New York City (NYC) Pilot Update at the System Design Milestone

Jonathan Walker (Program Manager, Research & Demonstration, USDOT ITS-JPO)
Mohamad Talas (NYCDOT, NYC CVPD Project Management Lead)
Bob Rausch (TransCore, NYC CVPD Site Deployment Lead)
David Benevelli (TransCore, NYC CVPD System Engineering Lead)
TODAY’S AGENDA

- Purpose of this Webinar
  - Present the conceptual overviews and status reports of the New York City pilot project, as well as the technical challenges and lessons learned of the system design process.

- Webinar Content
  - Connected Vehicle Pilot Deployment Program Overview
  - New York City Pilot Overview
  - System Design Overview
  - Challenges and Lessons Learned
  - Stakeholder Q&A

- Webinar Protocol
  - Please mute your phone during the entire webinar
  - You are welcome to ask questions via chatbox at the Q&A Section
  - The webinar recording and the presentation material will be posted on the CV Pilots website
- Participate in **Design/Build/Test Phase** Webinars/Conference Presentations from the three Pilot Sites (see website for exact dates and times)

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- Public Webinars
- Conference Presentations

- 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
New York City CV Pilot Deployment Concept

Speaker

Mohamad Talas, PE, PTOE, PhD
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
NYC Transportation Challenges
Sample Accident Statistics

Source: NYCPD https://trafficstat.nypdonline.org/
The Time is Now!

- NHTSA proposed rulemaking that will require all new vehicles to transmit **Basic Safety Messages** is out for comment.
- First new cars with connected vehicle technology available for sale/lease in 2017.
- Aftermarket safety devices (ASD) will bring existing vehicles into the connected environment.

NYCDOT and our Stakeholder’s experience will test the standards and shape the future of CV Technology!
Project Participants

Stakeholders
Fleet Owners and Users

Project Team

[Logos and names of various stakeholders and project team members]
Needs Considered

- **Safety**
  - Need to “manage” speed (25 MPH city-wide except Fwy)
  - Need to reduce crashes
    - vehicle-to-vehicle crashes
    - pedestrian injuries
    - crashes & injuries at intersections
    - crashes involving buses
    - crashes of vehicles with infrastructure
  - Need to inform drivers of serious travel restrictions

- **Management**
  - Collect performance metrics (safety benefits, traffic conditions)
  - Protect privacy
  - Manage apps in the urban environment (traffic and geometries)
  - Manage and monitor overall operational integrity of the system
  - Data needs for the independent evaluator
  - Support OTA software and parameter updates
Overall Project Concept

Source: NYCDOT
Field Infrastructure Concept

**Typical Vehicle**

- Vehicle CAN of J Bus
- GPS DSRC (2 channel)
- After Market Safety Device (ASD)
- Verify Proper Operation
- Alerts, warnings, driver information
- POWER

- DSRC V2V
- DSRC V2I
- After Market Safety Device (ASD)
- POWER

**NYCWiN**

- GPS DSRC (2 channel)
- City Owned Network (Fiber or citynet)
- Optional Traffic Controller
- Traffic Controller

Source: NYCDOT
V2V applications work *wherever* equipped vehicles encounter one another.

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

The CV project leverages the City’s ITS investments

Source: NYCDOT
Deployment of CV Technology in a Dense Urban Environment

- Up to 8,000 fleet vehicles with After Market Safety Devices (ASDs):
  - ~5,850 Taxis (Yellow Cabs)
  - ~700 MTA Buses
  - ~1,050 Sanitation & DOT vehicles
  - ~400 UPS vehicles

- Pedestrian PIDs ~100 units

- Roadside Units (RSU) at:
  - ~353 Locations
  - ~8 on FDR
  - ~28 on Flatbush Ave
  - ~202 Manhattan Ave
  - ~79 Manhattan Cross
  - ~36 Support locations (airports, river crossings, terminal facilities)
Performance Metrics & Evaluation Methods
While preserving privacy  47 Metrics

Safety Needs (ConOps)

Safety applications

Developed Questions for Evaluation

Performance Measurement Metrics ~47

Reduce Veh-Veh 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
System Design Overview

Speakers

Bob Rausch, PE
David Benevelli, PE
V2V Safety Applications

- Vehicle Turning Right in Front of Bus Warning (VTRW)
- Forward Collision Warning (FCW)
- Emergency Electronic Brake Light (EEBL)
- Blind Spot Warning (BSW)
- Lane Change Warning/Assist (LCA)
- Intersection Movement Assist (IMA)

V2V applications based on existing demonstrations and prior developments and documentation
CV Applications - 2

V2I Safety Applications

- Red Light Violation Warning RLVW
- Speed Compliance SPD-COMP
- Curve Speed Compliance CSPD-COM
- Speed Compliance/Work Zone SPDCOMPWZ
- Oversize Vehicle Compliance OVC
  - Prohibited Vehicle (Parkways)
  - Overheight
- Emergency Communications and Evacuation Information (Using the traveler information features) EVACINFO
- Mobile Visually Impaired Ped Signal System PED-SIG
- Pedestrian in Signalized Intersection Warning PEDINXWALK
- CV Data for Intelligent Traffic Signal System I-SIGCVDAT
Operations, Maintenance, and Performance Analysis

- RF Monitoring: RFMON
- OTA Firmware Update: FRMWUPD
- Parameter Up/Down Loading: PARMLD
- Traffic data collection: TDC
- Event History Recording: EVTRECORD
- Event History Up Load: EVTCOLLECT
### Where Did We End in Phase 1?

- **Phase 1**

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- Documents Located: [https://www.its.dot.gov/pilots/cv_pubs.htm](https://www.its.dot.gov/pilots/cv_pubs.htm)
Where Did We End in Phase 1?

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<th>Project Phase I: ConOps, Requirements, Deployment Plan</th>
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Phase - 1
- Interfacing with Planning and the Regional Architecture

Phase 0
- Concept Exploration and Benefits Analysis

Phase 1
- Project Planning and Concept of Operations Development

Phase 2
- System Definition and Design

Phase 3
- System Development and Implementation

Phase 4
- Validation, Operations and Maintenance, Changes & Upgrades

Phase 5
- System Retirement/Replacement

Source: NYCDOT
System Architecture

- Architecture Views
  - Enterprise: roles and relationships between organizations
  - Physical: physical objects (systems and devices), their application objects, and high-level interfaces between physical objects (information flow triple)
  - Communication: communication protocols between application objects
  - Functional: abstract functional elements (processes) and their logical interactions or data flows that satisfy the requirements

- Standard message sets for interoperability
  - BSM
  - MAP
  - SPaT
  - TIM
  - RTCM

- Merged information flow triples (data flow name, source, destination)
- Coordination with all three CV Pilots
System Architecture: Physical

Layer 0 (Simplified)

NYCDOT TMC

(1-2A-B) Center to Field

(1-2A) Field to Field

RSU

Signal Controller

(2A-C) Short Range Wireless

(2A-C) Short Range Wireless

PID

Bus ASD + Commercial Vehicle ASD + Light Duty Vehicle ASD

NYU (NYCDOT IRB)

(1A) Network Time Protocol

(2C-D) SCMS End Entity Interface

Location and Time Service (LTS)

USDOT Production SCMS

(2C) Wide-Area Wireless

Source: NYCDOT
- Defined the protocol stack covering the ‘triples’ throughout the system

- One example protocol diagram for communication view in the NYC CVPD project for the Dedicated Short Range Communication WAVE Short Message Protocol from the SET-IT (ARC-IT) tool

- Identification of the standards

Source: NYCDOT
System Architecture: Functional

- Generic ASD context for event data lifecycle
  - Event Recording
  - Event Collection
  - Event Upload and Data Obfuscation
System Architecture to System Design

- Device Procurement Specifications
  - ASD
  - RSU
  - PID
  - TMC HSM
- RF Test Equipment
- Ped Detection Equipment
- Controller Firmware

- Vendor solicitation, demonstration, and request for expression of interest and proposal (RFEIP)

- Interface Control Document (ICD) and Standards Plan
- Standard message sets for interoperability
- Development of management applications for operations, maintenance, and performance analysis at NYCDOT TMC
- Refinement of system, design, and interface requirements

- Stakeholder engagement: development installation procedures and standard operating procedures (SOP) with the vendors
NYCDOT Traffic Management Center (TMC)
- Hardware
  - Redundancy and data protection through storage area network (SAN)
    Smart Array 2042
    - Share data
    - Balance processing tasks
  - Base software configuration
    - Windows Server 2016
    - Microsoft SQL Server 2016 - Standard Edition
    - A virtualized server environment established with Microsoft’s Hyper-V technology
TMC / CV System Software

- ASD Management
  - Processes: parameter update, monitoring, maintenance, software updates
  - Reports: malfunction, RF, status (sighting, warnings)
- RSU Management
  - Processes: editor, communication manager (ASD), communication control (TMC), mobile RSU, software updates
- RSU Status
  - Processes: monitor, communication manager (ASD), TransSuite ATMS Map, System Logger, Alarm System, NYC DoITT
  - RF propagation status
- MAP and TIM management – Includes Security Signing
- Security (HSM, Aerolink, SCMS support)
TMC / CV System Software (Cont.)

- Performance Evaluation
  - Crash data from existing NYC PD records
  - Event data from safety applications
  - Fleet operator data from anonymous vehicle operators
  - Number of events (by event type) during Before and After periods
- Event Data Obfuscation
- Travel Time calculations
  - Feed Adaptive control system – Midtown-in-Motion
- Operations monitoring
Next Steps

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Phase 1:
- Interfacing with Planning and the Regional Architecture
- Concept Exploration and Benefits Analysis
- Project Planning and Concept of Operations Development
- System Definition and Design
- System Development and Implementation
- Validation, Operations and Maintenance, Changes & Upgrades
- System Retirement/Replacement

Source: NYCDOT
Challenges and Lessons Learned

Speakers

Bob Rausch, PE
David Benevelli, PE
Challenges Resolved

- Privacy
- Security
- ASD Procurement
- Location
- CV Application Tuning
- Traffic Signal Controller Interface
Lesson 1: Privacy

- Privacy is a critical issue for our stakeholders.
- It is more complex than NYCDOT and USDOT previously imagined.
- Plan additional time for understanding the issues, formulating workable solutions, and negotiating agreements with the many stakeholders.
- Data collection schemes need to be tempered by the privacy issues.
- Deployment of a “production CV system” is different from an R&D platform!
- For every step, evaluate the impact on privacy
  - Focus: **privacy by design**
  - Stakeholders needed reassurance on protection of privacy

- Address privacy of safety/operational data using multiple tools
  - MOUs
  - Onboard data encryption
  - Collection time limits
  - Data obfuscation, sanitization, normalization
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
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
Lesson 2: Security -
Maintaining a Trusted Environment

- Integration with USDOT SCMS
  - SCMS development in parallel with project
  - SCMS Proof-of-Concept (POC) End Entity (EE) requirements continue to be refined
  - SCMS POC is to be released for production shortly
  - SCMS PlugFest sessions
  - Signing TMC content generates new requirements
  - Protecting SCMS investment (FIPS-140-2 Level, HSM)
  - Policies for certificate life-cycles
  - IPv4 and IPv6 access

- Address security in all aspects of the CV and DOT system
  - TMC security (physical, system access needs)
  - Devices & networks (operating firewalls, NATs, management)
  - Complexity and troubleshooting
  - Security monitoring
Lesson 3: ASD Procurement

- NYC fleets are a special case
- Data collection needs for performance measures
- Application maturity lower than expected
  - No industry application performance requirements available
- Transportation agency’s to consider user’s equipment
  - Fleets vs private vehicles

✔ Tools, tools, tools, ...
  ✔ System Engineering Process (needs, requirements, specifications, traceability)
  ✔ Leverage existing device vendor experience
  ✔ Request for Expression of Interest and Proposal Process
  ✔ RF tools (interference detection, protocol analyzers, GPS repeaters, ...)
  ✔ Security monitoring
Lesson 4: Location

- GPS accuracy in the urban canyon is challenging
  - Limited sky views limit satellite connections
  - Bridges, roadway decks, and short tunnels limit sky views
  - Relative V2V and absolute V2I accuracy needs

☑ Require supporting techniques to improve location accuracy
  ☑ Dead reckoning
  ☑ CAN bus integration for speed information
  ☑ Inertial Management Unit (IMU) integration
  ☑ RSU triangulation
Lesson 5: CV Application Tuning

- One application, three different experiences
  1) Your Grandmother would be comfortable
  2) It does its job as you gasped that it felt close
  3) Its aggressive and all passengers looking for their virtual brake pedal

- Key is tuning for urban density and speeds to balance alerts versus false alarms
  - Consistent expectations
  - Performance tradeoffs
  - Stage open sky testing and urban canyon testing
Lesson 6: Controller Interface

- Controller interface required for SPaT data source

✔ Employ DRAFT NTCIP 1202-v3
  ✔ First implementation
  ✔ Standards based
  ✔ Single vendor
  ✔ Active owner participation
  ✔ Future interoperability?
Challenges Outstanding

- SCMS POC Protection
  - FIPS-140-2 Level
  - Integration of Hardware Security Modules (HSM)
  - TIM/MAP signing at data generation source - TMC
  - Policies for certificate life-times
  - Certificate capture and storage for potential CRL use

- Interoperability
  - Messages
  - Channel allocation
  - Applications

- CAN bus integration
- Location Referencing
  - RTCM need?
Interoperability

- Interoperability with interfaces, applications, channel allocation
- Standard message sets (Adding SSPs to messages, security profiles)
  - BSM
    - BSM Part II content required for trucks & fleet operations
    - Multi-unit vehicle length
    - Over-height application
  - MAP
    - Mapping crosswalks
  - SPaT
  - TIM
  - PSID usage for SSM and SRM
  - WSA assignment
- Agreed to conventions for using standards in compatible manner
- SCMS certificate requests
- OTA software updates and application tuning
Challenge
Only DSRC Communications

Public Safety V2V Applications Channel (Dedicated)

Control Channel

Service Channel*
WSMP or IPv6

Service Channel*
WSMP or IPv6

Emergency Vehicles

Not used in NYC

DSRC only communications
Plan on using 6 channels – Dual Radios

*Service Channel: uploading log files; downloading firmware & application parameters and security certificates
Challenges Forthcoming

- Vender intellectual property (IP) vs. parameter tuning
- Bandwidth for OTA updates (time required)
- Devices from multiple vendors
- Installation in a wide variety of vehicles, antenna location and cable routing paths, CAN bus integration
- Intersection deployment planning
  - Mast arm visibility
  - Controller cabinet location
- Standards evolution and stability
- Misbehavior reporting/detection, CRL
- Performance evaluation, simulation modeling
- Pedestrian recruitment
- DSRC on PIDs
Infrastructure Experience

- DSRC Licensing (FCC)
  - Class C devices required three applications per site to license the full channel range (~1000 total)
  - A long process (+16 months)
  - 75 Km airport range (LGA, JFK, ENW, TEB)
    - Heliports / Seaplane (Four in Manhattan)
  - Requires Interdepartment Radio Advisory Committee (IRAC) coordination (NTIA, FAA, ...)
  - Waiver requests to expedite the process
    - IRAC geographic coordination
    - Antenna EIS
  - Working with USDOT/FCC to improve the process with a goal of bulk data exchange
MAP generation
  - Manage costs (utilize existing tools, survey needs)
  - Adopt conventions
    - Intersection approach (standalone, interlaced, mid-point)
    - Crosswalk approach (link, end-points, combination)
  - Assumptions
    - Each intersection map must stand-alone for CV app use
    - Maps don’t link together (interlaced)

Tool Improvement Examples
- Photo dating
- Zoom levels
- Lane identification
- Connections
- Encoding size
- Error messages

Working with USDOT tool to improve the next generation
Current Activities

- Working with stakeholders & vendors
  - Developing installation procedures and installation verification environment
    - Have outfitted a number of vehicles
  - Interface to CAN and J bus
  - Working with sample and prototype units
- Procurement
  - Final negotiations with 2 vendors for ASD and installation kits
  - Working with vendors on design and deployment “issues”
- Developing Software for Back Office CV support
  - Have connected to sample RSUs
  - Developing performance measures analysis and obfuscation software
- Final execution of MOUs with stakeholders – details have been worked out
- Did sample Initial RF interference study of critical locations – awaiting RF test Eqpt.
- Moving forward on the integration of a Level 3 HSM at TMC to sign TIM, MAP, [RTCM]
- Working with standards organizations – SPaT, MAP, BSM, TIM, ISO (19091) for conformance to standards and updating standards to meet NYC requirements
- Cooperating with our Sister Sites for interoperability testing
Please keep your phone muted

Please use chatbox to ask questions

Questions will be answered in the order in which they were received
Join us for the Getting Ready for Deployment Series

- Discover more about the CV Pilot Sites
- Learn the Essential Steps to CV Deployment
- Engage in Technical Discussion

Visit the Pilot Site Websites for more Information:

- NYC DOT Pilot: https://www.cvp.nyc/
- Tampa (THEA): https://www.tampacvpilot.com/
- Wyoming DOT: https://wydotcvp.wyoroad.info/

Contact for CV Pilots Program:
Kate Hartman, Program Manager
Kate.hartman@dot.gov

Contact for Pilot Sites:

- Kate Hartman, WYDOT Site AOR
  Kate.Hartman@dot.gov
- Jonathan Walker, NYCDOT Site AOR
  Jonathan.b.Walker@dot.gov
- Govind Vadakpat, THEA Site AOR
  G.Vadakpat@dot.gov