Autonomous Vehicles

Kevin Lacy, PE, State Traffic Engineer
Nomenclature – Connected Vehicles

Vehicles Connected to:

Each other sending information to each other about speed, braking, other information needed to make decisions.

The Infrastructure to determine roadway conditions, signal condition, levels of congestion on various routes, much more.

NHTSA working on proposed rules for new vehicles to have communication equipment. The rule is expected in 2016, we should expect some time lag in the requirement to allow automakers sufficient time to react.
Nomenclature – Autonomous
### Terminology

<table>
<thead>
<tr>
<th>SAE (J3016)</th>
<th>No Automation</th>
<th>Driver Assistance</th>
<th>Partial Automation</th>
<th>Conditional Automation</th>
<th>High Automation</th>
<th>Full Automation</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDA*</td>
<td>Driver only</td>
<td>Assisted</td>
<td>Partly automated</td>
<td>Highly automated</td>
<td>Fully automated</td>
<td>Driverless</td>
</tr>
<tr>
<td>BAS</td>
<td>Driver only</td>
<td>Assisted</td>
<td>Partially automated</td>
<td>Highly automated</td>
<td>Fully automated</td>
<td></td>
</tr>
<tr>
<td>NHTSA**</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3/4</td>
<td></td>
</tr>
</tbody>
</table>

* used on this platform  
** only roughly corresponding with the other taxonomies
Autonomous Vehicles Not a New Concept

1957 Advertisement about electricity and electronics.

Herbie the Love Bug from the 1968 Disney Shows.

Knight Rider series in the 80’s
Some forms of “Automation” and “Connectivity” have been around

Cruise Control invented in the late 40’s became available as an option on many cars in 70’s

Windshield Wipers
- Intermittent wiper invented in 60’s (a form of automation for comfort and convenience)
- Automatic Wipers in 80’s (because of the inconveniences of turning on the wipers and judging the best speed of the wipers).

Automatic headlights 60’s more common in the 80’s

Lane Departure Warning and Lane Keep Assist (LKA) – beginning development in 1992, on the market in 2001 in Japan, 2004 in the US

Parking Assist - developed in the late 90’s, on the market in Japan early 2000’s, USA and Europe 2009
Some forms of “Automation” and “Connectivity” have been around

Adaptive Cruise Control – Development as early as 1992 warning only; 1997 controlling throttle; 2006 speed and distance control available.

Others Blind Spot Information Systems – 2007 with the first counter steering controls in 2010

Connectivity

• Cell phones
• Navigation
• Traffic conditions via phone, internet and mapping Apps
• Phone Apps for intravehicular communication WAVES, Gas Buddies
• ** No routinely available communications that cause an action of the vehicle without driver intervention ... yet.
• Auto pilot Road Trains – demonstrated
• Other vehicle to infrastructure communication testing in various sites; smart city grant opportunities to promote
Autonomous feature available today

**BMW, Lexus, and Mercedes** – Safety and convenience features like automatic cruise control, automatic parking, lane keeping and automatic braking using radar, cameras and other sensors.

**Tesla** – Autopilot features include lane keeping, automatic breaking, automatic cruise control, blind spot detection, using forward facing sonar and camera, (with ultrasonic sensor monitoring the space 360 degrees around the car)+++

**General Motors** – “Super cruise” available 2017

**Audi** – “Traffic Jam Assist “ that can self drive in stop and go traffic up to 40 mph.

**Google** – proposing to remove all driver interfaces (not steering wheel, brake or accelerator).

**All OEM, New Entrants** – Seems like something new everyday
Rate of Adoption of Technology
### Rate of Adoption of Technology

<table>
<thead>
<tr>
<th>Technology</th>
<th>Years to 90% Adoption in US</th>
<th>Percent Adoption per year</th>
<th>Barriers to Adoption Rate</th>
<th>Benefited Rate of Adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automobiles</td>
<td>75</td>
<td>1.2</td>
<td>Infrastructure, Manufacturing, cost</td>
<td>Tax Dollars/Fees Funded infrastructure expansion</td>
</tr>
<tr>
<td>Electricity</td>
<td>42</td>
<td>2.1</td>
<td>Infrastructure, Production</td>
<td>Tax Dollars/Fees Funded infrastructure expansion</td>
</tr>
<tr>
<td>Telephone</td>
<td>73</td>
<td>1.2</td>
<td>Infrastructure</td>
<td>Tax Dollars/Fees Funded infrastructure expansion</td>
</tr>
<tr>
<td>Radio</td>
<td>23</td>
<td>3.9</td>
<td>Widespread Distribution from single place</td>
<td>Widespread Distribution from single place</td>
</tr>
<tr>
<td>Television</td>
<td>13</td>
<td>6.9</td>
<td>Widespread Distribution from single place</td>
<td>Widespread Distribution from single place</td>
</tr>
<tr>
<td>Cable/Pay TV</td>
<td>1960's never achieved 90%</td>
<td>1.8 per year</td>
<td>Infrastructure, cost, competition</td>
<td>Widespread Distribution from single place</td>
</tr>
<tr>
<td>Cell phone</td>
<td>14</td>
<td>6.4</td>
<td>Infrastructure, cost</td>
<td>Widespread Distribution from single place</td>
</tr>
<tr>
<td>Internet</td>
<td>20</td>
<td>4.5</td>
<td>Initial Infrastructure in place (Telephone &amp; Cable)</td>
<td>Initial Infrastructure in place, cell phones</td>
</tr>
<tr>
<td>Smartphone</td>
<td>3</td>
<td>30.0</td>
<td>Infrastructure</td>
<td>Infrastructure in place, manufacturing in place, computer technologies mature at a much faster pace</td>
</tr>
<tr>
<td>Clothes Washer</td>
<td>76</td>
<td>1.2</td>
<td>Cost</td>
<td></td>
</tr>
<tr>
<td>Air Conditioning</td>
<td>53</td>
<td>1.7</td>
<td>Cost</td>
<td></td>
</tr>
<tr>
<td>Stove</td>
<td>58</td>
<td>1.6</td>
<td>Cost</td>
<td></td>
</tr>
<tr>
<td>Microwave</td>
<td>27</td>
<td>3.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connected Vehicle</td>
<td>?</td>
<td>Maybe Never</td>
<td>The &quot;connected&quot; part of the infrastructure</td>
<td>Infrastructure in place, manufacturing in place, computer technologies mature at a much faster pace</td>
</tr>
<tr>
<td>Autonomous Vehicle</td>
<td>?</td>
<td>likely quicker than we expect</td>
<td></td>
<td></td>
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This chart was primarily ownership or equipped, when we talk about autonomous vehicles, there is a chance we will never see 90% ownership. Considering how the transportation on demand concept (Uber, Lyft, etc.) is growing at a very rapid pace, we may be looking at a 90% utilization as the measure of adoption.
Some Potential Barriers

**Government**
- Regulations
- Security

**Cost**
- Currently premium options on high end vehicles
- Maintaining the high cost technology

**Legal and Liability Issues**
- New issues we have not yet encountered
- Who is responsible?

**Public Acceptance**
- Driving is a popular past time
- Trust
What does this mean for NCDOT?

Road Maintenance

Will there be more emphasis on road markings?
Will we have to place more emphasis on technology if the infrastructure to vehicle connectivity concepts matures and becomes a requirement?
Will we be required to provide new services?

Transportation Facilities

What impact will AV have on traffic volumes?
How do we consider this in the transportation planning realm?
What does this mean for NCDOT?

**Driver Licenses**
- Will there be a need to have licensed drivers?
- If so, who provides that?

**Vehicle Registration**
- Will it increase or decrease?

**Public Transportation**
- Will there be smaller vehicles that provide door to door services?
- Will there be a demand for the large buses?
- What about intra city public transit?
- Will large mass transit system become more or less cost competitive?

**Freight Movement**
- Will we allow trucks to move without drivers?
- Will companies want trucks to move without someone providing security?
- What about Hazardous material?
What are we doing to prepare for Autonomous Vehicles?

NCDOT has started a comprehensive study to look at this issue holistically from the state perspective.

Two Key Project Objectives and Deliverables Include:

1) Assess the Department and the state’s current conditions with regard to autonomous vehicle (AV) testing and operations for the immediate term, medium term, and long term. These conditions include:
   • Vehicle Code
   • Liability/Tort
   • Road owners (NCDOT and municipality) operations and maintenance
   • Surface transportation planning (metropolitan planning organizations, municipalities, and NCDOT)
   • University Research and Development
   • Industrial research, development, and collaboration
   • Regional (e.g., multi-state) coalitions and efforts

2) Provide road map of near-term action items for NCDOT and other key state agencies, guidance recommendations for other stakeholders, and a forecast of key exogenous milestones and issues that may impact North Carolina autonomous vehicle readiness and deployment.
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