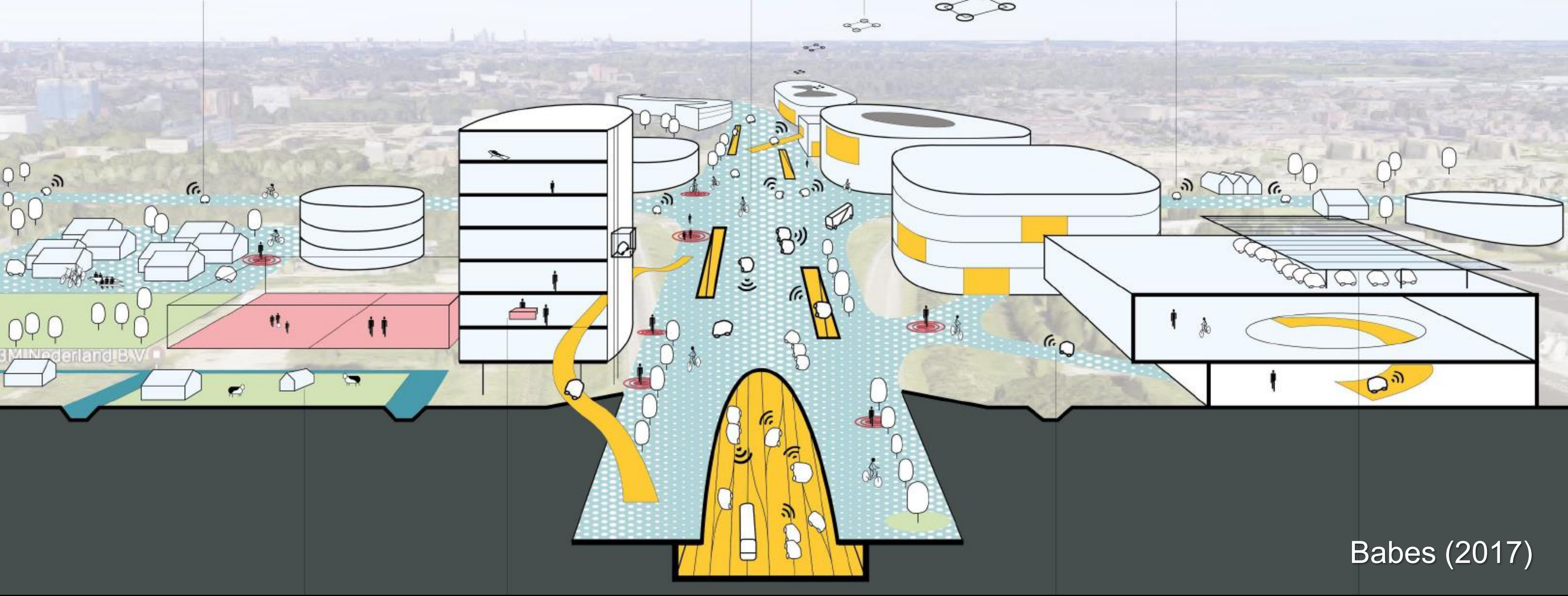

Spatial Impacts of Automated Driving

Bart van Arem, Delft University of Technology, The Netherlands

Invited presentation Strategic Innovation Promotion Program - Innovation of Automated Driving for Universal Services (SIP-adus) workshop, Tokyo, 13-15 November 2018.

Spatial and Transport Impacts of Automated Driving

2016-2020, www.stad.tudelft.nl

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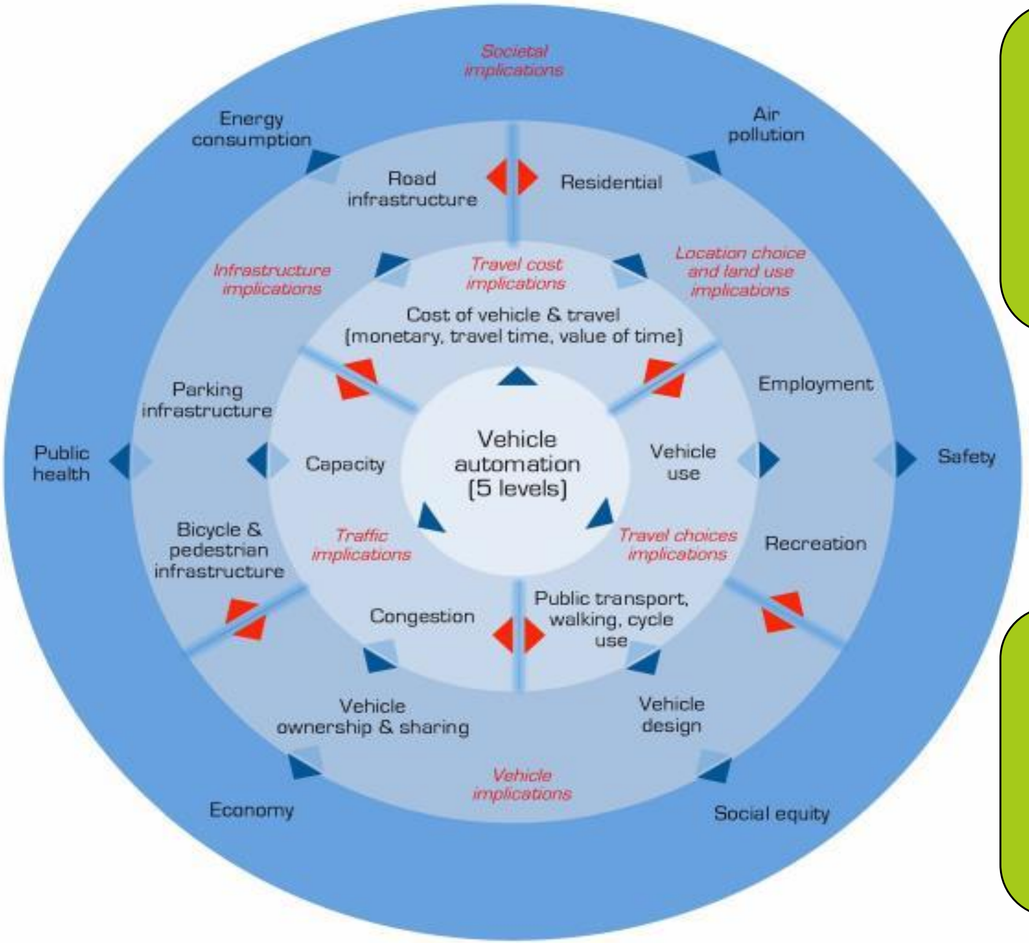
RSM Erasmus University · VU University Amsterdam · Hogeschool Rotterdam · TU/e · NWO

Spatial and Transport Impacts of Automated Driving

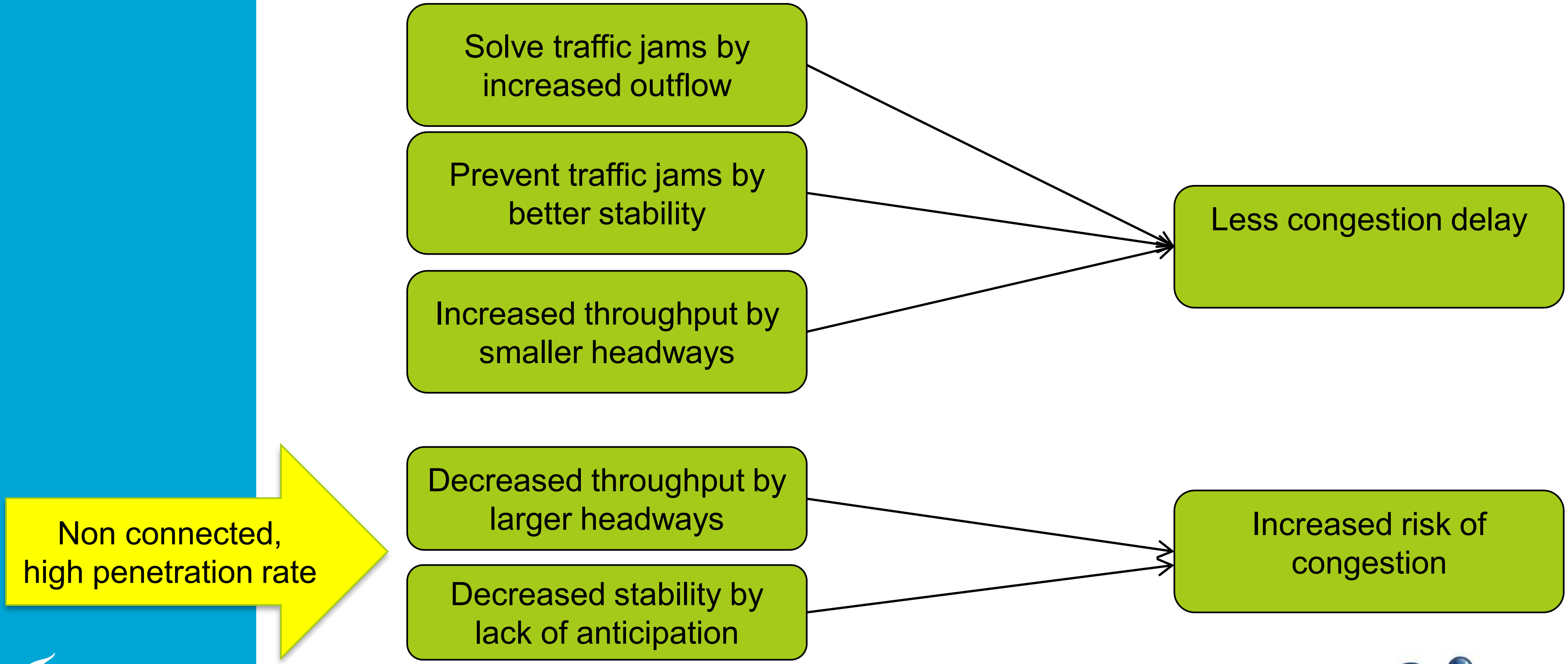


Much progress short term and small scale impacts on driver behaviour and traffic flow.

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.

Potential impacts on traffic



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Spatial and Transport Impacts of Automated Driving

General findings on motorway capacity

"CACC can double roadway capacity"

- on motorways without on/off ramps -

Many microsimulations
Different reference cases
ACC and CACC
Hardly any bottlenecks

Arnaout & Bowling, 2011; Arnaout & Arnaout, 2014; Delis, Nikolos, & Papageorgiou, 2015; Fernandes, Nunes, & Member, 2015; Grumert, Ma, & Tapani, 2015; Hoogendoorn, van Arem, & Hoogendoorn, 2014; Huang, Ren, & Chan, 2000; Michael, Godbole, Lygeros, & Sengupta, 1998; Monteil, Nantes, Billot, Sau, & El Faouzi, 2014; Ngoduy, 2013; Rajamani & Shladover, 2001; Shladover, Su, & Lu, 2012; van Arem, van Driel, & Visser, 2006; Yang, Liu, Sun, & Li, 2013; Carbaugh et al., 1998; Hall et al., 2001; Le Vine et al., 2015; Michael et al., 1998; Talebpour & Mahmassani, 2016; Wang et al., 2016a, b; Xie et al., 2016; Zhou et al., 2016)

ACC changes motorway capacity between -5% and +10%
At bottlenecks change is less than +10%
Additional benefits: improving stability (CACC) and reducing capacity drop
CACC increase capacity further at penetration rates beyond 40%

Hoogendoorn et al (2014), Automated driving, traffic flow efficiency and human factors: literature review, Transportation Research Record
Milakis et al (2017), Policy and society related implications of automated driving, Journal of ITS.

Value of travel time in private vehicles

VOTT

The amount a traveller is willing to pay for 1 minute travel time reduction.

VOTT ↑

Trip is less useful or comfortable, traveller is willing to spend more for a shorter trip

VOTT ↓

Trip is useful and comfortable, traveller is willing to spend less for a shorter trip

Value of time in private vehicles: a stated preference experiment

Assume your next trip is from home to work,
which option would you choose?

A. Conventional car	B. AV – office interior	C. AV – leisure interior
Travel time: 15 Min Travel costs: € 4.50	Travel time: 45 Min Travel costs: € 4.50	Travel time: 30 Min Travel costs: € 7.50
Walking time: 6 Min	Walking time: 0 Min	Walking time: 0 Min
AV activity: driving	AV activity: working extra time	AV activity: do whatever you want
Travel companions: friends and/or family	Travel companions: friends or family	Travel companions: alone

242 respondents;
results excluding 96 non traders

	Mean value of travel time
Conventional car	7,91
AV Office interior	4,97
AV Leisure interior	10,47

Office interior aligns with work activities

Leisure interior does not align with work activities

De Looff et al (2017), Value of travel time changes as a results of vehicle automation – a case study in the Netherlands, TRB 97th Annual Meeting, paper 18-03109

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Spatial and Transport Impacts of Automated Driving

Automated Vehicles in National Market and Capacity Analysis (NMCA)

NMCA

Updated every 4 year to identify main transport problems

Used to support major transport infrastructure decisions

Typical horizon 20 years

Uses Dutch National Transport Model (LMS)

What if AVs could deliver substantial capacity improvement in 20 years?

Smit et al (2017), Will Self-Driving cars impact the long term investment strategy for the Dutch national trunk road system? Proceedings European Transport Conference

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Spatial and Transport Impacts of Automated Driving

Results* motorways

	AV Penetration rate cars	AV Penetration rate trucks	PCU car HWN	PCU truck HWN*	ΔVOT car	ΔVOT truck
Truck platooning	0%	40%	1	0,75	0%	-20%
Autonomous	30%	40%	1,15	0,75	-5%	-20%
Cooperative	30%	40%	0,7	0,75	-5%	-20%
Cooperative VOT	30%	40%	0,7	0,75	-20%	-20%

Capacity –4,5%

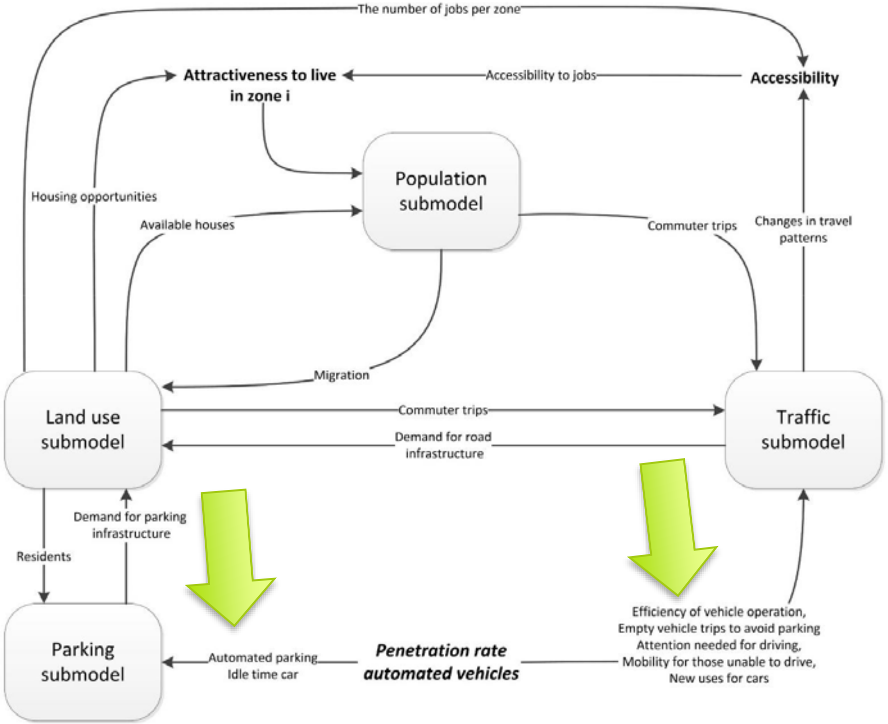
Capacity + 9%

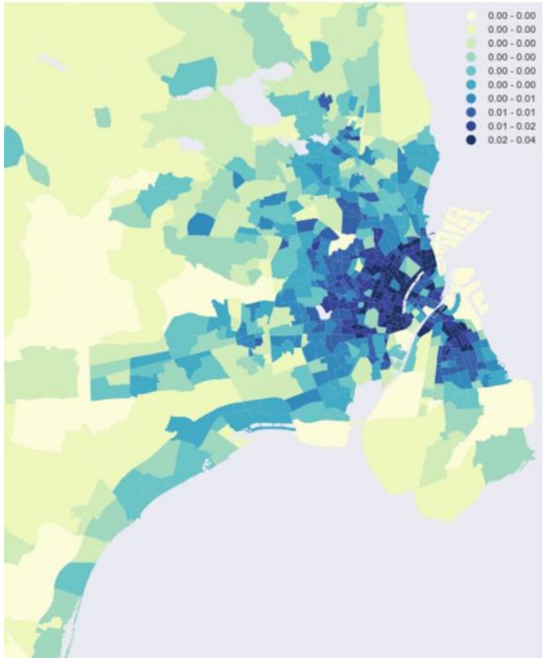
KM driven	Morning peak	Evening peak	Other	Total
Truck platooning	100.9	100.8	100.9	**100.8** ↑
Autonomous	99.1	100.2	99.0	**99.8** ↓
Cooperative	105.3	103.2	105.4	**103.9** ↑
Cooperative VOT	106.4	105.0	106.7	**105.5** ↑

Vehicle loss hours	Morning peak	Evening peak	Other	Total
Truck platooning	97.6	95.9	99.6	**97.8** ↓
Autonomous	103.6	107.9	104.7	**105.3** ↑
Cooperative	91.0	80.0	91.9	**87.9** ↓
Cooperative VOT	94.0	83.9	95.1	**91.3** ↓

* Results are indications. Functionality to assess impacts of AVs is still experimental.

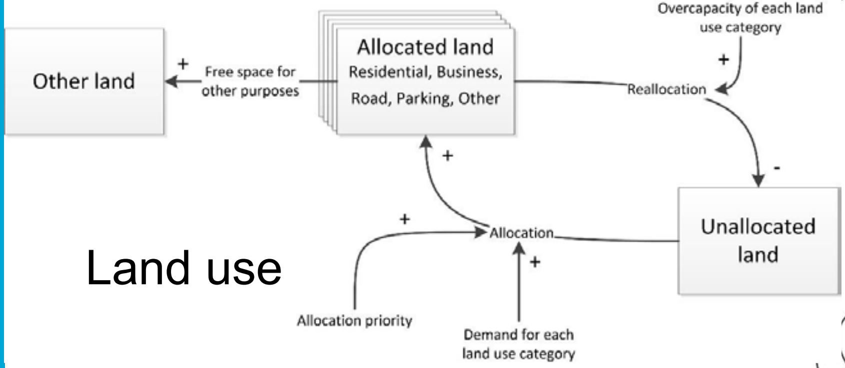
Toward spatial implications of Automated Driving



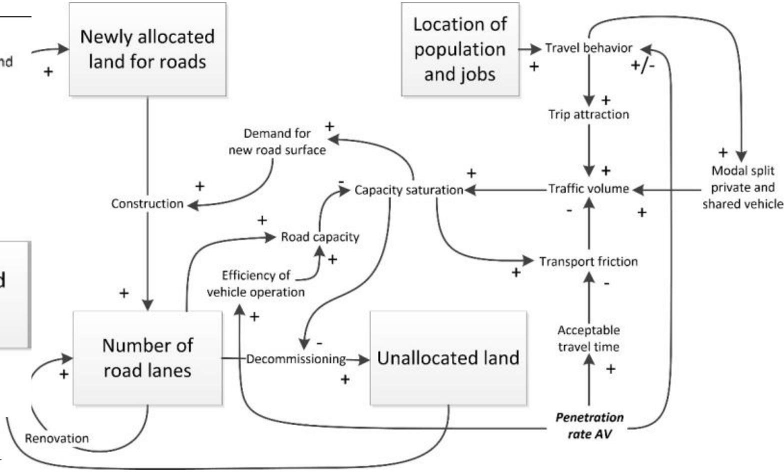


Legene et al (in preparation), Transportation and spatial impact of automated driving in urban areas- An application to the Greater Copenhagen Area

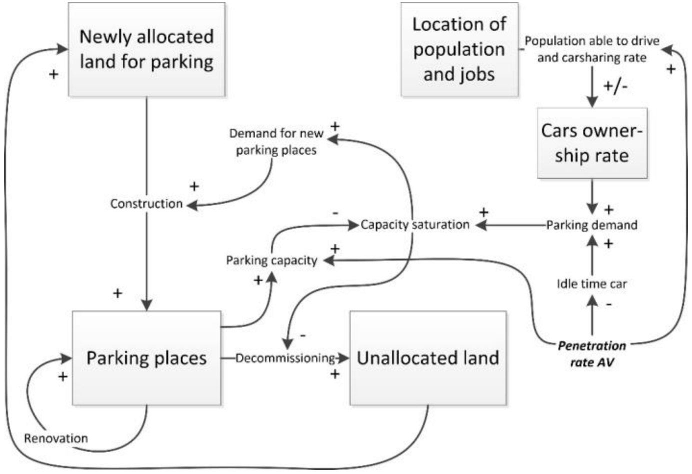
Land use



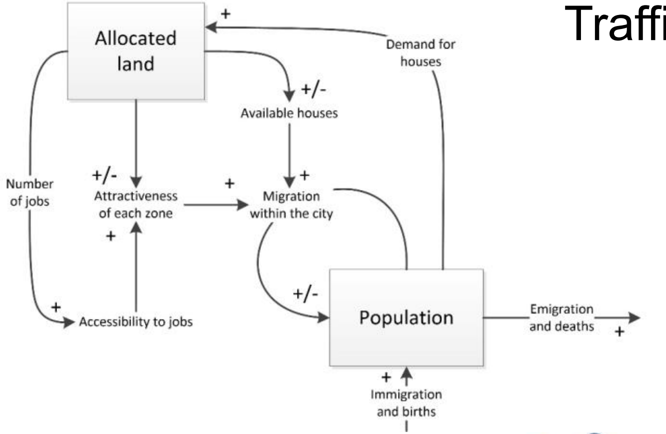
Traffic



Parking



Population



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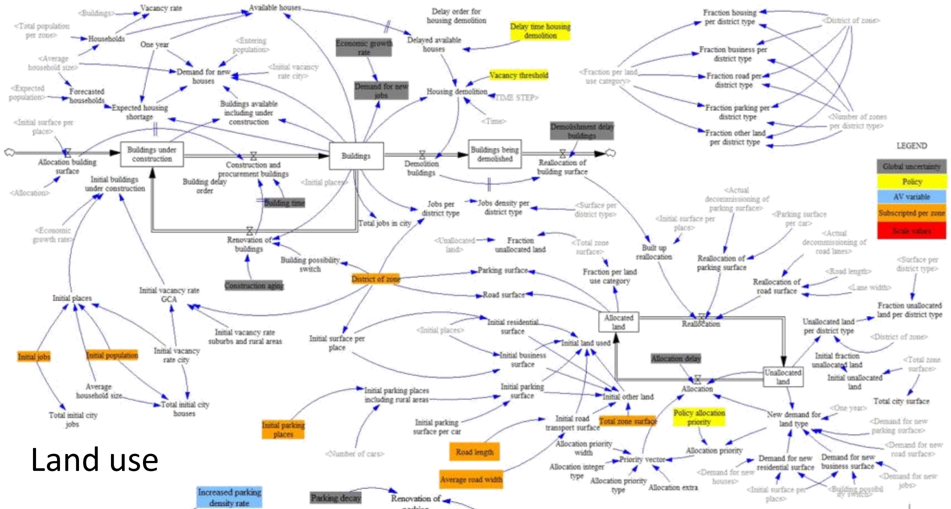
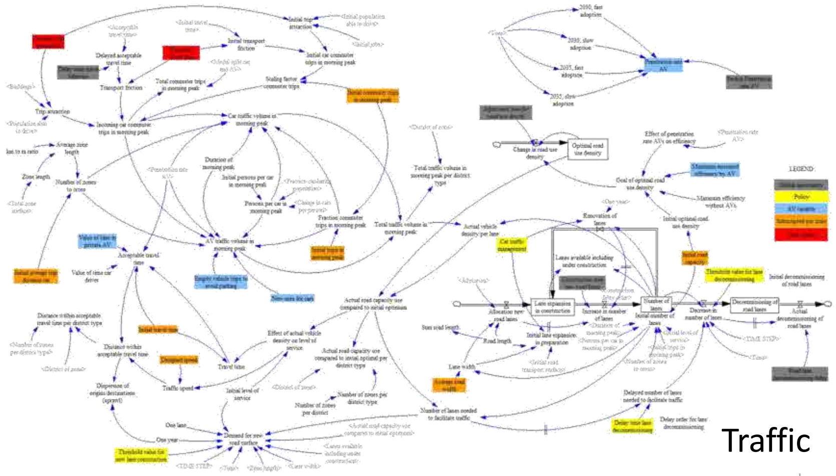
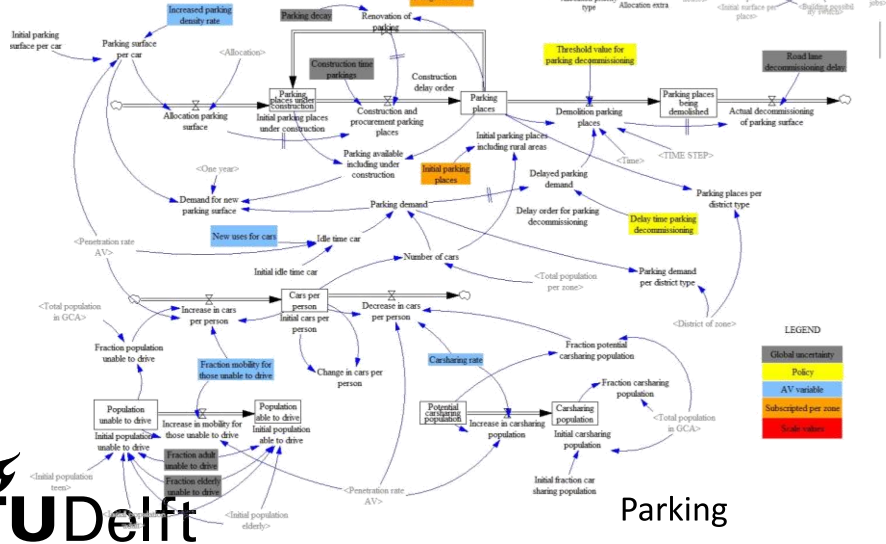
Spatial and Transport Impacts of Automated Driving



Land use



Traffic



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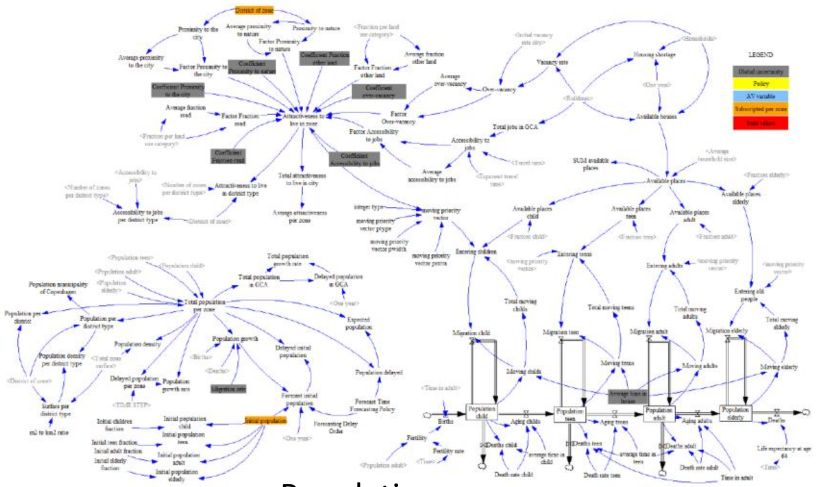

Population

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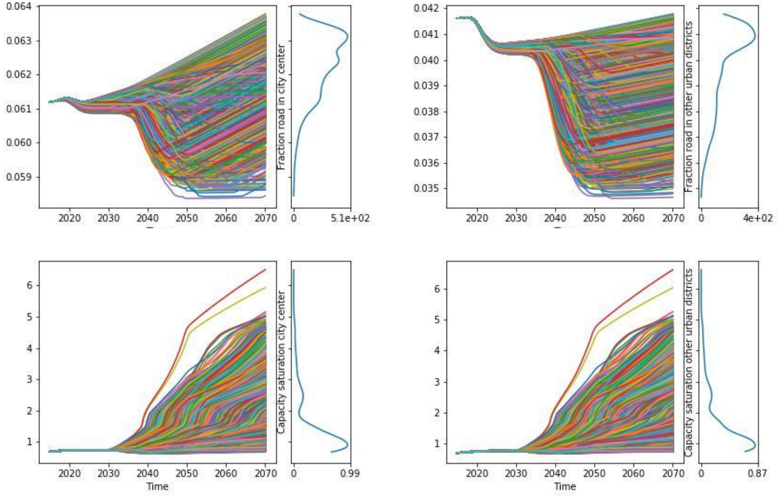
System dynamic simulations

Uncertainties

Penetration rate AVs
Efficiency vehicle operation
VOTT
Increased mobility
Idle time car
Parking density rate
Car sharing rate

2015-2070
Time step 1/32 yr



AREA KPI's

Attractiveness to live
Population
Accessibility to jobs
Average trip distance
Incoming trips
Congestion level
Road surface
Parking surface

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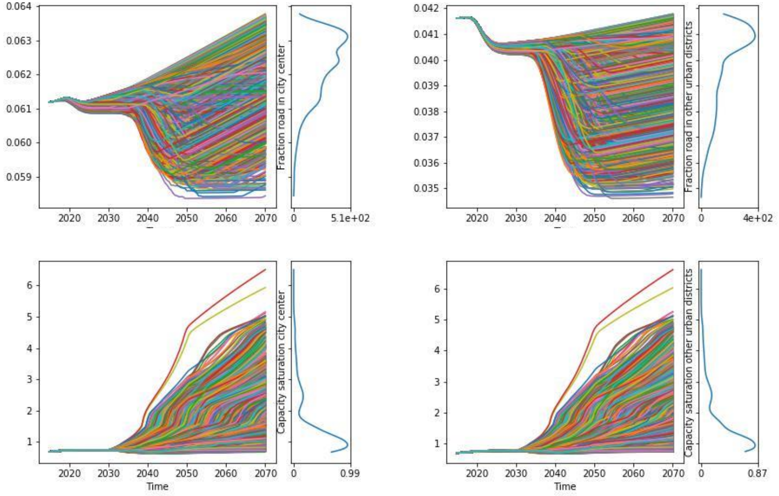
Spatial and Transport Impacts of Automated Driving

System dynamic simulations

Main sensitivies

Penetration rate AVs
Efficiency vehicle operation
VOTT
Increased mobility
Idle time car
Parking density rate
Car sharing rate

2015-2070
Time step 1/32 yr



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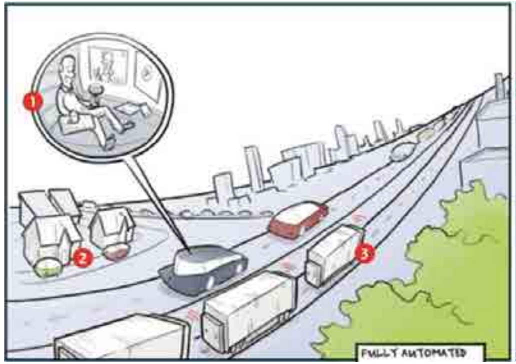

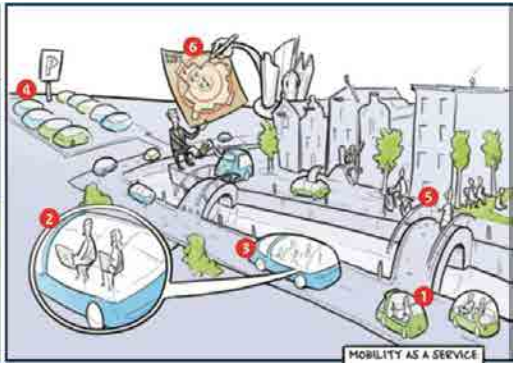

Undesirable AV futures
Very low VOTT
No sharing

Much more trips
Increased congestion, especially in city centre
No land use savings

Desirable AV futures
Low VOTT
High level of sharing

Land use saving	City centre	Other urban districts
Road infrastructure	-	4%
Parking	8%	5%

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Spatial and Transport Impacts of Automated Driving

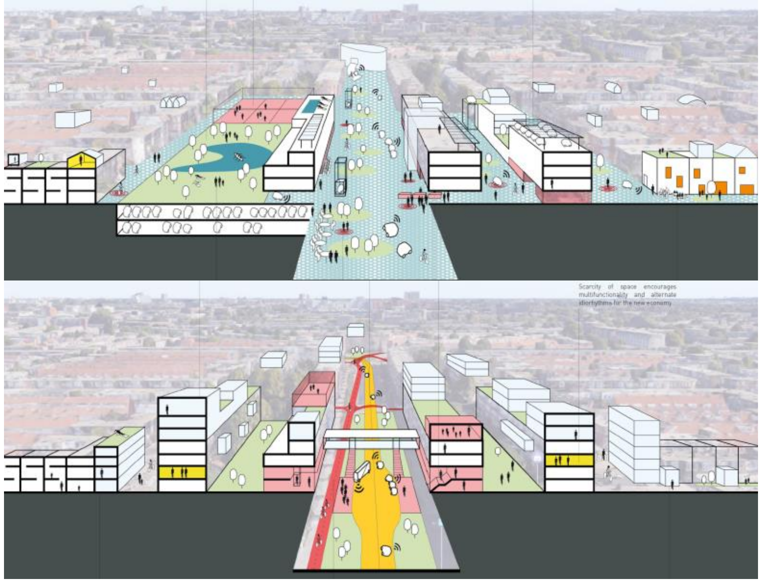
TAKE AWAYS

Spatial impacts of Automated Driving

System dynamics and basic transport models provide first order impacts

Ranges available for changes roadway capacity and Value of Time

Land use savings require high penetration rate and high level of sharing



Improve models using real-world experience
Extend to land use, urban design, smart grids

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