PA Turnpike Connected Work Zone Pilot

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Pennsylvania Turnpike Commission

Dwight Shank
Iteris

December 5th, 2018
• PA Turnpike CAV Roadmap – Selection of CV Pilot
• Connected Work Zone Pilot
  • Architecture
  • Evaluation Metrics
  • Installation and Integrations
  • Evaluation Preliminary Findings
  • Lessons Learned
CAV Roadmap
CAV Roadmap Project

• Project executed February 2016
• Prime – AECOM
• Subs – Information Logistics and TTI
• Roadmap Tasks:
  • Research current standards and best practices
  • Identify potential projects for short/mid/long term
  • Align with capabilities of PTC infrastructure readiness, planned projects, and in-house capabilities
  • Develop Implementation plan, starting with a “Quick Win” project
• Roadmap completed April 2017
• Executed CV pilot project December 2017
# Application Areas

## V2I Safety
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

## V2V Safety
- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

## Road Weather
- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

## Environment
- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priorities
- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveller Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AV Charging / Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

## Mobility
- Advanced Traveler Information System
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (Transit, Freight)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN)
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
- Emergency Communications and Evacuation (EVAC)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance
- Drayage Optimization

## Agency Data
- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies

## Smart Roadside
- Wireless Inspection
- Smart Truck Parking
Figure 1. What are Connected and Automated Vehicles?
CV Top Priorities

- Weather
- Traffic Incident Management
- Safety
- Work Zones
## CV Deployment Plan

<table>
<thead>
<tr>
<th>Short-Term 0-4 Years ▼</th>
<th>Mid-Term 4-10 Years ▼</th>
<th>Long-Term Beyond 10 Years ▼</th>
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<tbody>
<tr>
<td>• Warnings about Upcoming Work Zone (Work Zone Safety)</td>
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<td>• Speed Harmonization (SPD-HARM) (Traffic Network)</td>
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<td>• Road Use Charging (Congestion Pricing)</td>
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<td>• Vehicle Data for Traffic Operations (Traffic Network)</td>
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<td>• Performance Monitoring and Planning (Traffic Network)</td>
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# Short Term Projects – Quick Wins

## CAV Safety Core Focus Areas

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## Traffic Incident Management

## Roadway Safety

## Road Weather Safety
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## Why Pilot CV for Work Zone?

### Work Zone Crash Summary

**Fiscal Year - Total**

<table>
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<tr>
<th>Fiscal Year</th>
<th>Work Zone Total Crashes</th>
<th>Work Zone Fatal Crashes</th>
<th>Vehicle Miles Traveled (Crashes per MVMT)</th>
<th>Capital Spending (Crashes per Million)</th>
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<tr>
<td></td>
<td>Total</td>
<td>Injury</td>
<td>PDO**</td>
<td>Total</td>
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<tr>
<td>FY2014</td>
<td>214</td>
<td>70</td>
<td>141</td>
<td>3</td>
</tr>
<tr>
<td>FY2015</td>
<td>267</td>
<td>100</td>
<td>162</td>
<td>5</td>
</tr>
<tr>
<td>FY2016</td>
<td>327</td>
<td>103</td>
<td>220</td>
<td>4</td>
</tr>
<tr>
<td>FY2017</td>
<td>283</td>
<td>86</td>
<td>197</td>
<td>0</td>
</tr>
<tr>
<td>FY2018</td>
<td>173</td>
<td>50</td>
<td>122</td>
<td>1</td>
</tr>
<tr>
<td>FY2019***</td>
<td>89</td>
<td>36</td>
<td>53</td>
<td>0</td>
</tr>
<tr>
<td>5 Yr Average</td>
<td>253</td>
<td>82</td>
<td>168</td>
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* June 1st through May 31st
** Property Damage Only
*** June 1st through Oct 31st
Why Pilot CV for Work Zone?

- Maintenance on board with Pilot – willing to test technology on maintenance vehicle
- Quick deployment
- Open communications among stakeholders
- Easy access to troubleshoot equipment throughout pilot
- Effective coordination of work zone vehicle operations and evaluation vehicle
Connected Work Zone Pilot
Connected Work Zone Pilot Overview

• Project Team
  • Gannett Fleming, Iteris, Information Logistics, Drive Engineering

• Project Objectives
  • Evaluate DSRC mobile (OBU) technology
  • Evaluate Vehicle data feed for alerts into Waze and TripTalk
  • Operate with “No interaction needed from Operator”

• Operational Scenarios
  • Stationary Work Zone
  • Mobile Work Zone
Pilot Primary Tasks

• Develop Conops, Requirements, System Design, Evaluation Plan
• Software / Firmware development
• Waze / TripTalk Application Integrations
• Hardware procurement / Installation
• Integration and Testing
• Evaluation
Evaluation Metrics

• What % of transmitted messages were received V2V, Waze & TripTalk?

• Distance from TMA that messages were disseminated V2V, Waze & TripTalk?

• Was messaging provided for relevant direction of travel?

• Message Latency?

• Number of vehicles equipped with DSRC capable devices on PTC that transmitted BSM?
System Architecture

[V2N Diagram]
System Architecture
CV WZ implementation, Evaluation, Lessons Learned
Key Requirements

• OBU application is on at all times in maintenance zone

• OBU application sends simple messages when
  • Vehicle in preconfigured geofence of maintenance zone
  • Vehicle moving slowly or stopped
  • Time during preconfigured construction schedule

• V2V Communication between maintenance vehicle and evaluation or OBU-equipped vehicle (via DSRC)
  • Implemented using Roadside Alert

• Communication to ILog for Waze via wireless ISP over Internet*
  • OBU application provides alert information to servers
  • Servers generate CIFS 2.0 message every 30 seconds
  • Servers terminate message with comm failure from OBU

* Communication for Trip Talk App added
Enclosure Design/ Equipment Install by Gannet Fleming
Task 4.3 Operational Evaluation (WAN feeds)

PTC InfoLogistics Servers

- WAZE FEEDS
- PTC APP

Cohda MK5
Cisco IR809

PTC

WAZE: Active Constr. Incident
Mobile Vehicle App

Travelers on Turnpike
Travelers on Turnpike

Evaluation Team/Travelers
Evaluation Hardware
Project Status

- Initiated December 2017
- OBU and router installed on maintenance vehicle in June 2018
- OBU firmware last updated in August 2018
- System in operation during routine maintenance activities starting in August
- Notification via Waze incomplete
  - Alerts being retrieved by Waze servers
  - Alerts not displayed on Waze app or website map
- Evaluation of information display using mobile phone app using Trip Talk in place of Waze
  - Alerts successfully displayed on Turnpike’s Trip Talk app
Evaluation Metrics

• What % of transmitted messages were received V2V, Waze & TripTalk?
  • V2V - 100%
  • TripTalk - 83%
  • Waze - 0%
  • No false alarms

• Distance from TMA that messages were disseminated V2V, Waze & TripTalk?
  • V2V – 0.1 - 0.2 miles
  • TripTalk – 0.4 - 1.2 miles
  • Waze – N/A

• Was messaging provided for relevant direction of travel?
  • V2V – 100% for moving WZ, unreliable for stationary
  • TripTalk – >90%
  • Waze – N/A
Evaluation Metrics (Cont.)

• Message Advance Warning?
  • V2V – ~15 seconds prior to encounter
  • TripTalk – ~60 seconds prior to encounter
  • Waze – N/A

• Number of vehicles equipped with DSRC capable devices on PTC that transmitted BSM?
  • 2 on Penn Turnpike in ~20 hours of TMA operation during evaluation
  • 2 additional off Penn Turnpike by evaluation vehicle en route
Lessons Learned

• Initial implementation handles vast majority of work zone situations correctly
• CV-DSRC stable platform for providing near real-time moving vehicle/work zone status
• CV-DSRC-based system reliably provides data for use by mobile phone travel apps
• CV-DSRC can be integrated with commonly used wireless gateway for wide area communications
• Cohda OBU powerful Linux computer
  • Capable of mapping applications not included in pilot
• Installation approach (system on when ignition on) highly reliable
  • No resistance from operations
• GPS solutions not sufficiently reliable at lane level (as configured for this pilot)
  • GPS solution confidence may be able to determine when insufficiently accurate
Lessons Learned (Cont.)

• Need to evaluate design trade-offs with regard to work crew intervention

1. No intervention (this pilot)
   • More sophisticated logic required for some situations
     • Maintenance vehicle on overpass
     • Maintenance vehicle in nearby service area
     • Maintenance vehicle reversing to stop

2. Crew/Driver Activation
   • Adds one more thing for crew to do
   • Less risk of errors due to omissions in programming
Questions??

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