New York City Connected Vehicle Performance Highlights

Mohamad Talas PE. PH.D.
Director, System Engineering
NYCDOT
Agenda

- Project overview
- Fleet description
- Data collection & processing
- Event observations
- Lessons
- Questions?

Program documentation:
https://www.its.dot.gov/pilots/cv_pubs.htm
NYC CV Pilot Deployment Goals

- Primary Goal:
  - Improving safety through the reduction of vehicle and pedestrian crashes, injuries, and fatalities

- Secondary Goal:
  - Improving mobility and reliability through crash prevention and lower crash severity

- Measure System Performance in meeting these goals
  - Data collection system was designed around project performance measures addressing privacy concerns and data collection costs
NYC CV Infrastructure

- Infrastructure: 450 Roadside Units (RSU)
- Vehicles: 3000 (about 200 OBU installs remain)
- Safety applications: 13
- Operations applications: 8
- This is a **large scale** deployment with challenges:
  - Location accuracy – urban canyons
  - RSU density
  - Application arbitration/interference
  - DSRC media only – channel management
  - First full-scale security deployment
  - Security boundary expanded to include all ITS communications
  - Utilize edge computing concepts to minimize bandwidth
### Vehicle-to-Infrastructure (V2I) Pilot Area
- Red Light Violation Warning
- Speed Compliance
- Curve Speed Compliance
- Speed Compliance/Work Zone
- Oversize Vehicle Compliance
  - Prohibited Facilities (Parkways)
  - Over Height
- Vehicle Turning Right in Front of Bus Warning
- Emergency Communications and Evacuation Information (Traveler Information)

### Vehicle-to-Vehicle (V2V) Citywide
- Forward Collision Warning
- Emergency Electronic Brake Light
- Blind Spot Warning
- Lane Change Warning/Assist
- Intersection Movement Assist

### Pedestrian Applications
- Pedestrian in Signalized Intersection Warning – to vehicles
- *Mobile Ped Signal System – Visually Impaired navigation assistance*
Fleet Description
## Participating Fleets

### New York City Pilot (NYCDOT)

<table>
<thead>
<tr>
<th>Service</th>
<th>Complete</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Transportation (DOT)</td>
<td>1,216</td>
<td>1,229</td>
</tr>
<tr>
<td>TransCore</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>MTA/New York City Transit</td>
<td>11</td>
<td>TBD</td>
</tr>
<tr>
<td>Office of Chief Medical Examiner (OCME)</td>
<td>27</td>
<td>52</td>
</tr>
<tr>
<td>Parks Dept. (Parks)</td>
<td>275</td>
<td>311</td>
</tr>
<tr>
<td>Dept. of Correction (DOC) + Probation</td>
<td>297</td>
<td>297</td>
</tr>
<tr>
<td>Dept. of Environmental Protection (DEP)</td>
<td>132</td>
<td>285</td>
</tr>
<tr>
<td>DCAS Fleet Share</td>
<td>77</td>
<td>77</td>
</tr>
<tr>
<td>TLC Fleet (DCAS)</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>Dept. of Homeless Services (DHS)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Dept. of Design and Construction (DDC)</td>
<td>38</td>
<td>91</td>
</tr>
<tr>
<td>Dept. of Buildings (DOB)</td>
<td>69</td>
<td>286</td>
</tr>
<tr>
<td>Dept. of Info. Tech. &amp; Telecom. (DOITT)</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Housing Preservation &amp; Development (HPD)</td>
<td>26</td>
<td>55</td>
</tr>
<tr>
<td>Dept. of Health (DHMH)</td>
<td>28</td>
<td>58</td>
</tr>
<tr>
<td>Administration for Children's Services (ACS)</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Human Resources Administration (HRA)</td>
<td>86</td>
<td>86</td>
</tr>
<tr>
<td>Office of Emergency Management (OEM)</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Dept. of Consumer Affairs (DCA)</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Dept. of Education (DOE)</td>
<td>61</td>
<td>47</td>
</tr>
<tr>
<td>Anheuser Busch</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>MTA Bridges and Tunnels</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>NYC TLC Taxis</td>
<td>1</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Total Equipped Vehicles** | As of May 31, 2021 | 2,640 | 3,000
## Fleet Vehicles

Vehicle CAN bus interface provides speed data for Dead Reckoning to improve location accuracy.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Models</th>
<th>Years</th>
<th>Range</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chevrolet</td>
<td>6</td>
<td>10</td>
<td>2011 – 2020</td>
<td>432</td>
</tr>
<tr>
<td>Chrysler</td>
<td>1</td>
<td>1</td>
<td>2019 – 2019</td>
<td>2</td>
</tr>
<tr>
<td>Dodge</td>
<td>1</td>
<td>4</td>
<td>2014 – 2017</td>
<td>16</td>
</tr>
<tr>
<td>Ford</td>
<td>21</td>
<td>15</td>
<td>2006 - 2021</td>
<td>975</td>
</tr>
<tr>
<td>IC Corp</td>
<td>1</td>
<td>7</td>
<td>2009 – 2017</td>
<td>85</td>
</tr>
<tr>
<td>International</td>
<td>1</td>
<td>1</td>
<td>2020 – 2020</td>
<td>3</td>
</tr>
<tr>
<td>New Flyer</td>
<td>2</td>
<td>2</td>
<td>2017 - 2018</td>
<td>3</td>
</tr>
<tr>
<td>Nissan</td>
<td>1</td>
<td>4</td>
<td>2013 – 2017</td>
<td>81</td>
</tr>
<tr>
<td>Nova</td>
<td>2</td>
<td>4</td>
<td>2010 – 2019</td>
<td>4</td>
</tr>
<tr>
<td>Orion</td>
<td>1</td>
<td>3</td>
<td>2006 – 2009</td>
<td>4</td>
</tr>
<tr>
<td>Ram</td>
<td>1</td>
<td>2</td>
<td>2016 - 2017</td>
<td>75</td>
</tr>
<tr>
<td>Toyota</td>
<td>7</td>
<td>13</td>
<td>2007 – 2020</td>
<td>959</td>
</tr>
<tr>
<td><strong>Total Equipped Vehicles</strong></td>
<td><strong>45</strong></td>
<td></td>
<td><strong>As of May 31, 2021</strong></td>
<td><strong>2,640</strong></td>
</tr>
</tbody>
</table>
Fleet Weekly Operations

Criteria Jan 3 – May 29, 2021

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Jan 3 – May 29, 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMT</td>
<td>4,138,000</td>
</tr>
<tr>
<td>Hrs</td>
<td>277,000</td>
</tr>
<tr>
<td>BSM Generated</td>
<td>15,967,000,000</td>
</tr>
<tr>
<td>BSM Evts/Ops Used</td>
<td>26,000,000</td>
</tr>
</tbody>
</table>

Miles (x100)  
Hrs (x10)  
Veh (CV-GT)
OBU Data Collection (Monthly)

Criteria Jan 1 – May 31, 2021

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>3,994,427</td>
</tr>
<tr>
<td>Vehicle-Days</td>
<td>87,280</td>
</tr>
</tbody>
</table>

In Progress

- Ssl_Files
- Ota_Files
- Bc_Files
- Rf_Files
- Evt_Files
### OBU-OBU V2V Contacts (Daily)

#### Criteria Jan 1 – May 31, 2021

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Jan 1 – May 31, 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>3,994,427</td>
</tr>
<tr>
<td>Vehicle-Days</td>
<td>87,280</td>
</tr>
</tbody>
</table>
Data Processing
Safety is Job #1.

- Once alerts are activated in a vehicle, they won’t be silenced.

User Needs related to Performance Measurement

- Maintain privacy of users throughout pilot and data collection
- No enforcement
- No driver evaluation

Performance Measurement Program considers:

- Consider impacts of CV data combined with data from other sources.
- Approach to collecting the performance information.
- Approach to using data collection bins of performance information.
- Control Group vs Treatment Group

**FHWA-JPO-16-302, Performance Measurement and Evaluation Support Plan - NYCDOT**
## Performance Measures

**FHWA-JPO-16-302**

### Connected Vehicle Pilot Deployment Program Phase 2

**Performance Measurement and Evaluation Support Plan**

- **New York City**
- **www.itis.dot.gov/index.htm**
- **Updated: March 31, 2021**

<table>
<thead>
<tr>
<th>User Need</th>
<th>Category</th>
<th>NYCDOT Needs</th>
<th>CV Application</th>
<th>No.</th>
<th>Performance Measure Metrics</th>
<th>Question for Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manage Speeds</td>
<td>Safety, Mobility</td>
<td>Discourage Spot Speeding</td>
<td>Speed Compliance</td>
<td>1</td>
<td>1a. Number of stops (average and distribution measures)</td>
<td>Does speed limit adherence increase and speed variability decrease within the vehicle fleet on a given study roadway segment for a given time period (cycle length basis) from the Before period to the Pilot period, and from control group to the treatment group? Is this accompanied by an overall increase, decrease or no change in average segment speed?</td>
</tr>
<tr>
<td>Manage Speeds</td>
<td>Safety</td>
<td>Improve Truck Safety</td>
<td>Curve Speed Compliance</td>
<td>2</td>
<td>2a. Speed related crash counts, by severity</td>
<td>Do the number of curve speed violations on each applicable studied roadway segment decrease from the Before period to the Pilot period, and from control group to the treatment group?</td>
</tr>
<tr>
<td>Manage Speeds</td>
<td>Safety</td>
<td>Improve Work Zone Safety</td>
<td>Speed Compliance / Work Zone</td>
<td>3</td>
<td>3a. Speed in zone work (average and distribution measures)</td>
<td>Do the number of work-zone speed violations on each applicable studied roadway type decrease from the Before period to the Pilot period, and from control group to the treatment group?</td>
</tr>
<tr>
<td>Reduce Vehicle to Vehicle Crashes</td>
<td>Safety</td>
<td>Reduce Vehicle to Vehicle Accidents</td>
<td>Red Light Violation Warning</td>
<td>4</td>
<td>4a. Fatality crash counts</td>
<td>Do the number and severity of red-light violations at each studied intersection decrease from the Before period to the Pilot period, and from control group to the treatment group?</td>
</tr>
<tr>
<td>Reduce Vehicle to Vehicle Crashes</td>
<td>Safety</td>
<td>Reduce Accidents at High Incident Intersections</td>
<td>Vehicle Turning Right in Front of Bus Warning</td>
<td>5</td>
<td>6a. Right-turning related conflicts</td>
<td>Do the number of bus / right turn vehicle crashes decrease from the Before period to the Pilot period, and from control group to the treatment group?</td>
</tr>
<tr>
<td>Reduce Vehicle to Pedestrian Crashes</td>
<td>Safety</td>
<td>Improve Pedestrian Safety on Heavily Traveled Bus Routes</td>
<td>Pedestrian in Signalized Crosswalk Warning</td>
<td>6</td>
<td>7a. Pedestrian related crash counts, by severity</td>
<td>Do the number of pedestrian related crashes decrease from the Before period to the Pilot period, and from control group to the treatment group?</td>
</tr>
<tr>
<td>Reduce Vehicle to Pedestrian Crashes</td>
<td>Safety</td>
<td>Improve Safety of Visually and Audibly-impaired pedestrians</td>
<td>Mobile Accessible Pedestrian Signal System (PED-SIG)</td>
<td>8</td>
<td>8a. Qualitative Operator Feedback</td>
<td>Does the mobile app improve participants’ perceived safety when crossing signalize intersection?</td>
</tr>
<tr>
<td>Reduce Vehicle to Infrastructure Crashes</td>
<td>Safety</td>
<td>Address Bridge Low Clearance Issues/Enforce Truck Route Restriction</td>
<td>Oversized Vehicle Compliance</td>
<td>9</td>
<td>9a. Number of Warnings generated</td>
<td>Do the number of low clearance violations decrease from the Before period to the Pilot period, and from control group to the treatment group?</td>
</tr>
<tr>
<td>Inform Drivers of Serious Incidents</td>
<td>Mobility</td>
<td>Inform Drivers</td>
<td>Emergency Communications and Evacuation Information</td>
<td>10</td>
<td>Number of vehicles receiving information when generated</td>
<td>Do CV vehicles receive the information warnings when generated?</td>
</tr>
<tr>
<td>Provide Mobility Information</td>
<td>Mobility</td>
<td>Replace Legacy Measurements</td>
<td>Intelligent Traffic Signal System Connected Vehicle Data (I-SIGCVDATA)</td>
<td>11</td>
<td>11a. Segment speed (average and distribution measures) from CV compared to legacy detection systems</td>
<td>Do the CV based mobility metrics compare favorably to legacy detection systems or provide better information?</td>
</tr>
<tr>
<td>Manage System Operations</td>
<td>System Operations</td>
<td>Ensure Operations of the CV Deployment</td>
<td>NA</td>
<td>12</td>
<td>System performance statistics (system activity, down time, radio frequency monitoring range on ASDs and RSUs, number of event warnings by app)</td>
<td>Does the system operate reliably?</td>
</tr>
</tbody>
</table>
Data Processing at the Back Office

- Decrypt
- Decode
- Fuse Obfuscate & Vet
- Export

Discards
ASD Event Log Obfuscation

Raw ASD Action Log Data

Obfuscated ASD Action Log Data

- Obfuscation process to scrub precise time and location data and assign to bins
- Non-obfuscated data will be destroyed following the obfuscation process
Event observations so far …
May 2021: Ingested

- 17,435 Total Fleet Events
- 2640 Installed Vehicles
- May VMT: 957,000 (Est)
- May Hrs: 66,000 (Est)

Notes:
- All collected events
- May 20 treatment begins
- Includes early ASD firmware versions
- Includes test vehicle events
- Includes silent & treatment events
CV Events by Type (Released)

May 2021: Released

- 14,520 Fleet Events
- Includes both Silent and Active Alerts

Notes:
- Disregards early ASD firmware versions
- Disregards Test Vehicle Events
- Includes Events passing error tests
- Includes Treatment and Control Vehicles
Forward Collision Warning (fcw) Events

May 2021: 2,946 Events
Intersection Movement Assist

Intersection Movement Assist (ima) Events

May 2021: 588 Events
Speed Compliance (spdcomp) Events

May 2021: 8,606 Events

V2I areas only
Red Light Violation Warning (rlvw) Events: Many Maps

- Sample RLVW Event
- 24 Different MAP messages heard in 17 seconds
- MAPs heard as far as nearly 1.5km from host vehicle
Obfuscated Event Analysis
Sample: EEBL Warning

Time:
Warning Issued in Host Vehicle at:
(X,Y) = (0, 0) meters
time = 0 seconds

Target Vehicle Rapid Deceleration
Breadcrumbs Analysis

8 sec

11 sec

32 sec
CV Project Lessons
Lessons

- **Location accuracy remains a challenge in the urban canyon environment.** Urban location accuracy requires more than GPS.

- **Grade separation is a challenge** in dealing with elevation element of location accuracy. Elevation is an essential component of the safety applications in the urban environment.

- The number of FCW and SPDCOMP events dominate the data collected and tend to skew any analysis of events spanning multiple types.

- **Breadcrumb were essential to analyzing anomalies and operational issues.**

- O&M data collected confirms RF data reception ranges impact OBU & RSU device loading due to device density.

- **Need to collect additional data:** Until we began analyzing events, we couldn’t determine that there is additional information that would make analysis easier. For example, for RLVW, adding the specific intersection identification triggering the alert in the event header would make analysis easier. Also, when analyzing BSMs, the MAP/SPaT/TIM being heard would impact interpretation of driver behavior.
Conclusions

- Effective CV operations **don’t require every BSM to be recorded.**
- **Equipping a fleet** requires cooperation beyond normal IOO organizational knowledge. **Consider costs of vehicle & driver time** – scheduling, maintenance, vehicle policies of the agency, etc.
- **MAP message maintenance requires on-going resources.** (Bus Lanes, bike lanes, phase sequences, lane markings, turn policies, speed limits, …)
- If we were starting over …
  - **Budget for Vehicle CAN integration** for improving location accuracy; **required far more resources** than estimated (money, time, people). Function (vehicle make, model, year) – NYC has 45 combinations – differences year to year, model to model, as well as Mfr.
  - Recognize the **ACTUAL maturity of the devices and applications.** The project spent considerable efforts Investigating fundamental protocol issues, re-boot frequency, anomalies with edge and corner cases, impact of density (RSU, OBU), RF range, ripple effect of security requirements for the ITS infrastructure, SCMS access, standards ambiguities, …
Contact for CV Pilots Program:
Kate Hartman, Program Manager
Kate.Hartman@dot.gov

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

Website: [http://www.its.dot.gov/pilots](http://www.its.dot.gov/pilots)
Twitter: [@ITSJPODirector](http://twitter.com/ITSJPODirector)
Facebook: [https://www.facebook.com/USDOTResearch](https://facebook.com/USDOTResearch)

CV Pilot Sites Document Repository
[http://www.its.dot.gov/pilots/cv_pubs.htm](http://www.its.dot.gov/pilots/cv_pubs.htm)

Please visit the CV pilots website for the recording and the briefing material of the previous webinars:
[http://www.its.dot.gov/pilots/technical_assistance_events.htm](http://www.its.dot.gov/pilots/technical_assistance_events.htm)
Questions?

Mohamad Talas, PE., PhD.
Mtalas@dot.nyc.gov