Road Transport Automation and Transportation Planning

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Outline

- Basic concepts
- Levels of automation
- Examples of automation applications
- Possible deployment timelines
- Key sources of uncertainty
- Scenario-based planning
What is an automated vehicle?

- There are many types of automation
  - What vehicle control functions are being automated?
  - Who or what is monitoring the driving environment?
  - Is a human driver expected to deal with exceptions?
  - What is the operating environment?
    - Types of roads and sharing with other road users
    - Connected vehicle infrastructure

- Other terms you may hear
  - Autonomous
  - Driverless
  - Self-driving
**Automated**
- At least some control of vehicle functions
- Does not depend on CV technology
- Examples: current applications (forward collision avoidance, traffic jam assist), Google car

**Connected**
- V2V, V2I, V2P communications
- Advisories and warnings to the driver
- Example: Safety Pilot

**Automated and Connected**
- Example: Cooperative Adaptive Cruise Control
Potential Impacts of Automation

- Crash avoidance and severity reduction
- Closer car following
- More efficient intersection performance
- Increased lane and intersection capacity
- More options for non-drivers
- Lower tailpipe emissions and energy consumption
- Induced travel
- Reduced crash and pollution costs
- Increased productivity

Two paths to automation

Any operating environment

Manual Control

Limited operating environment

Automaton

Incremental improvements to driver assistance functions
“Something Everywhere”

Full automation under all roadway and driving conditions that can be managed by a human driver (SAE Level 5)

Car as a service
- Google, CityMobil, etc.
  “Everything Somewhere”
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### SAE (2014) and NHTSA (2013) Levels

<table>
<thead>
<tr>
<th>SAE Name</th>
<th>SAE</th>
<th>NHTSA</th>
<th>NHTSA Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human driver monitors the driving environment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No automation</td>
<td>0</td>
<td>0</td>
<td>No automation</td>
</tr>
<tr>
<td>Driver assistance</td>
<td>1</td>
<td>1</td>
<td>Function-specific automation</td>
</tr>
<tr>
<td>Partial automation</td>
<td>2</td>
<td>2</td>
<td>Combined function automation</td>
</tr>
<tr>
<td><strong>Automated driving system monitors the driving environment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conditional automation</td>
<td>3</td>
<td>3</td>
<td>Limited self-driving automation</td>
</tr>
<tr>
<td>High automation</td>
<td>4</td>
<td>4</td>
<td>Full self-driving automation</td>
</tr>
<tr>
<td>Full automation</td>
<td>5</td>
<td></td>
<td></td>
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</tbody>
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SAE J3016: [http://www.sae.org/misc/pdfs/automated_driving.pdf](http://www.sae.org/misc/pdfs/automated_driving.pdf)

<table>
<thead>
<tr>
<th>Level</th>
<th>Example Systems</th>
<th>Driver Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adaptive Cruise Control OR Lane Keeping Assistance</td>
<td>Must drive <strong>other</strong> function and monitor driving environment</td>
</tr>
<tr>
<td>2</td>
<td>Adaptive Cruise Control AND Lane Keeping Assistance</td>
<td>Must monitor driving environment (system nags driver to try to ensure it)</td>
</tr>
<tr>
<td></td>
<td>Traffic Jam Assist</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>“Traffic Jam Pilot”</td>
<td>May read a book, text, or web surf, but be prepared to intervene when needed</td>
</tr>
<tr>
<td></td>
<td>Driverless valet parking in garage</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>“Highway driving pilot”</td>
<td>May sleep, and system can revert to minimum risk condition if needed</td>
</tr>
<tr>
<td></td>
<td>Closed campus shuttle (driverless)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Automated taxi (even for children)</td>
<td>No driver needed</td>
</tr>
<tr>
<td></td>
<td>Car-share repositioning system</td>
<td></td>
</tr>
</tbody>
</table>

Source: Shladover and Bishop: ITSA webinar on 15 July 2015
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- **Examples of automation applications**
- Possible deployment timelines
- Key sources of uncertainty
- Scenario-based planning
Automatic Braking

Status

* Level 1 application
* Uses radar and camera to sense objects in front that pose an immediate collision threat
* Available today, but not widely used
* Will be required in Europe for new trucks

Impacts

* Significant observed reduction in rear-end crashes and injury claims
* Other areas (mobility, environment, etc.) have little impact

Source: Ford Motor Company, Collision Warning with Brake Support
## Adaptive Cruise Control (ACC)

### Status

- **Level 1 application**
- Uses radar to keep a safe distance to the lead vehicle
- Available today, but not widely used

### Impacts

- **Safety**
  - Potential reduction in exposure to crash situations
  - Does the driver stop paying attention?
- **Mobility**
  - Capacity impacts unclear, depends on following distance chosen
- **Other impacts** are limited
Cooperative Adaptive Cruise Control

**Status**

* Level 1 application
* Uses radar and V2V communications to keep a safe distance to the lead vehicle
* May include close-headway platooning
* Being tested for cars and trucks

**Impacts**

* Safety
  * Potential reduction in exposure to crash situations
* Mobility
  * Increase in freeway lane capacity, with closer headways and better string stability
* Energy / Environment
  * For trucks, reduced aerodynamic drag with close-headway platooning
## ACC and Lane Keeping

### Status

- Level 2 application
- Uses multiple sensors to maintain awareness of other vehicles and road markings
- Available today, but not widely used

### Impacts

- **Safety**
  - Potential reduction in exposure to crash situations
  - What happens if the driver stops paying attention?
- **Mobility**
  - Capacity impacts unclear, depends on following distance chosen
  - For transit, may facilitate shoulder running with precise lane-keeping
- Other impacts are limited
Driverless Shuttle

Status

* Level 4 application
* Uses multiple sensors to maintain awareness of the environment, including other road users
* Prototype testing
  * CityMobil in Europe

Impacts

* Safety
* Personal Mobility
  * Possible significant benefit
* Land Use
  * May facilitate new land uses

Source: CityMobil
Automated Taxi

Status

* Full Automation
* Level 5 application
* Operates on most roads, no driver needed
* Uses multiple sensors to maintain awareness of the environment, including other road users
* Does not exist
* When will it exist? Opinions range from
  * Within the next 10 years, to
  * Never

Impacts

* Safety
* Vehicle Mobility
* Energy / Environment
* Personal Mobility
* Land Use
* Public Health
* Economy

Source: Steven M. Johnson
Outline

* Basic concepts
* Levels of automation
* Examples of automation applications
* **Possible deployment timelines**
* Key sources of uncertainty
* Scenario-based planning
* Dates to consider:
  1. An application is in some production vehicles
  2. An application is in most/all new production vehicles
  3. An application is in most/all of the fleet

* Variables
  - Adoption in new vehicles
  - Retrofits
  - Fleet turnover rate
When will we see level 3-5 automation?

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- **Key sources of uncertainty**
- Scenario-based planning
Sources of Uncertainty

- Technology
- Policy
- User Issues
Technology

- **Important technological elements**
  - Sensors
  - Image processing
  - Dynamic maps
  - Data via V2X communications
  - Self driving

- **Challenges, especially at the higher levels of automation**
  - Cyber security and privacy
  - Environmental perception under diverse conditions
  - Fault detection and accommodation
  - Software safety – ensuring that complex systems will work safely
Policy

- **Planning and policy are linked**
  - NHTSA connected vehicle rules.
  - State motor vehicle rules.
  - Do we encourage new urban mobility (Uber/Lyft etc.)?
  - Do we actively encourage C/AV?

- **Implications for investment**
  - Capacity of existing infrastructure.
  - Role of transit.
  - Who pays for V2I?

- **Management and Operations**
  - Can we improve road performance.
  - Road performance with mixed levels of manual to automated vehicles.
  - Reduced car ownership.
User issues

* **Driver role in L2 / L3 automation**
  * Will the driver stay sufficiently engaged?

* **Willingness to use automation**
  * Capital and per-trip cost
  * Willingness to cede control of driving and/or routing
  * Perception of value: safety, convenience, multi-tasking

* **Willingness to share vehicles, rides and data**
  * Owned vs. shared vehicle cost
  * Convenience and perception (safety) of ride-sharing
  * Privacy concerns for data

The “user” could be a person, household, or also a freight provider or fleet manager.
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Scenario Analysis

* Is not a point forecast, but rather an exploration of plausible futures
* **One approach:**
  * Identify factors (driving forces) of interest in AV development (Examples: technology, policy, user acceptance, economy, environment)
  * Assess which are most important and most uncertain.
  * Use them to construct a scenario matrix of plausible futures.
  * For each scenario, estimate the impacts
    * Market penetration
    * Safety, congestion (VMT), energy/environment, accessibility, land use, economic impacts
Example: Dutch Scenario Study

<table>
<thead>
<tr>
<th>Driver</th>
<th>High technological development</th>
<th>Low technological development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>AV... in standby</td>
<td>AV... in demand</td>
</tr>
<tr>
<td>Policy</td>
<td>Restrictive AV Policies</td>
<td>Supportive AV Policies</td>
</tr>
<tr>
<td>Customers’ Attitude</td>
<td>AV... in doubt</td>
<td></td>
</tr>
<tr>
<td>Economy</td>
<td></td>
<td></td>
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<tr>
<td>Environment</td>
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For each of the four scenarios, prepared estimates for 2030 and 2050:

- AV market penetration
- Value of time (decrease due to less onerous travel with automation)
- Road capacity
- Vehicle kilometres traveled

Remainder of this Webinar

- A scenario study performed by the Atlanta Regional Commission
- Putting planning for automated vehicles in the context of performance based planning
- Impacts of connected and automated vehicles on planning products, data and workforce development