Automated Driving: Taking the Dream to Reality

Bart van Arem, Delft University of Technology, The Netherlands

Automated Vehicles Workshop, Coimbra, Portugal, June 12th 2017
Dutch society and economy depend on transport

- Dense road network
- Port of Rotterdam
- High traffic volumes
- Schiphol airport
Automated driving?
Rivium Buses (Rotterdam)

Separated track
Road based transponders
Supervisory control
Since 1999…
<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>na</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>Driver</td>
<td>Limited</td>
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<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>
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<td></td>
<td>ADS (“System”) performs the entire DDT (while engaged)</td>
<td></td>
<td></td>
<td></td>
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<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>Fallback-ready user (becomes the driver during fallback)</td>
<td>Limited</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>
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Automated driving

Driver assistance/
Partial automation

Driver needs to be able to
intervene at all times

Automated parking,
autocruise

Conditional/ High
automation

Vehicle in control in special
conditions

Taxibots, platooning,
automated highways

Comfort, efficiency, safety, costs

Mode choice, location choice, urban
and transport planning

TU Delft
Automated vehicles can improve traffic efficiency and safety

Netherlands to facilitate large scale testing of automated vehicles
The Experience

EU Transport Ministers in automated vehicles through Amsterdam (16 Km)
10 participants: Renault, BMW, Daimler, Jaguar/Land Rover, Vedecom, Tesla, Volvo Cars, Audi, PSA, DAVI/TNO
‘National Platoon Test’

10 ‘platoons’ of 5-6 vehicles
16 March 2016
A2 Motorway
Moderate traffic, good road conditions
Production vehicles with ACC and LKS
Experienced and/or trained drivers

+ trust increases with experience
+ platoons recovered from cut-ins
- occasional driver intervention needed
- alertness decreases in time
iGame 2016

Multi-vendor platooning
Merging on motorway
Cooperative Intersection
Emergency vehicle warning

28-29 May 2016
10 student teams
Winner: Halmstad University (Sweden)
Interregional Automated Transport NL–DE

➢ To better prepare mobility and logistics for future markets

Technology development
Acceptance and comfort
Infra adaptations
Business modelling
Airport Shuttle Weeze (D)
FoodValley Wageningen (NL)
Aachen-Vaals (D-NL)
Truck Platooning (Flowers) (NL-D)

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<td>SME</td>
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</table>

2017-2020 M€ 8,5

Courtesy Martijn Bruil, Province of Gelderland
Automated Vehicles Last Mile
Routes & Instrumentatie

Star light camera - 7
Overzichtscamera - 12
Cyclosense - 20
Radar - 4
Control room
Ontvangstruimte
Garage
Waarschuwingsbord

Green Village
Omhoud testterrein
EU Truck Platooning Challenge

Courtesy Tom Alkim
Real life cases for Truck Platooning

- Royal Flora Holland (NL)
- GreenPortLogistics (D)
- Bakermans (2016)
- RWS (2016)
Automated transport for disabled people

Children with Multiple Complex Disabilities

Need for flexible and safe transport 400 m between home and day care
Steward and helper present

Light traffic, moderate infrastructure adaptations

Automate wheelchair ready vehicle?
Make automate vehicle wheelchair ready?
Scientific challenges: understanding the spatial and transport changes

- Automated Driving
- Travel and location choice behaviour
- Freight and Logistics applications
- Infrastructure service networks
- Urban design and traffic safety
- Spatial structure and economy
- Regional spatial and transport system
- Accessibility
- Economy
- Traffic Safety
- Urban quality
Application

Regional case studies: passenger cars, freight, public transport, parking

Spatial impacts, urban design, agglomeration

Business cases

Modelling tools, impacts, risks, benefits

Metropoolregio Rotterdam-The Hague
Province Zuid-Holland
Province North-Holland
Municipality of Amsterdam
Rotterdam The Hague Airport
Municipality of The Hague
Municipality of Rotterdam
AMS Advanced Metropoliton Solutions
SmartPort
SWOV Institute for Road Safety Research
RET NV
Mobycon
Province Gelderland
DTV Consultants
Connekt ITS Netherlands
Municipality of Delft
Rijkswaterstaat
KiM
CROW
Transdev-Connexxion
RDW
TNO
Goudappel Coffeng
Meaningful human control (MHC) of automated driving systems

... so much more than robot-dilemmas

What is MHC?
How to design with MHC?
How can humans execute MHC?
Is MHC still effective?

Use cases

2017-2020 M€ 0,5
Human Factors
Deployment
Legal
Impact
Technical

Knowledge automated driving

http://knowledgeagenda.connekt.nl/engels/

Courtesy Tom Alkim & Joop Veenis
From dream to reality

- Human factors
- Traffic flows with cooperative and automated vehicles
- Deployment scenarios
- Spatial and Transportation Impacts
- Ethical issues
- Field trials

- Sensor data fusion
- Positioning
- Wireless communication
- State estimation
- Path planning
- Swarm intelligence
- Ethical issues
- Field trials

Thank you!