



Connected Vehicle Architecture Workshop

CVRIA Overview

June 16, 2016

Workshop Agenda

- Introduction 9:00 AM
- CVRIA Overview 9:20 AM
- CVRIA Website Tour 9:50 AM
- National ITS Architecture / CVRIA Integration 10:20 AM
- Break 10:35 AM
- Attendee Feedback on CVRIA 10:50 AM
- SET-IT Software Tour 11:20 AM
- SET-IT Use Example 11:50 AM
- Wrap-up 12:20 PM
- Adjourn 12:30 PM

Session Topics

- Training and Resources
- Connected Vehicle Background
- CVRIA Development
- CVRIA Purpose
- CVRIA Overview

CVRIA Training and Resources

- CVRIA website at www.iteris.com/cvria/
- On-line Training Courses
 - Introduction to CVRIA
 - Introduction to SET-IT

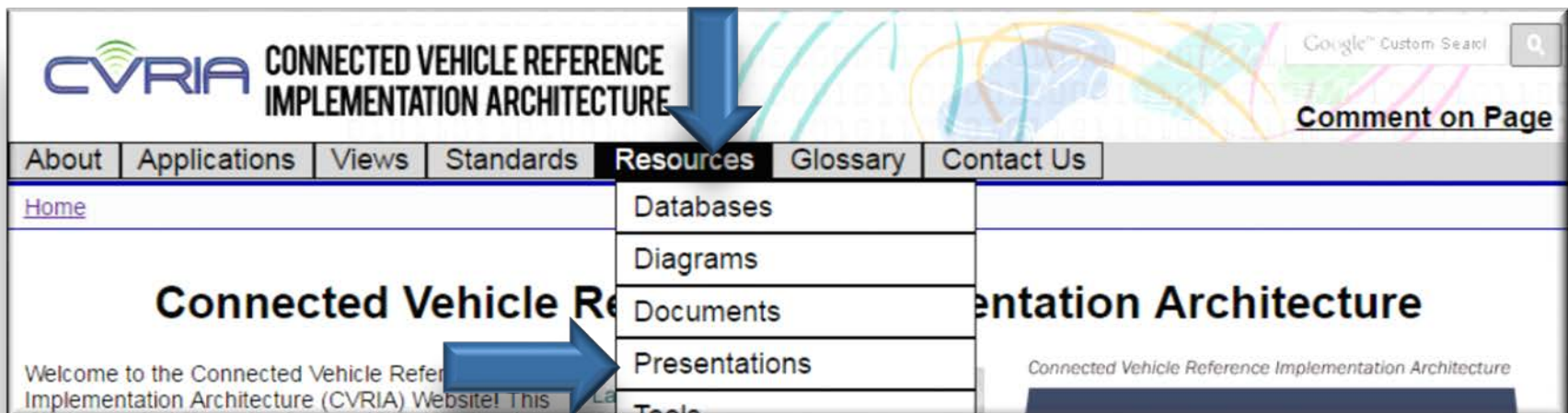
The image is a screenshot of the CVRIA website. At the top left is the CVRIA logo and the text 'CONNECTED VEHICLE REFERENCE IMPLEMENTATION ARCHITECTURE'. To the right is a Google Custom Search box and a 'Comment on Page' link. Below this is a navigation bar with tabs for 'About', 'Applications', 'Views', 'Standards', 'Resources', 'Glossary', and 'Contact Us'. The 'Resources' tab is selected, and a dropdown menu is open, listing 'Databases', 'Diagrams', 'Documents', 'Presentations', 'Tools', and 'Training'. A blue arrow points from the 'Resources' tab to the dropdown menu, and another blue arrow points from the 'Training' option to the main content area. The main content area features the title 'Connected Vehicle Reference Implementation Architecture' and a large graphic of a person at a computer with a flowchart.

CVRIA Training and Resources

■ CVRIA Webinar Series

□ <http://www.iteris.com/cvria/html/resources/presentations.html>

- | | | |
|--------------------------------------|---|--|
| 1. Red light Violation Warning | 7. Weather Responsive Traffic Management | 14. Pedestrian in Signalized Crosswalk Warning |
| 2. Curve Speed Warning | 8. Enhanced Maintenance Decision Support | 15. Integrated Multi-Modal Payment |
| 3. Speed Harmonization | 9. Smart Roadside Initiative | 16. Incident Scene Pre-Arrival Staging Guidance for Emergency Responders |
| 4. Intelligent Traffic Signal System | 10. Freight Advanced Traveler Information Systems | 17. Incident Scene Work Zone Alerts for Drivers and Workers |
| 5. Emergency Vehicle Priority | 11. Data Distribution | |
| 6. ECO Approach and Departure | 12. Communications Support | |
| | 13. Core Authorization | |



The screenshot shows the CVRIA website header with the logo and title "CONNECTED VEHICLE REFERENCE IMPLEMENTATION ARCHITECTURE". A navigation bar includes links for "About", "Applications", "Views", "Standards", "Resources", "Glossary", and "Contact Us". A dropdown menu is open under "Resources", listing "Databases", "Diagrams", "Documents", "Presentations", and "Tools". A blue arrow points to the "Resources" link in the navigation bar, and another blue arrow points to the "Presentations" option in the dropdown menu. The main content area features the title "Connected Vehicle Reference Implementation Architecture" and a welcome message.

Connected Vehicle Training/Resources

- ITS ePrimer, Chapter 13: Connected Vehicles
 - <http://www.pcb.its.dot.gov/eprimer/module13.aspx> - USDOT's Professional Capacity Building (PCB) program
- Connected Vehicle Basics (an overview of the connected vehicle program)
 - http://www.pcb.its.dot.gov/t3/s140424_cv_basics.asp - USDOT's Talking Transportation Technology (T3) series
- National Connected Vehicle Field Infrastructure Footprint Analysis
 - <http://stsmo.transportation.org/Pages/Connected-Vehicles.aspx>



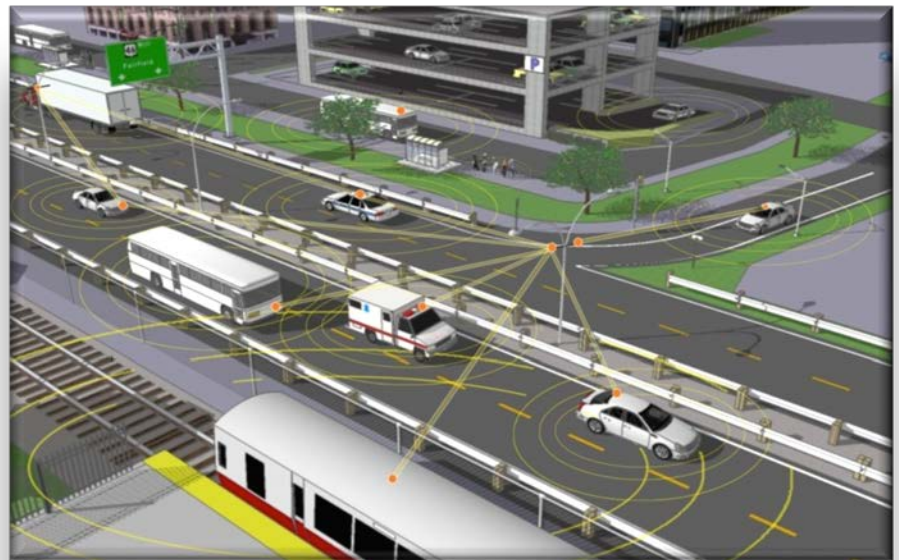
Connected Vehicle (CV) Concept is Not New

- User Service Bundle for concept of Advanced Vehicle Safety Systems (AVSS) in early 1990s United States National Program Plan for the Intelligent Transportation System (ITS)
- Early National ITS Architecture inclusion of Vehicle Collision and Crash Avoidance, Vehicle Safety and Automated Vehicle Operation
- Automated Highway System (AHS) Testing in San Diego, August 1997
- Ongoing USDOT Research Program evolving from AHS, Vehicle Infrastructure Integration (VII) & Connected Vehicle



Enabling Connected Vehicle Environment

- Communications Technology
 - Wide-Area Wireless Communication
 - Short Range Wireless Communication
 - Internet
- Institutional
 - Rise of the Smart Device
 - Expectation of Connectivity
 - Privacy
 - Security



Why Connect Vehicles Now?

- Improve vehicle safety
- Communications standardization
 - 5.9 GHz Dedicated Short Range Communications Family
 - SAE J2735 Message Set for Wireless Communication to/from the Vehicle
 - Basic Safety Message (BSM)
 - Various Vehicle Probe Data Communications
 - Others...
- Motivated coalition of stakeholders including automakers

USDOT Proposed Rule-Making

- “Light Vehicle” Vehicle-to-Vehicle (V2V) Communications Advance Notice of Proposed Rulemaking (ANPRM) issued
- Others expected



Connected Vehicle is inherently complex

Improve Transit Reliability

- Connection Protection
- Transit Signal Priority

Improve Pedestrian Safety

- Pedestrian in Signalized Crosswalk Warning
- Intersection Movement Assist

Improve Air Quality

- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing



We Need a Common Language

- CVRIA is in response to managing the complexity of Connected Vehicle
- CVRIA models the Connected Vehicle functions and communications on a number of levels



System Architecture

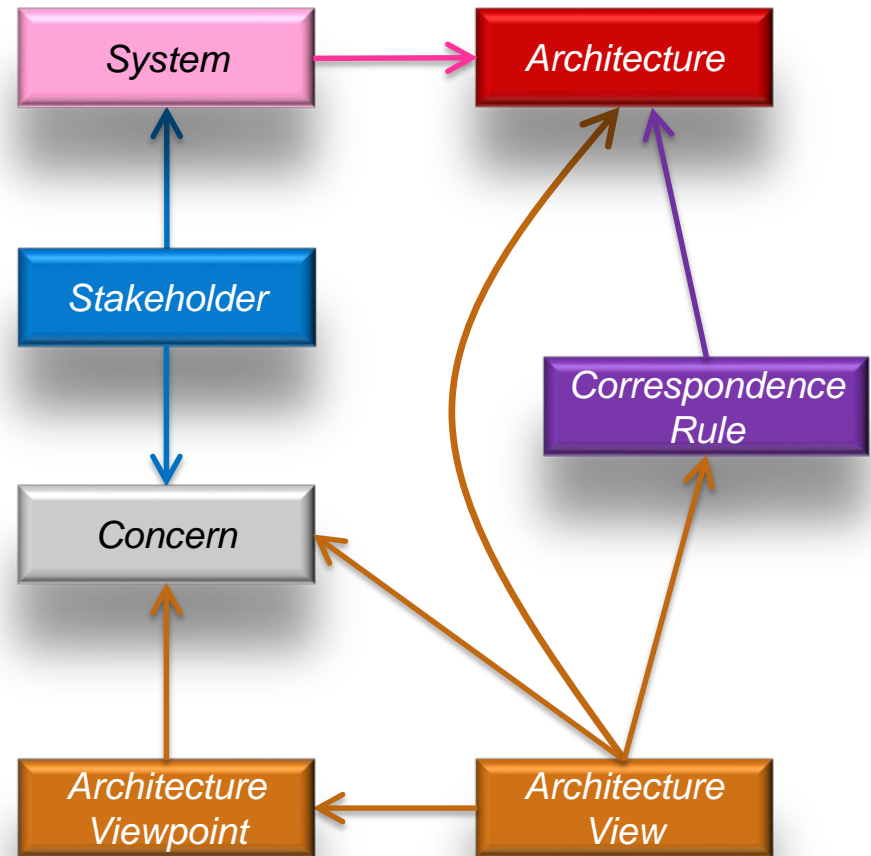
A System... has an Architecture

Stakeholders... have interests in the system

Stakeholders... have concerns

Architecture viewpoints... frame concerns

Architecture views... address concerns

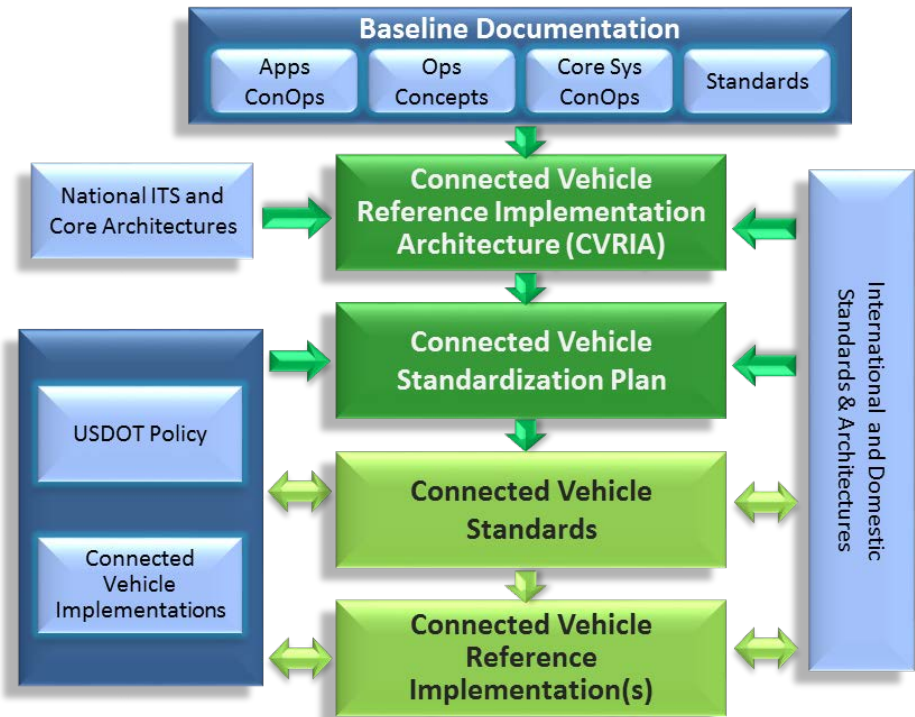


Correspondence rules define how artifacts in one viewpoint are related to artifacts in another.
The sum of architecture views make up the architecture

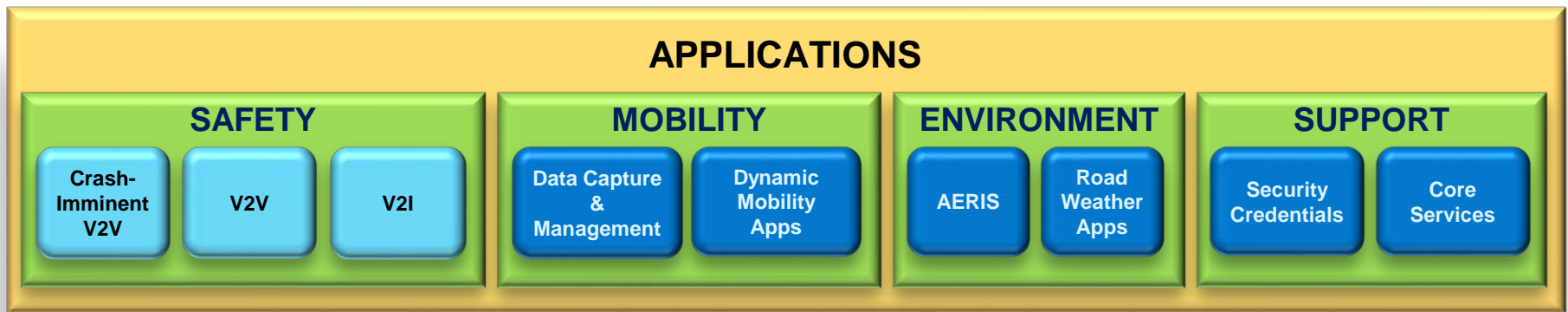


CVRIA

- Connected Vehicle Reference Implementation Architecture (CVRIA) development
 - Followed ISO/IEC/IEEE 42010-2011 Systems and Software Engineering – Architecture Description
 - Collected needs and requirements from connected vehicle research work (Applications) and other sources
 - Developed a multi-faceted architecture



Background of CVRIA



- Landscape: Safety, Mobility & Environmental Applications with common supporting infrastructure
- Looking ahead ... 10-20 years from now when 80% of vehicles are equipped in some way – maintaining a robust connected vehicle environment
- With so many applications exposing so many opportunities for integration an architecture is needed to put the components together



Purpose of CVRIA

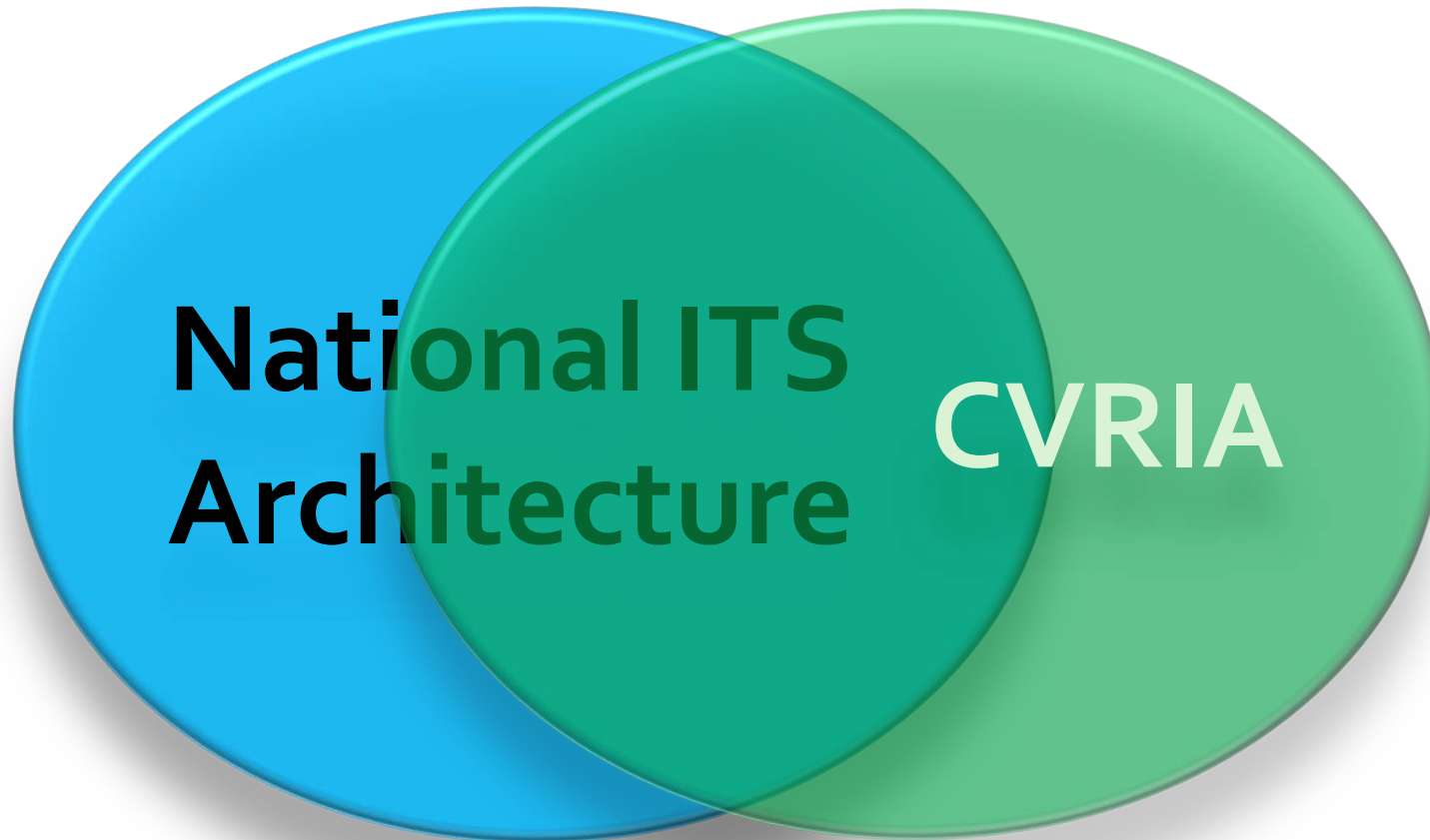
- To establish a framework for
 - integrating connected vehicle technologies and
 - identifying interfaces for standardization
- By...
 - Identifying connected vehicle needs/requirements
 - Developing a multi-faceted system architecture
 - Identifying and prioritizing candidate interfaces for standardization



CVRIA Uses

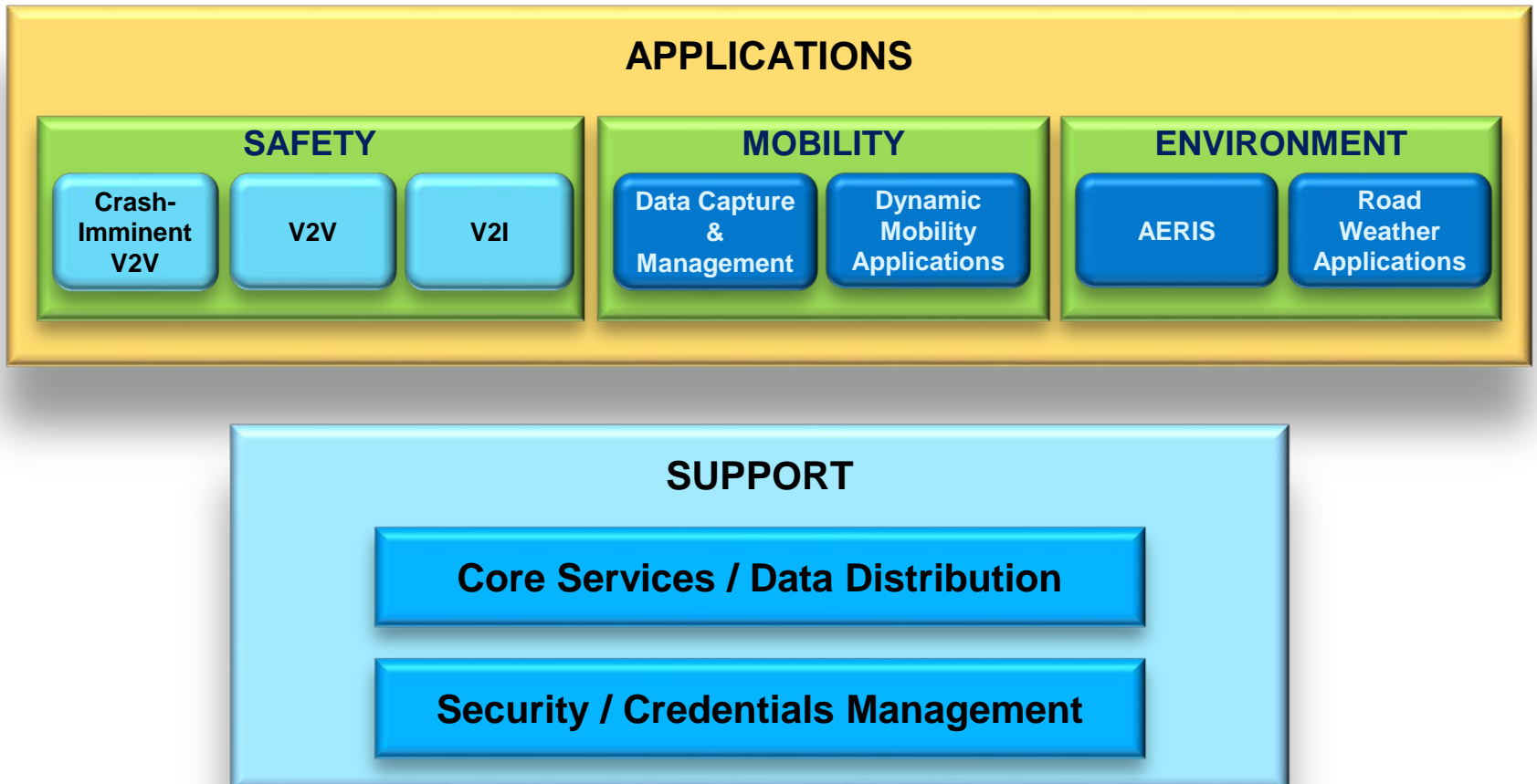
- In near term – Define interfaces/functions/standards to support early deployments, e.g. SE Michigan 2014, CV Pilot Deployments, etc.
- In longer term – CVRIA will be integrated with the National ITS Architecture to include connected vehicles in regional ITS architectures/plans and future transportation projects

CVRIA & National ITS Architecture



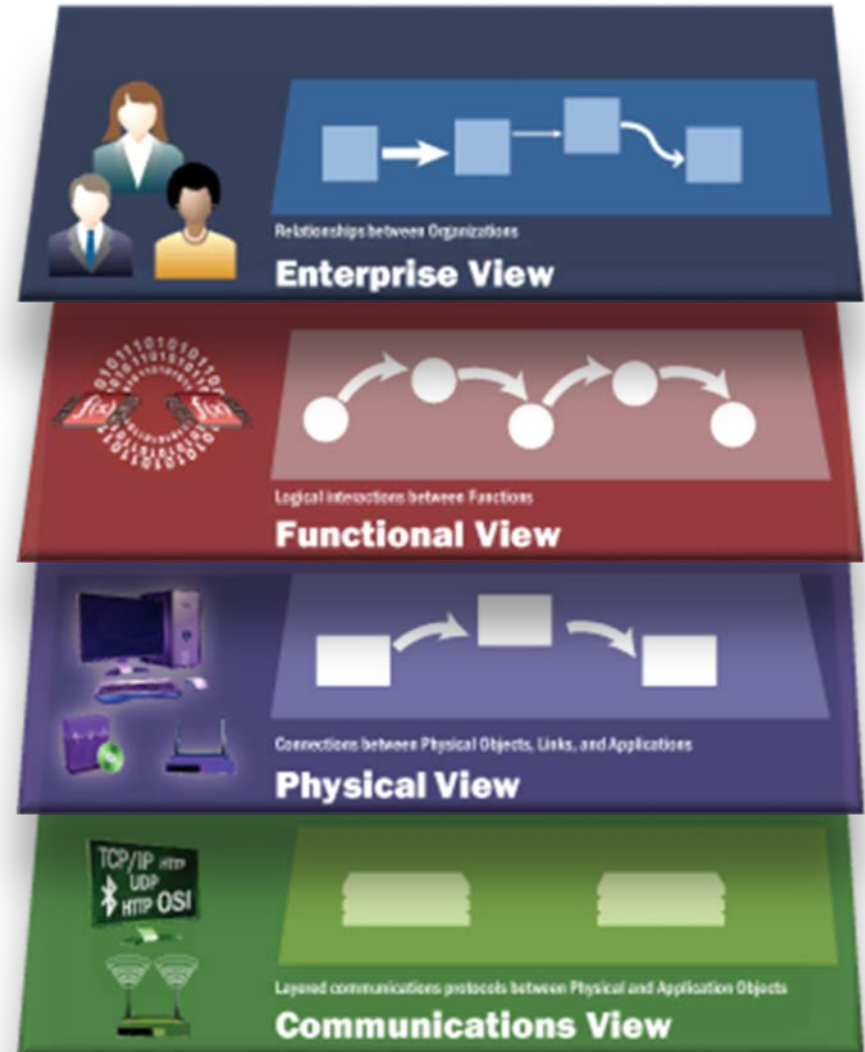
- CVRIA takes advantage of the National Architecture defined entities, interfaces, and definitions

CVRIA Covers Breadth of CV

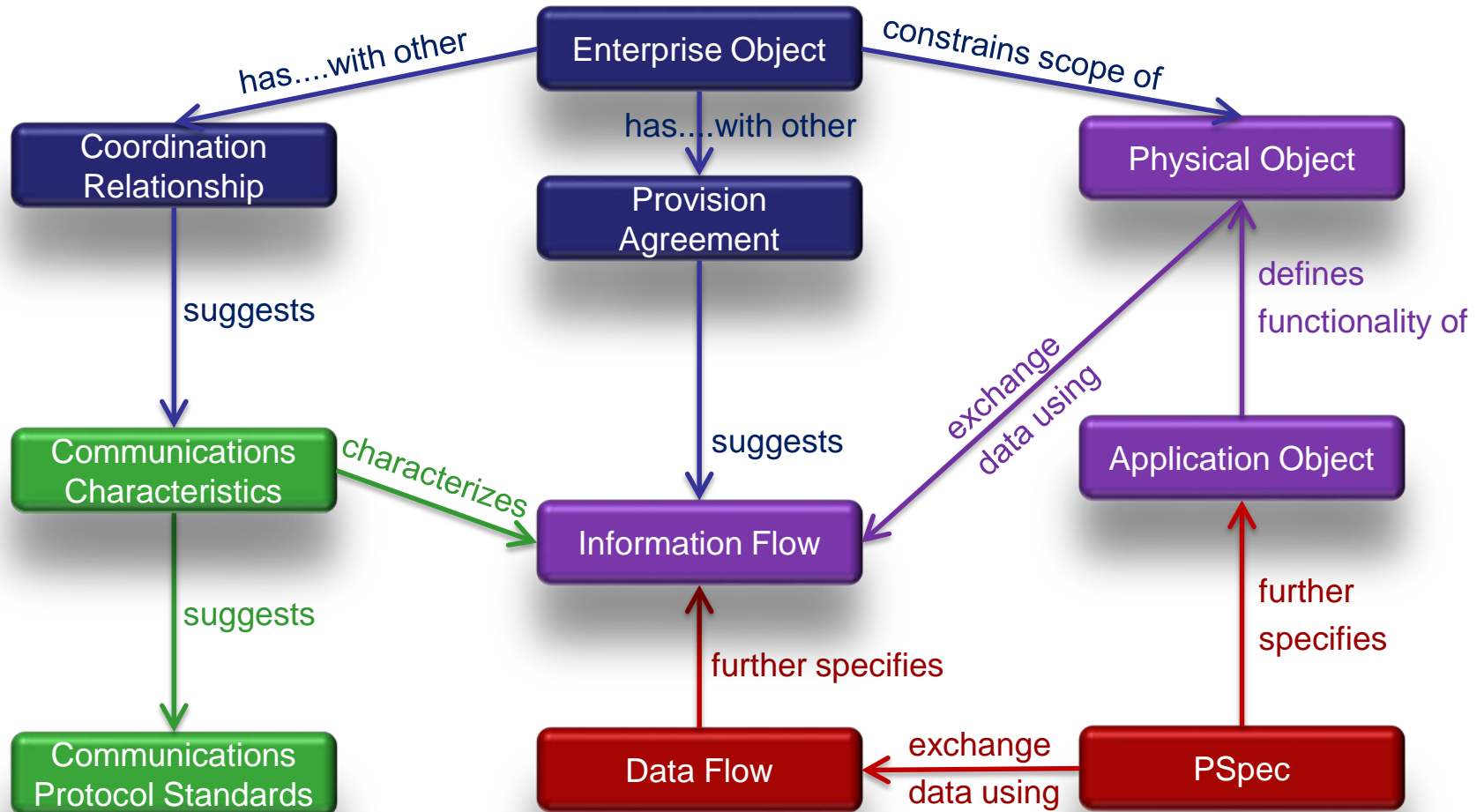


CVRIA Views

- Used to capture stakeholders' concerns
 - Enterprises to carry out applications
 - Functions to satisfy requirements
 - Physical objects to implement that functionality
 - Communications protocols necessary



CVRIA Viewpoint Correspondence

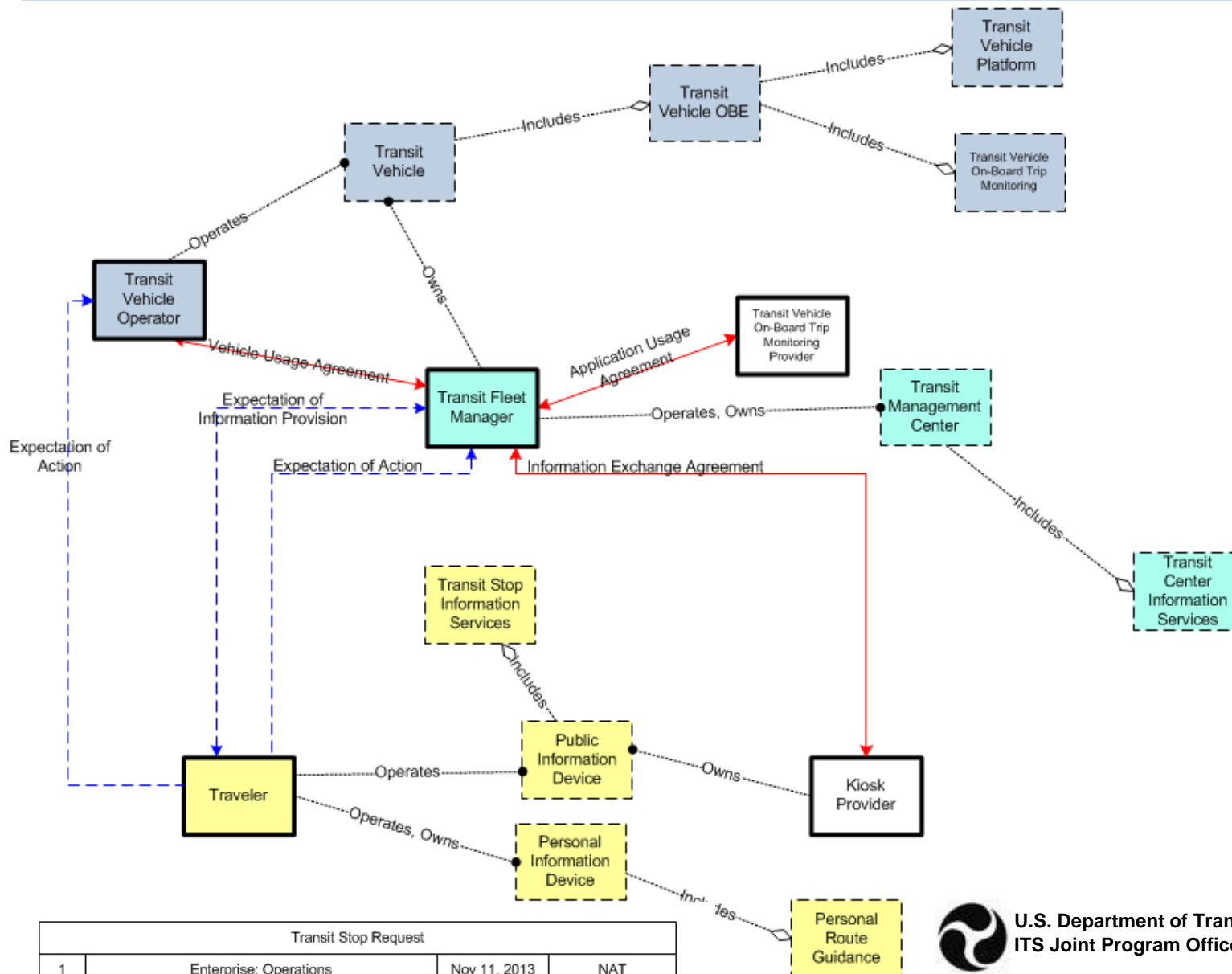


CVRIA Enterprise View

- Depicts:
 - Relationships between organizations
 - Roles organizations play in delivery of services within the connected vehicle environment
- Addresses system life cycle



CVRIA Enterprise View Example



CVRIA Functional View

- Depicts:
 - Abstract functional objects (processes)
 - Flows of data between those processes
- Identifies options for...
 - What functionality is in the CVE?
 - What are the interfaces between logical objects?
 - What data flows over those objects?
 - Information Security, including
 - Trust management
 - Privacy protection
 - Anonymity protection
 - Information integrity assurance



CVRIA Functional View Example

Includes Processes:

Level	Name	Type	Allocated to Application Object
4.1	<u>Operate Transit Vehicles and Facilities</u>	Collection	
4.1.1	<u>Process On-Board Systems Data</u>	Pspec	- <u>Transit Vehicle On-Board Trip Monitoring</u> - <u>Transit Vehicle On-Board Information Services</u>
4.1.2	<u>Determine Transit Vehicle Service Status</u>	Pspec	- <u>Transit Vehicle On-Board Trip Monitoring</u> - <u>Transit Vehicle On-Board Information Services</u>
4.1.3	<u>Provide Transit Vehicle Location Data</u>	Pspec	- <u>Transit Vehicle On-Board Trip Monitoring</u>
4.1.4	<u>Manage Transit Vehicle Deviations</u>	Pspec	- <u>Transit Center Information Services</u>
4.1.6	<u>Manage Transit Vehicle Operations</u>	Pspec	- <u>Transit Center Information Services</u>
4.1.7	<u>Provide Transit Advisory Interface on Vehicle</u>	Pspec	- <u>Transit Vehicle On-Board Information Services</u>
4.1.8	<u>Manage Individual Service Requests</u>	Pspec	- <u>Transit Center Information Services</u>

Includes Data Flows:

Source Pspec	Data Flow	Destination Pspec
<u>Determine Transit Vehicle Service Status</u>	<u>transit vehicle deviations from schedule</u>	<u>Manage Transit Vehicle Deviations</u>
<u>Determine Transit Vehicle Service Status</u>	<u>transit vehicle passenger connection request</u>	<u>Manage Transit Vehicle Deviations</u>
<u>Determine Transit Vehicle Service Status</u>	<u>transit vehicle connection request mode</u>	<u>Manage Transit Vehicle Deviations</u>
<u>Determine Transit Vehicle Service Status</u>	<u>transit service status</u>	<u>Manage Transit Vehicle Operations</u>
<u>Determine Transit Vehicle Service Status</u>	<u>transit vehicle schedule deviation</u>	<u>Manage Transit Vehicle Operations</u>
<u>Determine Transit Vehicle Service Status</u>	<u>transit vehicle eta</u>	<u>Manage Transit Vehicle Operations</u>
<u>Determine Transit Vehicle Service Status</u>	<u>transit vehicle service update</u>	<u>Manage Transit Vehicle Operations</u>



CVRIA Physical View

- Depicts:
 - Physical objects that interact to deliver services
 - Interfaces and flows of information between those physical objects
- Identifies options for...
 - What devices are involved in delivering safety, mobility, environmental applications?
 - What are the physical interfaces in each device?
 - What functions do those interfaces support?
 - What functionality is allocated to devices, and what is allocated to humans?

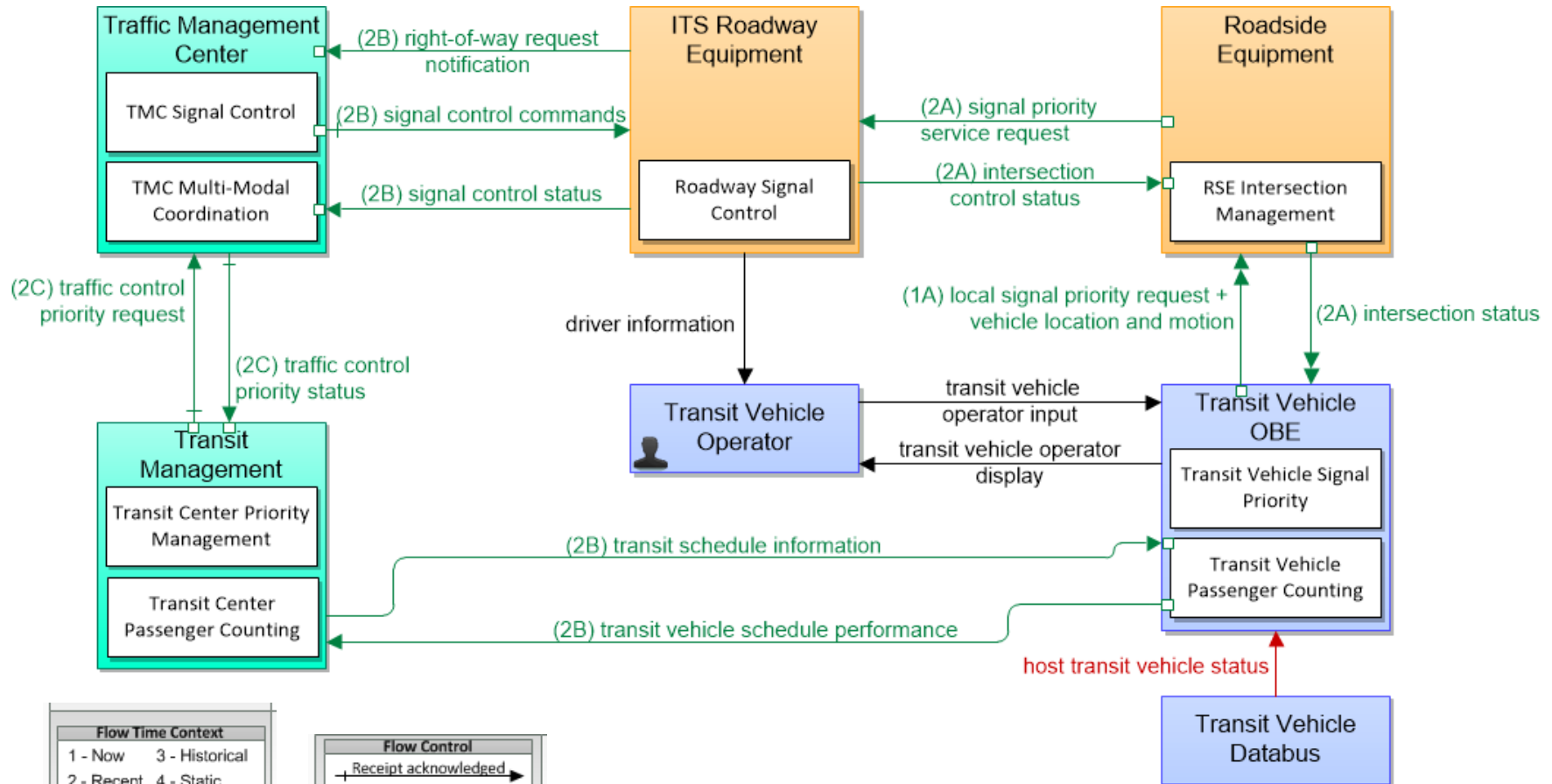


CVRIA Physical View (cont.)

- Additional Considerations:
 - What devices require information security safeguards and what are they?
 - Operational security
 - Device physical security
 - Environmental protections for devices
 - Contingency planning for failure
 - Maintenance
 - Security prior to disposal



CVRIA Physical View Example - Transit Signal Priority Application



Flow Time Context	
1 - Now	3 - Historical
2 - Recent	4 - Static
Flow Spatial Context	
A - Adjacent	D - National
B - Local	E - Continental
C - Regional	
Flow Cardinality	
Unicast	→
Multicast	→▷
Broadcast	→▷▷

Flow Control	
+ Receipt acknowledged	→
□ Transaction initiated by left-hand party	→
Flow Security	
Clear text, No Authent.	→
Encrypted, No Authent.	→
Clear text, Authenticated	→
Encrypted, Authenticated	→

Transit Signal Priority			
5	Physical	Jul 8, 2015	NAT

CVRIA Communications View

- Depicts:
 - Layered communications protocols that support communications between physical devices
- Identifies options for...
 - Identity and appropriateness of protocols at all layers
 - How these protocols ensure or support:
 - Anonymity preservation
 - Non-repudiation
 - Message integrity
 - Status of protocols as standards or privately provided protocols and the implications of their use from an evolve-ability perspective

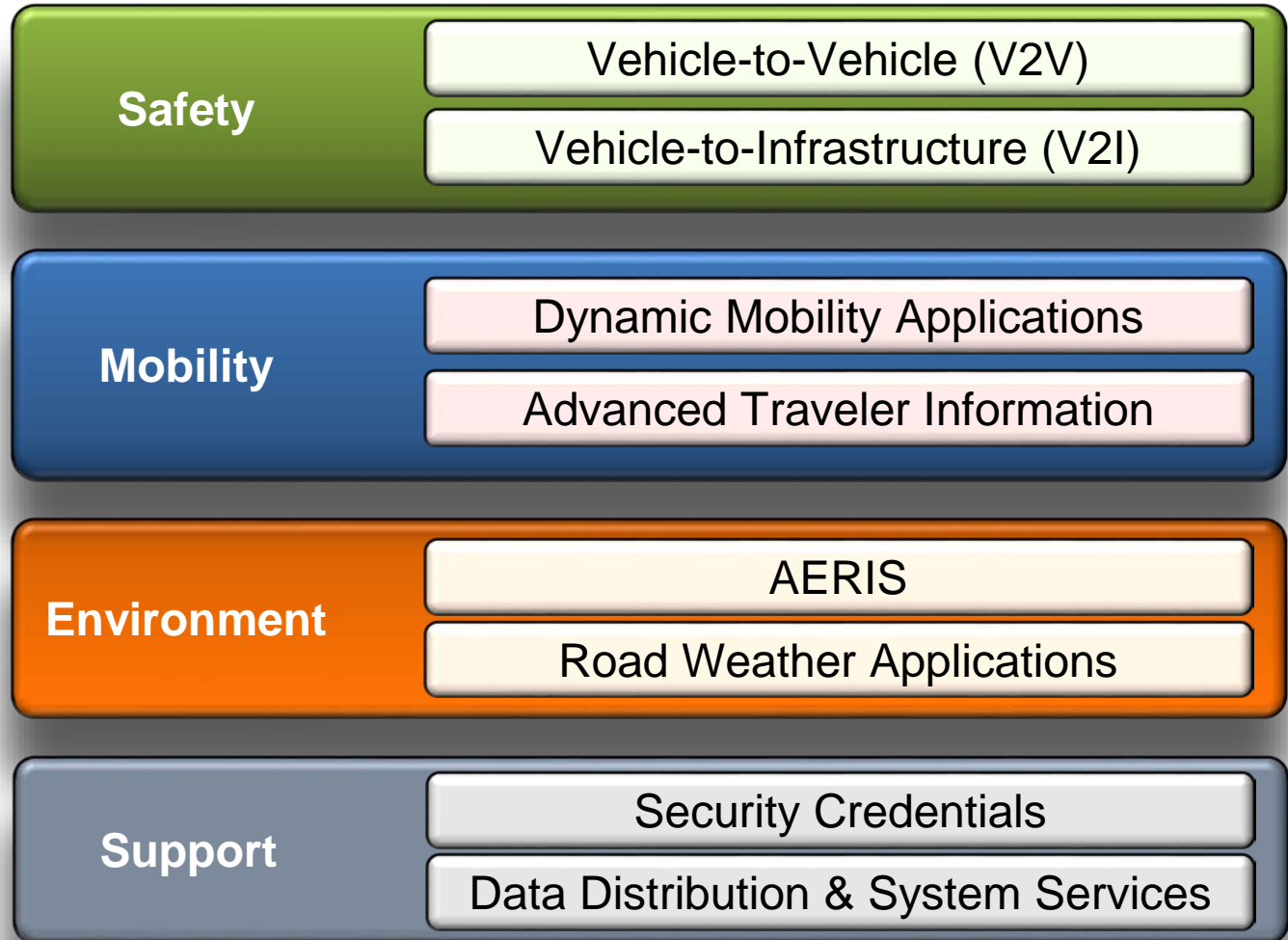


CVRIA Communications View Example

DSRC-WSMP		
local signal priority request -->		
Transit Vehicle OBE		Roadside Equipment
ITS Application Information Layer SAE J2735	Security Plane IEEE 1609.2	ITS Application Information Layer SAE J2735
Application Layer Undefined		Application Layer Undefined
Presentation Layer ISO ASN.1 DER	Security Plane Undefined	Presentation Layer ISO ASN.1 DER
Session Layer Undefined		Session Layer Undefined
Transport Layer IEEE 1609.3 WSMP		Transport Layer IEEE 1609.3 WSMP
Network Layer IEEE 1609.3 WSMP		Network Layer IEEE 1609.3 WSMP
Data Link Layer IEEE 1609.4, IEEE 802 MAC, IEEE 802.11p		Data Link Layer IEEE 1609.4, IEEE 802 MAC, IEEE 802.11p
Physical Layer IEEE 802.11p		Physical Layer IEEE 802.11p

Connected Vehicle Applications

Since 2003, USDOT-sponsored research has identified ~100 applications to address Safety, Mobility, Environmental needs, as well as address security/privacy concerns and other system support services



CVRIA Website Links Views to Applications

APPLICATIONS

SAFETY	MOBILITY	ENVIRONMENT	SUPPORT
<div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin: 5px;">Crash-Imminent V2V</div> <div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin: 5px; margin-left: 20px;">V2V</div> <div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin: 5px; margin-left: 20px;">V2I</div>	<div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin: 5px;">Data Capture & Management</div> <div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin: 5px; margin-left: 20px;">Dynamic Mobility Apps</div>	<div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin: 5px;">AERIS</div> <div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin: 5px; margin-left: 20px;">Road Weather Apps</div>	<div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin: 5px;">Security Credentials</div> <div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin: 5px; margin-left: 20px;">Core Services</div>

Enterprise View
Relationships between Organizations

Functional View
Logical Interactions between Functions

Physical View
Connections between Physical Objects, Links, and Applications

Communications View
Layered communications protocols between Physical and Application Objects

CVRIA CONNECTED VEHICLE REFERENCE IMPLEMENTATION ARCHITECTURE

[About](#) | [Applications](#) | [Views](#) | [Standards](#) | [Resources](#) | [Glossary](#) | [Contact Us](#)

[Home](#) > [Applications](#) > Restricted Lane Warnings

Restricted Lane Warnings

The Restricted Lane Warnings application provides the connected vehicle with restriction information about the travel lanes, such as if the lane is restricted to high occupancy vehicles (HOV), transit, or public safety vehicles only or has defined eco-lane criteria. A connected vehicle can use this information to determine if the vehicle is in a lane that has lane restrictions.

[Enterprise](#) | [Functional](#) | [Physical](#) | [A-Interconnect](#) | [Communications](#) | [Requirements](#) | [Sources](#) | [Security](#)