USDOT Guidance Summary for Connected Vehicle Deployments

Data Sharing

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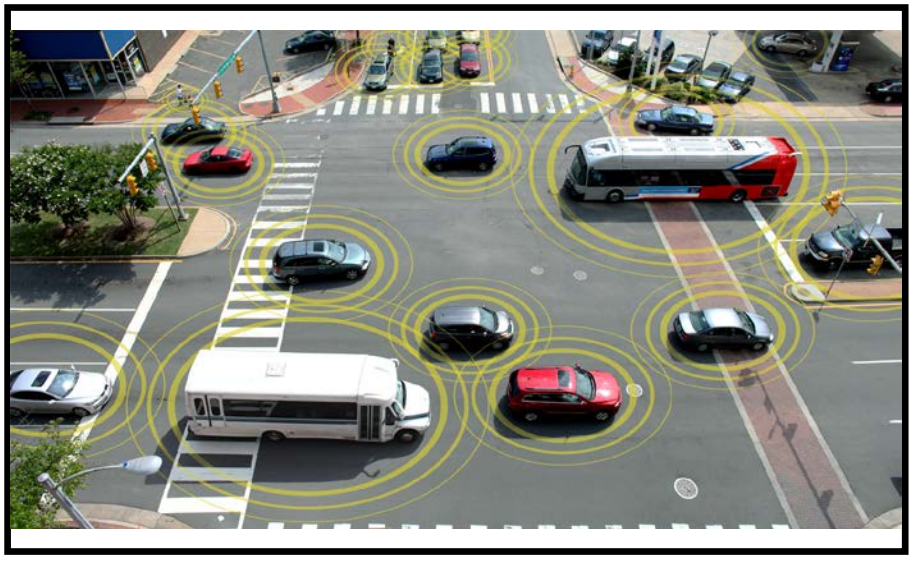

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16. Abstract

The document provides guidance to Pilot Deployers in the timely and successful completion of Concept Development Phase deliverables, specifically in developing the Data Sharing Framework portion of the Performance Measurement and Evaluation Support Plan in Task 5 and corresponding requirements in the System Requirements Specification (SyRS) document in Task 6.

The document provides a summary of key challenges that the Sites may face and methods that can be used to overcome them. The document also identifies key deliverables that are pertinent to the support of the data sharing effort and a summary of the technical support available from the USDOT.

This document does not replace or alter the work statement defined in the Broad Agency Announcement (BAA); rather it provides technical guidance to the pilot deployers in completing the tasks and deliverables described in the statement of work.

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1 Introduction

1.1 Purpose of the Report

The purpose of the "USDOT Guidance Summaries" series of papers is to assist Pilot Deployers in the timely and successful completion of Concept Development Phase deliverables. This report provides guidance for preparing a Data Sharing Framework, which is one component of the deliverable for Task 5: Performance Measurement and Evaluation Support Plan, and for preparing data sharing requirements for the Task 6 deliverable: System Requirements Specification.

Since the Connected Vehicle (CV) Pilots projects are funded by the USDOT Connected Vehicle program, a major objective of the CV Pilots program is to generate data that can be widely used for further research into connected vehicle applications and deployments, including other CV Pilot projects. Page 67 of the Broad Agency Announcement (BAA) for the CV Pilot program states:

> ***"Data sharing. Connected vehicle, mobile device, and infrastructure sensor data captured during the operational phase of the effort is expected to be broadly shared with the community to inform other deployers and prospective deployers of connected vehicle applications. However, data sharing is subject to the protection of intellectual property rights and personal privacy. Appropriately prepared system control, performance and evaluation data are expected to be shared with the USDOT and posted in timely fashion on resources such as the Research Data Exchange."***

Since performance and evaluation data are expected to be shared with the research community, the requirement for delivering a Data Sharing Framework is stated on page 16 of the BAA as part of Task 5:

> ***"Data Sharing Framework. The Performance Measurement Plan shall include a Data Sharing Framework, a description of performance measurement data to be generated and transmitted to COR, including the frequency of these updates. These data, at a minimum, shall include system performance against the performance measures selected to be routinely and periodically reported throughout Phase 3. The description of these data shall include the sources of field data, the format and nature of the performance data reported, and Action Log entries contemporaneous with data collection ... The Data Sharing Framework shall be consistent with the Privacy Operational Concept, and shall describe how the Privacy Operational Concept is expected to be operationalized in the Pilot Deployment."***

System requirements related to data sharing shall also be included in the System Requirements Specification (SyRS) document required by Task 6:

> ***"The Contractor shall develop a System Requirements Specification (SyRS) Document based on the COR-approved ConOps … At a minimum, the following requirements shall be included … Data Requirements including data-sharing requirements." (page 17)***

This guidance paper provides background for the USDOT repositories to which CV Pilot data should be submitted, and suggestions for providing data and related metadata. This paper also provides suggestions for how data may be exchanged among components of the Pilot, as described in the Connected Vehicle Reference Implementation Architecture (CVRIA) and the Concept of Operations for the Southeast Michigan Test Bed.

1.2 Organization of the Report

Section 1 of the report is this introduction. Section 2 provides the background of the data repositories supported by the Connected Data Systems program and describes some key reference documents. Section 3 describes the data and metadata deliverables. Section 4 discusses key challenges in the provision of data and Section 5 discusses technical support available from USDOT. The final section provides references.

2 Background

2.1 Key Relevant Programs

This section provides background information for three important topics relevant to data sharing. The first two topics are the proposed recipients of the shared data from CV Pilots: the USDOT Research Data Exchange and the Saxton Traffic Operations Laboratory, and project evaluators. The third topic is the Southeast Michigan 2014 Test Bed, which serves as a model for connected vehicle implementation, including data generation, transmission and storage, and security.

2.1.1 The Research Data Exchange

One goal of the USDOT Connected Data Systems program is to enable the active acquisition and systematic provision of integrated, multisource data to enhance current operational practices and transform surface transportation systems management. The Research Data Exchange (RDE) is a web-based resource that collects, manages, and provides access to multi-source and multi-modal transportation data to support the development and testing of Intelligent Transportation System (ITS) and connected vehicle applications. This data-sharing capability allows researchers, application developers, and others to significantly reduce the cost and time required to collect and compile data for analysis or research for connected vehicle-related ITS applications.

The RDE provides access to connected vehicle and passenger related data involving transit vehicles, maintenance vehicles, probe vehicles, traffic monitoring and reporting devices, incident detection systems, traffic signals, and weather and other types of ITS sensors. These types of data enable the analysis and research of a wide range of issues and factors.

Data accessible through the RDE is quality-checked, well-documented, and freely available to the public. The RDE currently has ITS and connected vehicle data from 13 locations to support the analysis and development of connected vehicle applications. More data environments are in the pipeline for being added, including data from several Dynamic Mobility Application (DMA) prototypes and two prototype operational data environments. The RDE is continuously evolving, and has recently launched Release 2.2 with new features and data.

In addition to providing data and metadata, the RDE has a section where RDE data users are encouraged to share their work with other researchers by posting project descriptions for discussion and collaboration.

The construction and operation of the Research Data Exchange are currently performed by Indrasoft, Inc. This contract may be extended or replaced during the duration of the CV Pilot program. The task of preparing collections of data and metadata for publication on the RDE is currently performed by Booz Allen and Hamilton, but during late 2015 this contract will transition to Noblis, Inc. under subcontract to Cambridge Systematics. Contact information for these contractors may be obtained upon request from the RDE program manager.

Readers are encouraged to explore the RDE at **www.its-rde.net** and to register as RDE users.

2.1.2 Saxton Traffic Operations Laboratory

The Saxton Transportation Operations Laboratory (Saxton Laboratory) is a state-of-the-art facility for conducting transportation operations research. The laboratory is located at Federal Highway Administration's (FHWA) Turner-Fairbank Highway Research Center (TFHRC) in McLean, VA. The laboratory enables FHWA to validate and refine new transportation services and technologies before committing to larger scale research, development, testing, and deployment phases, and serves as a gateway where Federal staff, contractors, and academia collaborate on cutting-edge research. The Saxton Laboratory also supports professional development and technology transfer of innovative service concepts and technologies through knowledgeable onsite staff, physical prototype systems, and advanced simulation capabilities.[1]

The data stored in the Saxton Lab are not available to the public. Any data generated by the CV Pilots that cannot be shared to the public because of intellectual or commercial property rights or privacy considerations will be stored within the Saxton Lab. Access to such data will be limited on a case-by-case basis with proper credentials.

The construction and operation of the Saxton Laboratory are currently performed by Leidos, Inc. The contract is limited in duration; it may be extended or replaced during the duration of the CV Pilot program.

2.1.3 The Southeast Michigan 2014 Test Bed

The USDOT ITS JPO Connected Vehicle (CV) Test Bed in Oakland County, Michigan (known as the Southeast Michigan Test Bed) was implemented in 2007 to serve as the development and test facility for the Proof of Concept engineering project conducted by the USDOT and the auto industry, to determine the feasibility and technical limitations of DSRC operating at the 5.9 GHz bandwidth. Over the past few years, the Southeast Michigan Test Bed has gone through numerous enhancements, including geographical expansion and technical and architectural updates, designed to support the connected vehicle industry's evolving needs for a test and development environment.[2]

CV Pilot contractors are encouraged to consult the Test Bed Concept of Operations for examples of how data sharing has been successfully accomplished. For example:

> ***One of the fundamental concepts underpinning the 2014 Southeast Michigan Test Bed is that data and/or information generated, situational or otherwise, is characterized by two key state elements: its time context and its space context. These two characterizations determine the relevance of the data/information to the recipient based on the recipient's proximity (in time and /or space) to the source of the data. All data/information that is generated within the Southeast Michigan Test Bed will accordingly be time and location stamped at creation. This allows each data recipient to respectively adjudicate the relevance and value of the data.3***

CV Pilots are encouraged though not required to employ DSRC communications in the 5.9 GHz band using the IEEE 1609 -Wireless Access in a Vehicular Environment (WAVE) protocol suite. The

[1] http://www.fhwa.dot.gov/research/tfhrc/labs/operations/
[2] Southeast Michigan Test Bed 2014 Concept of Operations, December 2014. p. 14
[3] Ibid. p. 18

Southeast Michigan Test Bed has extensive experience implementing these communications, and CV Pilot contractors should consider adopting the data communications capabilities established by the test bed and documented in the Concept of Operations. Additionally, CV Pilots are invited to consider the data collection, transmission, and storage capabilities of the Southeast Michigan Test Bed as tested.

2.2 Key References

The first four references are relevant to the provision of data to the RDE and the Saxton Lab and are available from RDE program manager, Gene McHale or Dale Thompson. The first three documents were written by Booz Allen Hamilton as the current test data sets contractor describing the steps for assessing submissions of data to the RDE and preparing data for inclusion. The fourth document was written by Noblis.

The next two documents are in the series of guidance white papers provided to the CV Pilots contractors, relating to performance measurement and evaluation support. They relate to data sharing since the data are being shared for the purposes of performance measurement and evaluation support.

The remaining documents relating to the Connected Vehicle Reference Implementation Architecture (CVRIA) and the Southeast Michigan 2014 Test Bed are available online at the provided URL.

- Data Transfer Guidance for Dynamic Mobility Applications Bundle Teams", September 2013. This document was developed to provide guidance to contractors for the USDOT Dynamic Mobility Applications program, but the contents apply to providers of data from the CV Pilot program as well. The contents describe the recommended procedure for evaluating the quality and usefulness of the data, for determining the structure of the data, and for documenting the data.
- Adding Data to the Research Data Exchange and Saxton Transportation Operations Laboratory: Process and Issues to Consider. September 2014. This document presents additional guidance to data providers.
- Data Distribution Rights Document, September 2015. This document is a template for documenting data distribution rights, certifying that the data provider is authorized to present the data the USDOT, and that USDOT has the rights to distribute it, either freely on the RDE, or in a restricted fashion in the Saxton Laboratory.
- Metadata Guidelines for the Research Data Exchange, January 2012. This document presents guidelines for writing metadata documentation that describes the format and values of the data and provides background on how, where, and when the data were collected. Providers of data to the RDE are required to provide documentation conformant to these guidelines, which are based on ATSM 246-05 guidelines for metadata.
- Concept of Operations for the Southeast Michigan Test Bed 2014. This document is available on the collaborative Southeast Michigan Test Bed Project portal http://cps-vo.org/SE-Michigan-2014-Project, operated by Vanderbilt University for the dissemination of documentation developed by the Southeast Michigan Test Bed project team Access to the portal can be arranged by contacting Walt Fehr, USDOT at Walton.Fehr@dot.gov.
- UDSOT Guidance Summary for Connected Vehicle Pilot Site Deployers: Performance Measurement.
- UDSOT Guidance Summary for Connected Vehicle Pilot Site Deployers: Evaluation Support.

- Connected Vehicle Reference Implementation Architecture (CVRIA). http://www.iteris.com/cvria/ The CVRIA is a tool that identifies and maps the key interfaces across the connected vehicle environment. It contains four views: enterprise, functional, physical, and communications. The CVRIA contains relevant views for safety, mobility, environmental, and support applications.
- The Systems Engineering Tool for Intelligent Transportation (SET-IT) is designed to implement and complement the CVRIA. CV Pilot contractors may consider using SET-IT to develop the data sharing framework. http://www.iteris.com/cvria/html/resources/tools.html
- The use of ITS standards is strongly encouraged. Information about these standards can be found at https://www.standards.its.dot.gov/DevelopmentActivities/PublishedStandards.

3 Required Deliverables

The deliverable connected to data sharing is the Data Sharing Framework, part of the Performance Measurement and Evaluation Plan required in Task 5. The Data Sharing Framework will describe plans for sharing performance and evaluation data with the project evaluator, and for sharing the same data with the public via resources such as the RDE.

Requirements related to data sharing must also be included in the System Requirements Specification (SyRS) required in Task 6.

The following subsections present considerations for providing data to the RDE, with the expectation that the same considerations will apply to provision of data to the performance evaluator.

3.1 Collected Data

As quoted in Section 1, the CV Pilots Statement of Work calls for "Connected vehicle, mobile device, and infrastructure sensor data captured during the operational phase of the effort."

It is expected that CV Pilots projects will generate data that will be used for determining the successful performance of the deployed applications and for evaluating the potential benefits and effects of such applications. Data may be generated by instrumented vehicles, roadside devices, connected travelers with mobile devices, Traffic Management Centers, or any other entity involved in the pilot deployment. These data may be transmitted between entities or may be stored on the originating devices. In any case, generated data should be stored in a methodical fashion, and transmitted to the site deployment evaluator and to the RDE or the Saxton Lab, either during the operation of the pilot deployment or shortly after its conclusion.

Data that are available to the public in the RDE must be free of restrictions for access or use. A data rights document must accompany the data certifying that the USDOT has the right to distribute the data freely. Data that cannot be shared with the public will be sent to the Saxton Lab, together with documentation describing who may access the data and the conditions for doing so.

The desirable data properties in the following list will facilitate evaluation activities, as well use by potential future user of the data. It is recommended that CV Pilot contractors consider these data properties and design the data sharing framework to achieve them.

- The data are in a standard (e.g. comma-separated value (CSV)) format that enables other parties to read the data without the need of proprietary software.
- The data conform to an appropriate ITS Standard, e.g. SAE J2735 for DSRC communications, SAE J2354 for center-to-center communications, or IEEE 1512 for incident management. See the USDOT website https://www.standards.its.dot.gov/DevelopmentActivities/PublishedStandards for a complete list of ITS standards.
- The data are grouped in files of manageable size to facilitate file transfer and processing.

- The data contain timestamps that establish the time at which time each record was recorded and location identifiers.
- The data contain identifiers that specify the vehicle or device from which the data were collected.
- The data are as disaggregated as practical; future users can aggregate data as appropriate to the study at hand.
- Data are collected simultaneously from as many different sources and different modes as possible, with synchronized timestamps.
- The data are as error-free as possible. This implies:
    - checks for error-free operation before official data collection starts
    - checking data after collection to remove any clearly erroneous values
    - adding flags to indicate the presence of suspect but not clearly erroneous values

These desirable properties should be kept in mind when designing the data collection and storage procedures in the data sharing framework. Evaluation of the data produced in a CV Pilot deployment is an integral part of each CV Pilot test. Data features that facilitate evaluation as part of the CV Pilot will also facilitate re-use of the data by other researchers and implementers when the data are shared.

Interested parties are invited to browse data environments on the RDE as examples of these data properties.

3.2 Metadata

Metadata, or "data about data" is necessary to describe for future users the content of the data and information about how and when the data were collected.

Submissions of data to the RDE must be accompanied by standard metadata documentation, as specified in the document "Metadata Guidelines for the Research Data Exchange (January 2012). These guidelines, based on ASTM 2468-05 "Standard Practice for Metadata to Support Archived Data Management Systems," specify the contents and format of a metadata documents that includes the following:

1. Identification information
2. Data quality information
3. Spatial data organization information
4. Spatial reference information
5. Entity and attribute information
6. Distribution
7. Metadata reference information

Thus, the document describes how, where, and when the data were collected, the data type and possible values for each data element, and contact information. A metadata document conformant to the guidelines document named above is present on the RDE for each data environment; interested parties are invited to download these documents as examples.

The RDE features the ability for users to perform text searches on the metadata documents, looking for text phrases of interest to help identify data sets containing certain types of information or to find definitions of certain types of data.

Data providers are welcome to provide additional documentation beyond the standard metadata document described above. Such documentation will be included with the data on the RDE in addition to the standard metadata document.

Data submitted to the Saxton Lab should follow the same guidelines for data quality and metadata documentation as the guidelines specified for the RDE.

4 Key Challenges

This section discusses several challenges to consider when designing data collection capabilities and procedures.

4.1 Structuring the Data

Data within the RDE is structured in a hierarchy. Each major collection of related data from a single location and obtained under the same contract or agreement is called a *data environment*. Within each data environment are multiple *data sets*. Generally speaking, each data set contains a certain type of data, such as highway detector data or traffic signal timing data or weather data. Within each data set are one or more *data files* that contain data for a certain time period and/or local area.[4]

It is anticipated that all the data from a single CV Pilot project will make up one data environment. Within that data environment will be a collection of data sets. Each data set will consist of data files that share common content and format. For example, one data set might contain multiple data files, each of which contains data from the same type of sensor but for a different time period and/or location.

Providers of data to the RDE will work with the RDE Test Data Sets Contractor to work out a good hierarchical definition of data sets and data files for the data collected by the CV Pilot project (see Section 5). Providers of data to the Saxton Lab will work in a similar fashion with the Saxton Lab contractor.

A related issue to address is the method for transferring the data from the CV pilot operator to the evaluator and to the USDOT data repository. Depending on the nature and size of the data files, the data may be transmitted directly over the Internet, or may be placed on a "cloud storage" device for later retrieval, or may be transmitted on one or more hard drives. In any case, special security measures are required if the data contain any PII or proprietary information.

4.2 Archived or Real-Time Data

The majority of data environments in the RDE are archived. That is, the data files were populated, quality-checked, and transmitted to the RDE well after they were created, and RDE users download files containing historical data.

However, for one data environment in the RDE – Integrated Mobile Observation (IMO) data from vehicles owned by the Minnesota Department of Transportation – data are received by the RDE in real-time, immediately after they are received from the instrumented vehicles via cellular communication. RDE users may download a program that enables them to receive the IMO data in real-time as well, immediately after they are received by the RDE. Providers of data from CV pilots

[4] RDE FAQ at http://rde.indrasoft.net/rdeabout/faq

are encouraged consult with the RDE contractor and the Test Data Sets contractor to explore the possibility of making data available to the RDE in real-time. Real-time data is especially useful to researchers testing potential CV applications.

A hybrid of real-time and archived data is the concept of playback. With playback capabilities, archived data records may be provided to subscribers in small increments over time, as if they were being sent in real-time. This capability is useful for development and testing of algorithms intended to process CV data in real-time. Providers of data from CV pilots are encouraged to explore the possibility of making data available through the RDE in a playback mode.

The data clearinghouse and the data warehouse at the Southeast Michigan Test Bed are examples of real-time and longer-term data storage respectively.

4.3 Personally Identifiable Information and Proprietary Data

A key consideration in providing data from CV Pilots is to ensure that proprietary data or data containing Personally Identifiable Information (PII) is not released to the public. As stated in the BAA: "Data sharing is subject to the protection of intellectual property rights and personal privacy." Pages 11 through 14 of the BAA discuss PII and the need for diligence when collecting, transmitting, or storing data that may contain PII. If any data containing PII is generated during the operation of the pilot test, the provider must ensure that PII is removed before the data are shared.

USDOT has been diligent in developing procedures and algorithms to ensure that no data environments on the RDE contain PII. Data from infrastructure devices such as traffic counter, traffic signals, and weather stations is not a problem. However all image data, whether still photos or videos, must be checked or blurred to ensure that no recognizable faces, license plates, or other identifying features are visible. Vehicle trajectories are not a problem if they come from public vehicles such as transit buses or state-owned maintenance vehicles, but trajectory data from private individuals must be carefully processed (sanitized) to ensure that study of the trajectory data cannot reveal identifying stops such as residence, workplace, schools, or other habitual stops that could be used to identify the driver. USDOT has developed a program for sanitizing trajectory data based on deleting portions of trips related to such stops, as well as using map-based data to ensure that a minimum number of intersections have been traversed after the data cutoff, to generate sufficient ambiguity about the driver's destination. Data providers should consult with the Test Data Sets contractor to learn more about the sanitization algorithm.

In addition to considerations of trajectory data, the data should not contain information that could enable someone to identify a specific vehicle, such as license plate, vehicle identification number (VIN),or even exact length and width.

Proprietary data such as commercial routing or customer information may not be included in the shared data.

4.4 Timeliness of Data Provision

As stated in the BAA: “Appropriately prepared system control, performance and evaluation data are expected to be shared with the USDOT and posted in timely fashion on resources such as the Research Data Exchange.”

No specific time periods are mentioned in the BAA, nor is there a firm definition on what “timely” means. However, one lesson learned from previous data collection efforts is that the sooner the data are quality checked and documented, the better. In fact, data quality checks and documentation should not wait until the data collection is finished, but should be an integral part of the data collection process from the start.

5 Technical Support

5.1 Test Data Sets Contractor

Providers of data for the RDE will work with the RDE Test Data Sets Contractor to agree on a good structure for the data and to ensure the documentation is complete. The test data set contractor has worked out a set of steps for engaging in this process. The most basic outline of this process is as follows:

1. **Engage** – the RDE team will meet the CV deployment team to chart a way forward in supplying data to the RDE, with the intent of supporting all the stakeholders' objectives
2. **Explore** – survey the data that is already being collected as well as those that may add value to the data collection process with minimal cost and effort
3. **Structure and Document** – collaborate with the CV deployment team to logically organize and document the collected data to facilitate ease of use by the end users
4. **Post** – together with the CV deployment team, the RDE team will take necessary steps to upload the data and documentation to the RDE online data environment.[5]

Additional documentation and assistance relating to the provision of data to the RDE is available from the RDE Test Data Sets contractor.

5.2 Data Sharing Webinar

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 sharing of connected vehicle data.

1. Preparing Data for the Research Data Exchange for Connected Vehicle Deployments

This webinar highlights the range of issues to consider with collecting, preparing and submitting data from the USDOT supported connected vehicle deployments for posting on the Research Data Exchange (RDE). Mr. Walter During from the Federal Highway Administration (FHWA) describes the expectations with sharing data from Connected Vehicle Pilot Projects with the USDOT. Dr. Jon Obenberger from the FHWA will discusses the objectives, currently available data, and information desired to post on the RDE with Connected Vehicle Pilot Projects. Mr. Rick Glassco presents the issues to consider and requirements associated with preparing and submitting the information to support posting data from Connected Vehicle Pilot Projects on the RDE.

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.

[5] From "Data Transfer Guidance for Dynamic Mobility Applications Bundle Teams", September 2013", with "DMA Bundle Team" changed to "CV deployment team"

References

The first four references are available from the RDE Program Manager. The Last two documents are available at the URL listed.

- Data Transfer Guidance for Dynamic Mobility Applications Bundle Teams", September 2013
- Adding Data to the Research Data Exchange and Saxton Transportation Operations Laboratory: Process and Issues to Consider. September 2014
- Metadata Guidelines for the Research Data Exchange, January 2012.
- Volunteer Data Contribution Agreement, September 2015
- Concept of Operations for the Southeast Michigan Test Bed, December 2014. http://cps-vo.org/SE-Michigan-2014-Project
- Connected Vehicle Reference Implementation Architecture (CVRIA) http://www.iteris.com/cvria/
- SET-IT architecture drawing tool: http://www.iteris.com/cvria/html/resources/tools.html
- ITS Standards: https://www.standards.its.dot.gov/DevelopmentActivities/PublishedStandards.

Appendix: List of Acronyms

Table A-1: Acronym List

Acronym	Meaning
AMS	Analysis, Modeling, and Simulation
BAA	Broad Agency Announcement
ConOps	Concept of Operations
COR	Contracting Officer's Representative
CPD	Comprehensive Pilot Deployment
CV	Connected Vehicles
DMA	Dynamic Mobility Applications
ITS	Intelligent Transportation Systems
MED	Mobility, Environmental, and Public Agency Efficiency Evaluation Designer
MEP	Mobility, Environmental, and Public Agency Efficiency
PII	Personally Identifiable Information
RDE	Research Data Exchange
SED	Safety Evaluation Designer
SID	Survey Instrument Designer
SMEP	Safety, Mobility, Environmental, and Public Agency Efficiency

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