

# U.S. Department of Transportation's Connected Vehicle Reference Implementation Architecture (CVRIA) Training and Workshop

## Purpose

The U.S. Department of Transportation (USDOT) hosted the fourth in a series of interactive workshops<sup>1</sup> to discuss and seek feedback on its CVRIA efforts. CVRIA provides a consistent framework to guide the planning and deployment of Connected Vehicle technologies. The three-day training session and workshop (June 10-12, 2015) was designed to bring together State and local government stakeholders who are planning Connected Vehicle deployments, device manufacturers who need to know the overall scope of the architecture, researchers and academics, and standards developers.

The workshops have provided an important opportunity for external stakeholders to review, provide feedback, and shape CVRIA. The results are expected to affect a wide variety of public and private organizations. Results from previous workshops include:

- Information sharing about the advancement of the CVRIA and training on CVRIA and SET-IT;
- Stakeholder input on architecture viewpoints and the relationship to their implementations or existing systems;
- Stakeholder feedback on interface and standards gap analysis; and
- Feedback on standardization needs and the ability to leverage current developments in standards.

Input from previous workshops also assisted in the development of SET-IT, a tool that facilitates development of local/regional architectures by implementers and decision-makers to guide their deployments.

Approximately 30 participants attended this workshop each day. Participants represented a broad cross-section of Connected Vehicle stakeholders, including members of public sector owners/operators of transportation systems, private sector integrators and operators, technology companies, non-profit technology research organizations, and academia.

## Training Session

The first day was a training session that:

- Introduced CVRIA through a guided tour of the CVRIA website (<http://www.iteris.com/cvria/>) and walkthrough of the training materials (<http://www.iteris.com/cvria/html/resources/cvriatraining.html>); and

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<sup>1</sup> The CVRIA team has conducted three public workshops: one in April 2013 (Summary Report: [http://www.its.dot.gov/press/2013/cvria\\_workshop.htm](http://www.its.dot.gov/press/2013/cvria_workshop.htm), Documents and Presentations: <https://www.standards.its.dot.gov/Exit?page=http%3A%2F%2Fwww.iteris.com%2Fcvria%2Fhtml%2Fresources%2Fdouments.html>) one in February 2014 (Summary Report: [https://www.standards.its.dot.gov/Content/documents/workshop\\_CVRIA\\_02-14.aspx](https://www.standards.its.dot.gov/Content/documents/workshop_CVRIA_02-14.aspx)) and another in August 2014 (Workshop Presentation: [https://www.standards.its.dot.gov/Content/documents/workshop\\_CVRIA\\_08-14.pdf](https://www.standards.its.dot.gov/Content/documents/workshop_CVRIA_08-14.pdf)).

- Provided training on SET-IT (<http://www.iteris.com/cvria/html/resources/tools.html>). Participants followed along as the presenter walked through the SET-IT training (<http://www.iteris.com/cvria/html/forms/setittrainingform.php>) and led the participants through new exercises uniquely suited to the live training environment. Participants were able to comment on the current design and add input on future versions by discussing the potential purposes and desired attributes of the SET-IT tool.

Throughout the training, it was expressed that the applications defined in the CVRIA website are one approach to engineering particular applications and there may be other approaches to implementing a given application. The approaches found on the website are meant as a starting point for planners and decision makers to visualize the overall scope of their projects. SET-IT allows them to personalize application concepts to best fit their individual needs and resources.

Please see Appendix A for the Training Session Agenda.

## Workshop Sessions

The following two days were focused on presentations and discussions focused on the latest results of Connected Vehicle architecture developments and standards analyses.

### Architecture Discussions

The first day of the workshop began with a set of presentations focused on the architecture and identified, for participants, how to find standards recommendations within the CVRIA. The Architecture team presented on updates and expectations for CVRIA 2.0. Next steps for CVRIA include:

- Release of version 2.0 in July 2015;
- Updates throughout the remainder of 2015 and into 2016, released as CVRIA 2.1, 2.2, etc.; and
- Integration of CVRIA into the National ITS Architecture in 2016 (current version 7.1 of the National ITS Architecture will become version 8.0 when unified with CVRIA).

Participants asked questions about how the architecture was developed. The Architecture team clarified that they did not develop any applications. Instead, the Intelligent Transportation Systems Joint Program Office (ITS JPO) and modal partners contracted with stakeholders and technology experts to develop Concepts of Operations, System Requirements, and demonstrated prototypes. Using the information from these efforts, the Architecture team developed the applications found on the CVRIA website, illustrated in the four defined viewpoints. The team noted that they continually seek input to improve and/or provide alternative options to the architecture.

The discussion also focused on the goal of CVRIA. The team noted that a critical goal for CVRIA is to facilitate technical interoperability, but that it does not require implementers to make applications have an identical “look and feel.” It was also emphasized that CVRIA is not intended for making detailed design choices, but rather for helping planners and decision makers to visualize the overall scope of the system to be designed.

## **Standards Discussions**

The second set of presentations focused on the analyses regarding standards for a comprehensive cooperative ITS environment. The presentations included a review of the status of the current, fundamental Connected Vehicle standards along with results from a U.S.-based analysis as well as analyses that have been conducted internationally. These presentations established the foundation for a more detailed discussion on standards development needs while also informing participants on the ongoing work of the USDOT and its partners.

The Standards team noted that by developing detailed architecture viewpoints, such as those within CVRIA, one is able to identify the necessary communication flows and interfaces that may require standards. In identifying this list, the analysts were able to identify required standards that benefit the public interest, existing standards that may be leveraged or modified to meet needs, and gaps.

As there is a global interest in ITS and Connected Vehicle technologies (referred to in other parts of the world as Cooperative ITS) presenters briefed participants on a number of current global standards research initiatives and discussed the potential opportunities for collaborative development of future standards. They noted that international harmonization of standards is critical to ensure a global marketplace but also helps to leverage limited budgets as well as global expertise.

Discussion with participants allowed for the clarification that not all data flows or interfaces need to be standardized; and that the analysis only seeks to identify standards when:

- Standards are in the public interest; for instance, they support the needed interoperability, security, or privacy; or
- Industry is unlikely to advance standards as there is no associated business model.

## **Breakout Sessions**

After presentations and discussion, workshop participants separated into two discussion groups. These smaller groups allowed interested stakeholders to have more detailed discussions regarding Connected Vehicle implementation needs and tools; or standards needs and priorities.

### **Breakout Session on Connected Vehicle Implementation and Tools**

In the exchange on architecture and implementation stakeholders discussed the potential uses of systems such as CVRIA and SET-IT along with any desired features that are currently missing in these systems. The discussion was guided by questions such as:

- *How do you currently make use of your ITS Regional or Statewide Architecture?*
- *What is the value of that tool? What features do you wish it had?*
- *Do you see these features in CVRIA and SET-IT? What other features would you find valuable?*
- *Have you begun the process of planning or developing project plans for Connected Vehicle implementations?*
- *What are the major challenges you are running into?*

- *What are key questions about interoperability that you would like to discuss?*

The exchange focused predominantly on the features and potential opportunities of the Architecture tools. Stakeholders expressed their desire for:

- A more top down approach to the SET-IT tool:
  - Start with planning view (Turbo arch) and then go to project level (SET\_IT layer 2)
  - Be able to show data going through the cloud
  - Tie Layer 0/1 with Layer 2 to sync changes between them
  - Provide an ability to import diagrams (and its data, including interfaces) from other projects as a starting point
  - Provide an ability to import a listing of default names of core elements for a region/agency
  - Distinguish between objects/elements that are being built as part of the project vs those that are supporting the project and we are leveraging (gray out the physical box, but not the enterprise)
  - Show the needs statements (helpful in training/help/outreach but also CVRIA). For instance, some needs might show needs for a Curve Speed Warning app but not why that specific app is needed.
  - Add link to Benefits for each app once they're available.
- A way to sync the Regional ITS Architecture and the Connected Vehicle Architecture;
- A description and purpose for layer 0; and
- Guidance or exploration on back-haul communications systems;
- Guidelines for “naming”, “placement”, usage of architecture to drive consistency within an organization;
- Interim guidance on architecture coordination between regional versus early Connected Vehicle architectures; and
- Ability to export the methodology of CVRIA development to other domains.

As part of this breakout session stakeholders were also provided with a list of tools and products under development by the ITS JPO and FHWA to guide deployment. The group identified their greatest challenges to implementation:

- Incomplete or misinformation on technology capabilities;
- Need for guidance on how to address vulnerabilities and securing a system from end-to-end;
- Information for how to add certification processes to entities that currently do not need to be certified (e.g., Traffic Signal Controllers);
- Performance requirements; and
- Guidance on liability and obsolescence.

In discussion, participants noted that they desire that SET-IT integrate a location to access the standards that match with the exact architecture. In addition to being very helpful, they also noted their delight with the ConOps creator.

The group also brainstormed a list of additional tools that would be useful for implementers, particularly when working with decision makers. Additional tools and products suggested include:

- A “sales” – type outreach – document for constituents that provides information on benefits, benefits versus costs, and other aspects of the value of choosing Connected Vehicle technologies;
- Guidance on DSRC channel usage and on equipment density/siting:
  - Information on congestion mitigation techniques
  - Guidance for the appropriate use of at least Channel 172 and Channel 184
  - Service Channel planning
- Guidance on mitigation techniques for technology turnover, given varying lifecycles, and how to leverage existing equipment;
- Performance requirements;
- More information on Policy and the relationship of the NHTSA rule and the FHWA Guidance; and
- Simulation results from modeling, Cost Benefit Models that are up-to-date and used consistently to see benefits / impacts of applications.

### **Breakout Session on Connected Vehicle Standards and Prioritization**

The group discussed was guided by the following questions:

- *What are your thoughts about the identification of gaps in the categories presented?*
- *What are your top standards and were they represented?*
- *Our summary included thoughts on gaps associated with existing standards. Are you in agreement with those gaps? Can you add detail to our analysis?*
- *Are there other industry standards that we should be considering? If so, what are they and why?*
- *How do you perceive that standards will enable your implementations...in other words, what do you think that standards will do for your operations?*
- *What are your thoughts regarding the harmonization of priorities in this analysis and in the ETSI, AU and SAE analyses?*

The conversation with participants focused, predominantly, on understanding the security and spectrum performance standards. A question on the current security approaches in the Ann Arbor test-bed led to a discussion on the need and usefulness of certificate-based standards and whether the certificate-based techniques are being tested for sufficiency in a Connected Vehicle Environment and whether other potential security techniques had been analyzed. The facilitators provided the participants with the NHTSA Technology Readiness report link

(<http://www.nhtsa.gov/staticfiles/rulemaking/pdf/V2V/Readiness-of-V2V-Technology-for-Application-812014.pdf>). This report accompanied the U.S. DOT’s Advanced Notice of Proposed Rulemaking (ANPRM) and describes the technologies and tests completed at the Safety Pilot Model Deployment site.

Concern was voiced over a number of topics:

- The role of core required standards and their implications on security and privacy—*does implementation of a core standard with an application create other potential vulnerabilities and how will implementers know?*;
- Discrepancies in the timeline and need for security of hardware versus software when implementing in the near-term;
- The differences in securing a private versus transit vehicle and the potential problem of congesting the DSRC channel when fleets leave or return to the maintenance yards at the beginning or end of the day;
- Performance of spectrum particularly with regard to the ability to re-transmit messages in adequate time to process and react when vehicles are travelling at high speeds;
- The required memory for a certification revocation file.

The facilitators again turned to information associated with the NHTSA Technology Readiness report.

Some discussion was had on the need to measure and communicate benefits of Connected Vehicle technologies clearly, and on the need/desire for further stakeholder outreach on standards. To focus on the Connected Vehicle standards priorities, facilitators re-presented the list of priority standards from the gap analysis. The following conversation resulted in a comparison of the USDOT results versus European- and SAE-identified priorities. It was identified that the USDOT top priority gaps are directly comparable to similar analysis done in Europe as well as by SAE, although terminology differs.

### **Stakeholder Inputs and Feedback:**

- Stakeholders appeared generally impressed by the usefulness of CVRIA and the Systems Engineering Tool for Intelligent Transportation (SET-IT) in developing a regional and local architecture. Importantly, users understood that these tools provide the basic processes for developing their architectures and that they will need to provide local data and information to tailor the architecture to their specific conditions.
- Participants also commented on the thoroughness of the standards gap analysis. Through dialogue and exchanges, it was identified that the gap analysis done by the USDOT and its partners appears comparable and complementary to similar analyses done in Europe as well as by the SAE community, although terminology differs.
- Participants expressed significant interest in the cyber security, security management, and dedicated short-range communications standards within a Connected Vehicle Environment.
- Stakeholders identified that an optional Connected Vehicle 101/102 course could be added to the beginning of the workshop to ensure all participants have a sufficient technical knowledge base to gain more out of the workshop.
- Based on various discussions throughout the workshop, it appears that the products and tools that are in development with the Federal Highway Administration (FHWA) will be useful to implementers. Participants were able to identify additional tools or enhancements to current tools.

## Workshop Participant Take-Aways

On the final day of the workshop, stakeholders were asked for their insights from the presentations and discussions; and to identify additional material to add to this workshop for future planned workshops. Participants offered the following inputs to the CVRIA team<sup>2</sup>:

- *The CVRIA offers what appears to be “well-bounded structural views”. A consideration from other technology architectures is the need for resilience and flexibility (e.g., cockpit development is restrained by mechanical constraints, which created challenges in integrating newer technologies). A future workshop could address how Connected Vehicle technology will evolve and the plans for ensuring that standards or implementations do not solidify a certain type of technology. The question posed to the CVRIA team was, “What sorts of architecture impacts are dictated by standards and if we change standards what do we need to change in terms of the architecture?”*
- *Participants applauded the CVRIA team, noting that it was impressive to see how much work has already been accomplished.*
- *The workshop provided value in that participants noted their ability to return to their offices and inform their colleagues on the basics of Connected Vehicle technologies, some of the benefits, and the information that tools exist to help with project planning. Other questions still need to be addressed such as:*
  - *How do participants get Connected Vehicle technologies into their planning processes? (note: ITS JPO and FHWA are performing an analysis and developing guidance/tools)*
  - *How do participants integrate regional ITS architectures with this new CVRIA? (note: this will be part of the unified National ITS Architecture 8.0 release)*
  - *What are the policy and regulatory implications within each State? (note: ITS JPO and FHWA are performing State/local legislative analysis)*
- *Some participants noted the need for context on the basics of Connected Vehicle (which led to the suggestion to also present CV 101 as part of the workshop). Others noted that this training/workshop event provided a significant amount of detail and that access to on-line resources is important to be able to review/re-access some of the details.*
- *Some of the participants who are implementers desire additional case studies on intersections; but also guidance on how to quantify the benefits on system performance, efficiency, and mobility. Further insights offered that implementers will need CVRIA and SET-IT to address:*
  - *Corridors*
  - *Full city scales*
  - *A needs database to support defining, at the beginning of each project, the reasons why each application is needed within that project*
- *Some participants found themselves looking into the future and asking if there was any analysis on what occurs after 20 years if you implement these technologies today. Are there consequences to be taken into account in addition to the benefits? What are the trade-offs?*
- *A key request from implementing participants is for the standardization between TMC software and “roadside” standards.*

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<sup>2</sup> The bullets are a summary list of insights provided by participants that is not meant to be comprehensive, but to highlight key points that are useful to the CVRIA program managers and team in considering next steps.

- *Some participants noted the lack of participation by actors outside of transportation (e.g., consumer side, advertising and insurance). The question was asked whether there was a way to reach out to these industries that will likely play a role in the future.*
- *Participants need guidance on back-haul systems; there is a lack in bandwidth requirements for back-haul (note: ITS JPO and FHWA are developing pre-deployment guidelines through the Pooled Funds Study which is expected to address these needs).*
- *Participants desire a “tangible roadmap” that provides a clear schedule that will determine what will happen at what time. This roadmap is desired to identify when elements of Connected Vehicle technologies, applications, standards are fully deployment capable and when it is feasible to update the existing systems after deployments.*

After the discussion that resulted in these insights for the CVRIA team, the workshop was brought to a close with the CVRIA team thanking the participants for their efforts throughout the 2.5 day event.

## Appendix A: Training Session Agenda

Module	Title	Learning Outcomes	Time
	Access to Draper Lab	Please bring a photo ID and allow for time to receive your badge	8:00 - 9:00
<b>1</b>	Introduction to CVRIA	Explain the objectives of Connected Vehicle, the importance of communications in Connected Vehicle, and the need for CVRIA.	9:00 – 9:30
<b>2</b>	CVRIA Website Tour	Tour the CVRIA website and illustrate the CVRIA components. Finish with an example of how a project initiator might use CVRIA to inspire deployment ideas.	9:30 – 10:15
	<b>BREAK</b>		10:15 – 10:30
<b>3</b>	Suggestions for Project Developers	Explain the use of CVRIA content in project scoping, stakeholder coordination, and project design.	10:30 – 10:50
<b>4</b>	CVRIA Use Examples	Explain Connected Vehicle project examples and how CVRIA was used in their development. Use the SEMI project architecture and the new CV Smart Parking application concept.	10:50 – 11:45
	<b>LUNCH</b>		11:45 – 1:00
<b>5</b>	Background & Intro to SET-IT Training	Explain and introduce the SET-IT software tool. Identify the purpose of SET-IT in project development and list the main features.	1:00 – 1:20
<b>6a</b>	SET-IT Walk-Through	Identify the key features of SET-IT used to create Connected Vehicle project architecture.	1:20 – 1:55
	<b>BREAK</b>		1:55 – 2:05
<b>6b</b>	SET-IT Walk-Through, continued	Continue the walkthrough, focusing on the Sample Project, including its content and outputs.	2:05 – 2:40
<b>7</b>	Developing a Project using SET-IT	Explain how to use SET-IT to create a project with two Connected Vehicle applications and how to use SET-IT to output your project.	2:40 – 3:10
	<b>BREAK</b>		3:10 – 3:20
<b>8</b>	SET-IT and the CV Environment	Understand support applications in the sample project. Explain why each is important then use the previous exercise to see how it affects the layer 0 (scope of project).	3:20 – 3:45
<b>9</b>	Resources & Conclusion	CVRIA, Connected Vehicle resources; closing questions/answers.	3:45 – 4:00

## Appendix B: Workshop Session Agenda

### CVRIA Workshop, Thursday, June 11, 2015

	LEAD PRESENTER	Time
<b>Access to Draper Lab/Receipt of Badge</b> (please be prepared to show picture identification)	<b>Draper Lab</b> 555 Technology Square, Cambridge, MA 02139 (617) 258-1000	8:00-9:00am
<b>Welcome: Dr. Kaigham (Ken) J. Gabriel, CEO, Draper Lab</b>		9:00-9:15am
<b>Introduction:</b> <ul style="list-style-type: none"> <li>Objectives of Workshop</li> <li>Context: Importance of CVRIA and Standards analysis</li> <li>Architecture Update</li> <li>Standards update</li> </ul>	<b>Suzanne Sloan, USDOT</b>	9:15-9:30am
<b>Architecture Update:</b> <ul style="list-style-type: none"> <li>Standards in CVRIA <ul style="list-style-type: none"> <li>Communications Viewpoint</li> <li>Mapping to OSI model</li> <li>Differences with NTCIP</li> </ul> </li> <li>What can be expected with Version 2</li> <li>Next steps with Version 2.1 and 2.2, eventual integration with US National ITS Architecture</li> <li>Question session</li> </ul>	<b>David Binkley, Iteris</b> <b>Tom Lusco, Iteris</b>	9:30am-11:30 am
<b>Break</b>		10:30-10:50am
<b>Summary of Current Relevant Standards Development Activities:</b> <ul style="list-style-type: none"> <li>Update on SAE J2735, SAE J2945.x</li> <li>Update on NTCIP</li> <li>Update on ISO 19091 standard</li> </ul>	<b>Blake Christie, Noblis</b>	11:30 am – 12:00 pm
<b>Lunch</b>		12:00pm-1:15pm
<b>Standards Analysis Update:</b> <ul style="list-style-type: none"> <li>Overview</li> </ul>	<b>Suzanne Sloan, USDOT</b>	1:15pm-1:30pm
<b>Gap Analysis from Australian, European (ETSI, TNO), and others</b>	<b>Suzanne Sloan, USDOT</b>	1:30pm-2:00pm
<b>Review of Analysis Approach and Gap Analysis Summary:</b> <ul style="list-style-type: none"> <li>Methodology/Approach to Determine Gaps and Priorities</li> <li>Summary of Recommended Priorities</li> <li>Question session</li> </ul>	<b>Chris Karaffa, Booz Allen Hamilton (BAH)</b> <b>Jim Marousek, BAH</b>	2:00-3:00pm
<b>Break</b>		3:00-3:15pm
<b>Break out Groups – Instructions:</b>	<b>Suzanne Sloan, USDOT</b>	3:15-3:30pm
(1) Discuss: Technical Exchange on Implementation	<b>David Binkley, Iteris</b> <b>Jim Marousek, BAH</b>	3:30-5:00pm
(2) Discuss: Technical Exchange on Standards and Priorities	<b>Chris Karaffa, BAH</b> <b>Blake Christie, Noblis</b>	3:30-5:00pm
(3) Discuss: Connected Vehicle Tools/Products Overview	<b>Suzanne Sloan, USDOT</b>	3:30-5:00pm
<b>Conclusion/End of Day</b>		5:00pm

**CVRIA Workshop, Friday, June 12, 2015**

<b>Access to Draper Lab/Receipt of Badge</b> (please be prepared to show picture identification)	<b>Draper Lab</b>	8:00-9:00am
<b>Summary/Recap of Previous Days</b>	<b>USDOT</b>	9:00-9:30am
<b>Report-Out of results—20 minutes each group</b>	<b>Break-out Group facilitators</b>	9:30-10:30am
<b>Break</b>		10:30-10:45am
<b>Questions/Full Group Discussion of results</b>	<b>USDOT</b>	10:45-11:30am
<b>Summary:</b> <ul style="list-style-type: none"><li>• Next Steps/Actions for CVRIA team</li><li>• Ideas for next workshop</li></ul>	<b>USDOT</b>	11:30-12:15pm
<b>Conclusion/End of Workshop</b>	<b>USDOT</b>	12:30pm