ARIZONA CONNECTED VEHICLE PROGRAM

Arterial Connected Vehicle Test Bed Deployment and Lessons Learned

Faisal Saleem
ITS Branch Manager & SMARTDrive Program Manager
Maricopa County Department of Transportation
Presentation Outline

- Connected Program Overview
- Technology Overview
- Concept and Application Development
- Evolution of the MCDOT SMARTDrive Test Bed
- Lessons Learned
Maricopa County, Arizona

- Approximately 9,226 sq. miles
- 4th largest County in United States
- Greater in population than 24 States (about 4 million)
- County Seat: Phoenix
- 24 cities and towns
- 5 Indian Communities
Overview

- Program is a Collaboration between MCDOT SMARTDrive Program and ADOT Connected Vehicle Initiative
- Executive Level Champions
- Engaged in National Program since inception (one of 10 lead AASHTO States)
- Membership in National Cooperative Transportation Systems Pooled Fund
- Strong Partnership (ADOT, MCDOT, University of Arizona, Public Safety, USDOT, Private Partners)
Arizona Connected Vehicle Program

Overview

- Funding (ADOT, MCDOT, USDOT)
- Technical Expertise (U of A and agency staff)
- Support Staff (TMC, public relations, maintenance)
- Freeway and Arterial Deployments
Challenges

- Safety - 107,348 crashes in 2013 in Arizona (34k injuries, 777 fatalities)
- Delays – Approximately 36 hours per peak traveler (Phoenix)
- Emergency response delays increasing and safety issues for responders
Why Connected Vehicles?

- Significant opportunity for safety and efficiency
- Advance Integrated Corridor Management
- Existing arterial infrastructure to support Connected Vehicle Applications – low investment
- AASHTO Footprint Analysis Projects 80% of signals with Connected Vehicle technology by 2040 (250,000 intersections and 25,000 other locations)
Developed VII Strategy Paper in 2006 - Focus Areas

- Enhance traffic signals operations
- Develop intelligent priority system for all users – transit, emergency vehicles, pedestrians, general purpose vehicles
- Enhance emergency responder safety and reduce response time
An Intersection

Signal Controller
Vision of an Intersection

Equipped

Wifi? Bluetooth? 3G or 4G?

DSRC 5.9GHz?
Basic Building Blocks.....

Vehicle(s)...
+ Connected Vehicle Equipment

On Board Equipment (OBE)
After Market Safety Device (ASD)

DSRC 5.9 GHz Radio

Communications Dialog
Cooperative Applications

Connected Vehicle Infrastructure Equipment
Road Side Equipment (RSE)

MAP Data
Digital Description of Roadway
(D. Kelley, 2012)

L. Head, 2014
Basic Messaging...

- Basic Safety Message (BSM)
  - Temporary ID (privacy)
  - Position (GPS)
  - Motion
    - Speed
    - Heading
    - Steering Wheel Angle
    - Acceleration
  - Brakes
  - Vehicle Size
  - Part II (optional)

L. Head, 2014
Basic Messaging including Infrastructure ...

- Signal Phase and Timing Data
  SPaT (SAE J2735) (10 Hz)

- Basic Safety Message
  (SAE J2735 BSM) (10 Hz)

- Map Data (SAE J2735) (1 Hz)

- Digital Description of Roadway
  (D. Kelley, 2012)

- All message transmission is broadcast
  WAVE Message (IEEE 1609)

L. Head, 2014
DSRC Channels

Basic Message Transfer

Traffic Controller

Stream(BSM)
Stream(SPaT)

RSE

Broadcast(MAP, 172)
Broadcast(BSM, 172)
Broadcast(SPaT, 172)

Set(pos, veh)

OBE

Broadcast(BSM, 172)
Broadcast(SPaT, 172)

Vehicle

Stream(BSM)
Stream(SPaT)

Set(pos, veh)
Concept Development (2007)

Traffic Signal Priority
- Multiple Requests
- GPS Intersection Map
- DSRC 2-way communications between vehicles and signal (V2I)

Ramp Meter Priority
- GPS Ramp Map
- DSRC 2-way communications between vehicles and controller (V2I)

Ad-Hoc Warning Beacon
- GPS Roadway Map
- DSRC communications between vehicles and vehicles (V2V)
Parking Lot Demo

Signal Priority Demo

Ramp Meter Priority Demo
Isolated Intersection Demo

February 22, 2010
First Live Intersection Test of Emergency Vehicle - IntelliDrive\textsuperscript{SM}

67\textsuperscript{th} Avenue and Southern Maricopa County, AZ
Field Test Location – Anthem, AZ

- Equipment Installation
- Test and Verification
- Application Tests and Evaluations

Pole Mounted Roadside Equipment (RSE)
MCDOT SMARTDrive Demonstration
Anthem Field Test Applications

- Application 1: Integrated Traffic Signal Priority for Emergency Vehicles and Transit
  - Multi Vehicle Incident Response through several signals
  - Transit Priority
  - Agencies define priority policy
Application 2: Pedestrian Application

- Smartcross GUI Developed by Savari through USDOT SBIR Project
- Pedestrian Crosswalk Status
- Sound enabled
- Extension request
Application 3: Traveler Information

- OBE transitions to RSE
- Initiates Incident Warning
- Dissemination
  - In-vehicle
  - Cell Phone
  - TMC
Priority Message Transfer

Traffic Controller
- Set(Request)
- Set(Status)
- Set(Request)

RSE
- Broadcast(WSA, 178)
- Broadcast(SRM, 182)
- Broadcast(SSM, 182)

OBE
- Set(pos, veh, class)
- Estimate(serviceT, inLane)
- Set(pos, veh, class)

Priority Vehicle
In Vehicle Display

Emergency Vehicles have priority over Transit
Serves as Test Bed Multi-modal Intelligent Traffic Signal System (MMITSS) Pooled Fund Project along with Caltrans Test Bed

- Intelligent Traffic Signal System (ISIG)
- Transit Signal Priority (TSP)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Freight Signal Priority (FSP)

Demonstrated at ITS World Congress Belle Isle Tech Showcase
MMITSS Architecture
MMITSS Basic Concepts

Priority Hierarchy
- Rail Crossings
- Emergency Vehicles
- Transit
  - BRT
  - Express
  - Local (Late)
- Pedestrians
- Trucks

Section 1
- Priority for
  - Trucks

Section 2
- Priority for
  - Transit
  - Pedestrians

Real-Time Performance Measures
- Volume (by mode)
- Delay (by mode)
- Throughput (by mode)
- Stops (by mode)
Cost Estimates

- DSRC Direct Cost (Maricopa County – 13k, AASHTO Study Average: 17k) will result in 10-15% cost increase from present
- Backhaul (Maricopa County – 4k, AASHTO – 40k)
- Signal Controller – 3k
- O&M ASSHTO (10 year annualized) - $2k - $3k
- Vehicle installation cost
- Application cost – varies
- Data cost
Value of Test Bed: Failures

Vehicle?

Infrastructure?
Lessons Learned

• Institutional champions, partnerships, strong technical team and national engagement are key
• Still in research phase – plan for several iterations
• Needs strong staff support – (ITS, research team, PIOs, IT, signal techs etc.)
• Basic CV concept of operations supports priority control applications
• DSRC is viable for traffic signal priority v2x communications
• DSRC radios are environmentally robust
Lessons Learned

- Vehicles can communicate with multiple RSE’s and must determine which MAP is relevant
- National communications standards, e.g. NTCIP, provides a reliable interface to the traffic signal controller
- OBE's can serve as adhoc RSE's for travel information application
  - DSRC antenna placement is critical to achieve effective range
  - Security is an important consideration
Questions?