HOW TO BRING CONNECTED VEHICLES TO YOUR TOWN

Program Manager: Kate Hartman
WHAT TO EXPECT IN THIS SESSION

- Summarize progress-to-date in the Connected Vehicle Pilot Deployment Program
- Discuss anticipated benefits of each pilot site
- Share challenges and lessons learned by the deployers’ first-hand experience
- Preview critical milestones and next steps in preparation for an operational phase starting in May 2018
SESSION AGENDA

- Introduction and CV Pilots Overview
  Kate Hartman, Chief of Research, Evaluation & Program Management, ITS JPO, USDOT

- New York City DOT Pilot Deployment
  Robert Rausch, Vice President, TransCore

- Wyoming DOT Pilot Deployment
  Ali Ragan, Project Manager, Wyoming Department Of Transportation

- Tampa (THEA) Pilot Deployment
  Bob Frey, Planning Director, Tampa Hillsborough Expressway Authority (THEA)

- Q&A
CV PILOT DEPLOYMENT PROGRAM GOALS
**The Three Pilot Sites**

- Reduce the number and severity of adverse weather-related incidents in the I-80 Corridor in order to improve safety and reduce incident-related delays.
- Focused on the needs of commercial vehicle operators in the State of Wyoming.

- Improve safety and mobility of travelers in New York City through connected vehicle technologies.
- Vehicle to vehicle (V2V) technology installed in up to 8,000 vehicles in Midtown Manhattan, and vehicle to infrastructure (V2I) technology installed along high-accident rate arterials in Manhattan and Central Brooklyn.

- Alleviate congestion and improve safety during morning commuting hours.
- Deploy a variety of connected vehicle technologies on and in the vicinity of reversible express lanes and three major arterials in downtown Tampa to solve the transportation challenges.
Starting from May 2018, these deployments are scheduled to enter an operational phase.
Robert Rausch

NYCDOT Pilot Deployment
New York City is aggressively pursuing “Vision Zero”
“Traffic Death and Injury on City streets is not acceptable”
Vision Zero Goal: to eliminate traffic deaths by 2024

CV is being added to other changes: 25 MPH, Bicycle, SBS, PED Plazas

NYC Pilot will evaluate Safety benefits of CV technology
- Reduce crashes
- Reduce pedestrian Injuries
- Use CV Technology to assist the visually impaired

- Address CV deployment challenges
  - Dense urban environment
  - Large number of vehicles & different vehicle types
THE CONNECTED VEHICLE TECHNOLOGY (CV)

BSM Message
Vehicle Information
Location
Heading
Speed
Path History

BSM Message
Supports:
V2V Safety Applications

BSM Message
Supports:
V2I Safety Applications

MAP Message
Intersection Geometrics
Stop Bar
Lanes
Permitted Movements

SPaT Message
Signal Phase & Timing
Start time for:
Green, Yellow, Red
Walk, Don’t Walk

TIM Message
Traveler Information
Speed Limits & Zones
Work Zones & Detours
Curve and Roadway Conditions

Roadside Unit
Traffic Controller
Key Benefits:
- 802.11p technology similar to 802.11a
- Low latency communication (<50ms)
- High data transfer rates (3 - 27 Mbps)
- Typically 300M and 360°
- Up to 1000 M for emergency vehicles
CV  Security and Privacy - By Design

- Supported by a Security Credential Management System - SCMS
- Authentication of messages (signed by a certified originator)
- Encryption of Messages (where needed)
- Rotating security certificates ~ 60 per week
- Changing identifiers - 5 min 2 KM
  - MAC Address, Temporary ID’s, message counters
- Misbehavior Detection - “detection of bad actors”
- Certificate Revocation List Distribution
  - List Bad Actors and compromised devices
- Special Service Permissions for privileged Vehicles
  - Emergency Vehicles, Transit Vehicles, Freight

Protects against tracking
More than 10 years
- Proof of Concept - ended 2008
- Safety Pilot (Ann Arbor MI)
  - 2700 vehicles – “BSM broadcast” no applications
  - ~70 vehicles OEM integrated,
  - ~300 vehicles After Market Devices
  - ~25 Roadside devices
- Many other small trials, tests, demonstrations
  - 1-25 intersections
  - 10-25 vehicles

Our Stakeholders
Vehicle-to-Vehicle (V2V) Safety Applications
- Vehicle Turning Right in Front of Bus
- Forward Collision Warning
- Emergency Electronic Brake Light
- Blind Spot Warning
- Lane Change Warning/Assist
- Intersection Movement Assist

Vehicle-to-Infrastructure (V2I) Safety Applications
- Red Light Violation Warning
- Speed Compliance
- Curve Speed Compliance
- Speed Compliance/Work Zone
- Oversize Vehicle Compliance
  - Prohibited Facilities (Parkways)
  - Over Height
- Emergency Communications and Evacuation Information (Traveler information)

Other Applications
- Intersection Navigation - Visually Impaired
- Pedestrian in Crosswalk Warning
- Travel time data for Traffic Signal Control
NY Goes “All-In”

- Up to 8,000 **fleet vehicles** with **Aftermarket Safety Devices (ASDs)**:
  - ~5,900 Taxis (Yellow Cabs)
  - ~ 700 MTA Buses
  - ~1000 Sanitation & DOT vehicles
  - ~400 UPS vehicles

**Pedestrian Applications**
- 100 Pedestrian **PIDs**
  - Visually Impaired
- PED in Crosswalk detection

**~350 Roadside Units (RSU)**
- ~310 Intersections
- ~40 Support locations (airports, river crossings, terminal facilities)

**Interesting Statistics:**
- Vehicles are in motion or active ~**14 hours per day**!
- Average taxi drives 197 miles per day
- Fleet total Vehicle Miles Traveled:
  - >1.3 Million Miles per day
  - ~40 Million Miles per month
V2V applications work wherever equipped vehicles encounter one another.

The CV project leverages the City's transportation investments in infrastructure.
CHALLENGES WITH THE DENSE URBAN ENVIRONMENT
**CHALLENGES - 1**

- **Location Accuracy**
  - Initial Testing 6th Ave - GPS was not good enough - Urban Canyons
  - **Solutions**
    - Multiple Mechanisms for maintain location accuracy
      - RSU triangulation
      - Inertial Navigation
      - Map Matching
      - Tethered to the host vehicle

- **Stakeholder fears of loss of privacy**
  - Data collection - combined with Police Records through subpoena
  - **Solutions**
    - Limited data collection (no personal information)
    - Encryption and automatic log “destruction”
    - Obfuscation, normalization, aggregation
CHALLENGES - 2

- **Limitations of the backhaul network**
  - NYC is all wireless - Costs driven by usage
  - **Solutions**
    - Edge computing - convert *data* to *Information* @ RSU
    - Limited data collection - enough to prove benefits
    - O&M data to manage operational state (RF Levels, uptime, errors, etc.)

- **Security** - CV requires a trusted environment
  - **Solutions**
    - Upgraded communications security TMC <-> RSU & TMC <-> Controller
    - Upgraded security practices @ TMC systems, login, & physical access
    - Upgraded links to all external systems
    - Updated security software for existing traffic controllers
CHALLENGES - 3

Availability of **DSRC** for cellphone: PED applications
- SPaT/MAP critical for the PED navigation for the visually impaired

**Solutions**
- Modified PED application to use cellular service (4G/LTE)
- Modified Traffic Controller: transmit SPaT information to PED servers
- Modified TMC systems: transmit MAP information to PED servers
- Adapted application to “work” with cellular network

Need scaleable approach: **tune, update, and add applications** -- **DSRC**
- Support for incremental deployment and updates to software

**Solution**
- Developed a common approach to over-the-air (OTA) updates
- Uses simultaneous broadcast – to hundreds of ASDs
- Efficient utilization of bandwidth
CHALLENGES - 4

- Human Interface
  - CV applications provide warnings and alerts

- Solution
  - After Market Devices - NYC using **audio only**
  - Optimizing alerts using tones, words, and combinations
USDOT launched 3 pilots to “find” and solve the challenges

**NYC:** Urban Density - affects applications (tuning), location technology, DSRC propagation, backhaul requirements & limitations, & data collection.  

Lessons Learned!

- Standards being updated from Lessons Learned
- Security elements are being deployed for the first time

Security Is Crucial To CV Deployment

Pilot lessons will serve as a foundation for future deployment!
BRINGING CV TECHNOLOGY TO YOUR CITY

- The USDOT is continuing to develop **tools** and **software**
- Optimizing the applications
- Certification programs being developed - interoperability
- Optimizing installation procedures - easier and cheaper!

**To be ready**
- Upgrade your controllers and backhaul
- Examine and upgrade your networks, IT environment, and security practices
- Program your projects – budgetary estimates are more accurate now!
Ali Ragan

Wyoming DOT Pilot Deployment
A PROBLEM WORTH SOLVING

Image source: WYDOT
A PROBLEM WORTH SOLVING

IN 1 YEAR PERIOD ALONE

- 700 COMMERCIAL VEHICLE ACCIDENTS
- 906 NON-COMMERCIAL VEHICLE ACCIDENTS
- 1,552 HOURS ROAD CLOSURES

1600+ CRASHES IN 1 YEAR

- 18 FATALITIES
- 271 INJURIES
- 1,317 PROPERTY DAMAGE
MEETING A REAL NEED

EN-ROUTE HAZARD AWARENESS

Using Dedicated Short Range Communication (DSRC) capability between vehicles and roadside infrastructure to provide new applications to support driver awareness.

VEHICLE TO VEHICLE
- Forward collision warning
- Distress notification

VEHICLE TO INFRASTRUCTURE
- Alerts and advisories
- Road weather warnings
- Work zone warnings
The most critical component for our project success is stakeholder buy-in:

- Validate our understanding of the problem
- Shape the solution
- Engage participation
CASTING A WIDE NET

- Weather Industry
- Trucking Industry
- Safety coalitions
- Law Enforcement
- Other programs in the Department of Transportation

U.S. Department of Transportation
STRUCTURE FOR SUCCESS

- Support from state’s technology group
- Agency-wide project
  - Support for the project came from the top, but we still worked to get buy in
  - The project scope required cooperation from many different departments; we needed buy-in and that involved sharing credit

Image source: WYDOT
USDOT RESOURCES

- Explanations of how connected vehicles work
  - UMTRI meeting: Seeing another deployment
  - Fact sheets and infographics
- Systems like SCMS, ODE, Pikalert
- Project oversight
  - Kept on track
Technology

Telecommunications

Security
THREE COMMUNITY NEEDS

Know your problems

Know your audience

Know your capabilities
Bob Frey

Tampa (THEA) Pilot Deployment
THEA CV PILOT

South by Southwest: How to Bring Connected Vehicles to Your Town

Why CV?
Change = Opportunity

"Innovation is the process of turning ideas into a manufactural and marketable form."
— Watts Humprey

• History of Innovation
  • First Reversible Elevated Lanes
  • First full All Electronic Toll Road in Florida
  • First to use image based tolling in Florida
  • First to operate an AET Reversible Express Lane in the US

• Supportive State Legislators

• Visionary Executive Director

• Supportive Board of Directors

• Innovative Partners: CUTR, FDOT, City of Tampa, Hillsborough County

AT THEA, WE SEE NEW TECHNOLOGY AS AN OPPORTUNITY. AGENCIES TAKING PART IN ITS DEVELOPMENT WILL BE THE FIRST TO REALIZE THE SAFETY, OPERATIONAL AND FINANCIAL REWARDS.
CAN A LOCAL AGENCY LEAD CHANGE?  
ALL AGENCIES CAN CONTRIBUTE TO GOOD TRANSPORTATION

- “Contract for CUTR study “Tampa Bay: An Automated Vehicle Catalyst?” (THEA Board action 6/24/13)

- THEA worked with FDOT to co-host first AV/CV Summit in Florida & supporting State initiatives

- Joined the USDOT Affiliated Test Bed Program

- Participating in FDOT’s Statewide initiative by being on working group, bring local and tolling perspective

- Actively marketed Test Bed
  - Audi was the first to test in Florida on facility the week of July 21, 2014

- USDOT CV Pilot
  - THEA lead the Tampa CV Pilot and paid all local matches to bring this technology to Tampa.
  - Created a public/private partnership team on US DOT Pilot Deployment

THEA AND OTHER LOCAL AGENCIES CAN LEAD INITIATIVES AND DEMONSTRATIONS THAT BENEFIT CUSTOMERS, CONSISTENT WITH NATIONAL AND STATEWIDE INITIATIVES.
THEA PILOT DEPLOYMENT OVERVIEW
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>TRAFFIC STUDIES</th>
<th>USE CASE/NEED</th>
<th>PRIVATE SECTOR INPUT</th>
<th>CV APPLICATIONS</th>
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<tr>
<td>REL at Twiggs Street</td>
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<td>MORNING BACKUPS</td>
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<td>V2V SAFETY EEBL and FCW</td>
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<tr>
<td>Twiggs Street - Courthouse</td>
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<td>PEDESTRIAN CONFLICTS</td>
<td></td>
<td>V2V SAFETY Vehicle Turning in Front of Bus</td>
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<td>PEDESTRIAN SAFETY</td>
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<tr>
<td>Meridian Avenue</td>
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<td>WRONG WAY ENTRIES</td>
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<td>BRT-REL to Marion Street</td>
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<td>TRAFFIC PROGRESSION</td>
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<tr>
<td>Channelside</td>
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<td>BRT OPTIMIZATION</td>
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<td>TRIP TIMES SAFETY</td>
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<td>MOBILITY I-Sig</td>
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**SOLVING REAL PROBLEMS: PILOT DEPLOYMENT ISSUES AND APPLICATIONS RELATIONSHIPS**
Morning Backup

Forward Collision Warning (FCW)
Emergency Electronic Brake Light (EEBL)
End of Ramp Deceleration Warning (ERDWW)
Intelligent Signal Systems (I-SIG)

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)
Pedestrian Safety

Pedestrian in a Signalized Crosswalk Warning (Ped-X)

Pedestrian Collision Warning (PCW)
Transit Signal Priority

- I-SIG
- Transit Signal Priority (TSP)
- IMA
- Pedestrian Transit Movement Warning (PTMW)
Streetcar Conflicts

Vehicle Turning Right in Front of Transit Vehicle (VTRFTV)

PTMW
Traffic Progression

- Probe Data Enabled Traffic Monitoring (PDETM)
- Pedestrian Mobility (PED-SIG)
- I-SIG
- IMA
### Participants

<table>
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<tr>
<th>Description</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Privately Owned Vehicles</td>
<td>1,600</td>
</tr>
<tr>
<td>Pedestrian Smartphones (Android devices only)</td>
<td>500+</td>
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<tr>
<td>TECO Line Streetcar</td>
<td>9</td>
</tr>
<tr>
<td>Hillsborough Area Regional Transit (HART) buses</td>
<td>10</td>
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Source: Siemens
Safety warnings integrated into the rear-view mirror, visual (with auditory alert) examples shown below.

**Electronic Brake Lamp Warning**

**Exit Ramp Deceleration Warning**

Source: Brand Motion and Global 5
IN VEHICLE SYSTEM - APP WARNING GRAPHICS

- **ERDW (V2I)**: [5.2.2]
  - REL, Backups (Queue/Speed)
  - SAD - Speed Advice Message

- **EEBL (V2V)**: [5.2.6]
  - Emergency Electronic Brake Light (All locations)
  - SAD - EEBL Message

- **PCW (V2I)**: [5.2.4]
  - Pedestrian in a Signalized Crosswalk (Courthouse)
  - SAD - Pedestrian Crash Warning Message

- **IMA (V2V)**: [5.2.7]
  - Intersection Movement Assist (Position/Speed/Heading)
  - SAD - IMA Message

- **TSP (V2I)**: [5.2.8]
  - Transit Signal Priority (Bus)
  - SAD - Priority Granted

- **VTRFTV (V2V)**: [5.2.3]
  - Vehicle Turning Right in Front of a Streetcar/Pedestrian
  - SAD - Potential Crash Warning (Vehicle)
  - SAD - Warning Vehicle Turning (Streetcar)

- **WWE (V2I)**: [5.2.1]
  - Wrong Way Entry Warning (@ REL & Twiiggs)
  - SAD - Going Wrong Way Alert
  - SAD - Wrong Way Driver Alert

Source: Brand Motion
BENEFITS: CONNECTED VEHICLE COMMUNICATION

Vehicles have 360 degree awareness of surroundings.

Communicate with other vehicles 10 times per second.

“Basic Safety Messages”
EXAMPLE OF FRAMEWORK FOR SMART CITIES

- Mobility as a key outcome
- Four enabling technology suites
- Application layer on top of that foundation
- Framework for connecting people with opportunities
  - 4 systems
  - 4 districts
  - 4 outcomes
- CCTN ties it all together
Q&A

NYCDOT

Tampa (THEA)

WYDOT

USDOT
Contacts for CV Pilots Program/Site AORs:

- Kate Hartman, Program Manager, Wyoming DOT Site AOR; Kate.Hartman@dot.gov
- Jonathan Walker, NYCDOT Site AOR; Jonathan.b.Walker@dot.gov
- Govind Vadakpat, Tampa (THEA) Site AOR; G.Vadakpat@dot.gov

Visit CV Pilot and Pilot Site Websites for More Information:

- CV Pilots Program: http://www.its.dot.gov/pilots
- NYCDOT Pilot: https://www.cvp.nyc/
- Tampa (THEA): https://www.tampacvpilot.com/
- Wyoming DOT: https://wydotcvp.wyoroad.info/