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
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
Examples of connected vehicle applications in various markets

Mainly B2B: INRIX

Mainly Consumer: Waze

Commercial vehicles: Drivewyze

Transit: Nextbus
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 in the research phase.
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 would also work for other applications

- Research is underway to test the safety benefits of DSRC-based applications
Why DSRC Matters

Up to 80% of non-impaired crash types may be impacted by connected vehicle technology

Source: NHTSA

Based on initial estimates & studies. Actual benefits are not determined at this time.
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
Connected Vehicle: DSRC Technologies & Applications

• Six V2V safety applications are being 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

Time-line

2013 NHTSA Decision on DSRC for V2V for Light Vehicles
2014 NHTSA Decision on DSRC V2V for Heavy Vehicles

If NHTSA initiates regulatory action, final regulation could take 3-5 years plus a phase-in period

Fleet penetration is necessary for benefits (timing depends on aftermarket)

2013 Decision

Model Deployment Field Test
Evaluation
Regulatory Development
Fleet Penetration

2013
2018-20
2025-30
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>Entering the market</td>
<td>Research</td>
<td>&lt; 1 year</td>
</tr>
<tr>
<td>Level 3</td>
<td>Research</td>
<td>Research</td>
<td>5-7 years</td>
</tr>
<tr>
<td>Level 4</td>
<td>Research</td>
<td>Research</td>
<td>5-15 years</td>
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</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 currently under discussion at federal level
Implementation Issues
DSRC-Based Vehicles

• A **security network** is necessary and must be established in order to mandate DSRC in new vehicles
• The security network will likely be the responsibility of the OEMs
• NHTSA can require OEMs to create a security network
• Public agencies with V2I applications *may* have to participate security network
• Cost and performance requirements are not currently known
Security System & Applications Infrastructure

Definition Underway

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

V2V communication via DSRC
Public Agency Preparation

Connected vehicles 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>-</td>
<td>NA</td>
</tr>
<tr>
<td>Procure Data</td>
<td>Now</td>
<td>-</td>
<td>NA</td>
</tr>
<tr>
<td>Participate</td>
<td>Emerging</td>
<td>Planning</td>
<td>-</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)
Bluetooth Traffic Monitoring

Bluetooth Sensors

Bluetooth Signal *
Time = 8:03:26 AM

Travel Time = 2:32 Minutes
Speed = 51.7 MPH

Time = 8:05:58 AM

* Bluetooth signals come from cell phones, PDAs, laptops, GPS, car radios…
** Provisional patent received
Public Agency Preparation Today

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

- 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

- DSRC Leader:
  - DSRC affiliated test bed
  - Early adopter of RSEs
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 *if* NHTSA regulates. There will be small to moderate fleet penetration.

**Automated vehicles** will have increasing functionality (levels 2 and 3 or maybe more).
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.
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
Public Agency Preparation
5 to 10 years

Be a Participant: If DSRC is required, 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
Public Agency Preparation
5 to 10 years

Be a participant:

- **Automated vehicles** will have increasing functionality (levels 2 and 3 or maybe more).
- 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
• Stay in the game
  – Connected vehicle pooled-fund study
  – Affiliated test beds
Public Agency Preparation

Watch for:

• NHTSA’s 2013 decision on DSRC
  – DSRC data content
  – Watch for any DSRC security requirements for infrastructure

• AASHTO’s Infrastructure Footprint Analysis

• FHWA’s planned 2015 guidance on V2I implementation

• Automation evolution
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