Connected Vehicles and Signalized Intersections

September 23, 2015
Wisconsin ITS Forum 2015
Dan Vanada, Director of Product Management

(Content provided by Gary Duncan, Chief Technology Officer)
Today's Transportation Problems

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
Connected Vehicles

- The vehicle awareness of Connected Vehicles opens the door to a myriad of radical improvements in Safety, Mobility and the Environment.
- Many expect the impact on transportation to be bigger than anything since the signalized intersection or even the invention of the automobile.
- In safety alone, Connected Vehicles have the potential of addressing approximately 80% of the vehicle crash scenarios involving unimpaired drivers!
Key Technology Enabler – 5.9GHz DSRC (Dedicated Short Range Communications)

• What is it?
  – Special WiFi radio (802.11p) adapted for low latency
    • Latency < 0.2 milliseconds – well suited for Safety Applications
    • Range: max ~1,000 meters; min 300 meters
  – NA Frequency 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
DSRC Products

• Onboard Unit (OBU)
  – Vehicle radio and supporting equipment
    • Vendors: Denso, Delphi, Siemens, Savari Networks, Choda Wireless, Arada Systems, Kapsch
  – Aftermarket devices
    • Plug into vehicle’s OBD port
  – Collectively, “Onboard Equipment” (OBE)

• Roadside Unit (RSU)
  – Infrastructure equipment
    • Vendors: Savari Networks, Choda Wireless, Arada Systems, Siemens, Denso, Kapsch
  – Collectively, “Roadside Equipment” (RSE)
Forms of “Connected Vehicle”

• V2V – Vehicle to Vehicle

• V2I – Vehicle to Infrastructure
Forms of “Connected Vehicle”

• V2X – Vehicle to Vulnerable Road Users
Basic CV Messages
From SAE J2735 Standard

• Broadcast by Vehicle
  – **BSM** (Basic Safety Message)
    • Vehicle position, speed, heading, acceleration, brake status, size, steering, …
    • Every 100 milliseconds

• Broadcast by Infrastructure
  – **SPaT** (Signal Phase and Timing)
    • Every 100 milliseconds
  – **GID/MAP** (Intersection Map)

• Specific Communication
  – **SRM** (Service Request Message)
    • i.e. Priority Request
  – **SSM** (Service Status Message)
Connected Vehicle Applications
# 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
- Intelligent Traffic Signal 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
Intersection Related CV Apps

• 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.
Example CV Application

• Univ. of Arizona under the direction of Dr. Larry Head is developing a set of intersection applications called Multi-Modal Intelligent Traffic Signal System (MMITSS)
  – Family of applications, leading off with Priority Control
  – Handles multiple, simultaneous priority requests
  – Live test deployments in AZ and at ITSA World Congress
  – Pooled fund research with equipment support from Econolite and Savari
Connected Vehicle
Moving Toward Deployment
Real-World Testing to Support Deployment

Econolite is supporting Test Beds in California, Arizona, Michigan and Texas
Funded CV Pilot Deployments

• CV Safety Pilot – Ann Arbor, MI, 2013
  – 3,000 DSRC equipped vehicles; 6 DSRC intersections

• 1st wave of Pilot Deployments
  – Just announced 3 projects
    • New York City
    • Tampa, FL
    • Wyoming
  – More could be added if funds become available

• 2nd wave of Pilot Deployments
  – Planned for 2017
V2I Deployment Coalition

- Provide leadership for the Connected Vehicle Deployment Program
- Establish CV deployment strategies
- Lead and provide support on continued technical research to support CV deployment
- Support CV standards development
- Provide input and refinement to the CV Deployment Guidelines
- First meeting - June 2015 in Pittsburgh
  - 150+ attendees - cross section of public, private, academic & OEM’s
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.
Connected Vehicle and the Signalized Intersection
CV Intersection Block Diagram

DSRC Radio (RSU)

DSRC
802.11p
IEEE 1609
SAE J2735

DSRC Radio (OBU) Equipped

Traffic Cabinet

Connected Vehicle Applications Processor

NTCIP 1202
[& 1211]

Controller

SAE J2735
(or alternative)

Connected Vehicle Backhaul

Traffic Management System

ECONOLITE Group, Inc.
Specification Considerations

• Modern Signal Controller
  – Require NTCIP 1202 v3.05 (support for J2735 messages)
  – Consider ATC standard controller with comm module slot

• Processor to run Connected Vehicle Applications
  – Standalone black box or…
  – Integrated into controller—either fully integrated or plugin
    • If sharing controller processor, sufficient processing power and memory must be specified
  – May be possible to run some applications in RSU
Specification Considerations

• One or more DSRC radios (RSU)
  – Geometry could require more than one for good coverage
  – In-cabinet equipment to support the RSU (i.e. surge prot.)
  – POE will require 48VDC source

• Network backhaul with sufficient bandwidth
  – For security management, data, and path to Internet for cellular/wifi apps
  – May be able to use existing network or high speed cellular

• Design/Planning, installation, setup, training, maintenance, on-going software license fees
Potential CV Intersection Costs

- AASHTO DSRC RSE Cost Estimates (per site)
  - Site deployment costs - $17-18K
  - Backhaul costs - $4-40K (depending on existing network)
  - Ongoing O&M costs - $2-3K per year

- No specific funding has been set aside by the FHWA for DSRC deployment other than Pilot Deployments
  - Deployment can be funded using typical intersection funding program
Connected Vehicles
Timeline
Connected Vehicle Penetration

• NHTSA is expected to issue a NPRM in late 2015 (under new accelerated schedule) that will mandate the use of DSRC. Mandate will probably require DSRC by the 2020 model year vehicles.
  – Focused mainly on V2V

• At ITS World Congress in 2014 Cadillac committed to install DSRC radios in certain 2017 models
The Path to Deployment

Guidelines, Best Practices, Took Kits

Goal: Deploy Stable, Interoperable, Reliable Systems
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

- ~ 61K Intersections
- ~ 250K Intersections

Source: AASHTO CV
Footprint Analysis
Connected Vehicles Resources
Deployment Guidance

• AASHTO CV Infrastructure Footprint Analysis
  - Provides information on deployment requirements, costs, example plans, etc.

• FHWA V2I Deployment Guidance & Products
  - Guidelines to help owner/operators deploy V2I
  - Due to be published late in 2015

• V2I Deployment Coalition
  - Joint effort by AASHTO, ITE, ITSA
  - Work output for Deployment Guidance, Initiatives, Research, Standards and Partnerships
CONNECTED VEHICLES ARE COMING...

...and your community can be part of the evolution of this exciting new technology.

Questions?