Welcome

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U.S. Department of Transportation
Office of the Assistant Secretary for
Research and Technology

I261:
Vehicle-to-Infrastructure (V2I) ITS Standards for Project Managers

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Target Audience

- Public sector managers of surface transportation systems and agencies
  - Understand how to prepare for a connected vehicle environment and how it can address their transportation needs
- Procurement officials for surface transportation agencies
  - Understand how the standards can help design an implementation to address their transportation needs
- Decision-makers
  - Understand the impacts of a V2I environment on the transportation system and how they do business
- Private and public sector users including manufacturers
  - Understand how they may benefit from a V2I environment

Recommended Prerequisite

- I101: Using ITS Standards: An Overview

Curriculum Path

I101
Using ITS Standards: An Overview

I261
Vehicle-to-Infrastructure (V2I) ITS Standards
for Project Managers

STANDARDS ITS TRAINING

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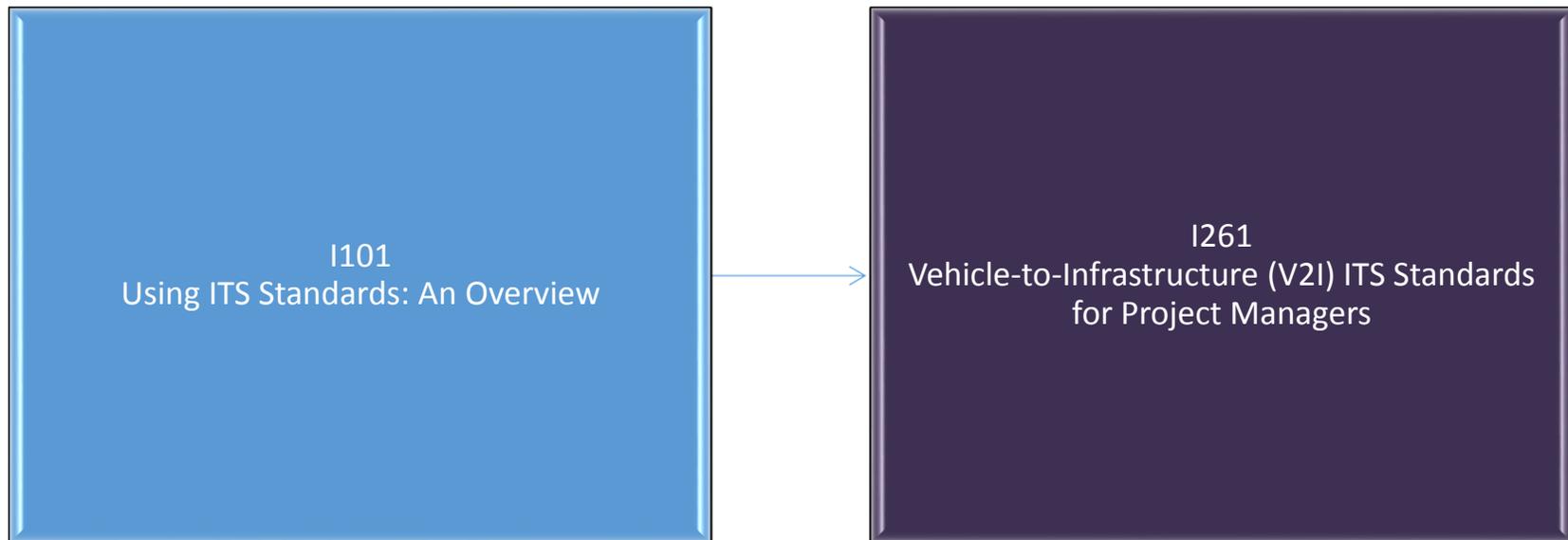
Learning Objectives

1. Describe the connected vehicle environment

2. Discuss the V2I environment

3. Describe the roles of the standards in a connected vehicle environment

4. Identify and address high-level technical and institutional challenges to deploying a V2I environment

5. Describe the current status of the connected vehicle environment

Learning Objective #1: Describe the Connected Vehicle Environment

- Identify a connected vehicle environment

- List the benefits of a V2I connected vehicle environment

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Identify a Connected Vehicle Environment

Transportation Challenges

Safety
33,561 highway deaths in 2012
5,615,000 crashes in 2012
Leading cause of death for ages 4, 11-27

Mobility
5.5 billion hours of travel delay
$121 billion cost of urban congestion

Environment
2.9 billion gallons of wasted fuel
56 billion lbs. of additional CO_2

Source: US Department of Transportation

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Identify a Connected Vehicle Environment

Vehicles

- Have safety devices and sensors

- Are a navigation device

- Are a multimedia center

In addition, millions of people carry mobile devices today that have Global Positioning System (GPS) and can access data…

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Identify a Connected Vehicle Environment

What if….

- Vehicles shared their sensor information with other vehicles and the roadway

- Vehicles shared their current position with other vehicles and the roadway

- Vehicles can receive information from the roadway that can reduce the likelihood of incidents

- Vehicles can receive information from the roadway to improve mobility (e.g., reduce delays)

Identify a Connected Vehicle Environment

Example Vehicle Data:

Latitude, Longitude, Speed, Brake Status, Turn Signal Status, Vehicle Length, Vehicle Width, Bumper Height
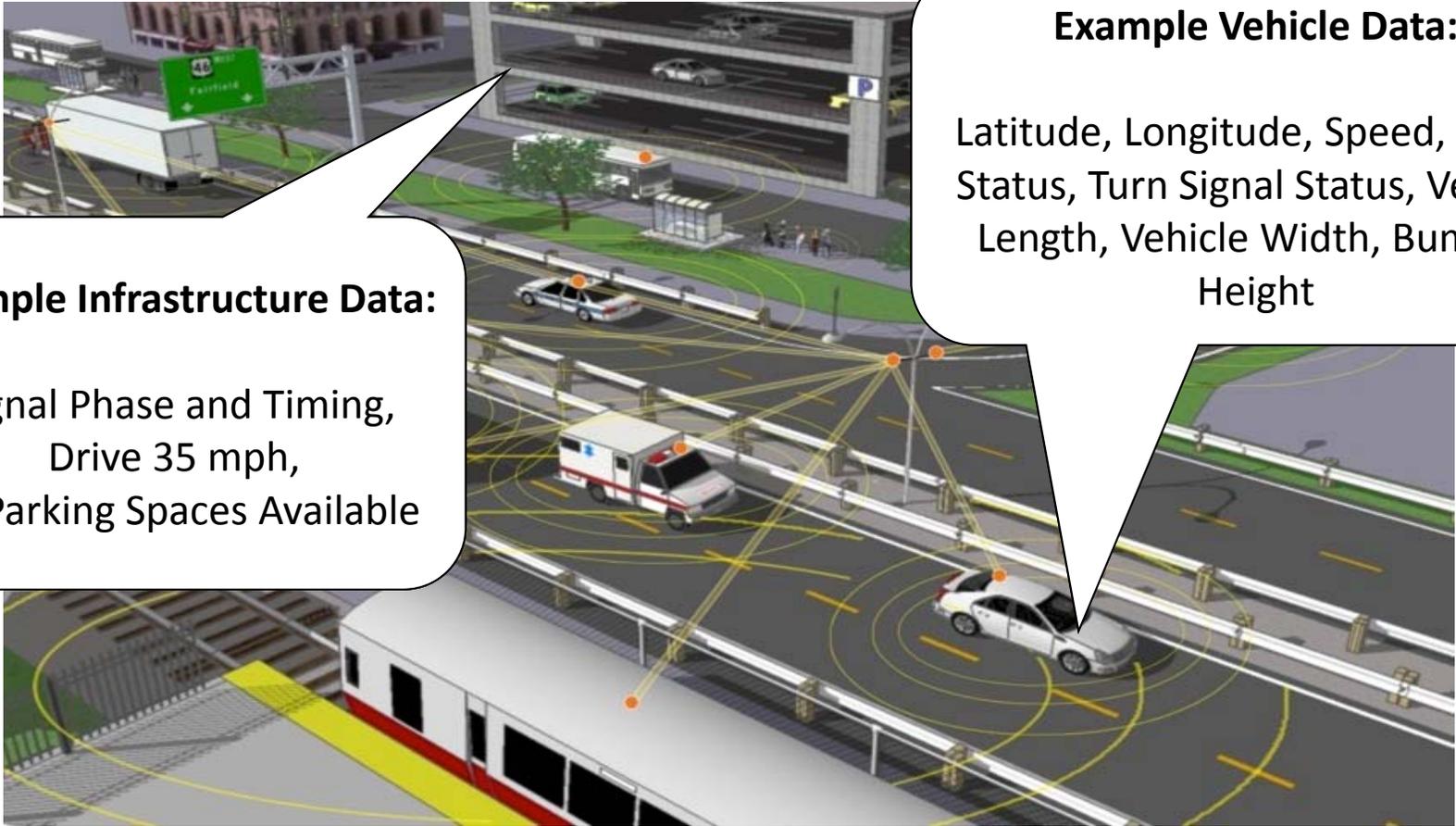
Example Infrastructure Data:

Signal Phase and Timing,
Drive 35 mph,
50 Parking Spaces Available

Source: US Department of Transportation

Identify a Connected Vehicle Environment

What is the connected vehicle environment?

- A research program to explore how transportation connectivity can enable applications that provide safety, mobility, and environmental benefits

- Transportation connectivity consists of
  - Vehicles wirelessly sending information about itself to other vehicles (vehicle-to-vehicle)
  - Vehicles wirelessly exchanging information with the infrastructure (vehicle-to-infrastructure)
  - Vehicles, infrastructure, and other mobile devices wirelessly maintaining real-time connectivity

- Connected Vehicle Reference Implementation Architecture (CVRIA). http://iteris.com/cvria/

Identify a Connected Vehicle Environment

NHTSA ANPRM

- August 2014, National Highway Traffic Safety Administration (NHTSA) released an Advance Notice of Proposed Rulemaking (ANRPM) and a supporting research report

  - Federal Motor Vehicle Safety Standard (FMVSS) No. 150, to require vehicle-to-vehicle (V2V) communications capability for light vehicles and to create minimum performance requirements for V2V devices and messages

  - V2V and vehicle-to-infrastructure (V2I) systems could potentially address 81% of all vehicle crash types

- Notice of Proposed Rulemaking (NPRM) by 2016

Identify a Connected Vehicle Environment

In addition to safety, the connected vehicle environment:

- Can address mobility challenges – address non-recurring congestion through V2V and V2I communications, including reducing crashes

- Can address environment challenges – increased fuel efficiency and reduced recurring congestion

- Can lead to a new class of vehicles – connected and possibly autonomous

  - May impact engineering analysis and design

- V2V will open the gates for V2X: V2I, V2P

Source: US Department of Transportation

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Identify a Connected Vehicle Environment

This module focuses on the vehicle-to-infrastructure (V2I) aspects

- Module I262 focuses on the vehicle-to-vehicle (V2V) aspects

- Introduces the standards (existing and under development) that will enable the V2I connectivity

- Allows project managers to begin planning and deploying devices and components that conform to these standards to realize the benefits from V2I connectivity

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List the Benefits of a V2I Connected Vehicle Environment

Safety Benefits

- The infrastructure can use information from vehicles to improve safety, such as respond to incidents, remove obstacles, or treat the roadway

- Vehicles can receive information from the infrastructure to increase situational awareness and reduce the number, reduce the severity, or eliminate crashes by:

  - Driver advisories: upcoming delays or work zones, suggested travel speeds

  - Driver warnings: potential red light violations, potential obstacles in the roadway, ice patches ahead, low bridge clearances

  - Vehicle controls

List the Benefits of a V2I Connected Vehicle Environment

Mobility Benefits

- Information from the vehicle to infrastructure

    - Real-time traffic probe data for the entire road network to optimize the roadway network

    - Provide improved incident response

- Information from the infrastructure to vehicles

    - Provide focused, relevant traveler information

List the Benefits of a V2I Connected Vehicle Environment

Environmental Benefits

- Information from the vehicle to infrastructure

  - Generate and capture real-time environmental data to create actionable information to support green transportation choices

  - Select traffic management strategies based on environmental benefits

  - Improve road weather information and management

- Vehicles can receive information from the infrastructure

  - Select optimal vehicle speeds or travel routes

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Which of the following is NOT a method to reduce crashes in a V2I environment?

Answer Choices

a) Through a website

b) Through driver warnings

c) Through infrastructure controls

d) Through vehicle controls

Review of Answers

a) Through a website

   Correct! Information on a website will not prevent crashes in a V2I environment

b) Through driver warnings

   Incorrect. Driver warnings may be presented to a driver based on information broadcasted from the infrastructure

c) Through infrastructure controls

   Incorrect. An infrastructure device may perform an action to prevent a crash

d) Through vehicle controls

   Incorrect. A vehicle may take control based on information broadcasted from the infrastructure

Summary of Learning Objective #1

Describe the Connected Vehicle Environment

- Identify a connected vehicle environment

- List the benefits of a V2I connected vehicle environment

Learning Objective #2: Discuss the V2I Environment

- List the components of a V2I environment

- Discuss the potential communications technologies that may be deployed in V2I

- Identify V2I applications

- Describe the information that needs to be exchanged between the components to support V2I applications

List the Components of a V2I Environment

On-Board Equipment (OBE):

- Broadcasts a set of "basic" data such as vehicle location, speed, and direction of travel; AND/OR

- Receives data from other vehicles or the infrastructure

RoadSide Equipment (RSE):

- Receives a set of "basic" data from an OBE on vehicles; AND/OR

- Broadcasts information to vehicles or other mobile devices

Traffic Signal Controller
- Backhaul and Security
- Communications to Back Office

- SPaT Message
- Positioning Information
  - Which Road?
  - Which Lane?
  - Where in Lane?
- Geographic Intersection Design (GID)
- Corrections to Positioning
- Map Data Message

RSE
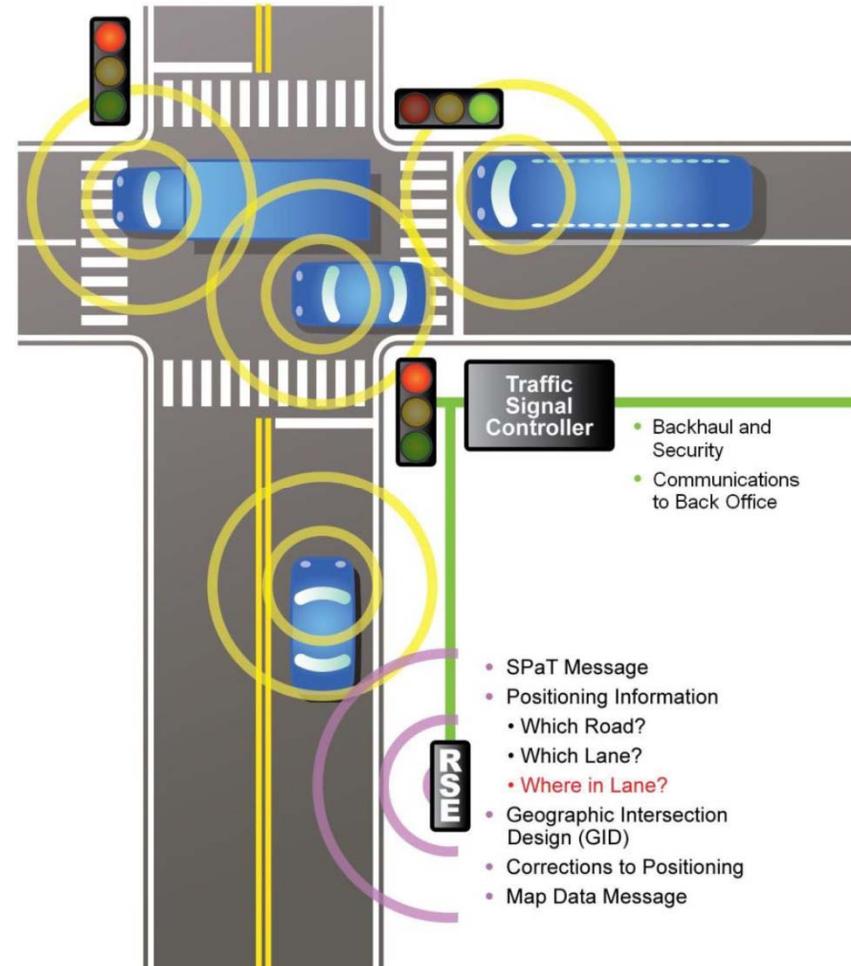
List the Components of a V2I Environment

On-Board Equipment (OBE)
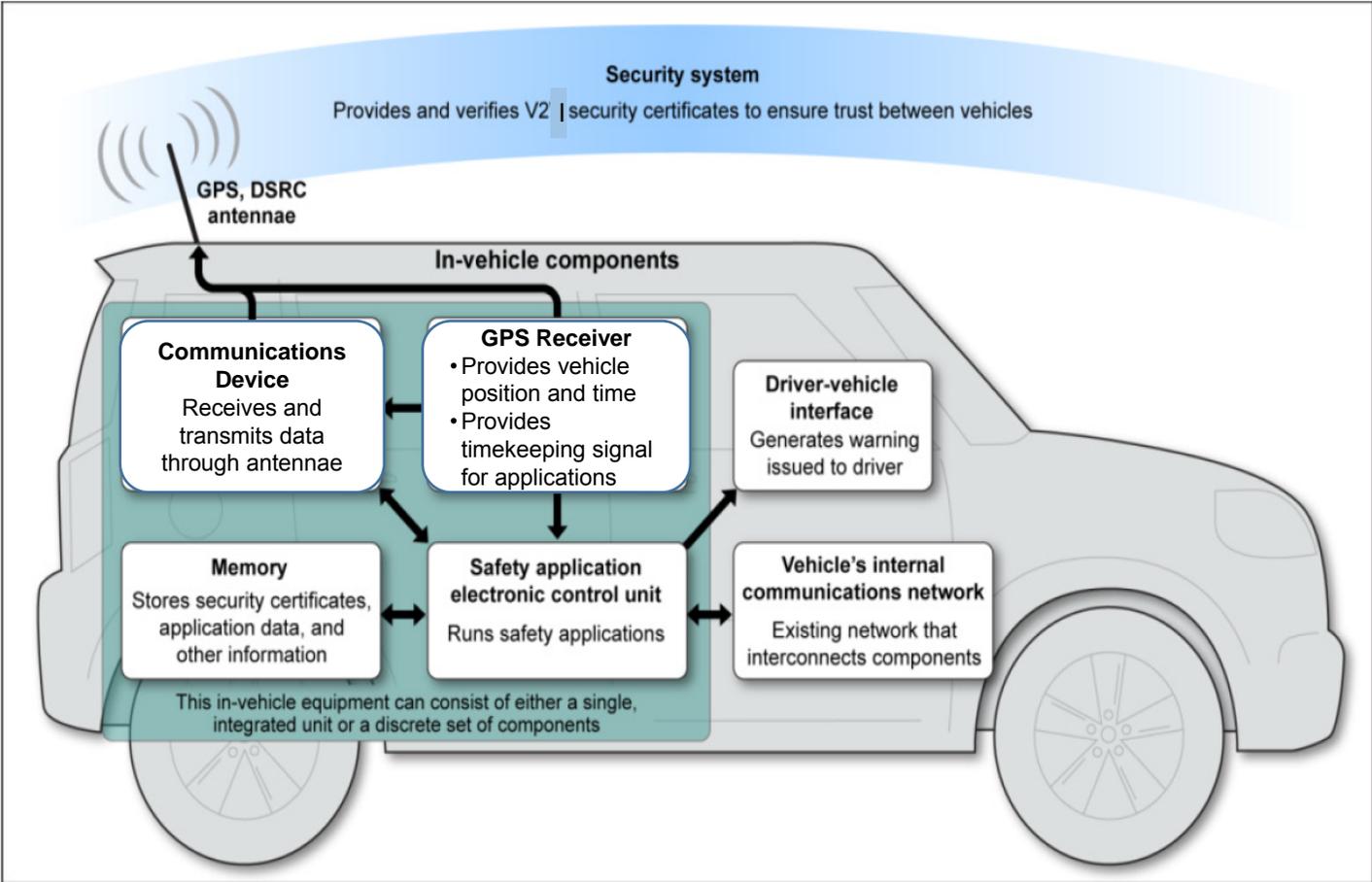
Source: Crash Avoidance Metrics Partnership and GAO

List the Components of a V2I Environment
RoadSide Equipment (RSE)

GPS, Wireless Antenna

CABINET

Wireless Communications Device
Receives and transmits data through an antennae

GPS Receiver
• Provides position and time
• Provides timekeeping signal for applications

Memory
Stores security certificates, application data, and other information

Application Processing Unit
Processing unit that runs the applications

Backhaul Modem Device
Receives and transmits data with a center

Pole

- **RoadSide Unit (RSU) -** Represents the DSRC radio alone

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Discuss the Potential Communications Technologies That May Be Deployed in V2I

Wireless Local Area Network (WLAN)

- Short to medium range broadcast communications (under 300m)

- Examples

  - Dedicated Short Range Communications (DSRC)

  - Wi-Fi

  - Bluetooth, including follow-ons such as AllSeen

  - Maybe LTE-D

  - 3GPP (3rd Generation Partnership Project) investigating using LTE mobile networks for V2X

Discuss the Potential Communications Technologies That May Be Deployed in V2I

DSRC – FCC Definition

- *The use of non-voice radio techniques to transfer data over short distances between roadside and mobile radio units, between mobile units, and between portable and mobile units to perform operations related to the improvement of traffic flow, traffic safety and other intelligent transportation service applications in a variety of public and commercial environments. DSRC systems may also transmit status and instructional messages related to the units involved.*

  - Note: An ASTM standard is incorporated into the FCC Rule

Source: Federal Communications Commission, Dedicated Short Range Communications of Intelligent Transportation Services – Final Rule, FR Doc No: 99-30591

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Discuss the Potential Communications Technologies That May Be Deployed in V2I

DSRC Frequencies

Frequencies vary in the U.S., Japan, and Europe

- In the United States, 75MHz of spectrum in the 5.9 GHz band

- (7) 10MHz Channels (provides the necessary bandwidth)

    - Channel 178 is the control channel

    - Channel 172 service channel for safety data

    - Channel 184 service channel for high powered public safety eligible

Discuss the Potential Communications Technologies That May Be Deployed in V2I

DSRC Advantages

- Low latency

    - Information can be transmitted at a high rate

    - Critical for most safety applications

    - Data can be transmitted 10 times per second

- Short to medium range (< 300 meters reliably)

    - Advantage – only interested in messages from nearby devices

    - Higher power permitted for emergency response vehicles (range can be 1 km)

- No subscription necessary

Discuss the Potential Communications Technologies That May Be Deployed in V2I

Wireless Wide Area Network (WWAN)

- High-Speed Cellular Data (LTE, LTE-Advanced, 5G)

  - Advantages

    - Provide high bandwidth data communications

    - Widely deployed

    - Increasingly available in vehicles

  - Disadvantages

    - Not suitable for low latency applications

    - Requires subscriptions

Identify V2I Applications

Application

- A piece of software that processes inputs for a specific use or purpose.

- Could be burned on a chip

- It is through applications that we obtain the benefits of a V2I environment

The next several slides list the most cited applications identified by USDOT for V2I:

- Not all V2I applications are listed

- Most applications will use its own (device) sensor readings in addition to inputs from other devices

Identify V2I Applications

V2I Safety Applications

- **Curve Speed Warning**
  - Informs connected vehicles that it is approaching a curve

- **Red Light Violation Warning (RLVW)**
  - Provides connected vehicles approaching an instrumented signalized intersection with information regarding the signal timing and the geometry of the intersection

- **Pedestrian in Signalized Crosswalk Warning**
  - Provides connected vehicles about the possible presence of pedestrians in a crosswalk at a signalized intersection

- **Oversize Vehicle Warning (OVW)**
  - Uses external measurements taken by the roadside infrastructure, and broadcasts them to connected vehicles

Source: Connected Vehicle Reference Implementation Architecture (CVRIA)

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Identify V2I Applications

V2I Safety Applications (cont.)

- **Stop Sign Gap Assist**
- **Stop Sign Violation Warning**
- **Railroad Crossing Warning (RCW)**
- **Reduced Speed Zone Warning (RSZW)**
- **Restricted Lane Warnings**
- **Spot Weather Impact Warning**
- **Warnings about Hazards in a Work Zone (WHWZ)**
- **Warnings about Upcoming Work Zone (WUWZ)**
- **Transit Vehicle at Station/Stop Warnings**

Source: Connected Vehicle Reference Implementation Architecture (CVRIA)

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Identify V2I Applications

V2I Mobility Applications

- **Advanced Automatic Crash Notification Relay (AACNR)**
  - Enables a connected vehicle to automatically transmit an emergency message when the vehicle is disabled

- **Vehicle Data for Traffic Operations (VDTO)**
  - Uses probe data information obtained from connected vehicles to support traffic operations, including incident detection and the implementation of localized operational strategies

- **Intelligent Traffic Signal System**
  - Uses both vehicle location and movement information from connected vehicles and infrastructure measurement of non-equipped vehicles to improve traffic signal operations

Source: CVRIA

Identify V2I Applications

V2I Mobility Applications (cont.)

- **Traffic Signal Priority**
  - Allows fleet vehicles to request a priority at one or a series of intersections

- **Advanced Traveler Information Systems**
  - Provides for the collection, aggregation, and dissemination of a wide range of transportation information, including traffic, transit, road weather, and workzone data

- **Traveler Information – Smart Parking**
  - Provides users with real-time location, availability, type (e.g., street, garage, AFV only), and the price of parking

- **Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)**
  - Provides warnings and alerts relating to incident zone operations to connected vehicles

Source: CVRIA

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Identify V2I Applications

V2I Environmental Applications

- **Enhanced Maintenance Decision Support System (EMDSS)**
  - Incorporates road weather data from connected vehicles into the existing Maintenance Decision Support System (MDSS) capabilities

- **Road Weather Advisories and Warnings for Motorists**
  - Collects road weather data from connected vehicles to develop short term warnings or advisories to individual motorists

- **Eco-Traffic Signal Timing**
  - Optimizes traffic signals for the environment

- **Electric Charging Stations Management**
  - Provides an exchange of information between connected vehicles and charging station to manage the charging operation

Source: CVRIA

Describe the Information That Needs to Be Exchanged Between the Components to Support V2I Applications

For this scenario, what data is needed for these applications?

- Location (latitude, longitude, elevation) from the vehicle

- Speed and direction of travel from the vehicle

- Sudden vehicle movements (acceleration rate and brake status) from the vehicle, indicating potential incidents or obstacles

- Weather data (e.g., temperature, windshield wiper status, vehicle lights) from the vehicle

- Signal phasing and timing information at signalized intersections

- Intersection geometry

- Traveler information – e.g., incident information, travel suggestions

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Which of the following is not a V2I safety application?

Answer Choices

a) Red Light Violation Warning

b) Forward Collision Warning

c) Curve Speed Warning

d) Stop Sign Gap Assist

Review of Answers

a) Red Light Violation Warning

Incorrect. Involves a vehicle receiving signal timing and geometry information from the infrastructure.

b) Forward Collision Warning

Correct! Forward Collision Warning is a V2V safety application.

c) Curve Speed Warning

Incorrect. Involves a vehicle receiving the curve geometrics and current environmental conditions from the infrastructure.

d) Stop Sign Gap Assist

Incorrect. Involves a vehicle receiving warnings and alerts about vehicle movement gaps from the infrastructure.

Summary of Learning Objective #2

Discuss the V2I Environment

- List the components of a V2I environment

- Discuss the potential communications technologies that may be deployed in V2I

- Identify V2I applications

- Describe the information that needs to be exchanged between the components to support V2I applications

Learning Objective #3: Describe the Roles of the Standards in a Connected Vehicle Environment

- Summarize the benefits of standards

- Identify the ITS standards to support communications between the components

- Identify the information and performance requirements that are supported by the ITS standards

- Identify the hardware specifications supported by USDOT

Summarize the Benefits of Standards

General Communications Requirements

Required for Deployment:
Different manufacturers.

How do we trust each other?
Authentication.

How do we communicate?
Wireless on the same frequency.

What language are we using?
Agree on the grammar and dictionary.

How many people are talking in the room?
Talk louder or softer or change rooms or channels.

Summarize the Benefits of Standards

Standards are Essential!

- Supports interoperability to maximize potential benefits

  - Interoperability – The ability of two or more systems or components to exchange information and use the information that has been exchanged[1]

  - E.g., AM/FM radio broadcasts

- Makes testing easier

- Helps with the design and procurement of a system

[1] *IEEE Std. 610.12-1990: IEEE Standard Glossary of Software Engineering Terminology*

Identify the ITS Standards to Support Communications Between the Components

Communications Standards

- **Transmission Standards**
  - ASTM 2213-03
  - IEEE 802.11-2012
  - IEEE 1609 Family

- **Interface Standard**
  - SAE J2945 Family
  - ISO 19091 Family

- **Data Standard**
  - SAE J2735

IEEE 802.11-2012

IEEE 1609 Family

SAE J2945 Family
ISO 19091 Family

SAE J2735

Identify the ITS Standards to Support Communications Between the Components

ASTM 2213-03

Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems — 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications

- Describes a MAC and PHY specification for wireless connectivity using DSRC services
    - PHY: the radio chips and the intervening environment in between
    - MAC: the message protocols that allows applications to 'connect' to the PHY
- Basis for IEEE 802.11p amendment

Identify the ITS Standards to Support Communications Between the Components

IEEE 802.11-2012

IEEE Standard for Information Technology – Telecommunications and Information Exchange Between Systems Local and Metropolitan Area Network-Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

- Provides wireless connectivity among fixed, portable, and moving stations (STAs) within a local area
- Supports wireless connectivity in vehicular environments
- Specifies channel bandwidths, operating classes, transmit power classification, transmission masks, and alternate channel requirements in the 5.9 GHz spectrum
- IEEE 802.11p amendment is included in IEEE 802.11-2012

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Identify the ITS Standards to Support Communications Between the Components

IEEE 1609.x Family

IEEE 1609.0™-2013, Architecture (Guide)

- Describes the architecture and operation of a Wireless Access in Vehicular Environments (WAVE) system based on IEEE 1609 standards and IEEE Std 802.11-2012

- Enables the development of interoperable low-latency, low overhead WAVE devices that can provide communications in support of transportation safety, efficiency, and sustainability, and that can enhance user comfort and convenience

Identify the ITS Standards to Support Communications Between the Components

IEEE 1609.x Family (cont.)

IEEE Std 1609.2™-2013, Security Services for Applications and Management Messages

- Specifies security processing requirements and application message sets for secure WAVE radio system operation
- Specifies communications security for WAVE Service Advertisements and WAVE Short Messages and additional security services that may be provided to higher layers

Identify the ITS Standards to Support Communications Between the Components

IEEE 1609.x Family (cont.)

IEEE Std 1609.3™-2010, Networking Services

- Specifies networking services required for operation of a WAVE system that employs standard IPv6 protocol, introduces a WAVE Short Message Protocol (WSMP), and provides a collection of management functions supporting WAVE services

Identify the ITS Standards to Support Communications Between the Components

IEEE 1609.x Family (cont.)

IEEE Std 1609.4™-2010, Multi-Channel Operation

- Specifies extensions to IEEE Std 802.11-2012 MAC layer for multichannel operations, i.e., operating alternately on the control channel and one of several service channels

- Includes the following features:
  - Channel timing and switching
  - MAC-layer readdressing in support of pseudonymity

Identify the ITS Standards to Support Communications Between the Components

IEEE 1609.x Family (cont.)

IEEE Std 1609.11™-2010, Over-the-air Electronic Payment Data Exchange Protocol for ITS

- Application-level IEEE 1609 standard, communication technology independent, specifies a payment over-the-air protocol referencing ISO standards

IEEE P1609.12™, WAVE - Provider Service Identifier Allocation (PSID)

- Specifies allocations of WAVE identifiers defined in the IEEE 1609™ series of standards
- Records the Provider Service Identifier (PSID) allocation decisions made by the IEEE 1609 working group, and other identifiers used by the WAVE standards

Identify the Information and Performance Requirements That Are Supported by the ITS Standards

SAE J2735

Dedicated Short Range Communications (DSRC) Message Set Dictionary

- Defines messages and data elements

Basic Safety Message (BSM)

- Message set to be broadcasted by vehicles

- Part I contains "basic" data elements that are necessary for safety applications and are expected to be broadcasted frequently

- Part II data elements are broadcasted less frequently as needed or as requested

- Expected to be broadcasted using DSRC
  - Can be read by an RSU

Identify the Information and Performance Requirements That Are Supported by the ITS Standards

SAE J2735

BSM Part I includes (partial list):

- **Location** (longitude, latitude, elevation) – where it is
- **Positional Accuracy** – how accurate is the position
- **Speed** – the rate at which the vehicle is moving
- **Transmission** – the status of the transmission gears
- **Heading** – the direction the vehicle is facing
- **Steering Wheel Angle** – the rate for change of direction
- **Acceleration** – the rate the vehicle speed is changing
- **Brake System Status** – if brakes are being applied

Identify the Information and Performance Requirements That Are Supported by the ITS Standards

SAE J2735

BSM Part II:

- Part II data elements are broadcasted as needed or as requested
- **Event Flags** – indicates an unusual event has occurred. Includes hazard lights, anti-lock brake system activated, traction control system activated, stability control activated, hard braking, stop line violation, external lights changed, wipers changed, flat tire, vehicle disabled, air bag deployment
  - Also indicates if the vehicle is an emergency vehicle on a service call, or a vehicle placarded for and carrying hazardous materials
- **Obstacles** – based on vehicle sensors or sudden vehicle movements to avoid a potential obstacle

Identify the Information and Performance Requirements That Are Supported by the ITS Standards

SAE J2735

BSM Part II:

- **Vehicle weight and height** (including trailer weight)

- **Exterior Lights** – status of lights for environmental purposes or to determine the driver's intent

- **Wipers** – rate of wipes

- **Environmental Data**
  - Air temperature
  - Sun sensor
  - Air pressure
  - Rain sensor

Identify the Information and Performance Requirements That Are Supported by the ITS Standards

SAE J2735

- **MAP Data Message.** Message to provide roadway geometric information – currently only intersection geometry
  - Lane widths, path, location
  - Lane types – driving lanes, crosswalks, special lanes, barriers
  - Lane attributes – allowable movements

- **Traveler Information Message (TIM).** Provides focused traveler information to the public
  - Can assign start times, duration and priority
  - Applicable regions or direction of travel
  - Content based on SAE J2540, ITIS Phrase Lists (International Traveler Information Systems)

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Identify the Information and Performance Requirements That Are Supported by the ITS Standards

SAE J2735

- **Signal Phase and Timing (SPaT).** Provides signal phase and timing information from one or more traffic signal controllers
  - General controller status
  - What movements (by lane) are currently allowed and when will the movement state end
    - Includes signal indication
    - Includes vehicle and pedestrian counts
    - Tied to the MAP data message

- **Signal Request / Signal Status Message (SRM/SSM).** Provides signal priority request and status messages for fleet vehicles
  - Uses approach and desired egress lane, and estimated times

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Identify the Information and Performance Requirements That Are Supported by the ITS Standards

SAE J2735

- **Probe Messages**. Collects, stores and forwards sensor data from along a segment of roadway from the vehicle

- **Emergency Vehicle Alert (EVA).** Broadcasts warning messages to other vehicles that an emergency vehicle is operating in the vicinity and additional caution is required

- **Roadside Alert (RSA).** Intended for alerting or roadway hazards

- **Intersection Collision Avoidance (ICA).** Uses information from vehicles to build intersection collision avoidance systems

- **National Marine Electronics Association (NMEA) Corrections, Radio Technical Commission for Maritime Services (RTCM) Corrections.** Used to calibrate GPS locations for vehicles and mobile devices to increase the absolute and relative accuracy

Identify the Information and Performance Requirements That Are Supported by the ITS Standards

SAE J2945 Family

- Currently titled Dedicated Short Range Communications (DSRC) Minimum Performance Requirements

- Each standard (J2945/n) may contain a concept of operations, requirements, information level dialog definitions, and the design content in the form of messages and data elements (defined in SAE J2735) for a specific interface (or set of applications)

  - Defines the operational and performance requirements

    - How often a message is sent (minimum, typical, maximum)

    - Minimum quality requirements

Identify the Information and Performance Requirements That Are Supported by the ITS Standards

SAE J2945 Family

- J2945/0 will define common requirements for DSRC

    - Includes systems engineering content (Concept of Operations, requirements, message exchanges, and message content)

- J2945/3 – Placeholder for V2I infrastructure centric applications

- J2945/4 – Placeholder for MAP/SPAT intersection safety applications

- J2945/5 – Placeholder for traveler information messages (TIM)

- J2945/6 – Performance Requirements for Cooperative Adaptive Cruise Control and Platooning

- J2945/9 – Performance Requirements for Safety Communications to Vulnerable Road Users

Identify the Information and Performance Requirements That Are Supported by the ITS Standards

SAE J3067

Candidate Improvements to Dedicated Short Range Communications (DSRC) Message Set Dictionary [SAE J2735] Using Systems Engineering Methods

- An informational report with systems engineering content
- Includes a concept of operations (user needs), requirements content (including performance content), and design content
- Includes traceability matrices between user needs, requirements, and design
- To be used as a template for developing SAE J2945 family and the next revision of SAE J2735

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Identify the Information and Performance Requirements That Are Supported by the ITS Standards

ISO TS 19091 Family

- Under TC 204 – Intelligent transport systems, Working Group 18 – Cooperative Systems
- Co-operative ITS – Using V2I and I2V Communications for Applications Related to Signalized Intersections
  - Defines the message, data structures and data elements to support exchanges between the roadside equipment and vehicles
  - Provides systems engineering content, including operational use cases, functional and performance requirements, and the design content in the form of messages and data elements
  - Specifies the details of the SPaT, MAP, SSM, and SRM messages in SAE J2735
  - Expected to be balloted in September 2015

Identify the Information and Performance Requirements That Are Supported by the ITS Standards

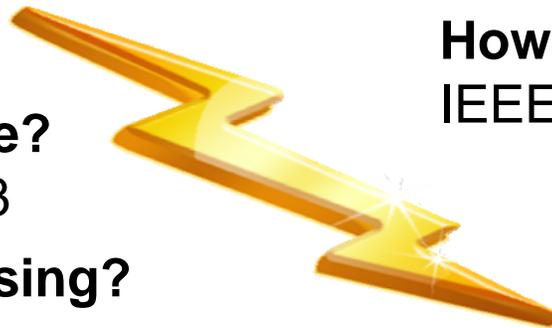## General Communications Requirements (Using DSRC)

How do we trust each other?
IEEE 1609.2 enables it.

How do we communicate?
IEEE 802.11, IEEE 1609.3

What language are we using?
SAE J2735, SAE J2945

How many people are talking in the room?
IEEE 1609.4

Identify the Hardware Specifications Supported by USDOT

Research Qualified Products List

Hardware specifications being used in the Southeast Michigan Test Bed

- Each specification is based on the standards
- 5.9 GHz DSRC Vehicle Awareness Device Specification v3.8
    - http://www.its.dot.gov/testbed/PDF/Vehicle_Awareness_Device_Specification-r3-8%2020140322.pdf
- 5.9 GHz DSRC Aftermarket Safety Device Specification v3.1
    - http://www.its.dot.gov/testbed/PDF/ASD_Device_Design_Specification_3_1%2020140322.pdf

Identify the Hardware Specifications Supported by USDOT

Research Qualified Products List (cont.)

- 5.9 GHz DSRC Roadside Equipment Device Specification v3.0

  - http://www.its.dot.gov/safety_pilot/pdf/T-10001-T2-05_RSE_Device_Design_Specification_v30.pdf

- DSRC Roadside Unit (RSU) Specifications Document v4.0

  - http://www.its.dot.gov/testbed/PDF/USDOT_RSUSpecification4%200_FInal.pdf

ACTIVITY

Which of the following is a data standard?

Answer Choices

a) IEEE 802.11-2012

b) IEEE 1609.x Family of Standards

c) SAE J2735

d) USDOT FHWA Vehicle Awareness Device Specification

Review of Answers

a) IEEE 802.11-2012

   Incorrect. IEEE 802.11 is a communications and transmission standard.

b) IEEE 1609.x Family of Standards

   Incorrect. IEEE 1609.x Family of Standards are communications and transmission standards.

c) SAE J2735

   Correct! SAE J2735 is a data standard that describes both messages sets and the data dictionary used by the message sets.

d) USDOT FHWA Vehicle Awareness Device Specification

   Incorrect. USDOT FHWA DSRC RSU Specifications Document v4.0 is a specification.

Summary of Learning Objective #3

Describe the Roles of Standards in a Connected Vehicle Environment

- Summarize the benefits of standards

- Identify the ITS standards to support communications between the components

- Identify the information and performance requirements that are supported by the ITS standards

- Identify the hardware specifications supported by USDOT

Learning Objective #4: Identify and Address High-Level Technical and Institutional Challenges to Deploying a V2I Environment

- Describe technical challenges to deploying V2I

- Describe institutional challenges to deploying V2I

- Describe strategies and approaches to acquire and deploy V2I

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Describe Technical Challenges to Deploying V2I

NHTSA ANPRM

- Only applies to V2V communications
  - V2I is not mandated
  - Rulemaking is expected to require light vehicles to support broadcasting and receiving BSM, but not other messages
- What investments can be made to leverage national deployment of connected vehicles in transportation to improve safety, mobility and the environment?
  - Another technology for collecting information and improving safety, mobility and the environment
  - Take advantage of:
    - National interoperability and functionality not found in today's ITS deployments
    - Real-time data without significant investments

Describe Technical Challenges to Deploying V2I

Standards are Still Evolving

- Align with NHTSA regulatory decision on V2V deployment and research needs
  - Guidance provided to SDOs to have stable, approved, and published standards by September 2015
- Updates to standards based on prototypes and field tests
  - For example, there is a "wish list" for Part II data elements from stakeholders
- Harmonization of protocols and standards with each other and international efforts

Describe Technical Challenges to Deploying V2I

Implementation Issues

- Vehicles need to be equipped to gain benefits
    - At least one vehicle must broadcast to or receive from the infrastructure
- Managing the environment and the challenges during the "roll out"
    - Few vehicles will be "fully" equipped
    - Managing the entire range of capabilities – different vehicles have different devices and different capabilities
- Near-field tracking is possible
- Not a substitute for decisions based on sound transportation engineering principles

Describe Technical Challenges to Deploying V2I

Testing / Certification

- Define testing program and certification
  - Conformance testing (to standards)
  - Compliance testing (with regulations or legal requirements)
  - Dependent on the implementation's requirements and applications
- Degree of maturity of current standards for certification testing (self-testing, third-party testing, establishing accredited laboratories for device testing and certification)

Describe Technical Challenges to Deploying V2I

Regulatory Issues

- Requirement for coexistence **if** band sharing with unlicensed users is required by FCC (75 MHz allocation in 5.9 GHz band for safety applications in vehicular environments)

  - December 17, 2003 FCC Report and Order – safety applications have primary status over non-safety applications

- Government entities – geographic license based on jurisdictional area of operations

- Non-government entities licensed on application's area of operations

- Coordination across jurisdictions and boundaries will be necessary

Describe Institutional Challenges to Deploying V2I

Privacy

- Privacy between users and 3rd parties

- Can't track a vehicle to its source and destination without appropriate authorization (e.g., electronic payments)

- IEEE 1609.3 describes the use of changing MAC address at random intervals

- SAE J2945 standards address this by assigning and changing an identifier on a frequent basis

Describe Institutional Challenges to Deploying V2I

Security

- Exchange of trusted and authenticated data between users and applications

- Message validity

  - For example, to authenticate basic safety, traveler information, roadway geometric information (MAP) and signal timing information (SPaT) messages

- Designing a security certificate management system

  - Based on IEEE 1609.2, which defines how to use, revoke, and refresh certificates

Describe Strategies and Approaches to Acquire and Deploy V2I

Deployment

- Start considering V2I communications and standards when new ITS equipment and traffic signal controllers are purchased and installed

  - Reliable power supply

  - Secure backhaul communications link

  - Equipment that are NTCIP standards conformant

  - Electronic map or geometric description of the surrounding area in SAE J2735 format

  - Roadside cabinet space to house an external devices

  - Plans for future mounting for a DSRC RSU and other roadside equipment

Describe Strategies and Approaches to Acquire and Deploy V2I

Procurements

- Develop standards-based specifications
  - Conformance to the transmission standards, interface standards, and data standards required for the implementation
  - Select communications media(s) to be supported
  - Support security infrastructure

- Develop Test Plans
  - Identify the scope of and the purpose for testing
    - Identify how to verify conformance to the referenced standards
    - Identify the system requirements (e.g., application functions)
  - Identify how testing will be performed

Describe Strategies and Approaches to Acquire and Deploy V2I

Conformance

- Each standard should have a conformance clause (statement)

    - Understand what the conformance clause means

    - Understand when the conformance clause applies

    - Understand how to test for conformance to the standard

        - There are other PCB modules on testing:

        - T101 – Introduction to ITS Standards Testing

        - T201 – How to Write a Test Plan

        - T202 – Overview of Test Design Specifications, Test Cases and Test Procedures

ACTIVITY

What is a challenge to deploying connected vehicles during the initial "rollout"?

Answer Choices

a) Each automobile vendor uses its own protocol

b) There have been no field tests of connected equipment

c) No expected rule requiring vehicles be equipped

d) Very few vehicles are equipped

Review of Answers

a) Each automobile vendor uses its own protocol

Incorrect. Standards have been developed.

b) There has been no field tests of connected equipment

Incorrect. Numerous field tests have been conducted using connected equipment.

c) No expected rule requiring vehicles be equipped

Incorrect. NHTSA has proposed rulemaking requiring light vehicles be equipped.

d) Very few vehicles are equipped

Correct! During the rollout, very few vehicles are expected to be equipped.

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Summary of Learning Objective # 4

Identify and Address Technical and Institutional Challenges to Deploying a V2I Environment

- Describe technical challenges to deploying V2I

- Describe institutional challenges to deploying VI

- Describe strategies and approaches to acquire and deploy V2I

Learning Objective #5: Describe the Current Status of the Connected Vehicle Environment

- Introduce standards and research activities underway
- Provide key schedule milestones for the connected vehicle environment
- List resources for further reading and information

- *Note: as of June 2015*

Introduce Standards and Research Activities Underway

IEEE 802.11-2012

- 802.11RevMc scheduled for review and comment in March 2016
    - Assess potential changes needed for alignment to any NHTSA proposed rulemaking

Introduce Standards and Research Activities Underway

IEEE 1609 Family

- P1609.2 – converting to use ASN.1 for next revision (2015)
- P1609.3 – Miscellaneous Corrections (2015)
- P1609.11 – Plan revisions if needed following publication of referenced ISO standards revisions
- P1609.12 – May consider revision before 4Q2015 - essential for operation of DSRC radio system

Introduce Standards and Research Activities Underway

SAE DSRC Technical Committee

- Acceleration of standards to support NHTSA V2V Rulemaking Activities
- SAE J2735
    - Possible reconsideration of BSM elements based on pilot deployments
    - Considering changes for the Signal Request Message and Signal Status Message
- SAE J2945
    - J2945/3 – Placeholder for V2I infrastructure centric applications
    - J2945/4 – Placeholder for MAP/SPAT intersection safety applications
    - J2945/5 – Placeholder for traveler information messages (TIM)
    - Other J2945/n as efforts warrant

Introduce Standards and Research Activities Underway

Security Credential Management System (SCMS)

- October 2014, NHTSA released a Request For Information seeking information related to the security system to support V2I operations
    - Noted that the security system will not be established by NHTSA regulation
    - Envision a V2I SCMS to support trusted, safe/secure V2I communications and to protect driver privacy appropriately
    - A SCMS Manager for managing Certificate Management Entities (CME)
- Designed to protect the security and privacy of data exchanges in the CV environment
- Will reference IEEE 1609.2

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Introduce Standards and Research Activities Underway

Certification Testing

- USDOT released a Request For Applications (RFA) in June 2014 to establish a certification environment for connected vehicle devices and applications

    - Intent to enter a cooperative agreement with one or more existing facilities to conduct qualification and certification testing for connected devices

- Proposed device and application certification that includes:

    - Environmental Capabilities (e.g., temperature, vibration, weather);

    - Communication Protocol Capabilities (e.g., DSRC interoperability);

    - Interface Abilities (e.g., message syntax and content)

    - Overall Application Abilities (i.e., verifies the system level function)

    - SCMS

Source: US Department of Transportation

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Introduce Standards and Research Activities Underway

USDOT

- FHWA V2I Deployment Guidelines
  - A guidance document, not regulation
  - What and how to implement infrastructure and supporting systems
    - Guidelines
    - Best Practices
    - Toolkit
  - Supporting high-priority applications
  - http://stsmo.transportation.org/Documents/V2I_DeploymentGuidanceDraftv9.pdf
  - Final Expected Summer 2015

Introduce Standards and Research Activities Underway

V2I Deployment Coalition

- Forming a deployment coalition to support implementation
  - Members include AASHTO, ITE, ITS America
- Represent and address stakeholder needs
- Forum to offer assistance in deploying V2I
- Dissemination of tools, reference materials, and other technical assistance

Introduce Standards and Research Activities Underway

Connected Vehicles Research

- Southeast Michigan Test Bed
  - Real-world, operational conditions to test applications, services and components using the latest standards and architecture
- USDOT Connected Vehicle PlugFests. Events where devices can be tested for interoperability using standards
- Dynamic Mobility Applications (DMA)
- Data Capture and Management (DCM)
- Applications for the Environment: Real-Time Information Synthesis (AERIS)
- Road Weather Connected Vehicle Applications

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Provide Key Schedule Milestones for the Connected Vehicle Environment

NHTSA

- February 3rd, 2014 – Decision to move forward with V2V communications for light vehicles

- August 18, 2014 – USDOT issues Advance Notice of Proposed Rulemaking to Begin Implementation of Vehicle-to-Vehicle Communications Technology

- Decision on heavy vehicles was expected end 2014

- Sent letters to IEEE and SAE asking that these standards be updated and mature by end of 2015 for deployment purposes

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ACTIVITY

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What is the current status of connected vehicle standards?

Answer Choices

a) The standards are stable so no revisions are needed

b) The standards are being revised based only on lessons learned from pilot deployments and field tests

c) The standards are being revised based only on existing USDOT regulations

d) The standards are being revised based on lessons learned and harmonization with each other

Review of Answers

a) The standards are stable so no revisions are needed

Incorrect. The standards are currently being revised based on lessons learned from pilot deployments and harmonization.

b) The standards are being revised based only on lessons learned from pilot deployments

Incorrect. The standards are being revised based on lessons learned and harmonization efforts.

c) The standards are being revised based only on current USDOT regulations

Incorrect. There are no current USDOT regulations regarding the connected vehicles environment.

d) The standards are being revised based on lessons learned and harmonization with each other

Correct! The standards are being revised based on field tests and to harmonize the standards with each other.

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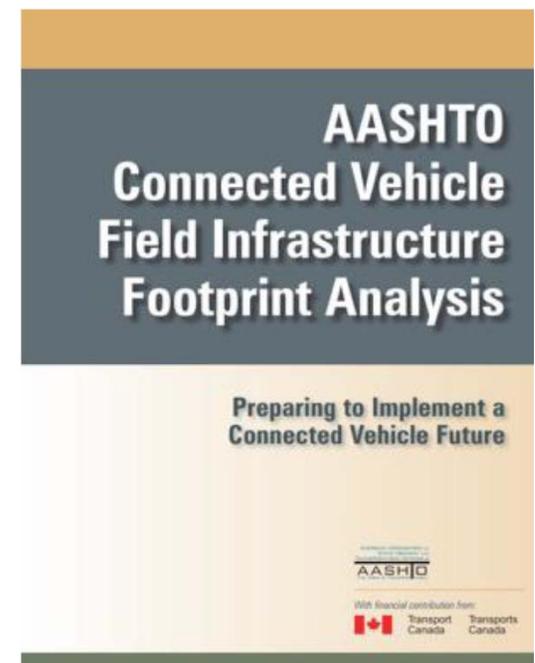# List Resources for Further Reading and Information

Connected Vehicle Reference Implementation Architecture (CVRIA)

- A reference framework that spans all ITS standards activities and provides a means of detecting gaps, overlaps and inconsistencies between the standards

- Can be used as a resource for planning or deployment
  - Includes an application list, which will include emerging application requirements and standards to be considered for deployment for each application

- Will be migrated to the next major revision of the US National ITS Architecture

- Connected Vehicle Reference Implementation Architecture (CVRIA). http://iteris.com/cvria/

List Resources for Further Reading and Information (cont.)

AASHTO Connected Vehicle Field Infrastructure Footprint Analysis

- Provides guidance to state agencies and DOTs, including:
    - Infrastructure needs at regional and national levels
    - Illustrations of typical deployments
    - System and equipment needs and siting requirements
    - Operations, maintenance and institutional issues
    - Deployment cost estimates

- http://stsmo.transportation.org/Documents/AASHTO%20Final%20Report%20_v1.1.pdf

List Resources for Further Reading and Information (cont.)

ITS Standards

- ASTM E2213 – 03 (2010) – Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems – 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications, ASTM, http://www.astm.org/Standards/E2213.htm

- IEEE 802.11-2012 – IEEE Standard for Information technology – Telecommunications and information exchange between systems. Local and metropolitan area networks – Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, IEEE, http://standards.ieee.org/about/get/802/802.11.html

- IEEE 1609 Family of Standards for Wireless Access in Vehicular Environments (WAVE), IEEE, http://standards.ieee.org/develop/wg/1609_WG.html

List Resources for Further Reading and Information (cont.)

ITS Standards

- SAE J2735_2015 – Dedicated Short Range Communications (DSRC) Message Set Dictionary, SAE, http://standards.sae.org/wip/j2735/, http://www.sae.org/standardsdev/dsrc/, http://standards.sae.org/j2735_201504/

- SAE J2945 – Dedicated Short Range Communications (DSRC) Minimum Performance Requirements (Work in Progress), SAE, http://standards.sae.org/wip/j2945/

- SAE J3067 – Candidate Improvements to Dedicated Short Range Communications (DSRC) Message Set Dictionary [SAE J2735] Using Systems Engineering Methods, SAE, http://standards.sae.org/j3067_201408/

List Resources for Further Reading and Information (cont.)

Resources for Further Reading

- ISO/AWI TS 19091 – Intelligent transport systems – Cooperative ITS – Using V2I and I2V communications for applications related to signalized intersections, http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=63941

- USDOT website: http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm

- See Student Supplement for additional resources

Summary of Learning Objective # 5

Describe the Current Status of the Connected Vehicle Environment

- Introduce standards and research activities underway

- Provide key schedule milestones for the connected vehicle environment

- List resources for further reading and information

What We Have Learned

1) The connected vehicle environment is about transportation
   <u>connectivity</u>.

2) The V2I environment consists of on-board units and roadside
   units broadcasting information to support:

   a) <u>safety</u> applications

   b) <u>mobility</u> applications

   c) and <u>environmental</u> applications

What We Have Learned

3) Connected vehicle standards are critical to support
   interoperability .

4) Some of the institutional issues are:

   a) security

   b) privacy

   c) and data ownership

5) Standards maintenance is continuing to include new
   requirements and to incorporate lessons learned .

QUESTIONS?

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