Preparing for the Future of Transportation
PennDOT’s Approach to Automated Vehicles

Mark C. Kopko
Special Advisor – Transformational Technology
Pennsylvania Department of Transportation
717.783.1903
markopko@pa.gov
Automated Vehicle

Audi RS 7 piloted driving concept
Driver assistance systems
10/14

Front camera:
- Audi active lane assist
- ACC with Stop&Go function
- Speed limit display
- Audi pre sense / front / plus
- Audi adaptive light

Ultrasonic sensors at side:
- Park assist with display of surroundings

Front, rear and top-view cameras:
- Parking system plus with front and rear camera
- Park assist with front and rear camera

Ultrasonic sensors at rear:
- Parking system plus with front and rear camera
- Park assist with display of surroundings

Infrared camera:
- Night vision assistant with highlighting of detected pedestrians

Rear radar sensors:
- Audi side assist
- Audi pre sense rear / plus

Crash sensors:
- Front protection adaptivity
- Side protection
- Rear impact protection

Front radar sensors:
- ACC with Stop&Go function
- Audi pre sense / front / plus
Cooperative Automated Vehicles
Levels of Automation

### SAE Automation Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation&lt;br&gt;Zero autonomy; the driver performs all driving tasks.</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance&lt;br&gt;Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation&lt;br&gt;Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.</td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation&lt;br&gt;Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.</td>
</tr>
<tr>
<td>4</td>
<td>High Automation&lt;br&gt;The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation&lt;br&gt;The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.</td>
</tr>
</tbody>
</table>
Automated Vehicle Progression
Current Technology
Automated Vehicle Timeline

- **2018**
  - Waymo
  - Tesla
  - Mobileye

- **2019**
  - OXbotica
  - Delphi
  - *pending regulatory approval

- **2020**
  - nuTonomy
  - Nissan
  - NVIDIA
  - Toyota
  - Volkswagen
  - Daimler

- **2021**
  - General Motors
  - Volvo
  - Audi
  - Mercedes-Benz
  - Baidu
  - *advanced level 4

- **2025**
  - Continental
  - Intel
  - Volkswagen
  - Daimler
  - Bosch
  - Ford

- **Level 4 – High Automation**
  - Driver not needed

- **Level 5 – Full Automation**
  - No steering wheel

*London to Oxford only*
Automated Vehicle Penetration Projections

(as a percentage of all vehicles on the road)

2020’s: Large Price Premiums (01%-02%)
2030’s: Moderate Price Premiums (10%-20%)
2040’s: Minimal Price Premiums (20%-40%)
2050’s: Standard on Most New Vehicles (40%-60%)

Source: GHSA
How Will Our Roads Change – Lanes

Human Error
- Eliminate driver wander
- Reduction up to 20%

Consistent Wheel Paths

Reduced Following Distance
- Platooning

Dedicated Lanes
- HOV/HOT → AV Lanes
- Hard Shoulder Running
How Will Our Roads Change – Markings/Signage

Reduced Signage
- Incorporated
- Connected

Pavement Markings
- 6” vs 4”
- Tapes vs. Paint

HD Mapping
How Will Our Roads Change – Pick-up/Drop-off Locations

Reinventing the Curb

Fighting for Space
- AVs
- Shared Mobility
- Deliveries
- Transit
How Will Our Roads Change – Parking

Self Parking
  – Reduces on-street parking

Urban Centers Shift
  – Remote Parking
How Will Our Roads Change – Electrification

AVs + Evs
- Shared Mobility Model
- Weight

Dynamic Electric Vehicle Charging
- Shared Mobility Model
- Select locations
How Will Our Roads Change – Situational Awareness

Lots of Data
- 4,000GB per day

Pavement Conditions
- Roughness
- Potholes
- Traction
- Visual Imagery
How Will Our Roads Change – Work Zones

Work Zone Warnings
- Pattern Changes
- Speed Reductions

Safety Alerts
- Drivers
- Workers

Work Zone Automation
- TMAs
What is Pennsylvania Doing to Prepare?
The Need for AVs in Pennsylvania

1,188 Roadway Fatalities in 2016

264m Annual Hours of Delay

133m Gallons of Fuel Wasted Annually

950k Physically Disabled Citizens

769k Licensed Drivers aged 75+

2016 Numbers
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

- **Highly Automated Vehicle Advisory Committee**
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 five testers
  • Other applications under review
AV Testing & Testers

AURORA
Qualcomm
Carnegie Mellon University
UBER
ADVANCED TECHNOLOGIES CENTER

ARGO AI

1 tester
4 tester

pennsylvania
DEPARTMENT OF TRANSPORTATION
CAV Deployments

**Current**
- **Cranberry**: 11 RSUs
- **Ross Twp.**: 11 RSUs
- **Pittsburgh**
  - Proving Grounds
  - 24 RSUs
  - 45 RSUs
  - 726 OBUs
- **Smart Corridor**: Proving Grounds
- **Autonomous Shuttle**: Pilot
- **Harrisburg**: 8 RSUs

**Planned**
- **Penn State**: Proving Grounds
- **Autonomous Truck Mounted Attenuator**: Pilot
- **CV Work Zone**: Pilot
- **Philadelphia Region**: 160 RSUs
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]
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
International/National/Regional Participation

• International
  • Australia Peer Exchange
  • China Automotive Technology and Research Center (CATARC)
  • France Peer Exchange

• National
  • AASHTO - CAV Working Group
  • AAMVA - AV Best Practices Working Group
  • Cooperative Automated Transportation (CAT) Coalition
  • Multiple Pooled Fund Studies
  • Multiple TRB and NCHRP Projects

• Regional
  • Smart Belt Coalition
  • I95 Corridor Coalition
Public Outreach

• Speaking Engagements
  – 111 engagements in 2017

• Demonstrations
  – Harrisburg demonstration for Legislature
  – Gettysburg demonstration for law enforcement
  – State College demonstration for key stakeholders

• Pennsylvania AV Summit
  – Policy discussion with a focus on local government, workforce development, and planning.
  – 1st Summit – State College 2017
    • 300 attendees
  – 2nd Summit – Pittsburgh 2018
    • 400 attendees

www.paavsummit.org
QUESTIONS?

Mark Kopko
Special Advisor – Transformational Technology
717.783.1903
markopko@pa.gov