a comprehensive, workable procurement approach. ✓ The acquisition program office team met biweekly for at least a year before the award which developed clear channels of communication amongst the team federal team.

Lessons Learned – Acquisition Strategy and Outreach
Pursue outreach activities with traditional communities. [Fed/Tech] OBSERVED RESULT: The ITS community was well informed and the solicitation received a lot of robust proposals. ✓ Outreach included preparing flyers, slide decks, and speaking engagements within the ITS community well before the solicitation went out.
Provide generic examples of deployment concepts based on addressing local needs as a key element of pre-procurement engagement. [Fed/Tech] OBSERVED RESULT: Comprehensive and robust proposals that address a variety of issues to the local area of study. ✓ The program did provide six hypothetical example concepts stepping through identifying local issues, formulating performance measures, and selecting an integrated portfolio of applications to address these issues. ✓ The diversity of the selected sites and the unique environments they possess contributed to an excellent range of CV solutions and lessons learned for future deployments.
Pursue outreach activities with nontraditional communities. [Fed/Tech] PREDICTED RESULT: Wider variety of proposals consisting of various stakeholder groups instead of just the existing ITS community. o Although the solicitation received a lot of proposals, additional outreach could have been conducted through mailing lists and ads outside of the ITS community.
Investigate data ownership and subpoena issues in detail prior to the solicitation development process – and provide this detail in the solicitation. [Fed/Tech] PREDICTED RESULT: Reduction in time spent after award investigating and resolving data-related policies/issues. o The solicitation was unclear on data ownership which led to sites concerns over subpoenas. After some back-and-forth around the issue, an investigation led to specific language that clarified protections for safety-related research data. Had this been understood before award, this would have saved several weeks of delay caused by uncertainty. For more lessons learned related to this topic see Section 7.1.
Include basic educational material so non-experts can be engaged and understand the nature of the proposed program. [Fed/Tech] PREDICTED RESULT: More informed and educated proposal submissions. o To submit a proposal for this solicitation, it was necessary to have a working knowledge of CV. If going beyond the ITS community, there would need to be more effort put in to educate the public on the benefits of CV technology.

2.1.2 Program Structure and Timeline

The overall objective of Phase 1 was to set the stage for a connected vehicle deployment that has an observable measureable near-term impact, deployed on-time and within budget. The length of Phase

1 was only twelve months but included complex deliverables such as: Concept of Operations (ConOps), System Requirements Specification (SyRS), and Comprehensive Deployment Plan (CDP). Overall the high-tempo timeline was met but the pilot sites did report that they were rushing to finish deliverables while maintaining quality.

Table 2-2: Lessons Learned about Program Structure and Timeline

Lessons Learned – Program Structure and Timeline
Make evaluation and performance measurement an early topic in concept development. [Fed/Tech] OBSERVED RESULT: Giving early consideration to performance measurement reduced the amount of rework to the concept later on to meet evaluation goals. ✓ Development of the concepts with the evaluation in mind helped solidify a key goal of the pilot deployments.
Offer federal technical expertise through a USDOT Subject Matter Expert (SME) for each task. [Fed/Tech] OBSERVED RESULT: Even though deployments were complex and required a lot of diverse elements coming together in an integrated system, a USDOT SME for each task proved to be a critical factor in making rapid progress. ✓ Each task area of Phase 1 had a designated SME from the federal team.
Ensure that there is a clear support structure of federal SMEs, contractor assistance, consistent program meetings, and on-time deliverable reviews to keep the sites on-track with the aggressive timeline. [Fed/Tech] OBSERVED RESULT: Regular meetings kept the federal SMEs, technical support, and sites on the same page. ✓ The Phase 1 meetings consisted of monthly all-site meetings, biweekly site coordination meetings, and weekly program-level federal team meetings.
Break deployment planning aspects into a dozen key elements that begins with a Concept of Operations and ends with a Comprehensive Deployment Plan. [Fed/Tech] OBSERVED RESULT: Each deliverable helped establish the necessary background and knowledge needed to complete the next. ✓ The deliverables required in Phase 1 and their timing and relationships turned out to be reasonably useful and accurate. For example, completing the Security Management Operational Concept between the ConOps and SyRS development. However, the linear nature of the pilot, coupled with fixed price deliverables made it difficult to go back and revise documents based on evolving pilot concepts. It is recommended to add a final task to update all deliverables as final documents and not require 508 compliance versions in the interim.

Lessons Learned – Program Structure and Timeline

Track deliverable status closely. [Fed/Tech]

OBSERVED RESULT: Effectively tracking the status of deliverables was key to ensuring on-time completion of the project (pay by deliverable was a good approach).

✓ The federal team maintained a deliverable tracking spreadsheet updated weekly which communicated on-time, upcoming, and overdue deliverables.

Be as frank and transparent as possible regarding technological maturity of deployment-related systems and resources. [Fed/Tech, Sites]

PREDICTED RESULT: Deployments could be better planned if the systems and resources, including standards, are more fully developed.

- Many foundational elements related to the deployments were still in development. For example, a federal Security Credential Management System (SCMS) was under development at the same time the sites were preparing their plans. ITS standards were also evolving during Phase 1 which complicated the planning effort.

Emphasize financial sustainability in concept development. [Fed/Tech]

PREDICTED RESULT: Lowered risk of maintaining deployment capabilities after the USDOT-funded pilot period is complete.

- The sites were required to tailor the concept to the budget. The project sustainability and long-term funding goals originally envisioned for the pilot were not fully addressed (e.g., Pilots focused solely on how to lower costs rather than how to find creative approaches for covering the costs, whatever they might be). Long-term funding goals were never identified as a priority other than noting that systems shall continue to be in operation.

Concept development schedules may need to be tailored for diverse sites. [Sites]

PREDICTED RESULT: Sites able to tailor individual schedules to meet demands of their stakeholders or to better suit the climate of their local deployment site.

- The differing nature and scopes of all three sites made it difficult for each site to adhere to the same schedule. While the sites had the opportunity at the beginning of Phase 1 to propose an alternative schedule, it was difficult to know at that time how the schedule might have been effectively altered.

Stagger deliverables, where possible, so that dependent deliverables can be conducted after the review of precursor deliverables have been received. [Sites]

PREDICTED RESULT: The draft of a dependent deliverable would not need to be revised after a review of a previous deliverable reveals key flaws or gaps.

- Although the deliverable timeline was doable, in some cases the sites had to move to the next task while the previous one was still under review. In some cases, combining some deliverables may be been useful. For example, the Application Deployment Plan (ADP) and CDP might be combined for consistency and expediency.

2.2 Program Communications

After the USDOT awarded three CV pilot sites, the USDOT was faced with the challenge of managing and coordinating highly interrelated tasks among three pilot site teams operating in diverse environments. This subchapter covers how the USDOT efficiently yet effectively managed consistent communications and facilitated the sharing of critical information across multiple teams.

2.2.1 Coordination Meetings

The federal team utilized the following meetings to manage progress throughout Phase 1:

- Weekly USDOT Program Coordination meetings
- Bi-weekly Site Coordination meetings
- Monthly All-Site Coordination meetings
- Task-related and/or in-person site meetings on an as-needed basis

Table 2-3: Lessons Learned about Coordination Meetings

Lessons Learned – Coordination Meetings
Conduct consistent federal team meetings with clearly communicated agendas and outreach plans. [Fed/Tech] OBSERVED RESULT: Created a well-informed set of project team members. ✓ The USDOT held weekly internal program meetings and prepared an agenda, outreach plan and 60 day outlook for each meeting, helping keep everyone in the loop.
Pull together the entire federal team in-person well before the kickoff. [Fed/Tech] OBSERVED RESULT: Provided an opportunity to address cross-cutting activities and tasks. ✓ Engaging with federal team members early on helped get a pulse on what types of projects were currently being worked on and how they could help enhance the work planned for CV Pilots
Create a non-competitive environment among pilot sites. [Fed/Tech] OBSERVED RESULT: Increased collaboration amongst the sites. ✓ As rivalry was discouraged, the sites collaborated through the sharing of materials to build ideas off of each other. The sites also united in requesting desired documentation from third parties.
Ensure the federal and site teams have sufficient depth. [Fed/Tech] OBSERVED RESULT: Deep federal project teams with multiple individuals resulted in a less-overwhelming workload. ✓ Through proper delegation, the teams brought to bear relevant experts related to each project task.

Lessons Learned – Coordination Meetings
Maintain a balance between consistency among sites and allowing sites to operate autonomously. [Fed/Tech] OBSERVED RESULT: Balancing the empowerment of team leads to operate autonomously and maintaining centralized program management kept all teams informed and connected. ✓ During Phase 1, the sites shared lessons learned and attended the same all-site/technical meetings. However, the sites were also each individually managed by their respective CORs and worked on their own concepts individually.
Utilize follow-up breakout sessions. [Fed/Tech] OBSERVED RESULT: Improved opportunity to more deeply explore certain issues without hijacking general meetings. ✓ The projects team often followed up progress meetings with breakout sessions where the team would deliberate current issues while they were still fresh in everyone's mind.
Consider additional in-person events. [Sites] PREDICTED RESULT: More efficient communication regarding critical topics. o As the sites were located at different parts of the country and not within reasonable distance to USDOT, meetings were typically held as teleconferences. While there were only a few in-person meetings taking place throughout the course of Phase 1, they were credited as being more productive than over-the-phone meetings.
Ensure that decisions made at key meetings are formally documented. [Sites] PREDICTED RESULT: Prevents the group from having to rehash issues that have already been resolved. o Meeting minutes were taken and distributed after each meeting. However, on key issues such as privacy, some of the teams felt that they had to revisit these topics more than they expected after the mutually agreed upon conclusion of the meeting.

2.2.2 Deliverable Review Process

The CV pilot sites were required to develop and deliver various technical deliverables to the USDOT under each of the 13 tasks in Phase 1. Examples of these deliverables included:

- Project Management Plan
- Concept of Operations
- Security Management and Operating Concept
- Safety Management Plan
- System Requirements Specification
- Performance Measurement Plan
- Human Use Approval Summary
- Partnership Status Summary
- Outreach Plan
- Comprehensive Deployment Plan
- Deployment Readiness Summary

These deliverables had to be reviewed and approved, at a minimum, by the USDOT COR but in most cases, these documents were reviewed by many of the USDOT federal CVPD team members. The USDOT had 10 calendar days to review draft deliverables and make comments. Often there were deliverables that would go through several rounds of reviews and revisions causing a lengthy review period that overlapped with other tasks.

Table 2-4: Lessons Learned about the Deliverable Review Process

Lessons Learned – Deliverable Review Process
Provide technical reviewers the opportunity to visit the sites in-person. [Fed/Tech] OBSERVED RESULT: Reviewers had a better understanding of the deployment area and its' challenges. ✓ The technical team visited each of the sites and drove on the deployment corridors in order to get familiarized with the road geometry, traffic volumes and other factors of the areas. Seeing the deployment area themselves helped provide the technical experts with the necessary context needed to properly review the documents.
Promote final deliverables for use by the public. [Fed/Tech] OBSERVED RESULT: Increased opportunity for stakeholders and other early deployers to be engaged. ✓ USDOT advertised all webinars that were open to the public and posted all public webinars and final deliverables to the CV Pilots website, where stakeholders and shadow deployers could easily access the materials. The CV Pilots website remains one of the most visited sites within the ITS JPO website, with frequent downloads of posted project documents.
Plan for multiple reviews of complex deliverables. [Fed/Tech] PREDICTED RESULT: Submittal of final deliverables within a realistic schedule. o Some critical deliverables required multiple reviews for the draft, revised, and final versions of the documents, which was not originally built into the schedule. As a result, a no-cost contract modification had to be done to extend the due dates for several final deliverables. - Budget more review time for complex deliverables (more than one iteration and more than one-week turnaround time). - Engage in early review of an expanded outline to promote understanding and consistency in deliverable expectations before writing the draft. - Avoid exactly the same deliverable due dates across multiple projects. Otherwise the review team only has the same amount of time to review multiple documents.
Consolidate deliverables where possible. [Sites] PREDICTED RESULT: Less time spent documenting overlapping or redundant content. o Several of the requested deliverables required frequent references to material from separate deliverables. Sites therefore devoted a good amount of time to cross-referencing materials to make sure deliverables did not contradict earlier deliverables.

2.2.3 Communicating Expectations

The CV pilot sites during Phase 1 were expected to develop their preliminary proposed idea into a structured concept that is suitable for further design, building, testing, and operation. The CV pilot sites were expected to refine their proposed approach and create a clear set of documents defining deployment scope and requirements; training, security, performance measurement, and safety management plans; partnering arrangements and contracts; and develop a preliminary deployment site plan.

Table 2-5: Lessons Learned about Communicating Expectations

Lessons Learned – Communicating Expectations
Reinforce program mission and goals as a part of CV pilot sites outreach efforts. [Fed/Tech] OBSERVED RESULT: Emphasized importance of USDOT role in pursuing such an innovative project and its potential impacts. ✓ The first few slides of every public webinar presented the project's missions and goals.
Set clear expectations in project scope while conveying a clear maturity status of products coming out of related research programs. [Fed/Tech] PREDICTED RESULT: Improved understanding of what is truly being "piloted." o There was a learning curve for the FHWA team in terms of what could be expected from the team and the challenges they faced. Early on, the pilot sites did not realize the amount of development for some applications that would still be needed prior to deployment.
Assert that CORs are the ones who provide the final definitive guidance. [Fed/Tech] PREDICTED RESULT: Clarity of USDOT direction keeps sites on track. o At times, the pilot sites would receive conflicting guidance from the federal team. In a complex deployment with multiple federal staff providing guidance and advice, it is imperative to ensure that sites understand that only the COR provides definitive direction.
Consider adapting deliverable scope when site deployments have significantly different total budgets. [Fed/Tech] PREDICTED RESULT: Appropriately scaled planning efforts to meet project needs. o A significant challenge to the CV pilot sites was that the number and type of deliverables required remained the same across all three sites although each site had a different budget.

3 USDOT Technical Assistance

A series of USDOT-sponsored technical assistance events has been developed to assist not only the three selected CV pilot sites, but also other early deployers of connected vehicle technologies to conduct Concept Development activities. The following sections describe the lessons learned from the USDOT technical assistance effort.

3.1 Technical Webinars and Roundtables

The USDOT technical assistance in most areas of Phase 1 followed a similar approach:

- A **Technical Assistance Webinar** around the time frame where CV pilot sites indicated in their project schedules that they would begin work in that task area. These were usually public webinars to benefit the early deployer community beyond just the CV pilot sites.
- Follow-on **All-Site Virtual Roundtables** occurred periodically from the time of the first webinar until the time at which the key deliverable in this area was completed. All CV pilot sites are invited to participate. In each virtual roundtable, sites reported how things are going, brought key questions and issues for discussion, and the USDOT provided technical assistance as needed in the effort or took action items for more complex requests. The All-Site Virtual Roundtables were hosted by the USDOT Task Coordinator not open to the public.

The exception is in the Systems Engineering track (Tasks 2 and 6) where a Connected Vehicle Reference Implementation Architecture (CVRIA) Bootcamp initiated the area of work, followed by All-Site Virtual Roundtables dedicated to the development of the Concept of Operations (ConOps) and Systems Requirements Specification (SyRS) deliverables. The goal of these technical assistance events was to *reduce the risk of mutual surprise* when task deliverables are sent to the USDOT for comment and approval – by providing a format for consistent technical exchange in the time frame the deliverables are being prepared. CV pilot sites reported back to the USDOT that they found the guidance at the technical assistance webinars and collaboration at the all-site roundtables was useful and valuable.

Table 3-1: Lessons Learned about Technical Webinars and Roundtables

Lessons Learned – Technical Webinars and Roundtables
Conduct regular technical webinar and roundtables with all CV pilot sites and provide clear and published agendas. [Fed/Tech] OBSERVED RESULT: CV pilot sites were able to prepare questions ahead of time and the knowledge shared benefited all three sites. ✓ Agendas were included on each meeting invitation.

Lessons Learned – Technical Webinars and Roundtables
Tailor all-site roundtables to the CV pilot sites and their individual challenges. [Fed/Tech] OBSERVED RESULT: The all-site roundtables were particularly helpful because they tailored to the CV pilot sites and their individual challenges. ✓ Slide decks and other meeting materials were constructed with the individual challenges of each site in mind.
Start technical assistance early on. [Fed/Tech] OBSERVED RESULT: Providing assistance before a task or deliverable is started prevented unnecessary work by both the USDOT and the CV pilot sites. ✓ The technical webinars and roundtables were scheduled toward the beginning of each task and the scheduled distributed to sites well ahead of time.

3.2 Guidance, Outlines, and Templates

Additional technical guidance provided by the USDOT and supported by Noblis technical support included webinar briefing outlines and deliverable templates. These helped the CV pilot sites level their expectations about what should appear in the deliverables. The CV pilot sites were eager to consume USDOT technical assistance especially since the deployments were complex and required a lot of diverse elements to come together in an integrated system.

Table 3-2: Lessons Learned about Guidance, Outlines, and Templates

Lessons Learned – Guidance, Outlines, and Templates
Build enough time into the Phase 1 schedule to provide technical assistance. [Fed/Tech] OBSERVED RESULT: During Phase 1, there was just enough time built into the schedule to provide assistance. ✓ The USDOT and technical assistance team provided deliverable templates, roundtables, and outlines for key deliverables and tasks. o More time spent on the SyRS walkthrough would be helpful because it is a critical moment to catch potential inconsistencies, inaccuracies, and provide better clarity. o Provide additional Dedicated Short Range Communications (DSRC) technical expertise to pilot sites. The allocation of messages to different DSRC channels is a critical component of the system that required additional USDOT technical expertise and guidance.

Lessons Learned – Guidance, Outlines, and Templates
Maintain consistent outlines and templates across all pilot sites. [Fed/Tech] OBSERVED RESULT: Providing the same outline to all CV pilot sites kept all parties on the same page as to the content and format of the deliverable, making for an easier review process. ✓ The sites were given templates and outlines for major deliverables. o Although the templates were helpful to the CV pilot sites, they did not always show a lot of creativity beyond what was provided in the templates once they got them, particularly when time was short.
Provide deliverable templates earlier to CV pilot sites and in 508 compliant format. [Sites] PREDICTED RESULT: Particularly for CV pilot sites of larger scope, receiving the deliverable templates as much as 4-5 deliverables in advance would be helpful. Final documents were expected to be 508 compliant but the templates were not 508 compliant. o Pilot sites often had to rush to finish deliverables on time and in the template provided to them.

3.3 Encouraging CV Pilot Site Coordination

Although the three CV pilot sites were not required to coordinate, the USDOT encouraged the sites to collaborate and share lessons learned with each other. It was helpful that the CV pilot sites were not competing with each other and could be more open to sharing their deliverables as examples.

Table 3-3: Lessons Learned about Encouraging CV Pilot Site Coordination

Lessons Learned – Encouraging CV Pilot Site Coordination
Encourage CV pilot sites to share information with each other. [Fed/Tech] OBSERVED RESULT: The CV pilot sites coordinated well but sometimes took a little encouragement. ✓ The CV pilot sites coordinated well but sometimes took a little encouragement.
Use the Phase 1 deliverables as examples for future deployments. [Fed/Tech] OBSERVED RESULT: The deliverables from the CV pilot sites can be used as examples for other early deployers to follow. ✓ It was extremely beneficial to the CV pilot sites in Phase 1 to meet with and see examples from those who have already implemented CV technology.

4 Security and Privacy

As a companion document to the ConOps, the Security Management Operating Concept was developed to describe the underlying needs of the Pilot Deployment to protect the privacy of users, ensure secure operations, and outline a concept that addresses these needs. The following sections describe the lessons learned from the development of the Security Management Operating Concept.

4.1 Role of the SCMS

Vehicle and infrastructure messages must be trusted for the system to work. The Security Credentials Management System (SCMS) is the entity that issues, distributes, and revokes security credentials for devices operating in the system. A stipulation in the Broad Agency Agreement (BAA) requires the pilot sites to utilize the USDOT's prototype national-level SCMS as a key tool for implementing a Public Key Infrastructure (PKI) based system for communication security controls.

Table 4-1: Lessons Learned about the Role of the SCMS

Lessons Learned – Role of the SCMS
Keep informed about progress of the SCMS. [Fed/Tech] OBSERVED RESULT: Improved timeline planning for the development of the CV support software being integrated with the SCMS. ✓ The role of the SCMS and what it would or would not do was a complicated issue throughout Phase 1 that did not have a simple answer. The USDOT provided the pilot sites with draft and final versions of the SCMS Proof of Concept document that featured detailed requirements and specifications for the SCMS POC system (i.e., interfacing via RSUs/OBUs/ASDs). In addition, the USDOT conducted a webinar for the CV Pilot sites that provided an overview of the document.
Be flexible when following the Federal approach for determining requirements that NIST has developed. [Fed/Tech] OBSERVED RESULT: Improved approach for building security into the cyber-physical system. ✓ The sites were encouraged to follow NIST guidance for determining the specific security approaches (controls) needed in their CV Pilot systems. However, it was noted that the current Federal guidelines on security are focused on IT systems and not cyber-physical systems, so that the sites needed to be accommodating.

Lessons Learned – Role of the SCMS
Recognize that security "requirements" recommended by applying the NIST-based approach may not be implementable at a reasonable cost. [Fed/Tech] OBSERVED RESULT: Proper financial assessment of security needs. ✓ The sites were encouraged to be flexible when applying the NIST-based approach as it was likely that their required security level would not be available in commercial off-the shelf (COTS) products.

4.2 Privacy

As privacy is an ongoing concern for the public, it is essential that the system protects user privacy to encourage stakeholder buy-in. This includes ensuring that the vehicle information communicated does not identify the driver or vehicle and preventing the possibility of vehicle tracking. While developing the Security Management Operating Concept, the pilot sites had to address how privacy would be protected as well as how any required PII would be appropriately handled.

Table 4-2: Lessons Learned about Privacy

Lessons Learned – Privacy
Communicate CV data needs to pilot sites early and clearly. Respond as efficiently as possible to concerns from deployers regarding privacy. [Fed/Tech] OBSERVED RESULT: Reduce the likelihood of project delay. ✓ When it became apparent that privacy concerns were a potential deal breaker for the participation of major stakeholders associated with one of the pilot sites, an in-person meeting was held at the USDOT, where the issue was addressed head on. A conclusion was eventually met that left all parties satisfied.
Be aware that while privacy is built-in by design from the ground up, data requirements for the performance measurement element can violate the protection of user privacy. [Sites] OBSERVED RESULT: Balance between stakeholder concerns (protection of privacy) and data requirements. ✓ The data privacy and performance measurement success factors came into conflict when planning how to obtain vehicle information and driver behavior to fully evaluate the success of the Pilots. After several back and forth deliberations between the federal team and pilot team members, a reasonable strategy was developed that ensured the CV Pilot Evaluation Team could verify contract requirements for performance measurement (e.g., statistical analyses) while allowing the pilot deployer to discard sensitive data elements, including "time" and "location" data.

Lessons Learned – Privacy
Involve a privacy specialist in the project to match what is in regulations and what is in spirit of what a site wants to do. [Fed/Tech] PREDICTED RESULT: Avoid legal setbacks by ensuring privacy compliance. o It is critical to have someone familiar with privacy laws that can converse in a technical manner to check local requirements. Only once you have a good understanding of the legal ramifications should you start coming up with the technical specifications.
Understand that privacy is a legal construct that demands close participation from attorneys; communicate the workload to attorneys that are involved. [Fed/Tech] PREDICTED RESULT: Avoid legal setbacks by ensuring privacy compliance. o It proved challenging for the USDOT to get the involvement of the USDOT legal team to review the privacy implications associated with the pilot deployment projects. While the USDOT met with attorneys prior to the project's initiation, more prep work could have been done.
Convey to the pilot(s) upfront what the requirements are regarding the privacy element to avoid any misunderstanding of data privacy and the institutional issues that can follow. [Fed/Tech/Sites] PREDICTED RESULT: Less likelihood of the sites underestimating the level of effort required to deal with privacy issues. o Maintaining user privacy was far more complex than the sites and USDOT first realized. There was concern over what data was appropriate to collect and how to put forth the data collection design. The pilot sites had to consider ALL users' priorities and concerns relating to privacy and liability and factor them early into the security and privacy concept and ultimately the system requirements.
Understand and clearly communicate what contractually binding Federal privacy requirements, if any, are binding on 1) contractors and 2) grant recipients. [Fed/Tech] PREDICTED RESULT: A clearer understanding of binding requirements vs. guidance, ensuring requirements are addressed from the start, reduced delay, and improved mutual understanding between all parties. o The Federal government has strong privacy regulations that apply to Federal agencies and contractors acting on their behalf. It was less clear whether or not these regulations applied to the CV pilots, and the question was complicated because phase 1 was a contract with private companies, while phases 2 and 3, which are the actual deployment, are grants to public agencies.
Consider every angle for potential privacy issues (e.g. you must look at the consequence of subpoenas.) [Sites] PREDICTED RESULT: Proper vetting of potential privacy issues. o Though the sites thought about the potential conflicts of collecting trajectory data, there were some hypothetical uses of the data they did not anticipate. For example, the potential to recreate accident scenes and thus recreate PII using collected data was not originally considered.

5 System Engineering

In this concept development phase, the three pilot sites followed system engineering process in the IEEE Standard to develop the system engineering documents, which include Concept of Operations (ConOps) and System Requirements Specification (SyRS). The site also developed an Application Deployment Plan (ADP) to describe the additional functionality and/or performance elements required to further develop, tailor, and integrate applications for use within the Pilot Deployment. The following sections describes the lessons learned from the development of these system engineering related documents.

5.1 Establishing a Concept

Concept development is the first step in the systems engineering life cycle and determines what the system should accomplish. In the early months on the project, the sites spent time working closely with stakeholders to identify user needs and system capabilities. It was also during this phase that the teams became aware of many of the potential obstacles and risks associated with their planned deployments.

Table 5-1: Lessons Learned about Establishing a Concept

Lessons Learned – Establishing a Concept
Utilize the systems engineering process. [Fed/Tech] OBSERVED RESULT: Utilizing the systems engineering process helped flesh out issues associated with RSUs, data, device ranges, etc. earlier on when it was less costly. ✓ The CV Pilot sites followed the systems engineering process in Phase 1. o It may have been beneficial to not focus solely on the V-Model and instead take advantage of other PMP and SE approaches.
Be mindful that concept development takes time to conduct prior to procuring, designing, and installing equipment. [Fed/Tech] OBSERVED RESULT: Deployers are willing to "do the hard work now" rather than later, which would be more challenging and expensive. ✓ The CV Pilot teams conducted a detailed SyRS walkthrough with each pilot site.
Use standards (intelligently) to help advance the deployment's systems engineering. [Fed/Tech] OBSERVED RESULT: The use of standards helped create a solid deployment effort in Phase 1. ✓ CV Pilot sites followed standards throughout the systems engineering process.

Lessons Learned – Establishing a Concept
Recognize that more specifics in planning and concept are often needed to fully realize taking existing DMA or other applications from their current state to being deployment ready. [Fed/Tech] PREDICTED RESULT: Deployment sites will better understand the readiness of existing applications. o On some occasions, the sites did not adequately account for every detail in development including testing and verification. There needed to be more understanding of the difference between the deployment of a "production CV system" and a research and development platform which both require different approaches.
Develop an approach to integrate the CV pilot with existing transportation systems' management and operations. [Sites] PREDICTED RESULT: Deployments integrate more easily into existing operations. o The pilot sites reported that they needed to look more into the use of non-CV technology as part of the deployment concept and solution.
Prepare for concept evolution. User needs will expand and you must keep up to meet the actual needs of the project. [Sites] PREDICTED RESULT: A potential issue could arise if the deployments do not keep up with the changing user needs in the region. o Pilot sites could create more agile deployments to respond to concept evolution.
Acquire as much existing documentation related to connected vehicle research and deployments as possible. [Sites] PREDICTED RESULT: Prevent spending unnecessary time "reinventing the wheel." o The sites mentioned that they wished they had been provided access to more documentation from previous CV projects that occurred prior to the start of Phase 1. Specifically, they cited that documentation from the Vehicle-to-Vehicle technology research and demonstrations from the Crash Avoidance Metrics Partnership (CAMP) would have been helpful to use as a basis for project development.

5.2 Requirements Development

The sites worked to develop testable system requirements based on the user needs identified by the individual pilots' stakeholders. These requirements will be used as the basis for system design activities in Phase 2.

Table 5-2: Lessons Learned about Requirements Development

Lessons Learned – Requirements Development
Develop verifiable system requirements that will work with evolving standards. The critical part of this process is to have a solid set of User Needs and well-formed Concept of Operations. [Sites] OBSERVED RESULT: It was a learning experience for sites to develop system requirements that were verifiable despite evolving standards. ✓ The pilot sites paid close and constant attention to standards as they developed their system requirements.
Utilize but do not rely solely on the CVRIA and Systems Engineering Tool for Intelligent Transportation (SET-IT) tools. [Sites] OBSERVED RESULT: The CVRIA and SET-IT tools were not as comprehensive as presumed by the pilot sites. ✓ Updated versions of the CVRIA and SET-IT tools have since been released that now feature more consistency among views, diagrams and tables.
Develop a good understanding of what is available from the SCMS and vendors for RSU/OBU device capabilities and software integration. [Sites] OBSERVED RESULT: The pilot sites reported that a good understanding of the SCMS was important because of the deployment goal to develop a realistic system of systems build and develop verifiable tests. ✓ As the ODE and SET-IT tools continue to evolve into production tools, this process will become better defined.
Draw on a sample SyRS to illustrate how requirements are broken down and to assist in this process. [Fed/Tech] PREDICTED RESULT: Using a sample SyRS may help prevent site teams from having to conduct multiple requirement reviews. o Pilot sites did not follow a sample SyRS and conducted multiple requirements reviews in order to effectively develop verifiable requirements in support of future system design activities.
Insist on the release of fundamental operating requirements for "existing" applications – including test procedures. [Sites] PREDICTED RESULT: Existing applications sometimes did not provide enough information for pilot sites to easily prepare their own system requirements. The sites mentioned that requiring applications to include test procedures and other fundamental operating requirements would be helpful. o Pilot sites utilized existing applications in the deployment concepts but often had trouble finding the necessary documentation.

Lessons Learned – Requirements Development
Know that filing for DSRC licensing for RSUs is a very time consuming process as application has to be done through the FCC on an individual basis. [Sites] PREDICTED RESULT: With enough pressure from stakeholders, in the future the FCC may offer a batch method for submitting RSU license requests. o The pilot sites initially spent more time on filing for DSRC licensing than originally expected. After reaching out to the FCC, the pilot sites were eventually provided a process for the batch submission of RSU license requests.

5.3 Interoperability

These pilot deployments are intended to accelerate the deployment of interoperable connected vehicle technologies. True interoperability is not just dependent on formal standards, but also on common usages, interpretations and patterns. Phase 1 required the sites to start thinking about how their local deployment would fit into a national deployment. In Phase 2, the sites will have to prove that they are capable of achieving interoperability by having one or more in-vehicle or mobile devices from a different CV Pilot Deployment site successfully interact with their local deployment.

Table 5-3: Lessons Learned about Interoperability

Lessons Learned – Interoperability
Be cognizant of the high risk of non-interoperability associated with several different applications being deployed. [Fed/Tech] OBSERVED RESULT: Maintaining a realistic understanding of all applications being deployed helped sites manage the risks of deploying several applications at once. ✓ Pilot sites thought carefully about how their local deployment would fit into national deployment.
Be patient as the USDOT strives to be in position to revitalize with relevant updates and upgrades in a few years. [Fed/Tech] PREDICTED RESULT: To maintain interoperability, the USDOT may need to be in a position to revitalize and upgrade deployments in the future. o There was no funding in Phase 1 put toward the updates and upgrades that may need to be considered in the future.

6 Performance Measurement and Evaluation Support

The sites developed a Performance Measurement Plan in the Concept Development Phase to ensure effective performance measurement against identified targets was embedded as a core Pilot Deployment capability and to support an independent evaluation of the pilot deployments. The following sections describe the lessons learned from the development of the Performance Measure Plan.

6.1 Performance Measurement Linkage to Other Tasks

The performance measurement task was directly related to several other tasks in that it identified data sources for data collection, described plans to include modeling and simulation, and included a data sharing framework consistent with the Privacy Operational Concept. The Performance Measurement Plan also was meant to be mutually consistent with and appropriately cross-referenced with the SyRS. This task proved a challenge to the CV pilot sites as they needed to clearly understand the project benefits and how the inputs and outputs would be used.

Table 6-1: Lessons Learned about Performance Measurement Linkage to Other Tasks

Lessons Learned – Performance Measurement Linkage to Other Tasks
Link concept development activity to the evaluation effort. [Fed/Tech] OBSERVED RESULT: Performance measures well-aligned with the deployment concept. ✓ The plans for the pilot's impact assessment was a major driver of concept development. The sites found it helpful to have the Performance Measurement Plan tailored to identify data flows that would support the evaluation effort.
Conceive measures that are straightforward, explainable, that quantify the project benefits, and that are achievable given data availability. [Sites] OBSERVED RESULT: Data collection that is feasible and valuable. ✓ The sites began identifying performance measures by understanding the project benefits to their various stakeholders and knowing how inputs and outputs would be generated and used.

Lessons Learned – Performance Measurement Linkage to Other Tasks
Understand that performance measurement and development takes time and thought. [Sites] OBSERVED RESULT: Rationalized MOEs that meet project goals. ✓ Performance measures were prepared with the project teams, not in a vacuum, and were affirmed by the project technical staff. Along with the measures, thought was focused on how the measures would be evaluated and how specific evaluation designs would be established to accommodate data needs.

6.2 Role of IE

The COR provided broader evaluation-related capabilities required to support a site-specific independent evaluation effort. This was a challenge for the CV Pilot Deployment because the CV pilot sites first assumed that the IE played a supervisory role over their evaluation activities.

Table 6-2: Lessons Learned about the Role of IE

Lessons Learned – Role of IE
Make clear to the pilot sites that the IE does not play a supervisory role over their performance evaluation activities. [Fed/Tech] OBSERVED RESULT: Heightened willingness by sites to cooperate and share collected data. ✓ In Phase 1, although an IE had not been named, the sites were apprehensive about what data they would be required to hand over and the limits to what they could do with it. But after several discussions with the sites on the role of the IE, the sites are now eager to work with the IE.
Acknowledge the need for the inclusion of an IE in the deployment. [Fed/Tech] PREDICTED RESULT: Prevention of bias in the evaluation. o Most CV pilot sites have their own local needs and problems they want to address, hence limiting in scope their focus. An Independent Evaluation effort ensures that other useful experiments and conclusions beyond a site's initial needs are possible. For this reason, the CV Pilots Program presented in the BAA their plans for acquiring a third-party independent evaluator.
Bring the IE on board early on in the concept development phase. [Fed/Tech] PREDICTED RESULT: Assurance that the CV pilot sites are collecting the data needed for a proper independent evaluation. o An IE was not selected for the project until the start of Phase 2, so there was not a third party to examine the types of data being proposed for collection during the concept development phase. The USDOT Evaluation Team was able to minimize the impact by assessing the sites' performance measurement plans and identifying additional data needs.

6.3 Impact on non-Connected Vehicles

One challenge of the CV Pilot Deployment will be modeling connected vehicles in environments with non-connected vehicles.

Table 6-3: Lessons Learned about the Impact on Non-Connected Vehicles

Lessons Learned – Impact on non-Connected Vehicles
Do not overlook non-CV technologies as part of your CV deployment. [Sites] PREDICTED RESULT: Effectively reach out to a larger community. o While the sites looked primarily at CV applications, it was apparent that some areas would have benefited more from non-CV technology for certain use cases. For example, a larger set of people would be affected by a dynamic message sign broadcasting congestion alerts to everyone rather than a CV application that only alerts equipped vehicles.

6.4 Leveraging Guidance from Previous Evaluation Efforts

One of the key objectives for CV pilot sites was to take what had primarily been CV research and apply to real-life deployments, a task that proved to require very different approaches. Early connected vehicle research projects provided invaluable information about what was possible in the real-life deployments. Those early activities have supported the development of and enabled the Pilot Deployment projects. The owners of those research projects had the benefit of absolute control over the participants, vehicles and data which allowed for analysis to be conducted and yielded important results. This allowed the CV Pilot teams to understand the challenges associated with a different landscape – one that involved private companies that may or may not be willing to share all their data. The CV Pilot teams then had to adapt to the reality of their own environments and landscapes.

Table 6-4: Lessons Learned on Leveraging Guidance from Previous Evaluation Efforts

Lessons Learned – Leveraging Guidance from Previous Evaluation Efforts
Enlist the help of evaluation teams from relevant research projects to share their experiences. [Fed/Tech] OBSERVED RESULT: Improved understanding from the lessons learned from other projects. ✓ The USDOT Evaluation team took advantage of previous evaluation studies including the Integrated Corridor Management and Safety Pilot Model Deployment projects by meeting with members of their Evaluation team.

7 Data Governance and Sharing

The sites each proposed a Data Sharing Framework for generating and sharing their performance measurement data with the independent evaluators and with the public via platforms such as the USDOT's Research Data Exchange (RDE). The following sections describe the lessons learned from the data sharing planning effort in Phase 1.

7.1 Data Governance and the Sharing of Data

While preparing the Data Sharing Framework, the sites each outlined data sharing requirements to set the stage for data collection. This process posed critical questions such as who owns the data and what data needed to be obfuscated or anonymized before being shared. As stated in the BAA, connected vehicle, mobile device, and infrastructure sensor data captured during the deployment are expected to be broadly shared with the community to better support the needs of ITS researchers and developers while reducing costs and encouraging innovation. This data sharing capability, however, is subject to the protection of intellectual property rights and personal privacy and must be handled securely. See also Section 6 discussing performance measurement and evaluation.

Table 7-1: Lessons Learned about Data Governance and the Sharing of Data

Lessons Learned – Data Governance and the Sharing of Data
Communicate CV data needs to pilot sites early and clearly. [Fed/Tech] OBSERVED RESULT: The USDOT got the sites to understand why USDOT needed the CV data, while also acknowledging their privacy concerns. ✓ It would have been useful to have lawyers involved in this process to communicate the data needs more clearly.
Include more information on data ownership and subpoenas in the solicitation. [Fed/Tech] PREDICTED RESULT: Clearer expectation on data ownership. o One suggestion was to add a deliverable on data governance that would be helpful in defining data capture and retention early.
Cultivate better understanding of data needs and current communication networks. [Sites] PREDICTED RESULT: CV applications create tons of data per day but the current communication networks will not be able to support the back end.

Lessons Learned – Data Governance and the Sharing of Data
Prepare for pushback on data sharing from pilot sites. [Fed/Tech] PREDICTED RESULT: Pilot sites will be better prepared for data sharing challenges. o The fear one of the sites had of data being subpoenaed and being faced with litigation was not an issue that surfaced during previous projects (e.g. the Safety Pilot Deployment in Ann Arbor, Michigan).
Clarify the language in the solicitation on data sharing. [Fed/Tech] PREDICTED RESULT: USDOT's expectations regarding data sharing might have been managed more effectively by crafting the language in the BAA differently**.** o USDOT could have more clearly articulated the data requirements for the applicants responding to the BAA. However, the USDOT was able to work with the sites to resolve the issue, which has been documented in the Performance Measurement and Independent Evaluation Support deliverable.
Specify more robust data acquisition to fully support the evaluation. [Fed/Tech] PREDICTED RESULT: By conceding to privacy concerns, USDOT would not be able to utilize all of the data that is needed to grow this technology and data analysis. o USDOT had to devote additional time to address privacy concerns in order for the data to be useful in evaluation of CV technologies.

8 Human Use Approval and Participants Training

In this task, Human Use Approval was obtained from an Institutional Review Board (IRB) and documented in the Human Use Approval Summary. A high-level Participant Training Plan and Stakeholder Education Plan was developed for the recruitment and training of all travelers, drivers, and other personnel participating in the Pilot Deployment. This plan identified the roles that participants will take during the pilot deployment, including a description of their activities and responsibilities, and training requirements needed to ensure as-planned execution of the pilot deployment in the operational phase. The following sections describes the lessons learned from the development of the Participant Training and Stakeholder Education Plan.

8.1 IRB Process

The IRB process was new to several of the CV pilot sites and it was a challenge to understand the role that they play.

Table 8-1: Lessons Learned about the IRB Process

Lessons Learned – IRB Process
Have an understanding of the Institutional Review Board (IRB) process and timeframes. [Fed/Tech] OBSERVED RESULT: Improved planning and management of schedule risk. ✓ The sites participated in IRB and Human Protections Training (offered through NIH, CITI, etc.) as needed to avoid pitfalls and to maximize the probability of IRB approval.
Research provisions where an individual's documented consent may not be required. [Sites] OBSERVED RESULT: Getting IRB approval for waived or modified informed consent provisions. ✓ Gaining documented informed consent is a key aspect of human subjects research, particularly where safety risks are present. However, there can be some flexibility in determinations of consent requirements regarding fleet vehicles. The Pilot teams were able to simplify the consent requirements by working with the USDOT to enable the IRB to approve participation based on employer (e.g., transit agency) agreement.
Confirm that the scope and timing of activity, including partner organizations, is consistent with the proposed IRB's role. [Fed/Tech] PREDICTED RESULT: Minimize the number of amendments needed for approval. o Due to continuous growth in project scope and definition, the sites were forced to make amendments to their IRBs going into Phase 2.

Lessons Learned – IRB Process
Wait until after the initial concept development phase is complete to solicit IRB Approval [Sites] PREDICTED RESULT: Less time spent working on a pre-mature task. o While the sites understood that a Human Use Approval Plan was necessary for a pilot deployment that involved human subjects, they thought there were still too many unknown factors about human use in Phase 1 and that IRB approval may have been a more suitable requirement for Phase 2.

8.2 Recruitment and Training

In Phase 1 of the CVPD Program, the high-level plan for the recruitment of travelers, drivers, and other personnel participating in the Pilot Deployment coincided with the plan for training these participants.

Table 8-2: Lessons Learned about Recruitment and Training

Lessons Learned – Recruitment and Training
Tie recruitment activities in with local outreach activities and view training as a separate task. [Fed/Tech] OBSERVED RESULT: Knowledgeable participants pre-deployment. ✓ The sites offered several information sessions for interested stakeholders during the concept development phase to promote the projects and to garner participant interest. However, specific training activities are not expected to take place until Phase 3 of the project.
Incentivize participation in the deployment through benefits. [Fed/Tech] OBSERVED RESULT: Enhanced participant buy-in; retention of participants throughout the study period. ✓ For some of the sites, an incentive package was expected to be a central focus of the recruitment message. For example, for drivers of personal vehicles, plans were made to offer toll discounts and SiriusXM subscriptions as compensation for their participation in the pilot.
Convey to the participants the difference between connected vehicles and automated vehicles. [Sites] OBSERVED RESULT: Less initial confusion among stakeholder groups about the objective of the pilot and how connected vehicles work. ✓ When pitching the connected vehicle concept to stakeholders and local agencies, the sites made sure that agencies understood that connected vehicles utilize driver assistance technology but that drivers of equipped connected vehicles do in fact have to intervene.

Lessons Learned – Recruitment and Training

During the concept development phase, limit the training task to a technical memo rather than a full report. [Sites]

PREDICTED RESULT: Less time spent drafting a document based on an underdeveloped task.

- Although training and education activities are not expected to take place until Phase 3, a Training and Stakeholder Education Plan was required under Phase 1. It proved difficult for the sites to develop a plan detailing the needs and approaches for training the participants before the concept of the deployment was fully fleshed out.

9 Institutional Issues, Financial Sustainability, Partnerships and Outreach

The Pilot sites needed to address many institutional issues as they moved toward deployment. There was also a need to plan to achieve financial sustainability. The development and implementation of agreements, contracts and subcontracts among partner organizations was documented in the Partnership Status Summary. This included an agreement on the main elements of the ConOps, performance measures and targets, operational changes associated with the pilot deployment, governance framework and processes, and financial agreements. A Deployment Outreach Plan, as part of the Comprehensive Pilot Deployment Plan was developed for the management of outreach activities and the accommodation of requests for site visits by media, researchers, and others. The Deployment Outreach Plan described the outreach activities for installation, testing, operations, and maintenance during Phases 2 and 3. The following sections describes the lessons learned from the development of the Partnership Status Summary and the Deployment Outreach Plan.

9.1 Addressing Institutional, Financial, Partnership and Outreach Issues

Each CV Pilot site had a different approach to choosing and developing institutional partnerships and relationships offering a variety of experiences and lessons learned.

Table 9-1: Lessons Learned about Addressing Institutional, Financial, Partnership and Outreach Issues

Lessons Learned – Addressing Institutional, Financial, Partnership and Outreach Issues
Inventory institutional, financial, partnership and outreach issues at the beginning. [Fed/Tech] OBSERVED RESULT: Helped to prepare Project Management Plan including work breakdown structure, schedule and risk management plan ✓ The technical support team prepared Guidance that was a useful reference for many of these issues o There is a natural tendency to focus on technical issues concerning deployment and underemphasize institutional, partnership, and financial issues

Lessons Learned – Addressing Institutional, Financial, Partnership and Outreach Issues
Involve stakeholders early and often. [Fed/Tech] OBSERVED RESULT: Involving stakeholders early on led to the development of better concepts and more buy-in. ✓ The federal team and pilot sites reached out early and consistently to stakeholders to assure them their participation was a key to success.
Encourage CV pilot sites to choose partners that provide experience in all tasks and areas. [Fed/Tech] OBSERVED RESULT: The pilot sites were highly successful in Phase 1 due to well-rounded teams including a variety of subcontractors. ✓ Pilot sites chose subcontractors that helped with the overall strengths and weaknesses of the existing pilot site team.
Draft Memorandums of Understanding (MOUs) after the designs have been finalized. [Fed/Tech, Sites] OBSERVED RESULT: At the end of Concept Development (but prior to design) it may be difficult to draft detailed MOU for partners, especially commercial partners, to sign on to because the details associated with the final design will not have been made yet. ✓ Early engagement and obtaining a letter of support allowed one project team to collaboratively identify the areas of concern and work towards a MOU that will be mutually agreeable in Phase 2. o One suggestion for future early deployers is to start as early as possible in acknowledging the types of agreements required. Refine and sharpen the understanding of the requirements and contents over time as the agreements are developed.
Have professional Public Relations (PR) subcontractor or a communication team on each pilot site team. [Fed/Tech] OBSERVED RESULT: Pilot sites with professional PR teams developed higher quality outreach plans. ✓ Pilot sites were not required to have a PR team but some chose to.
Participate in face-to-face vendor demonstrations. [Fed/Tech] OBSERVED RESULT: Face-to-face demos allowed the vendors to show the maturity of their applications and provide the deployment team with an opportunity ask detailed technical, programmatic and intellectual property related questions. ✓ The pilot sites hosted face-to-face demonstrations with venders and stakeholders.

Lessons Learned – Addressing Institutional, Financial, Partnership and Outreach Issues
Leverage local stakeholders and champions. Engage leadership early. [Sites] OBSERVED RESULT: Input from stakeholders and leadership helped the pilot teams understand the operational constraints and concerns of the potential system users that sites needed to consider to ensure the concept reflected reality. Also, the local knowledge gained from the stakeholders helped to understand the potential project benefits which led to initial performance measures identification. ✓ A lot was learned from engaging the local project stakeholders early in Phase 1 that directly guided the development of the concept of operations and system architecture development.
Plan with post-pilot operation and financial sustainability in mind. [Sites] OBSERVED RESULT: The CV Pilot Program is expected to result in an operational system that will continue beyond Phase 3. ✓ The CV pilot sites were careful to consider the financial and partnership requirements beyond the pilot demonstration.
Start exploring equipment suppliers early. Building agreements with equipment suppliers is a long and uncertain activity. [Fed/Tech] PREDICTED RESULT: If agreements with equipment suppliers are solidified earlier, there would be less risk to schedule slippage. o Some agreements with equipment suppliers took longer than expected.
Engage procurement and contracting personnel early. [Sites] PREDICTED RESULT: For procurement, questions like management of inventory for on-board equipment need to be resolved early, especially when non-agency fleets are involved. o With the amount of procurement necessary, only one pilot site engaged their procurement and contracting personnel early in Phase I.

10 Deployment Readiness

The Comprehensive Pilot Deployment (CPD) Plan was developed to summarize the overarching Pilot Deployment concepts and expected outcomes. The plan describes the objectives, performance measures, requirements, applications, geographic scope, and general nature of the deployment. The Deployment Readiness Summary addresses key elements of the Pilot Deployment required to initiate the Phase 2. The following sections describes the lessons learned from the development of the Comprehensive Pilot Deployment Plan and the Deployment Readiness Summary.

10.1 Technological Maturity of Applications

A significant challenge for the CV pilot sites in Phase 1 was the lack of technological maturity in connected vehicle applications and standards. Much of CV technology was not deployment ready and should have been considered as a pre-production prototype. A key missing piece to deployment readiness was the Secure Credential Management System (SCMS) which was incomplete at the time of Phase 1. The USDOT made an effort to clarify to the CV pilot sites about the maturity of CV applications but CV pilot sites still assumed a level of technological maturity that CV applications have not reached yet. Truly understanding the level of technological maturity and how to integrate into existing systems was a big challenge for the CV Pilots.

Table 10-1: Lessons Learned about the Technological Maturity of Applications

Lessons Learned – Technological Maturity of Applications
Develop an approach to integrate CV applications with existing transportation management and operation systems. [Sites] OBSERVED RESULT: Ease in monitoring system performance. ✓ One CV Pilot site noted that integration with existing legacy systems at the Traffic Management Center (TMC) enables the CV environment to become part of the overall management framework. By developing the interfaces to the TMC systems, the CV pilot elements exchange information with the traditional ITS systems, reducing the burden on operators to monitor another silo-ed technology element as part of their regular job functions.

Lessons Learned – Technological Maturity of Applications
Initiate early discussions and information sharing regarding the Phase 2 and 3 Notice of Funding Opportunity (NOFO). [Fed/Tech] OBSERVED RESULT: Allows agencies to investigate options for coming up with the required cost share. ✓ Sites may not be well-versed in what can be used as cost-share. In some cases, site policies themselves may have to be altered to meet deployment needs. For example, one pilot site had a policy regarding no reductions in toll revenue without offsets – this was clarified to include federal deployment money as offsetting to enable the discounting of tolled trips by pilot participants.
Recommend that early CV deployers spend time exploring applications on the Open Source Application Development Portal (OSADP). [Fed/Tech] PREDICTED RESULT: Accelerated progress towards the end-state of application development. o The OSADP enables stakeholders to collaborate and share insights, methods, and source code related to connected vehicle applications. By utilizing resources available on the OSADP, the sites could reduce costs through the prevention of uncoordinated, proprietary and duplicative mobility applications research and testing.
Clarify the maturity of CV applications in the Broad Agency Announcement [Fed/Tech/Sites] PREDICTED RESULT: Prevent false expectations on the technological maturity of applications. o Some federal CVPD team members thought that the level of technological maturity was clear to the CV pilot sites but some thought it could have been clearer early on. The sites were a little surprised that the applications were not as mature as expected. To address the non-deployment ready nature of the applications, at least one site explicitly stated in their RFI that they were interested in purchasing turn-key applications, and that any necessary application development would be the responsibility of the vendors.
Recommend that early CV deployers do not assume technology will continue to exist in the long term. [Fed/Tech] PREDICTED RESULT: Prevent dependence on obsolete technology. o The CV pilot sites often specified out beyond the likely longevity of prototype applications which drove up unnecessary costs.
Expect risk in the deployment plan due to the variability of deployment readiness of CV applications. [Sites] PREDICTED RESULT: Balance between risk management and the scope and complexity of the planned deployment. o Early deployers and the USDOT need to be realistic about what can be accomplished. Even with reasonable expectations, deployers must also have a certain amount of risk tolerance to pursue a project of this magnitude, as there are bound to be hiccups along the way.

APPENDIX A. List of Acronyms

Acronym	Meaning
ADP	Application Deployment Plan
ASD	Aftermarket Safety Device
BAA	Broad Agency Announcement
CAMP	Crash Avoidance Metrics Partnership
COR	Contracting Officer Representative
COTS	Commercial Off-The-Shelf
CPD	Comprehensive Pilot Deployment Plan
CV	Connected Vehicle
CVPD	Connected Vehicle Pilot Deployment
CVRIA	Connected Vehicle Reference Implementation Architecture
DMA	Dynamic Mobility Applications
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
ICM	Integrated Corridor Management
IEEE	Institute of Electrical and Electronics Engineers
IRB	Institutional Review Board
ITS	Intelligent Transportation Systems
MOU	Memorandum of Understanding
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology
NOFO	Notice of Funding Opportunity
NYC	New York City
OBU	Onboard Unit
ODE	Operational Data Environment
OSADP	Open Source Application Development Portal
PII	Personally Identifiable Information
PKI	Public Key Infrastructure
PMP	Project Management Plan
RDE	Research Data Exchange
RSU	Roadside Unit
SCMS	Security Credential Management System
SET-IT	Systems Engineering Tool for Intelligent Transportation
SME	Subject Matter Expert
THEA	Tampa Hillsborough Expressway Authority
TMC	Transportation Management Center
USDOT	U.S. Department of Transportation

Acronym	Meaning
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
WYDOT	Wyoming Department of Transportation

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