Connected Vehicle Reference Implementation Architecture (CVRIA) Workshop

June 11 and 12, 2015

Draper Labs
Workshop Objectives

- Update on CVRIA status
- Summarize Standards Development Activities
- Review Standards Analyses
- Break-Out Sessions: Technical Exchange
Overview – CVRIA Architecture

CVRIA provides a unifying framework and common language for the development and deployment of a wide variety of connected vehicle applications.

- Supports flexibility and innovation
- Allows project planning to be consistent with national ITS architecture
- Enables CV deployments to be applied across jurisdictional boundaries
- Critical structure to help all stakeholders manage the inherent complexity of CV development, deployment and operations
- Helps identify institutional considerations

CVRIA leverages the National ITS architecture

Deployers can use CVRIA to experiment

- Develop deployments that meet unique regional needs
- USDOT has defined and tested a series of model implementations
Overview - Standards

- CVRIA helps identify high-priority interfaces for standardization
- Some CV standards will be mandated by NHTSA
- Most will be voluntarily developed through collaboration
  - Wide variety of stakeholders
- Communications standards have matured
  - 5.9 GHz DSRC
  - J2735 message set – addresses Basic Safety Message
- USDOT and others have analyzed existing standards
  - Identified gaps
Breakout Sessions: We Need Your Ideas

- Initial design, development and testing are nearing completion
- Now, we are starting conversations with the people who are going to be doing the work of commercializing and deploying CV.
- Today’s breakout sessions:
  - Architecture and Implementation
  - Standards and Priorities
  - Tools and Products
National ITS Architecture Team

CVRIA Update

June 11, 2015
Agenda

- Standards in CVRIA
  - Communications Viewpoint
  - Mapping to the OSI Model
  - Differences with NTCIP
- CVRIA version 2
- Next steps: versions 2.1, 2.2, 8.0 (!)
- Questions
CVRIA Viewpoints

A System has an Architecture

Stakeholders have interests in the system

Stakeholders ... have concerns

Architecture viewpoints ... frame concerns

Architecture views ... address concerns

The sum of architecture views make up the architecture
CVRIA Viewpoints cont’d

Enterprise, Physical, Functional and Communications Viewpoints

Enterprise View
- Application Diagrams
- Enterprise Database
- E-Context Diagrams

Physical View
- Application Diagrams
- Physical Database
- P-Context Diagrams

Functional View
- Lists of processes (Data Flows)
- Needs
- Requirements
- Functional Database
- Requirements Database

Communications View
- Protocol Diagrams
- Communications Database
Correspondence rules define how artifacts in one viewpoint are related to artifacts in another.
Coordination Relationship suggests Communications Protocol Standards

Enterprise Object has...with other Provision Agreement

Physical Object includes Application Object

Information Flow suggests Data Flow

Data Flow further specifies PSpec

Communications Protocol Standards suggests Communications Characteristics

Characterizes

Enterprise Object constrains scope of Physical Object

Enterprise Object has...with other Provision Agreement

Coordination Relationship suggests

Application Object defines functionality

exchange data using

Information Flow suggests

Constrains

Communications Characteristics constrains Information Flow

Communications Protocol Standards suggests Coordination Relationship
Communications Viewpoint Concerns

- Do communications protocols exist to support meeting the safety, mobility and environmental missions?
- What data flows across CVRIA interfaces?
- Are there any restrictions to the kinds of data that can flow over CVRIA interfaces?
- What are the physical interfaces in each device required to make applications function?
- What physical interfaces are shared between functions?
- Do appropriate communications protocols exist at all layers?
- Are these protocols standards?
- What provisions for ensuring the privacy of communications are included in the communications protocols?
- What provisions for ensuring the anonymity of originators are included in the communications protocols?
- How do the communications protocols protect the integrity of messages?
Communications Model

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## Communications Diagrams

Protocol stacks identify the standards at various layers

<table>
<thead>
<tr>
<th>Layer</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Information Layer</td>
<td>Data Structure, meaning and control (SAE J2735)</td>
</tr>
<tr>
<td>Facility Layer</td>
<td>Rules and procedures for application data exchange (ETSI TR 102 863)</td>
</tr>
<tr>
<td>Encoding Layer</td>
<td>Rules for representing bits and bytes for interoperability (ISO ASN.1 DER (ITU X.680-3, X.690))</td>
</tr>
<tr>
<td>Session Layer</td>
<td>Rules for dialogue management (RFC 1057 (RPC))</td>
</tr>
<tr>
<td>Transport Layer</td>
<td>Rules for exchanging data between endpoints (IEEE 1609.3)</td>
</tr>
<tr>
<td>Link Layer</td>
<td>Rules for data exchange between adjacent devices (IEEE 802.2)</td>
</tr>
<tr>
<td>Physical Layer</td>
<td>Signaling (IEEE 802.11p)</td>
</tr>
</tbody>
</table>
Model Comparisons

CVRIA Model
- Process Information Layer
- Facility Layer
- Encoding Layer
- Session Layer
- Transport Layer
- Link Layer
- Physical Layer

OSI Model
- Application Layer
- Presentation Layer
- Session Layer
- Transport Layer
- Data Link Layer
- Physical Layer

ITS-S Ref Architecture
- Applications
- Facilities Layer
- Networking and Transport
- Access Layer
- Physical Layer

NTCIP Framework
- Information Level
- Application Level
- Transport Level
- Subnetwork Level
- Plant
CVRIA Communications Model Diagrams

- Easiest access – through Physical!
  - Navigate to the physical diagram of your choosing
  - Click on the information flow you are interested in
  - Stack options appear
CVRIA Model Diagram Options

- Many links have multiple stacks
- Many stacks have standards choices at some layers
- As the architecture is further developed, the number of choices will expand and selection criteria added
CVRIA Communications Database

- Graphics are nice...but the architecture is mostly database-driven
- Some statistics:
  - 490 Information Flows
  - 1725 Information Flow Triples (Object-Flow-Object), each with unique characteristics
    - Data time relevance
    - Data spatial relevance
    - Message acknowledgement required?
    - Data/message encryption required?
    - Message authentication required?
    - Cardinality
    - Initiator
Boil it down a bit. There are seven types of links in the CVRIA

- Fixed Point C2C and C2I
- Wireless C2V, C2P
- Short Range Wireless V2I, V2V, V2P, P2I
- Fixed Point or Wireless (typically C2P)
- Human Interfaces
- On-board Interfaces
- Contact/proximity interfaces

With various requirements and constraints, we end up with 17 communications ‘profiles’, each of which has a few choices in the stack

Most choices go like this:

- Pick Physical-> pick Link & Transport
- Pick Encoding
- Pick Process Information Layer
CVRIA Version 2.0

- New Applications and Changes to Existing Applications
  - New Physical objects
  - New Flows
  - New Requirements
  - New Communications Profiles
  - Increased correspondence between Functional and Physical
  - Revisions to document sources, definitions, standards
  - Increased focus on ‘Support’ applications
- Additional supporting information
- SET-IT Release V2.0 in parallel
- Expected late June / early July 2015
CVRIA 2.x Communications Enhancements

- **New Questions – Interfaces:**
  - Are there any restrictions to the kinds of data that can flow over CVRIA interfaces?
  - What are the physical interfaces in each device required to make applications function?
  - What physical interfaces are shared between functions?
  - What dialogs are part of a given information flow?
  - What messages are part of the dialog, and what is the format and contents of those messages?
  - What is the state of an interface or dialog, given the state of message exchange?

- **New Questions – Information Security:**
  - What provisions for ensuring the anonymity of originators are included in the communications protocols?
  - How do the communications protocols provide non-repudiation of messages?
  - How do the communications protocols protect the integrity of messages?
New Questions – Performance:

- What are the Quality of Service requirements for a given message delivery?
- What are the (message, object) Positioning accuracy requirements?
- What are the (message, object) Timing accuracy requirements?
- What is the maximum latency of a message transmission?
- What is the maximum time delay from measurement to reception (incorporates latency, but also internal delays)?
- What is the minimum required communications distance of the message?
- What is the maximum expected communications distance of the message?
- If the message is to be multicast or broadcast, what is the geo-dissemination area for the message?
- What is the minimum throughput required to support the flow?
- What is the size of the APDU?
Two separate architectures—related, but different, with different specifications that address some different concerns.

One unified architecture, with one set of tools, that address the superset of concerns.
Questions?

- CVRIA can be explored at [www.iteris.com/cvria](http://www.iteris.com/cvria)

Contact Information

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- SET-IT Team: setit@iteris.com
- Tom Lusco: ctl@iteris.com
- David Binkley: dnb@iteris.com
Purpose

- Provide development status of the ITS standards related to connected vehicles
ITS Standards Related to Connected Vehicles

- Characterized as:
  - Vehicle to Vehicle/Infrastructure/Device (V2V, V2I, V2x) standards:
  - Infrastructure related standards
  - Protocol standards
Standards related to connected vehicle

- SAE J2945/0, /1, /2 and others to be identified, related to specific applications
- SAE J2735 only a data dictionary
- ISO 19091 V2I applications for intersections
- IEEE 1609.2 Security Services
- IEEE 1609.3 WAVE Network Services
- IEEE 1609.4 WAVE Multi-channel Operations
- IEEE 1609.12 Identifier allocations
- IEEE 802.11 DSRC Radio

Other commercial mediums can be used 3G, 4G, LTE, etc.
Infrastructure Standards Related to Connected Vehicles

- NTCIP 1202 v3 for signalized intersection control
- NTCIP 1209 v2 for transportation sensor systems
- NTCIP 1103 v3 required for exception handling for CV
- NTCIP 1204 v4 for environmental and road way conditions
- NTCIP 1211 v2 for prioritization control at intersections
- NTCIP 1213 v3 for smart roadway lighting and electric charging
- TMDD v3.03c to traffic conditions
- NTCIP 2306 v1.69 protocol standard for TMDD

Predominantly interfaces between the RSE and roadside equipment
## Summary Status

<table>
<thead>
<tr>
<th>Standard</th>
<th>Status (as of 6/5/2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAE J2945/0</td>
<td>- First full draft now in review, and</td>
</tr>
<tr>
<td></td>
<td>- Ballot draft expected Sept. 2015</td>
</tr>
<tr>
<td>SAE J2945/1</td>
<td>- Version 2 now in review,</td>
</tr>
<tr>
<td></td>
<td>- Additional capabilities to be added in version 3, and</td>
</tr>
<tr>
<td></td>
<td>- Ballot draft (version 4) expected Sept. 2015</td>
</tr>
<tr>
<td>SAE J2945/2</td>
<td>- Rough draft in review,</td>
</tr>
<tr>
<td></td>
<td>- Ballot draft October 2015</td>
</tr>
<tr>
<td>SAE J2735-2015xx</td>
<td>- UPER draft in review,</td>
</tr>
<tr>
<td></td>
<td>- V2V Safety,</td>
</tr>
<tr>
<td></td>
<td>- V2I support,</td>
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<tr>
<td></td>
<td>- Ballot draft September 2015</td>
</tr>
</tbody>
</table>
# Summary Status

<table>
<thead>
<tr>
<th>Standard</th>
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</thead>
</table>
| IEEE 802.11| ▪ Completed  
▪ Additional capabilities being considered                                          |
| IEEE 1609.2| ▪ Published in 2013,  
▪ Being revised (Various minor corrections, use of ASN.1, Peer-to-Peer CRL, Mis-binding/Proof of Possession, Sync identifier changes, Certificate attachment rate, WSA Security)  
▪ Ballot draft expected September 2015                                                  |
| IEEE 1609.3| ▪ Published in 2010  
▪ Being revised (Congestion Control, WSA Enhancements, WSMP Modifications, WSA broadcast on SCH, Privacy Considerations)  
▪ Ballot draft expected October 2015                                                    |
| IEEE 1609.4| ▪ Published in 2010  
▪ Being revised (UPER draft in review, V2V Safety, V2I support)  
▪ Ballot draft expected September 2015                                                  |
## Summary Status

<table>
<thead>
<tr>
<th>Standard</th>
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</table>
| **IEEE 1609.12** | - Published in 2010  
- PSID allocations may cause modifications |
| **ISO 19091**    | - Working Group final review underway,  
- References J2735-2015xx, and  
- Ballot draft expected October 2015          |
## Summary Status

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<thead>
<tr>
<th>Standard</th>
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</table>
| **NTCIP 1202 v3** | ▪ ConOps & Requirements done, and  
▪ Ballot draft after March 2016                                                          |
| **NTCIP 1204 v4** | ▪ Started design stage for additional capabilities,  
▪ Design Walkthrough July 2015, and  
▪ Ballot draft expected fall 2015                                                        |
| **NTCIP 1209 v2** | ▪ Completed                                                                               |
| **NTCIP 1103 v3** | ▪ First draft reviewed, and  
▪ Ballot draft expected Jan 2015                                                          |
# Summary Status

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| NTCIP 1211 v2  | ▪ Completed  
▪ May require modifications to meet CV needs                                       |
| NTCIP 1213 v3  | ▪ Completed  
▪ Completed ConOps and Requirements,  
▪ In design stage now, and  
▪ Ballot draft expected in late 2015                                                   |
| NTCIP 2306 v1.69 | ▪ Completed                             |
| TMDD v3.03c    | ▪ Completed                             |
Questions?

Contact Information:
Steve Sill – ITS JPO ITS Standards Program Manager steve.sill@dot.gov
Blake Christie – Noblis, Inc. blake.christie@noblis.org
Connected Vehicle & Cooperative ITS Standards Gap Analysis: A Summary of Recent Research Initiatives

June 11, 2015
Topics for Discussion

- Overview and update on standards gap analyses
- Overview of Recent Research Initiatives on standards for connected vehicle environments
- Key findings Similarities & Distinctions
- Relevance
Overview and Update

- Most gaps are at OSI layer 7 (Application layer)
  - Some issues/questions at layers 4 and 5
- Rulemaking is prioritizing standards development needs
  - Goal: complete, correct, and stable standards for V2V
  - All other development work being deferred to meet NHTSA requirements
- USDOT expects to provide guidance to SAE regarding the next J2945.x later this summer
  - Evaluation of next standards to fund is nearing completion
- Expect to address all critical items in the next 2-3 years
There is Global Interest in Cooperative Systems & Standards Harmonization

- In 2009 DOT and EC signed agreement to promote cooperative systems and standards harmonization
- Identifying where standards are most needed is a critical element in standards harmonization
- US, EU, Netherlands and Australia have supported standards research
- Research has recommended an approach that can possibly lead to the development of a core set of application standards
Overview of Research Initiatives

- Seven (7) recent research initiatives to examine CV standards have been supported by U.S., EU, Netherlands and Australia with a focus on:
  - Cooperative ITS
  - Connected Vehicle

- Studies examined existing standards and standards currently under development
  - Some studies proposed standards frameworks

- Research outcomes and recommendations need to be examined
Research Initiatives

- **Interface Standardization Analysis** (Booz, Allen Hamilton)
  - Identifies and prioritizes CVRIA interfaces for standardization
  - Identifies gaps between CVRIA interfaces (and their functional needs) and the existing standards that would be used to implement them

- **Cooperative Intelligent Transport Systems: Standards Assessment** (Austroads)
  - Identifies a U.S. standards scenario and an EU standards scenario
  - Discusses differences, commonalities, and how each set of standards might be applicable to Australia and New Zealand.

- **Data Capture and Management Program Standards–related Requirements Collected** (Consensus Systems Technology)
  - Presents standards-related functional and performance requirements for DMAs, AERIS and road weather apps
  - Identifies inconsistent and/or duplicative standards
Research Initiatives (continued)

- **Development of the Long-Term Connected Vehicle Standards Framework (SAE International)**
  - Identifies CV applications that are strongest candidates for near-term standardization
  - Provides a framework and process to guide the development of connected vehicle standards – specifically the SAE J2735.x data dictionary and SAE J2945.x standards

- **D3.6b Report on Standards Activities (ERTICO-ITS Europe)**
  - Describes the on-going global and European Intelligent Transportation Systems standardization efforts – including iMobility Forum Standards Working Groups and standards activities that occurred in 2014

- **Overview of Standards for First Deployment of C-ITS – Prioritization Framework for the Netherlands (Rijkswaterstaat WVL)**
  - Provides an overview of standardization needs for C-ITS Services (Cooperative Intelligent Transportation Systems Services) to be deployed in The Netherlands in the near and mid-long term, with a focus on the Cooperative ITS Corridor
Research Initiatives (continued)

  - Specifies a security architecture for Intelligent Transport System (ITS) communications and is based upon the security services defined in TS 102 731
  - Identifies and describes the functional entities required to support security in an ITS environment and the relationships that exist between the entities themselves and the elements of the ITS reference architecture defined in EN 302 665
Similar Findings / Common Themes

- Mapping “priority applications” to standards crucial in identifying gaps
- Application prioritization is the recommended approach to identifying a set of core applications for standardization
- “Mixing and matching” standards not a feasible methodology
- The issue of “backwards” compatibility will need to be addressed
Differences

- Communication systems disparities exist
- Significant differences in US and EU security approach and security system designs
- Functional and performance requirements are not consistently defined across applications
Conclusions

- Research outcomes suggest there is some general agreement on developing a set of core application standards.
- Findings suggest further discussion in several key areas (including communications & security) needs to occur for a level of cooperative systems and standards harmonization to be possible.
- Research outcomes may assist the DOT in identifying and agreeing upon a set of first round “candidate” applications for near-term standards development.
Intelligent Transportation Systems (ITS)
Joint Program Office (JPO)

Prioritization of Connected Vehicle Interface Standards

June 11, 2015
CVRIA and Standards

- The USDOT’s Intelligent Transportation Systems (ITS) Joint Program Office (JPO) has developed a standards plan to inform ITS standards-related efforts and investment decisions. The plan will support:
  - the USDOT ITS connected vehicle research program, and
  - broad deployment of connected vehicle (CV) technologies

- The plan is based on the information exchanges and interfaces identified in the CVRIA

- The plan will evolve with technologies, implementation strategies, and policies

- The plan will help USDOT assure that the most critical CV standards needs are met

---

**Adopt ✓**
- Lower effort, cost
- Quicker implementation
- Modify interface to meet the standard

**Adapt ?**
- Increased effort, cost
- Extended implementation
- Adapt standard to the extent possible, adapt interface as necessary

**Create !**
- Greatest effort, cost
- Longest implementation
- Get it “just the way you like it”
Standards at Different Layers of the OSI Stack

- New standards or portions may be needed when *off-the-shelf* standards unavailable

  Adopt ✓ Adapt ? Create ❌

- At the lower layers, the most common approach will be to select *off-the-shelf* implementations

  Adopt ✓ Adapt ?
Analysis Framework: CV Objects & Interfaces

- Only seven defined interfaces in our model
- Each “object” represents multiple CVRIA object types
- Limited set of communication stacks for any interface
- We identify standards for each interface
- The “User” interface is outside of the scope of this effort
The objects listed represent categories consisting of multiple CVRIA objects.

<table>
<thead>
<tr>
<th>Object</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
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<td>Center</td>
<td>Data Center, Emergency Management Center, Traffic Management Center</td>
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<td>Border Inspection System, Electric Charging Station, Intermodal Terminal</td>
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<tr>
<td>RSE</td>
<td>DSRC Transceiver (roadside, fixed)</td>
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<td>Commercial Vehicle, Transit Vehicle, Light Vehicle, Freight Equipment</td>
</tr>
<tr>
<td>Mobile User</td>
<td>Vehicle Operator, Pedestrian (with mobile equipment)</td>
</tr>
</tbody>
</table>
Analysis Framework: Interface Descriptions

- Interfaces can typically be implemented using different technologies, which run the gamut from mature (stable) to emerging.
- Each technology will have a suite of standards that specify most, if not all of the five lower layers of the OSI protocol stack.
- For the most part, the standards at the lower layers are stable and mature.

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</tbody>
</table>
Analysis Framework: Information Exchange

- **Definition:** An information flow across a defined interface
  - CVRIA defines information flows from a specific source to a specific destination
  - Exchanges group flows that occur over the same type of interface (e.g., center-to-center)
    - These should use the same standard
  - A given information flow may occur across multiple interfaces
    - These *may* need different standards (e.g., due to aggregation issues, etc)

<table>
<thead>
<tr>
<th>Flow</th>
<th>Priority</th>
<th>BH</th>
<th>LF</th>
<th>LCV</th>
<th>RCV</th>
<th>C2C</th>
<th>Local</th>
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<tbody>
<tr>
<td>situation data collection parameters</td>
<td>15.87</td>
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<td></td>
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<tr>
<td>traffic images</td>
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<td></td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>traffic monitoring application info</td>
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<td>X</td>
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<tr>
<td>vehicle location and motion for surveillance</td>
<td>15.87</td>
<td></td>
<td>X</td>
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</tbody>
</table>
A “triplet” in the CVRIA is a combination of an information flow, its source, and its destination.
Summary of Findings

- Interfaces scored, sensitivity analysis performed: Interface rankings accepted as reasonable (slide 10)

- Interfaces aligned to standards: Standards identified in terms of USDOT involvement in standardization (slides 11-13)

- CVRIA analysis compared to other-party and international analyses: More similarities than differences—validation of the analysis (slide 14)

- Interfaces cross-walked to standards: A number of outstanding technical issues identified for future investigation and resolution (slides 15-17)
Identified Priority Applications

- **5 Core Applications**
  - 13 security related gaps
  - 14 other gaps

- **11 Top Tier Applications**
  - 49 gaps

- **13 Low Hanging Fruit Applications**
  - 11 have no additional gaps
  - 2 have one additional gap each

- **Total: 78 gaps in 18 of the above 29 applications**

- **4 Marginal Applications**
  - 2 additional gaps for vehicle emergency response
  - 4 additional gaps for warnings about upcoming work zones
  - 6 additional gaps for traveler information – smart parking
  - 36 additional gaps for border management systems
Gap Analysis Reporting

- Exchange description is derived directly from CVRIA information flow description

- For each gap identified:
  - Highlighted text of gap in description
  - Rated the USDOT interest in the gap (critical, important, useful, free market)
  - Identified related activities and relationship
  - Provided explanatory comments

<table>
<thead>
<tr>
<th>Exchange</th>
<th>Description</th>
<th>USDOT Interest</th>
<th>Related Activities</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCV</td>
<td>Emergency vehicle tracking data A regional connected vehicle exchange that provides the current location and operating status of the emergency vehicle.</td>
<td>Critical</td>
<td>SAE J2735: Defines messages for emergency vehicles and is supplemented with SAE J2945 (under development)</td>
<td>SAE J2945 should define rules that require the Emergency Vehicle Alert message to include the optional field for the location of the vehicle.</td>
</tr>
</tbody>
</table>
USDOT Interest Ratings

- **Critical Exchange**
  - Central concept of connected vehicle program
  - Between Physical Objects owned by disparate sources
  - Example: LCV – Vehicle Location and Motion
    - Central concept for providing various safety applications
    - Exchange among vehicles owned by disparate sources
    - Connected Vehicles not realized without standard

- **Important Exchange**
  - Central concept of connected vehicle program
  - Between Physical Objects owned by coordinated sources
  - Example: BH – Traffic Situation Data
    - Being able to collect and process data in real-time is a central concept of the connected vehicle program
    - Central system and RSEs typically owned by same entity
    - Agency specification could work in theory, but a standard would encourage a competitive market
USDOT Interest Ratings (cont.)

- **Useful Exchange**
  - Ancillary to concept of connected vehicles
  - Standard preferred for competition and integration
  - Example: C2C – Equipment Maintenance Status
    - Real-time reporting of maintenance activities between centers is not a requirement to realize connected vehicles
    - Standardizing this reporting would improve information
    - Information is directly related to public sector operations

- **Commercial Interest Exchange**
  - Standard not needed for successful connected vehicle program, from USDOT perspective
  - Advantages primarily accrue to private sector
  - Example 1: RCV – Map Updates
    - NOTE: This is separate from local roadway geometry
    - Appears to be for navigation/automation uses, rather than core connected vehicle concepts
    - Market appears to be service-based
  - Example 2: All Local Vehicle exchanges
    - Manufacturer-specific interface
Harmonization with SAE, Australia, and ETSI

- SAE, Australia, and European Telecommunications Standards Institute (ETSI) conducted independent, but similar prioritization efforts
  - Significant agreement was found among the four reports
- The Standards Plan provides a proposed harmonization of these four independent studies, resulting in a list of:
  - 5 Consolidated Core Applications
  - 17 Consolidated Top Tier Applications
  - 10 Consolidated Low Hanging Fruit Applications
    - 8 require no additional nominal work
  - Total: Consensus on 32 Applications (~70% agreement)
  - 9 Consolidated Marginal Applications
  - 7 applications/uses cases that could not be mapped to CVRIA applications

<table>
<thead>
<tr>
<th>Consolidated Ranking</th>
<th>Application</th>
<th>This Paper</th>
<th>SAE</th>
<th>AU</th>
<th>ETSI 102 638</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Tier</td>
<td>Forward Collision Warning</td>
<td>Top Tier</td>
<td>V2V Safety Awareness</td>
<td>Collision Warning</td>
<td>Slow vehicle warning / car breakdown warning</td>
</tr>
<tr>
<td></td>
<td>Incident Scene Work Zone Alerts for Drivers and Workers</td>
<td>Top Tier</td>
<td></td>
<td>In-vehicle Signage</td>
<td>Limited access warning / In-vehicle signage</td>
</tr>
</tbody>
</table>
Outstanding Issues

These technical issues were identified by stakeholders and workshop participants as near-term priorities for standardization

- Backwards Compatibility
  - Some standards not designed for graceful upgrades or even current interoperability
  - Standards should be reviewed prior to balloting

- Vehicle Security
  - DSRC security protects the wireless interface, but not the ITS Station equipment
  - A corrupt ITS Station can send validated messages
  - “Misbehavior” is not well defined and likely would not cover some types of attacks
  - Need to continue the NHTSA work to define a fully robust connected vehicle system
Outstanding Issues (cont.)

- **Vehicle Station Gateway (VSG)**
  - The current on-board diagnostics (OBD) port specification is inadequate for CV needs
  - Standardizing this interface would better enable after-market devices and define data quality
  - US Efforts should coordinate with ISO efforts to standardize VSG

- **Human Machine Interface (HMI)**
  - Historically has been a proprietary feature
  - New HMI features have real-time safety implications
  - Development of guidelines may be appropriate

- **Warehousing Data**
  - The CV environment will result in the production of a massive amount of data
  - Demonstration projects might help build consensus around the best way to handle the volume of data
Outstanding Issues (cont.)

- **Smart Roadside Initiative**
  - Commercial vehicle operations are not addressed in standards (and only partially in SAE J3067)
  - Need research to focus on needs, especially to recommend messages for backhaul and center-to-center exchanges

- **Data Format for Adaptive Signal Control**
  - New technology offers potential for new algorithms, such as using trajectory data
  - Research may be warranted into new algorithms that might propose new messages

- **Emissions**
  - Environmental applications aim to reduce emissions; best source for data is vehicle
  - Research is needed to determine what emissions data should be included in messages and at what frequency
Current and Near-Term Activities

- Industry Review of Tentative First Round Applications

- Formalize position on whether the USDOT should encourage and/or assist in the standardization of the Vehicle Platform to OBE interface

- Determine interface standardization activities
Consolidated Results – Marginal Applications

- **Environmental**
  - Road Weather Advisories and Warnings for Motorists
  - Road Weather Info and Routing Support for Emergency Responders
  - Road Weather Info for Freight Carriers
  - Road Weather Info for Maintenance and Fleet Management

- **Mobility**
  - Border Management Systems
  - Queue Warning
  - Traveler Information Smart Parking

- **Safety**
  - Oversized Vehicle Warning
  - Vehicle Emergency Response
Other Suggestions

- Fleet management
- Insurance and financial services
- Level (rail) crossing warning
- Local electronic commerce
- Rest area booking
- Road-vehicle to Rail-vehicle Collision Warning
- Vehicle software provisioning and update
Connected Reference Implementation Architecture (CVRIA) Workshop:
Breakout Sessions

June 11, 2015
Break-Out Instructions

- **Two Discussions:**
  1. Architecture and Implementation Technical Exchange / Connected Vehicles Tools/Products
  2. Standards Priority Technical Exchange
1. Architecture and Implementation Technical Exchange

- ARCHITECTURE:
  - 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?

- IMPLEMENTATION:
  - 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?
1. Connected Vehicles Tools/Products

- What type of products best support your use of ITS?
- What type of products/tools do you think you need to support Connected Vehicle environment implementation, operations, and maintenance?
- Where do you think your greatest implementation challenges are likely to be?
- Are you aware of the FHWA Guidance and reference documents and tools under development?
2. Standards Priority Technical Exchange

- **STANDARDS PRIORITY**: 
  - What are your thoughts about the identification of gaps in the four categories presented?
  - Is the alignment of standards to exchanges correct and complete?
  - What are your top standards and were they represented?
  - 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?

- **STANDARDS DEVELOPMENT**: 
  - 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 as we contemplate the set of standards needed for a complete connected vehicle environment? If so, what are they and why?
Connected Reference Implementation Architecture (CVRIA) Workshop:
Breakout Session Responses

June 12, 2015
1. Notes - Architecture and Implementation Technical Exchange

- **ARCHITECTURE:**
  - How do you currently make use of your ITS Regional or Statewide Architecture?
    - Identify projects
    - Roadmap for systems deployment
    - Next Steps
  - What features do you wish it had?
    - With CVRIA, more of a top-down approach
    - 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
    - Import diagrams (and its data, including interfaces) from other projects as a starting point
    - 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 more (in training/help/outreach) but the Needs should include more high-level Need for the app itself. Some needs show needs for a CSW app but not why do I need CSW to begin with
    - Add link to Benefits for each app once they’re available.
  - What else should be considered?
    - Guidelines for Naming, Placement, usage of architecture – to drive consistency
    - Interim guidance on architecture coordination – Regional vs CV
    - Be able to ‘export’ the methodology of CVRIA development for other domains

- **IMPLEMENTATION:**
  - What are the major challenges you are running into?
    - How do we sync Regional ITS Architecture with CV Arch
    - Not sure what purpose of layers (0) are
    - Blending multiple applications (and support services) into 1 diagram
    - Back-haul comm isn’t sufficient today (much less tomorrow)
1. Notes - Connected Vehicles Tools/Products

- Where do you think your greatest implementation challenges are likely to be?
  - Misinformation or incomplete information about what this technology can do
  - Back-haul – today’s infrastructure is lacking sufficient backhaul to support CV data
    » Will require discussions with carrier, guaranteed bandwidth, funding,
  - Security – addressing vulnerabilities (DoS, safeguards), securing the entire end-to-end system
  - Certification – especially of things like Traffic Signal Controllers
  - Maintenance – defining performance requirements, applied to Certification
  - What happens when it doesn’t work – driver still responsible, liability
  - Consider planned obsolescence,

- Are you aware of the FHWA Guidance and reference documents and tools under development?
- Of the list,
  - Where’s a Sales Document – something to help engineers ‘sell’ or ‘justify’ this to agency management
  - Where’s the DSRC Channel Use Guide
    - Channel 172 – what can go on it? Just BSMs? Congestion control issues
    - Where is DSRC Channel 184 guidance (public safety)? What is allowed on that channel?
  - Expand Siting Guide - Service Channel Planning? For deployments – density, placement
  - Guidance on what is considered a “Successful Deployment”
  - Mitigation techniques for technology turnover (varying lifecycles)
  - Gap between V2V vs V2I research
  - Performance Requirements
  - Where are the big picture questions answered? Policy
  - Add NHTSA V2V Readiness Report (with ANPRM); CV101, CV102
  - Simulation, Cost Benefit Models – is it up-to-date and used consistently to see benefits / impacts of applications
2. Notes - Standards Priority Technical Exchange

- Security-related Standards
  - Certificates
    - Standardization
    - Testbed implementations
    - Roles and responsibilities (i.e., authorities)
  - Encryption scheme
    - Currently adequate, but for how long?
    - Appropriateness to CV environment
  - FISMA
    - Uncertain compliance requirements
    - Appropriateness of existing NIST guidance for CV
2. Notes - Standards Priority Technical Exchange

- **Standards vs Capabilities**
  - Bidirectional influence and relationship between policy and technical limitations (bandwidth, processing, storage)
  - Concern about ability to implement certain requirements [standards] with existing technology, particularly with OBE
  - Revocation lists (3GB revocation lists)

- **Scaling effects:**
  - Effect of congestion (transit; highway)
  - Impact of temporally and spatially dense usage (e.g., bus depot start-up)
  - Relates back to relationship between standards and capabilities
2. Notes - Standards Priority Technical Exchange

- Priorities
  - US/European comparison
    - Initially appeared to be disparate priorities
    - Upon further consideration, more in common than not
  - Importance of common language

- Safety/Mobility/Environment Priorities
  - Current strategy is safety-centric
  - Need to communicate net benefits to the public in realistic quantifiable manner ("what’s in it for me?")
  - Need to consider how “safety” applications may improve mobility, “mobility” apps may have environmental benefits, etc.
2. Notes - Standards Priority Technical Exchange

- Consider more exhaustive and conclusive congestion impact testing for peak usage scenarios:
  - Transit
  - Highways
  - Pedestrian crowds
  - Overlapping messages
- Standards Strategy & CVRIA
  - Ensure that analysis and standards strategy keeps pace with CVRIA (e.g., Left-Turn Assist is added to CVRIA v2.0)
- Consider technology maturity when developing standards, requirements, policy
- Determine what additional public communications may be needed (i.e., outreach, education, advocacy)