Connected Vehicle Reference Implementation Architecture (CVRIA)
Stakeholder Workshop: San Jose, California
April 30 – May 1, 2013

The United States Department of Transportation (USDOT) conducted a workshop in San Jose, California on April 30 through May 1, 2013, to present and discuss the content of the Connected Vehicle Reference Implementation Architecture (CVRIA) project. The workshop was hosted by the Intelligent Transportation Systems Joint Program Office (ITS-JPO) and co-led by Steve Sill, USDOT/ITS Program Manager for Vehicle Safety Technology, ITS Architecture and, ITS Standards, and Walt Fehr, USDOT/ITS Program Manager for ITS Systems Engineering; and included members of the CVRIA team representing the USDOT/Volpe Center Policy team and contractor staff. This report describes the background of the project and summarizes the discussions that were conducted as part of the workshop.

Background

To enable successful implementation and operations of a connected vehicle environment, implementers will need to know where standards will be needed as well as architecture guidelines. Artifacts include a set of system architecture viewpoints that describe the functional, physical, and logical interfaces, enterprise relationships, and application dependencies within the connected vehicle environment (CVE). The standards plan includes a consolidated list of interfaces to be considered for standardization, and a plan for the development, modification, and adoption of standards to implement the defined interfaces.

Connected vehicle applications, technologies, and systems are intended to increase situational awareness in order to reduce or eliminate crashes. Their foundation is vehicle-to-vehicle (V2V) and vehicle-to infrastructure (V2I) data communications that enables real-time driver advisories and warnings of imminent threats and hazards on the roadway. The Connected Vehicle Reference Implementation Architecture (CVRIA) is a project that will result in a multitude of outcomes:

- An interface architecture for the connected vehicle environment.
- Identification of candidate interfaces to assess where standards will be needed.
- Analysis of whether new standards are needed or whether existing standards can be modified to meet needs (including the potential for harmonization with existing international standards development activities).
- Prioritization of standards development and modification activities that will form the basis of the ITS Standards connected vehicle work over the next 3-5 years.
- Identification of policy issues at an applications and link-by-link level.

The project is sponsored and led by the USDOT's Intelligent Transportation Systems (ITS) Joint Program Office (JPO), under the management of the ITS Architecture and Standards Programs and in cooperation

with the Systems Engineering and Test Bed Programs and the ITS Policy Program. The project is now underway, with an intended completion in early 2014.

Workshop Profile

The USDOT conducted the workshop in San Jose, California for the purpose of reaching out to stakeholders to:

- Describe the need for and scope of the CVRIA,
- Define the processes associated with developing a CVRIA, and
- Describe why and how stakeholders should provide input and guidance to the CVRIA's development.

Approximately 60 attendees participated in the workshop (not including the CVRIA team). The participants represented stakeholders from a broad cross section of the connected vehicle industry including:

- Private sector device makers, auto manufacturers, systems integrators, software developers, trade association representatives, standards developers, and contractors/consultants to the industry.
- Public sector state and local traffic and transit agencies staff.
- Academia and university researchers.

The CVRIA team began the workshop with the definition of "a connected vehicle reference implementation architecture"—what it is, and what results various participants can expect. For example:

- It is a tool for determining where standards are needed;
- It is a tool for identifying where policy issues are present and need to be addressed; and
- It can act as a blueprint for stakeholders to guide decisions about local implementations.

When each application is properly decomposed, it will allow all parties engaged in the connected vehicle environment to communicate using a common language.

Throughout the remainder of the workshop, the CVRIA team presented on the three main outputs of the CVRIA effort:

1. Architecture Development
2. Candidate Standards Identification, Prioritization, and Plan Development
3. Policy Analysis

General Session, Day One Morning

To open the workshop, Steve Sill and Walt Fehr welcomed the participants and thanked them for their participation, noting that stakeholder input at this early stage was an important element in success. They provided participants with an overview of the CVRIA project, its mission and goals, and what the team aims to accomplish in the coming months.

More specific discussions occurred in a series of breakout sessions (a snapshot of the agenda is provided below); outcomes of each are detailed in the remainder of these proceedings.

- Agenda -

Tuesday April 30

8:30	–	9:00	Welcome and Introduction: Overview of connected vehicle program
9:00	–	10:00	CVRIA Background and Overview
10:15	–	11:45	CVRIA Framework: Sources for Needs/Requirements, Multiple views plus an applications perspective, Website layout
1:00	–	1:15	Introduction to Six Example Applications
4:00	–	4:30	Wrap-Up: report form the breakout sessions; discuss plan for Day 2.

Wednesday May 1

8:30	–	8:45	Welcome and Recap
8:45	–	11:30	Architecture Breakout Discussions for Focus Applications 4 – 6
12:45	–	1:00	Report out from the morning breakout sessions
1:00	–	2:30	Discussion of Policy Issues and Analysis Process
2:45	–	3:30	Standardization Planning (taking the resulting outputs of the architecture to develop a plan for standardization)
3:30	–	4:00	Next Steps Discussion: Completing the architecture views; Developing the candidate standardization plan; Participating in future stakeholder engagement.

After opening remarks, the CVRIA architecture team members presented on the first element: Architecture Development.

Architecture Development

The CVRIA team presented an initial architecture "build" representing six connected vehicle applications. These examples were used to walk stakeholders through the construction of an "architecture view," to show them how the source materials were used, and to elicit comments, questions, and feedback. Each application was presented through a set of up to seven different diagrams or "views" showing the enterprise, physical, and functional views of the application during installation, operations, and maintenance.

As a group, the workshop participants walked through the Reduced Speed Zone Warning Application with the CVRIA architecture team, at a high-level, to get a sense of what the CVRIA architecture views offer. At this high-level, participants' primary comments and recommendations for the CVRIA team included the following.

- Participants commented on their desire to have a more focused approach applied to development of the architecture views. Their interest is in highlighting the connected vehicle interfaces and only noting connections to existing ITS and interfaces as, on the whole, they are very familiar with existing ITS and thus do not need additional detail unless the connected vehicle application

changes the nature of how existing ITS interfaces work. They noted that showing existing ITS to the side in order to provide context is useful; but to focus the diagrams predominantly on the connected vehicle portion of the applications.

- Participants noted that when illustrating the V2V Safety applications, the architecture team should just focus on the mobile interfaces. Some of the applications had interfaces with the infrastructure, such as the map update system, but those interfaces will be addressed with V2I applications.
- An important gap, noted by participants, is information about where and how certification and security/security credentials management apply to the interfaces.
- Participants noted a desire to have the architecture views illustrate the differences in the application when using an integrated on-board equipment (OBE) unit versus an aftermarket safety device (ASD).
- Participants questioned whether an "OBE" box in an architecture view was to broadly represent "all ITS" on a vehicle or just the actual communications. With this discussion, participants also wondered about using other in-vehicle data for predicting the vehicle state (kinematic model). The CVRIA team noted that this discussion was needed with the application developers, and that the job of the CVRIA team was to decompose the application as provided in the Concept of Operations (ConOps) documents.
- A general survey of the participants identified the priority with which they would like to see the applications be developed: (1) V2V / V2I Safety applications; (2) Security interfaces: (3) Traffic Signals related applications; (4) Mobility , Transit, traveler-focused applications; (5) Mobility – Public Safety; Environmental applications; and (6) supporting services.
- A final recommendation was an important reminder that many of the applications involve interfaces with private sector initiatives; and that the architecture team should aim not to suppress free enterprise, but to instead provide standardized interfaces allowing smaller companies to participate.

Reduced Speed Zone Warning

This V2I Safety application connects vehicles approaching a reduced speed zone with information on the zone's posted speed limit and/or if the configuration of the roadway is altered (e.g., lane closures, lane shifts).

Key Questions/ Discussion Points

- With regard to the enterprise view:
    - Participants noted a desire to see the relationship between ITS Roadway Equipment and Roadside Equipment.
- With regard to the physical view:
    - Participants discussed the types of warnings that an RSE might need to send the Vehicle OBE – whether the vehicle is at the speed limit or whether the vehicle is over the limit; and

decided that the CVRIA team should focus on providing the information about the speed limit, since the vehicle knows its own speed.
    - Participants thought the application should let the vehicle know when it leaves a reduced speed zone area as well as enters it. They also found that the "merging" portion of the application is probably too complex for this application, despite it being in the ConOps.
- Autonomous vehicles were discussed but participants found that this feature is out of scope for CVRIA, except for the feature of providing vehicles with the speed limit information.

Recommended Actions for the CVRIA Team

- The CVRIA architecture team noted participant guidance to:
    - Remove the concept of merge assistance, and
    - Add information to define where the reduced speed zone ends.
- The architecture team will take the action to discuss with the USDOT ITS program manager overseeing the development of this application.
- The architecture team also took action to show the enterprise relationships between the traditional ITS and the newer connected vehicle systems.

With this discussion as background, workshop participants split into two groups for the remainder of day one and the morning of day two. Each group covered the remaining applications.

Results of Break-Out Session Discussions

Intersection Movement Assist (IMA)

This V2V Safety application is intended to warn the driver of a vehicle when it is not safe to enter an intersection due to high collision probability with other vehicles.

Key Questions / Discussion Points

- Workshop participants discussed and recognized that there are differing levels of deployment and of vehicle capabilities, from:
    - Simple warnings to the driver with no direction on what to do,
    - Advising the driver what to do (e.g., turn right), and
    - Controlling the vehicle.
- With regard to the physical view of IMA:
    - They noted that this application will vary over time beginning with the more simple approach (warning), to the more complex (control). However, this timeline is dependent upon the automakers who have previously stated that they would only control the vehicle if other indications (i.e., non-connected vehicle sensors) verified the threat. It was also noted that the research into automated vehicles may build upon the "control" capabilities.
    - With this discussion, the CVRIA team decided to remove "intersection infringement information" from the physical diagram.

    - The inclusion of the map update system interface was discussed. While some implementations may use geographic data, participants felt that this interface added too much complexity to this V2V application to be represented in the diagram.
    - Participants also noted that while IMA represents a V2V application, it may eventually include data from the infrastructure, thus requiring a V2I interface(s).
- With regard to the enterprise view of IMA:
    - Participants discussed the notion of "someone else's car" and noted a potential need for proxy 'agreement' among vehicle owners. The policy members identified this as an issue to review, as this "proxy agreement" may, in fact, be satisfied by the trust enabled through encrypting data with digital certificates.
    - The term "certify" was discussed. In some cases it might simply be performance requirements or in others it might include specific testing environments that would be decided as the applications are developed.
    - Further, the idea that an application developer would certify their applications with a number of OEMs was discussed; this would need to be defined in the future, but standards and performance requirements could mitigate the cost.
    - In cases where a private application like V2V is used on fleet vehicles there would be a separate relationship between the vehicle owner and the operator of the vehicle, as shown on the diagrams.
    - It was noted also that the installation of aftermarket devices, where the vehicle manufacturer is no longer directly involved, may require separate relationships (i.e., standards, requirements, or agreements).

Recommended Actions by the CVRIA Team

- The CVRIA architecture team noted the need to simplify the physical diagram to focus on the V2V interfaces, and remove both the more complex intersection infringement flow, and the interface to the map update system.
- The CVRIA policy team noted a number of issues with IMA for further investigation.

Road Weather Advisories and Warnings for Motorists

This Road Weather Environmental application provides the capability of collecting road weather data from connected vehicles and using that data to develop short term warnings or advisories that can be provided to individual motorists.

Key Questions / Discussion Points

- With the presentation of the physical architecture views:
    - Participants discussed the inclusion of non-connected vehicle interfaces. While the focus of CVRIA is on the connected vehicle interfaces, it may still be beneficial to see the context of the other traditional ITS components.

    - Participants also noted a desire to "see" the content of the communications between the infrastructure and the vehicles including: road weather data, speed limit information, and a vehicle's measured current speed and indications of when that speed changes.
- With regard to the enterprise views:
    - Participants questioned whether, when raw data goes to the operations center, it might need authentication again before it goes back to the Roadside Equipment (specifically the advisory data message going out to the motorists, not the raw data being re-authenticated.)
    - They noted that the ability to archive road weather data is important for planning. There will be other support applications that will show how the archiving of connected vehicle data will work.

The discussion around this particular application raised a set of issues that may be common across all applications:

- Participants questioned whether the RSE has some basic intelligence, or if it is just a simple terminal. For instance, if a number of vehicles note that they are losing traction, does the RSE send a simple warning to following vehicles without going through the Information Service Provider (ISP)? The CVRIA team believes that the answer is "yes." While this feature remains to be defined as part of an RSE architecture (and, the feature may depend upon the application), it is likely that the RSE can support applications such as local warnings. The CVRIA team will take this up with the ITS program managers.
- Participants also discussed whether the CVRIA is a "standard" for developers or a "blueprint." The CVRIA team noted that the architecture presents different communications paths and implementers of applications can develop various alternatives depending on their needs and the market. Standards will help ensure that the application's objective remain the same for all developers.

Recommended Actions for the CVRIA Team

- Simplify the physical diagram to focus on the connected vehicle interfaces, but show the non-connected vehicle interfaces, if it adds to the overall understanding of the application.
- Remove the flow where the infrastructure "told" the vehicle its speed, since an equipped vehicle knows what its own speed is.
- Discuss RSE issues with the ITS program managers.

Transit Connection Protection

This mobility application uses real-time data to examine the arrival status of a transit vehicle, and to transmit a hold message to a vehicle or other mode of transportation (e.g. rail) for the traveler to make a successful transfer from one vehicle to another.

Key Questions / Discussion Points

- On a general level, many transit agencies have already invested in computer- aided dispatch/automatic vehicle location (CAD-AVL) that has nothing to do with connected vehicle. Those agencies will need to assess the cost benefit for moving to new software systems.
- Participants also discussed the simplicity of the current application, noting that the real benefit comes from the system's ability to make complex connections throughout the system with a major impact on mobility.
- Participants noted the importance of passenger loading data as part of this application; and further noted that passenger capacity is not known through today's technologies.
- This application would likely work better in a rural system with long headways, than in a tightly scheduled urban system.
- On the enterprise view, T-Connect, the connection protection application, assumes that the riders have a device which may bring up issues about social equity for those riders who do not.
- The discussion around this application highlighted the divide between current day connected applications on mobile devices, and "connected vehicle" applications. The CVRIA team noted that the architecture views give us all an opportunity to see where current-day mobile devices and their applications already either supply data into the system or resolve a particular mobility issue.
- They also noted that the architecture views can allow us to better discern the role for connected vehicle applications.
- Participants questioned how the security and privacy model for current-day devices impact or overlap with the security and privacy model for connected vehicle.

Recommended Actions

- After discussions with the ITS program manager, the CVRIA architecture team will add an interface between the Personal Information Device and the Transit Vehicle OBE to make this more of a connected vehicle / personal mobility application.
- The CVRIA architecture team will also add traffic management centers and information service providers to these views.

Dynamic Eco-Lanes Management

This environmental application from the Applications for the Environment: Real-Time Information Synthesis (AERIS) program employs communication technology to gather traffic and environmental information from multiple sources, including ITS Roadway Equipment, Connected Vehicle Roadway Equipment, and other systems. The system then processes this data and determines whether an eco-lane should be created or decommissioned along a roadway. The application manages the so-designated eco-lanes with the objective of reducing fuel consumption and overall emissions along the roadway segment.

Key Questions / Discussion Points

- In general, participants discussed:

    - Some of the applications similar to this one might be more viable in the longer term, once more connected vehicle technologies are deployed. It was noted that this was a "disruptive" technology.
    - It was also recognized that the necessary objectives may vary greatly depending on location. For instance, if a user is on an urban freeway versus in a national park, there are significant differences which will need to be incorporated in the decision making functionality of the application.
    - Participants discussed the benefit of being able to measure emissions when in a national park or other sensitive area. The CVRIA team noted that there were other environmental applications that focused on this outcome.
    - Participants noted that in this application, the distinction between conventional ITS and connected vehicle ITS was not as important, as they viewed it necessary that the architecture diagrams "capture the whole context." As a result, they recommended that the physical view be split into two diagrams to make it easier to read.
    - They noted that express lanes and tolling are not mentioned and should be added. However, eco-lane management is hard to enforce with tolling facilities, if you are a carpool.
- With regard to the enterprise view and policy issues:
    - Participants noted that implementing agencies will need to quantify the benefit of this application for their region in terms of trips reduced, mode shifts, or ability to change the times of people's commutes.
    - They also noted that the "emissions-based road-fee" function and "emissions-based pricing" are not considered in this particular application, but may be in other environmental applications.

Recommended Actions for the CVRIA Team

- Revise the traffic violations that are reported to the Enforcement Agency to be more specific about lane violations. Participants were concerned that more general traffic violations may be beyond the scope of the Connected Vehicle Program.
- Add an interface to the Information Service Provider to provide traveler information about Dynamic Eco-Lanes. Participants felt that was an important aspect of the application since demand management and behavior modification are potential beneficial outcomes of the Dynamic Eco-Lanes concept.

Freight Drayage Optimization

This mobility application covers the information exchanges between intermodal parties to provide short-haul, or drayage, truck load matching and container availability, and appointment scheduling at railroad and steamship line terminals. The application bundle includes a link from drivers and freight management systems dispatchers to an intermodal terminal reservation system and integrates an appointment function with Terminal Queue Status and Load Matching.

Key Questions / Discussion Points

- Participants discussed the following issues with regard to the application:
    - Due to the competitive nature of the freight industry, security will need to be incorporated into this and not added as an afterthought. We can use the same connected vehicle trust concept to enable a truck to interact with the terminal or the dispatcher.
    - There may be some parallels with dynamic ridesharing – matching available drivers with loads that need to be picked up.
    - This connected vehicle application will support independent owner-operators by defining standard open interfaces rather than closed proprietary systems that only large operators can afford.
    - Participants questioned whether the name of the application could be changed from "optimization" to "on-board," noting that the optimization benefit is really directed to the individual, and may not be for the freight system as a whole. There was concern about implying that this application will end up being a paradigm shift to this industry.
- With regard to the enterprise view:
    - Participants questioned whether "certification" was discussed in terms of whether all applications would be certified by one entity. It should be made clear that there could be more than one certification entity.
    - They also question whether or not there is an assessment or auditing process to ensure that data providers are giving quality information; that may become an opportunity for someone to provide that service to the industry.
    - If the data quality changes and it is no longer compliant with certification requirements, there may need to be rules in place to determine what happens to that provider and their ability to continue providing service.
- With regard to standards, participants desire a link to the National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) standards and a discussion of how they will be applied or used in the CVRIA.

Recommended Actions for the CVRIA Team

- The CVRIA architecture team will ensure that the security support applications will address the information, personnel, and operational security that would be needed for an application like this.
- The CVRIA policy team will look at the certification areas to make sure it is clear how that would work for an application like this that will primarily be used by private sector groups, but in the overall connected vehicle context.

Application Data Needs/Size of Data

An additional PowerPoint presentation was added on the second day when the entire set of participants gathered for the standards and policy presentations. With this additional presentation, Walt Fehr showed some of his analysis around the system of the "situation data" that would be needed by applications as a

basis for decision making. He noted that all who participate in the connected vehicle environment will need to start thinking about the data as a "notion of flow" as opposed to "point to point" transmission only.

Walt provided a few examples of this concept of flow, noting that it builds from the concept of "collect once, reuse for many purposes." However, even though data reuse helps with minimization, the data load is likely to be large. Walt provided a way to estimate the data load and he concluded that about 10 petabytes / second would be arriving at data processing centers. His question was whether that is bigger or smaller than current data loads of such enterprises as Netflix or Amazon. Walt's presentation is included in the overall set of presentations.

Standards Plan Development

Following the discussion on architecture applications, the CVRIA team described a candidate process for identifying and prioritizing candidate interfaces for standardization (see Figure 1 below). To enable successful implementation and operations of a connected vehicle environment, implementers will require the identification of where standards will be needed as well as architecture guidelines. Prioritization of where the USDOT applies its limited resources for standards development will be necessary.

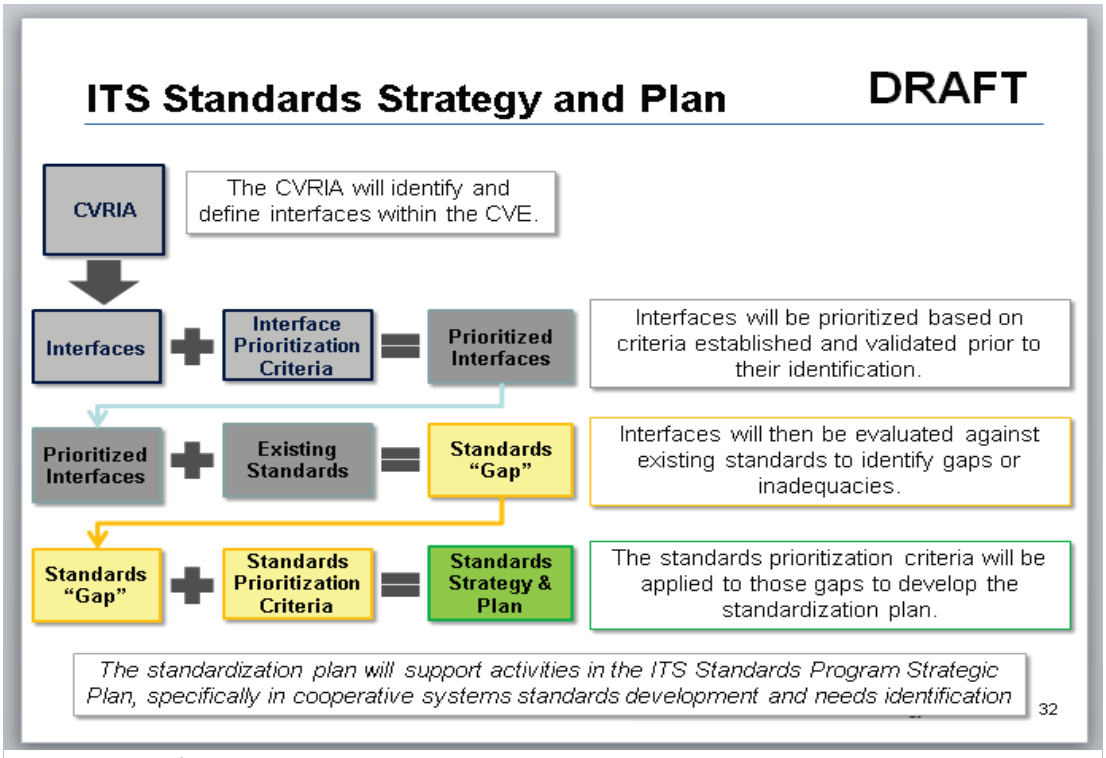

Figure 1. Interface Standardization Process

Participant Comments

Participants had questions on the analytical process of prioritization that the CVRIA standards team will clarify. Participants also commented on the need to pay attention to intellectual property rights as well as the need to ensure that private, proprietary interfaces do not become de facto standards.

- How can we implement a system with the lowest total lifecycle cost?
- What is the opportunity cost of not having a standard?
- What should our prioritization mean for a standards body? Should there be money for them to develop?
- Is there a threat to intellectual property rights?

An important question that arose and must be discussed as part of the identification process is whether a single standard may be required for interoperability in some places. The CVRIA standards team members noted that we all have to carefully identify, for each interface, the public interest in having interoperability established at the interface. Question were asked: Absent DOT participation, is there a significant risk that multiple standards may emerge? Or does no DOT participation open the door to a potential proprietary solution? And, if so, what are the public benefit implications? Once this determination has been made, the issue of whether one or more standards can be employed at an interface can be discussed.

Policy Analysis

The CVRIA team described the need for connected vehicle policy analysis that will be performed to identify where policy issues reside and identify the types of reasonable and feasible policy mitigations, if the government needs to be involved at all. The policy analysis will allow for the determination of issues such as governance and whether there are conflicting or competing interests; identification of risky or vulnerable points that require some level of access control, standards, certification, or enforcement policies; identification of points where existing laws, rules, or processes that will need significant change; parameters for making decisions; and the timeframes for those decisions, especially in relation to other connected vehicle decisions.

Participants discussed the policy issues that they deem most critical. In addition to the policy questions (see Figure 2) that form the basis for policy analysis, participants added the following: social equity, business models and/or limitations on public-private partnerships, data ownership and licensing models, data retention standards, system resiliency requirements, hierarchies of control, disaster response, liability, and certification.

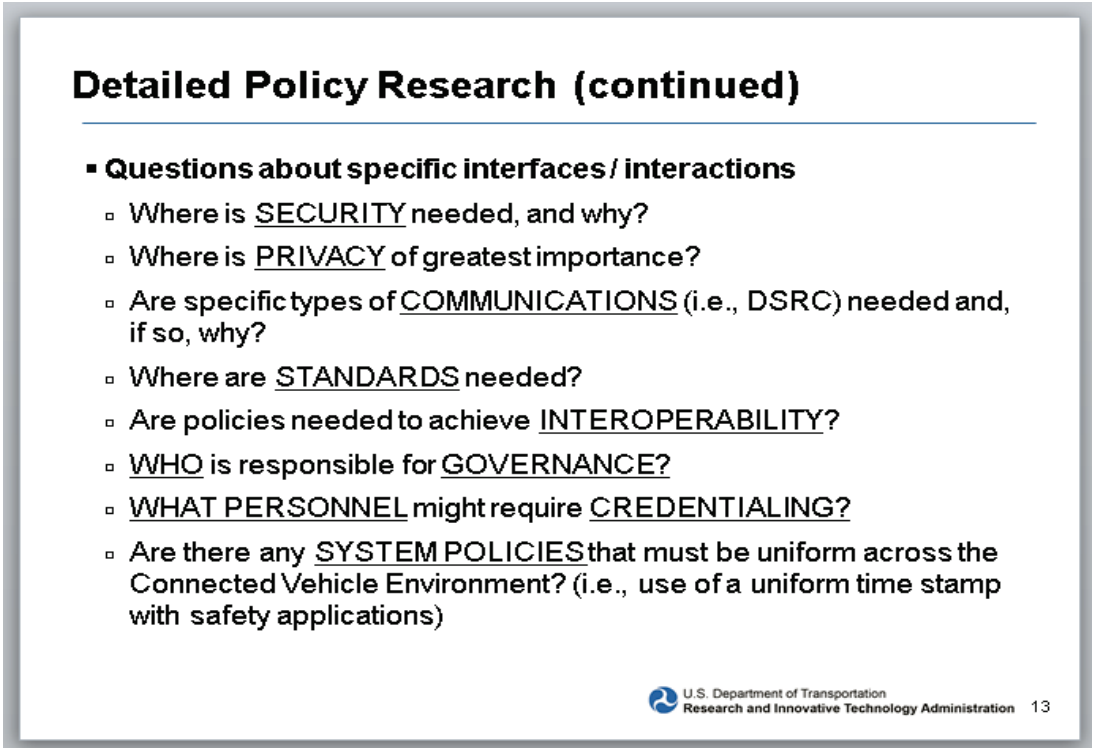

Figure 2: Guiding Policy Questions for Analysis

Participant Comments

Participant comments were wide-ranging on a number of policy and institutional issues:

- **Private Sector interests.** Questions from participants included:
  - What is the business model?
  - Is a private sector business model already in play?
  - The private sector will want to invest where they can make money, while managing risk. Possible areas of private sector interest mentioned during the meeting include:
    - Recovering the value that a private entity might add to data (what is the mechanism?), while managing the liability risk if the data should be bad.
    - Improving efficiency with freight drayage optimization, while managing the privacy and liability risks of sharing containers
    - Working with non-transportation infrastructure owners (e.g., street light, power, communications) to provide benefit both to them and to connected vehicle objectives
    - Will insurers support connected vehicle infrastructure on the grounds of improved safety? There is some precedent with seat belts and antilock brakes.

- **Data Ownership.** Questions and comments included:

- Will the USDOT Connected Vehicle Program work to identify data consumers and what they want? Participants discussed that most applications will likely need to be processed, rather than use raw data.
- Who owns the data? Previous rulings have indicated that the vehicle "owns" the data. How will the USDOT codify this into policy? Will it codify this position into policy?
- Who will monetize the data? Will it change for different applications?

- **Privacy.** Privacy will need to be considered throughout the project. It was noted that:
  - Privacy constraints are different on the government than on private industry. We give our data to industry every day.
  - For freight and transit, privacy issues are different (i.e., you want to track the vehicles in transit, and the trucking company wants to be able to track vehicles in freight).

- **Social equity**. Questions included:
  - Is it appropriate to exclude someone from a piece of public infrastructure?
  - Varying size communities may have different needs and capabilities; for example, a small town may have neither the resources or need for signal priority. However, at some point, connected vehicle ITS capabilities will become part of the basic infrastructure that people expect to use, no matter where they are.

- **Resiliency.** Participants noted that resiliency was a bigger issue than security.
  - What happens if a disaster strikes?
  - Are there plans for recovery and business continuity?
  - Is there a mechanism for the appropriate transfer of control of the system in an emergency?

- **Certification.** Questions included:
  - What is certified: the equipment, application, and/or the installation?
  - Will there be differing levels depending on the application? For example, safety critical applications may require a higher level of certification. One participant noted that the components of today's vehicle (e.g., radio, airbag, catalytic converter) receive varying treatment from regulators. We don't know yet where connected vehicle on-board equipment will fit in.
  - How does the use of performance versus design standards fit in? In general, performance standards (e.g., a 8-year warranty is required) are preferred to design standards (e.g., it must be made out of certain types of materials).

- **Scope.** CVRIA may need to include non-motorized (pedestrian, bicycle).

Conclusions

The workshop concluded with the CVRIA team committing to post the slides used during the event, along with documentation of the proceedings, to the CVRIA Website (http://www.iteris.com/cvria/index.html) — to ensure that additional stakeholders become involved and to keep the workshop participants informed of when new applications views are posted. The participants noted that they appreciated the opportunity for dialogue and that the level of interaction resulted in a successful meeting. Attendees were thanked for their time and participation in the meeting and asked for continued involvement in the effort.