Shaping the Future of American Mobility: Connected Automated Vehicles (CAV)

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Today’s Transportation Challenges

Safety
- 35,092 highway deaths in 2015¹
- 6.3 million crashes in 2015¹
- A leading cause of death for ages 1-44²

Mobility³
- 6.9 billion hours of travel delay
- $160 billion cost of urban congestion

Environment³
- 3.1 billion gallons of wasted fuel
- 60 billion lbs of additional CO₂

Data Sources:
²10 Leading Causes of Death by Age Group, United States – 2014, Centers for Disease Control and Prevention
³2015 Urban Mobility Scorecard, Texas A&M Transportation Institute and INRIX (August 2015)
U.S. DOT Connected Vehicle (CV) Research Program

- **Research Program**
  - Multimodal: ITS JPO, NHTSA, FMSCA, FTA, and FRA
  - Key Areas: Safety, Mobility, and Environment
  - Connected Vehicles: Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I)
  - Automated Vehicles and Connected Automation

- **Major Deployment Efforts**
  - Safety Pilot Model Deployment - 2011
  - Connected Vehicle Pilot Deployment Program - 2014
  - Smart City Challenge - 2016
  - Initial Deployments of Connected Automation Applications

- **Resources and Tools to Support CV Deployments**
**Vehicle Data**
latitude, longitude, time, heading angle, speed, lateral acceleration, longitudinal acceleration, yaw rate, throttle position, brake status, steering angle, headlight status, wiper status, external temperature, turn signal status, vehicle length, vehicle width, vehicle mass, bumper height

**Infrastructure Messages**
Signal Phase and Timing,
Fog Ahead
Train Coming
Drive 35 mph
50 Parking Spaces Available
Safety Pilot Model Deployment

SITE PLAN: ANN ARBOR, MICH.

Primary Model Deployment Routes:
- University of Michigan Campus/Medical Center
- Proposed Curve Warning Locations
- UMTRI Facilities (Showcase, Facilities, Equipment and Data Storage)
- Roadside Equipment Co-Located with Freeway ITS Installation
- Roadside Equipment Co-Located with Actuated Traffic Signal
- Roadside Equipment/SpaT-Enabled Traffic Signal

The Safety Pilot Model Deployment area includes more than 73 lane-miles of instrumented roadways.
CONNECT VEHICLE (CV) PILOT DEPLOYMENT PROGRAM

Spur Early CV Tech Deployment

Wirelessly Connected Vehicles

Mobile Devices

Infrastructure

Measure Deployment Benefits

Safety

Mobility

Environment

Resolve Deployment Issues

Technical

Institutional

Financial
CV PILOT DEPLOYMENT SITES SELECTED

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.

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.

Tampa (THEA)

- 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.
Data exchange will use DSRC (Dedicated Short Range Communications) or other wireless media. SCMS (Security Credential & Management System) will be used where appropriate.
USDOT Smart City Challenge

$500 million in partnerships identified in by the seven Smart City Challenge Finalists

150+ partnerships identified by the Smart City Challenge Finalist

78 applications received for the Smart City Challenge

7 Smart City Challenge Finalists announced in March 2016

1 Smart City Challenge Winner

#DOTSmartCity

www.transportation.gov/smartcity

U.S. Department of Transportation
USDOT Vision Elements

**TECHNOLOGY ELEMENTS**

- **Vision Element #1**
  Urban Automation

- **Vision Element #2**
  Connected Vehicles

- **Vision Element #3**
  Intelligent, Sensor-Based Infrastructure

**INNOVATIVE APPROACHES TO URBAN TRANSPORTATION ELEMENTS**

- **Vision Element #4**
  User-Focused Mobility Services and Choices

- **Vision Element #5**
  Urban Analytics

- **Vision Element #6**
  Urban Delivery and Logistics

- **Vision Element #7**
  Strategic Business Models & Partnering

- **Vision Element #8**
  Smart Grid, Roadway Electrification, & EVs

- **Vision Element #9**
  Connected, Involved Citizens

**SMART CITY ELEMENTS**

- **Vision Element #10**
  Architecture and Standards

- **Vision Element #11**
  Low-Cost, Efficient, Secure, & Resilient ICT

- **Vision Element #12**
  Smart Land Use
SMARTCOLUMBUS

Source: The City of Columbus
Automated Vehicles (AV)
Levels of Automation (SAE J3016)

<table>
<thead>
<tr>
<th>SAE Level</th>
<th>SAE Name</th>
<th>Description*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>Full-time performance by the <em>human driver</em> of all aspects of <em>dynamic driving task</em></td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>Driver assistance system controls either steering or speed while the <em>human driver</em> performs all remaining aspects of <em>dynamic driving task</em></td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>Driver assistance system(s) controls both steering and speed while the <em>human driver</em> performs all remaining aspects of <em>dynamic driving task</em></td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td><em>Automated driving system performs</em> all aspects of <em>dynamic driving task</em> <em>with the expectation that human driver will respond to a request to intervene</em></td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td><em>Automated driving system performs</em> all aspects of <em>dynamic driving task</em>, even if a <em>human driver</em> does not respond to a request to intervene</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td><em>Automated driving system performs</em> all aspects of <em>dynamic driving task</em> under all roadway and environmental conditions that can be managed by a <em>human driver</em></td>
</tr>
</tbody>
</table>

*Full definition available at:
www.sae.org/misc/pdfs/automated_driving.pdf
Automated Vehicles (AV) ...on a road near you?

Here Today

Level 1

Level 2

In Testing

Level 3

Level 4

Someday(?)

Level 5
Automated Vehicles (AV) …are here today

Most major manufacturers currently offer Level 1 systems (e.g., lane keep assist, adaptive cruise control);

some offer Level 2 systems (e.g., Tesla Autopilot, Audi Traffic Jam Assist).
Looking Ahead – Where Are We Going?

http://www.atzmut.com/the-rear-view-mirror/

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Leverage the Automated Safety and Technology Systems

- Including requirements for functional safety, cybersecurity, and system performance

**Automated Vehicle (AV)**
- Operates in isolation from other vehicles using internal sensors
- SAE Levels 1-5

**Connected Vehicle (CV)**
- Communicates with nearby vehicles and infrastructure
- SAE Level 0

**Connected Automated Vehicle (CAV)**
- Leverages autonomous automated and connected vehicles

Leverage the Communication Technology from the Connected Vehicle

- Including all types of communication with vehicles and infrastructure (Wi-Fi, DSRC, 4G/LTE/5G, etc.)
Automation can be a Tool for Solving Transportation Problems

- **Improving safety**
  - Reduce and mitigate crashes

- **Increasing mobility and accessibility**
  - Expand capacity of roadway infrastructure
  - Enhance traffic flow dynamics
  - More personal mobility options for disabled and aging population

- **Reducing energy use and emissions**
  - Aerodynamic “drafting”
  - Improve traffic flow dynamics

*... but connectivity is critical to achieving the greatest benefits*
FHWA has been funding research into CAV Level 1 applications

**Connected/Automated Light Vehicle and Truck Platooning**
Cooperative Adaptive Cruise Control (CACC) via Vehicle-to-Vehicle (V2V)

**Signalized Intersection Approach and Departure**
GlidePath via Vehicle-to-Infrastructure (V2I)

**Automated Traffic Flow Optimization**
Speed Harmonization via Vehicle-to-Infrastructure (V2I)

**Proof-of Concepts**
Lane Change, Merging and Weaving Operations
TFHRC Innovation Drive (Urban Testing)

- CCTV
- RSU
- Signalized intersection with SPaT / MAP
- Cabinet space with power & comms, available for future research
- Vehicle Pedestrian & Bike Detection
- Pedestrian Crossing with Countdown Timers
- Fiber Communications Backend
Federal Law Enforcement Training Center (Urban & Arterial Testing)

Existing
- Wire Mounted Traffic Signals
- Closed-Loop Test Track
- Ramps
- Pole-Mounted Traffic Signal
- Flat Space Open Testing
- Skid Pad

Newly Deployed:
- DSRC / Wi-Fi
- V2I Communications
Existing
- 4.5 mile long
- 207-foot wide tri-oval track with wide safety runoff areas
- Traffic Signals

Newly Deployed:
- DSRC / Wi-Fi
- V2I Communications
US Army Aberdeen Test and Evaluation Facility

CACC RREs/DOT Tests

FHWA Cadillac Platoon – Leader/Follower (1+4)

ATC Instrumentation Suite

ATC ATEF Course
Vehicle Testing & Evaluation

CAV Platooning
References

A. Federal Automated Vehicles Policy

B. U.S. DOT Intelligent Transportation Systems Joint Program Office
   http://its.dot.gov

C. Governors Highway Safety Association (GHSA)
   GHSA Autonomous Vehicle Report
   http://www.ghsa.org/resources/spotlight-av17

D. American Association of Motor Vehicle Administrators (AAMVA)
   Autonomous Vehicle Information Library http://www.aamva.org/autonomous-vehicle-information-library/

E. Automated Vehicle Symposium 2017
   Hilton San Francisco Union Square, July 11-13, 2017
   http://www.automatedvehiclessymposium.org/home