Accelerating solutions for highway safety, renewal, reliability, and capacity

Connected Vehicles and the Future of Transportation
Session Overview

• What are connected and automated vehicles?
• Connected vehicle technologies and applications
• Policy issues
• Public agency preparation
What are Connected and Automated Vehicles?
What is a Connected Vehicle?

Connected vehicles use wireless technology to “connect” vehicles to each other and/or to infrastructure (for example, cell tower, roadside equipment, hand-held device)

- Cellular
- Dedicated short-range communication (DSRC)
- V2V, V2I, V2X
Connected Vehicle: Cell Technologies & Applications

Cellular connection is established through:

- Carried-in devices like smart phones
- OEM-installed cellular equipment

Either option generates geo-located data used commercially

Image courtesy of KROMKRATHOG/FreeDigitalPhotos.net
Connected Vehicle:
Cell Technologies & Applications

• Connected vehicles are a growing market and an important part of automotive business models.
• App developers are proliferating.
• Consumers experience transportation differently.
  – Business models are evolving and OEMs are positioning for the future.
  – Apps may be independently developed or OEM-created/approved
  – Ford and GM opened their dashboards to app developers
  – GM installing high-speed LTE on new 2015 models
Connected Vehicle: Cell
Time-line

Cell-based connected vehicles are here now!
Examples of connected vehicle applications in various markets

Mainly B2B

Mainly Consumer

Commercial vehicles

INRIX

here

waze

Drivewyze

NEXTbus

SHRP2

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES
What is a Connected Vehicle?

Dedicated short-range communication or DSRC-equipped vehicles are a special type of connected vehicles using a mobile Wi-Fi standard particularly well suited to safety applications.

DSRC-based vehicles are moving from research into deployment.
Connected Vehicle: DSRC Technologies & Applications

Connection through OEM-installed DSRC

• DSRC provides high-speed (low latency), broadcast connection
  – DSRC is particularly suited for active vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) safety applications
  – DSRC also supports other applications

• Extensive research tested the safety benefits of DSRC-based applications

• DSRC development is moving forward
Why DSRC Matters

“V2V technology can address a large majority of crashes involving two or more motor vehicles.”

Source: NHTSA
How DSRC-Equipped Vehicles Work

latitude, longitude, time, heading angle, speed, lateral acceleration, longitudinal acceleration, yaw rate, throttle position, brake status, steering angle, headlight status, wiper status, external temperature, turn signal status, vehicle length, vehicle width, vehicle mass, bumper height
How DSRC-Equipped Vehicles Work

• DSRC functions at 5.9 GHz via spectrum allocated by the FCC for this purpose
  – Spectrum allocation is currently the subject of debate.
• Data from the vehicle (basic safety message) is broadcast 10x/second
• Both vehicles must be equipped with a DSRC transmitter and receiver
• V2V applications do NOT require infrastructure (except for the security network)
Connected Vehicle: DSRC Technologies & Applications

• Six V2V safety applications were tested in Ann Arbor, MI
  • Forward Collision Warning (FCW)
  • Emergency Electronic Brake Light (EEBL)
  • Blind Spot/Lane Change Warning (BSW/LCW)
  • Do Not Pass Warning (DNPW)
  • Intersection Movement Assist (IMA)
  • Left Turn Assist (LTA)

• V2V and V2I require a security network
Connected Vehicle: DSRC & NHTSA Rulemaking

- August 2014, NHTSA released an advance notice of proposed rulemaking which begins a regulatory process for DSRC in light vehicles
- NHTSA report “V2V Communications: Readiness of V2V Technology for Application”
  - Technical feasibility and additional research
  - Privacy
  - Security
  - Preliminary cost estimates
  - Safety benefits
Connected Vehicle: DSRC & NHTSA Rulemaking

- May 2015, Secretary Foxx announced intention to accelerate NHTSA rulemaking
- Late 2015, NHTSA V2V NPRM Interagency Review
- Fall 2015, Wave 1 of Connected Vehicle Pilot Deployments announced
- Winter 2015, FHWA draft V2I deployment guidance document pending release
## Connected Vehicle: DSRC

### Time-line

August 2014 NHTSA ANPRM released for light vehicles
Late 2015, NHTSA NPRM Interagency Review
Final regulation could take 3-5 years plus a phase-in period
Fleet penetration is necessary for benefits (timing depends on aftermarket)

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Safety Pilot</td>
</tr>
<tr>
<td>2014</td>
<td>Decision</td>
</tr>
<tr>
<td>2014</td>
<td>ANPRM</td>
</tr>
<tr>
<td>Late 2015</td>
<td>NPRM review</td>
</tr>
<tr>
<td>2016-19</td>
<td>Regulatory Development</td>
</tr>
<tr>
<td>2020-30</td>
<td>Fleet Penetration</td>
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</tbody>
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[SHRP2 Strategic Highway Research Program]

[Transportation Research Board of the National Academies]
What is an Automated Vehicle?

Some aspects of safety-critical control functions occur without direct driver input.

NHTSA’s Preliminary Statement of Policy

1. Provides an overview of NHTSA automated research program
2. Provides recommendations to states considering driverless vehicle operation
3. Provides levels of automation

(Note: DSRC is not required for automated vehicles)
NHTSA Preliminary Statement of Policy Concerning Automated Vehicles

NHTSA DEFINES VEHICLE AUTOMATION AS HAVING FIVE LEVELS

LEVEL 0
No automation
Driver is in complete and sole control of brakes, steering, throttle, and motive power at all times.

LEVEL 1
Function-specific automation
Automation of one or more functions: electronic stability control or pre-charged brakes.

LEVEL 2
Combined function automation
Automation of at least two functions, for example adaptive cruise control and lane centering steering.

LEVEL 3
Limited self-driving automation
Automation that takes over all safety-critical functions under certain traffic conditions. Driver is available for occasional control.

LEVEL 4
Full self-driving automation
Vehicle can perform all safety-critical driving functions for an entire trip. Driver is not expected to be available for control any time during the trip.
## Automated Vehicle Time-line

<table>
<thead>
<tr>
<th>Levels</th>
<th>Industry</th>
<th>NHTSA</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0</td>
<td>Available</td>
<td></td>
<td>Now</td>
</tr>
<tr>
<td>Level 1</td>
<td>On market</td>
<td>Evaluation</td>
<td>Now</td>
</tr>
<tr>
<td>Level 2</td>
<td>Rapidly entering the market</td>
<td>Research</td>
<td>Now &amp; growing</td>
</tr>
<tr>
<td>Level 3</td>
<td>Research</td>
<td>Research</td>
<td>3-7 years</td>
</tr>
<tr>
<td>Level 4</td>
<td>Research</td>
<td>Research</td>
<td>5-15 years</td>
</tr>
</tbody>
</table>
Policy Issues

Privacy
• Commercial & consumer apps via cellular connections are “opt-in”
• DSRC safety applications are designed to minimize collection of personal information

Data Ownership – Under study

U.S. DOT Authority
  NHTSA – Authority to regulate safety equipment in vehicles
  FHWA – Authority to provide guidance on roadside equipment

Driver Distraction – NHTSA distraction guidelines

Spectrum – DSRC relies on dedicated spectrum that is the subject of testing to evaluate options to share
Implementation Issues
DSRC-Based Vehicles

• A security credential management system (SCMS) is necessary and must be established in order to support DSRC in new vehicles
• USDOT is assessing the governance roles for the security network
• NHTSA released a RFI in October 2014 seeking input on establishing and operating the security system.
• Public agencies with V2I applications will have to conform to the security network
• Cost and performance requirements are not currently known
If infrastructure Definition Underway

V2V communication via DSRC

Definition Underway

Applications infrastructure for safety (via DSRC):
- Must be part of the “trusted” network
- Adhere to possible certification requirements
- Adhere to system governance
Public Agency Preparation

Connected vehicles (either cell or DSRC-based) are a powerful tool:

• Generate **data**
• Enable information **flow**
• Provide new **capabilities** for safety, mobility, environment and more
Public Agency Preparation

How do public agencies prepare for and leverage connected vehicles today for the public good?

• Capture data
• Procure data
• Be a participant
• Provide traveler information
## Connected & Automated Vehicle
### Today’s Status

<table>
<thead>
<tr>
<th></th>
<th>Cell</th>
<th>DSRC</th>
<th>Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture Data</td>
<td>Now</td>
<td>Testing</td>
<td>NA</td>
</tr>
<tr>
<td>Procure Data</td>
<td>Now</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Participate</td>
<td>Emerging</td>
<td>Planning</td>
<td>Research/Test</td>
</tr>
<tr>
<td>Apps</td>
<td>Now (soft safety, mobility, environment)</td>
<td>2022-2038 V2V hard safety</td>
<td>2018-2028 Level 3-4</td>
</tr>
</tbody>
</table>
Public Agency Preparation Today

Assess data/information:
- What data do you have
  - Signal data, freeway, incident, work zone, weather, other
- Is it easy to access - centralized
- What information do you need

Capture data:
- Traditional methods
- Bluetooth (V2I)
Public Agency Preparation Today

**Procure data:** Purchased data from third party companies may be appropriate

- Use FHWA NPMRDS data set
- What data is available from connected vehicles
- What data/information needs does it meet

**Considerations:**

- Assess data needs
- Purchase cost vs. installation, maintenance and operation cost
Public Agency Preparation Today

Be a Participant:
- Provide open data to enable app developers
  - Transit data
  - Some cities release signal, phase & timing (SPaT) data
  - Other data

Considerations:
- Does it further your public agency goals
- Data standards
Public Agency Preparation Today

Plan or Lead the Way:

- DSRC planning
  - High-crash intersections
  - Planned signal system upgrades
  - Corridors with intense data needs
  - Locations where DSRC fills a unique data need
  - AASHTO Infrastructure Footprint Analysis
  - FHWA’s “Vehicle to Infrastructure Deployment Guidance and Products”
Public Agency Preparation

Today

Plan or Lead the Way:

• DSRC Leader:
  – DSRC affiliated test bed
  – Connected vehicle architecture
  – Connected vehicle deployment coalition
  – Connected Vehicle Pilot Deployment Program
    • Wave 1 announced: Wyoming, NYC, Tampa
    • Wave 2 solicitation expected in early 2017
Public Agency Preparation

Today

Provide Traveler Information:

- States collect, manage and distribute traveler information
  - 511 via phone, web
  - Social media
Public Agency Preparation

What opportunities can public agencies expect and prepare for in the future for the public good?

• Capture data
• Procure data
• Be a participant
• Provide traveler information
Public Agency Preparation
5 to 10 Years

**Connected vehicles** will be pervasive due to consumer-driven markets. Data will be plentiful and available to travelers.

**DSRC-equipped vehicles** will be moving into deployment based on NHTSA regulation. There will be small to moderate fleet penetration.

**Automated vehicles** will have increasing functionality (levels 2 and 3 or possibly 4).
Public Agency Preparation
5 to 10 Years

Capture data:
• Specialized data still needed
• DSRC may meet some unique data needs (depending on the basic safety message)

Considerations:
• Purchase cost vs. installation, maintenance and operation cost
• DSRC RSE locations
  – Data intensive corridors
Public Agency Preparation  
5 to 10 Years

**Procure data:**
- More of an agency’s data needs will be fulfilled by purchasing connected vehicle and crowd-sourced data.

**Provide Traveler Information:**
- Private sector-driven industry will be main traveler information provider.
- Public agencies provide:
  - Unique data,
  - Advisory information,
  - Information for social justice purposes,
  - Complement private providers.
Public Agency Preparation  
5 to 10 years

Be a participant:

• Robust connected vehicle eco-system includes OEMs, content aggregators and app developers

• Public agencies can share data such as SPaT, road closures, work zones, speed limits, etc.
  – Open data enables app developers
  – Open data may generate new partnering opportunities

• Opportunities for shared access to public facilities (ROW, poles, power, etc)
Public Agency Preparation
5 to 10 years

Be a Participant: Based on NHTSA regulation, DSRC-equipped cars will emerge in the fleet
• Agencies may choose to install DSRC equipment in targeted locations
  – High-crash signalized intersections (V2I applications)
  – Key corridors where dense or unique data is needed

Considerations:
• Penetration rate of DSRC into the vehicle fleet
• Cost-benefit of a DSRC installation
• Refer to FHWA’s guidance document
Public Agency Preparation 5 to 10 years

Be a participant:

• **Automated vehicles** will have increasing functionality (levels 2 and 3 or 4).
• Public agencies can enable automated vehicles.
  – Clear striping and signage
  – Providing data and information for mapping
• Public agencies can be a receptive collaborator.
  – OEMs
  – App developers/content providers
  – Others
Public Agency Preparation

Your “to-do” list:

• Assess your data sources, status and needs
• Evaluate data procurement options
• Become an open data provider
• Study DSRC opportunities
  – High-crash intersections
  – Data intensive corridors
  – Budget for signal upgrades
  – Review FHWA’s draft guidance document
Public Agency Preparation

Your “to-do” list:

• Stay in the game
  – Updated regional ITS architecture for connected vehicles
  – Connected vehicle pooled-fund study
  – V2I deployment coalition
  – Affiliated test beds
  – FHWA NPMRDS data set
  – Connected Vehicle Pilots
Public Agency Preparation

Watch for:

• NHTSA’s NPRM
  – DSRC data content (BSM)
  – DSRC security requirements for infrastructure

• AASHTO’s Infrastructure Footprint Analysis

• FHWA’s guidance on V2I implementation

• Automation evolution
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