AUTOMATED VEHICLES

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What does autonomous transport really mean?
Evolution of key technologies

Kilde H Martin et al. 2017
6 levels of automation: From no driving automation (level 0) to full driving automation (level 5)

Role of driver and ADS: Automated Driving System
Three primary actors

Driver

Driving automation system

Tfo 2017

Other vehicle systems and components

Dynamic Driving Task (DDT)

Driver

Driving automation system

Tfo 2017
SAE J3016, **Dynamic Driving Task (DDT)**

**Strategic functions**
- Destination and Waypoint Planning
- Object and Event Detection and Response

**Tactical functions**
- Planning and execution for event/object avoidance and expedited route following

**Operational functions**
- Basic vehicle motion control
- Lateral vehicle motion control
- Longitudinal vehicle motion control

**DDT**
- Vehicle motion

Kilde: SAE J3016, tilpasset av SINTEF
Levels of automation

Dynamic Driving Task (DDT)

Basic vehicle motion control

Object and Event Detection and Response (OEDR)

Longitudinal vehicle motion control

Lateral vehicle motion control

Operational Domain Design (ODD)

DDT fallback
Driving automation system

Categorized into levels based on:

1. Whether the driving automation system performs either the longitudinal or the lateral vehicle motion control subtask of the DDT.
2. Whether the driving automation system performs both the longitudinal and the lateral vehicle motion control subtasks of the DDT simultaneously.
3. Whether the driving automation system also performs the OEDR subtask of the DDT.
4. Whether the driving automation system also performs DDT fallback.
5. Whether the driving automation system is limited by an ODD.
### Levels of driving automation

<table>
<thead>
<tr>
<th>Level</th>
<th>Name</th>
<th>Narrative definition</th>
<th>Sustained lateral and longitudinal vehicle motion control</th>
<th>OEDR</th>
<th>DDT fallback</th>
<th>ODD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Driving Automation</td>
<td>The performance by the driver of the entire DDT, even when enhanced by active safety systems.</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
<td>n/a</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>The sustained and ODD-specific execution by a driving automation system of either the lateral or the longitudinal vehicle motion control subtask of the DDT (but not both simultaneously) with the expectation that the driver performs the remainder of the DDT.</td>
<td>Driver and System</td>
<td>Driver</td>
<td>Limited</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Partial Driving Automation</td>
<td>The sustained and ODD-specific execution by a driving automation system of both the lateral and longitudinal vehicle motion control subtasks of the DDT with the expectation that the driver completes the OEDR subtask and supervises the driving automation system.</td>
<td>System</td>
<td>Driver</td>
<td>Driver</td>
<td>Limited</td>
</tr>
<tr>
<td>3</td>
<td>Conditional Driving Automation</td>
<td>The sustained and ODD-specific performance by an ADS of the entire DDT with the expectation that the DDT fallback-ready user is receptive to ADS-issued requests to intervene, as well as to DDT performance-relevant system failures in other vehicle systems, and will respond appropriately.</td>
<td>System</td>
<td>System</td>
<td>Limited</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>High Driving Automation</td>
<td>The sustained and ODD-specific performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Limited</td>
</tr>
<tr>
<td>5</td>
<td>Full Driving Automation</td>
<td>The sustained and unconditional (i.e., not ODD-specific) performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to intervene.</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Unlimited</td>
</tr>
</tbody>
</table>

**DDT**: Dynamic Driving Task  
**OEDR**: Object and event detection and response  
**ODD**: Operational domain design  

Society of Automotive Engineers, Revised 2016-09
ADS-equipped vehicles = Automated vehicles (levels 3-5)

- Remotely operated - monitored and / or controlled from outside
- Autonomous - based solely on vehicle's sensors
- Cooperative - Based on vehicle's sensors and other road information (C-ITS, V2X),
Examples

• A vehicle equipped with Adaptive Cruise Control that experiences a system failure. The driver complete the DDT: **Level 1**

• User stands outside the vehicle to initiate an automated parking maneuver (wireless device): **Level 2**

• ADS – equipped vehicles performing the entire DDT during traffic jams on freeways but not able to do so when it encounters a crash scene and issues a request to intervene: **Level 3**

• ADS – equipped vehicles designed to operate within a campus where they pick up and discharge passengers along a specific route: **Level 4**

• ADS – equipped vehicles capable of automatically navigating on all roads with the user input of the destination: **Level 5**
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