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The Impacts of Automated Driving (PPT)

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The Impacts of Automated Driving
自动驾驶的影响

Bart van Arem

INTEREST IN AUTOMATED DRIVING

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The Impacts of Automated Driving
Workshop Sino-Dutch Cooperation in Transport, Beijing, 21-22 April 2016
DAVI ONTHEROAD

A first drive with fully automated vehicle…

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DEFINITIONS AND SCENARIOS

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SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	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*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	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*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	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*	System	**System**	Human driver	Some driving modes
4	High Automation	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*	System	System	**System**	Some driving modes
5	Full Automation	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*	System	System	System	**All driving modes**

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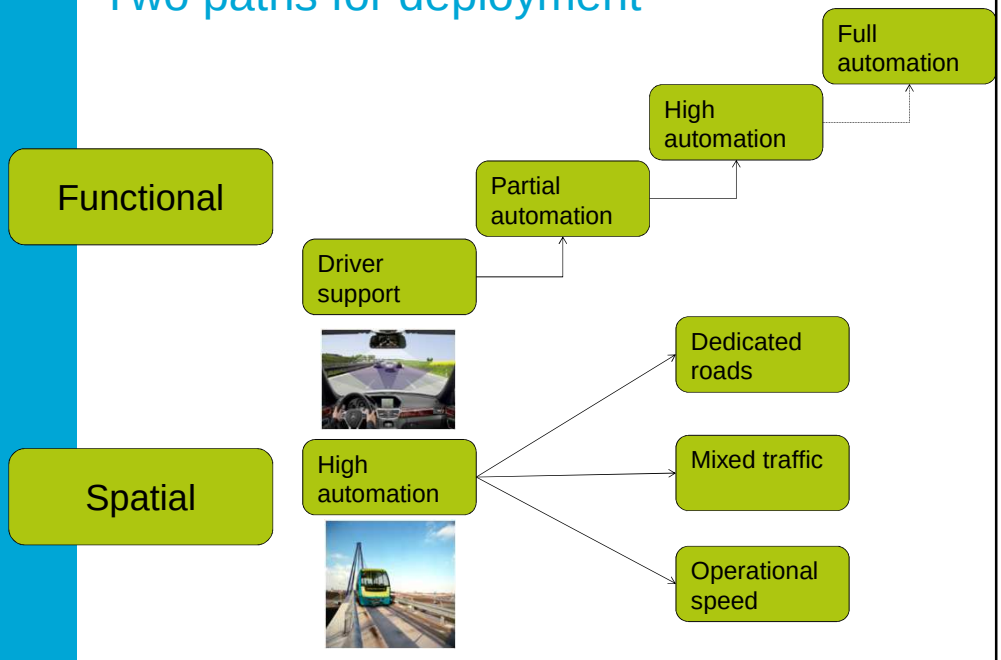
Two paths for deployment



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Personal Estimates of Market Introductions *(based on technological feasibility)*

Color Key: Now | ~2020s | ~2025s | ~2030s | ~~2075

Courtesy Steven Shladover

PATH

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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

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DRIVER BEHAVIOUR

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

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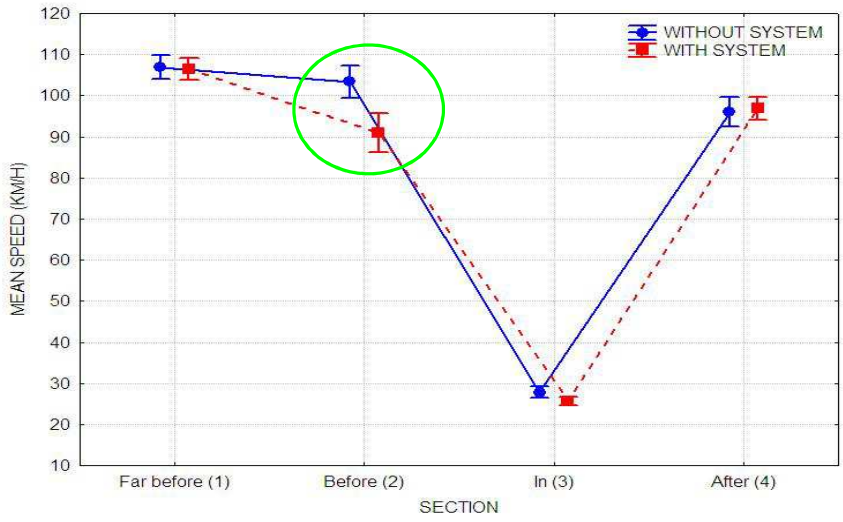
The congestion assistant

- 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

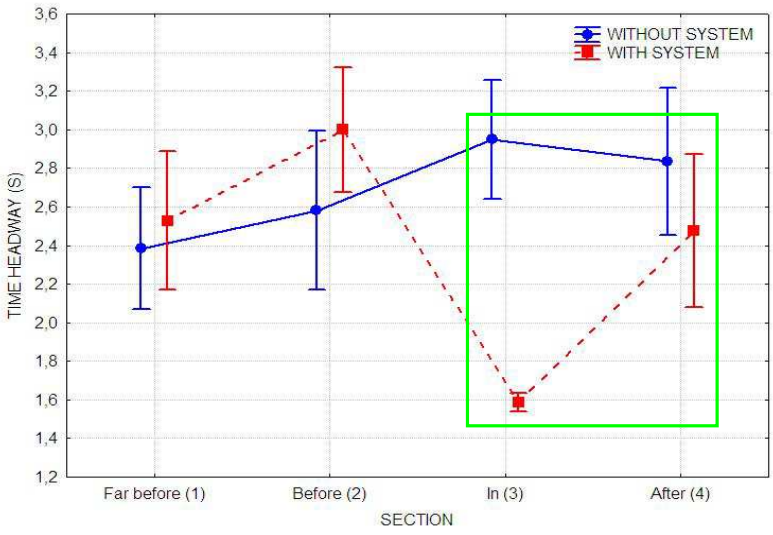
Impacts on driving behaviour

Motorway scenario with congestion
Impacts on driving behaviour
Acceptance

Effects on mean speed



Effects on time headway



May 31, 2006

TRAFFIC FLOW BEHAVIOUR

Potential impacts on traffic

Non connected
Large penetration

- 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

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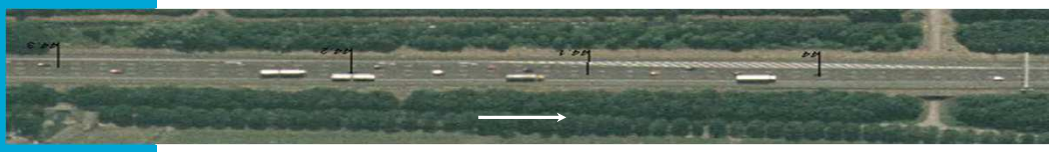
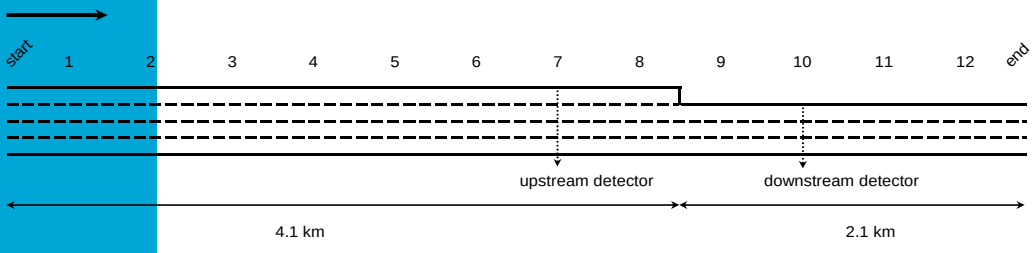
Traffic flow simulation: merging area A12 motorway, Woerden, the Netherlands





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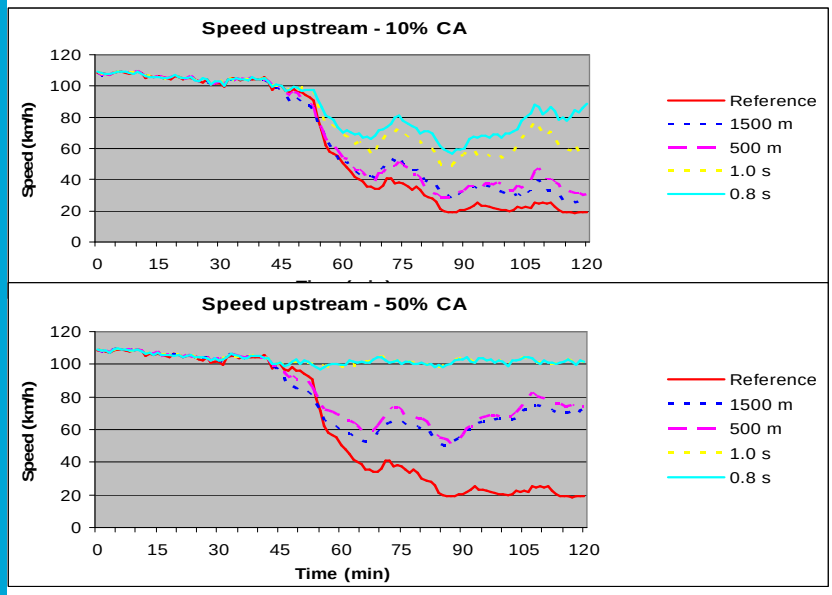
Results



General findings on motorway capacity

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

- 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?

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A20: bottleneck motorway, no more space to expand

How can AVs relieve congestion here?

ACCEPTANCE AND DEPLOYMENT

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Acceptance

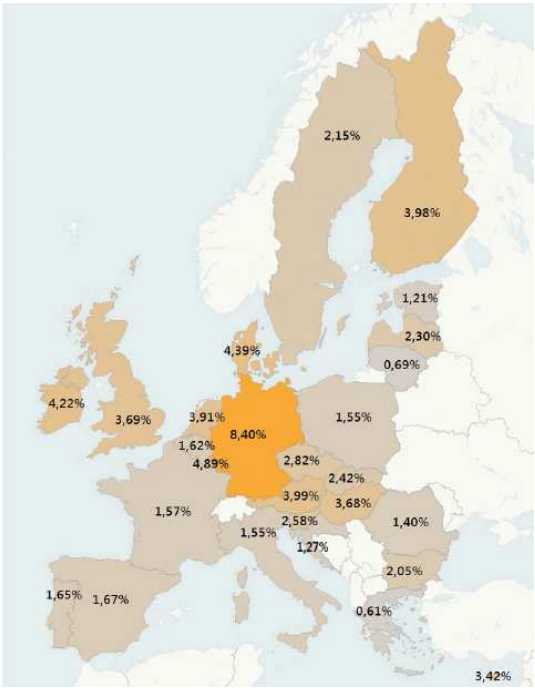
- Drivers state that they prefer warnings over control
- Control could be acceptable in special conditions such as congestion driving
- Acceptance of (different levels of) automation increases after (positive) experience
- Scepticism is declining

DEPLOYMENT RATES - EU27
BY MEMBER STATE

PS3
OBSTACLE & COLLISION WARNING

2012

PASSENGER CARS NEW REG. IN 2012



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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

IMPACTS ON STRATEGIC DECISION MAKING

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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)

Automated cars can improve traffic efficiency and safety

Netherlands to facilitate large scale testing of automated cars

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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, manoevering and safety?
- Level 4 certified roads?
- Geometric design, transition zones?

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Automated Driving

Spatial structure
Economy
Demography
Policy measures

Travel demand model

Trips (car, train, cycling, walking)

Flows, travel times, congestion

Transport network, Capacities, Passenger car equivalent, Value of time

Assignment model

Iterate until equilibrium

Prediction horizon reference scenario 2030

How can this model represent the impacts of Automated Driving?

Exploration using LMS

Automated Autonomous

5% capacity decrease on primary road network

	Index km travelled
Train	100.3
Car driver	99.8
Car passenger	99.7
Bus, tram, metro	100.2
Cycling	100.1
Walking	100.1
Total	99.98

Index congestion 115.7

Automated Cooperative

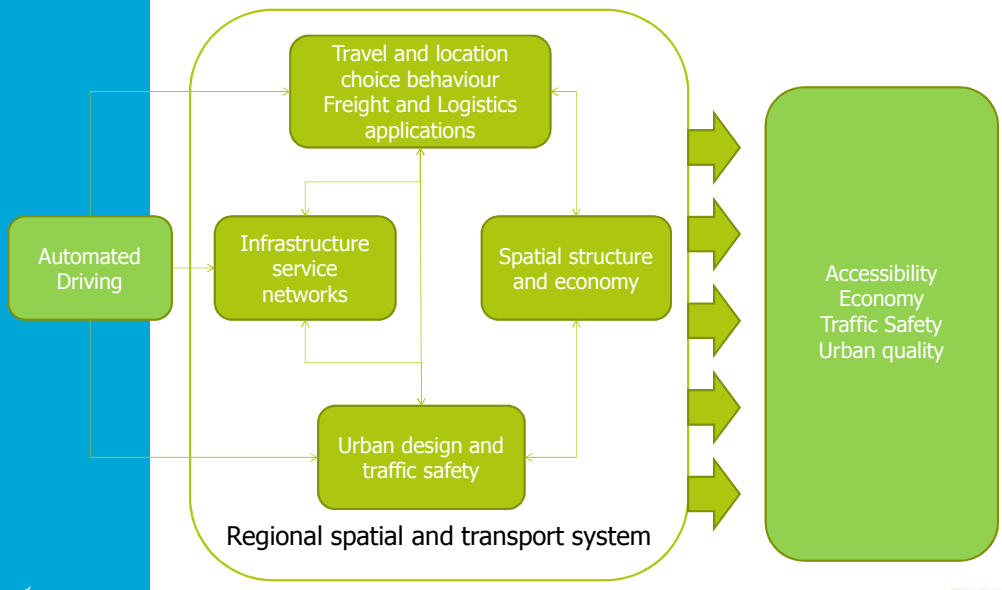
15% capacity increase primary road network
10% capacity increase secondary road network
10% decrease value of time commuting and business car trips

	Index km travelled
Train	98.8
Car driver	100.8
Car passenger	101.4
Bus, tram, metro	99.2
Cycling	99.3
Walking	99.4
Total	100.10

Index congestion 69.1

IMPACTS ON STRATEGIC DECISION MAKING

Scientific challenges: understanding the spatial and transport changes



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Data, theories and models

Specifications of Automated Driving

Behavioral response of traveller and companies

Spatial and transport data

Pilots, experiments, SP/RP surveys, public authority data

MRDH METROPOOLREGIO ROTTERDAM DEN HAAG · Provincie Zuid Holland · DAVI ONTHEROAD · RDW

.. and others

Travel and driver behavioral theories and models

Supply chain and business theories and models

Spatial and transport network models

Integrated model

Scientific partners, Consultancy firms Public authorities

STAD

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STAD: Spatial and Transport Impacts of Automated Driving

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2016

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WRAP UP…

The road to automated driving…

- 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

- International cooperation

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