Intelligent Transportation Systems (ITS)
Joint Program Office (JPO)

USDOT's Connected Vehicle Reference Implementation Architecture (CVRIA) Stakeholders Outreach Meeting

August 20-21st, 2014

Welcome: Agenda Review

August 20, 2014	TIMING	PRESENTERS
Registration	9:00-9:30am	ITS America
Welcome and Overview of Workshop Objectives **Introduction of CVRIA staff** **Logistics**	9:30-9:45am	USDOT leadership
Purpose and Structure of the Workshop • **Purpose** • **Overview:** o **Presentation on CVRIA In Use: Southeast Michigan Demonstration Project** o **CVRIA Updates** o **Standards Priorities/Emerging Plan:** o **Next Steps**	9:45-10:05am	Suzanne Sloan, USDOT
CV Pilot Program briefing	10:05-10:15am	Suzanne Sloan
CVRIA In Use • **Purpose and objectives of the project** • **How it came together** • **Status of the implementation** • **How it is being used (Plug and Play, testing, ITS World Congress demonstrations)** • **Lessons Learned**	10:15-11:15am	Walt Fehr, USDOT
Break	11:15-11:30am	

Agenda Review: Continued

August 20, 2014	TIMING	PRESENTERS
CVRIA Update • **Disposition of Stakeholder Feedback/Comments** • **SET-IT Tool** • **Next Steps**	11:30am-12:30pm	David Binkley and Tom Lusco, Iteris
Lunch	12:30-1:40pm	Carlos Alban, ITS America
Standards Analysis Results • **Presentation of the Results** • **Presentation of the methodology** • **Prioritization of the exchanges and mapping the top exchanges to existing standards** • **Mapping of the top exchanges to applications** • **Emerging Recommendations**	1:40-3:00	Chris Karaffa and Jim Marousek, Booz Allen Hamilton
Break	3:00-3:15pm	
Breakout Group Discussion #1: Validation of Results	3:15-4:45pm	
Concluding Remarks, Instructions for Next Day **Dinner Options**	4:45-5:00pm	Suzanne Sloan, Chris Karaffa, Carlos Alban

Agenda Review: Continued

August 21, 2014	TIMING	PRESENTERS
Welcome and Reflections on August 20th Work **Logistics regarding Breakout group discussion #2 & #3**	9:00-9:20am	Suzanne Sloan, Chris Karaffa
Breakout Group Discussion #2: Mapping of Exchanges to Standards	9:20am-12:00pm	
Lunch		
Breakout Group Discussion #3: Deployment Planning	1:00-2:00pm	
Report out on Discussions #2 and #3	2:00-2:30pm	Facilitators
Wrap-Up and Conclusions	2:30-3:00pm	USDOT, CVRIA team

Purpose of Today's Workshop

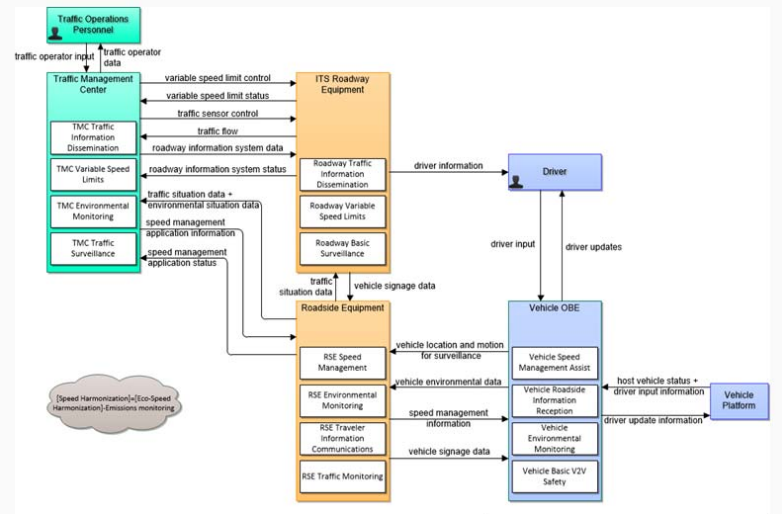
- **Provide update on the progress of the Connected Vehicle Reference Implementation Architecture (CVRIA)**
- **Highlight Southeast Michigan Demonstration Project, and what we are learning from it**
- **Describe and discuss tools being developed to assist in applying the CVRIA to design/develop connected vehicle applications and implementations**
- **Provide overview of CV Pilot Deployment Process**

Southeast Michigan Demonstration

- **Active since January 2014**
- **USDOT, contractors, local stakeholders working together**
- **Testing real-world systems and applications to see what works, what is missing**
- **Learnings have yielded critical advancements in:**
  - **Using multiple communications media**
  - **Development of “generic Ethernet frame”**
  - **Data distribution and warehousing concepts**

CVRIA Updates

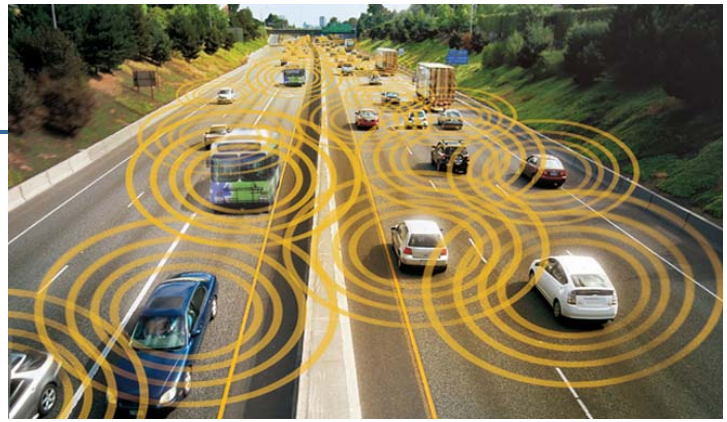
- **Architecture team will be drawing on stakeholders' comments on the CVRIA viewpoints to update the CVRIA**
- **New tool developed: SET-IT. Allows stakeholders to plan deployments using CVRIA language and graphic elements**



Standards Priorities/Emerging Plan

- **Standards Team has been identifying and prioritizing interfaces, data flows and message sets for standardization**
- **Key insights so far:**
  - Existing IP protocols will most likely work for lower level of OSI stack – we may be able to adopt/adapt them
  - Most need for specific CV standards in higher levels of OSI stack (levels 6 and 7)
- **We've begun process of mapping 500+ data exchanges back to apps to ID needs for new standards vs. adoption of existing ones**
  - Relationship of the apps to security credential management functions is currently undefined
  - Data flows within vehicles not addressed – OEMs will decide these

Breakout Groups

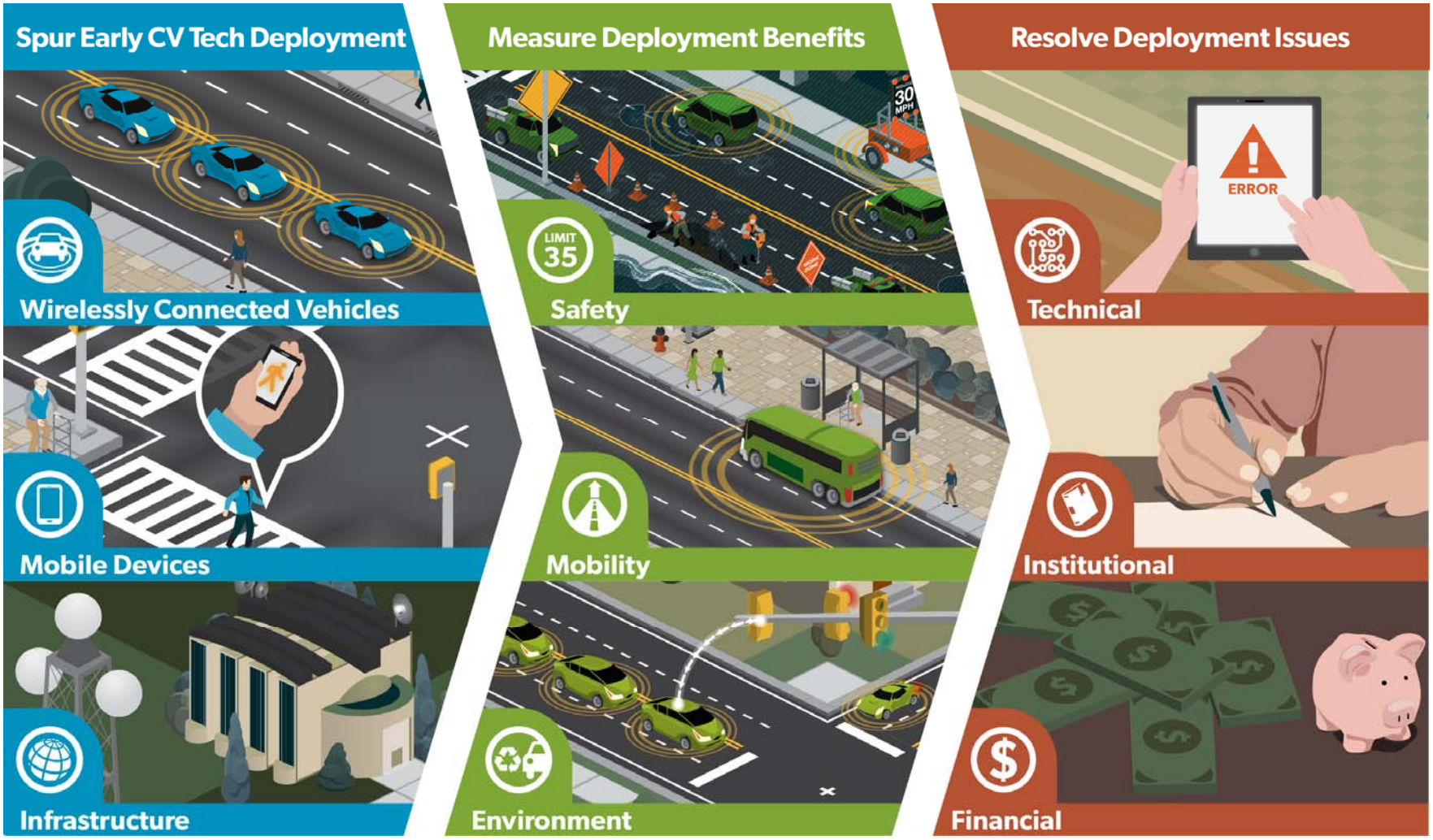


1) Afternoon today:
   - Reactions to the presentations
2) Tomorrow morning :
   - Quickly revisit results
   - Present exchange/standards mapping for the top applications
3) Tomorrow afternoon:
   - Discuss how results impact/support deployment

CONNECTED VEHICLE PILOT
Deployment Program

ITS Joint Program Office

PROGRAM GOALS



Pilot Deployment Process

- **Pilot Deployment Concept Development Process**
  - Identify Local Needs
  - Set Performance Goals
  - Select CV Applications That Work Together Meet Those Goals

- **USDOT Sample Pilot Concepts from Hypothetical Locations**
  - Hypothetical, but realistic examples of localities applying the pilot deployment concept development process

SAMPLE DEPLOYMENT CONCEPT – Downtown Sunnyside

~ Improving Congestion in an Urban Arterial Network ~

Improve Transit Reliability

- Connection Protection
- Transit Signal Priority

Improve Pedestrian Safety

- Mobile Accessible Pedestrian Signal System
- Pedestrian in Signalized Crosswalk Warning
- Intersection Movement Assist

Improve Air Quality

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

Synergies among applications increase benefits and reduce costs

SAMPLE DEPLOYMENT CONCEPT – HALLECK EXPRESSWAY

~ Improving Travel Time Reliability on an Urban Expressway~

Reduce Incident Delay

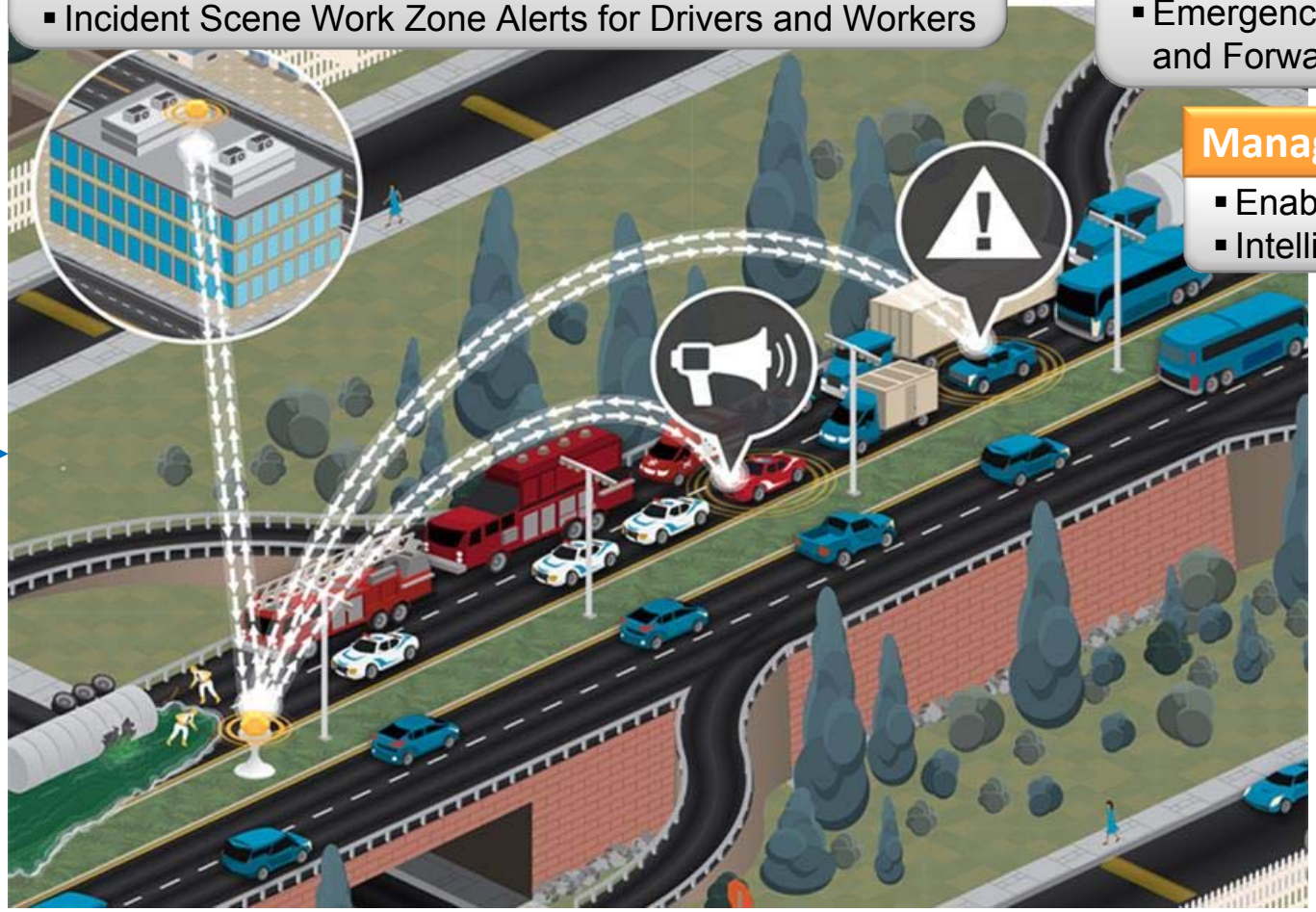
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders
- Incident Scene Work Zone Alerts for Drivers and Workers

Improve Bottleneck Throughput

- Speed Harmonization and Queue Warning
- Emergency Electronic Brake Lights and Forward Collision Warning

Manage Diversions Better

- EnableATIS
- Intelligent Signal Control



Synergies among applications increase benefits and reduce costs

SAMPLE DEPLOYMENT CONCEPTS – GREYPOOL COUNTY

~ Improving Safety and Mobility in a Rural Area ~

Increase Accessibility

- Dynamic Transit Operations

Improve Safety

- Red Light Violation Warning
- Stop Sign Gap Assist
- Left Turn Assist

Informing Drivers During Bad Weather

- Weather Response Traffic Information

Synergies among applications increase benefits and reduce costs

SAMPLE DEPLOYMENT CONCEPT – DISTRICT 13 OPERATIONS

~ Improving the Efficiency of Road Maintenance ~

Improve Snow Removal

- Enhanced Maintenance Decision Support System

Improve Management of Work Zones

- Work Zone Traveler Information

Improve Situational Awareness

- Probe-based Pavement Maintenance

Synergies among applications increase benefits and reduce costs

SAMPLE DEPLOYMENT CONCEPT – I-876 CORRIDOR

~ Improving Freight Movement in an Inter-State Corridor ~

Improve Freight Productivity

- Freight Advanced Traveler Information System
- Drayage Optimization
- Freight Signal Priority

Improve Truck Safety

- Smart Truck Parking
- Curve Speed Warning
- Do Not Pass Warning/Lane Change Warning

Synergies among applications increase benefits and reduce costs

CV Pilots Deployment Schedule and Resources

- Proposed CV Pilots Deployment Schedule

Schedule Item	Date
Request for Information (RFI) Issued	March 12, 2014
CV Pilot Program Stakeholder Workshop	April 30, 2014
Regional Pre-Deployment Workshop/Webinar Series	**Summer-Fall 2014**
Solicitation for Wave 1 Pilot Deployment Concepts	**Early 2015**
Wave 1 Pilot Deployments Award(s)	**September 2015**
Solicitation for Wave 2 Pilot Deployment Concepts	**Early 2017**
Wave 2 Pilot Deployments Award(s)	**September 2017**
Pilot Deployments Complete	**September 2020**

- Resources
  - ITS JPO Website: http://www.its.dot.gov/
  - CV Pilots Program Website: http://www.its.dot.gov/pilots

CVRIA In-Use

The Southeast Michigan 2014 Project

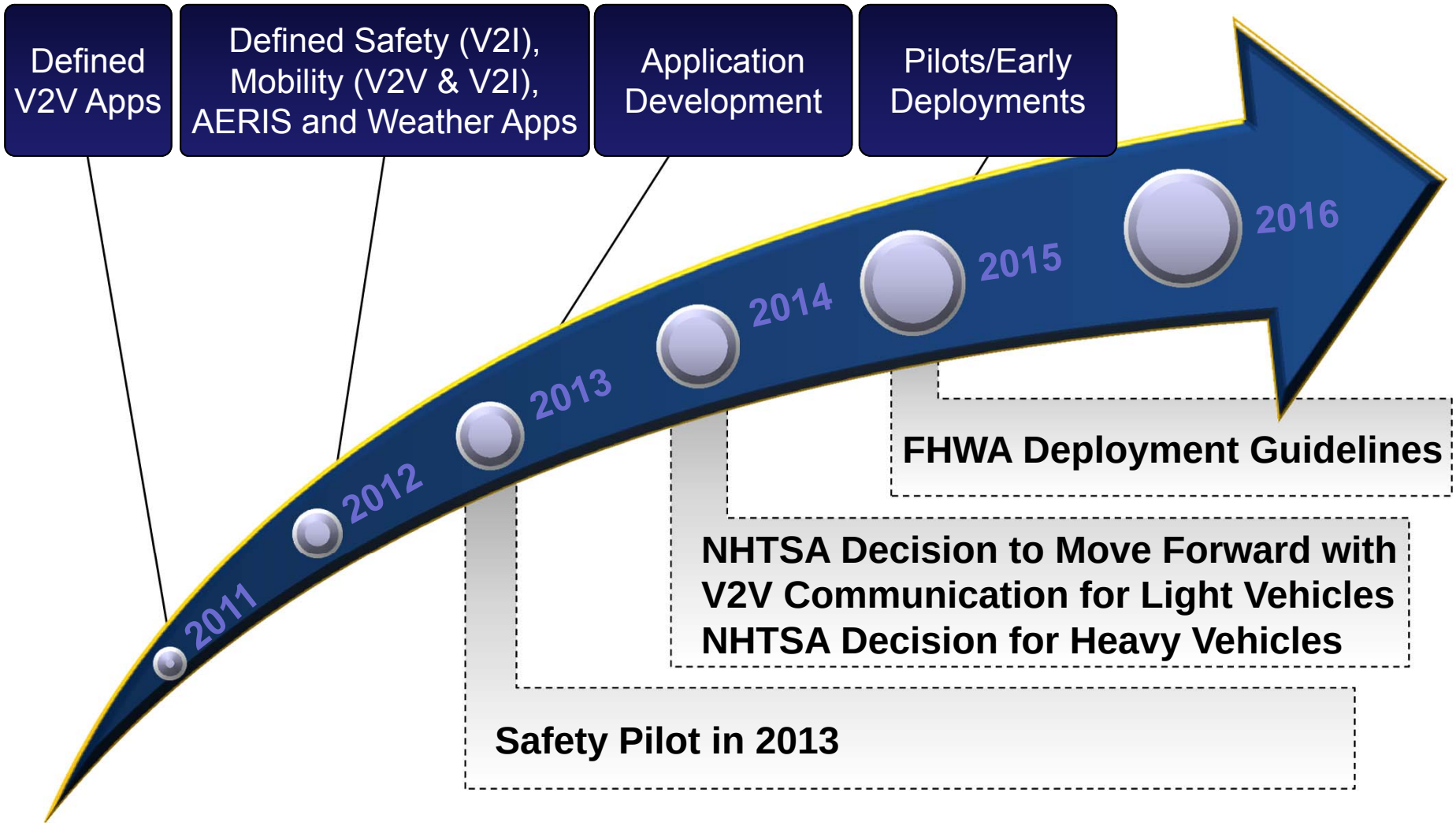
San Francisco

August 20, 2014

Welcome

- Presenter –
  - Tom Lusco, Iteris; ctl@iteris.com
  - for Walt Fehr, USDOT ITS Joint Program Office
    - walton.fehr@dot.gov
    - www.its.dot.gov
- Topics –
  - Overview
  - Communications
  - Architecture
  - Concept of Operations
  - Design

Path to Deployment



Project Overview

- **Communication security**
  - Common process for all information flows
  - Preserving “Privacy by Design”
- **Data flow and evolution**
  - Common processes, types of data
  - Full round trip
- **Multiple communication media**
  - DSRC on all 7 channels
  - Other IP transport media
- ***Tools***
  - *Consistent implementations*

A Variety of Communication Media, Data Needs

<u>Resources</u>: wired and wireless, the Internet

- **3,000 miles, 3,000 meters, 300 meters, 3 meters.**

<u>Requirements</u>: Two types of data distribution:

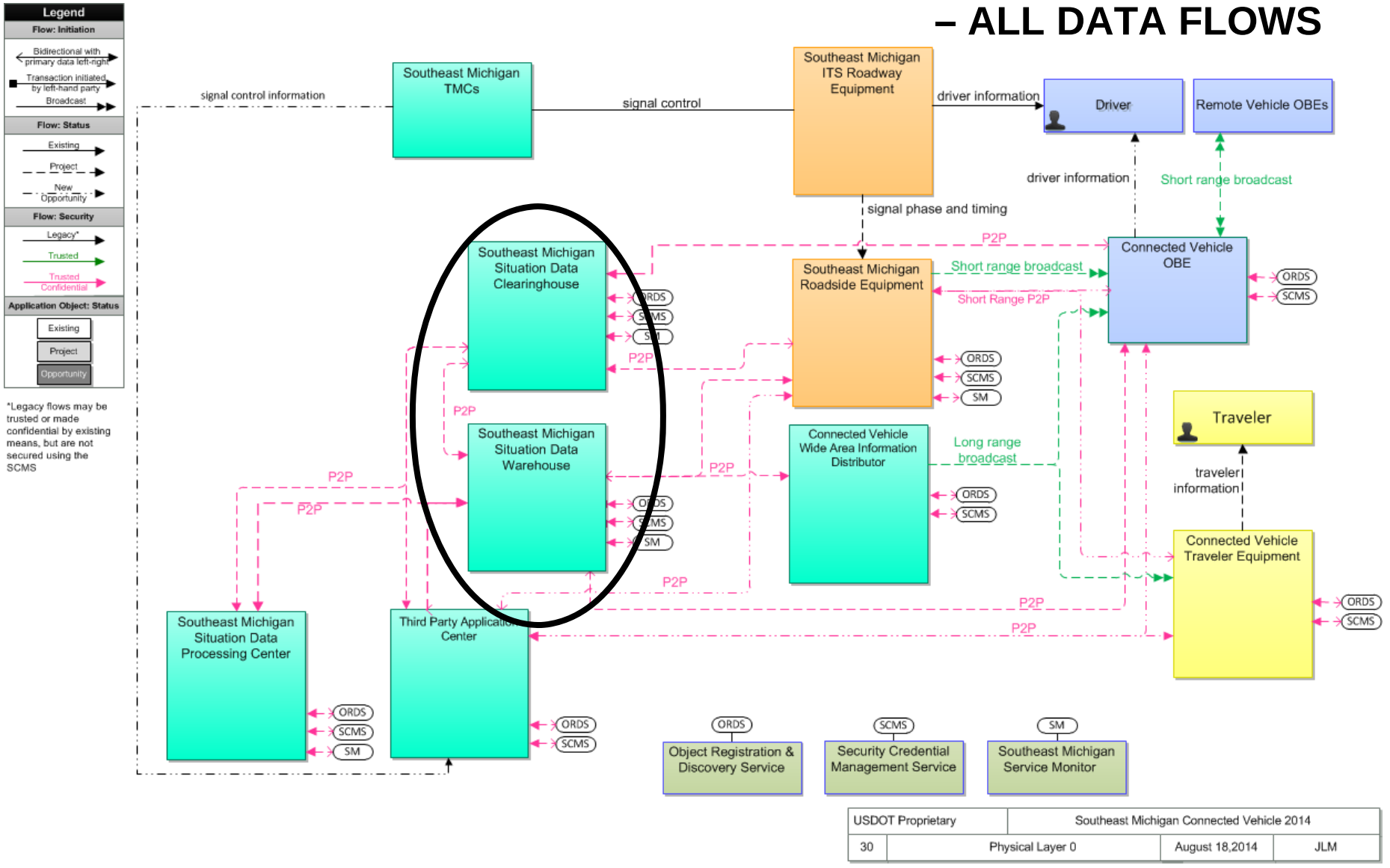
- **To all, To one.**

FOCUS

FOR THE BENEFIT OF ALL VEHICLES AND TRAVELERS, ACCESSIBLE TO ALL CONTENT PROVIDERS

- A base level of data for the benefit of all.
- Likely media: Satellite, Wide Area Network, 5.9GHz DSRC.
- Broadcast mode or Internet Protocol transactions or streams accessible by all.
- Data resources accessible to all contributors.

SOUTHEAST MICHIGAN 2014 PROJECT
– ALL DATA FLOWS



Affiliation of Test Beds

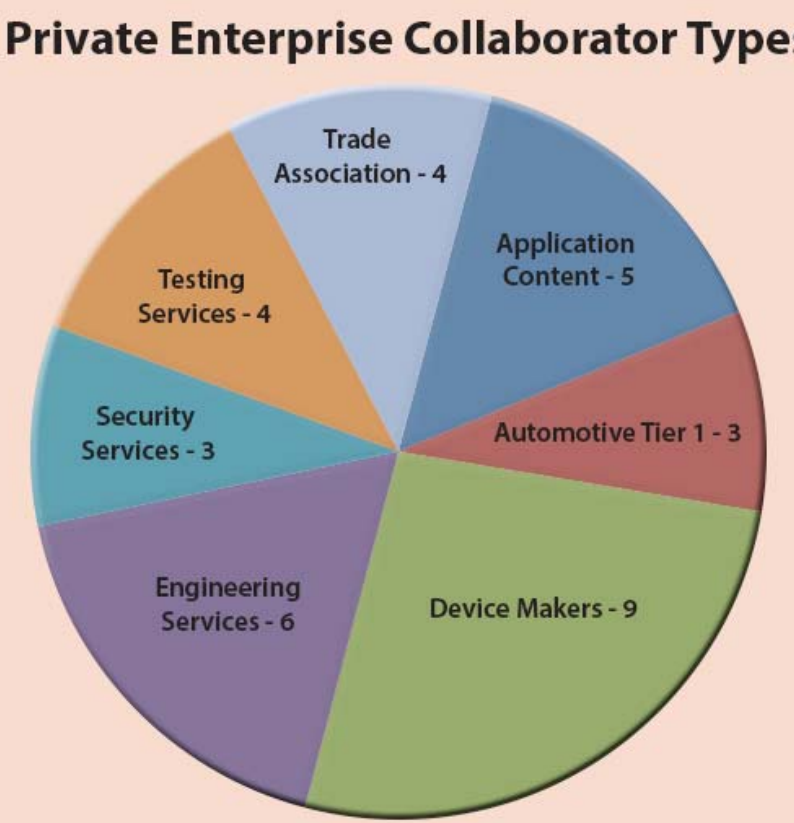
The OST-R has entered into 48 Memorandums of Agreement (MOA) with public, private, and academic organizations involved in the Affiliation of Test Beds. They include:

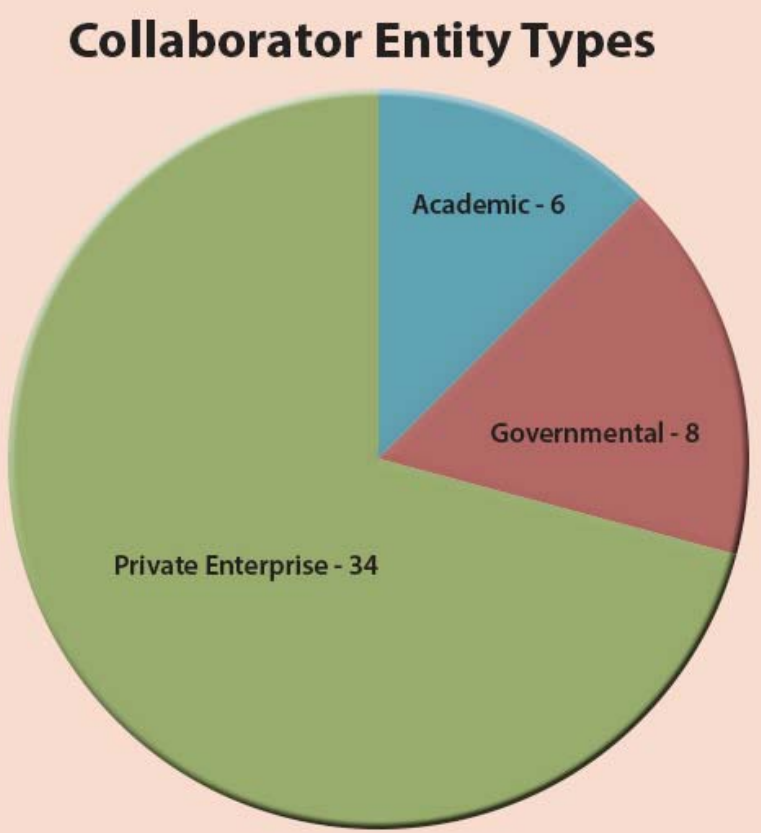
- Arada Systems
- Southwest Research Institute
- Detroit DPW
- Security Innovation
- Cohda Wireless
- Siemens Industry Inc.
- Dering & Estrada
- University of Michigan/UMTRI
- University of Arizona
- TIEMAC CORPORATION
- Tampa Hillsborough Expressway Authority
- DENSO Corporation
- Marben Products
- NextEnergy
- CETECOM
- Pioneer Advanced Solutions
- La Trobe University (Melbourne)
- OminiAir
- ITRI
- Autotalks LTD
- Connected Vehicle Trade Assc.
- Battelle Memorial Institute
- Rohde & Schwarz USA, Inc.
- MET Laboratories
- 7Layers Inc.
- Green Driver Inc.\ On Time Systems
- Virginia Tech Transportation Institute
- Illinois Tollway
- The Road Commission for Oakland County
- Contra Costa Transportation Authority
- Traffic Technology Solutions
- Savari Inc.
- Global Mobile Alert
- Case Western Reserve University
- University of Wisconsin Madison
- Unex Technology Corporation
- Sirius XM Radio Inc.
- Go-Light
- Pravala Networks

Latest

- The Regents of the University of California, Berkeley
- Renesas Electronics America, Inc.
- Vehicle Data Science Corporation
- UL, LLC
- Ericsson
- Commsignia LTD
- Aldis, Inc.
- eTrans2020
- Swiit Apps

Affiliated Testbed Breakdown



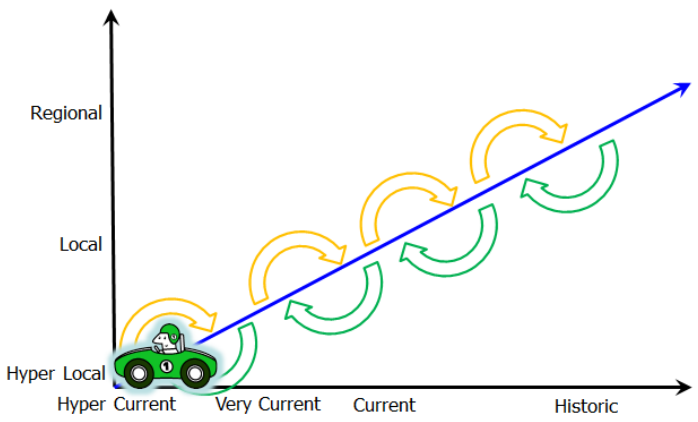


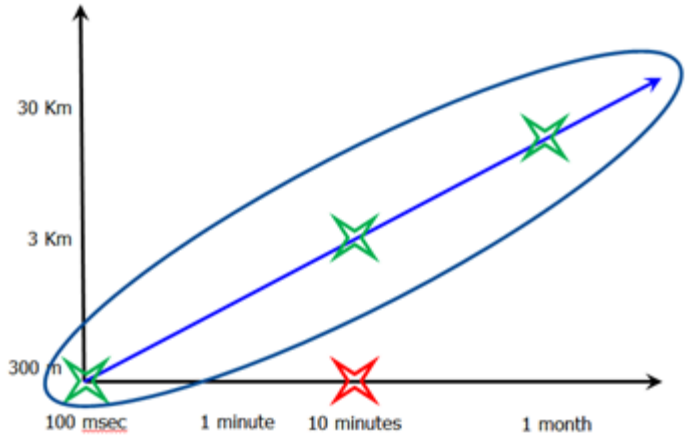
Southeast Michigan Communications Context

- Time and space context
- Security Requirements
- Preserving “Privacy by Design”

Time and Place Context

- **Situation Data**
  - The state of a key element of the system at a specific time
  - Defining the data flow and evolution
- **Time and Place Context** to Data and Information

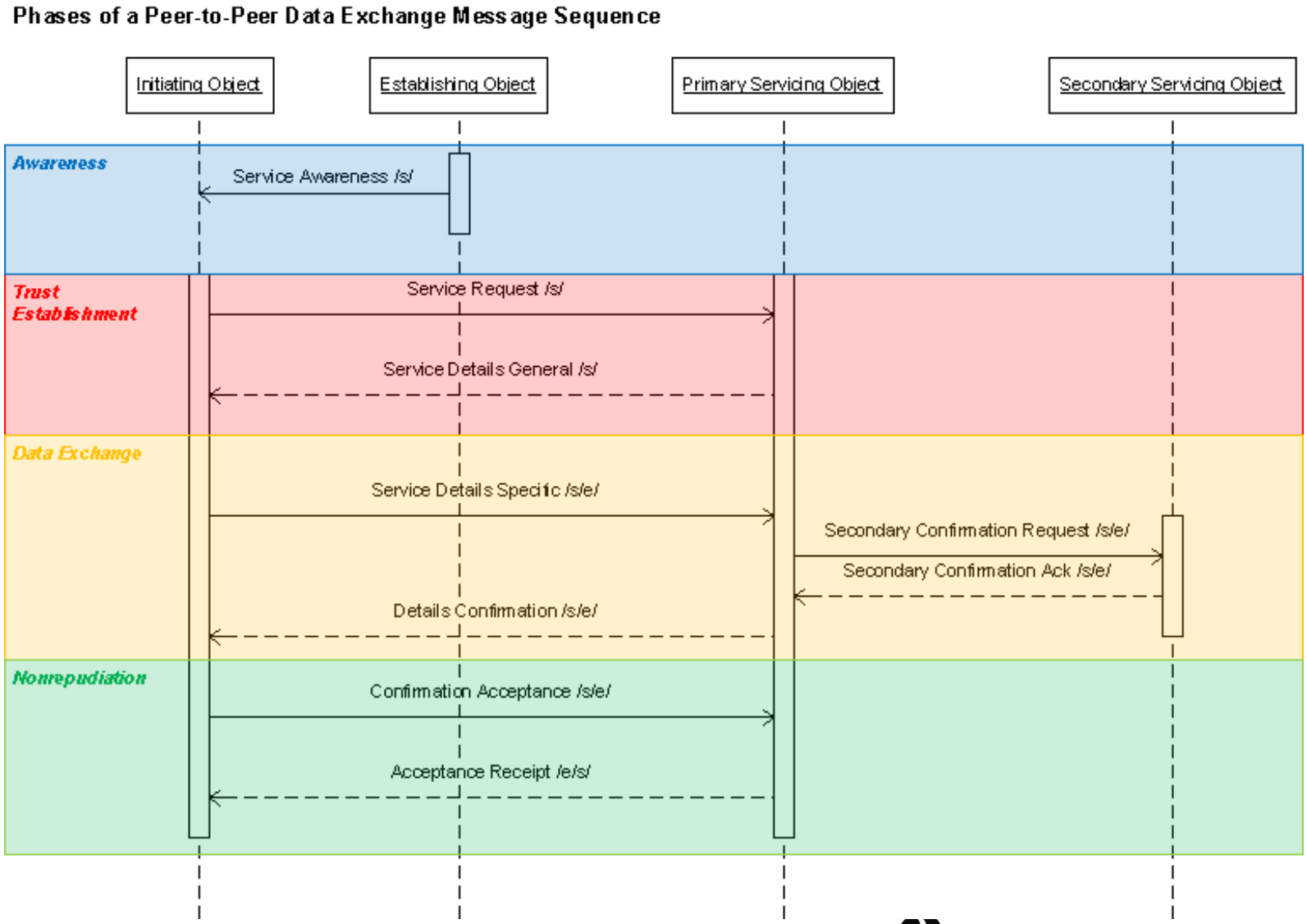




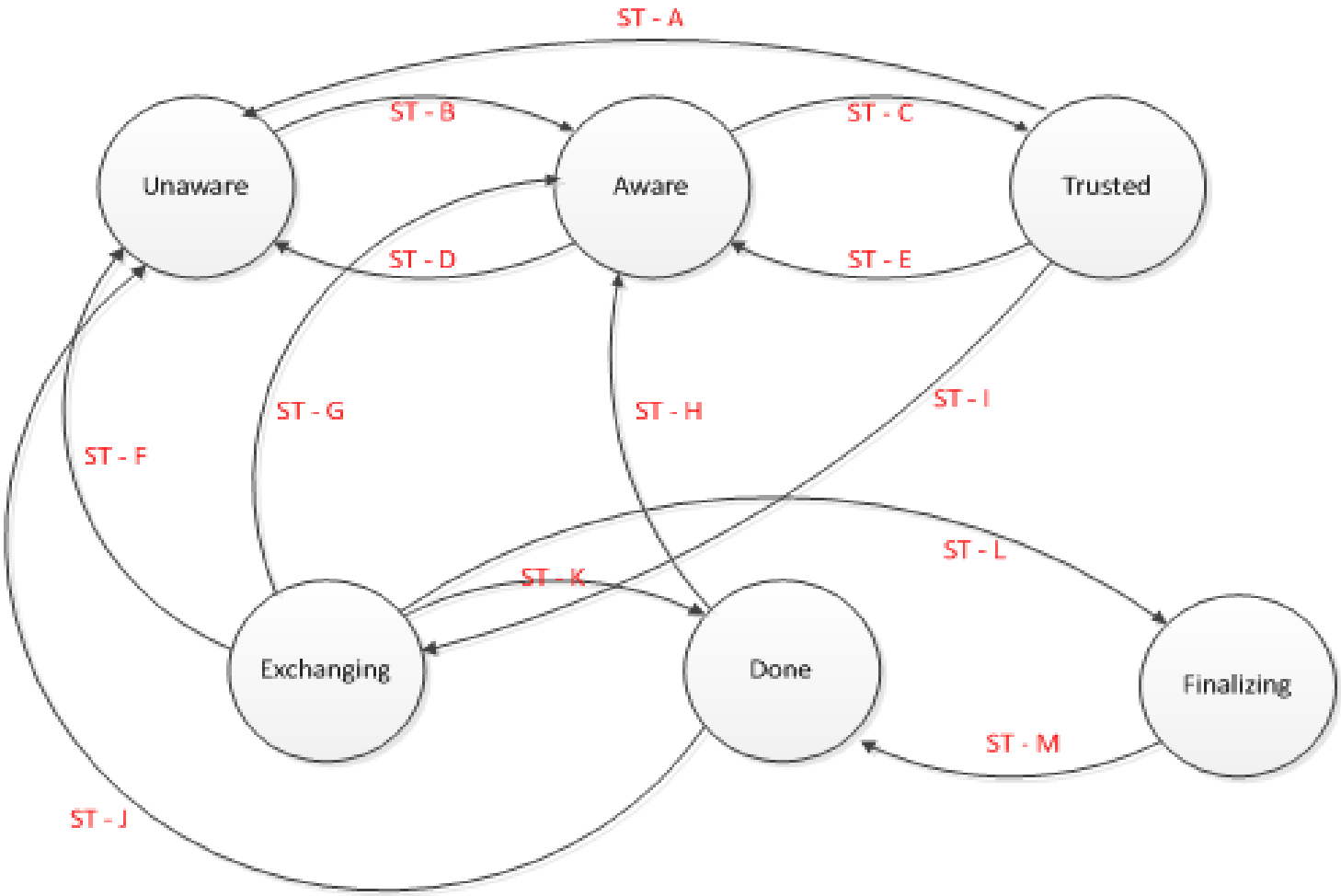
Privacy/Anonymity Concerns

- Formulated to protect the privacy of the users to the highest possible degree Possible.
- Challenging In a multi-application setting, because
  - The user may have higher privacy requirements than a specific application does,
  - There is an additional threat to the privacy of the user from correlations between applications.
- Some applications by their nature will have to reveal sensitive or user-specific information: for example, BSMs reveal vehicle location.
  - This makes it all the more important to ensure that applications do not reveal this information unless it is absolutely necessary, as revealing the information within application A will allow it to be correlated with information from application B.
- Further discussion of privacy and security for the multi-application setting can be found in EU-US ITS Task Force Standards Harmonization Working Group Harmonization Task Group 1 report 1-1, “Current Status of Security Standards”, section 14 and Annex C.

Transactional Unicast Communications



Communications State



Transactional Unicast Communications, cont.

- **Service Discovery**
- **Authorization**
  - The definition of “authorized to use the service” will be application specific.
- **Privacy**
  - ***Not*** require either party to reveal sensitive information unencrypted.
  - ***Not*** contain the User’s location information unless this is necessary as part of service or for the server to verify that the user is authorized to use the service.
  - ***Not*** use identifiers that can be straightforwardly linked to the User’s real-world identity (VIN, license number, etc.).
  - ***Use*** temporary and one-time identifiers. Separate instances of the exchange shall ***not*** use identifiers (USER MAC address, UE-ID (IMEI) , IP address, certificate, temporary ID, session ID, etc.) that have been used in a previous instance of the exchange.
- **Integrity**
- **Replay / message order**
- **Non-repudiation / Audit**
- **Performance**
- **Removal of Misbehaving Objects**

Broadcast Communications

- **Service Discovery**
- **Authorization**
  - The definition of “authorized to use the service” will be application specific.
- **Privacy**
  - ***Not*** require either party to reveal sensitive information unencrypted.
  - ***Not*** contain the User’s location information unless this is necessary as part of service.
  - ***Not*** use identifiers that can be straightforwardly linked to the User’s real-world identity (VIN, license number, etc.).
  - ***Use*** temporary and one-time identifiers. Separate instances of the exchange shall ***not*** use identifiers (USER MAC address, UE-ID (IMEI) , IP address, certificate, temporary ID, session ID, etc.) that have been used in a previous instance of the exchange.
- **Integrity**
- **Replay / message order**
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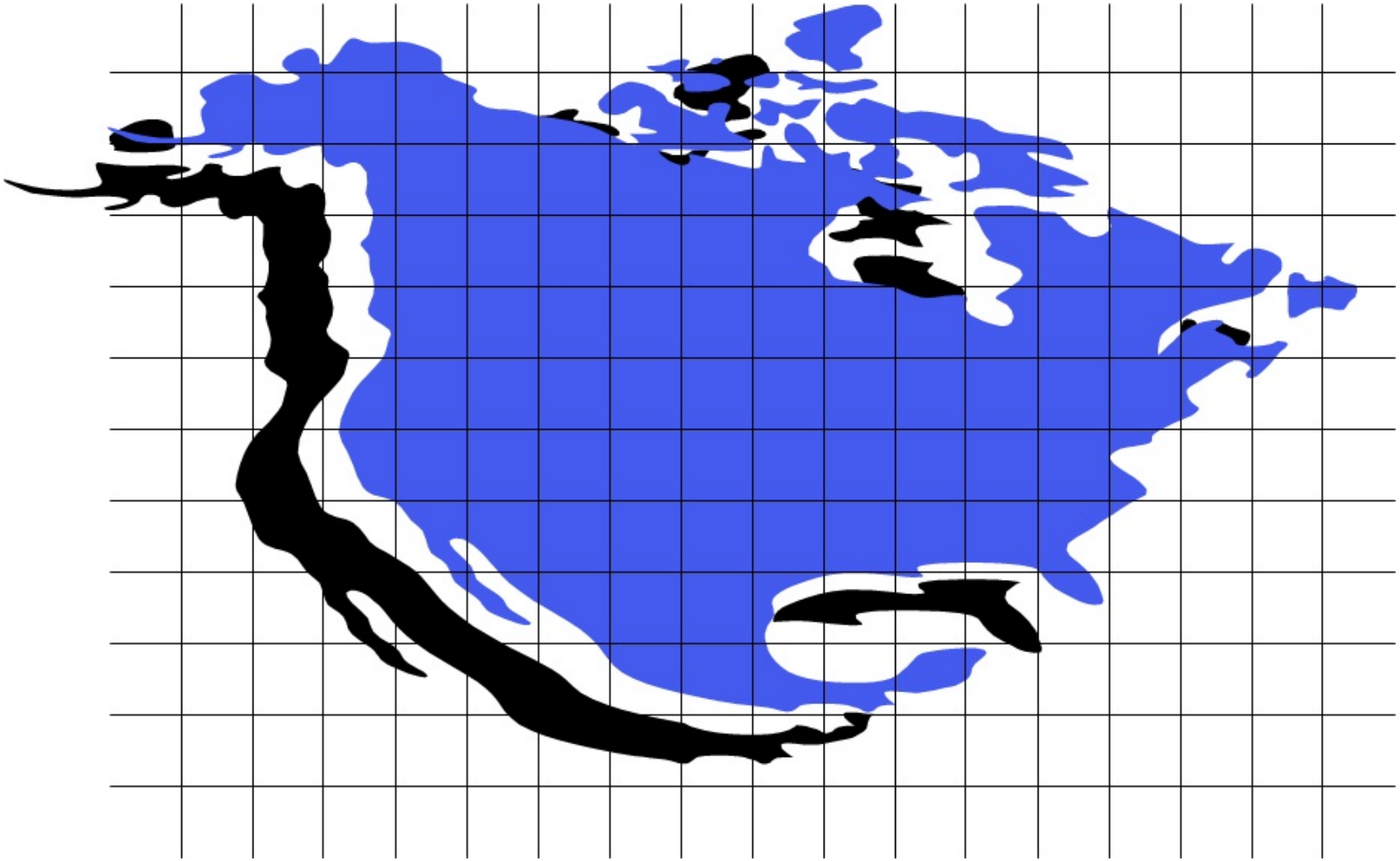
- **Performance**
- **Removal of Misbehaving Objects**

Uniform Implementations



Source: USDOT

Southeast Michigan Architecture

- Common language
- Physical, Enterprise, Communications Views
- Architecture as foundational tool

Other Engineering Disciplines Have Graphical Tools

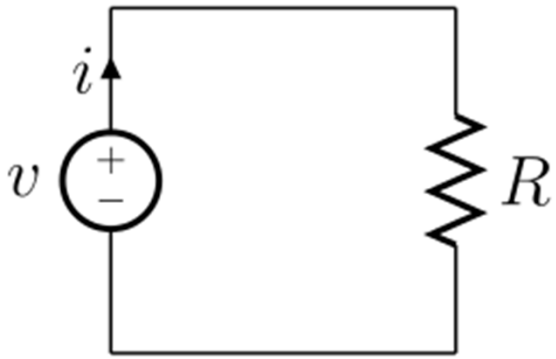
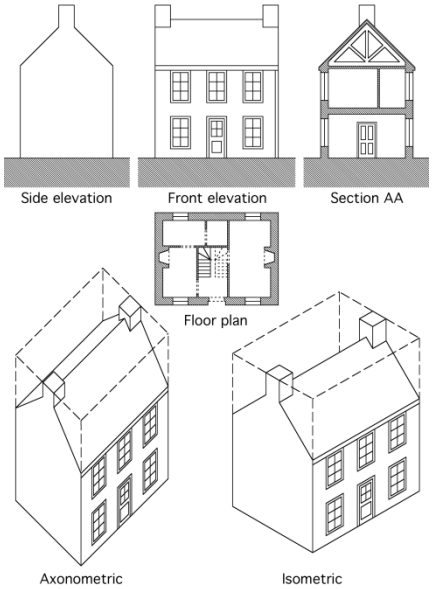


Image Source: Wikipedia



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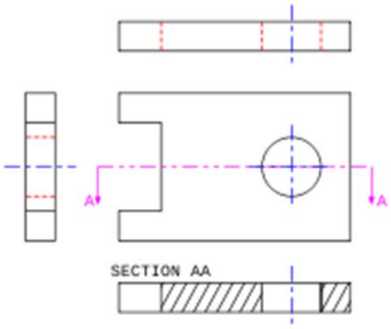
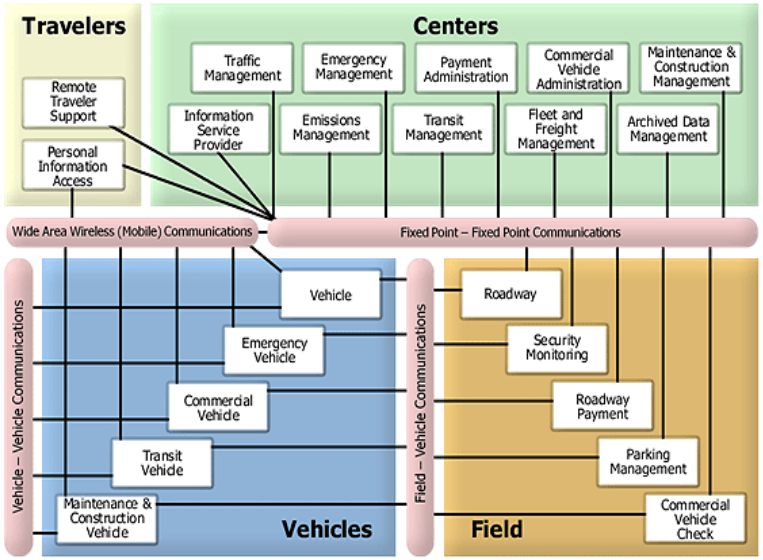


Image Source: Wikipedia

ITS National Architecture

- http://www.its.dot.gov/arch/index.htm



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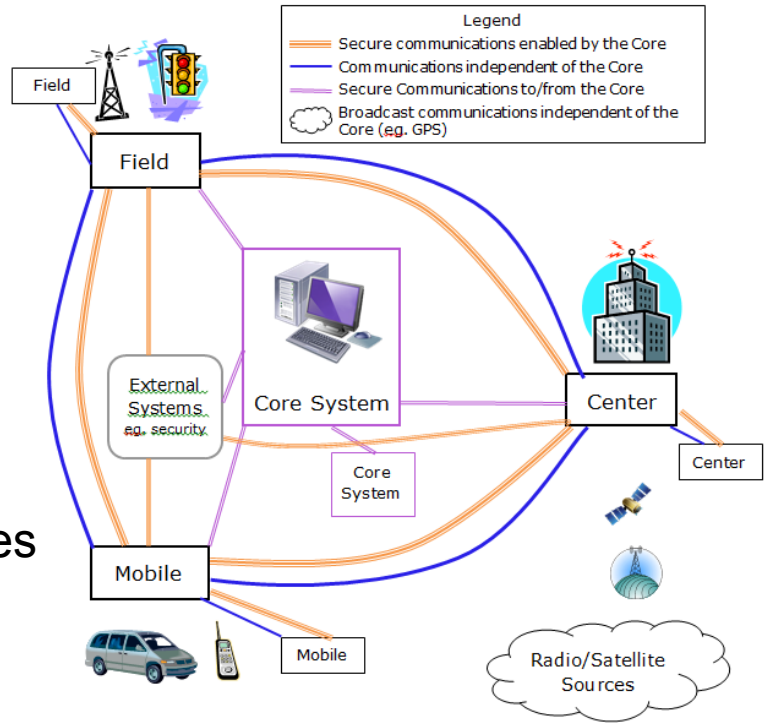


Image Source: USDOT

- Broadcast and Peer-to-Peer data exchanges
- Enable Big Data
- Multiple wireless communication media

Southeast Michigan Connected Vehicle 2014 Project Architecture

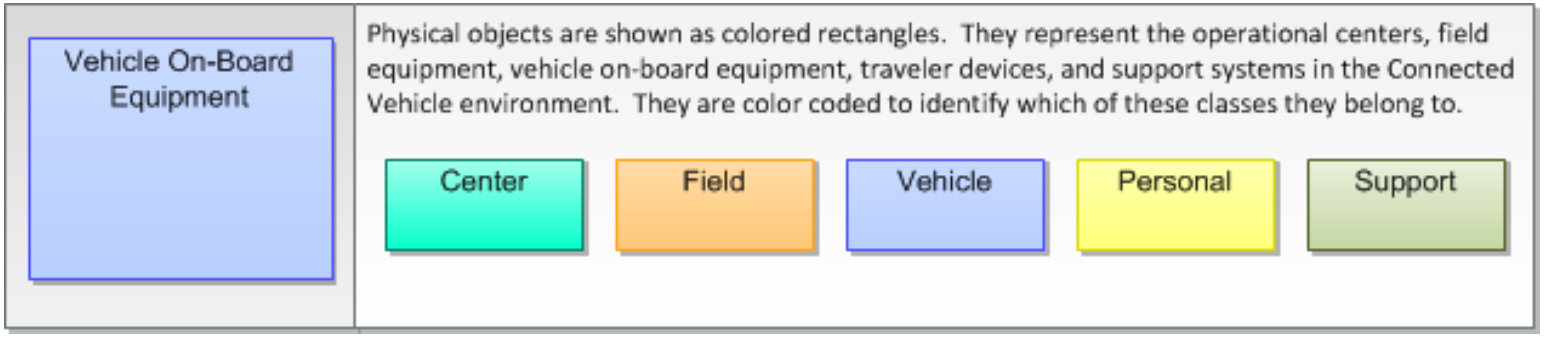
Complete Architecture shown in a set of views

- Physical view **[*THINGS*]** – overviews and specifics of objects and the information that flows between them, hierarchically arranged to show varying levels of detail.
- Enterprise view **[*PEOPLE*]** – includes installation, operations, maintenance and certification diagrams for each physical diagram
- Communication views **[*INFORMATION*]** – one for each information flow

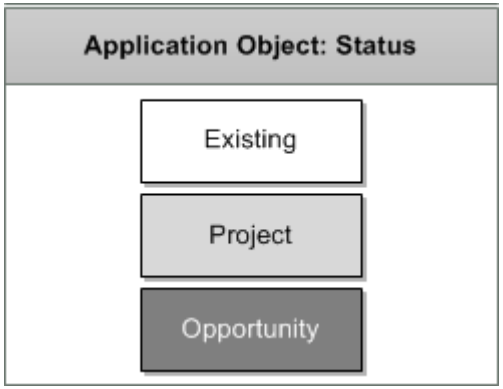
Southeast Michigan Project Architecture

- **Physical View**
  - Layer 0: The physical objects that participate, the interconnects between them
  - Layer 1: The project-specific functions performed by each physical object, and the data exchanged between them
  - Layer 2: Application-specific; shows only those objects that are part of the application, with more detail on the flow of data
- **Enterprise View**
  - Layer 0: The people and agencies that own and operate physical objects
  - Layer 1: The people and agencies that own and operate physical objects and application objects
- **Communications View**
  - For each information flow in the Physical View, the layered communications protocols necessary to implement the information flow

Physical View Architecture Constructs: Objects

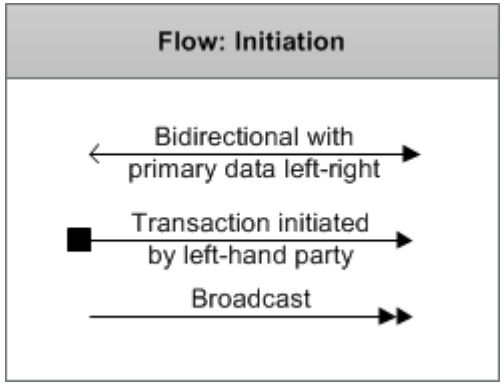


Application objects are also categorized according their implementation within the project.

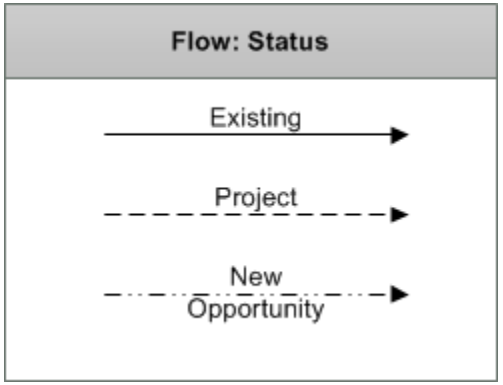


Physical View Architecture Constructs: Flows

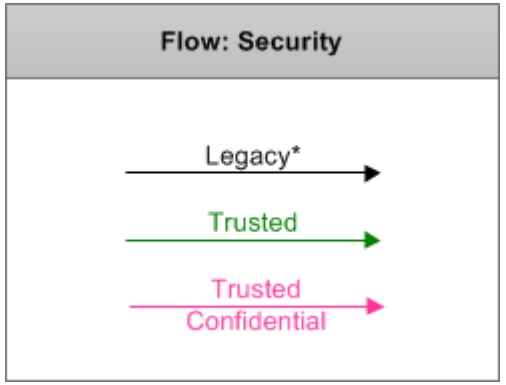
- Which device initiates the flow?
- What is the communication pattern?



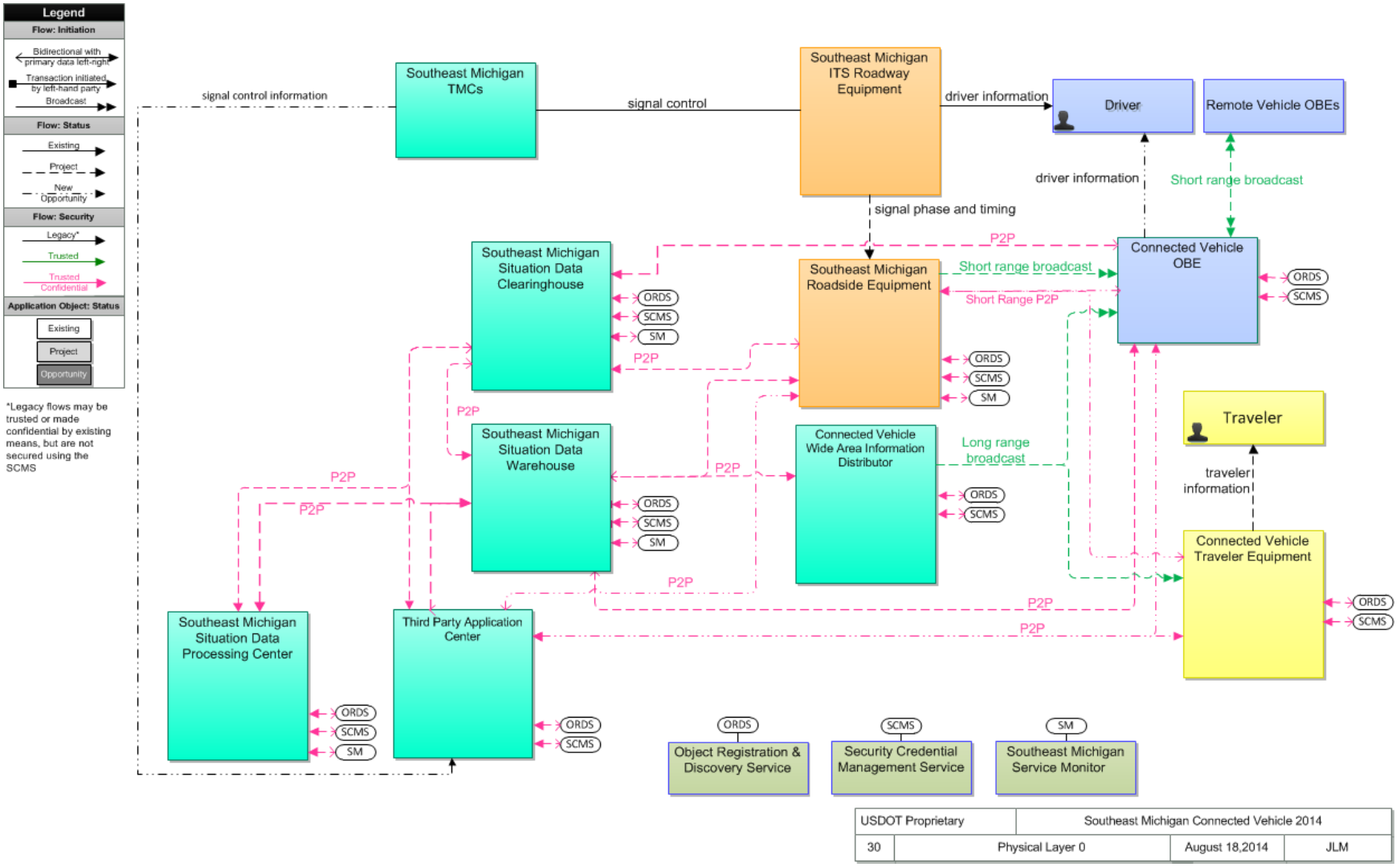
- Does the flow exist?



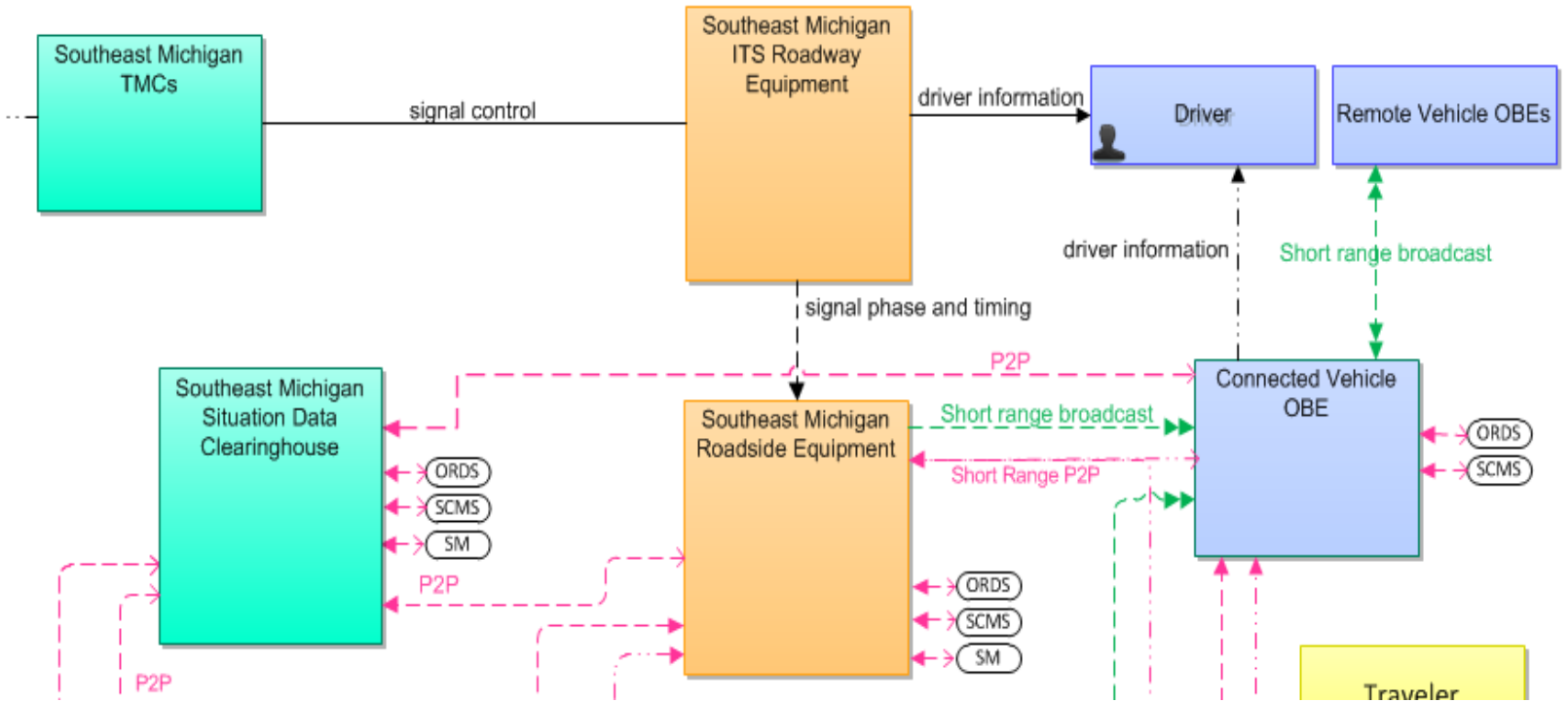
- What type of security does the flow require?



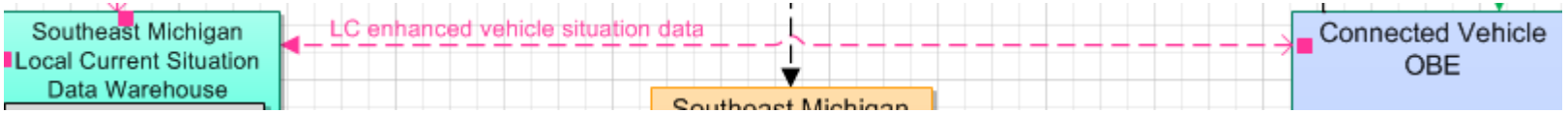
Physical View – Southeast Michigan 2014 Layer 0



Physical View Layer 0 Example



Physical View – LC Enhanced Situation Data



From this snippet we can see that the LC enhanced vehicle situation data flow has the following characteristics:

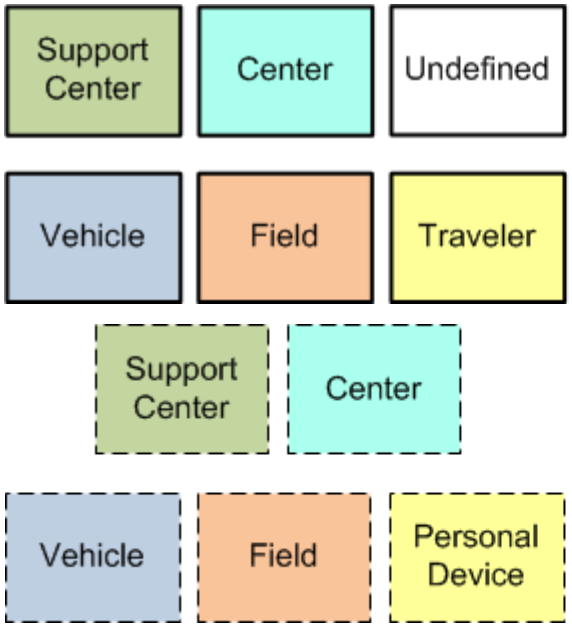
- The Connected Vehicle OBE initiates this data exchange
- This flow is encrypted and signed
- This flow is part of the testbed development

Communications View – LC Enhanced Situation Data

Vehicle-Center (RSE)					
LC Enhanced Vehicle Situation Data ->					
Southeast Michigan Connected Vehicle OBE Vehicle OBE Situation Data Generation		Roadside Equipment			Southeast Michigan Local Current Situation Data Warehouse Data Collection and Aggregation
SAE J2735 (2009) – Sequence Design					SAE J2735 (2009) – Sequence Design
ASN.1 BER					ASN.1 BER
(session layer unused)					(session layer unused)
UDP	IEEE 1609.2			IEEE 1609.2	UDP
IPv6		IPv6	IPv6		IPv6
1609.3, 802.2, 802.11p		1609.3, 802.2, 802.11p	IEEE 802.2		IEEE 802.2
5.9 Ghz wireless (802.11p) / 1609.4		5.9 GHz wireless (802.11p), 1609.4	Backhaul PHY[2]		Backhaul PHY[2]

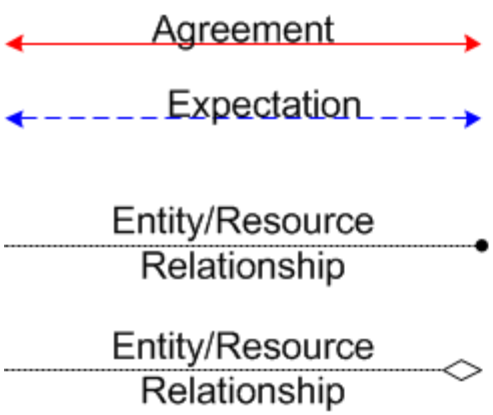
2: An Internet connection or private network connection that is routable between the RSE and the Southeast Michigan Local Current Situation Data Warehouse

Enterprise View Architecture Constructs



Enterprise objects (people, organizations) are shown as boxes with thick black borders, color coded by their relationship to the transportation environment

Physical objects are color coded the same as in physical view diagrams, but shown as rectangles with dashed lines.



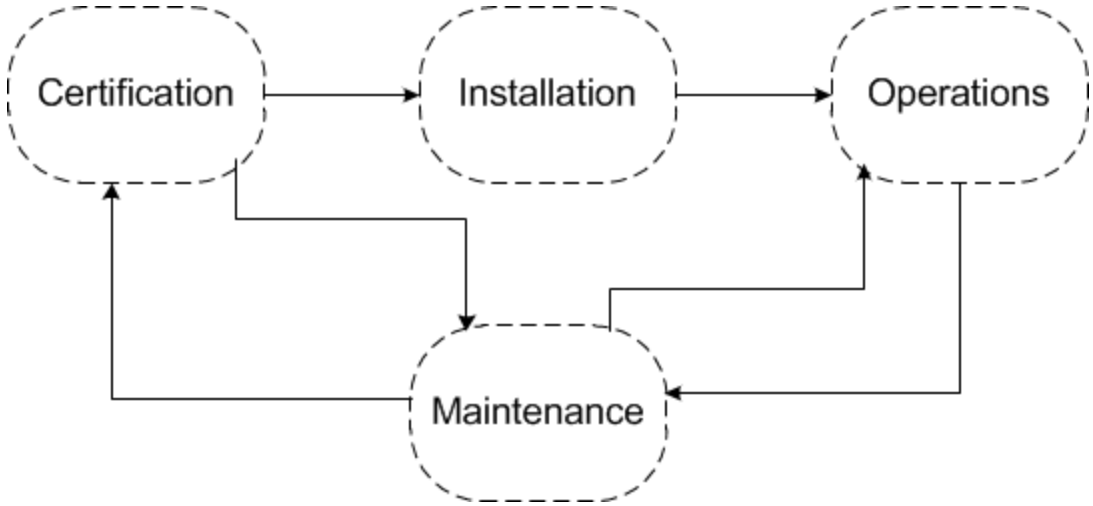
Formal coordination between people and/or organizations, documented in some contract or other form of written agreement that both parties acknowledge.

Information coordination between people and/or organizations, usually undocumented.

Relationship between people and/or organizations (e.g., member of) or between people/organizations and physical objects (owns, operates, maintains, installs, certifies etc.)

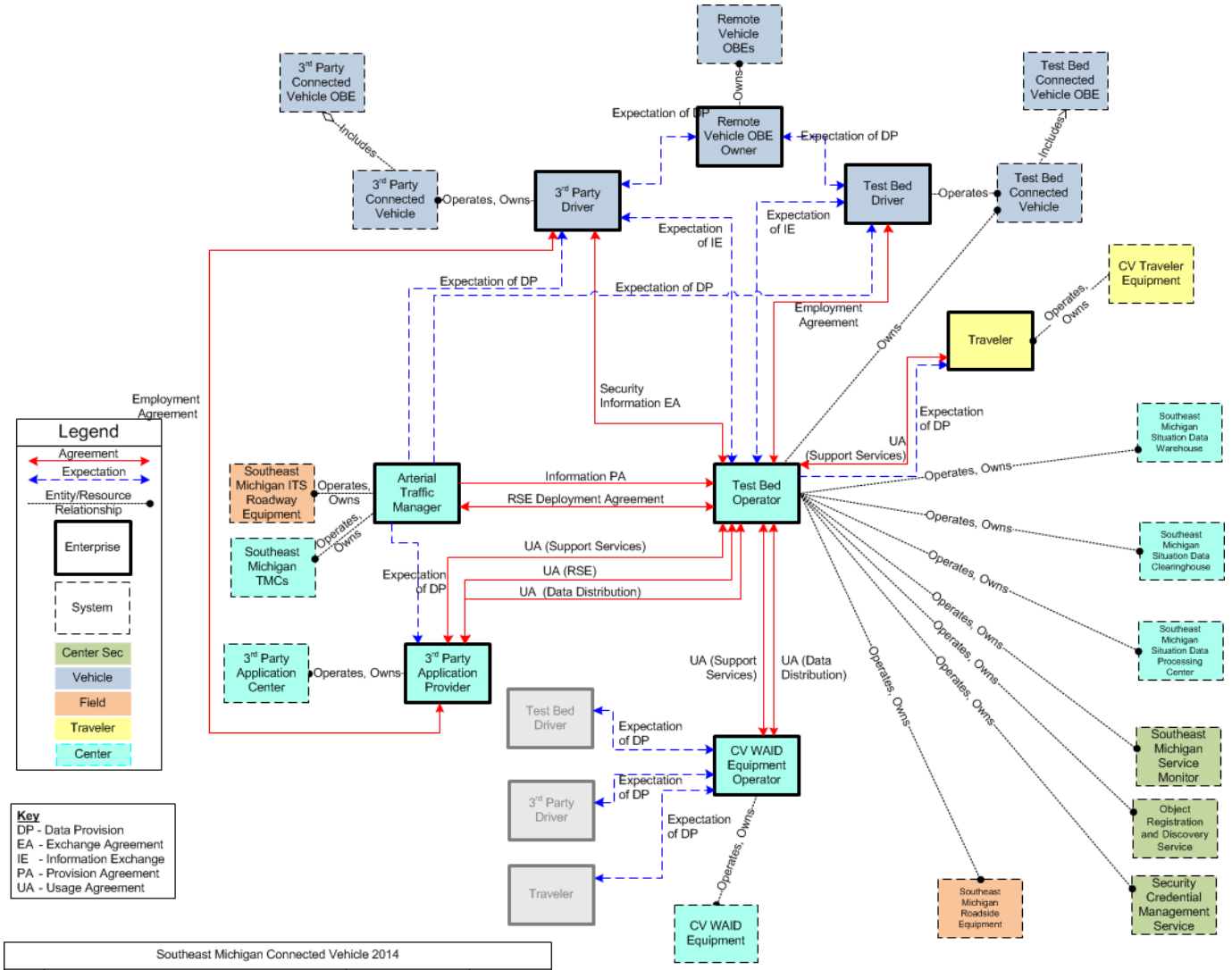
Relationship between physical objects that is relevant to people and/or organizations: includes, extends

Enterprise View – Life Cycle

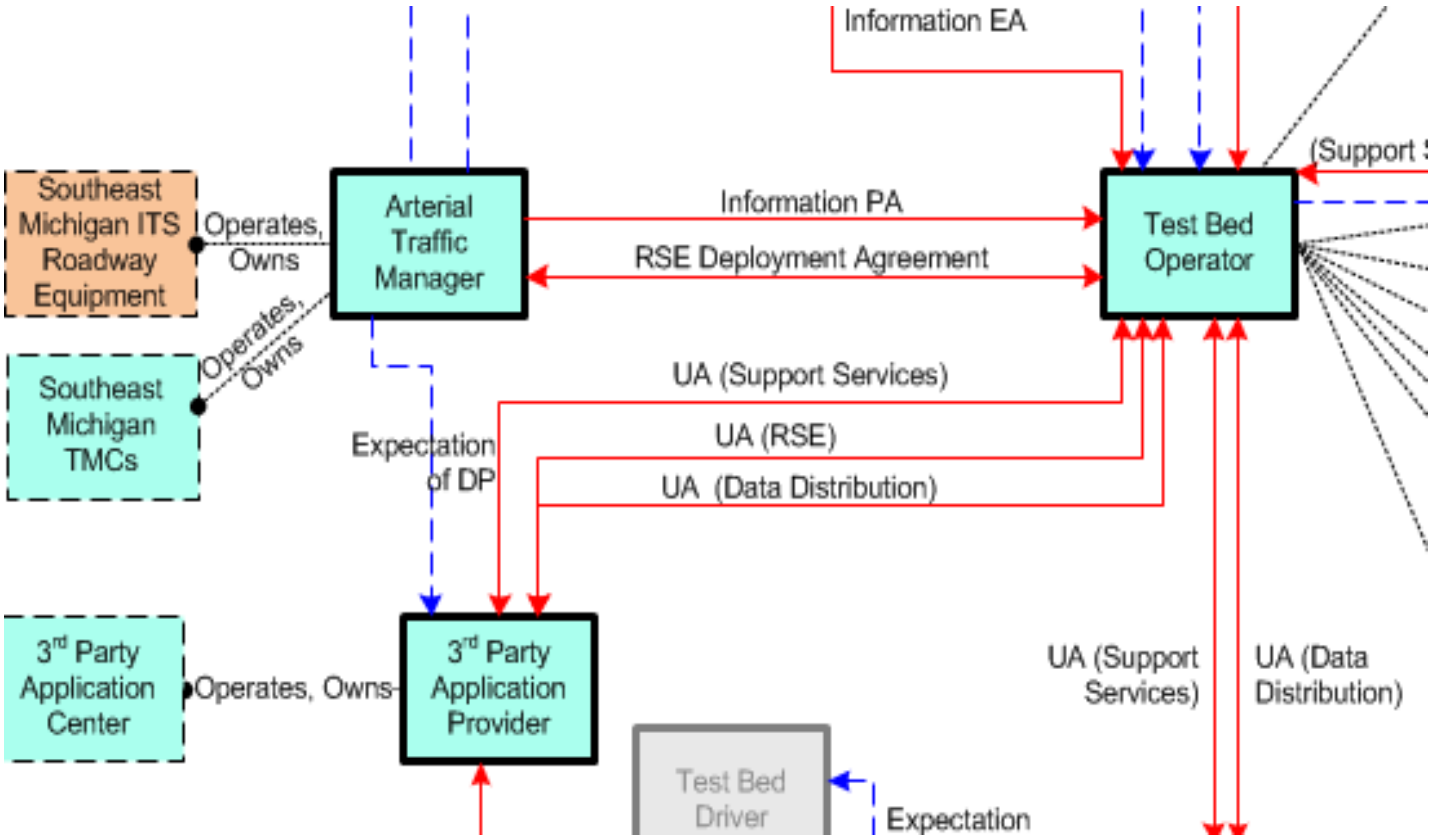


- Certification Phase: application and device approval, adherence to standards
- Installation Phase: deployment of applications and devices
- Operations Phase: operation of applications to provide benefits to end users
- Maintenance Phase: maintenance of applications and devices, and feedback of performance

Enterprise View – Southeast Michigan 2014



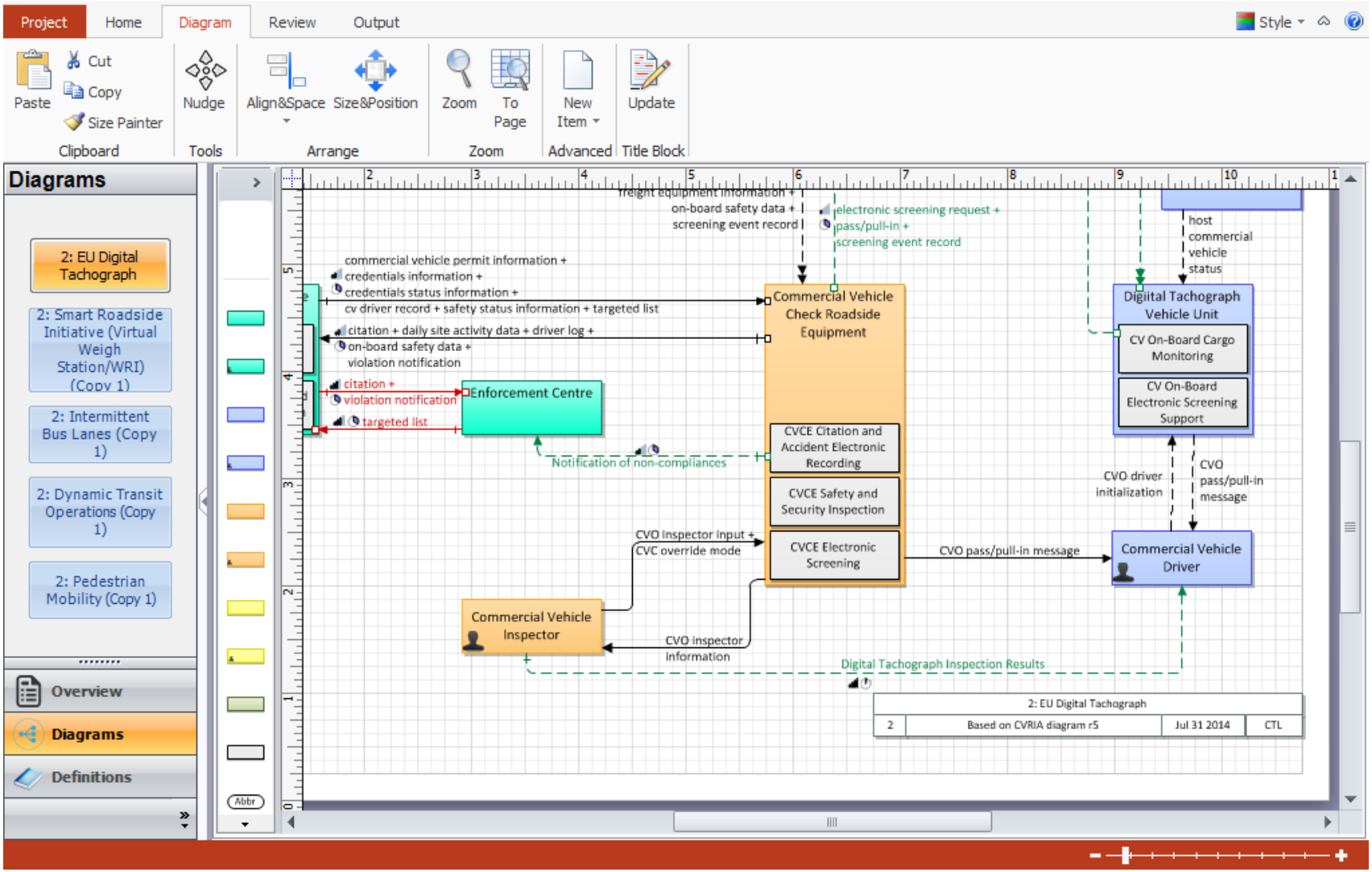
Enterprise View Layer 0 Example



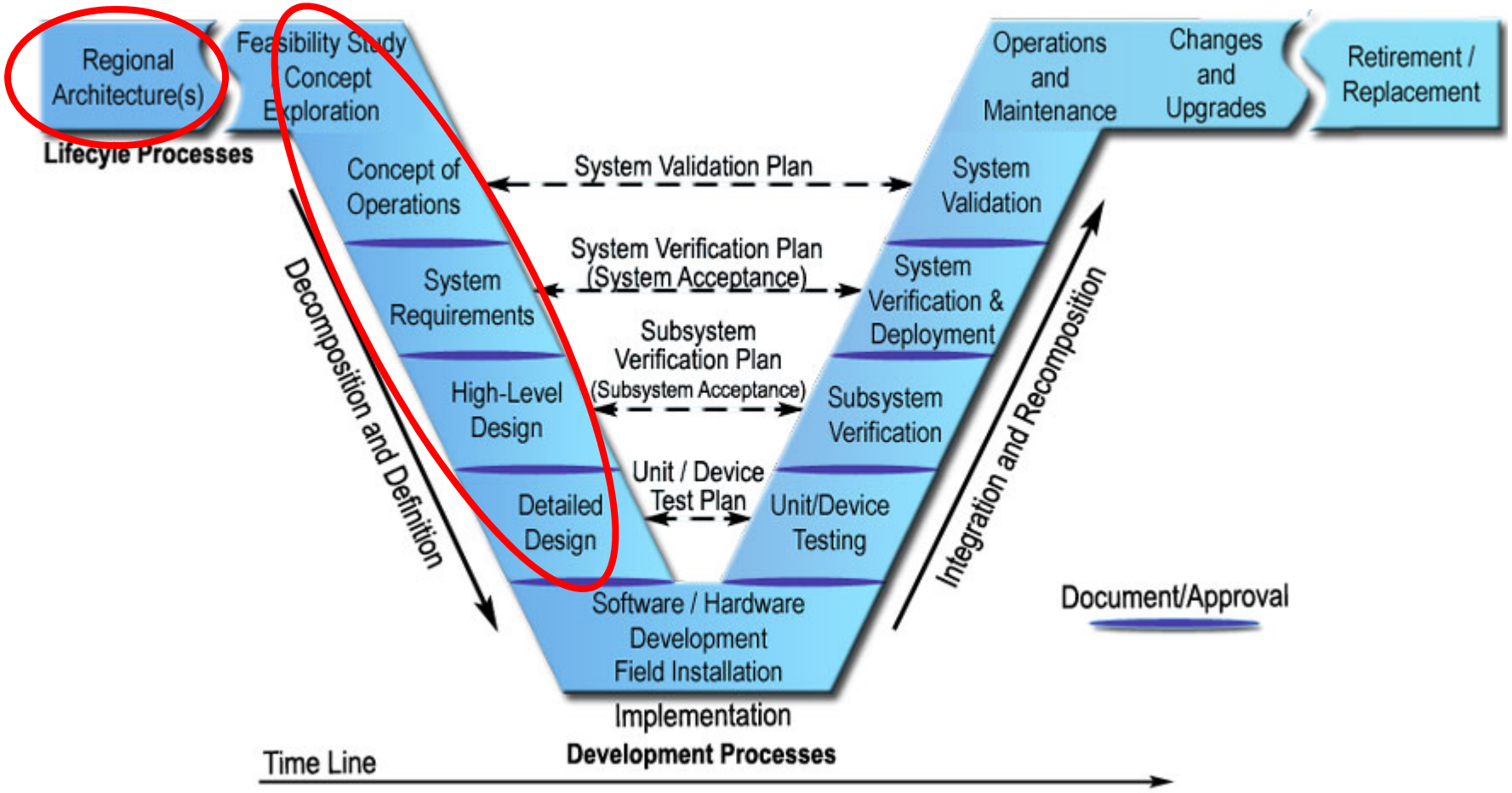
Project Architecture Tool Support

- All Southeast Michigan project architecture diagrams were drawn using the CVRIA Mini-Tool
- Short-term use method for drawing CVRIA-like diagrams, using the viewpoint specifications defined in the CVRIA
- Enables a common language
- Enables information exchange and re-use
- Provides a rich backdrop of work that has already been done to define the 85+ applications USDOT has already considered in some fashion

Architecture Tool



Architecture Tool Context



Concept of Operations: Key Concepts

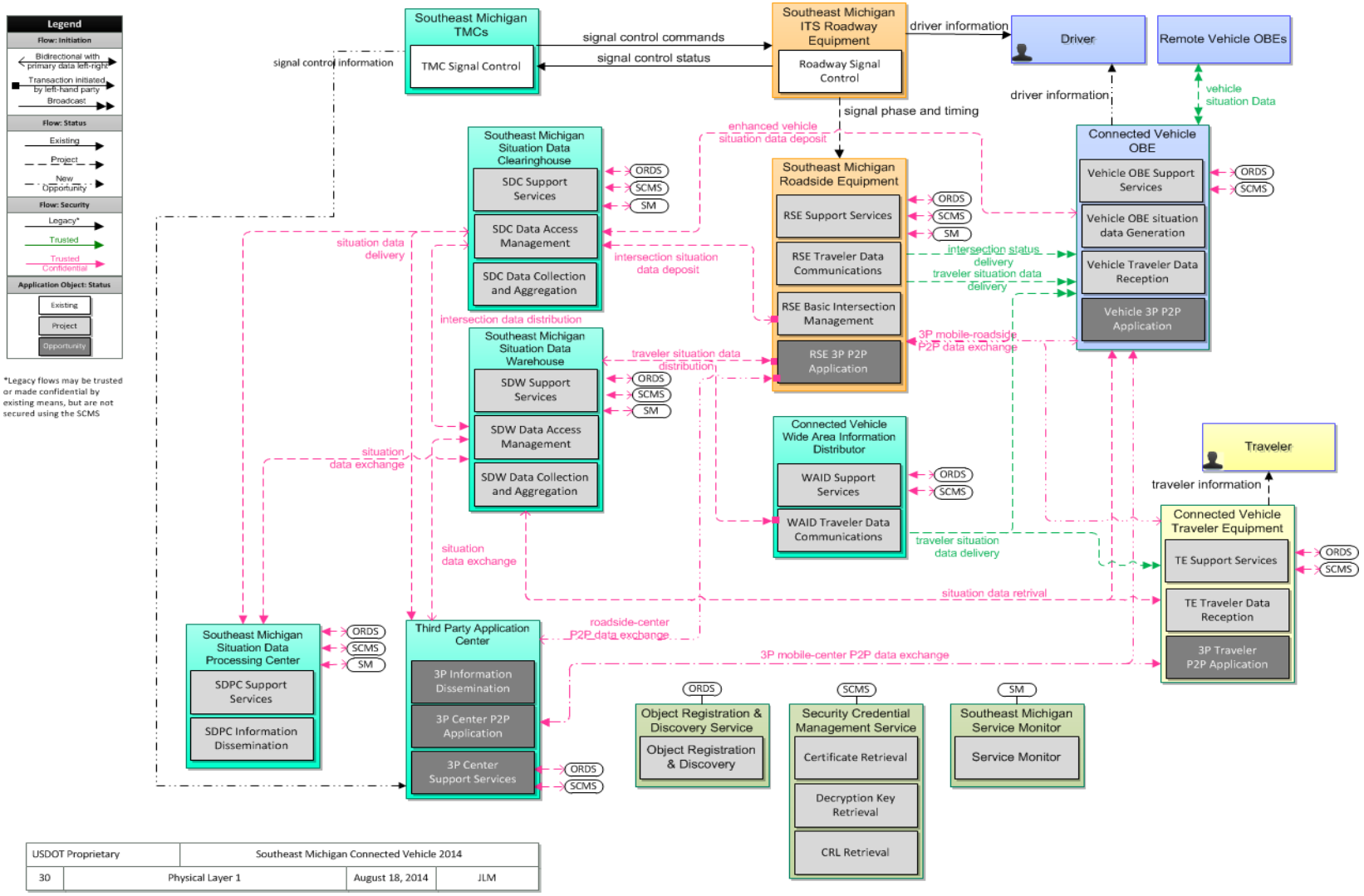
1. Test Bed Geographic Reference
2. Architecture
3. Data Context
4. Security by Design
5. Data Exchange Pattern
6. Operational Scenarios

ConOps: Geographic Reference

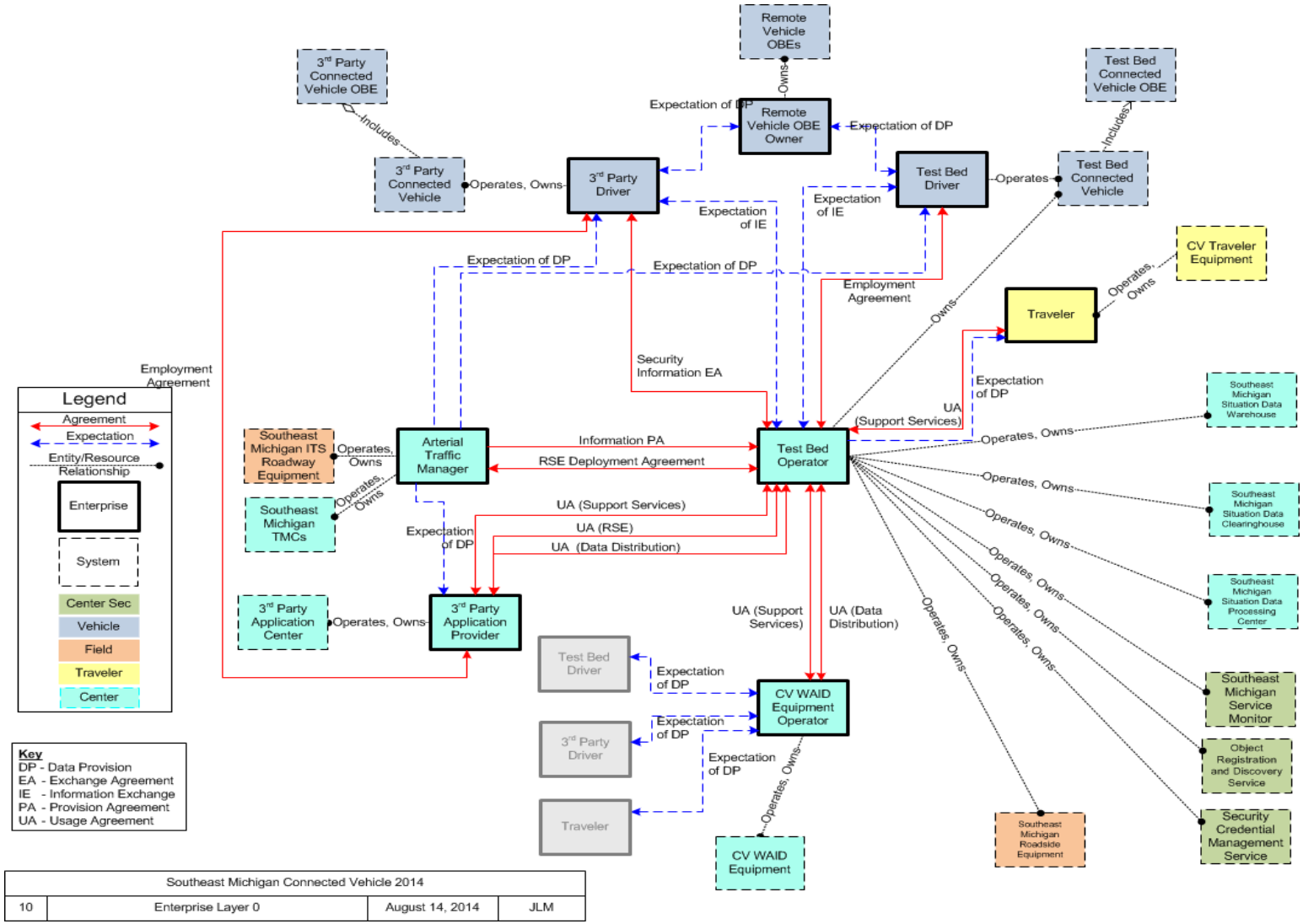
Geographic Reference

- The Test Bed is defined by a 2 degree by 3 degree rectangle
- Overlay grid of 10 millidegree^2 “tiles”
- This yields 60,000 identically sized and shaped tiles
- Each tile is identified by a pair of geo reference points for the NW and SE corners of the tile.

Concept of Operations: Architecture (L1 physical)



Concept of Operations: Architecture (enterprise)



Concept of Operations: Data Context

- Context of data:
  - Spatial relevance
  - Temporal relevance
- Security-related aspects of data:
  - Confidential?
  - Authenticable?
- Information flows are also characterized according to the delivery mechanism
  - Unicast
  - Broadcast
  - Initiator (source or destination)
- Development status:
  - Legacy/operational
  - Project/developing-deploying
  - Opportunity

ConOps: Concept - Security by Design

Security by Design is a guiding principle and one of the foundational concepts behind the goals and overall design of the 2014 Southeast Michigan Test Bed.

Concept of Operations: Data Exchange Pattern

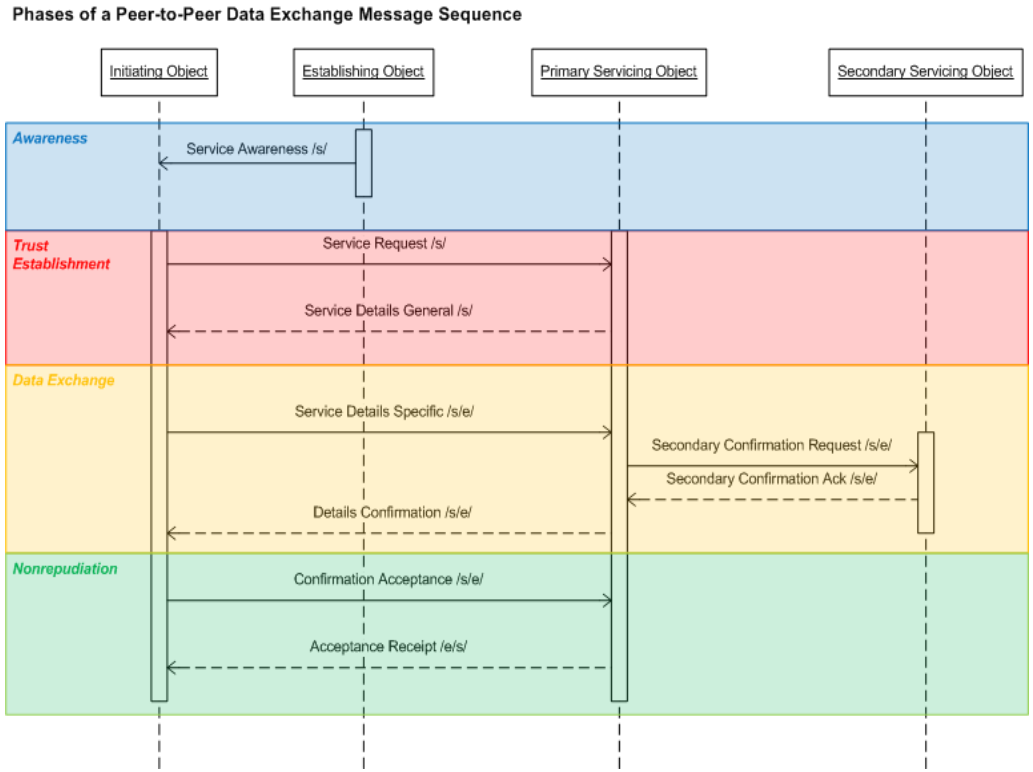
- Each Information Flow will follow this pattern
- There are four stages of the pattern

Service Awareness ▶

Trust Establishment ▶

Data Exchange ▶

Non-Repudiation ▶



ConOps: Example Operational Scenarios

1. **Enhanced Vehicle Situation Data** …generated by a CV OBEs and deposited in the Local Current Situation Data Warehouse. Delivered, based on subscribed criteria to the Situation Data Processing Center, and possibly one or more Third Party Application Centers
2. **Traveler Situation Data Broadcast** …an traveler (advisory) message and its associated dispatch instructions are generated by the Situation Data Processing Center or a Third Party Application Center and send to the Regional Historic Situation Data Warehouse. The Warehouse validates and sorts these messages into data stores based on the geographic area associated with the advisory message. Each RSE periodically requests advisory messages within a geographic boundary and constructs a radio "playlist" based on each messages dispatch instructions. Passing vehicles are able to receive these messages.

ConOps: Example Operational Scenarios

3. **Traveler Situation Data Broadcast** …an traveler (advisory) message and its associated delivery instructions are generated by the Situation Data Processing Center or a Third Party Application Center and send to the Regional Historic Situation Data Warehouse. The Warehouse validates and sorts these messages into data stores based on the geographic boundary associated with the advisory message. Connected Vehicles may periodically requests advisory messages within a geographic boundary. The Warehouse will bundle and deliver these messages to the requesting vehicle.
4. **Intersection Situation Data** …RSEs will generate periodic snapshots of Signal Phase & Timing (SPaT) messages. These will be bundled by each RSE, along with the current MAP, and deposited at the Regional Historic Situation Data Warehouse. Connected Vehicles may periodically requests advisory messages within a geographic boundary. The Warehouse will bundle and deliver these messages to the requesting vehicle.

High Level Design: Key Concepts

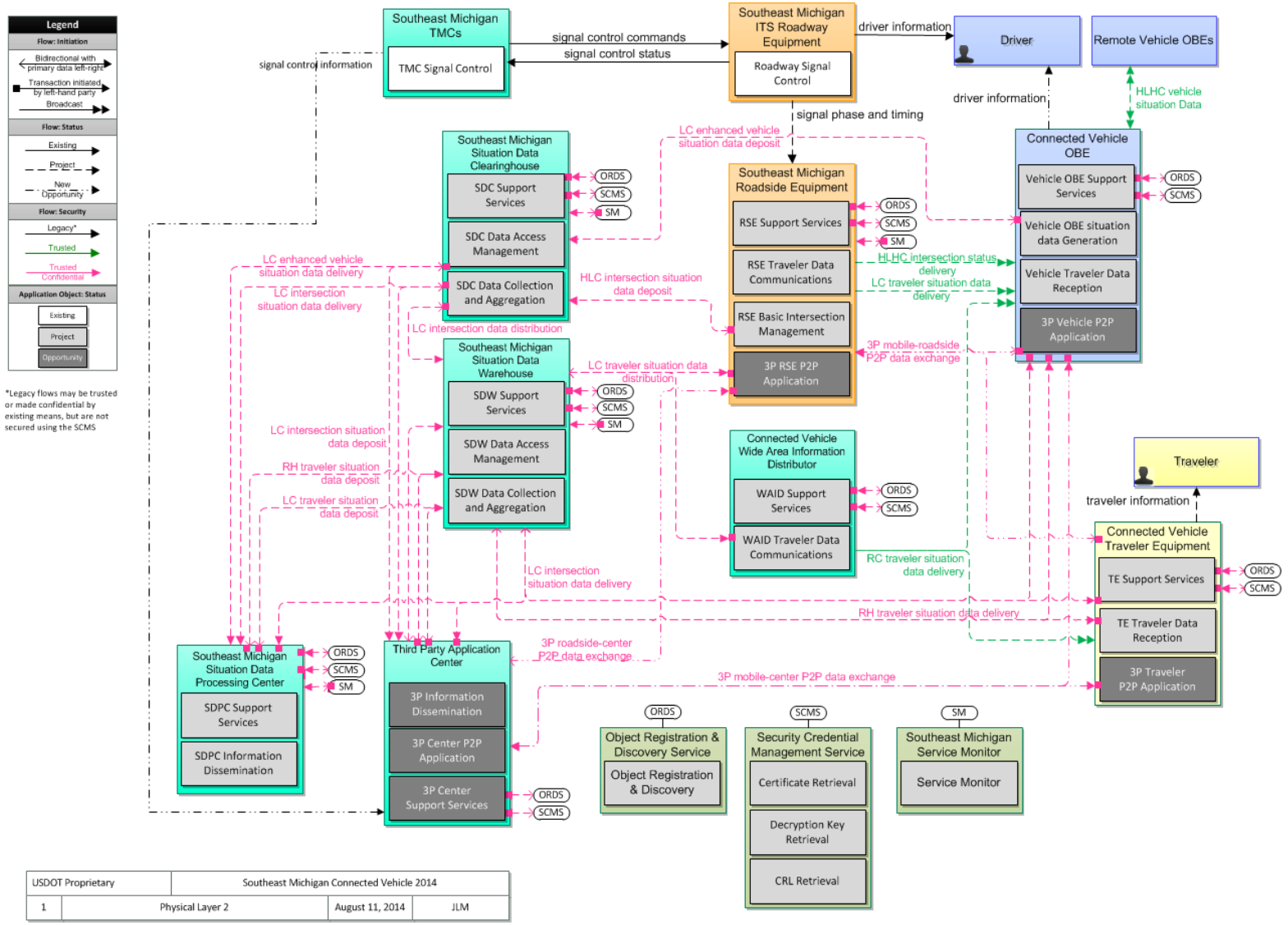
1. Layer 2 architecture

2. Detailed Communications View:

    1. Data Bundles

    2. Information flow state transition

HLD: Architecture Layer 2



USDOT Proprietary	Southeast Michigan Connected Vehicle 2014		
1	Physical Layer 2	August 11, 2014	JLM

High Level Design: Concept - Bundles

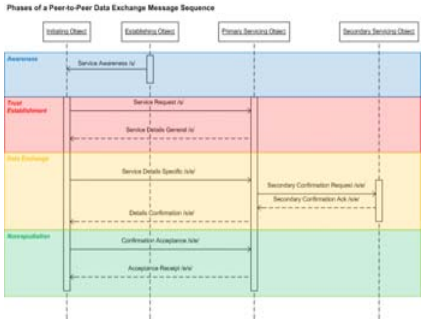
- Individual data objects (records) can be concatenated into a single consolidated data object call a “bundle”
- Contents of the APDU Header and APDU Body will be tailored for each information flow.
  - Security Header
  - APDU Header
  - APDU Body
  - Security Trailer
  - Contents of the Bundle Header and Bundle Main Body will be tailored for each information flow.

Header Segment		1609.2 Header	
		APDU Type = (see table below)	
		Body Length	
		Bundle Generation Time	
		Bundle Generation Location	
		Total Bundle Count	
Body Seg.	SAE J2735 EVSM 1	Safety Pilot BSM	Other Data Elements
	SAE J2735 EVSM 2	Safety Pilot BSM	Other Data Elements
	SAE J2735 EVSM 3	Safety Pilot BSM	Other Data Elements
	SAE J2735 EVSM 4	Safety Pilot BSM	Other Data Elements
	SAE J2735 EVSM 5	Safety Pilot BSM	Other Data Elements
	SAE J2735 EVSM 6	Safety Pilot BSM	Other Data Elements
	SAE J2735 EVSM 7	Safety Pilot BSM	Other Data Elements
	SAE J2735 EVSM 8	Safety Pilot BSM	Other Data Elements
		1609.2 Trailer	

HLD: Information Flows

Information flows will be described in a consistent framework…

- A tailored Message Sequence Diagram will be presented.
- Each of the four phases of the tailored message sequence will be sequentially described.
- Each phase description may include a high level description of message contents



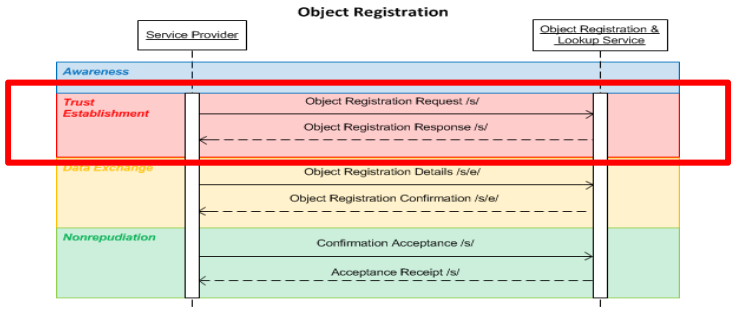
Object Registration – Trust Establishment

The Object Registration – Trust Establishment function provides a mechanism for a Southeast Michigan Test Bed objects to register with the Object Registration & Discovery Service their intent to have other Test Bed object made aware of their service offering.

Trust establishment will require that the Test Bed object previously obtain the appropriate security credential from the Security Credential Management Service (SCMS). Registered objects do not need to unregister, as the registration itself has a specified lifespan. Using the appropriate security credentials, the Test Bed object will generate, sign and send the following Service Registration Request Message to the Object Registration & Discovery Service.

Field	Description
EVSD Type[1]	• 'Fundamental EVSM Bundle Deposit" indicating that each record consists of Safety Pilot BSM & Other Data Elements • "Road Weather EVSM Bundle Deposit" indicating that each record consists of the Safety Pilot BSM & Road Weather Data Elements • "Environment EVSM Bundle Deposit" indicating that each record consists of the Safety Pilot BSM & Environmental Data Elements • "Electrical Vehicle EVSM Bundle Deposit" – indicating that each record consists of the Safety Pilot BSM & Electrical Vehicle Data Elements
Bundle Generation Time	The timestamp of when the bundle was generated. Bundles with a Bundle Generation Time value indicating that the bundle was generated before the time threshold based on the current value of the configurable (default 20 minutes) "EVSD Bundle Life Span" interval will be discarded.
Bundle Generation Location	The geographical location where the bundle was generated. Bundles with a Bundle Generation Location value indicating that the bundle was generated outside the defined Southeast Michigan Test Bed geographic region will be discarded. Bundles with a Bundle Generation Location value indicating that the bundle was generated within the defined Southeast Michigan Test Bed geographic region will be accepted.
Total Bundle Count	The number of bundles that are part of the delivery. This field is not used for bundle deposits, as each deposited bundle will be sent in a separate transaction.
EVSD Messages	One or more Enhanced Vehicle Situation Data Messages of the type indicated in EVSD Type

HLD: Object Registration Flow

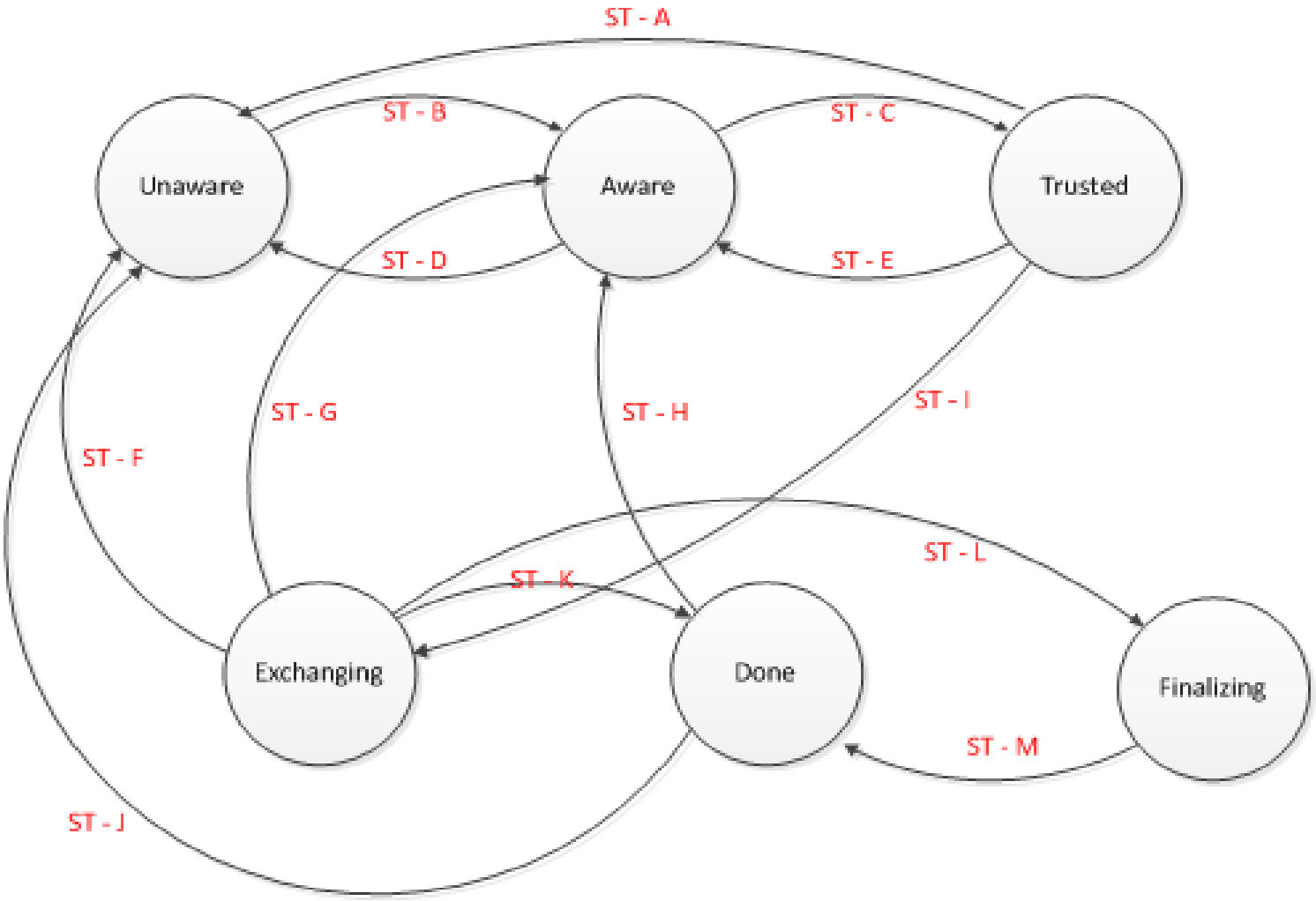


Initiating Object	Receiving Object	Signed?	Encrypted ?	Resend?
RSE, SDC, SDW, TPAC	ORDS	Yes	No	Yes

	IEEE 1609.2 Header
Header Segment	APDU Type="Object Registration Request"
	Flow Identifier
	Body Length="0"
	IEEE 1609.2 Trailer

Object Registration Request	Description
APDU Type	A unique identification of the type of an Application Protocol Data Unit. This identification can be used to distinguish different APDUs carried by messages for different purposes. It can be a single data field data element or a combination of multiple data fields data elements for APDU type identification
Flow Identifier	A temporary identification that is randomly generated by the initiating object for tracking subsequent transactions in a message sequence.
Body Length	Length of the body segment of the APDU

HLD: State Transition



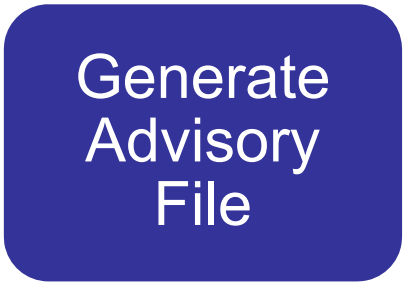
HLD: Valid State Transitions

State Transition	Start State	End State	Reasons
A	Trusted	Unaware	(1) Querying Object loses power (2) The ORDS loses power (3) Querying Object software crashes (4) ORDS discovery application crashes (5) Querying Object system reboots (6) ORDS system reboots
B	Unaware	Aware	Querying Object completes the Service Awareness phase with the ORDS
C	Aware	Trusted	Querying Object completes the Trust Establishment phase with the ORDS
D	Aware	Unaware	(1) Querying Object loses power (2) The ORDS loses power (3) Querying Object software crashes (4) ORDS discovery application crashes (5) Querying Object system reboots (6) ORDS system reboots
E	Trusted	Aware	(1) Security credential information of the Querying Object is no longer valid (2) Security credential information of the ORDS is no longer valid
F	Exchanging	Unaware	(1) Querying Object loses power (2) The ORDS loses power (3) Querying Object software crashes (4) ORDS discovery application crashes (5) Querying Object system reboots (6) ORDS system reboots
G	Exchanging	Aware	(1) Security credential information of the Querying Object is no longer valid (2) Security credential information of the ORDS is no longer valid
H	Done	Aware	Querying Object completes an Object Discovery dialouge with the ORDS
I	Trusted	Exchanging	Querying Object starts sending an Object Discovery Details message to the ORDS
J	Done	Unaware	(1) Querying Object loses power (2) The ORDS loses power (3) Querying Object software crashes (4) ORDS discovery application crashes (5) Querying Object system reboots (6) ORDS system reboots
K	Exchanging	Done	Not applicable
L	Exchanging	Finalizing	Querying Object starts the Nonrepudiation phase with the ORDS
M	Finalizing	Done	Querying Object completes the Nonrepudiation phase with the ORDS

Data Design

- Traveler Situation Data
- Intersection Situation Data

RSE 3.0



- Determine Broadcast Strategy
- Encode message
- Each file represents 1 Advisory Message

Requires operations personnel to determine\understand the broadcast strategy (i.e. PSID, DSRC Channel, Transmit Mode (Continuous or Alternating), message priority, signature, encryption, etc.)

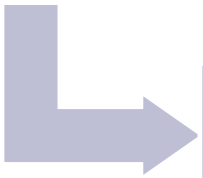
- Log into RSU
- Install file(s) in appropriate Directory

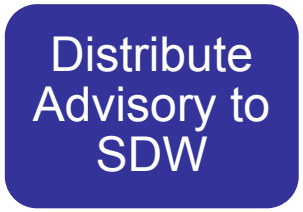
Requires operations personnel to have direct access to all RSUs and be knowledgeable in the operations of RSUs from multiple vendors.

- Broadcast by the RSU as DSRC WSMP Messages according to the broadcast instructions

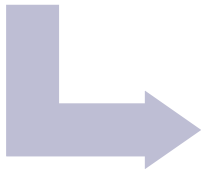
2014 Architecture

- Encode message

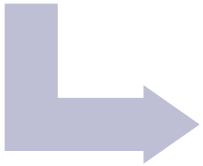




- Through the *RH traveler situation data deposit* interface



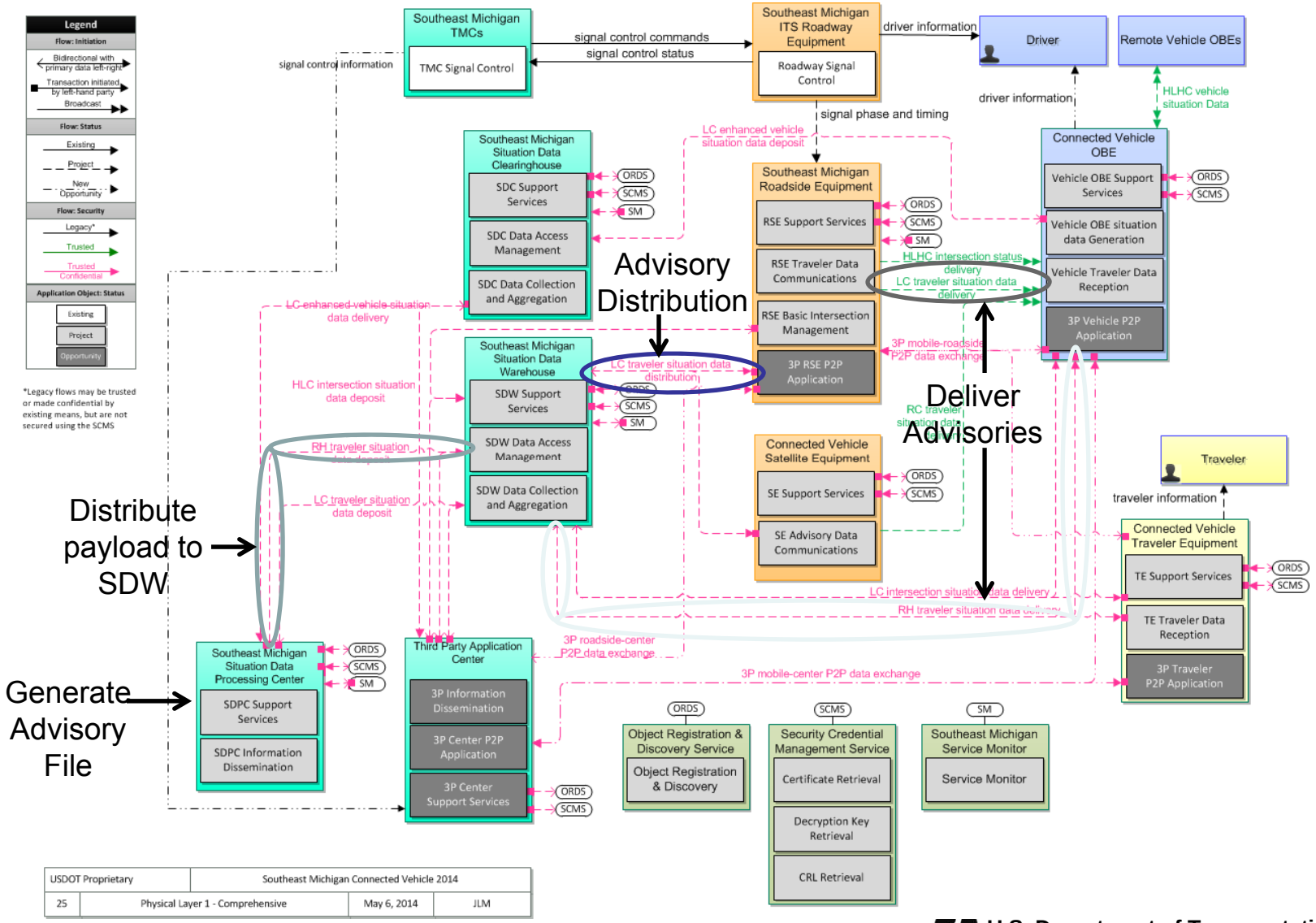
- Through the *LC traveler situation data distribution* interface for broadcast by RSU
- Or through the *RH traveler situation data delivery* interface for IP distribution directly to vehicles



- Through the *LC traveler situation data delivery* interface for broadcast by RSU as DSRC WSMP Messages, according to broadcast instructions
- Vehicles request bundles of advisories for a given, broader, geographical region, via IP

- Automates the message distribution process
- Situation Data Warehouse (SDW) assigns broadcast instructions\strategy based on message type
- Reduces knowledge base requirement of operations personnel
- Requires personnel to only have access to a single location (SDW)

2014 Architecture



GUI – based conventions, example 1

- Two lane roads, two-way stop signs.

Message ID: 7

Message Count: 0 (0 - 127)

Layer Type: 3 (Optional)

Select Number of Intersections 1

Next Step

- Screen 1 of the GUI:

- Message count can be varied.
- Layer Type 3 is intersection data.

Cont.

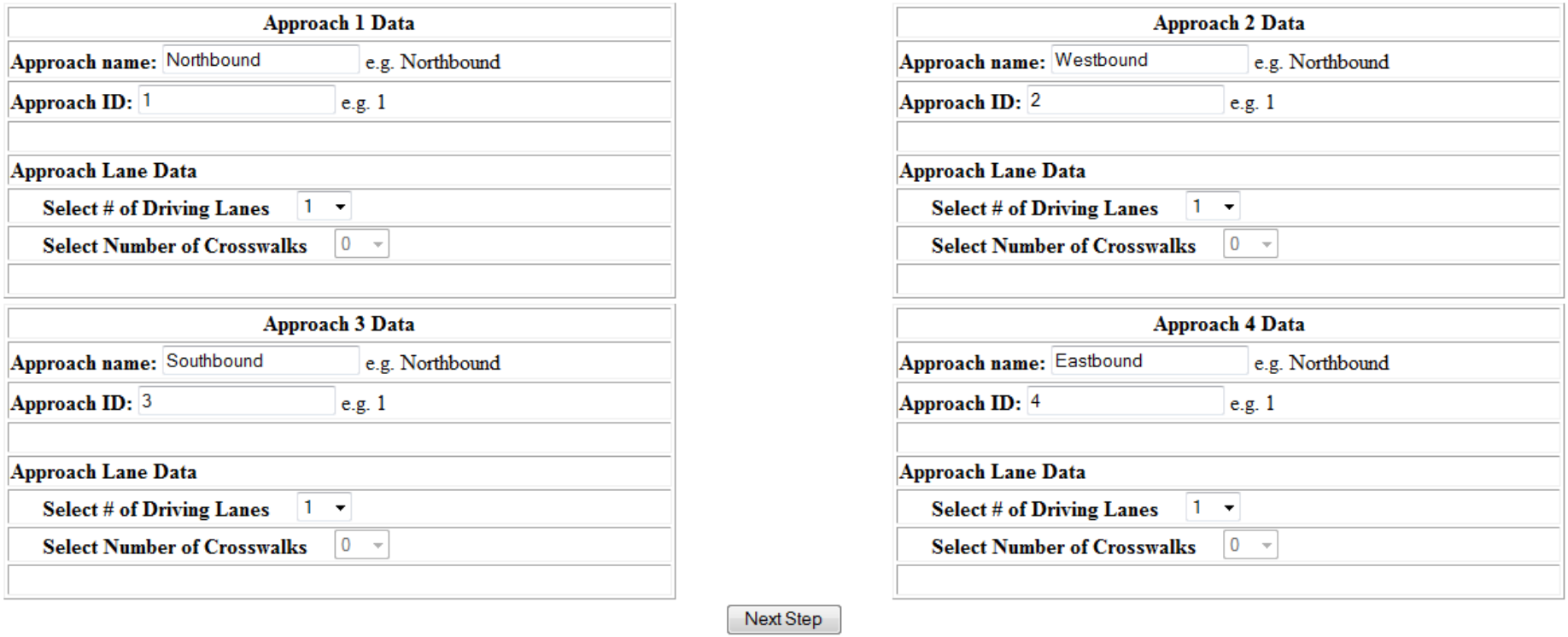
- Screen 2, Intersection location and ID:
- Reference point data is the location of the center of the intersection.
- Intersection ID is calculated from Lat, Lon, Elv values.

Intersection Sequence Data 1	
Descriptive Name: 1200N, Woodford Co, IL (Optional, Max Length = 63) e.g. Major Street and Minor Street, City, ST	
Reference Point Data - Use Decimal Degrees Notation	
Latitude: 40.765020	e.g. 42.12345
Longitude: -89.140284	e.g. -83.45678
Elevation: 224	(Optional) Enter Value in Meters
Intersection ID: C3FF22E0	Auto Generate Unique ID
Reference Intersection ID: 21004	(Optional)
Select Number of Approaches 4	

Next Step

Cont.

- Screen 3, Approaches:
- Start with Northbound at Approach number 1 and continue numbering counterclockwise.



Cont.

- Screen 5, ASN.1 encoded data:

Data Element and Value	Encoded Data
Message ID: 7	800107
Message Count: 0	810100
Layer Type: 3	830103
Number of Intersections: 1	
Intersection Descriptive Name: 2100E and 1200N, Woodford Co, IL	802032313030452061 6e6420313230304e2c20576f6f64666f726420
Intersection ID: C3FF22E0	8100

Approach Descriptive Name: Northbound	800a4e6f727468626f756e64
Approach ID: 1	810101
Number of Driving Lanes: 1	
Approach Drive Lane Number: 1	800101
Approach Drive Lane Width: 275	81020113
Approach Drive Lane Attributes: 14	82010e
Approach Drive Lane Offsets:	A310040600b0fcf800e004060000df1c00e0

3082011E80010781010083010 3A582010D3082010980203231303045 20
616E6420313230304E2C20576F6F64666F726420436F2C20494C8100A
2128004184C3F988104CADE45A88204000000E08302520CA781CA3031
A22F800A4E6F727468626F756E64810101A21E301C8001018102011382
010EA310040600B0FCF800E004060000DF1C00E03030A22E800957657
374626F756E64810102A21E301C800102810201138201 0EA31004060159
DC1300E004062E13000000E03031A22F800A536F757468626F756E6481
0103A21E301C800103810201138201 0EA3100406FF8B032900E00406000
0275900E03030A22E800945617374626F756E64810104A21E301C800104
8102011382010EA3100406FCA6FF9D00E00406D45C000000E087028191

SPaT

Approach Data		
Approach 1	Select Type of Light and Color for Approach	Set Time To Change
Lane Number: 1	Solid Ball	12002
	Green	
	State Confidence	
	Time Likely to Change	
Approach 2	Select Type of Light and Color for Approach	Set Time To Change
Lane Number: 2	Flashing Ball	12002
	Red	
	State Confidence	
	Time Likely to Change	
Approach 3	Select Type of Light and Color for Approach	Set Time To Change
Lane Number: 3	Solid Ball	12002
	Green	
	State Confidence	
	Time Likely to Change	
Approach 4	Select Type of Light and Color for Approach	
Lane Number: 4	Flashing Ball	
	Red	

- Stop signs will be encoded as a flashing Red Ball.
- Yield signs will be encoded as a flashing Yellow Ball.
- TimeMark will be encoded as 12002 - undefined time

Signal Phase Indications Encoding

	Green	Yellow	Red	Flashing
Ball	0x00000001	0x00000002	0x00000004	0x00000008
Left Arrow	0x00000010	0x00000020	0x00000040	0x00000080
Right Arrow	0x00000100	0x00000200	0x00000400	0x00000800
Straight Arrow	0x00001000	0x00002000	0x00004000	0x00008000
Soft Left Arrow	0x00010000	0x00020000	0x00040000	0x00080000
Soft Right Arrow	0x00100000	0x00200000	0x00400000	0x00800000
U-Turn Arrow	0x01000000	0x02000000	0x04000000	0x08000000

* Note: DARK = 0x00000000

The Signal Light State value is built by ORing the various bitmasks together for that approach.

DDateTime

Enter DDate Time or leave default value

201473113440

Time Stamp:	8004E8BBBD7F

- Absolute time when data elements are created.
- UTC within 1msec.
- DYear, DMonth, DDay,
- DHour, DMinute entered as integers.
- *DSecond entered as in integer in units of seconds.*

Bundle Header

Dialog ID:	800200A2
Sequence ID:	810105
Request ID:	820402E072F2
Bundle ID:	830101
Time To Live:	840102
Geo Region:	A51CA00C8004184C47098104CADE3BD4A10C8004184C38268104CADE4F7D
MAP Payload:	808201223082011E800107810100830103A582010D3082010980203231303045206 16E6420313
Time Stamp:	8004E8BBBD7F
SPAT Payload:	81363034800113A22f8100820100A528300882010183010486003008820102830104860030088 2
ISD Record	3082019B800200A2810105820402E072F2830101840102A51CA00C8004184C47098104CADE

- Geo Region automatically calculated based on the most Northerly, Westerly, Southerly, and Easterly points in lane definitions.

Key Takeaways

- Architecture is not just for planning anymore
- Cooperation and information sharing -> simpler, easier implementation
- Uniform approach yields faster implementation
- Too many choices!

Contact Information

- Walton Fehr - walton.fehr@dot.gov
- Tom Lusco - ctl@iteris.com
- Project Architecture SET-IT Tool: http://www.iteris.com/cvria/html/resources/tools.html
- CVRIA: http://www.iteris.com/cvria
- Test Beds: http://www.its.dot.gov/testbed.htm

CVRIA Update

David Binkley / Tom Lusco

CVRIA Update Topics

- CVRIA Orientation – Terminology and Structure
- CVRIA Updates from stakeholder inputs
- SET-IT tool walk-through
- Next steps over the next six months

Connected Vehicle Reference Implementation Architecture (CVRIA)

Basis is the National ITS Architecture and Core System Architecture

Requirements derived from a series of CV-related concepts of operations developed by the USDOT through 2012

CVRIA Development Project

USDOT project now underway:

- *Develop connected vehicle reference implementation architecture*
- *Systematically document and prioritize interfaces, available standards, and standards gaps*
- *Tactically engage key stakeholders for input and communication*
- *Identify policy and institutional issues*
- *Consider potential harmonization benefits/opportunities*

Interface Architecture

Enhance the National ITS Architecture, providing users with a framework for implementation

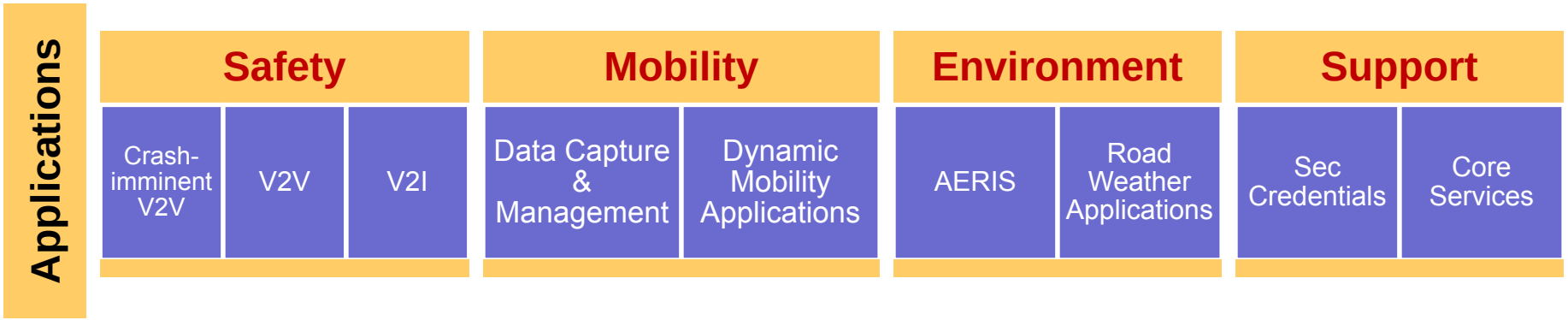
Standards Development Strategy & Plan

Define a roadmap to help USDOT meet its CV standardization objectives

Policy Options

Provide input to analysis to produce a policy foundation for architecture, standards, and certification

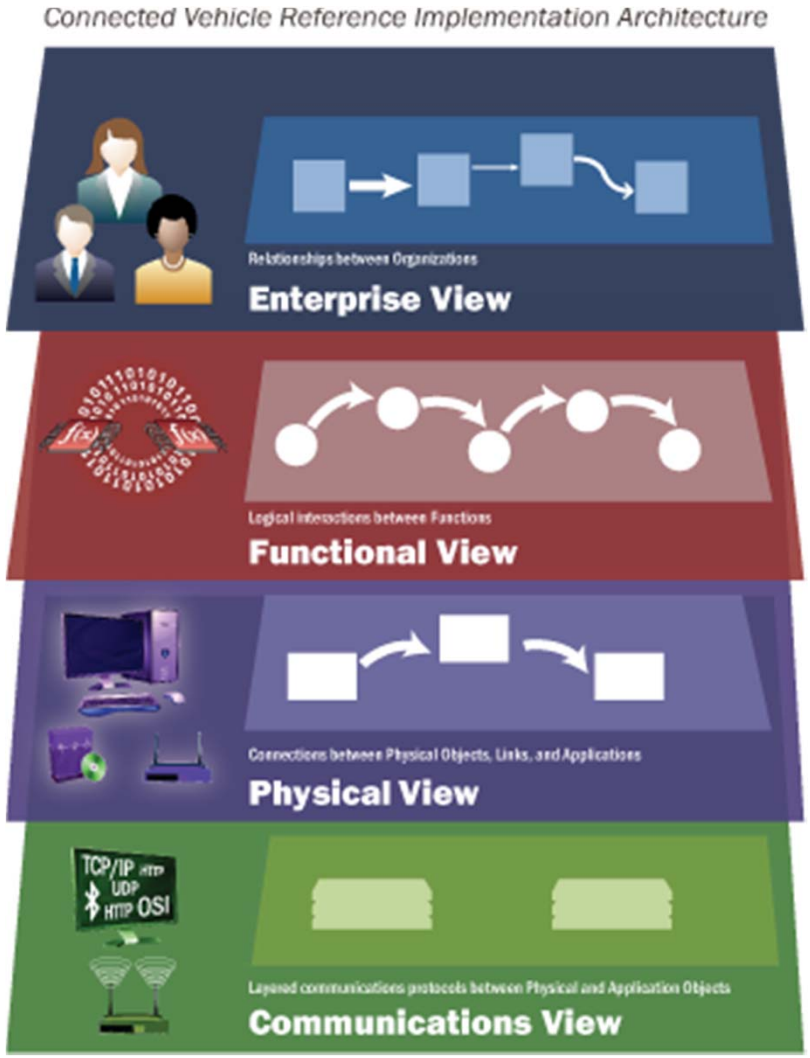
CVRIA Background and Purpose



- Looking ahead to a landscape of safety, mobility, and environmental applications with common supporting infrastructure based on common approaches, standardized interfaces
- With so many applications exposing so many opportunities for integration an architecture is needed to put the elements together
- Identifies:
  - Organizations
  - Users
  - Systems operated
  - Functions performed
  - Information exchanged
  - Communications protocols required

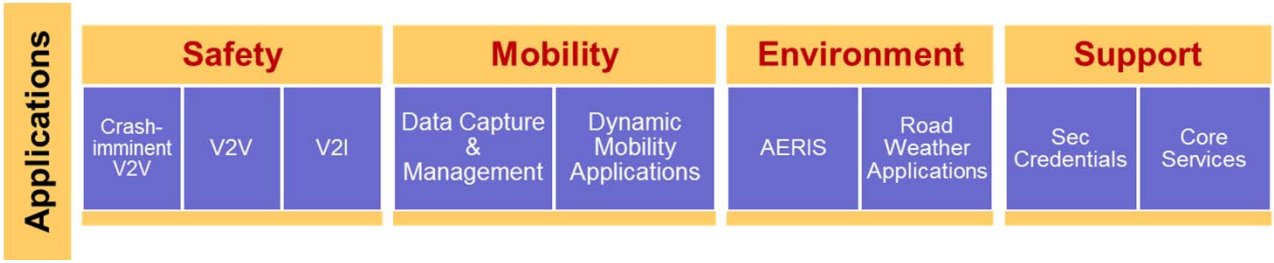
CVRIA Includes Multiple Views

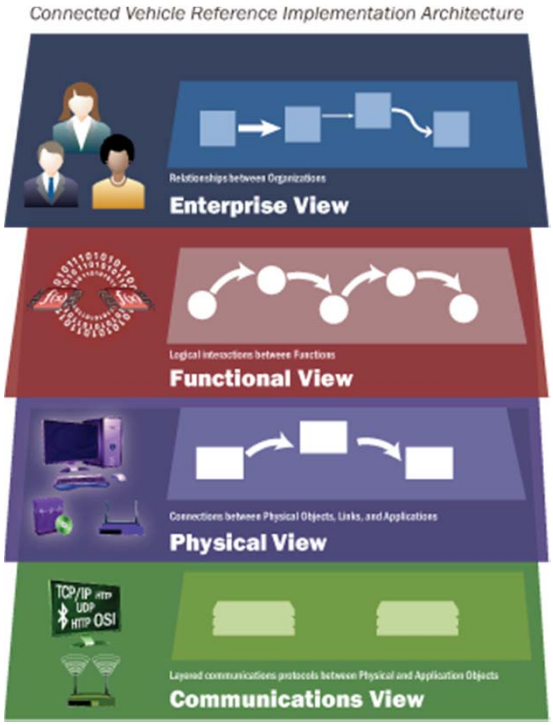
- Enterprise - Describes the relationships between organizations and the roles those organizations play within the connected vehicle environment
- Functional - Describes abstract functional elements (processes) and their logical interactions (data flows) that satisfy the system requirements
- Physical - Describes physical objects (systems and devices) and their application objects as well as the high-level interfaces between those physical objects
  - Interfaces provide potential standardization points
- Communications - Describes the layered sets of communications protocols that are required to support communications among the physical objects that participate in the connected vehicle environment

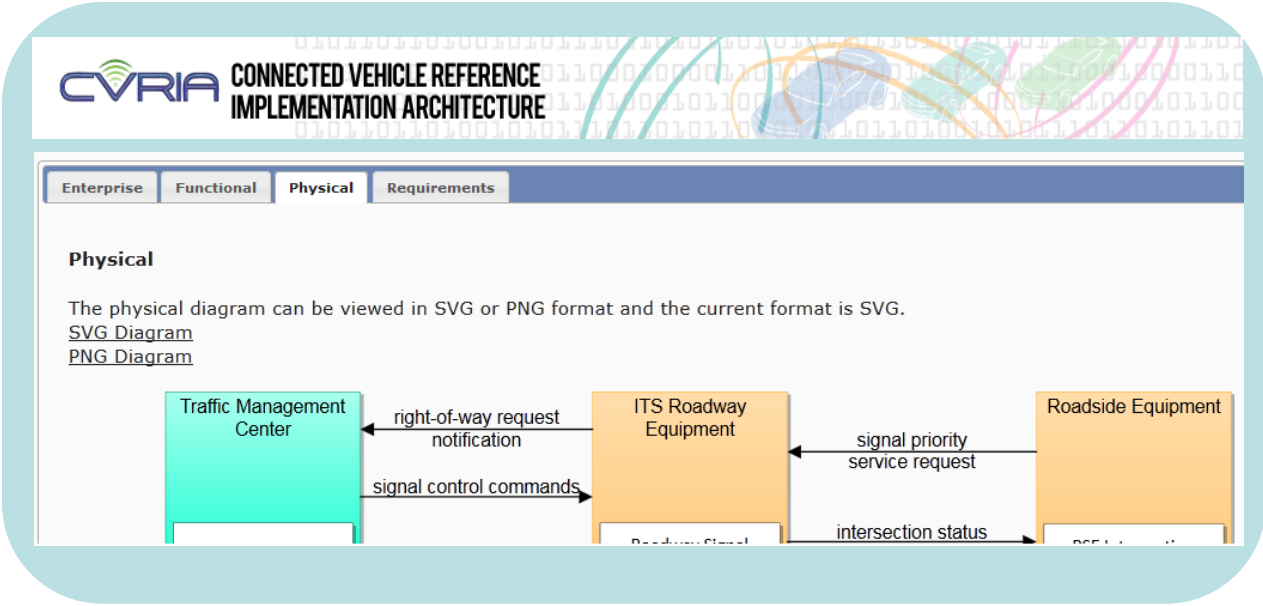


CVRIA Website Links Views to Applications

http://www.iteris.com/cvria/index.html

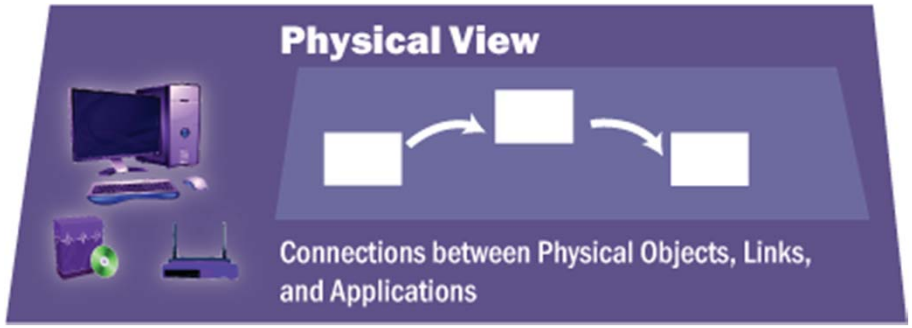




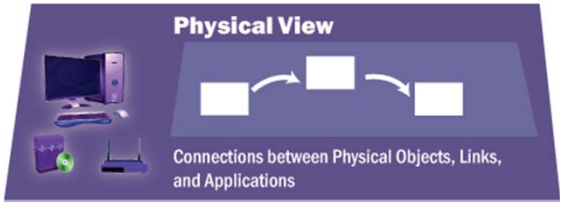


CVRIA Terminology

- Architecture Concepts and Terms that will be needed to discuss Interfaces and Standards
- Interfaces pull directly from the Physical and Communications Views



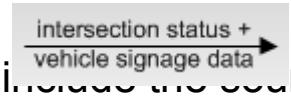
CVRIA Physical View Terms



- Depicted as a set of integrated Physical Objects that interact and exchange information to support the connected vehicle applications.
  - Color coded on diagrams to show 5 classes

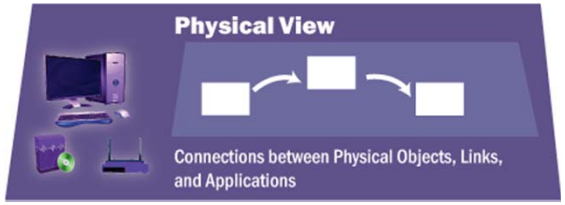
- Ph
  functionality and interfaces that are required to support a particular connected vehicle application.
  - White boxes inside the larger physical objects

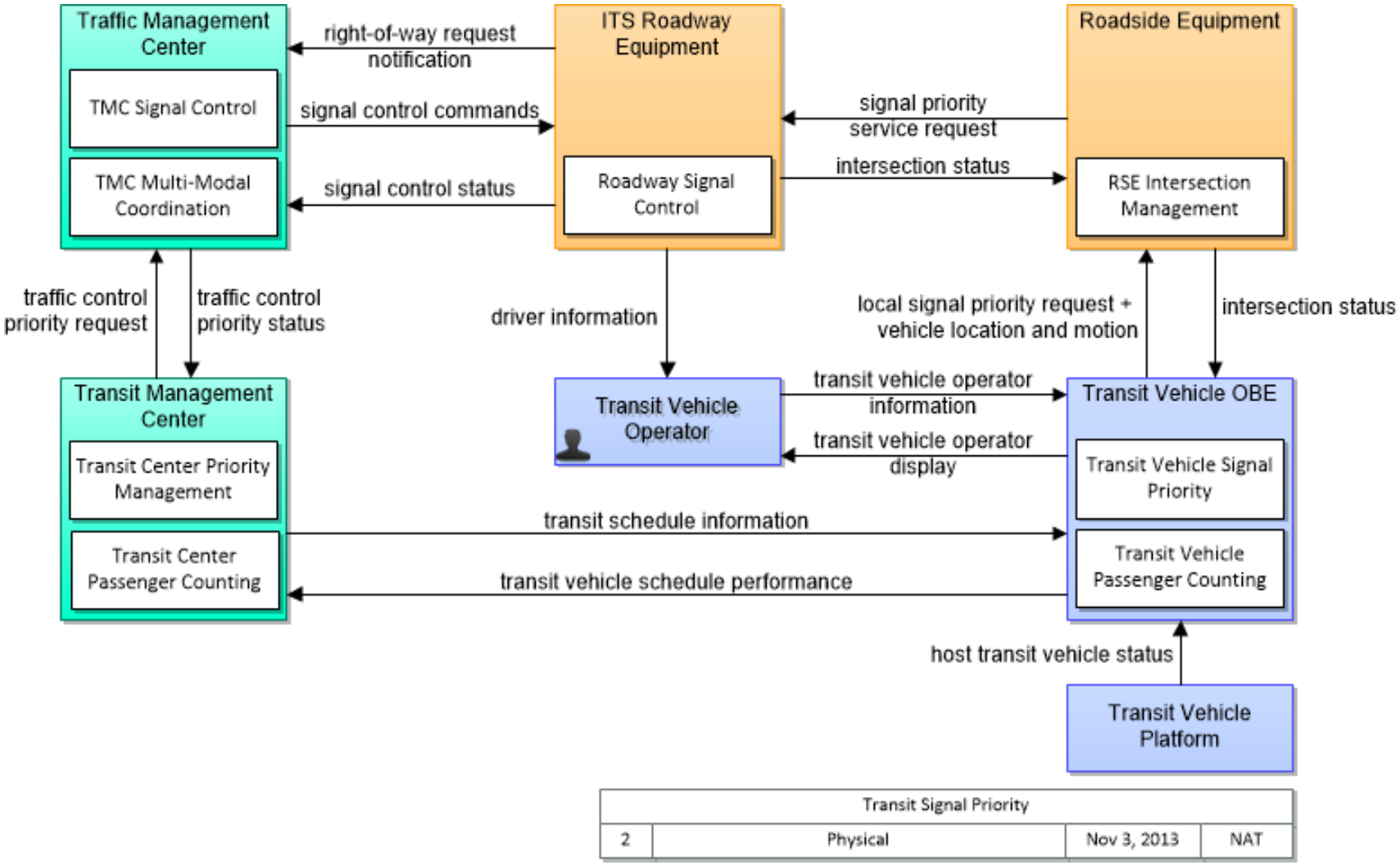
- Information Flows depict the exchange of information that occurs between Physical Objects and Application Objects.



- Information exchanges are identified by Triples that i[illegible]rce and destination Physical Objects and the Information Flow that is exchanged.

Physical View, example





CVRIA Status

- Website Created
  - Populated with Architecture Content for all 4 views
  - For all Connected vehicle applications
    - minus Security Credentials Management System (SCMS); to be completed as policy is defined
  - Contact Us and Comment on Page links provided for stakeholders to give feedback, either general ideas or specific needs for improvement
  - Standards tab to be updated with results of the standardization planning activity
- Resources Include
  - Presentation materials from previous stakeholder workshops and recent CVRIA webinars
  - Databases
  - Mini-Tool → a downloadable Visio file that allows project developers to create customized versions of the CVRIA physical and enterprise view drawings
    - Allows projects to be defined in same 'language' and format

CVRIA Stakeholder Inputs

- Users like you provide comments to us via the web page. The comments are directed to the appropriate portion of the team (web layout to our webmaster, physical view to our physical view architecture)
- To date, received input from
  - Vehicle Infrastructure Integration Consortium
  - DOT's Dynamic Mobility Applications program
  - AERIS program
  - SE Michigan project team
  - Numerous questions from public users
  - International deployments (Europe, Australia) that are implementing similar connected vehicle applications

CVRIA Stakeholder Inputs, continued

- Some questions have led to further analysis and will need to be incorporated into a major update of CVRIA, for example:
  - Better understanding of linkages between views, e.g. the links between the physical view and the enterprise view (needed to support implementation projects)
  - Some Dynamic Mobility applications have evolved significantly since the needs/requirements were originally captured
  - Variations in vehicle based equipment need to be more explicitly shown
- Process of developing tools have also led to changes to be folded into the architecture
  - Diagrams have been tweaked
  - Schema changes
  - Flow characteristics added to the diagrams

CVRIA Evolution

- CVRIA team will be issuing a call for applications through the ITS JPO and Connected Vehicle projects this fall
  - Looking for new or significantly modified connected vehicle applications that need to be reflected in the architecture (and that may lead to revised standards needs)
- In the meantime, the tools development process has identified some changes necessary to the architecture that may need to be corrected in the shorter term
- Rough Schedule:
  - **Fall: Call for application documents (will feed 2.0)**
  - December: CVRIA 1.x to support tools changes
  - Mid-2015: CVRIA 2.0 for new applications and interfaces

  - Down the road, CVRIA and National ITS Architecture will be merged as more and more regions will be planning and deploying ITS that includes connected vehicle applications

CVRIA Tools

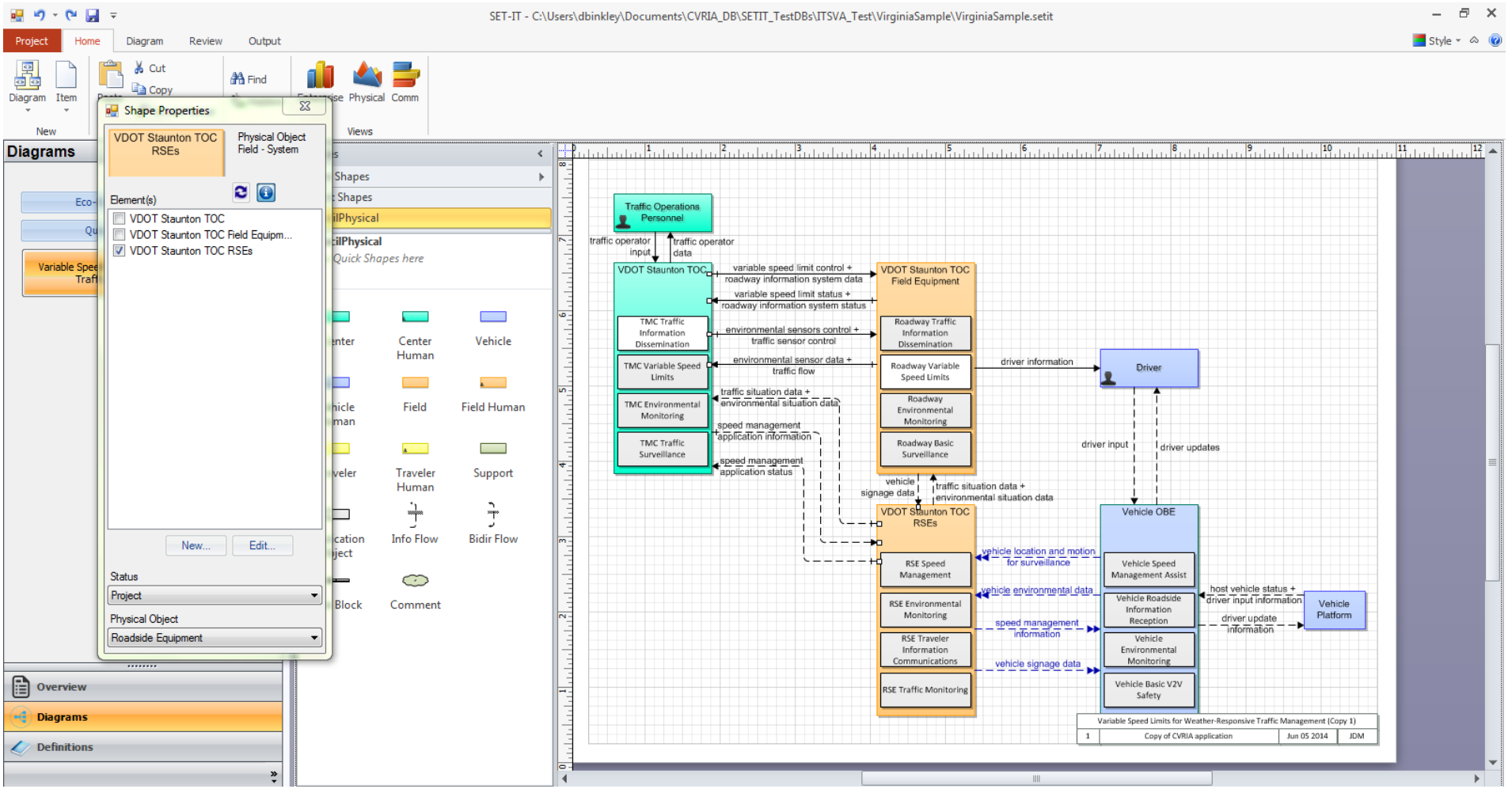
- CVRIA website and databases are available now as a resource – review material, understand connected vehicle applications in context, identify interfaces and standards that may be applicable to ones own project.
- To really use the architecture, additional tools are required
  - Create ones own diagrams and documentation using CVRIA's language and style
  - Customize the content from CVRIA with local names
  - Draw the relationships for ownership, operations, and maintenance of connected vehicle devices
- The System Engineering Tool for Intelligent Transportation (SET-IT)

SET-IT Development

- Incremental development process – allows for functionality to be rolled out to stakeholders early and then build on that.
- System Requirements:
  - Runs on Windows 7 or 8.1
  - Required Visio Professional 2010 or later (some performance issues with 2013)

- Version 0.4 released June 19th
  - Physical view drawing and database export support
  - CVRIA Physical application import
  - Information flow encoding similar to Mini-Tool
- Currently, Version 0.5
  - Added support for hierarchical Layered physical diagrams
- Subsequent monthly releases planned with increasing functionality
  - Next, adding stakeholders/relationships (beginning of enterprise)

SET-IT


SET-IT - C:\Users\dbinkley\Documents\CVRIA_DB\SETIT_TestDBs\ITSVA_Test\VirginiaSample\VirginiaSample.setit
Project
Home
Diagram
Review
Output
Shape Properties
VDOT Staunton TOC RSEs
Physical Object
Field - System
Element(s)
VDOT Staunton TOC
VDOT Staunton TOC Field Equipm...
VDOT Staunton TOC RSEs
New...
Edit...
Status
Project
Physical Object
Roadside Equipment
Diagrams
Overview
Definitions
Traffic Operations Personnel
VDOT Staunton TOC
VDOT Staunton TOC Field Equipment
TMC Traffic Information Dissemination
TMC Variable Speed Limits
TMC Environmental Monitoring
TMC Traffic Surveillance
Roadway Traffic Information Dissemination
Roadway Variable Speed Limits
Roadway Environmental Monitoring
Roadway Basic Surveillance
Driver
VDOT Staunton TOC RSEs
RSE Speed Management
RSE Environmental Monitoring
RSE Traveler Information Communications
RSE Traffic Monitoring
Vehicle OBE
Vehicle Speed Management Assist
Vehicle Roadside Information Reception
Vehicle Environmental Monitoring
Vehicle Basic V2V Safety
Vehicle Platform
traffic operator input
traffic operator data
variable speed limit control + roadway information system data
variable speed limit status + roadway information system status
environmental sensors control + traffic sensor control
environmental sensor data + traffic flow
driver information
traffic situation data + environmental situation data
speed management application information
speed management application status
driver input
driver updates
vehicle signage data
vehicle location and motion for surveillance
vehicle environmental data
speed management information
vehicle signage data
host vehicle status + driver input information
driver update information
Variable Speed Limits for Weather-Responsive Traffic Management (Copy 1)
Copy of CVRIA application
Jun 05 2014
JDM

CVRIA and SET-IT Evolution

- Near-term
  - CVRIA 1.x changes needed to support early releases of SET-IT
    - Diagram changes, physical, enterprise, and communications viewpoint specification changes,
- Mid-term
  - Issue major update for CVRIA and SET-IT
    - New/modified applications
    - Steve/Walt Will issue call for documents (ConOps/Reqs)
      - New or significantly modified connected vehicle applications that need to be reflected in the architecture

CVRIA and SET-IT Evolution

- Long-term
  - Integrate CVRIA and the National ITS Architecture using CVRIA viewpoint spec
  - Develop one tool that supports
    - C-ITS deployment
    - Regional ITS Arch Rule 940 requirements
- Longer-term
  - Assess how arch/tools can better support new C-ITS requirements, research, applications, and transportation planning

Intelligent Transportation Systems (ITS)
Joint Program Office (JPO)

Identification of Connected Vehicle Interfaces

Prioritized Standards Plan

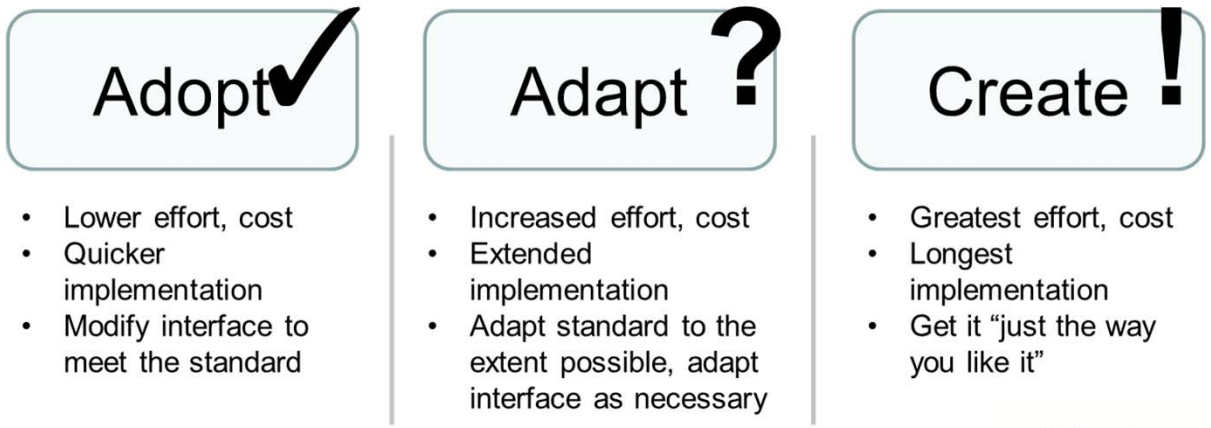
August 20-21st, 2014

CVRIA and Standards

The USDOT's Intelligent Transportation Systems (ITS) Joint Program Office (JPO) is developing a standards plan to inform ITS standards-related efforts and investment decisions in support of the USDOT ITS connected vehicle research program and to support broad deployment of connected vehicle (CV) technologies

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



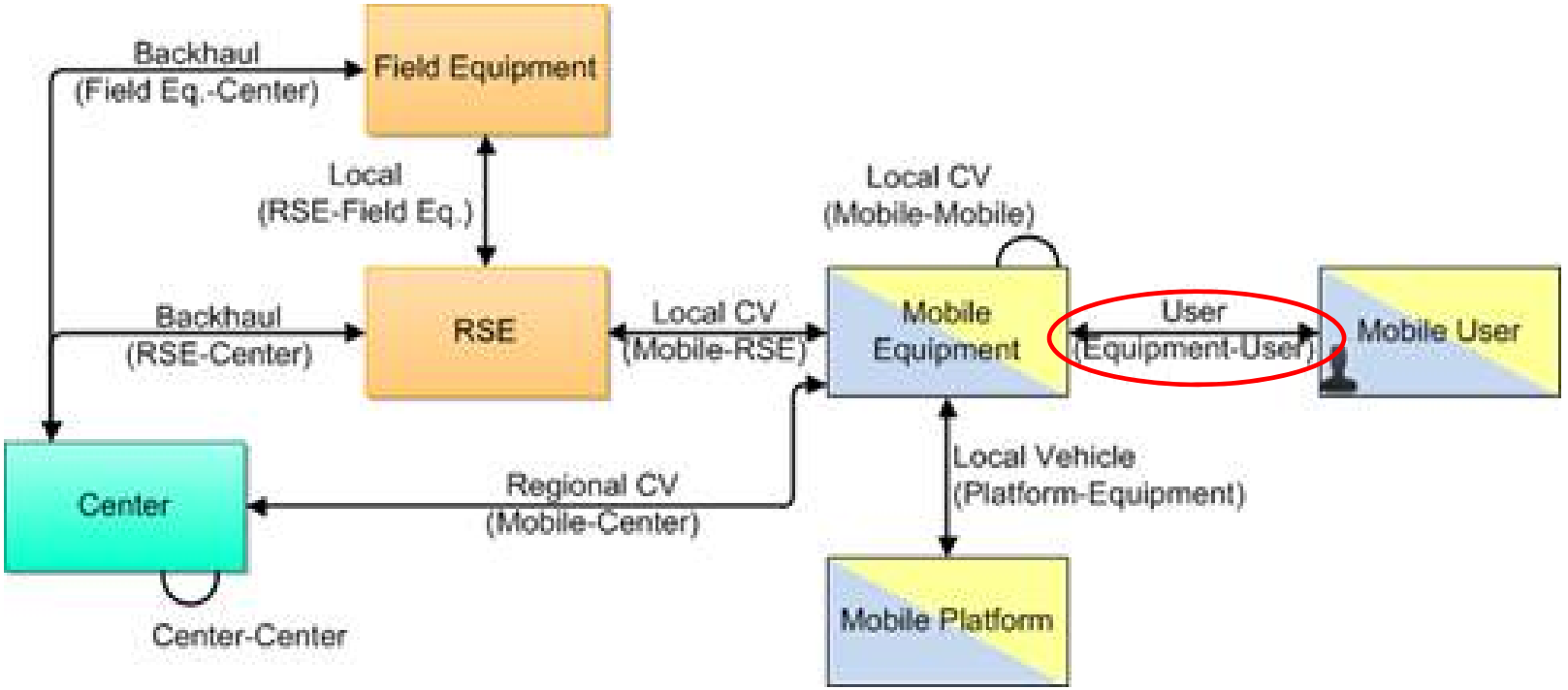
Guiding Principles

1. DSRC, while important, is not the only technology. Other communications technologies (e.g., 3G, 4G) will play a critical role.

2. Existing technology's could be adopted or adapted

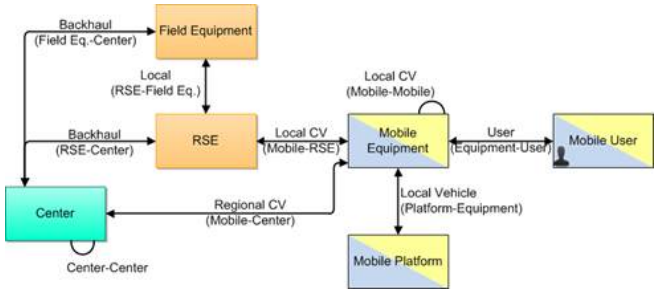
3. Emerging standards could be adapted

Analysis Framework: Six Objects & Seven 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

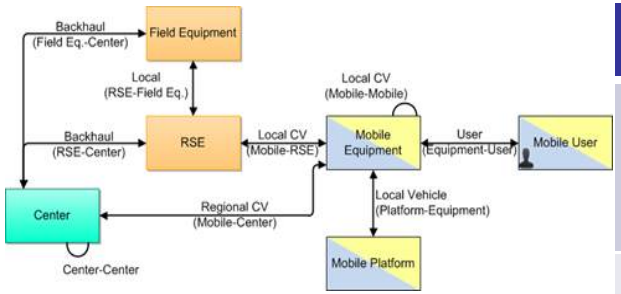
Analysis Framework: Object Descriptions



- The objects listed represent categories consisting of multiple CVRIA objects

Object	Examples
Center	*Data Center, Emergency Management Center, Traffic Management Center*
Field	*Border Inspection System, Electric Charging Station, Intermodal Terminal*
RSE	*DSRC Transceiver (roadside, fixed)*
Mobile Equipment	*Commercial Vehicle OBE, Transit Vehicle OBE, Personal Electronic Device*
Mobile Platform	*Commercial Vehicle, Transit Vehicle, Light Vehicle, Freight Equipment*
Mobile User	*Vehicle Operator, Pedestrian (with mobile equipment)*

Analysis Framework: Interface Descriptions

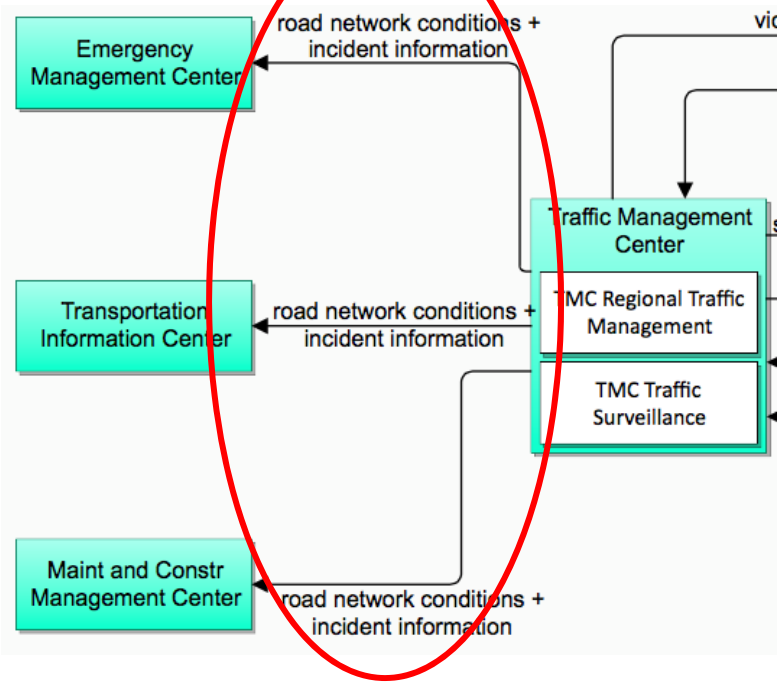


- Interfaces can typically be implemented using different technologies, which run the gamut from mature (stable) to emerging.
- Each technology will have a suite of standards that specify most, if not all of the five lower layers of the OSI protocol stack.
- For the most part, the standards at the lower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

Interface	Description
Backhaul	*Fixed or Wireless Interface from Roadside Connected Vehicle Equipment and Roadside ITS Equipment to Centers*
Center-to-Center	*Interfaces Between Centers*
Local	*Internal Interface Between Vehicle Systems and Mobile Connected Vehicle Equipment*
Local Field	*Roadside Connected Vehicle Equipment to Roadside ITS Equipment*
Local CV	*Mobile CV Equipment to: Mobile CV Equipment (V2V), or to Local Field (V2I)*
Regional CV	*Mobile Connected Vehicle Equipment to Center Wireless Interface (e.g. V2C)*

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)**



Flow	Priority	BH	LF	LCV	RCV	C2C	LV
situation data collection parameters	15.87	X					
traffic images	15.87	X				X	
traffic monitoring application info	15.87	X					
traffic monitoring application status	15.87	X					
traffic situation data	15.87	X	X				
vehicle location and motion for surveillance	15.87			X			
vehicle situation data	15.87			X	X		
vehicle situation data parameters	15.87			X	X		

Standards at Different Layers of the OSI Stack

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

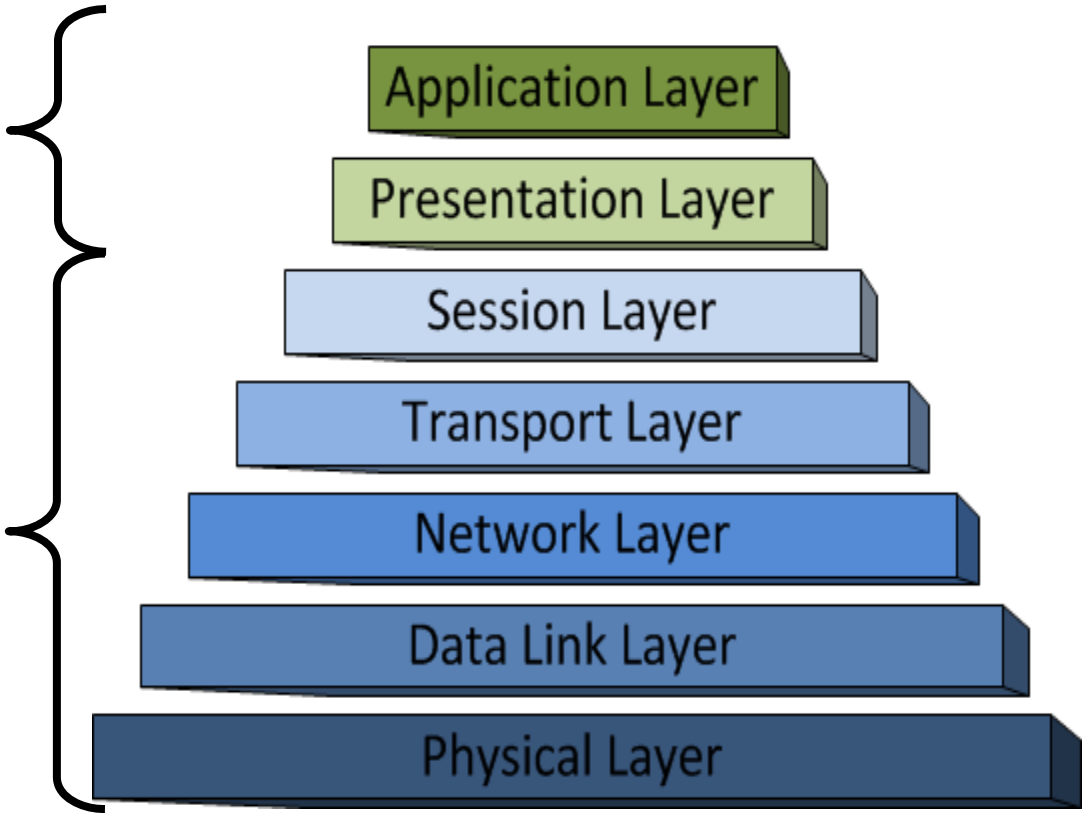
Adopt ✓ Adapt ? Create !

(steps 2-3)

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

Adopt ✓ Adapt ?

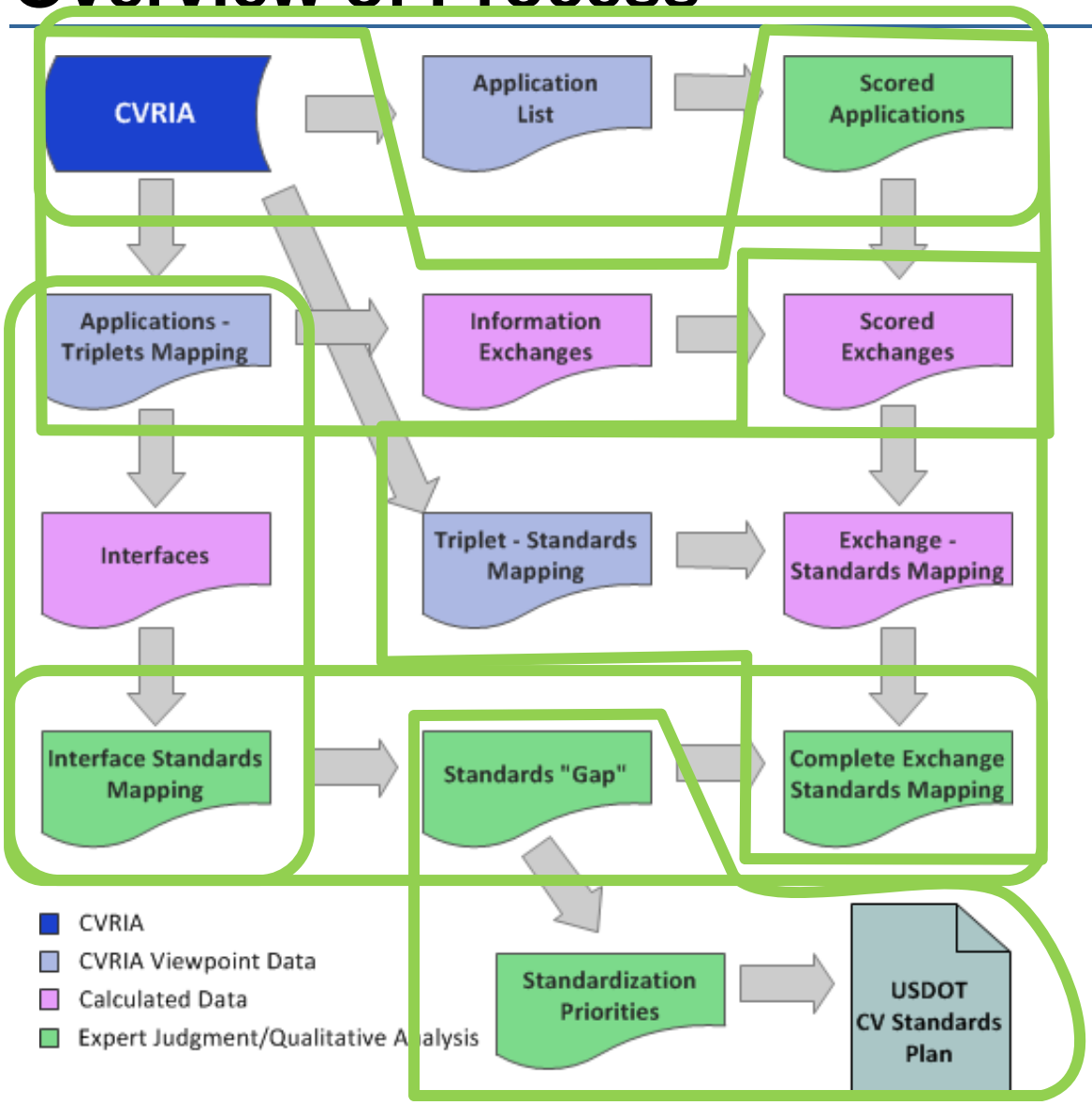
(step 1)



Standardization Process Overview

Step	Description
1	Map Standards to the Interfaces defined in a “simplified” CVRIA diagram
2	Score all CVRIA defined applications
3	Score the CVRIA Information Exchanges based on application scores
4	Map Standards to prioritized CVRIA Information Exchanges
5	Identify and characterize gaps based on Mapped Standards
6	Prioritize Work, and Develop Standards Plan

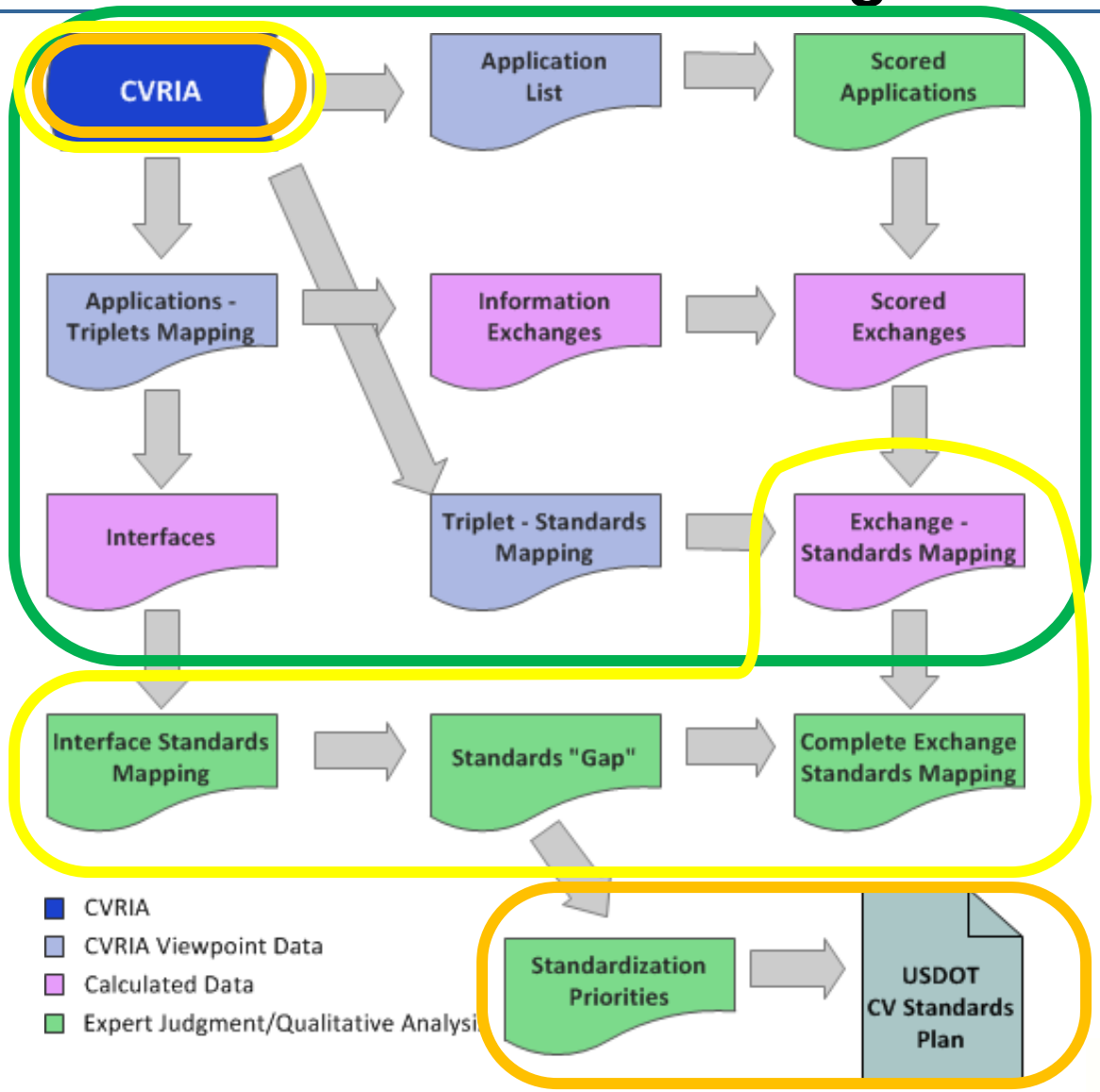
Overview of Process



Step 8: [illegible] Plan

A "triplet" is the CVRIA is a combination of an information flow, its source, and its destination.

Overview of Process – Progress

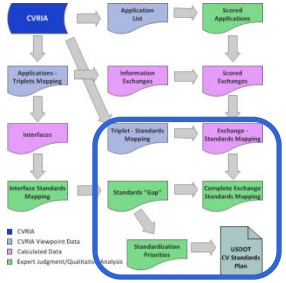


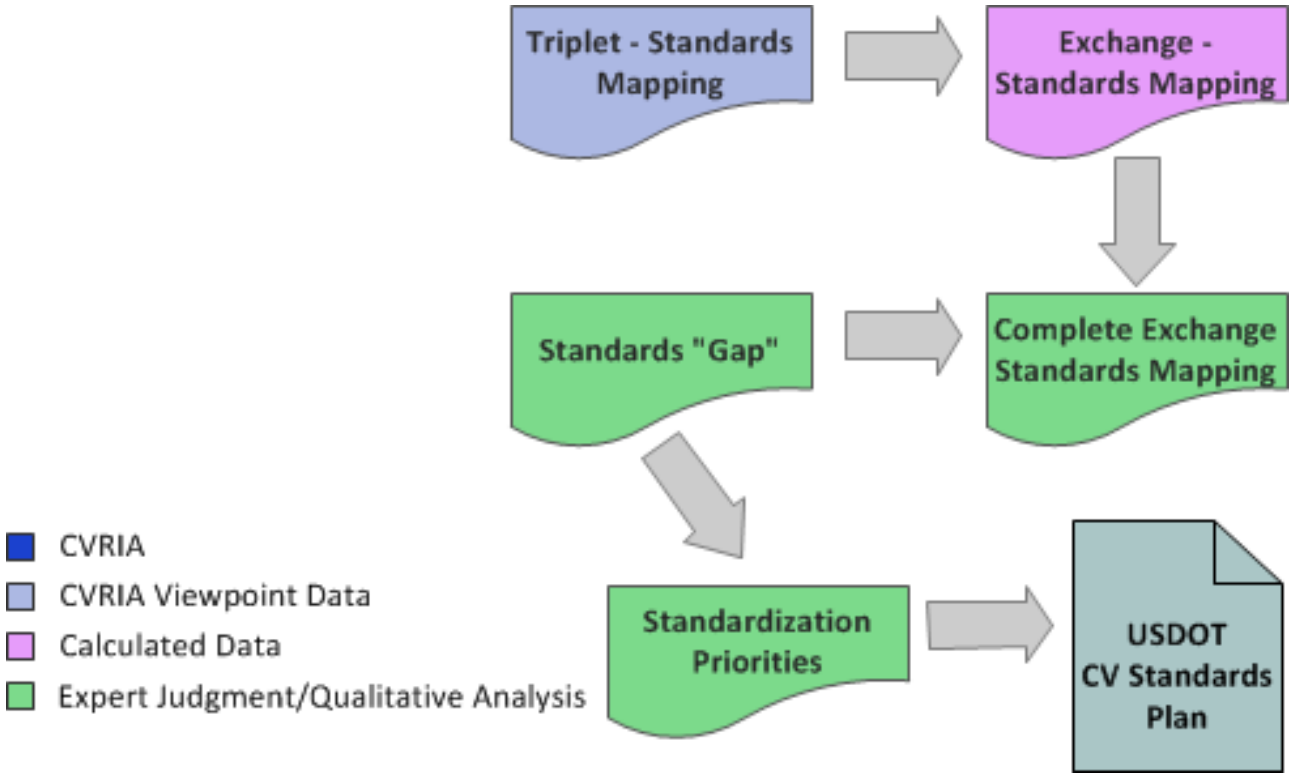
Completed

Current Activity

Planned Activity

Focus of Breakout Sessions

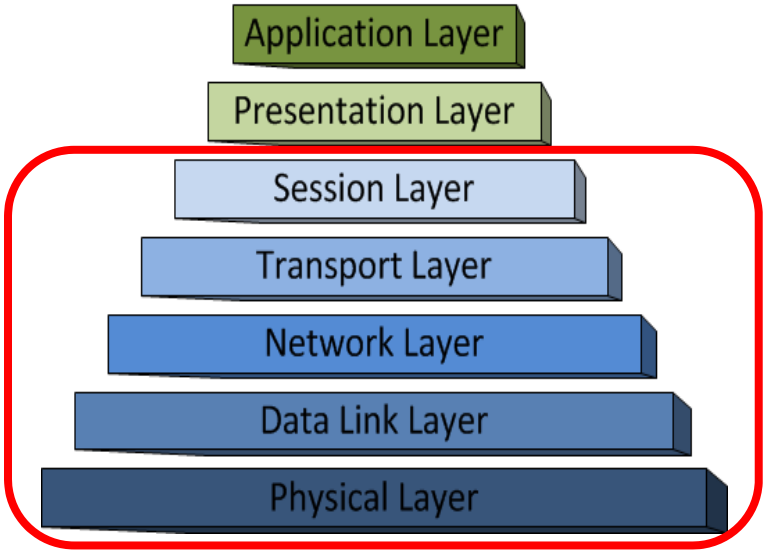


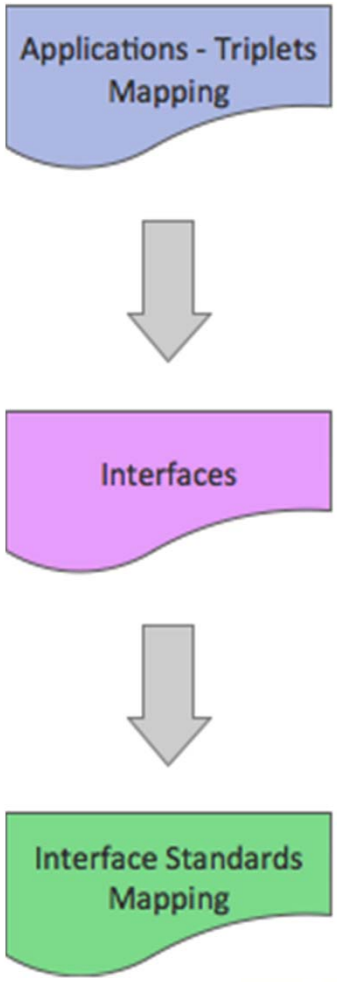


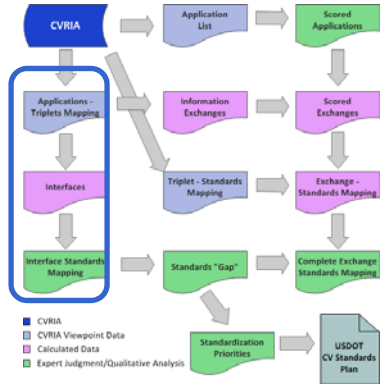
Step 1: Map Interfaces to Standards

An interface is a connection between two defined objects

- Interfaces are typically implemented using a complementary suite of protocols that support an integrated protocol stack
- Balance between flexibility and conformity which supports a wide range of uses
- Lower layers (1-5) of the protocol stack are can support a wide variety of uses







Step 1: Preliminary Results …Interface to Standards Mapping (1 of 2)

Interface Name	Applicable Technology	Maturity Level	Comment
Backhaul	Fiber	Mature, Widely Deployed	Generally widely used for backhaul
	Wireline	Mature, Widely Deployed	Widely used, generally being phased out in favor of wireless or fiber
	3G	Mature	Somewhat expensive; Used for intermittent backhaul; Useful for remote locations where wired/fiber connections are impractical
	LTE	Partially deployed	Somewhat expensive; Useful for remote locations where wired/fiber connections are impractical
	WiMAX	Mature, occasionally deployed, not widely used	Potentially much lower cost than fiber and/or LTE services; Best suited for urban applications with large number of RSEs being served ovber a relatively limited range
Center to Center	Fiber	Mature, Widely Deployed	Data and services interfaces generally not uniformly defined across all centers. May need to
	Wireline	Mature, Widely Deployed	
Local	Ethernet	Very mature, widely deployed	
	Bluetooth	Mature, widely deployed	Wireless approach may relive certain poer and cabling issues (e.g.separation of signaling and power lines in conduits, etc); May present interference and/or security issues
	WiFi	Very Mature; High bandwidth extensions (e.g. 802.11N and ac) may be useful for backhaul	Could address cabling issues (See above); May present interference and/or security issues
	6LoWPan	Emerging, not widely used	Short range M2M WPAN technolopgy based on IPv6; May be useful for interconnecting equipment in a localized area; ld address cabling issues (See above); Uncertain security aspects

Step 1: Preliminary Results …Interface to Standards Mapping (2 of 2)

Interface Name	Applicable Technology	Maturity Level	Comment
Local Connected Vehicle	DSRC/WAVE	Not Deployed, Standard Complete	Specifically designed to suport this interface
	WiFi	Very Mature; High bandwidth extensions (e.g. 802.11N) not applicable to mobile use	Widely available, Limited to IP based communication (not appropriate for broadcast)
	LTE Direct	Developmental, probably deployed around 2018	Potentially useful for V2I communicaitons in localized areas; May need new service advertisement (expression) development. Probably not realistic for V2V
	Bluetooth	Mature, widely deployed	Relatively short range; Currently requires pairing, which would need to be changed to make it useful; Would oprobably require additional profiles to support connected vehicles
	6LoWPan	Emerging, not widely used	Specialized M2M WPAN technolopgy based on IPv6; Not generally applicable to broadcats applications
Local Vehicle	CAN Bus/Various (SAE J1939+ for commercial/emergency vehicles)	Networks very mature; Vehicle interfaces not widely deployed beyond OBD-II	CAN message sets typically vehicle/maker specific. Probably need some sort of standard, or requirement for vehicle data in terms of common fromats and units, etc (e.g. a uniform Vehicle Interface)
Regional Connected Vehicle	3G Cellular	Mature, currently being phased out	High bandwidth used for voice and data; Exhibits capacity and mobiliy issues
	LTE	Partially deployed, adoption growing rapidly	4G/5G cellular standard. Useful for regional (wide area) connectivity for vehicle to center(s); LTE is an
User	Visual	Generally mature	Few UI Standards Exist, May need top level guidelines for these interfaces; generally highly proprietary
	Auditory	Primitive	
	Haptic	Primitive	

Step 2: Score Applications

- CVRIA Database is the baseline of all standards planning activities
- Applications are derived from the CVRIA and scored
- The CVRIA Applications are scored on averaged SME ratings of the following factors:
  - *Importance*
  - *Timeframe*
  - *Complexity*

Step 2: Application Scoring Factors

Applications are prioritized on the following basis…

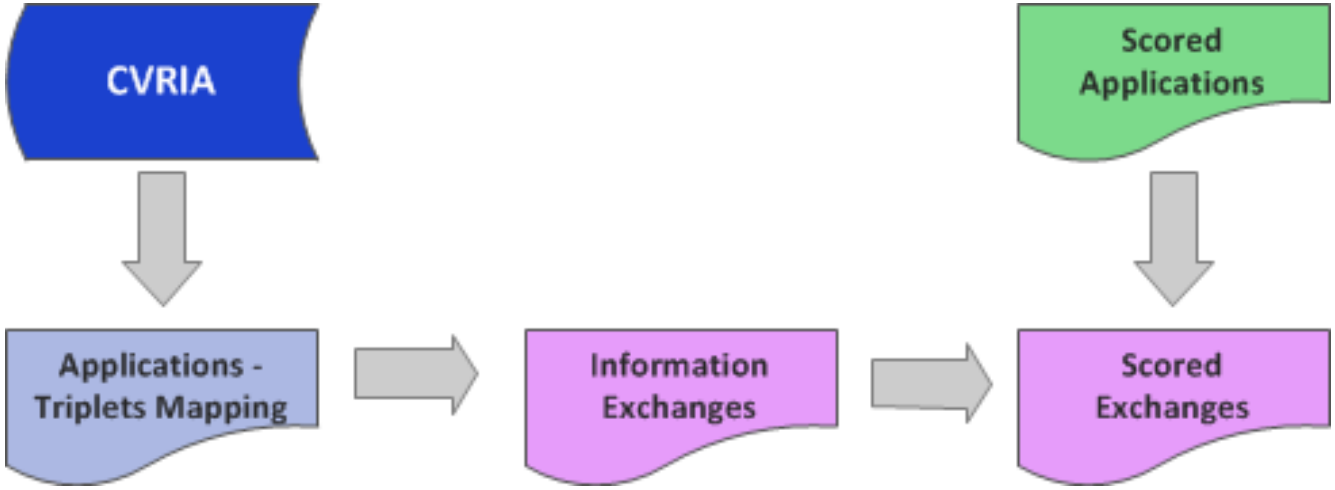
Criteria	Definition	Weight
Importance	Criticality of the this CVRIA application relative to other CVRIA applications	1.7
Timeframe	Anticipated timing of application implementation, reflecting the urgency of supporting standards	1.3
Complexity	Reflects the anticipated complexity of the implementation environment. A complex environment creates a greater need for supporting standards	1.0

Info Exchange	I	I-W	T	T-W	C	C-W	Total
Communications Support	3.9	**6.6**	4.0	**5.2**	3.7	**3.7**	**15.5**

Step 2: Preliminary Results "Top 20" Applications

Application Name	Importance	Timeframe	Complexity	App Priority
Vehicle Data for Traffic Operations	4.00	4.67	3.00	**15.87**
Red Light Violation Warning	4.38	3.50	3.00	**14.99**
Signal Phase and Timing	4.13	3.67	3.17	**14.95**
Emergency Vehicle Alert	4.25	4.00	2.17	**14.59**
Incident Scene Work Zone Alerts for Drivers and Workers	3.75	3.50	3.67	**14.59**
Curve Speed Warning	3.88	4.33	2.00	**14.22**
Emergency Electronic Brake Light	4.00	4.17	2.00	**14.22**
Advanced Traveler Information Systems	3.25	4.50	2.83	**14.21**
Forward Collision Warning	3.88	4.17	2.17	**14.17**
Emergency Vehicle Priority	3.75	3.67	3.00	**14.14**
Border Management Systems	3.25	3.33	4.17	**14.03**
Stop Sign Violation Warning	4.25	3.17	2.67	**14.01**
Vehicle Emergency Response	3.75	3.17	3.50	**13.99**
Warnings about Hazards in a Work Zone	3.75	3.00	3.17	**13.44**
Road Weather Advisories and Warnings for Motorists	3.38	3.33	3.33	**13.40**
Intelligent Traffic Signal System	4.00	2.50	3.33	**13.38**
Intersection Movement Assist	3.75	2.67	3.50	**13.34**
Situational Awareness	3.50	3.33	3.00	**13.28**
Spot Weather Impact Warning	3.50	3.33	3.00	**13.28**
Warnings about Upcoming Work Zone	3.50	3.67	2.50	**13.22**

Step 3: Score Exchanges



- A flow is a specific set of information between source and destination objects
- A flow may appear between multiple pairs of centers; we combine these into a single center-to-center exchange
- An “exchange” is an information flow over one of the major interface types.
- Exchange priority is the priority of the highest-scoring applications that uses the flow

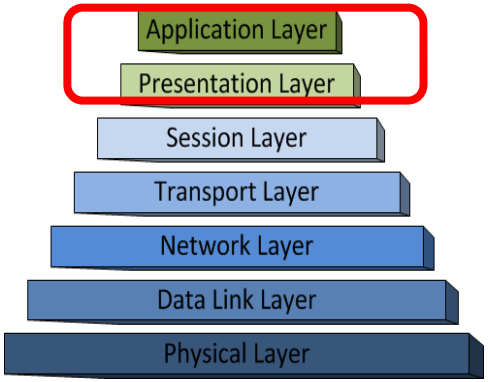
Step 3: Preliminary Scored Exchanges

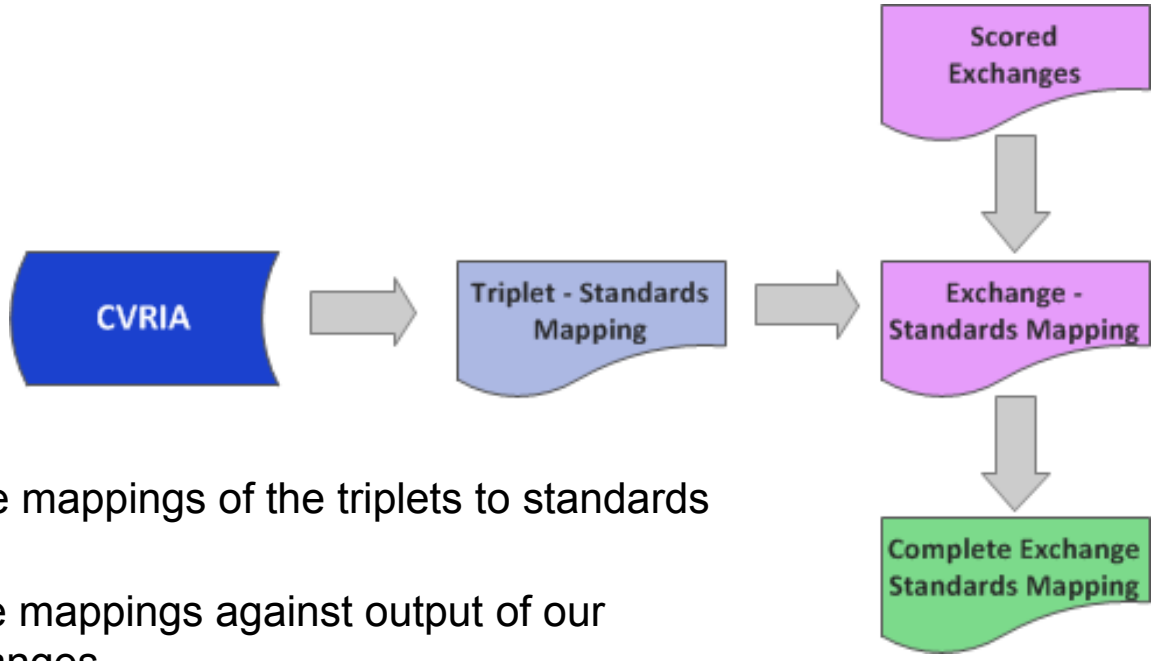
Flow	Priority	BH	LF	LCV	RCV	C2C	LV
incident information	15.87					✓	
road network conditions	15.87					✓	
situation data collection parameters	15.87	✓					
traffic images	15.87	✓					
traffic monitoring application info	15.87	✓					
traffic monitoring application status	15.87	✓					
traffic situation data	15.87	✓					
vehicle location and motion for surveillance	15.87			✓			
vehicle situation data	15.87			✓			
vehicle situation data parameters	15.87			✓			
video surveillance control	15.87	✓					
intersection geometry	14.99	✓		✓	✓		
intersection infringement info	14.99		✓	✓			
intersection safety application info	14.99	✓					
intersection safety application status	14.99	✓					
intersection safety warning	14.99			✓			
intersection status	14.99		✓	✓			
signal control commands	14.99	✓					
signal control status	14.99	✓					
vehicle location and motion	14.99			✓			

Acronyms

BH - Backhaul
C2C - Center-to-Center
L - Local
LCV - Local Connected Vehicle
LV - Local Vehicle
RCV - Regional Connected Vehicle

Step 4: Map Exchanges to Standards





- We exported the mappings of the triplets to standards from the CVRIA
- We paired these mappings against output of our prioritized exchanges
- SMEs manually mapped remaining exchanges to information/application level standards
- Results in a complete mapping between defined exchanges and information standards

Step 4: Preliminary Results …Highly Utilized Standards

- Of the top 70 prioritized exchanges, the following "parent" standards were identified as likely to require updates to support CVRIA interfaces
- 19 of the top 70 exchanges do not have "parent" standards identified for them at this time.

Standard	Supported Exchanges
NTCIP 1200 series	51
"Border/Commercial Vehicle" standards	42
SAE J2735	34
"Security" standards	22
ITE TMDD	14
APTA TCIP	5
ATIS	5
"Payment" standards	5
"Map Update" standard	2
IEEE 1512	2

Step 5: Identify and Define Standards Gaps

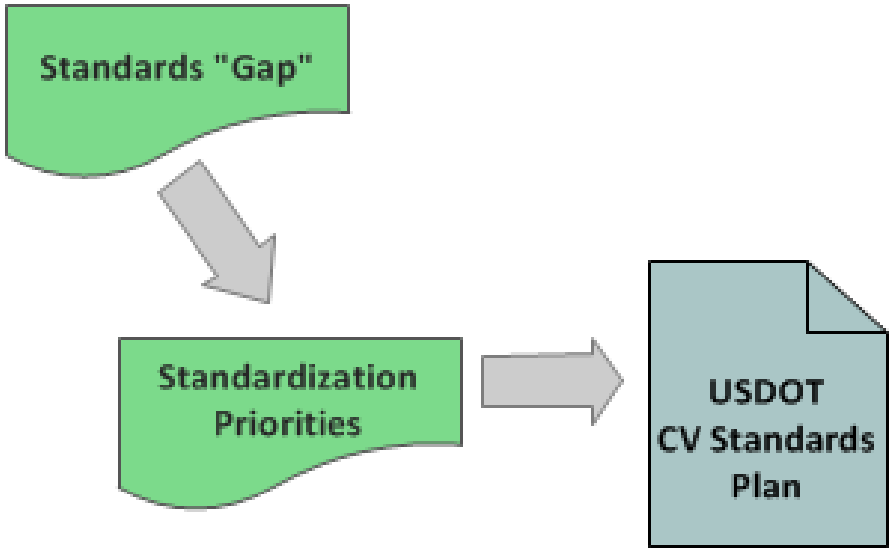
Each standards mapping is assessed to identify gaps

- The mappings are then reviewed to determine if the standard is both
  - Completed (i.e., approved)
  - Sufficient for the needs of CV applications
- Exchanges and interfaces that are not fulfilled are noted as “gaps”
- In Progress…
  - Identified gaps are then assessed and qualified according to the degree and nature of the gap. E.g. “missing”, “emerging” “message gap”.
  - Defining the gaps with respect to each relevant application’s needs will provide an actionable list of gaps within each standard
  - Gap prioritization within each Standard will be based on the scores of the relevant applications and information exchange

Step 6: Prioritize Work & Develop Plan

We recognize that there are multiple teams that can work in parallel

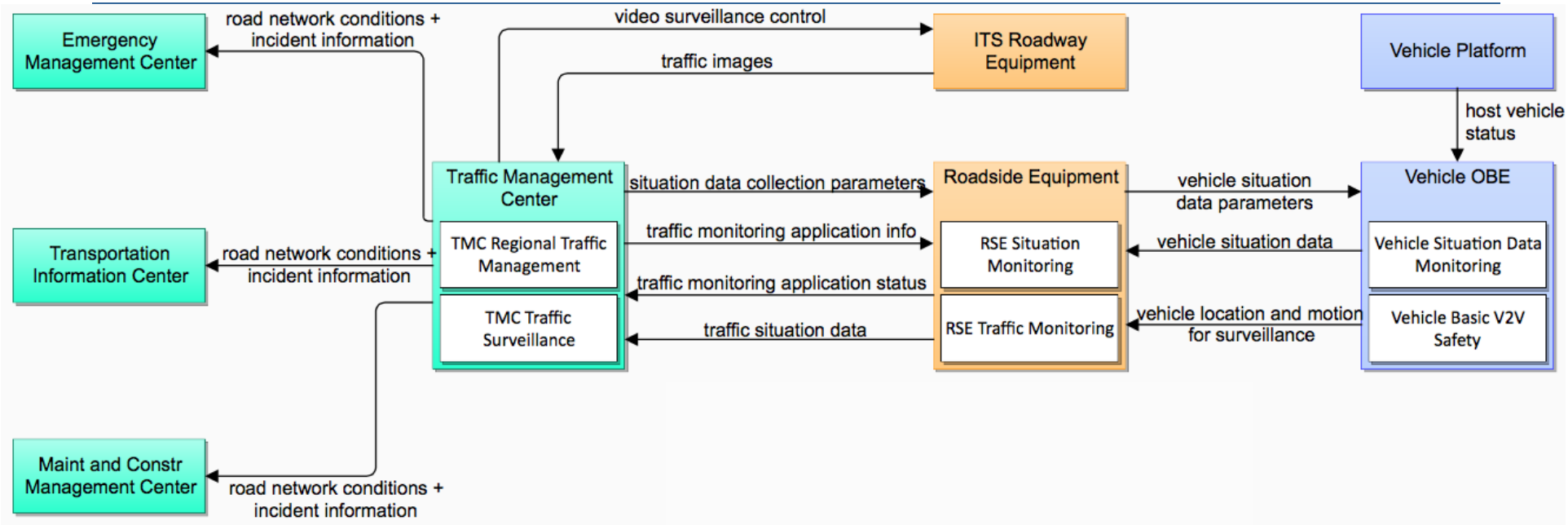
- A final review of highest priority gaps
  - Eliminates any futuristic exchanges
  - Identifies where USDOT support is needed
  - Produces a listing of the highest priority additions/revisions for each standard (or identifies need for new standards)



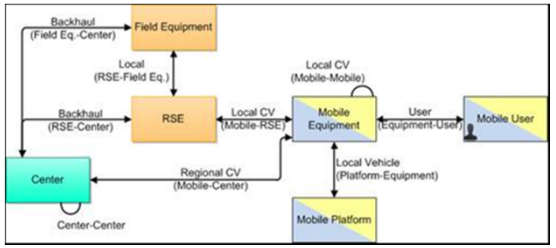
Identifying and Defining the Standards Gaps

- **Gaps may be functional…**
  - No message to send truck weight to roadside
  - No message from personal devices to vehicles
- **Gaps may be in performance…**
  - Timeliness of message responses not defined
  - Unclear how congestion on DSRC channels will be mitigated
- **Gaps will be identified at a high level based on an evaluation of available needs and requirements against existing standards.**
- **Quantifying gaps may require additional analysis and validation of more detailed application requirements.**

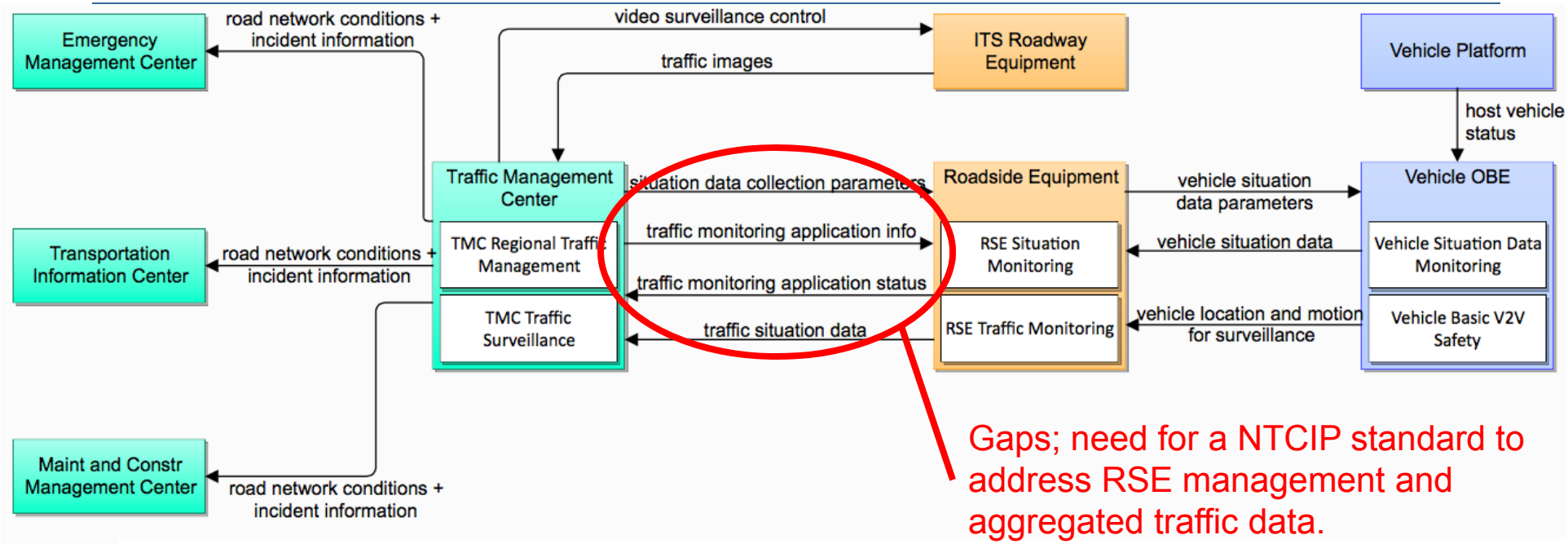
Example – Vehicle Data for Traffic Operations



- Application is among those with the highest score
  - Uses Center-to-center, Backhaul, Connected Vehicle, and Local Vehicle Interfaces
  - Uses TMDD, NTCIP, J2735, etc.
  - All flows must be standardized for application to interoperate



Example – Vehicle Data for Traffic Operations



- Application among highest priority
- Standards Gaps:
  - Each exchange was mapped to a standard
  - 4 exchanges were identified as not being fully addressed
    - All related to collecting situation data from vehicles and relaying to center
- Potential Priorities for
  - NTCIP 12xx (for future RSE management standard)

Preliminary Observations

USDOT Standards Program to champion development of standards needed for prioritized applications and flows

- Identify the priorities for each standard rather than prioritizing standards against one another
- Address standards development at a more granular level – focus on the layers of the OSI Stack
- Look for opportunities to group applications for efficiency in message sets

Further refinement of high-priority applications

- The functional and performance requirements of high-priority applications and their flows should be reviewed and refined as research progresses
- High-priority applications may be subjected to additional analysis to further define Measures of Effectiveness/Performance and performance requirements
- ITS-JPO CV Program Managers are encouraged to continue providing input into future iterations of the USDOT CV Standards Plan

NTCIP 2202 (*Sample*)

Standard:	NTCIP 2202 – TP-Internet		
Supported Applications	Any application requiring routing from Vehicle through backhaul network to a center, including: Communications Support Integrated Multi-modal Electronic Payment	Needs	Will need to support IPv6 for some CV applications
Status	Approved	Standards Gaps	Prohibits use of IPv6
Result	Either rescind standard and issue guidance to industry to use IT standards, or update standard to define the preferred options of IPv6 to use within the backhaul environment.		

Next Steps

- **Currently**
  - Finalizing preliminary results
    - Draft initial standards plan
  - Planning for next USDOT internal workshop

- **Desired Involvement of USDOT Stakeholders**
  - Provide feedback on these findings and results will help us to refine content for the Standards Plan
  - Engage in standards development process where justified and helpful to facilitate standards development

Questions

Steve Sill
Program Manager, ITS Architecture and Standards
Steve.Sill@dot.gov
202-366-1603

Walt Fehr
Program Manager ITS Joint Program Office
Walt.Fehr@dot.gov
202-366-0278

Suzanne Sloan
Volpe National Transportation Systems Center
Suzanne.sloan@dot.gov
617-494-3282

Chris Karaffa
Senior Lead Engineer
christopher_karaffa@bah.com
703.377.4844

Jim Marousek
Senior Lead Engineer
marousek_james@bah.com
202.203.5402

http://www.iteris.com/cvria/html/resources/documents.html

http://www.standards.its.dot.gov/DevelopmentActivities/CVReference