Connected Vehicle Environment Concept of Operations
Acknowledgement of Support
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Disclaimer
Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the Author(s) and do not necessarily reflect the view of the U.S. Department of Transportation.
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TODAY’S AGENDA

01 | PURPOSE OF THIS WEBINAR
• Share concept development activities from Smart Columbus with connected vehicle technology stakeholders

02 | WEBINAR CONTENT
• Smart City Challenge Overview
• Smart Columbus Program Overview
• Connected Vehicle Environment Project Overview
• Smart Columbus Connected Vehicle Environment Project Concept of Operations
• Stakeholder Q&A
• How to Stay Connected

03 | WEBINAR PROTOCOL
• All participant lines have been muted during the webinar in order to reduce background noise
• Questions are welcome via chatbox during the Q&A Section
• The webinar recording and presentation materials will be posted on the Smart Columbus website
$40 MILLION
78 APPLIED • COLUMBUS WON

SMART CITY CHALLENGE

THE CITY OF COLUMBUS
ANDREW J. GINther, MAYOR

U.S. Department of Transportation
SMART COLUMBUS OVERVIEW
To empower our residents to live their best lives through responsive, innovative and safe mobility solutions.
To demonstrate how an intelligent transportation system and equitable access to transportation can have positive impacts on every day challenges faced by cities.
OUTCOMES

SAFETY  MOBILITY  OPPORTUNITY  ENVIRONMENT  AGENCY EFFICIENCY  CUSTOMER SATISFACTION
PROJECT PHASES AND TIMELINE

WHERE WE ARE GOING

- **Systems Engineering**
- **Develop and Procure**
- **Deploy, Operate and Maintain**
- **Data Collection/Analysis**
- **Solicit/Validate User Needs** | **Engage Stakeholders/Public** | **Communicate Progress/Participation Opportunities**

**Timeline:**
- **August 2016**
- **August 2018**
- **April 2019**
- **September 2019**
- **June 2020**
- **March 2021**

**SMRT COLUMBUS**
USDOT PORTFOLIO

ENABLING TECHNOLOGIES
- CONNECTED VEHICLE ENVIRONMENT

ENHANCED HUMAN SERVICES
- MULTIMODAL TRIP PLANNING/COMMON PAYMENT SYSTEM
- SMART MOBILITY HUBS
- MOBILITY ASSISTANCE
- PRENATAL TRIP ASSISTANCE
- EVENT PARKING MANAGEMENT

EMERGING TECHNOLOGIES
- CONNECTED ELECTRIC AUTONOMOUS VEHICLES
- TRUCK PLATOONING
ESSENTIALS OF THE OPERATING SYSTEM

Data Environment
- Data ingestion
- Streaming data
- Data tagging
- Data aggregation

Security
- Data encrypted in transit & at rest
- ID Access Management (IDAM)

Scalable Capacity
- Built with open source/open architecture
- Elasticity with AWS Cloud Services
- Microservices

Data Lake
- Fast and slow storage capacity
- Only store what we must; leave data at native source (for security & storage mgmt.)

Data Research Environment
- Social community
- Data discovery
- Visualization
- User dashboards

Shared Services
- Application hosting
- Function sharing through microservices (real-time ML, route optimizer)

Analytics
- Core analysis tools
- Machine learning
- Artificial intelligence
CMAX ROUTE
(BUS RAPID TRANSIT)
DEPLOYMENT AREA

Photo sources: Rickenbacker International Airport and Norfolk Southern Intermodal Yard
# DEPLOYMENT SIZE

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light-Duty Vehicle</strong></td>
<td></td>
</tr>
<tr>
<td>Private Vehicle</td>
<td>1019</td>
</tr>
<tr>
<td>City Fleet Vehicle</td>
<td>200</td>
</tr>
<tr>
<td>COTA Supervisor Vehicle</td>
<td>25</td>
</tr>
<tr>
<td><strong>Emergency Vehicle</strong></td>
<td></td>
</tr>
<tr>
<td>Fire Truck/EMS</td>
<td>30</td>
</tr>
<tr>
<td>Police Cruiser</td>
<td>80</td>
</tr>
<tr>
<td><strong>Heavy-Duty Vehicle</strong></td>
<td></td>
</tr>
<tr>
<td>Platoon Truck</td>
<td>10</td>
</tr>
<tr>
<td><strong>Transit Vehicle</strong></td>
<td></td>
</tr>
<tr>
<td>CEAV</td>
<td>6</td>
</tr>
<tr>
<td>COTA Transit Bus*</td>
<td>350</td>
</tr>
<tr>
<td>(fixed-route)</td>
<td></td>
</tr>
<tr>
<td>COTA Paratransit Bus</td>
<td>80</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,800</td>
</tr>
</tbody>
</table>

*Quantity may vary slightly depending on operational needs. Source: City of Columbus*
## CRASH HISTORY

### Non-intersection Related

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Total Crashes</th>
<th>Resulting Number of Injuries</th>
<th>Resulting Number of Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear-End</td>
<td>1,292</td>
<td>438</td>
<td>1</td>
</tr>
<tr>
<td>Angle</td>
<td>820</td>
<td>257</td>
<td>2</td>
</tr>
<tr>
<td>Sideswipe, Same Direction</td>
<td>635</td>
<td>87</td>
<td>0</td>
</tr>
<tr>
<td>All Others</td>
<td>239</td>
<td>79</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,986</strong></td>
<td><strong>861</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

### Intersection Related

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Total Crashes</th>
<th>Resulting Number of Injuries</th>
<th>Resulting Number of Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle</td>
<td>1,225</td>
<td>648</td>
<td>1</td>
</tr>
<tr>
<td>Rear-End</td>
<td>875</td>
<td>345</td>
<td>0</td>
</tr>
<tr>
<td>All Others</td>
<td>298</td>
<td>89</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,398</strong></td>
<td><strong>1,082</strong></td>
<td><strong>2</strong></td>
</tr>
</tbody>
</table>

*Source: 2014-2016 Mid-Ohio Regional Planning Commission*
**VEHICLE HIGH-CRASH LOCATIONS**

<table>
<thead>
<tr>
<th>2017 Rank</th>
<th>2016 Rank</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8</td>
<td>Cleveland Avenue and Innis Road</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>Karl Road at Morse Road</td>
</tr>
<tr>
<td>8</td>
<td>22</td>
<td>Morse Road at Westerville Road</td>
</tr>
<tr>
<td>10</td>
<td>40</td>
<td>Cleveland Avenue at Hudson Street</td>
</tr>
<tr>
<td>11</td>
<td>21</td>
<td>Cleveland Avenue at Oakland Park</td>
</tr>
<tr>
<td>18</td>
<td>4</td>
<td>Cleveland Avenue at Morse Road</td>
</tr>
<tr>
<td>40</td>
<td>7</td>
<td>Morse Road at Northtowne Boulevard / Walford Street</td>
</tr>
<tr>
<td>41</td>
<td>35</td>
<td>Morse Road at Sunbury Road</td>
</tr>
<tr>
<td>44</td>
<td>29</td>
<td>High Street at Fifth Avenue</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>VEHICLE HIGH-CRASH LOCATIONS (100 total)</strong></td>
</tr>
<tr>
<td>57</td>
<td>–</td>
<td>Cleveland Avenue at Eleventh Avenue</td>
</tr>
<tr>
<td>68</td>
<td>59</td>
<td>Morse Road at Stelzer Road</td>
</tr>
<tr>
<td>76</td>
<td>79</td>
<td>Morse Road at Sinclair Road</td>
</tr>
<tr>
<td>88</td>
<td>82</td>
<td>Cleveland Avenue at Weber Road</td>
</tr>
<tr>
<td>94</td>
<td>–</td>
<td>High Street at North Broadway</td>
</tr>
<tr>
<td>97</td>
<td>80</td>
<td>Henderson Road at High Street</td>
</tr>
<tr>
<td>–</td>
<td>45</td>
<td>Cleveland Avenue at Fifth Avenue</td>
</tr>
<tr>
<td>–</td>
<td>77</td>
<td>Morse Road at Tamarack Boulevard</td>
</tr>
<tr>
<td>–</td>
<td>95</td>
<td>Seventh Avenue at High Street</td>
</tr>
</tbody>
</table>
VEHICLE HIGH-CRASH LOCATIONS
DEPLOYMENT CONCEPT OVERVIEW
WHAT MAKES ALL THIS WORK?

• Basic Connected Vehicle elements
  • Vehicle On-Board Units (OBUs)
  • Roadside Units (RSUs)
  • Wireless communication technologies
  • Fiber optic network
  • Connected Vehicle Systems Engineering Architecture (CVRIA)
  • Data management
  • Security
WHO MAKES ALL THIS WORK?

- City of Columbus Traffic Management Division
- Existing traffic signal control system
- Participant cooperation
  - Local residents (private vehicle operators)
  - Central Ohio Transit Authority (COTA)
  - Department of Public Service vehicles
  - Department of Public Safety (Fire/EMS/Police)
CONNECTED VEHICLE OBJECTIVES

01 | Improve vehicle operator safety
02 | Improve intersection safety
03 | Reduce speeds in school zones
04 | Improve reliability of transit vehicle schedule adherence
05 | Improve emergency response times
06 | Reduce truck wait (delay) time at signalized intersections
    | Increase number of truck turns a day
07 | Improve traffic management capability
08 | Improve transit management capability
EXISTING CHALLENGE: VEHICLE OPERATOR SAFETY

TARGET AREAS
Linden

USERS
Light Duty Vehicle Operator

PERFORMANCE MEASURES
Leverage prior research
APPLICATION: EMERGENCY ELECTRONIC BRAKE LIGHT

Provides an output to drivers to improve awareness of emergency braking events.
APPLICATION: FORWARD COLLISION WARNING

Advises vehicle operators to take specific action in order to avoid or mitigate rear-end vehicle collisions in the forward path of travel.
APPLICATION: LANE CHANGE WARNING/BLIND SPOT WARNING

Provides output to vehicle operator to improve awareness of another vehicle in an adjacent lane positioned in a blind-spot zone.
EXISTING CHALLENGE: INTERSECTION SAFETY

TARGET AREAS
Primarily High Street, Morse Road, and Cleveland Avenue corridors, but enabled for all CV Environment intersections

USERS
Light duty vehicle operator

PERFORMANCE MEASURES
Performance Measures: Driver behavior change in the corridor (reduced crash rate at intersections, reduced rate of vehicles running red signal)
APPLICATION: INTERSECTION MOVEMENT ASSIST

Provides an output to drivers to improve awareness of approaching vehicles on conflicting approaches.
APPLICATION: RED LIGHT VIOLATION WARNING

This application provides an output to drivers to improve awareness when approaching a signal that will turn red before arriving at the intersection.
EXISTING CHALLENGE: REDUCE SPEED IN SCHOOL ZONES

TARGET AREAS
Linden STEM Academy (Cleveland Avenue), Clintonville Elementary (High Street), Our Lady of Peace School (High Street)

USERS
Light duty vehicle operator, traffic manager, pedestrian

PERFORMANCE MEASURES
Driver behavior change in the corridor (speed limit adherence during active school zone)

<table>
<thead>
<tr>
<th></th>
<th>0–20 mph</th>
<th>20+ mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>users</td>
<td>18%</td>
<td>82%</td>
</tr>
<tr>
<td>total</td>
<td>N=18042</td>
<td></td>
</tr>
</tbody>
</table>
APPLICATION: REDUCED SPEED SCHOOL ZONE

Provides an alert to vehicle operators in advance when braking is required to reduce to the posted school zone speed limit (20 mph).

Source: Roger Werth, The Daily News
EXISTING CHALLENGE: TRANSIT VEHICLE SCHEDULE ADHERENCE

TARGET AREAS
Cleveland Ave. Corridor
(CMAX route, see map)

USERS
Transit vehicle operator,
transit manager

PERFORMANCE MEASURES
On-time performance, running time,
headway reliability
APPLICATION: TRANSIT SIGNAL PRIORITY

Vehicles approaching from either the ‘main street’ and/or the ‘side street’ have the ability to communicate with roadside equipment at intersections to acquire priority/preemption status.
EXISTING CHALLENGE: IMPROVE EMERGENCY RESPONSE TIMES

TARGET AREAS
Signals along the connected corridors near fire and police stations along High Street, Morse Road and Cleveland Avenue.

USERS
Emergency vehicle operator

PERFORMANCE MEASURES
Emergency response times
APPLICATION: EMERGENCY VEHICLE PREEMPTION

This application allows an emergency vehicle (Police/Fire/EMS) to receive signal preemption when approaching equipped intersections.
EXISTING CHALLENGE: FREIGHT MOVEMENT

TARGET AREAS
High volume routes from logistic centers and a highway route to eastern Ohio

USERS
Heavy-duty vehicle operator

PERFORMANCE MEASURES
Travel time through intersection, number of daily truck turns
APPLICATION: FREIGHT SIGNAL PRIORITY

This application allows a heavy-duty vehicle to receive signal priority when approaching equipped intersections.
APPLICATION: INTENT TO PLATOON PRIORITY

Ensures the signal timing allows two heavy-duty vehicles that intend to form a platoon can travel together through the intersection.
EXISTING CHALLENGE: TRAFFIC MANAGEMENT DATA

TARGET AREAS
All corridors

 USERS
Traffic manager

PERFORMANCE MEASURES
Under development
APPLICATION: VEHICLE DATA FOR TRAFFIC OPERATIONS

Captures telemetry data from vehicles and traffic signal data and makes this data available to the TMC to support traffic operations.
EXISTING CHALLENGE: TRANSIT MANAGEMENT DATA

TARGET AREAS
All transit routes

USERS
Transit manager

PERFORMANCE MEASURES
Under development
APPLICATION: TRANSIT VEHICLE INTERACTION EVENT RECORDING

Enables COTA management staff to capture output (not issued to the transit vehicle operator) from applications so that it can assess the potential interactions and benefits that transit vehicle operators may receive should COTA decide to implement an UI on its transit vehicles.
STAKEHOLDER ENGAGEMENT SUMMARY
STAKEHOLDER ENGAGEMENT

WHO WE TALKED TO

- Expecting mothers
- Older adults
- Linden residents
- People who work in Linden
- Bicyclists
- Pedestrians
- Traffic managers
- Transit vehicle operators
- Transit managers
- Heavy-duty vehicle operators
- Emergency vehicle operators
WHAT WE LEARNED

• How residents get around
  • Car (their own or by getting a ride)
  • Walking
  • Bus
  • Bike

• General concerns
  • Personal safety when walking or riding a bike

• About this demonstration
  • Excited but concerned about the cost to buy and install new technology
  • Uncomfortable sharing personal information (privacy)
  • Interest in having a technology improve safety

• Preferences
  • Ability to choose how they’re alerted
  • Ability to switch between the type of alert – a voice, a beep or a light – depending on the day/trip
LESSONS LEARNED

WHAT WE LEARNED

• Stakeholder Engagement: be user focused from beginning

• Size and scope of project: be prepared to revisit and adjust if needed

• Vendor solutions: develop procurement strategy after needs established
NEXT STEPS

WHERE WE GO FROM HERE

System Requirements Specification
June 2018 – December 2018

Interface Control Document
December 2018 – April 2019

System Design
February 2019 – August 2019

Test Plan
May 2019 – September 2019

Installation Development
June 2018 – March 2019

Deploy / Test on roadside and in vehicles
June 2019 – August 2020

CV Environment Live
July 2020

Dates listed are for final version of document (not 508-compliant or refresh)
HOW TO STAY CONNECTED

USDOT CONNECTED VEHICLE ENVIRONMENT PROGRAM INQUIRES:
Kate Hartman, Program Manager
Kate.Hartman@dot.gov

SMART COLUMBUS INQUIRES:
Alyssa Chenault, Communications Project Manager
anchenault@columbus.gov

Upcoming Smart Columbus Webinars:
• Essentials of the operating system (SCOS)
• Multimodal Trip Planning Assistance/Common Payment System
• Overview of Mobility Assistance for People with Cognitive Disabilities
• Event Parking Management
• Smart Mobility Hubs
• Prenatal Trip Assistance
• Overview of Emerging Technologies: Connected Electric Autonomous Vehicles and Truck Platooning

Webinar recording and materials will be available at itsa.org and smart.columbus.gov
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SmartColumbus@columbus.gov

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