Self-Driving Vehicles - Challenges and Opportunities

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Self-driving functions vs Self-driving vehicles

Self-driving functions

Self-driving vehicles

[Images of various self-driving functions and vehicles]
There’s more than one revolution ongoing right now

- Self-driving vehicles
- Connected vehicles
- Shared economy
# SAE Levels of driving automation

<table>
<thead>
<tr>
<th>Level</th>
<th>Name</th>
<th>Narrative definition</th>
<th>Execution of steering and acceleration/deceleration</th>
<th>Monitoring of driving environment</th>
<th>Fallback performance of dynamic driving task</th>
<th>System capability (driving modes)</th>
<th>DoS level</th>
<th>NHTSA level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Human driver</td>
<td>n/a</td>
<td>Driver only</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>Human driver and system</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
<td>Driver assisted</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>the driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>System</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
<td>Partially automated</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Automated driving system (“system”) monitors the driving environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>Human driver</td>
<td>Some driving modes</td>
<td>Highly automated</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Some driving modes</td>
<td>Fully automated</td>
<td>3A</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>All driving modes</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
The driving task – Level 0-1

Level 0 – 1: The driver is in control

0-1: The driver is expected to be in control.
0-1: The vehicle is used as a tool.
1: Support can be given to the driver, but the driver is responsible for the execution
The driving task – Level 2-4

Level 2-4 The driver and the vehicle share the control

The vehicle is no longer a tool, instead the driver and the vehicle is expected to be in control together. Level 2-4 requires that the driver knows what he is expected to be responsible for, but also that the vehicle knows the status of the driver.

DVU: Driver Vehicle Unit
Challenges Level 2 - 4

- HMI
  - The driver must know the vehicles intentions (och vice versa)
  - The driver must know what is expected by him
- Transfer of control
- Is the human driver the best choice as the final resort?
- Legal issues
  - Who’s responsible, who’s to blame?
- Testing and evaluation
  - Learning effects
  - Trust
  - Experience
- Don’t do level 2 and 3….
The driving task – Level 4-5

Level 4-5 The vehicle is in control

There is no driver, only passengers
Challenges - Level 4-5

• Less challenges in terms of driver vehicle interaction but more technical challenges
• Testing and verification
• Effects on society and environment
  • Car ownership
  • The role of the car in our cities
  • More or less travel?
  • More or less congestion?
• Timing
  • There’s many ”Chicken or the egg” questions
Some potential scenarios
City and consumer benefits highest in scenarios 3 and 4…

1. The premium car drives itself
2. Autonomous vehicles rule the streets
3. Self-driving taxi revolution
4. Ride-shared self-driving taxi revolution

**Vehicle population**
- Limited city and consumer benefits: -1%
- Some city and consumer benefits: 8%
- Sizable benefits, but not without costs: -46%
- Highest benefits for city and consumer: -59%

**Impact**

- Emissions
- Accidents
- Parking space
- Mobility cost

1. In year 10; Note: calculations based on model city with tidal-style traffic and approx. 6M inhabitants and 1.34M private vehicles and taxis, modeled over a 10 year horizon, assumes no powertrain mix shift. Source: World Economic Forum; BCG analysis.
..but scenarios 3 and 4 also require fundamental change

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Implications for cities</th>
<th>Implications for car manufacturers</th>
<th>Implications for mobility brokers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The premium car drives itself</td>
<td>No benefits – No major change</td>
<td>Business model as is – No major change</td>
<td>One transport mode out of many – No major change</td>
</tr>
<tr>
<td>2</td>
<td>Autonomous vehicles rule the streets</td>
<td>Some benefits – No major change</td>
<td>Business model as is – No major change</td>
<td>One transport mode out of many – No major change</td>
</tr>
<tr>
<td>3</td>
<td>Self-driving taxi revolution</td>
<td>Considerable benefits – But major change and investment</td>
<td>New business model – Major change</td>
<td>May become the primary transport provider – Major change</td>
</tr>
<tr>
<td>4</td>
<td>Ride-shared self-driving taxi revolution</td>
<td>Most benefits – But major change and investment</td>
<td>New business model – Major change</td>
<td>May become the primary transport provider – Major change</td>
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Source: World Economic Forum, BCG analysis
A selection of current research at VTI

HaTric – HMI for self-driving vehicles, focus on Transfer of control. VTI will carry out a field experiment with novice and experienced drivers of Highway Pilot.

ADAS&ME – EU project coordinated by VTI combining automated functions, HMI and driver state.

Two methodology projects on how to evaluate effects on society

HF Auto – A Marie Curie project with two PhD students at VTI focusing on HMI and attention in automated driving.

Born to Drive – Can self-driving cars role of the assembly line and into the car dealer?
Research I think we need more of.

User and Stakeholder requirements – Right now technology is pushing and we need to know more to shape the future from the humans point of view.

Societal effects – What decisions should we make to maximise the benefits and avoid pitfalls?

How should we deal with different levels of automation?