TEXAS CONNECTED VEHICLE ACTIVITIES

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Traffic Operations Division

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Transportation Challenges Facing the U.S.

Safety
- 35,092 highway deaths in 2015
- 2.34 million injuries in 2014
- 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

Data Sources: NHTSA, CDC, TTI
Photo Source: U.S. DOT
Why Connected Vehicle Technology?

- Safety, safety, safety ... Real-time pre-crash warning
- There is new/emerging technology that offers an opportunity to enhance safety through Dedicated Short-Range Communication (DSRC).
- Also, the technology is different than traditional ITS deployments but the technology will leverage existing ITS networks for national interoperability along with an embedded privacy/security mechanism.
Fully Connected Vehicles

Infrastructure Data:
- Signal Phase and Timing,
- Drive 35 mph,
- 50 Parking Spaces Available

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

Source: U.S. DOT
Definition of Connected Vehicle

- The U.S. DOT defines a Connected Vehicle as one that can transmit and receive Basic Safety Messages (BSMs) following the WAVE protocol, established in Standard IEEE 802.11p which uses the ITS band of 5.9 GHz (5.85 – 5.925 GHz).

- The content and format of a BSM are defined in Standard SAE J2735.

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- Critical Safety Service Channels (SCH)
- Control Channel (CCH)
- Service Channels (SCH)
- High Power Safety
Why Use Dedicated Short-Range Communication?

- In October 1999, the Federal Communications Commission (FCC) allocated 75 MHz of spectrum in the 5.9 GHz band for vehicle safety applications.

- The USDOT’s commitment to DSRC highlights two critical points:
  - Safety will form the central focus for the CV technologies
  - DSRC is the only established communication option available in the near term that offers the latency, accuracy, and reliability for the active safety.

- According to White House’s press release (dated 9/19/2016),

  “DOT will be releasing a proposed rule to mandate that new vehicles have technology to transmit and receive a basic safety message.”
## Connected Vehicle Applications

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The 90th Annual Transportation Short Course

October 11, 2016
CV Safety Applications

Work Zone Warning
Alerts the driver to use caution when traveling through a work zone.

Curve Speed Warning
Alerts the driver if current speed is too fast for an approaching curve.

Source: U.S. DOT
CV Road Weather Applications

Road Weather Connected Vehicle Applications
Issues alerts and advisories of unsafe road weather conditions

Weather-Responsive Traffic Management
Connected vehicles provide road weather information to assist in adjusting signal timing intervals at signalized intersections and posted speed limits, including near work zones, when severe weather affects road conditions

Source: U.S. DOT
CV Mobility Applications

Queue Warning and Speed Harmonization
Warns drivers of congestion ahead, as well as provides target speed advice.

Oncoming Vehicles
Warns drivers of lane closings and reduced speeds when approaching incident zones.

Responder Vehicles
Warns on-scene responders of vehicles approaching the incident zone at speeds or in lanes that pose a high risk to their safety.

Source: U.S. DOT
**CV Environment Applications**

**Eco-Traffic Signal Priority**
Gives signal priority to transit vehicles approaching a signalized intersection, taking into consideration the vehicle's location, speed, type, schedule, and number of passengers. Priority decisions are based on real-time traffic and emissions data to produce the least amount of emissions at signalized intersections.

Source: U.S. DOT

**Eco-Approach and Departure at Signalized Intersections**
Traffic signals broadcast data about their current signal phase and timing (SPaT). Vehicle applications use these data to determine speed advice that can be presented to drivers allowing them to adapt their vehicle’s speed to pass the next traffic signal on green or to decrease to a stop in the most eco-friendly manner. More advanced applications leverage cooperative adaptive cruise control (CACC) capabilities. Start-stop technology may be used to turn the vehicle’s engine off while the vehicle is stopped at a red light.
CV Data Capture and Management Applications

Data Capture and Management
Collects data from connected vehicles, mobile devices, and the infrastructure to create multimodal applications that provide travelers with real-time information such as the status of traffic levels, parking availability, transit schedules, traffic signals, and road weather conditions.

Source: U.S. DOT
Texas CV Activities

- I-35 Connected Work Zone (CWZ)
- Accelerate Texas Center
- TxDOT CV Research
- TxDOT CV Demonstration
  - Over-height vehicle detection & warning
  - In-vehicle signing
  - Enhancing work zone safety with connected automation
  - Wrong-way driving detection & alert
  - Road condition monitoring
- TxDOT’s Involvement in National CV Initiatives
  - CVPFS, AASHTO CAV TWG, and V2IDC
I-35 Connected Work Zone

- Expand existing I-35 traveler information during construction
  - In-vehicle messaging for commercial vehicles
  - Communications
    - 1st Phase: Cellular
    - 2nd Phase: DSRC
- Enhancement to the Texas component of the U.S. DOT’s Freight Advanced Traveler Information System (FRATIS) project
  - Corridor optimization for freight
Accelerate Texas Center

- A public-private collaboration established to help position Texas to become the leader in the commercialization of automated and connected vehicle technologies
TxDOT CV Research

- TxDOT 0-6836: Commercial Truck Platooning
- TxDOT 0-6837: Assessment of Innovative and Automated Freight Systems and Development of Evaluation Tools
- TxDOT 0-6838: Bringing Smart Transport to Texans: Ensuring the Benefits of a Connected and Autonomous Transport System in Texas
- TxDOT 0-6845: Connected Vehicle Problems, Challenges and Major Technologies
- TxDOT 0-6847: An Assessment of Autonomous Vehicles: Traffic Impacts and Infrastructure Needs
TxDOT CV Research (cont’d)

- TxDOT 0-6848: Transportation Planning Implications of Automated/Connected Vehicles on Texas Highways
- TxDOT 0-6849: Implications of Automated Vehicles on Safety, Design and Operation of the Texas Highway System
- TxDOT 0-6851: Strategies for Managing Freight Traffic Through Urban Areas
- TxDOT 0-6867: Wrong-Way Driving Connected Vehicle Demonstration
- TxDOT 0-6875: Autonomous and Connected Vehicle Test Bed to Improve Transit, Bicycle, and Pedestrian Safety
- TxDOT 0-6877: Communications and Radar-Supported Transportation Operations and Planning (CAR-STOP)
Over-Height Detection and Warning

1: Infrastructure OH sensor detects OH vehicle
2: RSE identifies specific vehicle and warning is displayed to the driver
3: Vehicle exits and uses bypass – Warning is removed from driver display
4A: Vehicle does not exit – Additional warnings presented. Vehicle automatically slows if available.
4B: Vehicle is disabled or speed limited prior to hitting the bridge, if available. Emergency responders automatically notified.
In-Vehicle Signing (cont’d)

- Speed Limit: 65 MPH
- Interstate 410
- Jackson - Keller Rd
- West Ave
- Honeysuckle Lane
- 1/4 MILE
- Exit 18

- Exit 16
- EXIT ONLY
- Bridge may ice in cold weather

East Exit:
- Interstate 87
- El Paso

West Exit:
- Interstate 87
- San Antonio
Enhancing Work Zone Safety with Connected Automation

LEGEND

1. Maintenance crew can control automated crash cushion vehicle using tablets or gesture recognition
2. Automated crash cushion vehicle monitors other vehicles to predict impending collisions and can then notify other vehicles and road maintenance crew
3. Upstream vehicle receives advisory message regarding the stationary work zone
4. Traffic Management Center uses vehicle to infrastructure communication to monitor stationary work zone

To Infrastructure Devices
(Cameras, Electronic Signs, etc.)

Automated Crash Cushion Vehicle

Maintenance Crew

CAUTION ROADWORK AHEAD!

Camera

Gesture Recognition
Wrong-Way Driving Detection and Alert

- Region monitored for wrong way driver detection
- Roadside equipment monitors BSMs and detects wrong way driver
- Wrong way driver alerts generated via Infrastructure to Vehicle and approaching vehicles are alerted
- TMC operator and responders are notified of wrong way driver

Connected Vehicle Demonstrations
Wrong Way Driver Detection and Alert

1. Region monitored for wrong way driver detection
2. Roadside equipment monitors BSMs and detects wrong way driver
3. Wrong way driver alerts generated via Infrastructure to Vehicle and approaching vehicles are alerted
4. TMC operator and responders are notified of wrong way driver

Autonomous safe stop

Traffic Management Center

Vehicle Generates BSMs

Wrong Way Driver

No Message

Wrong Way Driver Ahead!

WARNING Wrong Way!
Road Condition Monitoring

- RCM Hardware
  - Accelerometer $10
  - Arduino $20

- RCM Algorithm
  - Process vertical acceleration data
  - Combine with GPS for speed and location
  - Calculate Roughness
  - Compare to threshold
  - Send message over DSRC
  - Plot on heat map
**RCM Components and Sub-functions**

**Vehicle**
- **Training:** Vehicle is driven on smooth roadway to determine system characteristics. (Executed Once)
- **Detection:** Vehicle classifies defects by comparing to training data. (Executed Continuously after Training)

**Defect Location and Severity**

**Storage:** Rating and location are stored for recall.

**Clustering:** Stored data from multiple vehicles is used to identify defects and problem locations.

**Display:** Data is made available to human operators for decision making.
TxDOT’s Involvement in National CV Initiatives

- Connected Vehicle Pooled Fund Study
  - Program to support the development and deployment of connected vehicle applications

- AASHTO Connected and Automated Vehicle Work Group
  - Promote the convergence of AV and CV to create “connected automated vehicles (CAV)”

- V2I Deployment Coalition
  - Support implementation of FHWA’s V2I Guidance
  - Provide leadership on CV Deployment Guidance
  - Establish CV Deployment Strategies
  - Provide Support on Continued Research to Support CV Deployment
  - Support Standards Development
V2I Deployment Guidance

- Chapter 1. Introduction
  - Intent of the document
  - Significance of V2I
  - Available Connected Vehicle Standards

- Chapter 2. Federal-aid eligibility for V2I deployments
  - General eligibility for V2I activities
  - Brief summary of Federal-aid Programs for V2I

- Chapter 3. Guidance
  - Hardware and Software device certification
  - Use of Right-of-Way
  - Use of public sector fleets (including incident responder vehicles)
  - Using Public-Private Partnerships (P3s)
  - Communication technologies
  - Security and privacy in a Cooperative ITS Environment
Funding for Infrastructure Deployment

- Key task facing TxDOT is the need to identify a funding mechanism.
  - Capital and ongoing operations and maintenance costs
- Consider various funding categories to support deployment.
  - ITS budget or federal/state funds with ITS eligibility
  - Highway safety improvement program
  - Funds set aside for congestion mitigation or air quality improvement projects
  - Public-private partnerships
- FAST-Act mainstreams CV infrastructure funding
Next Step

- Continue to develop and deploy CV applications for mobility and safety
- Identify viable options for financial and investment strategies
- Analyses required to support infrastructure deployment decisions
- Connected Vehicle Reference Implementation Architecture
  - Uniform process, tools and graphical language to support CV deployment and operations
  - Creates three distinct but related views:
    - Physical View (Things)
    - Enterprise View (People / Organizations)
    - Communications Views (Information)
  - SET-IT – Visio-based tool to create architecture views
Questions and Comments

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