Connected Vehicles 101
**ITS Professional Capacity Building Program**

- Offers FREE training to develop the ITS workforce
- Talking Transportation Technology webinars, with online archive
- ITS Standards – 36 modules
- ITS Transit Standards – coming soon
- eLearning Courses from Consortium for ITS Education (CITE):
  - Telecommunications and Networking Fundamentals
  - Network Design and Deployment Considerations for ITS Managers
- Workshops at ITS America state chapter meetings

[Image Source: ThinkStock/USDOT]

www.pcb.its.dot.gov
Connected Vehicle Resources

- ITS PCB Archived Webinars:
  - CV Basics – April 24, 2014
  - AASHTO Connected Vehicle Infrastructure Footprint Analysis Webinar – May 22, 2014

- ITS ePrimer – Connected Vehicle Module

- Contact: Mac Lister, Program Manager
  ITS Professional Capacity Building Program
  U.S. Department of Transportation
  708-283-3532
  Mac.Lister@dot.gov

www.pcb.its.dot.gov
# Course Format

<table>
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# Topic 1: Introduction to the Connected Vehicle Environment

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Topic 1: Introduction to the Connected Vehicle Environment

After this topic, you will be able to:

- Explain the concept of connected vehicles
- Describe the technology used for connected vehicles
- List the benefits and challenges of connected vehicle technology
http://clips.shadowtv.net/media/request/06e5ee4197d7490fa95c5ba08bea75c0/index.html
NBC Nightly News Video Summary

Connected vehicles have the potential to address approximately 80% of vehicle crash scenarios involving unimpaired drivers.

- Greater situational awareness:
  - Your vehicle can “see” nearby vehicles and knows roadway conditions you cannot see
  - 360-degree “visibility”

- Reduce or even eliminate crashes through:
  - Driver advisories
  - Driver warnings
  - Vehicle control
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 CO₂
Fully Connected Vehicles

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

Infrastructure Data:
- Signal Phase and Timing,
- Drive 35 mph,
- 50 Parking Spaces Available
US DOT/NHTSA Advance Notice of Proposed Rule Making on V2V Communications Technology

- Announced August 18, 2014, to seek public input to regulation to eventually require V2V devices in new light vehicles (60 day comment period)

- Primary purpose: enable collision warnings to drivers prior to a crash

- Based on several years of research including the Safety Pilot Model Deployment – 3,000 vehicle road test in Ann Arbor, Michigan

- Report on technical feasibility, privacy and security, and preliminary estimates on costs and safety benefits concludes:
  - V2V devices in light vehicles communicated as intended using security management system during Model Deployment
  - NHTSA has legal authority to mandate V2V (DSRC) devices in new light vehicles and require installation in commercial vehicles

- Security and privacy protections built into contemplated system

- Decision on heavy vehicles planned at end of 2014
Let’s Recap

- How do connected vehicles work?
Connected Vehicle Communications Technology

- 5.9 GHz DSRC
- 4G and older 3G cellular networks provide high-bandwidth data communications
- Other wireless technologies such as Wi-Fi, satellite, and HD radio may have roles to play
DSRC Communications Technology: How It Works

- Data is transmitted 10 times/sec (300m range)
- Privacy is built-in (vehicle location is NOT intended to be recorded or tracked)
- Wi-Fi radio adapted for vehicle environment
- Inexpensive to produce in quantity
- Original FCC spectrum allocation in 1999, revised in 2004 and 2006
Connected Vehicle Communications Technology: Benefits and Challenges

- Benefits of the DSRC communications technology:
  - Reduced price
  - Improved reliability $\rightarrow$ fewer false alarms
  - Increased performance $\rightarrow$ addresses more crash scenarios

- Challenges of the DSRC communications technology:
  - Both parties (vehicle/vehicle or vehicle/infrastructure) need to be equipped to gain benefit
  - Requires security infrastructure
Connected Vehicle Communications Technology: Benefits and Challenges (continued)

- **Benefits of 4G and 3G cellular technology:**
  - Widely deployed commercial networks
  - Increasingly available in vehicles
  - Mobility and environmental applications

- **Challenge of 4G and 3G cellular technology:**
  - May not be suitable for safety applications that require low latency
Topic 1 Wrap-up

- What communications technologies are used for connected vehicles applications?
- What are the benefits of the DSRC connected vehicle communications technology?
- What other communications technologies can be used for mobility and environmental applications?
- What is a major challenge of the connected vehicle technology?
## Topic 2: Connected Vehicle Applications

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Topic 2: Connected Vehicle Applications

After this topic, you will be able to:

- Describe the impact of connected vehicles on safety, mobility, and the environment
- Describe the connected vehicle applications for safety
- Describe the connected vehicle applications for mobility
- Describe the connected vehicle applications for the environment
- Identify which application would help alleviate your top transportation challenge
Connected Vehicle Applications

Safety
- V2V
- V2I

Mobility
- Dynamic Mobility Applications

Environment
- AERIS
- Road Weather Applications
Connected Vehicle Technology Animation
Connected Vehicle Applications: Safety

- **Safety**
  - V2V
  - V2I

- **Mobility**
  - Dynamic Mobility Applications

- **Environment**
  - AERIS
  - Road Weather Applications
# Safety Applications: V2V

<table>
<thead>
<tr>
<th>V2V Safety Applications</th>
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<tbody>
<tr>
<td>Forward Collision Warning</td>
<td>FCW</td>
</tr>
<tr>
<td>Emergency Electronic Brake Light</td>
<td>EEBL</td>
</tr>
<tr>
<td>Blind Spot/Lane Change Warning</td>
<td>BSW/LCW</td>
</tr>
<tr>
<td>Do Not Pass Warning</td>
<td>DNPW</td>
</tr>
<tr>
<td>Intersection Movement Assist</td>
<td>IMA</td>
</tr>
<tr>
<td>Left Turn Assist</td>
<td>LTA</td>
</tr>
</tbody>
</table>
Lauren is driving home with her son after a day at school. She is stopped at a red light. When the light turns green, she is about to move through the intersection when she is warned of a vehicle crossing the path in front of her. She quickly brakes to avoid a T-bone crash.
## Safety Applications: V2I

<table>
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</tr>
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<tbody>
<tr>
<td>Curve Speed Warning</td>
<td>CSW</td>
</tr>
<tr>
<td>Red Light Violation Warning</td>
<td>RLVW</td>
</tr>
<tr>
<td>Spot Weather Information Warning</td>
<td>SWIW</td>
</tr>
<tr>
<td>Reduced Speed Zone Warning</td>
<td>RSZW</td>
</tr>
<tr>
<td>Stop Sign Gap Assist</td>
<td>SSGA</td>
</tr>
<tr>
<td>Smart Roadside</td>
<td>SRI</td>
</tr>
<tr>
<td>Transit Pedestrian Warning</td>
<td></td>
</tr>
</tbody>
</table>
Charles is on his way to the senior center and does not notice the red light at the intersection. His car signals him to stop immediately.
Connected Vehicle Applications: Mobility

- **Safety**
  - V2V
  - V2I

- **Mobility**
  - Dynamic Mobility Applications

- **Environment**
  - AERIS
  - Road Weather Applications
## Dynamic Mobility Applications

<table>
<thead>
<tr>
<th>Application</th>
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<tbody>
<tr>
<td>Multimodal Intelligent Traffic Signal System</td>
<td>MMITSS</td>
</tr>
<tr>
<td>Intelligent Traffic Signal System</td>
<td>I-SIG</td>
</tr>
<tr>
<td>Transit Signal Priority</td>
<td>TSP</td>
</tr>
<tr>
<td>Mobile Accessible Pedestrian Signal System</td>
<td>PED-SIG</td>
</tr>
<tr>
<td>Freight Signal Priority</td>
<td>FSP</td>
</tr>
<tr>
<td>Emergency Vehicle Preemption</td>
<td>PREEMPT</td>
</tr>
<tr>
<td>Intelligent Network Flow Optimization</td>
<td>INFLO</td>
</tr>
<tr>
<td>Dynamic Speed Harmonization</td>
<td>SPD-HARM</td>
</tr>
<tr>
<td>Queue Warning</td>
<td>Q-WARN</td>
</tr>
<tr>
<td>Cooperative Adaptive Cruise Control</td>
<td>CACC</td>
</tr>
</tbody>
</table>
## Dynamic Mobility Applications

<table>
<thead>
<tr>
<th>Response, Emergency Staging and Communications, Uniform Management, and Evacuation</th>
<th>R.E.S.C.U.M.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident Scene Pre-Arrival Staging Guidance for Emergency Responders</td>
<td>RESP-STG</td>
</tr>
<tr>
<td>Incident Scene Work Zone Alerts for Drivers and Workers</td>
<td>INC-ZONE</td>
</tr>
<tr>
<td>Emergency Communications and Evacuation</td>
<td>EVAC</td>
</tr>
<tr>
<td>Enable Advanced Traveler Information Systems</td>
<td>Enable ATIS</td>
</tr>
</tbody>
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## Dynamic Mobility Applications

<table>
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<tr>
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<tr>
<td>Integrated Dynamic Transit Operations</td>
<td>IDTO</td>
</tr>
<tr>
<td>Connection Protection</td>
<td>T-CONNECT</td>
</tr>
<tr>
<td>Dynamic Transit Operations</td>
<td>T-DISP</td>
</tr>
<tr>
<td>Dynamic Ridesharing</td>
<td>D-RIDE</td>
</tr>
<tr>
<td>Freight Advanced Traveler Information Systems</td>
<td>FRATIS</td>
</tr>
<tr>
<td>Dynamic Travel Planning and Performance</td>
<td></td>
</tr>
<tr>
<td>Drayage Optimization</td>
<td></td>
</tr>
</tbody>
</table>
Mike is on his way to work and receives a queue warning that there is an incident up ahead. How can connected vehicle mobility applications help Mike get to work on time?
## Connected Vehicle Applications: Environment

<table>
<thead>
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<th>Safety</th>
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<tr>
<td>V2I</td>
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# Environment Applications: AERIS

## Cleaner Air Through Smarter Transportation

### ECO-SIGNAL OPERATIONS

- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driver
- Wireless Inductive/Resonance Charging

### ECO-LANES

- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Ramp Metering
- Connected Eco-Driver
- Wireless Inductive/Resonance Charging
- Eco-Traveler Information Applications
# Environment Applications: AERIS

## Cleaner Air Through Smarter Transportation

### LOW EMISSIONS ZONES
- Low Emissions Zone Management
- Connected Eco-Driving
- Eco-Traveler Information Applications

### ECO-TRAVELER INFORMATION
- AFV Charging/Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing
- Dynamic Eco-Transit Routing
- Dynamic Eco-Freight Routing
- Multi-Modal Traveler Information
- Connected Eco-Driving
### Cleaner Air Through Smarter Transportation

<table>
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<tr>
<th>ECO-INTEGRATED CORRIDOR MANAGEMENT</th>
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<tr>
<td>Eco-ECM Decision Support System</td>
</tr>
<tr>
<td>Eco-Signal Operations Applications</td>
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<td>Eco-Lanes Applications</td>
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<tr>
<td>Low Emissions Zones Applications</td>
</tr>
<tr>
<td>Eco-Traveler Information Applications</td>
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<tr>
<td>Incident Management Applications</td>
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</table>
Paul is driving to work and sees an advisory to adjust his speed to 35 mph. The traffic signal is telling him that if he adjusts his speed, he will arrive at the signal just as it is turning green. Using eco-approach and departure, he maximizes fuel savings, minimizes emissions, and may even get to work faster.
## Connected Vehicle Applications: Environment

**Safety**
- V2V
- V2I

**Mobility**
- Dynamic Mobility Applications

**Environment**
- AERIS
- Road Weather Applications
Environment Applications: Road Weather

<table>
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<tr>
<td>Motorist Advisories and Warnings (MAW)</td>
</tr>
<tr>
<td>Enhanced Maintenance Decision Support System (MDSS)</td>
</tr>
<tr>
<td>Vehicle Data Translator (VDT)</td>
</tr>
<tr>
<td>Weather-Responsive Traffic Information (WxTINFO)</td>
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</table>
Danielle sees a warning that she is approaching an icy road. A warning is transmitted from the car ahead of her, from a satellite, and from hardware on the roadside.

Data could have been collected from multiple sources in real-time. She has a lot of confidence because she knows that the data is coming from these sources in real-time.
Let’s Recap

- What are three connected vehicle application categories?
- What are the connected vehicle applications for safety?
- What are the connected vehicle applications for the environment?
- What are the applications concepts for mobility?
Activity

- In which area is your top transportation challenge?
Topic 2 Wrap-up

- Can you think of a deployment concept that can help alleviate your top transportation challenge?
- What are the applications within that deployment concept?
## Topic 3: Research Toward Implementation

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Topic 3: Research Toward Implementation

After this topic, you will be able to:

- Describe the three main connected vehicle research program components
- Describe the enabling technologies for the V2I reference implementation
- Describe the purpose of the connected vehicle reference implementation architecture (CVRIA)
- Describe how communication and exchange of data will occur between mobile, field, and center entities
- List questions to consider for connected vehicle infrastructure implementation
## Connected Vehicle Research Components

<table>
<thead>
<tr>
<th>Applications</th>
<th>Technology</th>
<th>Policy and Institutional Issues</th>
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![Mathematical equation on a blackboard](image)
Enabling Technologies

- Equipment
- Data
- Standards
### Role of Equipment in Connected Vehicles

#### Equipment

USDOT tested devices for placement on the Research Qualified Products List (RQPL). Five vendors of connected vehicle roadside equipment are currently on the list. Devices are based on RSE Specification v3.0.

Roadside Unit (RSU) Specification v4.0 is now available. It contains updates to the physical hardware, management information base (MIB), and firmware. Devices compliant with the 5.9 GHz DSRC RSU Specification v4.0 are expected to be available fall 2014.

Other connected vehicle deployments are encouraged to use equipment compliant with the RSU specification v4.0.

Results from Safety Pilot and Integrated V2I Prototype development will be used to develop a V2I reference implementation.

#### Data

#### Standards
# Role of Data in Connected Vehicles

<table>
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<th>Equipment</th>
<th>Data</th>
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<tr>
<td><strong>V2I Communications Support Safety, Mobility, and Environmental Applications:</strong></td>
<td><strong>Common functions shared across applications: positioning, mapping, and communications.</strong></td>
</tr>
<tr>
<td>• Signal Phase and Timing (SPaT) data supports red light violation warning (safety), arterial speed harmonization (mobility), and eco-signal operations (environment).</td>
<td><strong>Process for application testing (e.g., leverage Affiliated Test Beds).</strong></td>
</tr>
<tr>
<td>• The Basic Safety Message, developed for V2V safety applications, also supports the intelligent traffic signal systems mobility application.</td>
<td><strong>The traffic management center is involved in disseminating the real-time data that enables these applications.</strong></td>
</tr>
<tr>
<td>• Probe data supports transportation operations, traveler information, transportation planning, and asset management.</td>
<td></td>
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</tbody>
</table>

## Standards
# Role of Standards in Connected Vehicles

## Equipment

## Data

## Standards

### Interface Standards Are Essential

USDOT is working with public and private sectors to define:

- Communications standards for DSRC
- Other media, e.g., 4G LTE and/or HD radio may be used for appropriate applications
- Information exchange standards:
  - Message sets for V2X [SAE J2735]
  - Minimum performance requirements for V2X messaging [SAE J2945.x]
- Signal controller messages
- Certification processes will also be established to ensure off-the-shelf interoperability of devices
V2I Reference Implementation

- A system of specifications and requirements that allow the various components of V2I hardware, software, and firmware to work together
- An agency will be able to select the capabilities and applications desired at a given installation
Let’s Recap

- What are the three main components needed for V2I reference implementation?
Connected Vehicle Reference Implementation Architecture (CVRIA) Background and Purpose

Applications

- **Safety**
  - Transit Safety Applications
  - V2V
  - V2I

- **Mobility**
  - Data Capture and Management
  - Dynamic Mobility Applications

- **Environment**
  - AERIS
  - Road Weather Applications

- **Support**
  - Sec Credentials
  - Core Services
CVRIA Includes Multiple Views

- Enterprise
- Functional
- Physical
- Communications
Centers / Back-office Physical Objects

- Perform management and administration functions
- Supports connected vehicle—field and mobile devices
- Not necessarily a physical brick-and-mortar building
- Can be aggregated together or distributed across geographies or functionally
Field (13 Physical Objects)

- ITS infrastructure on or along the transportation network
- Surveillance
- Control devices
  - Signal control
  - Lane controls
  - Ramp meters
- Connected vehicle roadside equipment (RSE)
- Supply information
  - Signage
- Support payment
- Support credential/safety checks
Vehicles (19 Physical Objects)

- Covers the intelligent/cooperative on-board systems
  - Advanced safety systems
  - Navigation
  - Remote data collection
  - Information

- Fleet-type vehicles include special functionality:
  - Dispatch
  - Signal preemption/priority
  - Monitoring activities
  - Fleet management
  - Passenger services
  - Fare payment
Travelers (7 Physical Objects)

- Equipment to access transportation services
- “Personal” devices
  - Fixed personal computers
  - Personal mobile devices
**Connected Vehicle Architecture**

- USDOT developed the Systems Engineering Tool for Intelligent Transportation (SET-IT)
  - Software package to support connected vehicle project architecture
  - Connects to commercial drawing and database capabilities
  - Long-term plans to integrate CVRIA into existing National ITS Architecture
Connected Vehicle Supporting Services

- **Definition of General Services:**
  - Data Distribution
  - Security Credential Management
  - Infrastructure Management

- **Capabilities/Principles:**
  - Secure exchange of trusted data between users and applications without pre-existing relationship or entering into a permanent relationship
  - Assurance of privacy between users and from third parties
  - More efficient data collection from various sources and distribution to many users
Small Group Activity

- Based on the deployment concept you worked on previously, create a list for what information you would need to gather and what physical objects and interfaces would need to be established in order to get the program up and running.
Scenario: H.W. Halleck Expressway

The H.W. Halleck Expressway:

- Highly congested 10-mile urban freeway
- Multiple interchanges
- Natural bottleneck at the Colfax S-Curve
- Significant issue with incidents, both minor (frequent) and major
- Unreliable travel times
- Limited arterial diversion routes
Example Integrated Concept - H. W. Halleck ExpressWAY

- Messages for V2V Safety Applications also Support Incident Zone Management Safety
- Vehicle Probe Data Integrated with Freeway Sensors to Harmonize Flow
- Coordinated Multi-Agency Response Planning
- Signals Adapt to Prevent Gridlock
- Aggregated Data From Traveler Information Services Used To Predict Diversion Rates
Research Data Exchange

- Promotes sharing of archived and real-time data
- Multiple data environments
- Multi-source data
- Improved search and download functions
- Exploring integrated real-time data environments
- Adding additional data environments

www.its-rde.net
Open Source Application Development Portal

www.itsforge.net

- Portal for sharing documentation and source code from USDOT-sponsored application prototyping efforts
- By end of 2014, will be populated with materials describing 10+ connected vehicle applications
- Contributed code must meet documentation guidelines
- Search and download functions
- Release 1 is now available to the public
Using a scenario, describe the following roles:

- Describe the role of equipment in connected vehicles.
- Describe the role of data in connected vehicles.
- Describe the role of standards in connected vehicles.
- Describe the role of the connected vehicle reference implementation.
- Describe the role of the connected vehicle reference implementation architecture.
# Topic 4: Connected Vehicle Testing and Deployment

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Topic 4: Connected Vehicle Testing and Deployment

After this topic, you will be able to:

- Discuss opportunities with the Affiliated Connected Vehicle Test Beds
- List the steps and guidance required to deploy connected vehicles
- Describe how to become involved with the connected vehicle program
- Identify challenges to connected vehicle implementation
Connected Vehicle Test Bed Video

http://www.its.dot.gov/library/media/8testbed.htm
Affiliated Interoperable Test Beds

- The vision is to have multiple interoperable locations as part of one connected system moving toward nation-wide deployment.
  - Common architecture
  - Common standards
  - Independent operations
  - Shared resources
Overview of USDOT Test Bed Resources

- Qualified Product List for RSE
  - Five vendors
- Qualified Product List for Onboard Equipment (OBE)
  - Vehicle Awareness Devices
  - Aftermarket Safety Devices
- Portable RSE Trailers
- Network Listeners/Sniffers
- Test Bed Operations Staff
- Signal Phase and Timing (SPaT) Resources
  - Listeners
  - Interface standards from FHWA
- Security Credential Management System (SCMS)
  - 1609.2 certificate management system
Southeast Michigan Test Bed—2014

- The Southeast Michigan 2014 Test Bed:
  - Gives users the capability to test safety, mobility, and environment applications, services and components
  - Defines the “high level” system architecture using CVRIA as a reference and foundation
  - Introduces concepts in terms of functions and information flows
  - Illustrates concepts through selected operational scenarios

- The goals of the Southeast Michigan 2014 Project are to:
  - Assure trust in data exchanged
  - Protect the confidentiality of certain data exchanged
  - Protect the anonymity and privacy of individuals while operating in a multi-application, multi-industry, multi-medium environment
USDOT Connected Vehicle PlugFests

- Upcoming Events in 2014:
  - Hackathon: Early November 2014/January 2015, Novi, MI

- Past Events:
  - Detroit Area PlugFest: August 5-7, 2014
  - Palo Alto, CA PlugFest: June 24-26, 2014
  - Detroit Area PlugFest: May 13-15, 2014
  - Detroit Area PlugFest: March 12-13, 2014
Benefits of Test Bed Membership

- Designation of Affiliated Test Bed
- Access to USDOT support staff and resources
- Increased access to lessons learned, documentation, and other information from peers deploying test beds
- Test beds serve as a model for future permanent deployments
- Provide opportunities for future testing

Contact:
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U.S. Department of Transportation
Intelligent Transportation Systems Joint Program Office
Email: walton.fehr@dot.gov
Discussion

What would be beneficial to you in using the test beds?
Path to Deployment

- Defined V2V Apps
- Defined Safety (V2I), Mobility (V2V & V2I), AERIS and Weather Apps
- Application Development
- Pilots/Early Deployments

FHWA Deployment Guidelines

NHTSA Decision to Move Forward with V2V Communication for Light Vehicles
NHTSA Decision for Heavy Vehicles

Safety Pilot in 2013

U.S. Department of Transportation
ITS Joint Program Office
Infrastructure Deployment Planning

- National Connected Vehicle Field Infrastructure Footprint Analysis
- FHWA Deployment Guidance
- Standardized Interfaces
- Certification Processes for Equipment and Systems
- Nationwide Security Credential Management System (SCMS)
2015 FHWA Vehicle to Infrastructure Deployment Guidance and Products

- FHWA Guidance to state and local agencies for implementing V2I to ensure interoperability and efficient and effective planning, procurement, and operations.

- Goal is to:
  - Provide initial advice
  - Best practices
  - Technical support tools

- Draft release September 2014, with planned release in 2015

- Products and Tools:
  - Systems Engineering Process for V2I
  - V2I Benefit Cost Analysis Tool
  - V2I Planning Guide
  - Guide to V2I Cyber-Security
  - Guide to Licensing DSRC Roadside Units
  - Guide to V2I Communication Technology Selection
  - V2I Message Lexicon
The goals of the CV Pilots Program are to:

- Accelerate early deployment of Connected Vehicle technology
- Understand and estimate benefits associated with deployment
- Identify and solve key technical and institutional barriers

Pilots will serve as initial implementations of connected vehicle technology deployed in real world settings

Request for Information (RFI) issued March 2014 to help refine the plans for one or more pilot deployments

Procurement action anticipated for one or more pilot deployment concepts in 2015

See Deployment Concepts at:
http://www.its.dot.gov/pilots/cv_pilot_deployment.htm
Connected Vehicle Deployment Program - Goals

- Spur Early CV Tech Deployment
  - Wirelessly Connected Vehicles
  - Mobile Devices
  - Infrastructure

- Measure Deployment Benefits
  - Safety
  - Mobility
  - Environment

- Resolve Deployment Issues
  - Technical
  - Institutional
  - Financial
Connected Vehicle Deployment Program - Principles

- Pilots will be *pilot deployments*, that is, real-world environment deployments
  - If successful, deployed technologies are expected to remain as permanent operational elements

- There will be *multiple* pilot sites over time
  - Each site will have different needs, focus and applications
    - That is, pilot deployments must address a critical problem
    - The needs of each site must drive the application selection process

- Pilot deployments are expected to be both *large-scale and multi-modal*
  - *Large-scale* implies pilot deployments will have measureable impact, not a specific minimum geographic or vehicle fleet size
  - Sites will deploy *multiple applications* drawing on the products of USDOT and other connected vehicle research
Proposed Pilot Deployment Requirements

- Multiple connected vehicle applications must be deployed together
  - Cost-effectively leveraging captured CV and mobile device data
  - Address multi-modal problems

- Pilot deployments should leverage USDOT-sponsored research
  - Need not include all applications (in fact, this is unlikely to be practical)
  - May include new connected vehicle applications not considered by USDOT
  - All applications selected must work and have an impact

- Pilot deployments should include the capture of data from multiple sources
  - At a minimum, vehicles must represent one source of data used in the pilot deployment
Proposed Pilot Deployment Requirements

- Multiple forms of communications technologies are desired
  - DSRC desired as one communication technology
- Well-defined, focused, quantitative performance measures
  - Support an independent evaluation effort
- Share pilot deployment data and lessons learned
  - While protecting privacy and intellectual property
- Security and credentialing management system
- Integrated or carry-in devices for connected vehicles capable of generating an SAE J2735 Basic Safety Message (BSM)
Let’s Recap

- What are the steps USDOT is taking to deploy connected vehicles?
Get Involved

- How do I get involved?
- How does the private sector participate?
- What is the governance structure to get everyone to agree on common architecture and common standards?
- What funding or resources does USDOT have to offer?
Topic 4 Wrap-up

- What is the guidance required to deploy connected vehicles?
- What opportunities do the connected vehicle test beds offer?
- When will the Connected Vehicle Pilot Deployments occur?
## Topic 5: Policy and Institutional Issues

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<thead>
<tr>
<th>Topic</th>
<th>Title</th>
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<td>1</td>
<td>Introduction to the Connected Vehicle Environment</td>
<td>30 minutes</td>
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<td>2</td>
<td>Connected Vehicle Applications</td>
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<td>3</td>
<td>Research Toward Implementation</td>
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<td>4</td>
<td>Affiliated Connected Vehicle Testing and Deployment</td>
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<tr>
<td>5</td>
<td>Policy and Institutional Issues</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>
After this topic, you will be able to:

- Describe key policy challenges with connected vehicles
- Describe communications security policy issues with connected vehicles
- Describe privacy policy issues with connected vehicles
- Describe the costs and benefits of connected vehicles
Connected Vehicle Policy Program

- Conducts research on critical policy and institutional issues in support of enabling successful deployment of connected vehicle technologies.

- Issues are generally cross-cutting and require collaboration among multiple stakeholder groups.

- Policy research has been conducted in areas such as:
  - Communications Security
  - Privacy and Data Policy
  - Spectrum
  - Implementation
  - Standards Harmonization
  - Stakeholder Outreach
Communications Security Policy

- How do we know that the sender of a message should be ‘trusted’?
  - Need to validate messages exchanged between vehicles (V2V) and between vehicles and infrastructure (V2I)

- Requires Security Credential Management System (SCMS)
  - Organizational entities for operating security management system
  - Communications network for security updates
Privacy and Data Policy

- A user should not be tracked or identified (e.g. no personally identifiable information).

- Important to ensure that messages cannot be linked to personal information. Basic safety messages, certificates, and other information exchange should not link to personal identifiers.

- Data management policies.
Other Policy Challenges

- **Implementation**: FHWA V2I Deployment Guidance for Connected Vehicles

- **Standards Harmonization**: Conducting international collaboration to harmonize technical and policy standards

- **Spectrum**: Implications of possible spectrum sharing

- **Stakeholder Outreach**: Critical to inform development of policy options and to support policy decision-making process.
  [http://www.its.dot.gov/meetings/v2i_feedback.htm](http://www.its.dot.gov/meetings/v2i_feedback.htm)
Challenges to Connected Vehicle Deployment

- What are some challenges to implementing connected vehicles?
Benefits and Costs of V2V

- NHTSA Vehicle-to-Vehicle Communications: Readiness of V2V Technology for Application Report explores technical, legal, and policy issues relevant to V2V. It discusses benefits and costs, including:

  - Safety applications including IMA, FCW, and LTA, have proven effective in mitigating or preventing potential crashes, but more refinements needed. Two V2V safety applications, IMA and LTA, would potentially:

    - prevent 25,000 to 592,000 crashes, save 49 to 1,083 lives, avoid 11,000 to 270,000 MAIS 1-5 injuries, and reduce 31,000 to 728,000 property-damage-only crashes annually by the time V2V technology had spread through the entire fleet

  - NHTSA estimates V2V equipment and supporting communications would cost approx. $341 to $350 per vehicle in 2020. Could decrease to approximately $209 to $227 by 2058

  - Estimates of annual costs of the V2V system from $0.3 to $2.1 billion in 2020 depending on technology implementation scenarios and discount rates
### NCHRP 03-101: Benefits of Public Sector Connected Vehicle Deployment

- Reduced need for 511 infrastructure
- Reduction of infrastructure required to monitor traffic
- Lower cost of pavement condition detection
- Adaptive lighting
- Crash response and clean-up cost reduction
- Work zone accident reduction
- DOT vehicle fleet insurance reduction
- Improved access to data for planning studies
- Potential for improved long-term planning, program management
- Faster and more cost-effective response to public issues and policy change
- Ability to measure performance of DOT operations on an accelerated schedule
- Cost savings to transit agencies by better optimizing the fleet
- Increased safety may allow reorganization of safety roles at the DOT
Exploratory Research—Vehicle Automation

- Enhanced by connectivity to other vehicles and infrastructure

- Benefits of Connectivity
  - Increases availability, speed, and reliability of information
  - Enables coordination of automated traffic streams

- The full potential benefits of road vehicle automation can only be achieved through a connected environment
Topic 5 Wrap-Up

- What are the security challenges that the connected vehicle program faces?
- What are the data privacy challenges that the connected vehicle program faces?
- What are some cost and benefit categories related to connected vehicles?
Course Wrap-up

- What are the three main connected vehicle application categories?
- What are the three ITS research program components?
- What are the three categories of enabling technologies for the connected vehicle infrastructure?
- What are the four types of physical objects connecting to the core system?
- True or False: Test beds operate independently of each other.
- What are the goals of the Connected Vehicle Pilot Deployments?

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