Connected and Automated Vehicles
An Overview from the Federal and PennDOT Perspective
Presentation Agenda

- The Need
- Background
- Benefits
- Timelines
- USDOT Activities
- Pennsylvania’s Program
- PA AV Summit
Lives lost on our transportation system in 2017

39,141
Crashes due to human error

94%
Fatalities involved in drinking and driving in 2017

11,000
Fatalities where speeding was a factor in 2017

10,000
Fatal crashes involving distracted drivers in 2017

13,500
Annual % of roadway fatalities from crashes involving large trucks

13%
Victims in fatal large truck crashes who were not an occupant of the truck(s) involved 82%
Compared to the average worker, professional drivers are...

10 TIMES

...more likely to be killed on the job
Pedestrians killed by motor vehicles in 2017, representing 16% of all motor vehicle fatalities.
Average highway rail grade crossing fatalities per year

253
Motor vehicle crash deaths and deaths per 100 million miles traveled, 1975–2015

- Total deaths
- Deaths per 100 million miles

Deaths vs Rate


Deaths:
- 60,000
- 50,000
- 40,000
- 30,000
- 20,000
- 10,000
- 0

Rate:
- 6
- 5
- 4
- 3
- 2
- 1
- 0
“If I had asked people what they wanted, they would have said faster horses.”

- Henry Ford
### The 5 levels of driving automation

**For on-road vehicles**

<table>
<thead>
<tr>
<th>Level</th>
<th>Automation Type</th>
<th>Human driver monitors the road</th>
<th>Automated driving system monitors the road</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NO AUTOMATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>DRIVER ASSISTANCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>PARTIAL AUTOMATION</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>CONDITIONAL AUTOMATION</td>
<td></td>
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<tr>
<td>4</td>
<td>HIGH AUTOMATION</td>
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<td></td>
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<tr>
<td>5</td>
<td>FULL AUTOMATION</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **NO AUTOMATION**: Human driver steering and monitoring. Automated system is not present.
- **DRIVER ASSISTANCE**: Human driver steering and monitoring, automated system assists with driving.
- **PARTIAL AUTOMATION**: Automation with some driving modes, human still in control.
- **CONDITIONAL AUTOMATION**: Automation with some driving modes, human monitoring.
- **HIGH AUTOMATION**: Automation with some driving modes, human not in control.
- **FULL AUTOMATION**: Full automation, human not in control.

### Driving modes

- **No assistance**: Human driver in control.
- **Assisted**: Human driver assists with driving.
- **Patially automated**: Human driver monitors, some driving modes.
- **Highly automated**: Human driver not in control, some driving modes.
- **Fully automated**: Human driver not in control, full automation.
- **Autonomous**: Human driver not in control, fully automated.

**Transfer of responsibility**

- **Human**
- **Transfer of responsibility**
- **Machine**

*Sources: Evercore ISI, SAE International*
Connected Vehicles

Vehicle-to-Vehicle (V2V)

Vehicle-to-Infrastructure (V2I)

Source: U.S. DOT
Benefits of Connected Vehicles

- Safety
- Mobility
- Environment

Early CV Deployment

Full CV Penetration
Historical Timeline

- **FCC allocates 75 MHz of spectrum to DSRC (CV technology)**
  - 1948

- **Introduction of Cruise Control**
  - 2009

- **Google begins self-driving car project**
  - 1999

- **Mercedes and Infiniti produce cars with radar sensors and some autonomous driving features**
  - 2012

- **Tesla releases its Auto-Pilot self-driving mode**
  - 2015

- **Major acquisitions and partnerships (GM and Cruise Automation; GM and Lyft; Toyota and Jaybridge Robotics; Uber and Volvo)**
  - 2016

- **Google’s autonomous car passes a 14-mile driving test in Nevada**
  - 2012

- **NHTSA releases initial policy on autonomous vehicles**
  - 2013

- **Uber hires 40 Carnegie Mellon robotics researchers to work on AVs; Ford begins testing its self-driving cars in CA, AZ, MI**
  - 2015

- **NHTSA issues guidelines for testing and deployment of automated vehicles (Updated Annually)**
  - 2016
Industry Timeline

2018 to 2019
- Audi
- GM
- Tesla

2020 to 2024
- BMW
- Ford
- FCA
- Honda
- Hyundai

2025 to 2029
- Mercedes-Benz
- Nissan
- Toyota
- Uber
- Volvo

2030+
- Kia

Advanced Technologies Center
Waymo
Preparing for the Future of Transportation

An Update on Automated Vehicle Initiatives and Policy in the United States

Map of U.S. Automated Vehicle Test Sites

Source: NHTSA/Volpe Center – March 2019
AV 3.0 supports the safe development of automated vehicle technologies by:
- Providing new multi-modal safety guidance
- Reducing policy uncertainty and clarifying roles
- Outlining a process for working with USDOT as technology evolves
NHTSA’s multi-faceted research approach

- Leverages the National Institute of Standards and Technology (NIST) Cybersecurity Framework
- Encourages industry to adopt practices that improve the cybersecurity posture of their vehicles in the U.S.

NHTSA’s goal is to collaborate with the automotive industry to proactively address vehicle cybersecurity challenges, and to continuously seek methods to mitigate associated safety risks.
Preparing for the Future of Transportation

An Update on Automated Vehicle Testing in Pennsylvania
AV Testing Guidance

Guidance strengthen testing safety by focusing on the safety driver, not the AV technology.

- Update to 2016 AV Testing Policy
- Consulted key stakeholders including multiple AV testers and the AV Policy Task Force
- Guidance is voluntary, but compliance is expected
- Testers must submit a Notice of Testing
  - Tester Information (e.g., contact info and Point-of-Contact)
  - Vehicle Information (e.g., plate number, make/model, and VIN)
  - Safety Driver Information (e.g., name, license number, and training info)
  - Location of planned testing
  - Safety and Risk Mitigation Plan or NHTSA Voluntary Safety Self-assessment
  - Enhanced Performance Driver Training Plan **only if traveling over 25mph with one safety driver
- Letter of Authorization granted to two testers
  - Other applications under review
Semi-Annual Data Collection Form

To document and measure the progress of AV testing in Pennsylvania, PennDOT must collect fundamental data from all AV Testers.

Full Name
Company / Agency
Mailin Address City State Zip
Phone E-mail Reporting Date

Please indicate the approximate miles traveled by ADS-engaged AVs in Pennsylvania:

- 0 to 999 miles
- 1,000 to 9,999 miles
- 10,000 to 19,999 miles
- 20,000 to 34,999 miles
- 35,000 to 49,999 miles
- 50,000+ miles

Please indicate where the majority of testing occurred:

- Limited Access Roadways
- Arterial Roadways
- Rural Testing
- Urban Testing
- Other Testing

Please list the counties where AVs were tested on public trafficways:


Pennsylvania Automated Vehicle Testing Guidance | 2018

Please indicate the approximate number of employees in Pennsylvania involved with AV testing:

- 0 to 24 Employees
- 25 to 49 Employees
- 50 to 99 Employees
- 100+ Employees
- No Change Since Previous Submission

Please indicate, if applicable, the number of new jobs created in Pennsylvania as a result of AV testing:

- 0 to 24 Jobs
- 25 to 99 Jobs
- 100+ Jobs
- No Change Since Previous Submission

Please indicate, if applicable, the number of new facilities constructed, purchased, or rented in Pennsylvania as a result of testing:

- 0 to 1 Facilities
- 2 to 4 Facilities
- 5+ Facilities
- No Change Since Previous Submission
AV Testing & Testers

AURORA
Qualcomm
Carnegie Mellon University

UBER
ADVANCED TECHNOLOGIES CENTER

ARGO AI

APTIV

1 tester
5 tester

pennsylvania
DEPARTMENT OF TRANSPORTATION
Act 117 of 2018

1st AV Legislation in Pennsylvania

- **Automated Work Zone Vehicles**
  - Fully automated vehicles
  - Restricted to active work zones
  - Must be implemented by PennDOT or PA Turnpike

- **Platooning**
  - Limited to two or three buses, military vehicles or motor carriers.
  - Restricted to limited access roadways
  - Must have visual identifier
  - Must submit operations plan for evaluation
  - Policy active – April 22, 2019

- **Highly Automated Vehicle Advisory Committee**
Statewide CAV Strategic Plan

5 objectives per business area. Each includes:

- Foundational Needs
- Existing Gaps
- Applicable Day 1 Uses
- Recommend Actionable Steps
- Appropriate Level of Investment
- Timeframe
- Impacts to Existing and Planned Initiatives
- Metrics
- Assumptions
- Impacts to the Capability Maturity-Model
Partnership between PennDOT, PA Turnpike, and Penn State

- **Focus Areas**
  - Traffic Incident Management
  - Connected/Automated Vehicles
  - ITS/Tolling/Signals
  - Transit
  - Commercial Vehicles
  - Bike/Ped.
  - Aviation including UAV

- **Approach**
  - Feasibility Study [completed 2018]
  - ConOps/Business Plan/Facility Requirements [Ongoing]
  - Design [Fall 2019]
  - Construction [Fall 2020]
  - Operation [Spring 2022]
Conceptual Facility Design

1. 4 Point Roundabout with area for Green Space
2. Rural Intersections
3. Urban 4 Point Intersection (Leg 1 Simulates Multilane through with Left turn lane, Leg 2 Simulates Multilane through with right turn only, Leg 3 Simulates Left turn and Right turn only with concrete island and signal, Leg 4 Simulates a Typical Intersection layout with left turn into a rural intersection)
4. Automation Test Loop (Will have sections to simulate Type 31-S guide rail, Cable systems, and Concrete Jersey Barrier.)
5. Typical Bridge Section with embankments
6. Truck Turnaround area
7. Academic Building with Classrooms and Labs and Garage
8. Parking Lot Currently Showing 160 spaces
9. High Speed Testing with Return Loop
10. Truck Parking and Staging Area with Smart Truck Parking capabilities
11. 6 Lane Highway Section with on ramp and off ramp simulations
12. Overhead Tolling Gantry
13. City Simulation with Small Radii
14. Helipad
15. Active Traffic Management System
16. Signalized Urban Corridor
17. Railroad at Grade Crossing
18. Signalized Rural/High Speed Intersection
19. Queue Preemption
20. Ramp Meters
21. Aircraft Rescue Fire Fighting and Training Simulator
22. Potential Roadway Flooding Area
Upcoming Activates

- District DSRC Coordination Plan
  - July 2019
- Automated Work Zone Vehicles Policy
  - August 2019
- PennDOT/PA Turnpike Test Bench
  - August 2019
- AV Testing Guidance 2.0
  - September 2019
- CAV Infrastructure Deployment Policy
  - September 2019
- AV Incident Response Plan
  - December 2019
- CAV “Hotspots” Mapping
  - March 2020
- BAA Platooning
PTC Initiatives

- CAV Roadmap
- Connected Work Zone Pilot
- Lane Reservation System
- DSRC/C-V2X Test Lab
Sept. 4-6 • Pocono Manor, Pa.

www.PAAVSummit.org
Attendance is Growing
Leading Industry Topics

- Workforce/Education
- Planning/Forecasting
- Cyber Security
- Community/Local Government
- Project Finance/Business Models
- Transit
- Incident Management
- Multimodal
- Freight
- Technology
- Testing
- Safety
- Policy/Legal/Insurance
- Environment
- Infrastructure
- Economic Development
With the addition of:

**Ed Mortimer**
Vice President for Infrastructure & Transportation
at US Chamber of Commerce
QUESTIONS?
“There are almost no limits in terms of what a car can become”

- Bill Ford Jr