AASHTO STSMO Webinar

Connected Vehicles 102

Connected Vehicle Updates from around the Nation

February 19, 2015
Agenda

• 1:00  Opening Remarks
  ▪ John Nesbitt – Welcome & Introductions
  ▪ Gummada Murthy – Annual Meeting
  ▪ Patrick Zelinski – Webinar Protocol
  ▪ Jim Wright – Speaker Introductions

• 1:10  California’s Transitions from Research to Operations
  Greg Larson & Brian Simi

• 1:35  Events in Michigan
  Matt Smith

• 1:50  Texas and Automated Vehicle Development
  Jianming Ma

• 2:05  Connected Vehicle Pooled Fund Study
  Melissa Lance

• 2:20  Q&A from Chat Box
  Patrick Zelinski

• 2:30  Adjourn
  Jim Wright
Connected Vehicles: Evolution towards Operations

Prakash Sah, Brian Simi
Division of Research, Innovation and System Information
Division Of Traffic Operations
California Department of Transportation (Caltrans)

February 19, 2015
California Demographics

- Population: 38 Million people
- About one out of every eight Americans lives in California
- 22 Million licensed drivers
- 24 Million registered vehicles
- Sixth - Eighth largest economy in the world
- Trend-setters; early adopters of new technologies
Safety Challenges in California

- 1 million vehicle crashes each year
- 210,000 are injury-crashes
  - 3,000 Fatalities
  - 300,000 Injuries
- About 25% of fatalities occur at intersections
- Another 25% are lane/roadway departures
- Total Cost: more than $25 Billion per year
Mobility Demands in California

- 280 billion Vehicle-Miles-Traveled (VMT) each year, and growing at 2% per year
- State Highway System: 52,000 lane-miles
  - Only 10% of the roadways in California
  - Carries more than 60% of the VMT
  - It is the Lifeline of our economy
- 560,000 hours of delay on average each day
- 30% of this delay is caused by incidents!
- Total Cost: more than $21 Billion per year
California’s Strengths

• Proven Commitment to the Connected Vehicle Program
  • Caltrans and MTC have been engaged in it since its inception, using our own funding
  • Both are participants in the CV Pooled Fund Study, as well as the AASHTO CV Deployment Coalition
  • California Connected Vehicle Test Bed in Palo Alto

• Niches
  • OEM Labs
  • Strong relationships with regions and transit agencies, including MTC, LA Metro, and SANDAG, among others

• Partners
  • OEM Labs and other private partners
  • Other public sector (Gateway Cities COG, City of San Jose, Contra Costa County, Santa Clara VTA, SamTrans)
  • Academic (PATH, UC Riverside)
Connected Vehicle Applications

**SAFETY APPS (V2V)**
- Forward Collision Warning (FCW)
- Emergency Electronic Brake Light (EEBL)
- Intersection Movement Assist (IMA)
- Blind Spot Warning (BSW)/Lane Change Warning (LCW)
- Left Turn Across Path / Opposite Direction (LTAP)

**SAFETY APPS (V2I)**
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Stop Sign Violation
- Railroad Crossing Violation Warning
- Spot Weather Impact Warning
- Oversize Vehicle Warning
- Reduced Speed/Work Zone Warning
- Pedestrian Warning for Transit Vehicles
- Smart Roadside

**MOBILITY APPS**
- Integrated Dynamic Transit Operations (IDTO)
- Intelligent Network Flow Optimization (INFLO)
- Multi-Modal Intelligent Traffic Signal System (M-ISIG)
- Response, Emergency Staging and Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.)
- Enable Advanced Traveler Information System (EnableATIS)
- Freight Advanced Traveler Information System (FRATIS)

**ENVIRONMENT APPS**

**AERIS**
- Dynamic Low Emissions Zone
- Dynamic Eco-Lanes
- Eco-Traveler Information
- Eco-Signal Operations
- Eco-ICM
- Support AFV Operations

**Road Weather**
- Enhanced Maintenance Decision Support System
- Information for Maintenance and Fleet Management Systems
- Variable Speed Limits for Weather-Responsive Traffic Management
- Motorist Advisories and Warnings
- Information for Freight Carriers
- Information and Routing Support for Emergency Responders
Applications of Interest

• Safety
  • V2V Safety Applications
  • Cooperative Intersection Collision Avoidance Systems (CICAS), including Signal Violation Warning
  • End-of-Queue Alerts on Freeways (50% of freeway crashes!)
  • At-Grade Light Rail Crossing Collision Warning Systems

• Mobility
  • Traveler Information (collect vehicle probe data; process it into traffic information, and send it back to the driver)
  • Multi-Modal Intelligent Traffic Signal Systems (CV Pooled Fund Study project)
    • Intelligent Traffic Signal Systems (ISIG)
    • Emergency Vehicle Preemption (PREEMPT)
    • Freight Signal Priority (FSP)
    • Transit Signal Priority (TSP)
    • Mobile Accessible Pedestrian Signal Systems (PED-SIG)
  • Cooperative “Green Wave” along a signalized corridor
  • Integrated Dynamic Transit Operations
  • Speed Harmonization upstream from Bottlenecks

• Environmental (Eco-Driving)
California Connected Vehicle Test Bed

- Stanford
- Cambridge
- California
- Page Mill
- Portage/Hansen
- Matadero
- Curtner
- Ventura
- Los Robles
- Maybell
- Charleston

- New
- Existing
California Connected Vehicle Test Bed

1. Stanford
2. Cambridge
3. California
4. Page Mill
5. Portage/Hansen
6. Matadero
7. Curtner
8. Ventura
9. Los Robles
10. Maybell
11. Charleston
Example Installation

6. Matadero Avenue
RSE goes above mast arm on the vertical Antenna on the mast arm;
Needs Bracket
Actual Installation (Page Mill Road and El Camino Real)
National Request For Proposals

- Released on January 30, 2015; ~$65 Million
  - seeks operational deployments of connected vehicle applications with a needs driven focus
- Proposals must be received by Monday, March 16
- Caltrans leads a strong team of three regions:
  - MTC (District 4)
  - LA Metro; LA County (District 7)
  - SANDAG (District 11)
- Awards made in October 2015; 5-7 sites selected
- http://www.itsdot.gov/pilots
Connected Vehicles Pilot Deployment Program

- Phase 1; 12 months
  - Define Concept of Operations
  - Identify System Requirements and Performance Measures
- Phase 2; 20 months
  - Design
  - Build
- Phase 3; 18 months
  - Operate and Maintain
  - Independent Evaluation by third party
- Total of 4 years, 2 months (ends in January, 2020)

- FHWA Vehicle to Infrastructure Deployment Guidance and Products

Operational considerations

- Identify the needs and appropriate deployment opportunities
- Determine what applications to focus on
- Develop institutional awareness and support
- Local demonstration pilot project
- Long-range Transportation Planning
- Project development and deployment
  - Deployment Concepts
  - Development of design and procurement standards
- Staff development and training
Infrastructure Deployment Timelines

Figure ES-1 - Estimated Connected Vehicle Infrastructure Deployment Milestones
(Source: USDOT/AASHTO 2014)

U.S. Department of Transportation, Research and Innovative Technology Administration
Intelligent Transportation System Joint Program Office
Infrastructure Deployment

Timelines

Figure ES-2 - Deployment Timelines by Application Type (Source: USDOT/AASHTO 2014)
Questions and Discussion

For more information, please visit:

www.dot.ca.gov/research

Caltrans provides a safe, sustainable, integrated and efficient transportation system to enhance California’s economy and livability
Michigan Regional Connected Vehicle Deployment

Matt Smith, P.E.
ITS Program Manager
Michigan Department of Transportation
February 19, 2015
History of ITS

* **1960** - Freeway Service Patrols begin (Chicago)
* **1962** - CCTV deployment for freeway surveillance (Detroit)
* **1962** - Detector deployment for freeway surveillance (Chicago)
* **1967** - Freeway ramp metering (Los Angeles)
* **1967** - Reversible lane control (Seattle)
* **1971** - Integrated freeway/arterial system (Houston)
* **1972** - Bus bypass ramps (Minnesota)
* **1990** - Intelligent Vehicle/Highway (IVHS) concept introduced
* **1992** - Intelligent Transportation Systems (ITS) concept
* **2003** - Vehicle Infrastructure Integration program begins
* **2009** - IntelliDrive (Connected Vehicles) program begins
* **2012** - Safety Pilot Model Deployment
* **2015 +** Connected and Automated vehicles
DUAP - Data Collection and Usage

Data Inputs
- ATMS/MVDS
- RWIS
- NWS
- IMO/AVL
- Mobile
- Connected Vehicle

Data Outputs
- Planning/Asset Management
- Construction
- Maintenance
- Operations
- WX-TINFO

External Systems
- ATMS
- Mi Drive

Data Management
- Secure data storage
- Quality checking algorithms
- Data transformation
- Data analysis
- File and image processing
Big Data Vehicle Collection

Mounted Processing Unit or Data Acquisition

Bluetooth

Vehicle OBD

Antenna

Vehicle Power

Pavement Asset Condition Sensors

Other sensors expandable as needs are identified (i.e., atmospheric conditions, wheel speed sensors, camera, wipers, etc.)

VIDAS
Questions?

MDOT
TEXAS CONNECTED VEHICLE & AUTOMATED VEHICLE ACTIVITIES

Jianming Ma, Ph.D., P.E.
Texas Department of Transportation (TxDOT)
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<th>1</th>
<th>Texas Transportation System</th>
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<td>Central Texas I-35 Reconstruction Project (TIDC &amp; CWZ)</td>
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<td>3</td>
<td>Over-height Vehicle Detection &amp; Warning</td>
<td>8-10</td>
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<td>4</td>
<td>Automated Attenuator Truck Demonstration</td>
<td>11-13</td>
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<td>5</td>
<td>Connected &amp; Automated Vehicle Research</td>
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<tr>
<td>6</td>
<td>Q&amp;A</td>
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Texas – Transportation System

Mission
Work with others to provide safe and reliable transportation solutions for Texas.

Highways

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ITS Device

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<th>Total Count</th>
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Central Texas I-35 Reconstruction Project

Background

- 96 mile corridor central Texas - Waco District
- 10 active projects encompassing a length of 74 miles with 66 miles of work zones
- Costs: ~$2.0 B
  - Construction = $1.9B
  - Right-of-way = $450M
  - Utility relocation = $110M
- Traffic volume
  - 55,000 – 115,000 veh/day
  - Trucks: 25 – 35%
I-35 Traveler Information During Construction (TIDC)

- Highest level of construction traveler information
  - Travel time, incidents, closure information, delay, detours
  - E-mail, web, social media, roadside
  - Speed, travel time, volume, CCTV
- Temporary & long-term deployments
- Integration with Lonestar™
- Work zone end of queue warning
- 24/7 operations
I-35 Connected Work Zone (CWZ)

- 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
Over-height Vehicle Detection & Warning

Bridge Hit 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 Display to Driver

WARNING!
OVERHEIGHT!
Other Example Displays to Driver

- Speed Limit: 65 MPH
- Exit 18: Jackson - Keller Rd, West Ave, Honeysuckle Lane (1/4 MILE)
- Exit 16: Bridge, May Ice in Cold Weather
- Interstate 410
- Mile: 1 2
- West: El Paso
- North: 87
- East: 87
- South: San Antonio
- Exit only
Using Connected Vehicle (CV) and Automated Vehicle (AV) Technology

- Up to two hits a week
- Automate functions of attenuator trucks
  - Vehicle following (e.g., striping, mowing, and sweeping)
  - Stop/Start operation (e.g., guardrail, patching) – control with hand signals
- Demonstrated at 2014 ITS World Congress
Enhancing Work Zone Safety – Mobile Roadway Maintenance

LEGEND

1. Automated crash cushion vehicle follows lead maintenance vehicle
2. Automated vehicle monitors other vehicles to predict impending collisions
3. Traffic Management Center uses vehicle to infrastructure communication to monitor stationary work zone
4. Traffic management center implements rolling event response plan
5. Upstream vehicle receives advisory message regarding the mobile maintenance fleet

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Enhancing Work Zone Safety – Stationary Roadway Maintenance

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.)

CAUTION ROADWORK AHEAD!

Automated Crash Cushion Vehicle

Camera

Gesture Recognition

Maintenance Crew

Traffic Management Center

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Connected & Automated Vehicle Research

- **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 0-6848**: Transportation Planning Implications of Automated/Connected Vehicles on Texas Highways
Connected & Automated Vehicle Research

- **TxDOT 0-6849**: Implications of Automated Vehicles on Safety, Design and Operation of the Texas Highway System

- **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)
Questions?

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Connected Vehicle Pooled Fund Study
Connected Vehicle Pooled Fund Study

- The Pooled Fund Study (PFS) is a partnership of transportation agencies who have established a program to facilitate the development and evaluation of Connected Vehicle applications.

- The program will prepare state and local transportation agencies for the deployment of Connected Vehicle technologies.

- The program will result in the following outcomes:
  - Development and demonstration of Connected Vehicle-enabled system operations algorithms, tools and applications
  - Preparation for field demonstration tests
  - Lessons learned and identification of issues from field demonstrations
Current PFS Membership

Core/Voting Members
• VDOT is lead agency with administrative support from UVA
• Fourteen Core Members: Virginia, California, Florida, Michigan, Minnesota, New Jersey, New York, Pennsylvania, Texas, Utah, Washington, Wisconsin, Maricopa County and FHWA

Associate Members
• Palm Beach Co, FL; Oakland Co, MI; MTC (Bay Area), Transport Canada, Rijkswaterstaat and North Texas Toll Authority

Liaisons
• NCHRP/SHRP 2; AASHTO (strategic and deployment plans)
The PFS was initiated as a phased program

- **Phase I** - Research to educate to connected vehicle technologies
- **Phase II** - Develop and field testing connected vehicle applications
- **Dynamic Mobility Application** – Develop and field test a Multi-modal Intelligent Traffic Signal System (USDOT Partially Funded)
- **Phase III** – Continue develop and field testing connected vehicle applications

PFS Phase I Program
July 2009 – August 2012

• Connected Vehicle Traffic Signal Control Algorithm – Developed and evaluated a new traffic signal control algorithm using connected vehicle data

• Pavement Maintenance Support Algorithm – Determined the benefits of using CV probe data to develop IRI estimates and detect and map potholes

• Evaluation of Signal Phase and Timing Data – Developed CONOPS and benefits assessment for use cases of SPaT data

• Connected Vehicle Certification Program – Educated PFS members on potential issues related to a future connected vehicle certification program

• Aftermarket On-Board Equipment – Identified requirements for a Multi-Communications enabled OBE and provided recommendations for rapid introduction of equipment
PFS Phase II Program
September 2012 – December 2014

• Traffic Management Centers in a Connected Vehicle Environment – Investigated how the Connected Vehicle environment will change the TMC of the future, both technically and the role of TMC operators/managers (Complete)

• 5.9GHz DSRC Vehicle Based Road and Weather Condition Application – Develop and test a 5.9GHz DSRC application that is used on fleet vehicles for road and weather condition data. This data will supplement the Clarus system.
  • CONOPS – complete
  • Application development and infrastructure deployment - on hold
  • May field test along freeway in New York
PFS Phase II Program
September 2012 – December 2014

• **Surveying/Mapping for CV Applications** – contract almost established
  • UC Riverside, $150,000, December 2014 – November 2015
  • Analyze and document the surveying and mapping requirements for expected connected vehicle applications and determine best practices

• **Tracking the Status of Connected Vehicle Testbeds Deployment**
  • UVA CTS, $50,000, October 2014 (ongoing)
  • Document and share the current status and lessons learned from existing connected vehicle testbeds of CV PFS members
  • Task1: Develop a template for documenting testbed status – completed
  • Task2: Document current status and lessons learned for each testbed – in progress
Dynamic Mobility Application
Multi-Modal Intelligent Traffic Signal System
October 2011 – April 2015

- **Objective:** Develop and test a system that integrates connected vehicle information and devices into a more effective and safer traffic signal control system for multiple modes of travelers

- Funded in part by USDOT to support its Dynamic Mobility Application Program

- **Phase I** – Develop the CONOPS, systems requirements and system design (Complete)
- **Phase II** – Demonstrate and field test the system in two locations
  - Maricopa County, Arizona
  - El Camino Real, California

- **Status**
  - CONOPS – complete
  - Application development – in process
  - Infrastructure deployment – in process
Benefits and Challenges Realized through PFS

• **Benefits**
  • Identify issues that require further research or development
  • Readily available CONOPs and deployment documentation
  • Deployment lessons learned from other states

• **Potential Challenges**
  • Roadside Equipment is still maturing
  • Legacy equipment and communications systems in the field
  • Basic Safety Message is missing key information
  • Standards are not fully developed
Additional Information

- Cooperative Transportation Systems Pooled Fund Study
  [http://cts.virginia.edu/CTSPFS_1.html](http://cts.virginia.edu/CTSPFS_1.html)
  Melissa Lance – melissa.lance@VDOT.Virginia.gov