Connected Vehicles Moving Towards Deployment

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Connected Vehicles
Moving Towards Deployment
Session Overview

- Technology Overview
- Applications
- Deployment Support Efforts
- Timeline
- Recent Deployment Moves
Connected Vehicles have the potential of addressing approximately 80% of the vehicle crash scenarios involving unimpaired drivers!

NHTSA - V2V is a foundation to saving lives
Connected Vehicle Era

• Research into the feasibility and safety benefits of communicating between vehicles and vehicles to the infrastructure began around the turn of the century.

• Initial program focused mainly on safety applications a new wireless technology called Dedicated Short Range Communications (DSRC) radios.
More recently the program has been expanded to include safety, mobility and environmental applications that allow use of other communications technologies like WiFi and Cellular.

- Today “Connected Vehicles” are those that use wireless technologies to connect vehicles to each other and/or to the infrastructure (roadside, hand-held device, cell tower, etc.).
- Current focus is mainly on cellular and DSRC however tolling, telematics, and even transit priority are looked at as “connected vehicle” applications.
Connected Vehicle Era

- Connected Vehicles assume
  - Vehicle to Vehicle (V2V)
  - Vehicle to Infrastructure (V2I/I2V)
  - Vehicle to vulnerable road users - Pedestrians, bicyclists, motorcyclists (V2X)

- Bicyclist and Pedestrian Safety is a USDOT Priority
**Key Technology Enabler - DSRC**

- **What is it?**
  - Special Wi-Fi radio (802.11p) adapted for high speed/low latency environment
    - Very short latency times - well suited for CV Safety Applications
    - Provides ad hoc communications
  - Frequency Spectrum - 5.9GHz - EU/Asia 5.8GHz
    - Dedicated frequency set aside by FCC - local agency license
    - 75 MHz of dedicated Spectrum
  - Relatively inexpensive in production quantities

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### FCC DSRC Channel Designations

<table>
<thead>
<tr>
<th>Channel</th>
<th>Frequency (GHz)</th>
<th>5 MHz</th>
<th>20 MHz</th>
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<tbody>
<tr>
<td>CH 172</td>
<td>5.850</td>
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<td>CH 174</td>
<td>5.850</td>
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<td>CH 178</td>
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<td>CH 180</td>
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<td>CH 182</td>
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<td>CH 184</td>
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- **CH 172**: Collision Avoidance Safety
- **CH 178**: Control Channel
  - Advertise services on other channels
- **CH 184**: High Power Public Safety
Key Technology Enabler - DSRC

- **How the technology works**
  
  **Vehicle**
  - Messages transmitted by vehicles every 100 msec
  - Basic Safety Message (BSM)
    - Vehicle size, position, speed, heading, acceleration, brake status ...
  - Service Request Message (SRM) - for priority/preemption requests

  **Infrastructure**
  - Signal Phase and Timing (SPaT) (100msec)
  - Geometric Intersection Description (GID)/MAP
  - Service Status Message (SSM) - priority/preemption status

- **Minimum range of 300 meters - line of sight**

- **Requires vehicles to be equipped to take full advantage of safety application benefits**
  - V2I applications require roadside infrastructure
Security System

• Key element of V2V and V2I is implementation of a security system to insure a trusted communication environment exists.
  - Privacy by design
• Security architecture based on a system that manages, distributes and revokes digital certificates used to validate the communications
  - Security Credential Management System
DSRC Products

• Onboard Unit (OBU)
  - This is the vehicle radio and supporting equipment
  - Vendors
    • Denso, Delphi, Siemens, Savari Networks, Choda Wireless, Arada Systems, Kapsch
  - Aftermarket devices
    • Vehicle Awareness Device (VAD)
    • Aftermarket Safety Device (ASD)
    • Retrofit Safety Device (RSD)

• Roadside Unit (RSU)
  - This is the infrastructure equipment
  - Vendors
    • Savari Networks, Choda Wireless, Arada Systems, Siemens, Denso, Kapsch
Connected Vehicle Issues

• Privacy Concerns
  - DSRC design insures privacy (OBU MAC changes as it connects with an RSU). Personal information is not collected.
  - Commercial & Consumer apps via Cellular or Wi-Fi are “opt-in” so personal data can be collected (such a WAZE).

• Data Ownership - Under study by USDOT

• USDOT Authority
  - NHTSA - has authority to regulate safety equipment in vehicles. Broad interpretation expands this to roadside as RSE is part of the safety application.
  - FHWA has authority to provide guidance but can’t regulate
    • FHWA encourages use of CV but can’t require and as such is not directly funding DSRC infrastructure

• Spectrum
  - DSRC relies on dedicated spectrum that is currently under attack and being reviewed at Federal level
DSRC Spectrum Threat

- In 1997 the FCC allocated the frequency spectrum of 5.9GHz specifically to transportation applications.
- Two bills are now before Congress that propose opening up the 5.9GHz band for unlicensed WiFi use. This potentially poses a threat to the use of DSRC for safety applications.
- ITS America and others have petitioned the FCC and Congress to delay any action by the FCC until testing can show that DSRC for Connected Vehicles will not be impacted by opening the 5.9 GHz spectrum space to unlicensed use.
  - USDOT projects that a decision could be reach on spectrum sharing within 12 months after starting testing with Wi-Fi industry proposed prototypes.
High-Level V2I Architecture

AASHTO RSE Cost Estimates
• Site deployment - $17-18K
• Backhaul comm - $4-40K
• Ongoing O&M - $2-3K/yr
Source: CV Footprint Analysis
Example RSE Deployment Configuration
V2I Intersection Architecture
IV2I Prototype System Architecture

Integrated V2I Prototype Platform

Traffic Management Entity Interface (IP)
- INFLO TME App (incl SPD-HARM, Q-WARN)
- AERIS/Ecodriving TME App
- Road Weather TME App (incl WRTM)
- Road Weather Vehicle Data Translator
- MMITSS Central System

Local/Back Office User Systems Interface (IP)
- GPS Positioning
- Low Latency Wireless Communications (e.g. DSRC)
- Onboard Positioning Service
- Vehicle Weather Data Message Generator
- Onboard Map Service
- Vehicle and Nomadic Device App Platform(s)
- INFLO Message Generator (incl SPD-HARM, Q-WARN)
- V2I Safety App Vehicle Platform
- AERIS/Ecodriving Application

Low Latency Wireless Message Service
- Roadside Signage Message Service
- Rail Crossing Signal Request Sensor
- Pedestrian Crossing Request Sensor

Dynamic Roadside Message System

Traffic Signal Controller
- Traffic & Rail Signal Message Handler
- V2I Safety Application Infra Platform
- MMITSS Roadside Processor
- FRATIS Message Handler

Low Latency/Quasi-Static Message Storage

Local Road Surface Infra Sensor Systems
- Ped & Bicycle Infra Sensor Systems
- CMV Virtual Weigh Station Sensor Systems

Local Weather & Road Surface Message Handler
- Ped, Bicycle, Nomad Dev Data Aggregator

High Latency Wireless Message Service

MMITSS Central System
- Local/BO IVP Platform Install, Configure, Management
- Local/BO IVP Message Handler User Interfaces
- Local/BO IVP Quasi-static Data File Upload (incl Map)

Driver/User Message Arbitrator

An Econolite Group Company
# CV Applications Research

## V2I Safety
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

## V2V Safety
- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

## Environment
- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging / Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

## Mobility
- Advanced Traveler Information System (I-SIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN)
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
- Emergency Communications and Evacuation (EVAC)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance
- Drayage Optimization

## Agency Data
- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies
- Work Zone Traveler Information

## Road Weather
- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

## Smart Roadside
- Wireless Inspection
- Smart Truck Parking
Early V2V Safety Applications

- Blind Spot & Lane Change Warning
- Forward Collision Warning (FCW)
- Emergency Electronic Brake Lights (EEBL)
- Intersection Movement Assist (IMA)
- Do Not Pass Warning (DNPW)
- Left Turn Across Path/Opposite Direction (LTA/LTAP)
Intersection Related Connected Vehicle Applications

- Intelligent Traffic Signal Systems
- Transit signal priority
- Emergency Vehicle Preemption/Priority
- Pedestrian Mobility
- Freight Signal Priority

These applications require vehicles and roadside to be equipped with DSRC and application software.
Intelligent Traffic Signal System ISIG

• Improvements in control algorithms
  - Reduce delay
  - Increase throughput
  - Reduce congestion
  - Improve safety
  - Enhanced intersection awareness

• New equipment at the intersection
  - RSU to Controller Interface
  - RSU Radios
  - Application management
  - MAP/GID data
  - Combining BSM & local detection
Transit Signal Priority

- Expanded availability
- More efficient handling of multiple priority requests
- Reduce transit delay
- Improve transit delay variability
Emergency Signal Preemption/Priority

- Expanded availability
- Potential of priority rather than preemption - improving efficiency and safety
- More efficient and safe handling of multiple requests
- Reduce emergency vehicle delay
- Improve delay variability
Pedestrian Mobility

- Safer and more efficient service of mobile travelers
  - Pedestrians, Cyclists, etc.
  - Improved Controller and Vehicle awareness of mobile travelers
  - Safer crossing for disabled mobile travelers
Freight Signal Priority

• More efficient and safe service of heavy freight vehicles
• Improved controller awareness of approaching freight vehicles
• Reduce pavement damage
• Improve overall freight vehicle delay
Other Connected Vehicle Applications

- **Environmental - Cleaner Air Through Smarter Transportation**
  - Eco-Driving
  - Eco-Traffic Signal Timing
  - Eco-Speed Harmonization
  - Eco-Cooperative Adaptive Cruise Control
  - Dynamic Eco-Routing

- **Road Weather**
  - Motorist Advisories and Warnings (MAW)
  - Enhanced Maintenance Decision Support System (MDSS)
  - Weather-Responsive Traffic Information (WxTINFO)
Deployment will depend on having well-defined technologies, interfaces and process in place. Key research in support of this includes:

- SPaT & Related Messages for CV Applications
- Safety Pilot/Model Deployment
- Multi-Modal Intelligent Traffic Signal System (MMITSS)
- Integrated V2I Prototype
- Connected Vehicle Test Beds
- Connected Vehicle Pilot Deployments
Real-World Testing to Support Deployment

Econolite is supporting Test Beds in California, Arizona, Michigan and Texas
Goal: Deploy Stable, Interoperable, Reliable Systems
Deployment Actions

• Deployments have already taken place or are underway as part of research projects, test beds, and the CV Safety Pilot.
  - These deployments have been relatively small and mostly V2V focused but have included some V2I applications.
• Many State DOTs are looking to begin Pilot Deployments in the 2016 to 2017 time frame.
  - Depends in part on funding from the FHWA as part of the CV Pilot Deployment initiative.
• GM will begin selling vehicles equipped with DSRC and V2V applications beginning with the 2017 model year.
• Qualcomm, NXP and others have announced DSRC capable chip sets.
• NHTSA is expected to issue a NPRM in early 2016 that will mandate the use of DSRC. Anticipated OEMs will begin including DSRC and V2V applications in 2020 model year vehicles.
• FHWA role - facilitating effective deployments for those interested in implementing infrastructure enabled connected vehicle applications (Jeff Lindley)
DSRC OBE Market Penetration Projection

Assumes year 1 = 1% and reaches 75% in 2030

Source: VDOT Case Study
Infrastructure Rollout Projection

Source: AASHTO CV Footprint Analysis
Funding will be available in two waves (2015 and 2017) to develop and deploy applications that leverage the full potential of trusted communications among connected vehicles, travelers, and infrastructure to better inform travelers, enhance current operational practices, and transform surface transportation systems management.
CV Pilot Deployments

- Program seeks to spur innovations among early adopters of connected vehicle technology.
- The pilot deployments are expected to move research concepts into practical, effective and deployable capabilities.
- Deployments will involve partnerships of multiple stakeholders (private companies, agencies, transit, commercial and freight operators) and show multiple multi-modal applications.
  - Applications will involve more than just DSRC
- Sites are expected to become part of a permanent connected vehicle capability and be integrated into routine operational practice.
Program will consist of three phases:
- Phase 1: Concept Development (up to 12 months)
  - RFP for Phase 1 has just been released
- Phase 2: Design/Build/Test (up to 20 months)
- Phase 3: Operate and Maintain (18 months)

Project funding pool of around $150MM
- Funding ranges $2-5MM, $5-12MM, $20MM
- 1 or 2 $20MM projects will be awarded with 5-6 projects in the $2-12MM range
- Wave 1 - award anticipated Sept 2015 - Wave 2 - award anticipated Sept 2017
  - Wave 1 - 30 to 50 proposals submitted
V2I Deployment Coalition

• To address infrastructure needs for the deployment of Connected Vehicles - ITS America, ITE and AASHTO in conjunction with the FHWA have formed the V2I Deployment Coalition.

  - Coalition is a consortium of users, manufactures and academics that bring much needed infrastructure expertise to CAMP and the FHWA
  - Coalition will coordinate with CAMP/VIIC to help move Connected Vehicle technology towards deployment
    • In turn this will help speed V2I deployment
V2I Deployment Coalition Structure

Connected Vehicle Executive Leadership Team

V2IDC Executive Committee (consists of V2IDC Technical Work Group Chairs and USDOT Reps)

V2IDC

TWG 1: Deployment Initiatives
TWG 2: Deployment Research
TWG 3: Infrastructure Operator, OEM, and Supplier Partnerships
TWG 4: Deployment Guidance
TWG 5: Deployment Standards

USDOT ITS JPO FHWA FTA NHTSA Etc.
**V2IDC Proposed Objectives**

- Provide leadership for the Connected Vehicle Deployment Program
- Establish Connected Vehicle deployment strategies
- Lead and provide support on continued technical research to support Connected Vehicle deployment
- Support Connected Vehicle standards development
- Provide input and refinement to the Connected Vehicle Deployment Guidelines

- First meeting - June 4-5 Pittsburgh
  - 150+ attendees - cross section of public, private, academic, and OEM’s
Getting Involved

- Become aware - learn what you can about the CV program so that you understand how Connected Vehicles might impact and benefit your agency in the future.
  - JPO, RITA, FHWA, ITE, ITSA, AASHTO State DOT resources available including:
    - Presentations, articles, training material, etc.
  - FHWA V2I Deployment Guidance document
    - Update expected summer 2015
  - AASHTO CV Infrastructure Footprint Analysis
  - V2I Deployment Coalition
- Consider CV requirements in planning and intersection upgrade decisions
  - Consider ATC class controllers to insure they have the ability to be upgraded for CV in the future
- Make Connected Vehicle part of the discussion
  - State, MPO, Transit and Local Agency discussions needed
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