SIP-adus Workshop
2020

Automated Driving on the Path toward Enlightenment

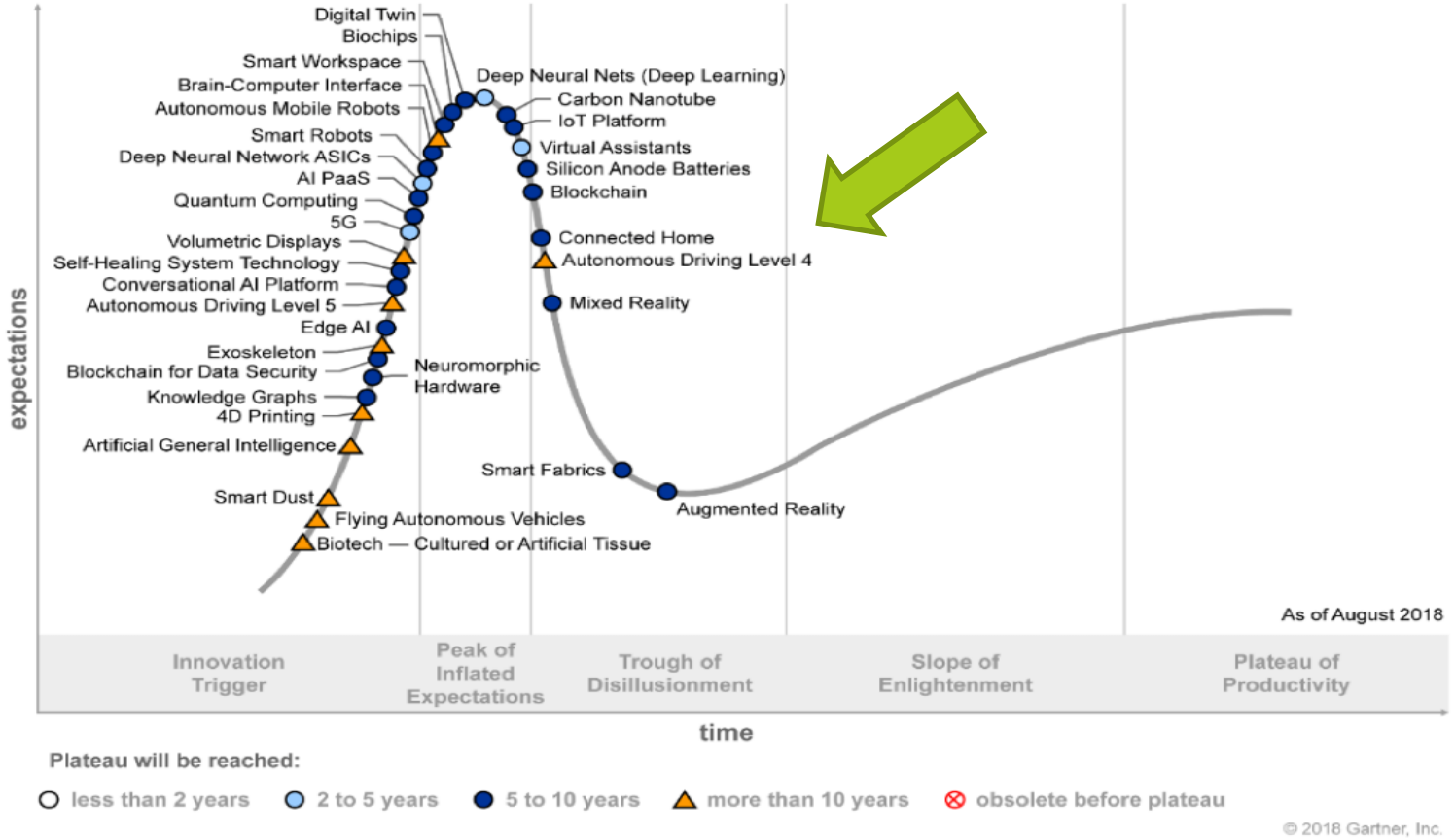
Bart van Arem

TU Delft

VeRDuS

NWO

Spatial and Transport Impacts of Automated Driving



TU Delft

Spatial and Transport Impacts of Automated Driving

2016-2021, 2,5 M€ , www.stad.tudelft.nl

TU Delft

RSM Erasmus University

VU University Amsterdam

Hogeschool Rotterdam

TU/e NWO

Spatial and Transport Impacts of Automated Driving

30 Academic, private and public partners

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

Spatial impacts, urban design, agglomeration

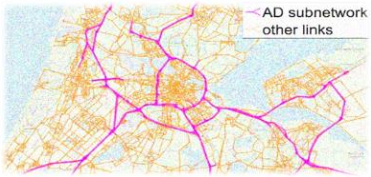
Business cases

Modelling tools, impacts, risks, benefits

TU Delft

Public space

Mobility



Methods and models

TU Delft

Spatial and Transport Impacts of Automated Driving

Public space

AVs moving into deployment

Appelscha
How to maintain public transport in shrinking rural areas? Easymile EZ10 on the bicycle lane.

Rivium ParkShuttle
Without a steward inside the vehicle, in Rotterdam and Capelle a/d IJssel! Served over 6,000,000 paxs since 1999

Container Exchange Route
AV s connecting Maasvlakte 1 and Maasvlakte 2 in Port of Rotterdam

AV in Japan
A case study conducted in regards to a demonstrator in Oku-Eigenji.

Over 100 shuttle experiments in the EU
Safety steward on board
Operational services very limited

How to operate safely in shared space?

TU Delft

Spatial and Transport Impacts of Automated Driving

Public space

https://www.mercedes-benz.com/en/mercedes-benz/innovation/research-vehicle-f-015-luxury-in-motion/


Public space
Nuñez Velasco (2019)

Public space

https://www.youtube.com/watch?v=jCCIAFpxrKY

TU Delft

UNIVERSITY OF LEEDS
Institute for Transport Studies (ITS)

nsport Impacts of Automated Driving

Public space

Findings

- Motion cues of vehicles are the most important factors (speed, distance)
- Little difference between response to automated and regular vehicles
- Intention cues (eHMIs) potentially useful
- Long term adaptation to exposure to automated vehicles uncertain

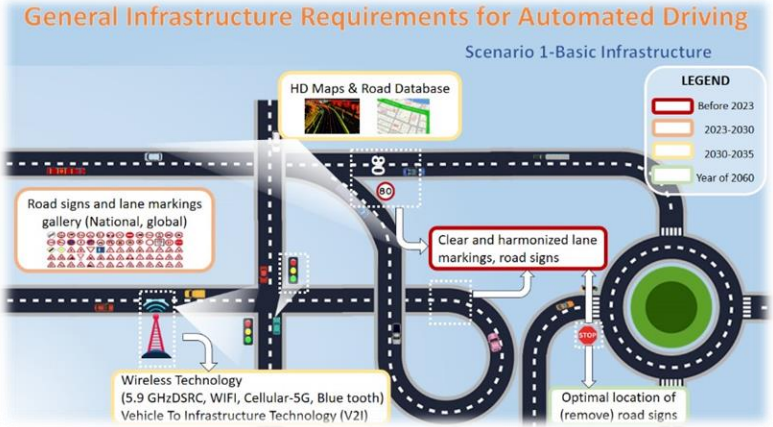
TU Delft

Spatial and Transport Impacts of Automated Driving

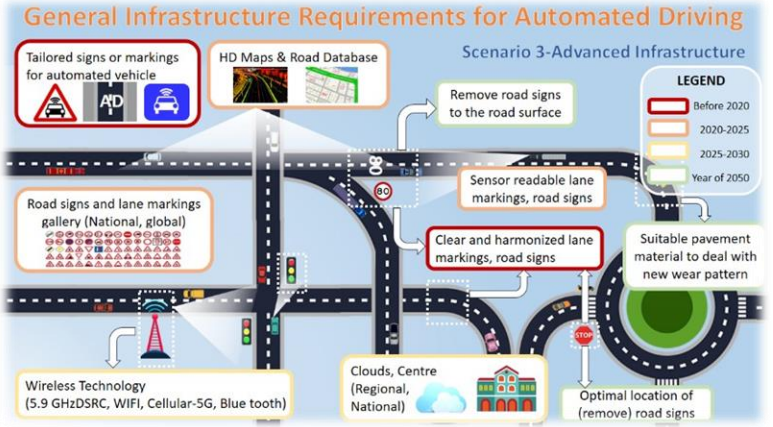
Mobility

Should we accommodate AVs on road networks?

Basic



Advanced



Lu et al. (2019)

Do we need this on all roads?

TU Delft

Spatial and Transport Impacts of Automated Driving

Mobility

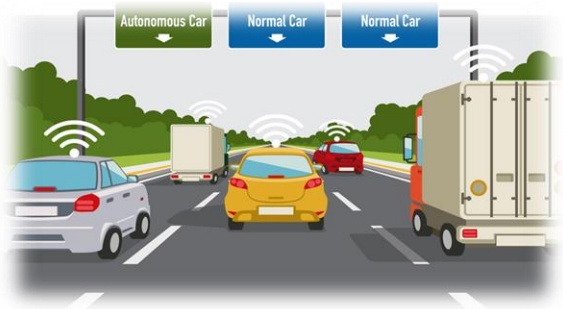
AV road readiness strategies

Mixed traffic

- Regular infrastructure
- Enhanced infrastructure

Dedicated AV infrastructure

- Dedicated AV lanes
- Dedicated AV links
- Dedicated AV zones



TU Delft

Spatial and Transport Impacts of Automated Driving

Mobility

A bi-level network design problem

Upper level:

Decide which link becomes
- AV-ready link (+
- Dedicated AV lane
- Dedicated AV link

To maximize total societal benefits

AV Network specification

Travel times, congestion levels

Lower level:

Network equilibrium with travelers' route choice

AV market penetration levels 10%, 30%, 50%,70%, 90%

Increasing roadway capacity for AV-ready, AV lane, AV link (and corresponding increasing investments)

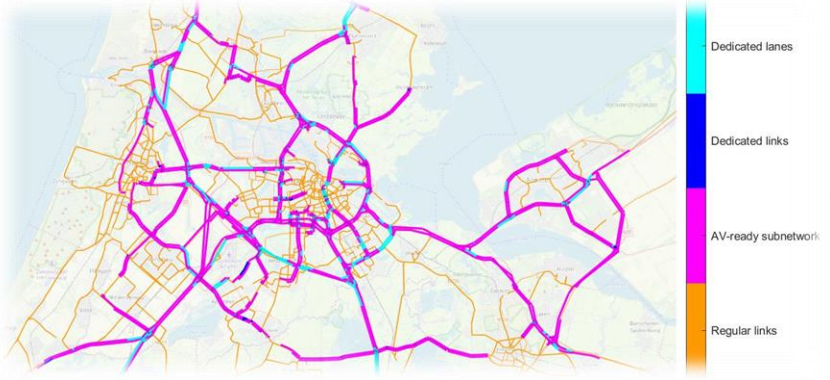
Decreased VOTT to 60-80% for AV driving

TU Delft

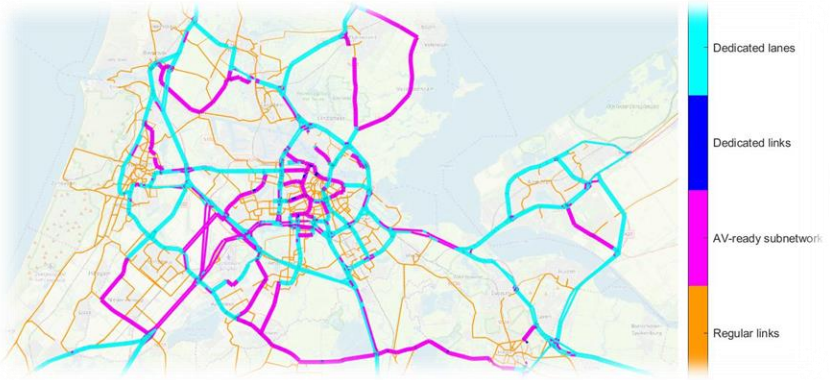
Spatial and Transport Impacts of Automated Driving

Mobility

10% AV MPR



50% AV MPR



0% MPR (base case)					
Class		**TTC (€)**	**TTT (h)**	**TTD (km)**	
All cars		611,704	35,656	1,530,514	
10% MPR					
Class	**TDTCS (€)**	**TTC (€)**	**TTT (h)**	**TTD (km)**	**TAC (€)**
CV		89.52%	89.22%	89.85%	
AV		8.87%	9.91%	10.03%	
All cars	323,021,014	98.39%	99.13%	99.88%	73,918,289
50% MPR					
Class	**TDTCS (€)**	**TTC (€)**	**TTT (h)**	**TTD (km)**	**TAC (€)**
CV		49.14%	48.54%	49.79%	
AV		40.02%	48.23%	50.30%	
All cars	2,174,874,404	89.16%	96.77%	100.09%	111,967,171
TDTSC	Total discounted travel cost savings				
TAC	Total Adjustment Costs				

Large benefits by enhancing a proportion of links

Mixed traffic first - gradually adding dedicated lanes

TU Delft

Spatial and Transport Impacts of Automated Driving

VOTT

VOTT ↓

Value of travel time in private vehicles

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

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

Methods and models

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

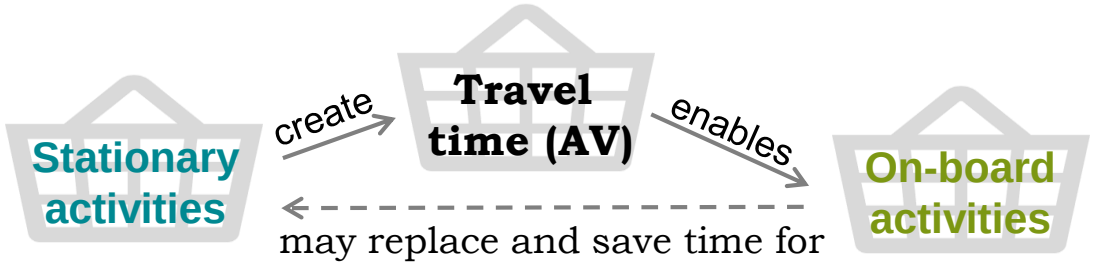
Office interior aligns with work activities

Leisure interior does not align with work activities

Convenience, safety and trust

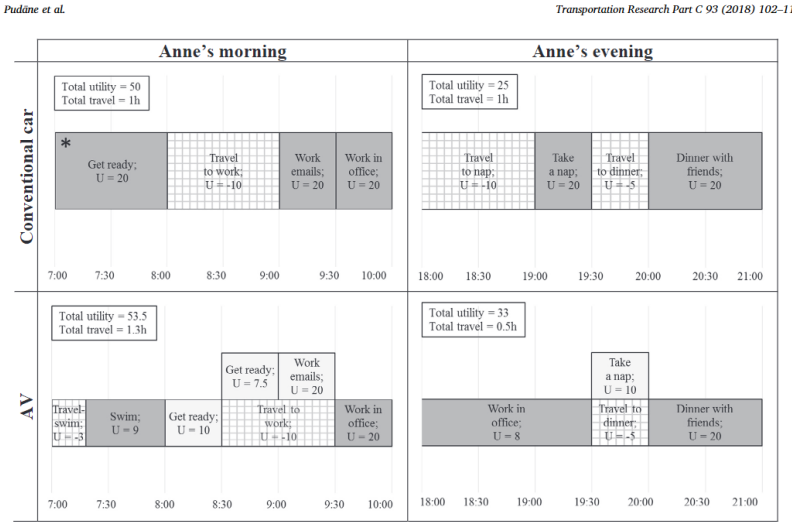
Correia et al (2019), On the impact of vehicle automation on the value of travel time while performing work and leisure activities in a car: Theoretical insights and results from a stated preference survey Transportation Research Part A: 119, 359-382

Stationary and **On-board** activities interact in daily schedules:



AVs allow to increase the role of **On-board** activities in this interaction.

By getting ready and doing emails in an AV, Anne finds time to go swimming and establishes higher daily utility.



Methods and models

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

Current models and methods, such as based on VOT useful.

New models and methods needed accounting for fundamental changes in activity scheduling.

TU Delft

Spatial and Transport Impacts of Automated Driving

Progressive deployment of Automated Driving taking place, but less fast as (some) expected).

Automated Vehicles and humans need to learn how to operate safely in shared space.

New methods and models for impact assessment needed to study the fundamental changes in impacts at high levels of automation.

Pilots and fieldlabs provide a high level of validity and a good connection between science and application.

Automated Driving needs to be considered in combination with public transport, zero-emission vehicles, cycling and new mobility modes.

On the path to Enlightenment

TU Delft, Erasmus Universiteit Rotterdam, Vrije Universiteit Amsterdam, TU Eindhoven, Metropoolregio Rotterdam–Den Haag, Provincie Zuid–Holland, Gemeente Amsterdam, Rotterdam The Hague Airport, Gemeente Den Haag, Gemeente Rotterdam, AMS Advanced Metropolitan Solutions, SmartPort , SWOV, RET NV, Mobycon, Provincie Gelderland, DTV Consultants, Connekt ITS Nederland, Gemeente Delft, Rijkswaterstaat, KiM, CROW, Transdev, RDW, TNO, Goudappel Coffeng, Provincie Noord–Holland, 2GetThere, &Morgen

Information and publications: www.stad.tudelft.nl

THANK YOU!

TU Delft