CONNECTED VEHICLE PILOT Deployment Program

NYC CV Pilot Deployment Project

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ITS Joint Program Office
TODAY’S AGENDA

- Project Overview
- Security
- Map Generation
- Operations and Management
- Pedestrian Applications
Pilot Sites

- **New York City**
  - Improve safety and mobility of travelers in New York City through connected vehicle technologies.
  - Vehicle to vehicle (V2V) technology installed in up to 10,000 vehicles in Midtown Manhattan, and vehicle to infrastructure (V2I) technology installed along high-accident rate arterials in Manhattan and Central Brooklyn.

- **ICF/Wyoming**
  - 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.

- **Tampa (THEA)** Tampa Hillsborough Expressway Authority
  - 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.
PROGRAM GOALS

- Participate in upcoming Webinars/Conference Presentations from the three Pilot Sites (see website for exact dates and times)
- Visit Program Website for Updates: [http://www.its.dot.gov/pilots](http://www.its.dot.gov/pilots)
- Contact: Kate Hartman, Program Manager, Kate.Hartman@dot.gov

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<td>Device Acquisition and Installation</td>
<td>ITE Annual Meeting</td>
<td>Operational Readiness</td>
<td>TRB</td>
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STAY CONNECTED

- Public Webinars
- Conference Presentations
Today’s Transportation Challenges

**Safety**
- 32,675 highway deaths in 2014
- 6 million crashes in 2014
- Leading cause of death for ages 11, 16-24

**Mobility**
- 6.9 billion hours of travel delay
- $160 billion cost of urban congestion

**Environment**
- 3.1 billion gallons of wasted fuel
- 56 billion lbs of additional CO₂

Data Sources:
Quick Facts: 2014 Data, National Highway Traffic Safety Administration (January 2016); 2015 Annual Urban Mobility Report, Texas Transportation Institute (Aug 2015); Centers for Disease Control
NYC Pilot Goal

“Traffic Death and Injury on City streets is not acceptable”

The NYC pilot will evaluate the safety benefits and challenges of implementing CV technology with a significant number of vehicles in the dense urban environment.

Source: USDOT
NYC Transportation Challenges

A 76-year-old Florida woman died Saturday after being struck by a taxi as she walked in a crosswalk in Manhattan, emergency officials said.
Project Goals

• Assess the application of CV technology in a dense urban environment.

• Focus on equipping fleets to enable a significant number of vehicle interactions in a concentrated area.

• Develop strategies to address daily operations of CV technologies.

• Assess the benefits of the CV applications with respect to safety and mobility
Vehicle to Vehicle (V2V) applications work *wherever* equipped vehicles encounter one another.

Vehicle to Infrastructure (V2I) applications work where *infrastructure is installed* (highlighted streets)

The CV project leverages the City’s transportation investments

Source: NYCDOT
CV Deployment Equipment

- Up to 8,000 **fleet vehicles** with Aftermarket Safety Devices (ASDs):
  - ~5,850 Taxis (Yellow Cabs)
  - ~1,250 MTA Buses
  - ~500 Sanitation & DOT vehicles
  - ~400 UPS vehicles
- Pedestrian **PID**s ~100 units for visually impaired
- **Roadside Units (RSU)**
  - at ~353 Locations
    - ~202 Manhattan Ave
    - ~79 Manhattan Cross
    - ~28 on Flatbush Ave
    - ~8 on FDR
    - ~36 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

Source: USDOT
CV Applications (A)

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

Vehicle-to-Infrastructure Safety Applications
- Red Light Violation Warning
- Speed Compliance
- Curve Speed Compliance
- Speed Compliance/Work Zone
- Oversize Vehicle Compliance
  - Prohibited Facilities (Parkways)
  - Over Height warning
- Pedestrian in Crosswalk
- PED-SIG
- Emergency Communications and Evacuation Information
CV “Support” Applications (B)

- Event Logging (what happened immediately before and immediately after an alarm or alert was issued.)
- Encounter Logging (Who have I seen)
- RF Data Collection (First/Last to verify radio operation)
- System logs for device management (system actions)
- Over-The-Air (OTA) uploading from ASD devices of log information (above) to the TMC systems for analysis
- Over-The-Air (OTA) downloading to ASD devices including software or firmware as well as configuration parameters.
Other Applications

- Access Security Credential Management System (SCMS)
- TMC signing of selected messages
  - TIM
  - MAP
  - Future RTCM
- Security Management for NTCIP communications
  - TMC ↔ Traffic Controller
  - Traffic Controller ↔ RSU
  - TMC ↔ RSU
- TMC Collection/Export SPaT data for PED applications
- Data “Obfuscation” and aggregation – Privacy protection
- Data Export – FHWA research data
- Data analysis – safety benefits and operating statistics
# System Engineering Process

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<th>Phase 1</th>
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<th>Phase 1</th>
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<th>Phase 4</th>
<th>Phase 5</th>
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<td>Concept Exploration and Benefits Analysis</td>
<td>Project Planning and Concept of Operations Development</td>
<td>System Definition and Design</td>
<td>System Development and Implementation</td>
<td>Validation, Operations and Maintenance, Changes &amp; Upgrades</td>
<td>System Retirement/Replacement</td>
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## Project Phase I: ConOps, Requirements, Deployment Plan
- Regional Architecture
- Needs Assessment
- Concept Selection
- Project Planning

## Project Phase II: Procurement Specifications Development
- Systems Engineering Management Planning
  - Concept of Operations
  - System Requirements
  - High-Level Design Subsystem Requirements
  - Detailed Design
- Software Coding Hardware Fabrication
- Unit Testing
- Subsystem Verification Subsystem Integration
- System Verification System Integration
- System Validation Initial Deployment

## Project Phase II: Application Design, Procurement Development, Integration
- Operations and Maintenance

## Project Phase II: Requirements, Verification, and Acceptance Testing
- Changes and Upgrades

## Project Phase III: Operations, Data Collection, and Assessment
- Retirement/Replacement

Source: NYCDOT
Performance Metrics & Evaluation Methods
While preserving privacy

Safety Needs (ConOps)

Safety applications

Developed Questions for Evaluation

Performance Measurement Metrics ~47

Reduce Vehicle to Vehicle Crashes

V2V & V2I Safety Applications for Crash Avoidance

- Does number of crashes decrease?
- Does number and severity of red light violations decrease?
- Does number of bus / right turn vehicle crashes decrease?

Data collection: Everything that “occurred” immediately before and after the alert

- Fatality crash counts
- Injury crash counts
- Property damage only crash counts
- Time to Collision
- Red light violation counts
- Red light violation crash counts
- Driver actions and/or impact of actions when they receive alerts
- Bus & right turn related crash counts
- Number of warnings generated
- Right-turning related conflicts
Key Factors

- V2V encounters can happen anywhere two equipped vehicles meet
- Fleet vehicles regularly return to terminal facilities
- Backhaul bandwidth is approximately half of the V2I/I2V connection
- Privacy matters
Performance Measures

- **Approach**
  - Collect all relevant raw data for each individual event
  - Provide for customization of event data collection
  - Store event data securely on ASD at time of collection
    - Encrypt
    - Limit life-time of data
  - Over-The-Air collection of raw data from ASD to RSU (support sites)
  - Obfuscate raw data and then aggregate into bins to obscure any individual event
All of the data collected during \( T_B \) is transferred to the event record, and after the trigger the data is collected and added to the record until \( T_A \) expires.

Source: NYCDOT
• Generic ASD context for event data lifecycle
  □ CV application parameter configuration
  □ Event identification
  □ Event info collection
  □ Store securely on ASD
  □ Move stored events to the back-office (upload)
  □ TMC event data obfuscation and aggregation
• Obfuscation process to scrub precise time and location data from the ASD action logs for privacy
  • Relative details retained
• Non-obfuscated data will be destroyed following the obfuscation process
Our Experience

I’m not crazy about reality, but it’s still the only place to get a decent meal.

-- Groucho Marx --
Security

- Securing the security system
  - Misbehavior detection and CRL distribution are non-existent or immature: pseudonym certificates limited to life-span of a week
  - Goal: sign data at its origin: MAP, TIM, RTCM
  - Lease Hardware Security Module to protect the cryptographic materials for signing
  - MAP & SPaT security needs differ: separate PSIDs
  - Service Specific Permissions applications

- Improving system and field infrastructure security
  - External interfaces
  - Inside the controller cabinet
Connection Diagram for NYC CV Pilot System

Icon: Connection Description

- 0: TMC Pass Through (random as needed)
- 0: TMC Controlled Push or Pull (long periods)
- 0: E-mail or File Transfer (Infrequent)
- 0: Planned for Future
- 0: TMC Pull (hourly)

Filename: NYC CVPD Connections IPv6-IPv4V3.vsd
Securing physically

Context for ASTC/RSU/TMC Infrastructure
Securing the data flows

Security Context for Traffic Controller Infrastructure

Exposed Ethernet Cable outside the cabinet
Exposed Ethernet Cable inside locked controller cabinet
Secure Wireless link (VPN, Cell)
Logical Data Exchanges

LAN/WAN

Traffic Controller Cabinet

ASC
Switch (IPv4) POE Inserter
RSU
Wireless modem/router
TMC
NTCIP
MAP, TIM, RTCM, OTA updates, log files, local BSMs

SCMS

Certificates

MAP, TIM, RTCM, OTA updates, log files, local BSMs

Certificates
NYC MAP Generation Approach

- Use Stand-alone instead of interlaced (egress lanes from adjacent intersection)
- Model all lanes
- Use Standard 32-bit offsets for all encoding
- Minimize field review
- Find cost effective determination of verification points

Why
- Provides application developer flexibility for switching
- Questions on signal propagation at building corners
## MAP Message Contents

<table>
<thead>
<tr>
<th>MAP Message Content</th>
<th>Construction</th>
<th>LLH Point Description</th>
<th>UPER Size (Bytes)</th>
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<tbody>
<tr>
<td>Vehicle Lanes + Ped</td>
<td>Frame+MAP</td>
<td>Explicit 64-bit full location</td>
<td>1610</td>
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<tr>
<td>Crosswalk Lanes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Lanes + Ped</td>
<td>Frame+MAP</td>
<td>Standard 32-bit offsets</td>
<td>1184</td>
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<tr>
<td>Crosswalk Lanes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Lanes + Ped</td>
<td>Frame+MAP</td>
<td>Compact</td>
<td>1184</td>
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<tr>
<td>Crosswalk Lanes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Lanes + Ped</td>
<td>Frame+MAP</td>
<td>Tight (smallest)</td>
<td>1104</td>
</tr>
<tr>
<td>Crosswalk Lanes</td>
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NYC: 2nd Ave @ E 60th St
Map Generation

- Tool capabilities
  - Image age
  - Verification point management
  - Node offset encoding (Explicit, Standard, Compact, Tight)
  - Lane widths
  - Revocable lanes for multiple purposes
    - Reversible
    - Exclusive vehicle vs mixed vehicle traffic
  - Computed lanes
  - Curb lane attributes
- Standards issues
  - Crosswalks
  - Bike boxes
  - Internal storage lanes
MAP Optimization Strategies

- Tight encoding

- Computed lanes (under development)

- Stub egress lanes - shorten (modified interlacing)

- Consolidate egress lanes – merge together
Operations and Management

- **RF Monitoring**
  - Encounter Logs (Who have I seen)
  - RF Collection (First/Last to verify radio operation)
- **ASD Monitoring**
  - OTA Log uploading
- **Over-The-Air (OTA) updates of ASD devices:**
  - software or firmware
  - configuration parameters
  - system status log
Pedestrian Issues

- Stakeholders are the visually impaired
  - Assistance crossing the street
  - Information about vehicles: All or nothing
  - Potential for cost reductions

- Positioning accuracy
  - Location augmentation
  - Working on external positioning system

- Pedestrian detection
  - Video/Infra-red detection
  - May restrict time-of-day operation to limit distractions
Next Steps

- Purchased and installed prototypes and samples (~35)
- Working with the vendors to develop OTA
  - For incremental tuning and “updates”
  - ASTC updated: exports SPaT and accepts PED detection
- Developing installation procedures with installers & vendors
  - Finalize installation agreements/contracts
- Finalize deployment preparation
  - Inventory Vehicle types
  - Finalize installation and test procedures
  - Finalize calibration procedures
- Complete Procurement of ASDs, RSUs and Ped Devices
- Ready, Set, …
The NYC CVPD Team

Thanks You

For more information contact:

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david.benevelli@transcore.com

NYCDOT Pilot: https://www.cvp.nyc/