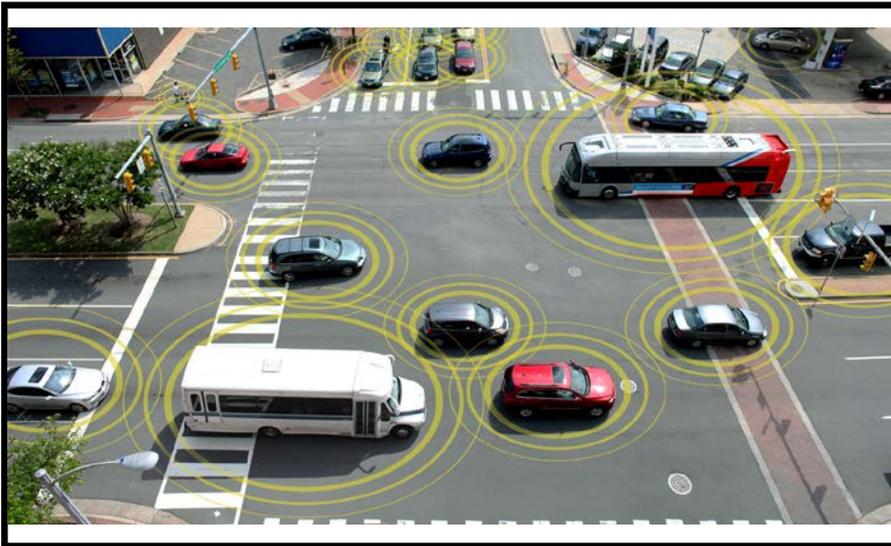# USDOT Guidance Summary for Connected Vehicle Deployments

Application Deployment

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16. Abstract

This document provides guidance material in regards to the Application Deployment Plan for the CV Pilots Deployment Concept Development Phase. Methods for application deployment are discussed with definitions for the successful management of each aspect. Important references are given in terms in-text footnotes, and additional guidance documents. How the Application Deployment Plan ties into Concept Development Phase deliverables is discussed. Major challenges are identified and how they can be overcome. The document concludes with a summary of technical support events.

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1 Introduction

1.1 Purpose of the Report

The purpose of this report is to assist Pilot Deployers in the timely and successful completion of Concept Development Phase deliverables. This includes a synthesis of considerations in key topic areas for the development of the Application Deployment Plan, additional background and guidance materials potentially helpful in the preparation of Concept Development Phase deliverables, and a summary of available technical support resources available to CV Pilot sites. This report covers application deployment concerns and processes that may emerge during the pilot deployment that can be taken to ensure a smooth and efficient Concept Development during the Concept Development Phase.

This document does not replace or alter the work statement defined in the Broad Agency Announcement, it only provides technical assistance to the pilot deployers in completing the tasks and deliverables described in the statement of work.

1.2 Organization of the Report

This report contains four additional sections and a reference section. Section 2 provides a general information on the requirements of CV application deployment. This includes key deployment guidelines to consider. Section 3 walks through the relevant deliverables and how each task relates to Application Deployment for a successful draft and final Concept Development Phase *Application Deployment Plan.* Section 4 summarizes the key challenges that may arise when developing an application during the CV pilots, including methods that can be used to overcome them. Section 5 provides a summary of technical support provided by the USDOT. Finally, the Reference sections are broken down into documents used in drafting this report and application deployment guidance.

2 Application Requirements

The following section provides all of the requirements for the deployment of the CV applications being developed by the contractor:

2.1 CV Application Deployment Guidelines:

New code developed under the CV Pilot must be made available through the OSADP.

- Any new application code, pseudo-code, and/or coding algorithms must be released on to the USDOT Open Source Application Development Portal (OSADP) website (www.itsforge.net). The OSADP website documents all of the required elements that must be provided for new applications to be submitted to the site and should be reviewed when developing the *Application Deployment Plan.*
- All applications that are made available on the OSADP must be licensed under an Open Source License. The preferred licensed for the OSADP is Apache 2.0 license. Other open source licenses will need to be evaluated by the OSADP team before they will be accepted on the OSADP.
- Commercial proprietary software may be used to modify the applications, with the understanding that all required exported files and instructions for recreating and modifying the application be posted on the OSADP to allow someone else with the same proprietary software to reproduce the concept.

Existing applications brought to the Pilot Deployment need not be made Open Source.

- Any proprietary software or tools that were developed outside of the CV Pilot Deployment work do not need to be made open source or available to the public. This can include applications developed under different contracts or in-house applications.
- However, any new interfaces or enhancements to these proprietary software or tools using Pilots funding will need to be made open source and be available on the OSADP.

At least one application needs to use the SCMS.

- One part of an application developed for the CV Pilot must use part or all of the Connected Vehicle Security Credential Management System (SCMS).
- Additional security management systems can be used either independently or in conjunction with SCMS for the applications as long as the requirement for one of the applications to use part of the SCMS is met.

Application requirements must be derived from the SyRS document.

- All application requirements must be derived from the System Requirements Specification (SyRS) document developed under Task 6. Contractors are encouraged to create a traceability

matrix for the application requirements so a clear path can be followed of the origin of the requirement to the application feature.

Follow software development best practices.

- Which development process is used for the application development is left to the discretion of individual Pilots but software development best practices are highly encouraged throughout the process. Best practices depend heavily on the process used, but should include traceability, coding standards, unit tests, regression testing, and user acceptance. The reference section Software Development Guidance at the end of this document provides reference for the cover best practices.

3 Deliverables

This section describes each individual deliverable by task as explained in the CV Pilots Broad Agency Announcement. While the main deliverable dealing with application deployment is the *Application Deployment Plan* of Task 7, elements of application deployment may need to be developed for many other deliverables in a number of other tasks. Below are each of the tasks which could include application deployment concerns. While the examples are not comprehensive, they should give a baseline for what may be considered when developing the application.

3.1 Application Deployment Plan Deliverable

During Task 7, the App*lication Deployment Plan* will be developed.   This document will be used to describe what additional functionality and/or performance elements will be required to further develop, tailor and integrate applications for use in the Pilot Deployment. Each application feature must be traced back to the System Requirements Specification (SyRS) document (Task 6). After each application modification is identified from the SyRS, an assessment of the amount of deployment work required for the design/deploy/test phase must also be included which will include schedules for both the work and the total cost of the work.

The *Application Deployment Plan* must also identify which, if any, of the expected open source software and other supporting contributions expected from the system design and development process are intended for posting to the OSADP.

Additional sections that are recommended for the *Application Deployment Plan* include:

1. A general description of potential architectures that could be used in the development of the applications to help estimate work and cost for application modifications.
2. The description of which applications development process will be used and how it will be implemented during the design/deploy/test phase.
3. Information on how the quality of the applications will be tracked and audited throughout the development of the application. This section should also include the software best practices that will be followed.
4. Information on how change control for the application modifications will be processed to reduce scope creep.
5. General information on quantity and type of staff required to modify the applications based on their role (e.g. tester, developer, UX designer, etc.)
6. Section covering how data from the applications will be collected and documented for use on the Research Data Exchange (RDE).
7. Application data flow diagram that shows how information will enter and exit the application. This diagram should also include information on how the performance metrics will be included.

3.2 Task 2 Concept of Operations

The *Concept of Operations* (page 7 of the BAA) will outline specific use cases relevant to the proposed Pilot Deployment concept where the applications are associated.

These use cases will provide the actors and preliminary functions for the applications which will feed the SyRS and in turn, the application development. When developing the *Application Deployment Plan* these use cases should be reviewed and incorporated into the document.

3.3 Task 3: Privacy and Security Management Operating Concept

The *Privacy and Security Management Operating Concept* (page 11 of the BAA) shall describe, at a high level, the concepts to be implemented to meet system security and privacy needs.

This report will document how sensitive data will be handled by the applications and must be considered in the *Application Deployment Plan*. Also, this report will provide information on how the security information and SCMS will be used which will need to coincide with the *Application Deployment Plan* information.

3.4 Task 4: Safety Plan

The *Safety Management Plan* (page 14 of the BAA) shall describe the underlying safety needs associated with the safety of all travelers, subjects, and other personnel associated with the Pilot Deployment.

These safety needs will generate requirements/constraints for the SyRS which will then be documented in the *Application Deployment Plan*. The amount of safety needs and requirements will be determined from the type of applications that are being modified.

3.5 Task 5: Performance Measurement and Evaluation Support Plan

The *Performance Measurement and Evaluation Support Plan* (page 14 of the BAA) is primarily a task dealing with technical aspects of the deployment, such as performance measures, action logs, field data collection, and ultimately modelling and simulation.

These performance metrics will need to be produced from the applications directly or post processes of the applications. How these metrics will be generated through the modifications to the applications should be included in the *Application Deployment Plan* to ensure all of the metric requirements can be met.

3.6 Task 6: Pilot System Requirements Specification

The *System Requirements Specification* will record at a minimum all of the functional, interface, performance and data requirements needed for the modifications of the applications for the Pilot.

Once this document is completed and approved by the COR, then the development of the *Application Deployment Plan* can begin. The SyRS will be the key input into the *Application Deployment Plan* by providing all of the requirements the application modifications will need to have. Working from these requirements, the *Application Deployment Plan* will document additional functionality / performance elements that are required to integrate the applications for the Pilot Deployment.

3.7 Task 9: Participant Training and Stakeholder Education Plan

The *Participant Training and Stakeholder Education Plan* (page 19 of the BAA) will plan for the recruitment and training of all personnel participating in the Pilot Deployment.

The *Application Deployment Plan will* be an input to the *Participant Training and Stakeholder Education Plan,* as the modifications to the applications documented in the *Application Deployment Plan* have the potential to dictate what types of training would be the most relevant to the users of the Pilot Deployment.

3.8 Task 12: Comprehensive Pilot Deployment Plan

The final Comprehensive Pilot Deployment plan is the culmination of the material prepared for tasks 2-11. Therefore, any application development concepts throughout the entire CV pilot deployment should be covered in this deliverable.

4 Key Challenges

The major challenges in application development include making sure to properly archive all of the Pilot code, supporting the integration and future use of the applications, understanding and using the Security Credential Management System, and controlling the cost and schedule of application development. In considering for these challenges, much arises, and should be dealt with to a satisfactory level. This section of the orientation material will touch upon just the top few major challenges that may arise during the CV pilots, and what can be done to ensure strong application development.

4.1 Archiving CV Pilot Code

A key consideration when modifying the applications for the Pilot is to understand that all of the development work that is being conducted for the Pilot must be shared as open source on the OSADP.

To add code, pseudo-code, algorithms or any other code related artifact to the OSADP, all of the requirements for the OSADP must be met. The submission requirements for the OSADP can be found on the OSADP website (www.itsforge.net) and should be referenced when looking to develop the *Application Deployment Plan.*   Once items are submitted to the OSADP for posting, a review of their contents will be conducted to determine if all of the items submitted met the OSADP standards. If OSADP standards are not met, then submitters will be asked to resubmit items with the proper corrections.   When developing the *Application Deployment Plan* additional time in the schedule should be added for changes to the OSADP submission information if required.

Another challenging area is determining what information to include in an OSADP submission. First, start with all of the requirements for the OSADP and make sure the content being submitted is clear, concise, complete, and provides enough information that other developers with similar technical backgrounds can download the information and work with the applications.   Additional supplemental information that should be considered when submitting to the OSADP is any information that will help other users of the software. This could be test data sets, unit testing information, example files, etc. If in doubt on whether or not to include information, check with the with the CV Pilots application lead, Gene McHale (Gene.McHale@dot.gov).

4.2 Supporting Integration and Future Use

One potential challenge from the Pilot project is promoting the reuse of materials used for the modification of the applications in future CV deployments.   To address this challenge, the total life cycle of the application development materials including code, pseudo-code, algorithms etc. should be considered early on.

When developing the *Application Deployment Plan,* concentrations on how application modifications will be used in the future should be a key goal. Using already defined tools to promote the integration

of the application with already existing systems and standard Application Protocols Interface (API) will help promote the modification of the application to be used in the future by other projects.

Developing code using best practices with the mind set of reusability will encourage future deployments to use the code. Developing software that is fully documented, organizing code into classes and libraries and using API encourages future developers to pick up the software. In addition, other software related artifacts should be documented and supplied through the OSADP for others, including, but not limited to: testing procedures, UD wireframes, and coding algorithm statements.

4.3 Utilizing the Security Credential Management System (SCMS)

It is a requirement of the contract that at least one of the applications used in the Pilot will need to use the USDOT SCMS. This can be a challenge for the project, as developers may not be familiar with the SCMS and may not know how to incorporate it into the Pilot.

To overcome this challenge, Pilot teams will need to take the time to understand the full capability of the SCMS so they can best determine where it will work within their Pilot Deployment. To gain understanding of the SCMS, the Pilot team should first start by reviewing the SCMS website (http://www.iteris.com/cvria/html/applications/app63.html) and attending one of the SCMS webinars.

For more detailed questions about the SCMS, teams should attend one of the Bi-Weekly Application roundtables or send their questions directly to the CV Pilots application lead, Gene McHale (Gene.McHale@dot.gov) or the CV Pilot security lead, Walton Fehr (walton.fehr@dot.gov).

If the SCMS capabilities do not meet all of the security requirements of the given Pilot Deployment, additional security management system may be required and should be looked at. These additional security management systems could be already created and used or developed specially for the Pilot Deployment. Note any newly developed security systems created with Pilot funding will have to be released on the OSADP and be open source.

4.4 Controlling Cost and Schedule

The CV Pilots timetables and budgets are very detailed with set goals and milestones. A challenge for the CV Pilot Deployments teams is to ensure that the schedules and costs for the Pilot are monitored and controlled throughout the life of the project to meet these milestones.

Software development, given its intangible nature and the uniqueness of software, makes it inherently difficult to estimate costs and schedule of its development. To minimize this risk, when determining developed estimates, the whole software team should be involved in the estimates and estimates should include time for development, testing, debugging, and following the documented software development policies for the project. This can include code documentation, code reviews, code archiving, and any other tasks required to produce reliable high quality applications. By including all of these times in the upfront estimating it will save time from having to do costly recoding of the applications after the fact.

Another challenge to controlling cost and schedule for the application development is requirement inflation or scope creep. To overcome this challenge, teams should ensure all requirements and thus features for the applications that are being modified are traced back to the SyRS and a defined change control process is defined for the Pilot. The change control process should document who has the right to request changes and who has the power to approve those changes if they are not already documented in the SyRS.

5 Technical Support Summary

Each Connected Vehicle Pilot Deployment will include different technologies and strategies. It is important to plan for the application development well before their implementation. For a list of the DMA bundles and their potential application development concerns, the *Connected Vehicle Data Capture and Management (DCM) and Dynamic Mobility Applications (DMA) Assessment of Relevant Standards and Gaps for Candidate Applications*[3] document can be a vital resource. This orientation material is by no means an exhaustive list of the application development concerns of Intelligent Transportation Systems in the Connected Vehicles Pilot Deployment, but a reference for developing an application deployment plan.

In addition, a series of USDOT-sponsored webinars were developed to assist early deployers of connected vehicle technologies with Concept Development activities. The webinar described below provides support for the development of an Application Deployment Plan.

1.   ***Utilizing the Open Source Application Development Portal for Connected Vehicle Deployments***

This webinar presents the USDOT perspective on the need for Open Source software and the USDOT developed tools already available. Gene McHale of the Federal Highway Administration describes the Open Source requirements for a CV Pilots application, the available applications and features on the Open Source Application Development Portal (OSADP) and how to submit an application to the OSADP. A live demo is also given of the OSADP website and relevant functions. The OSADP is a project focused on developing and maintaining a portal where researchers can download, upload and collaborate on Open Source transportation software.

To access the presentation slides and audio recording for this webinar, please visit the technical assistance page of the CV Pilots website: http://www.its.dot.gov/pilots/technical_assistance_events.htm.

References

1. Connected Vehicle Pilot Deployments: Phase 1 Concept Development, Broad Agency Announcement No. DTFH6115R00003, Federal Highway Administration, January 2015. https://www.fbo.gov/index?s=opportunity&mode=form&id=36ac05d6be6db2c92dd77 bda3965e245&tab=documents&tabmode=form&tabid=7c71a2c57d27b4c1185c15f069 d80180&subtab=core&subtabmode=list&=

2. Open Source Application Development Portal (OSADP) Release Process

   http://itsforge.net/applications/release-process

3. Research Data Exchange (RDE) https://www.its-rde.net

4. *Connected Vehicle Data Capture and Management (DCM) and Dynamic Mobility Applications (DMA) Assessment of Relevant Standards and Gaps for Candidate Applications*, FHWA-JPO-13-019, October 2012,

   http://www.its.dot.gov/dma/pdf/assessment_standards_applications.pdf

5. Connected Vehicle Security and Credentials Management

   http://www.iteris.com/cvria/html/applications/app63.html

6. Apache 2.0 License http://www.apache.org/licenses/LICENSE-2.0

Software Development Guidance

Guidance on Software Develop can be found in the following references:

1. W3C Mobile Web Application Best Practices, December 2010, http:www.w3.org/TR/mwabp/

2. IEEE std 1028 (IEEE Standard for Software Reviews and Audits) http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=4601582

3. ISO/AWI TS 19091 - Intelligent transport systems -- Cooperative ITS -- Using V2I and I2V communications for applications related to signalized intersections http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=63941

4. IEEE std 829 (IEEE Standard for Software and System Test Documentation) http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=4578271

5. IEEE std 830 (IEEE Recommended Practice for Software Requirements Specifications) http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=5841

6. IEEE std 1058 (IEEE Standard for Software Project Management Plans) http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=5978

7. Google Java Style Guide https://google.github.io/styleguide/javaguide.html

8. Python Code Style Guide https://www.python.org/dev/peps/pep-0008/

9. Microsoft .NET design Guidelines https://msdn.microsoft.com/en-us/library/ms229042.aspx

10. PHP Style Guide http://www.php-fig.org/psr/psr-2/

Appendix: List of Acronyms

Table A-1: Table of Acronyms

Acronym	Meaning
API	Application Protocol Interface
BAA	Broad Agency Annoucement
DCM	Data Capture and Management
DMA	Dynamic Mobility Applications
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
OSADP	Open Source Applications Development Portal
RDE	Research Data Exchange
SCMS	Security Credential Management System
V2V	Vehicle to Vehicle
SyRS	System Requirements Specification
V2I	Vehicle to Infrastructure

U.S. Department of Transportation
ITS Joint Program Office-HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free "Help Line" 866-367-7487
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