Automated Driving
A Silver Bullet for Urban Mobility? (PPT)

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Automated Driving – A Silver Bullet for Urban Mobility?

Bart van Arem, Delft University of Technology, The Netherlands

Smart Urban Mobility Symposium – Amsterdam- 29th June 2017

A first drive with fully automated vehicle…

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Spatial and Transport Impacts of Automated Driving

Rivium Buses (Rotterdam)

Separated track
Road based transponders
Supervisory control
Since 1999…

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WePod

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RADD
RESEARCHLAB AUTOMATED DRIVING DELFT

Automated vehicles can improve traffic efficiency and safety

Netherlands to facilitate large scale testing of automated vehicles

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Declaration of Amsterdam

Cooperation in the field of connected and automated driving

14-15 April 2016

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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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Many questions …

When fully automated vehicles will hit the market?

Will we travel safer?

Are we going to own or share cars?

Will we need more or less road infrastructures?

Will we still need buses?

Will there be more or less congestion?

Will we drive longer or shorter distances?

How much on-street and off-street parking spaces will still be needed?

How will cities evolve?

Will we consume more or less energy to travel?

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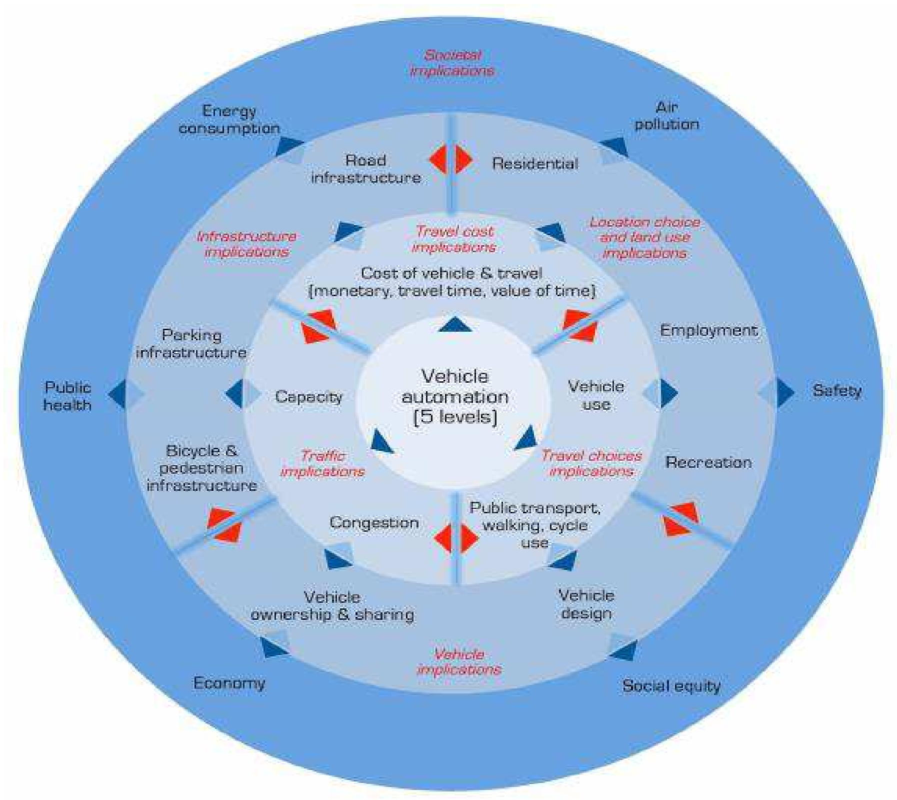

Much progress short term and small scale impacts on driver behaviour and traffic flow.

Research on longer term, indirect, wider scale impacts on mobility, logistics, residential patterns and spatial-economic structure in its infancy.

Milakis et al (2017), Policy and society related implications of automated driving, Journal of ITS.

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Spatial and Transport Impacts of Automated Driving

2016-2020 M€ 2,4

TU Delft RSM Erasmus University VU University Amsterdam Hogeschool Rotterdam TU/e NWO

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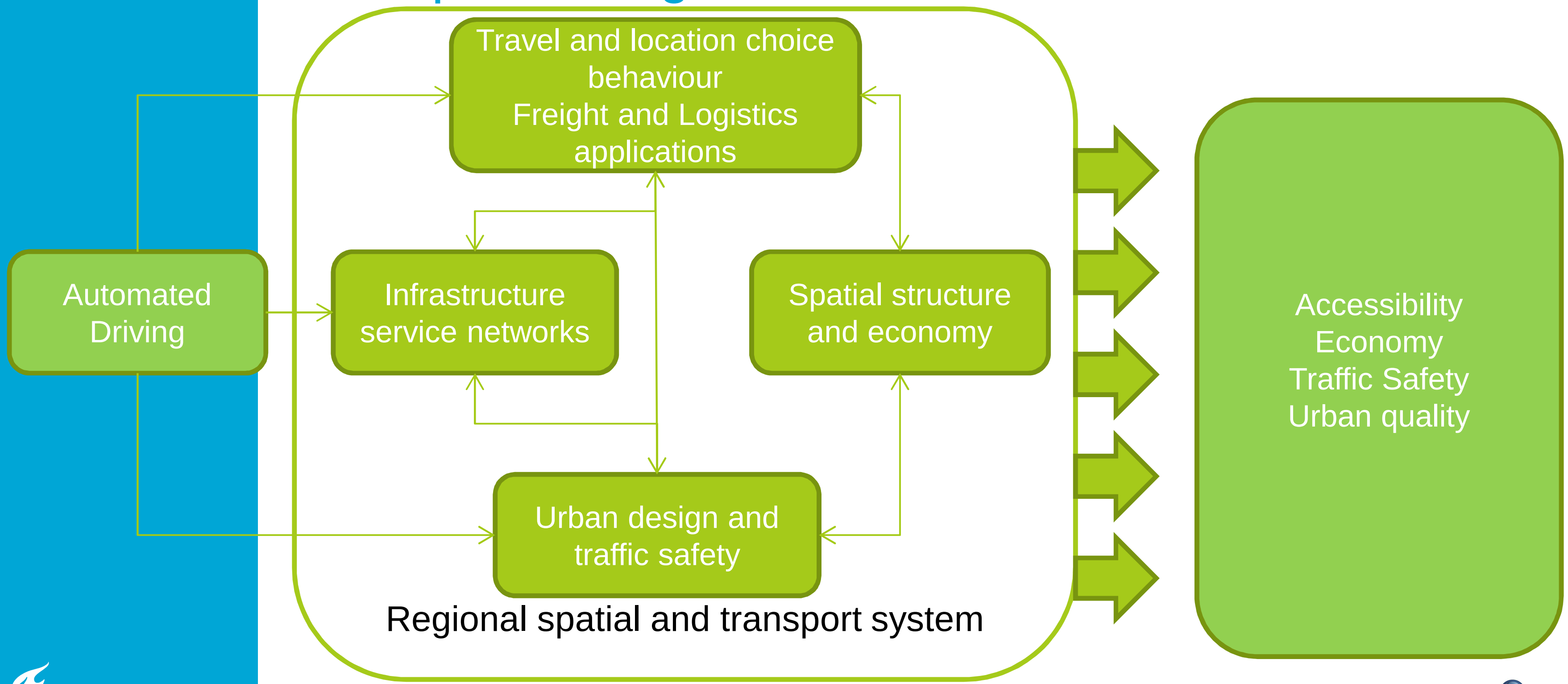
Scientific challenges: understanding the spatial and transport changes



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Application

Spatial and Transport Impacts of Automated Driving

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

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Trust?
Expectations?
Behavior?

Virtual Reality Experiment

- Visit of Welly

- 360º recordings
  with a dedicated camera

- VR glasses

Nunez Velasco et al (in prep)

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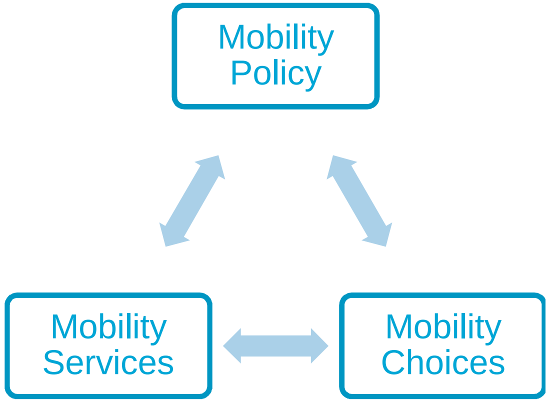
Shared automated Mobility, Car Ownership and Urban Parking Management

Vehicle **Automation** & Vehicle **Sharing** can increase efficiency of urban land use and the urban vehicle fleet

Modeling the interrelation between car sharing, car ownership and urban parking management



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Spatial and Transport Impacts of Automated Driving

Which of the following options would you choose for going from your home to your fictive work / educational institution?

1	auto-to-go	own vehicle	taxi	bus	self-riding vehicles
Cost for the trip	€ 3,60	€ 2,40	€ 3,60	€ 3,60	€ 3,60
Cost for parking	--	€ 5,00	--	--	--
Time to walk to and from vehicle or bus stop	2 minutes	6 minutes	--	6 minutes	--
Waiting time	--	--	4 minutes	7 minutes	4 minutes
Travel time in vehicle	15 minutes	15 minutes	15 minutes	20 minutes	15 minutes
Time to find a parking spot	4 minutes	4 minutes	--	--	--
	auto-to-go	own vehicle	taxi	bus	self-riding vehicle
I choose:	○	○	○	○	○

840 respondents
Amsterdam, Utrecht,
The Hague Rotterdam

Attributes were varied

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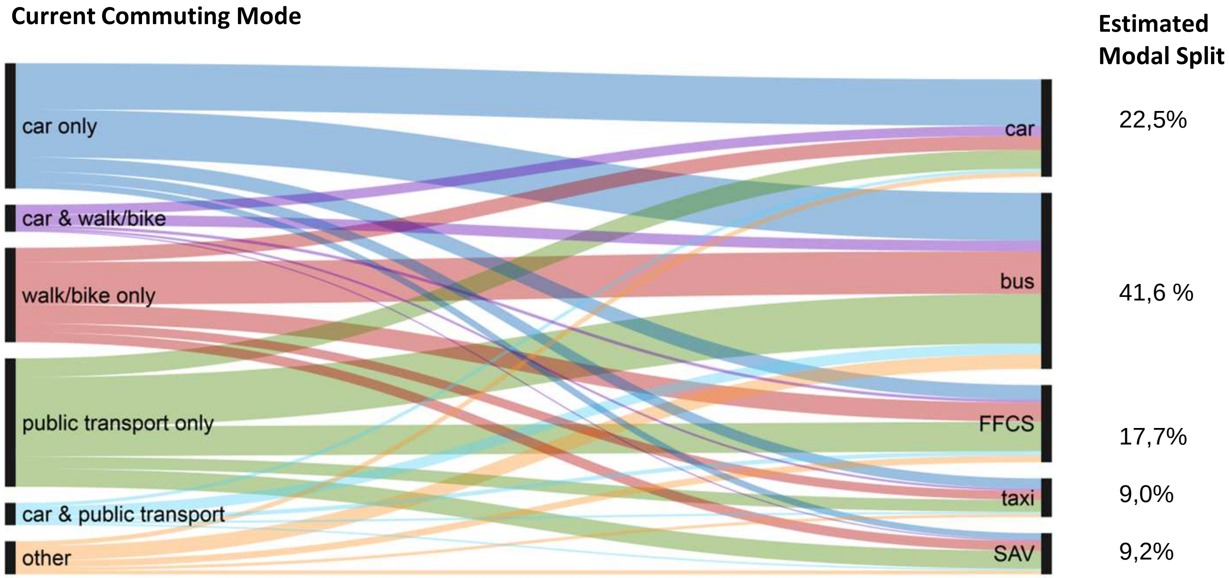

840 respondents
Amsterdam, Utrecht, The Hague Rotterdam

Next step: Activity based modelling of Amsterdam

MATSim

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Winter et al (2017), Mode Preferences in Times of Free-Floating Carsharing and Shared Automated Vehicles - a Stated Choice Experiment, submitted.

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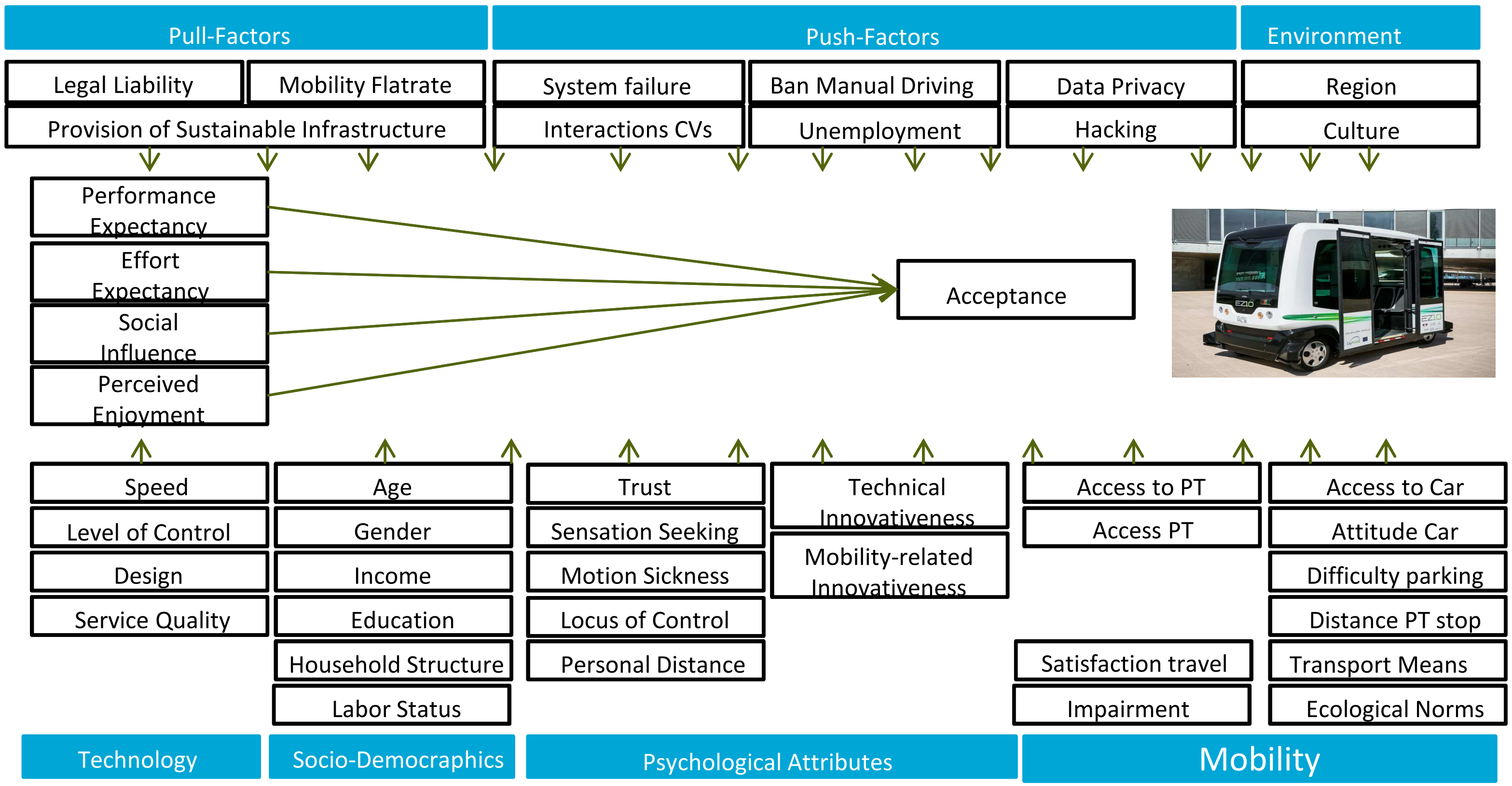
Unified Theory of Acceptance and Use of Technology (UTAUT) + Pleasure Arousal Dominance (PAD)

Theoretical Model for Acceptance of Driverless Shuttles



Nordhoff et al (2016), A Conceptual Model to Explain, Predict, and Improve User Acceptance of Driverless Podlike Vehicles, Transportation Research Record

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Attitude positive,
Willingness to share with others

AV easy to use
High level of trust in AV

AV considered useful, especially in relation to public transport

AV considered less useful by car users

EUREF Campus, Berlin,
8 km/h; 326 respondents, after driving
December 2016-April 2017

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Nordhoff et al (2017), User Acceptance of Driverless Shuttles Running in an Open and Mixed Traffic Environment, Proc 12th ITS in Europe Conference

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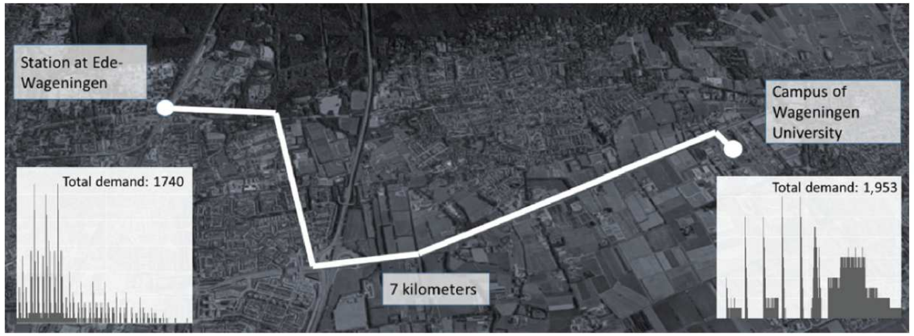
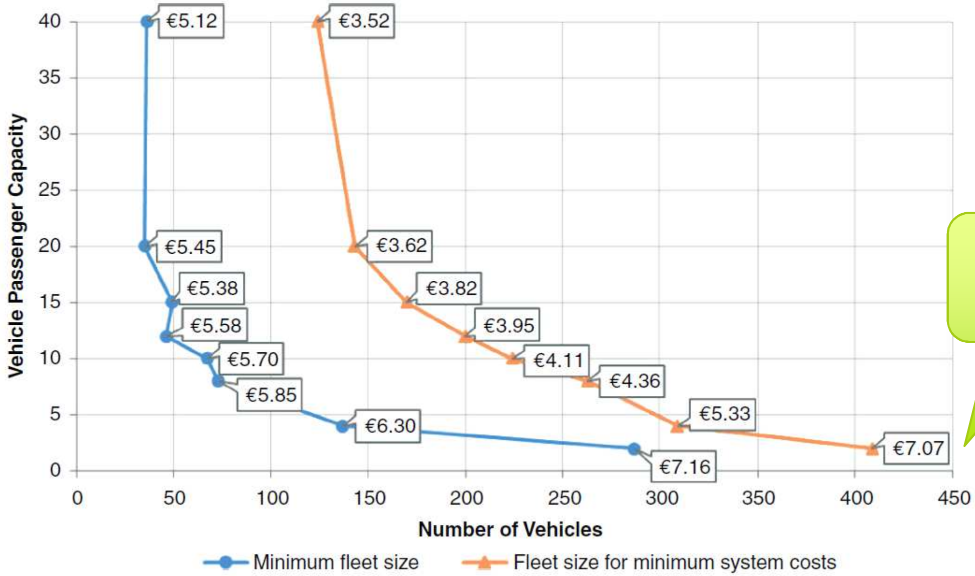


Vehicle capacity (2-40)
Dwell time (1-6 min)
Initial Vehicle Location
Demand level and randomness

Vehicle fixed and variable costs
Passenger generalized cost



System cost per trip

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Winter et al (2016), Designing an Automated Demand-Responsive Transport System, Transportation Research Record

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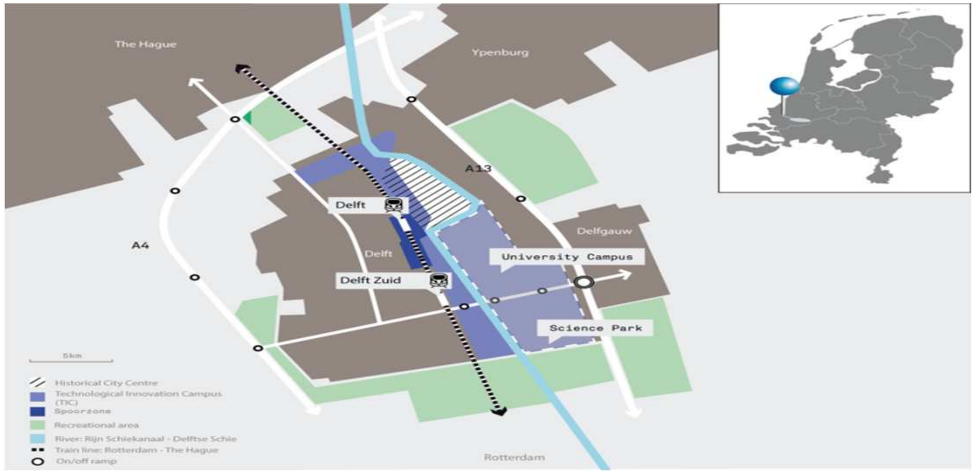
The new Delft-Zuid Station



ProRail (2014)

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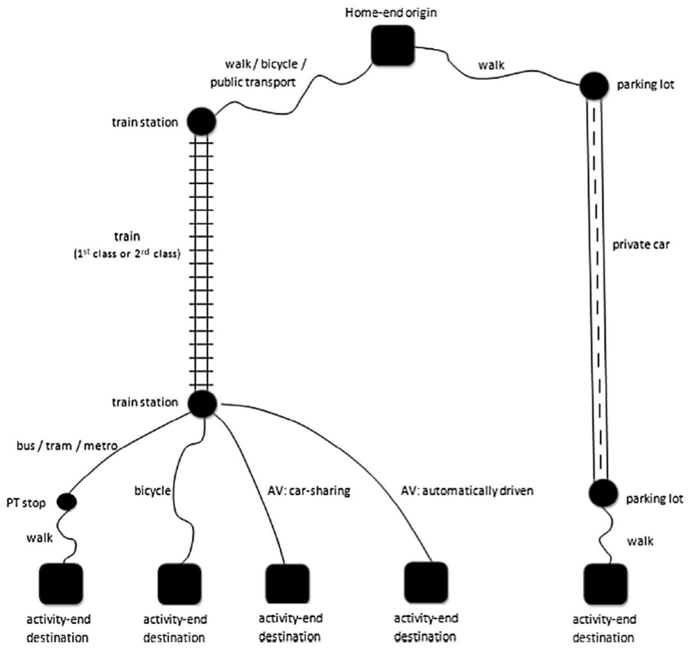

Imagine a trip you have to make from home to a certain activity, like your work, a business meeting or study. Imagine the activity for which you have to travel most frequently. There are different travel alternatives. Which alternative would you choose for this trip?

Main transport: train				Main transport: car
Travel time to the station and travel time in train: 30 min Costs trip to the station and train ticket 2nd class: €10,00 Costs trip to the station and train ticket 1st class: €15,00				Travel time and time required to find a parking place: 45 min
Egress				
Bus / tram / metro	**Bicycle**	**Cybercar – drive yourself**	**Cybercar – automatic driving**	
Waiting time: 10 min		Waiting time: 0 min	Waiting time: 6 min	
Travel time: 5 min	Travel time: 6 min	Travel time: 10 min	Travel time: 10 min	
Travel costs: €3,00	Travel costs: €0	Travel costs: €3,00 Travel costs when travelled 1st class: €2,00	Travel costs: €5,00 Travel costs when travelled 1st class: €1,50	Fuel costs and parking costs: €15,00
		Sharing vehicle? Yes	Sharing vehicle? No	
Walking time to destination: 6 min	Walking time to destination: 0 min	Walking time to destination: 0 min	Walking time to destination: 0 min	Walking time to destination: 2 min

Your choice

Train + bus/tram/metro	Train + bicycle	Train + cybercar (drive yourself)	Train + cybercar (automated driving)	Car
○ Train 2nd class	○ Train 2nd class	○ Train 2nd class	○ Train 2nd class	○
○ Train 1st class	○ Train 1st class	○ Train 1st class	○ Train 1st class	

N=761

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Willingness to pay for 10 minutes travel time reduction

Trip segment	Mode	Willingness-to-pay per 10 minutes
Main	Private car	**€1.80 - €1.90**
Egress	Bus/tram/metro	€0.55 - €0.65
Egress	Bicycle	€1.45 - €1.55
Egress	Automatic vehicle: manually driven	€0.85 - €0.95
Egress	**Automatic vehicle: automatically driven**	**€2.25 - €2.35**

1st class passengers prefer AV
Dual mode AV first step
Trust and reliability important

Yap et al (2015). Preferences of travellers for using automated vehicles as last mile Public Transport of Multimodal train trips. Transportation Research Part A.

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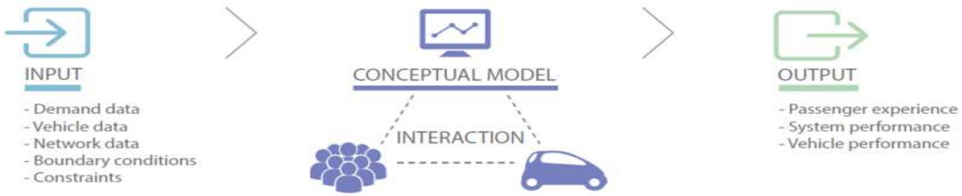

Scheltes & Correia (2017. Exploring the use of automated vehicles as last mile connection of train trips through an agent-based simulation model: an application to Delft, Netherlands. International Journal of Transportation Science and Technology

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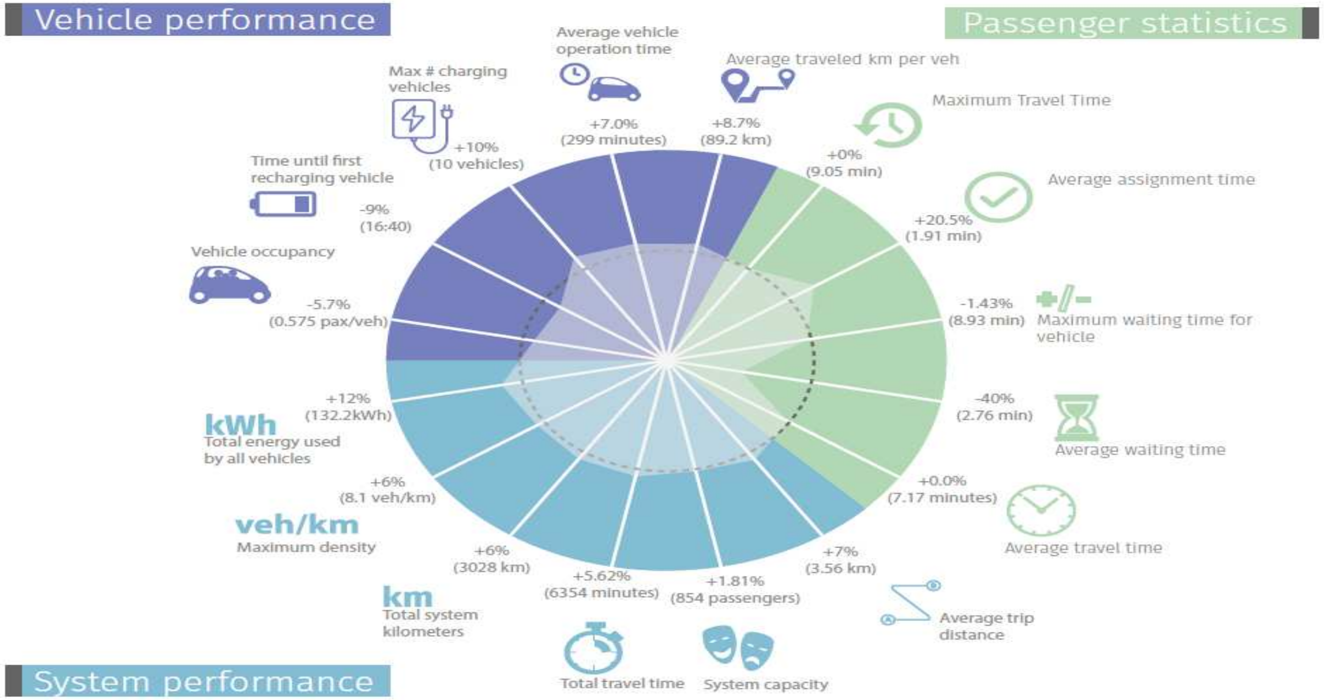
Effect of vehicle relocations



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Problem statement

City area | Reserved requests | Train station

Research questions

- What is the service area of this system?
- Which trip should be satisfied by this system?

Fleet size: 20 Service zones: 21

Fleet size: 40 Service zones: 35

Liang et al, (2016), Optimizing the service area and trip selection of an electric automated taxi system used for the last mile of train trips, Transportation Research E

Meaningful human control (MHC) of automated driving systems

… so much more than robot-dilemmas

- Moral philosophy
- Cognitive psychology
- Traffic engineering

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

Use cases

NWO Responsible Innovation

2017-2020 M€ 0,5

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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)
Truck Platooning (Flowers) (NL-D)

	D	NL
SME	8	9
LE	2	3
Research	1	2
Public Authorities	2	2

Courtesy Martijn Bruil, Province of Gelderland

2017-2020 M€ 8,7

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INTERREG Deutschland Nederland
Europäische Union Europese Unie

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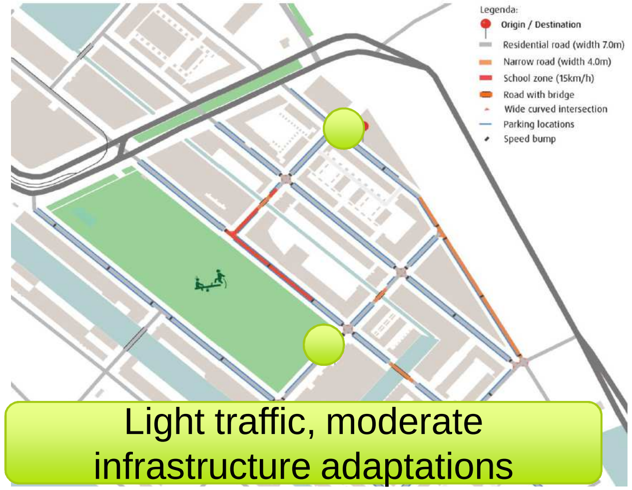
Automated transport for disabled people

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?

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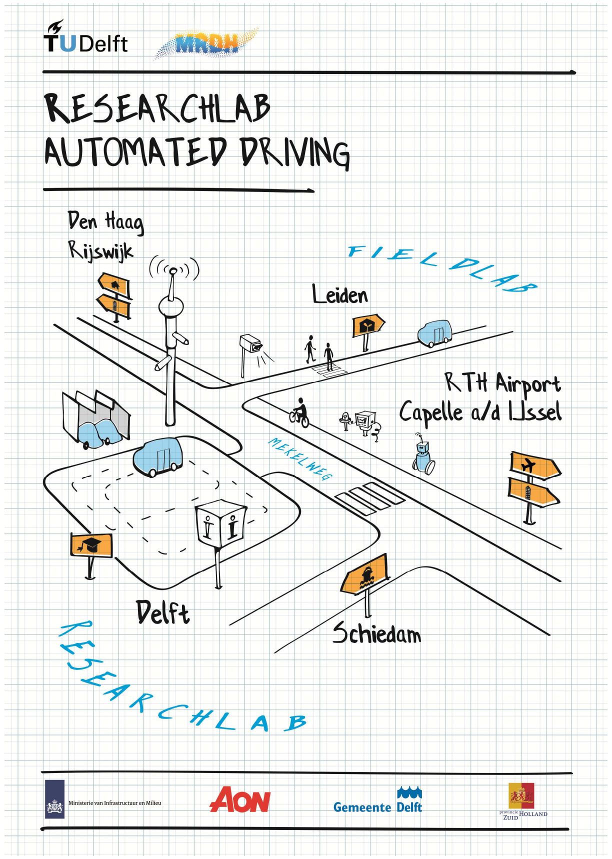
Omega

adviseurs mobiliteit Goudappel Coffeng

Automated Vehicles Last Mile



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MRDH METROPOOLREGIO ROTTERDAM DEN HAAG

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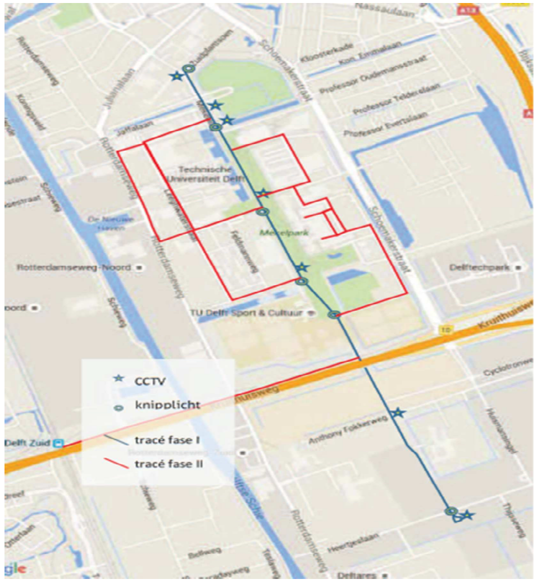
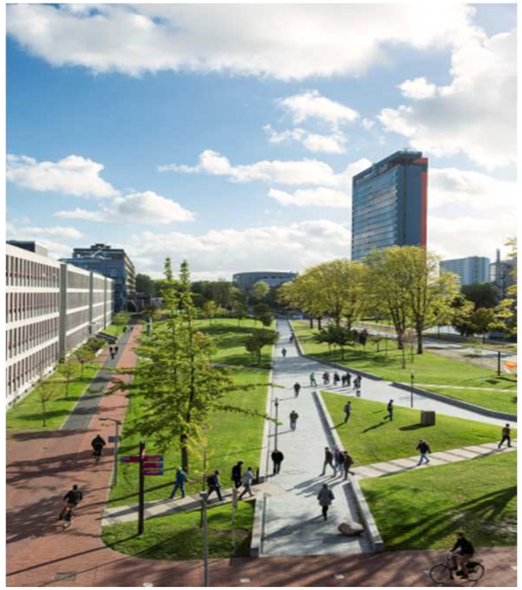
Research Lab Automated Driving Delft





MRDH
METROPOOLREGIO
ROTTERDAM DEN HAAG

Gemeente Delft

provincie ZUID HOLLAND

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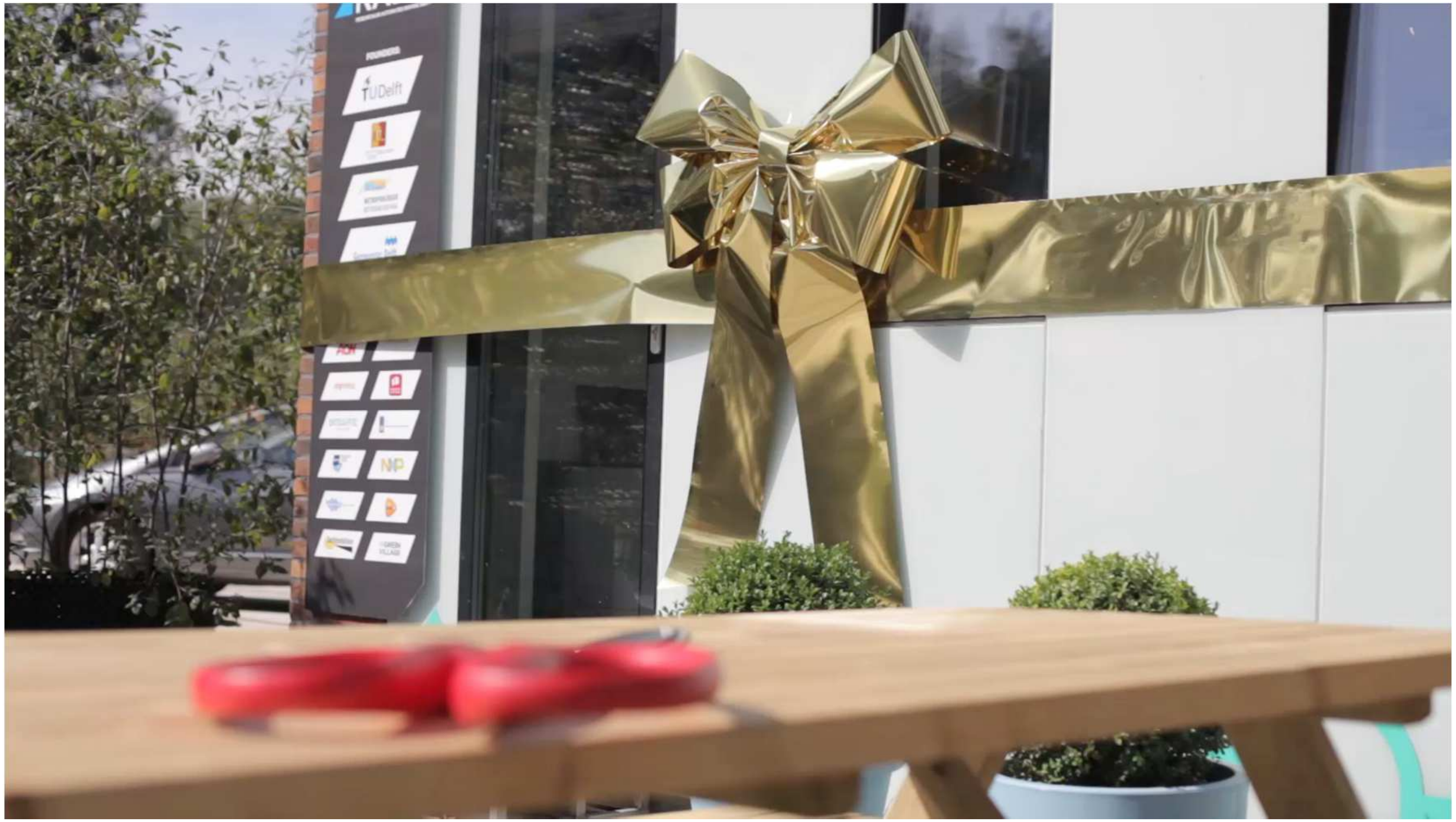

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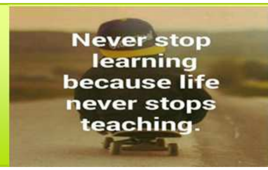
Automated driving can strengthen
public transport

Moving into increasingly complex situations
User acceptance growing



Automated driving in passenger cars,
freight transport, parcel and pizza delivery…

Smart urban mobility: automated driving,
walking, cycling, parking, sharing ,…

Thank you!

Spatial and Transport Impacts of Automated Driving