Automatisch rijden tussen droom en realiteit...

Bart van Arem
Automatisch rijden tussen droom en realiteit

Self Driving Car Summit, 12 oktober 2016, Expo Houte n
Dreaming about Automated Driving
Automated cars can improve traffic efficiency and safety

Netherlands to facilitate large scale testing of automated cars
Rivium Buses (Rotterdam)

Separated track
Road based transponders
Supervisory control
Since 1999…
Automatisch tijden tussen droom en realiteit
Self Driving Car Summit, 12 oktober 2016, Expo Houten

WePod
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Acceptance

- Drivers state that they prefer warnings over control
- Control could be acceptable in special conditions such as congestion driving
- Acceptance of (different levels of) automation increases after (positive) experience
- Scepticism is declining
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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
# Personal Estimates of Market Introductions
*(based on technological feasibility)*

<table>
<thead>
<tr>
<th>Everywhere</th>
<th>Some urban streets</th>
<th>Campus or pedestrian zone</th>
<th>Limited-access highway</th>
<th>Fully Segregated Guideway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 (ACC)</td>
<td>Level 2 (ACC+LKA)</td>
<td>Level 3 Conditional Automation</td>
<td>Level 4 High Automation</td>
<td>Level 5 Full Automation</td>
</tr>
</tbody>
</table>

**Color Key:**
- **Now**
- ~2020s
- ~2025s
- ~2030s
- ~~~2075
Fundamental changes in driving behaviour

Driver in control

Vehicle in control
Driver supervision

Workload,
- driving performance,
- attention,
- situation awareness
- risk compensation,
Driver Vehicle Interface,
- acceptance,
mode transition,
purchase and use
Driving Behaviour in Control Transitions between Adaptive Cruise Control and Manual Driving

Silvia Varotto

TU Delft

Automatically driving between dream and reality
Self Driving Car Summit, 12 October 2016, Expo Houten
Human behaviour during highly automated platooning

Daniel Heikoop
Potential impacts on traffic

- Solve traffic jams by increased outflow
- Prevent traffic jams by better stability
- Better distribution of traffic over network
- Decreased throughput by larger headways
- Decreased stability by lack of anticipation

Less congestion delay

Increased risk of congestion

Non connected
Large penetration

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The congestion assistant

- Detects downstream congestion
- Visual and auditive warning starting at 5 km before congestion
- Active gas pedal at 1,5 km to smoothly slow down
- Takes over longitudinal driving task during congestion
Traffic flow simulation: merging area A12 motorway, Woerden, the Netherlands
Results

![Graph showing speed upstream - 10% CA and speed upstream - 50% CA](image-url)

**Speed upstream - 10% CA**
- Reference
- 1500 m
- 500 m
- 1.0 s
- 0.8 s

**Speed upstream - 50% CA**
- Reference
- 1500 m
- 500 m
- 1.0 s
- 0.8 s
A20: bottleneck motorway, no more space to expand

How can AVs relieve congestion here?

3+2 cross weaving

Short on-ramp
General findings on motorway capacity

(Shladover, Su, & Lu, 2012)

<table>
<thead>
<tr>
<th>Percentage of ACC Vehicles</th>
<th>0%</th>
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- ACC can either have a small negative or a small positive effect on capacity (≈ -5% to +10%)
- Bottlenecks: increase <10%
- Positive effect stability and capacity drop
- Lower level roads?

- Many micro simulation studies
- Difficult to compare
- Focus on ACC and CACC
- Hardly any bottlenecks
Policy relevance

- Congestion and accessibility
- Safety
- Travel patterns
- Freight transport
- Public transport
- Socio-economic development
- Urban design
- Spatial structure
- Investment policies

National, regional, city authorities, public transport operators, Multimodal hubs (ports, airports)
Car driving more attractive!

- **Partial automation**: Better comfort, Less accidents, Less congestion
- **High automation**: Travel time can partially be used for other purpose
- **Full automation**: Travel time can fully be used for other purposes
Spatial implications

- Geometric redesign of roads and junctions
- Increasing sprawl residential and employment locations
- Concentration activities by better accessibility
- Redesign of urban, commercial, touristic areas
- No on street parking
- Combinations with car sharing, electric driving
Automated roads?

- Implication of changes in traffic load? Platoons, bridges, rutting?
- Automated driving under adverse roadway and weather conditions?
- Implications for traffic management? Opportunity or thread?
- eHorizon: automated driving cloud for real-time positioning, maneuvering and safety?
- Level 4 certified roads?
- Geometric design, transition zones?
### Exploration using LMS

#### Automated Autonomous

5% capacity **decrease** on primary road network

<table>
<thead>
<tr>
<th>Mode</th>
<th>Index km travelled</th>
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<td>Train</td>
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<tr>
<td>Car driver</td>
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<tr>
<td>Car passenger</td>
<td>99.7</td>
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<td>Bus, tram, metro</td>
<td>100.2</td>
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<td>Cycling</td>
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<tr>
<td>Walking</td>
<td>100.1</td>
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<tr>
<td><strong>Total</strong></td>
<td>99.98</td>
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#### Automated Cooperative

15% capacity **increase** primary road network
10% capacity increase secondary road network
10% decrease value of time commuting and business car trips

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<tr>
<td>Train</td>
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<tr>
<td>Car driver</td>
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<td>Car passenger</td>
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<td>Bus, tram, metro</td>
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<td>Cycling</td>
<td>99.3</td>
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<tr>
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<td>99.4</td>
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<tr>
<td><strong>Total</strong></td>
<td>100.10</td>
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**Index congestion**

- Automated Autonomous: 115.7
- Automated Cooperative: 69.1
Scientific challenges: understanding the spatial and transport changes

Regional spatial and transport system

- Automated Driving
- Infrastructure service networks
- Spatial structure and economy
- Urban design and traffic safety
- Travel and location choice behaviour
- Freight and Logistics applications

Accessibility
Economy
Traffic Safety
Urban quality
STAD: Spatial and Transport Impacts of Automated Driving
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
Municipality of Amsterdam
Rotterdam The Hague Airport
Municipality of The Hague
Municipality of Rotterdam
AMS Advanced Metropolitan 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
Stay tuned!

stad.tudelft.nl
LinkedIn groep SURF-STAD
info@stad.tudelft.nl

Establish the automated driving network in the Netherlands

Dissemination tools
- Risk assessment and business case tools
- Workshop sessions, CoP by practical partners with interested parties

External activities
- Yearly STAD event combined with possible pilots
- Newsletters & website for interested parties

Internal STAD activities
- 3 monthly sessions for and by the consortium
- Alignment of practical and academic partners
.. and what about ethics?

... so much more than robot-dilemmas

Responsibility  Values  Triple helix  Equity, fairness  Collaborative design
Privacy  Security  Testing  Sustainability  Mixed traffic
Authority transitions  Laws and regulations  ....
Wij moeten ook nog leren:

- Slimme auto of simpel verkeer?
- Acceptatie en gebruik?
- Hype en realisme?
- Wie betaalt?
- Wanneer is de slimme auto verantwoordelijk?
- Marketing of wetenschap?
- ICT of automotive?
- Gevolgen mobiliteit en ruimte?
- …
Van droom naar realiteit...

- Develope efficient and reliable technology
- Collect, analyse and publish large scale real-world experience
- Study spatial, transport and societal impacts
- Regulations, type approval
- Awareness, ambitions, expectations, reality checks
Automatisch rijden tussen droom en realiteit

Self Driving Car Summit, 12 October 2016, Expo Houten

Research Lab Automated Driving Delft

Platform Beter Benutten

TU Delft

Gemeente Delft

Metropoolregio Rotterdam Den Haag