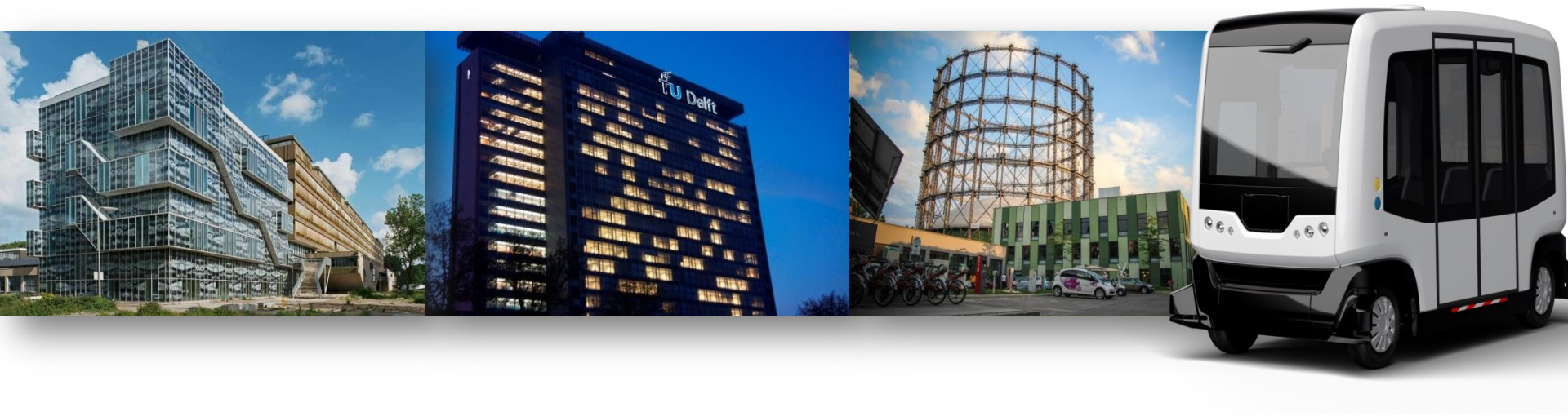


A Conceptual Model To Explain, Predict and Improve User Acceptance of Driverless Vehicles

TRB Paper

S. Nordhoff

Focus on Level 4 or Highly-Automated Vehicles defined by SAE Standard J3016

Level	Name	Narrative definition	Execution of steering and acceleration/ decelaration	Monitoring of driving environment	Fallback performance of dynamic driving task	System capability (driving modes)	BASt	NHTSA
***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	**Driver only**	**0**
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 performs all remaining aspects of the dynamic driving task	Human driver and system	Human driver	Human driver	Some driving modes	**Assisted**	**1**
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 performs all remaining aspects of the dynamic driving task	**System**	Human driver	Human driver	**Some driving modes**	**Partially automated**	**2**
***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**	**Highly automated**	**3**
Focus 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**	**Fully automated**	**3/**
5	**Full Automation**	the driving mode-specific 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**		**4**

Definiton 4P (driverless pods)

- Two vehicle types of SAE level 4

4R (regular)

4P (pod-like)

- Driverless: no actuators
- Operation under restricted operational range without need for driver action
- Manual driving beyond operational range impossible
- First-mile/last-mile solutions, link to PT

Research Questions & Objectives

- To what extent can 4P acceptance be successfully modelled?
- To what extent does 4P acceptance change within and between subjects?
- What are additional boundary conditions/contingency factors to achieve large-scale adoption of driverless vehicles?
- Development of conceptual model as holistic, integrative and systematic representation of user acceptance
- Validation of current knowledge on user acceptance of automated vehicles under real-life conditions („real“ vehicles)

AV Acceptance: Current Knowledge

More than one in two motorists inclined to buy self-driving car: 83% driving comfort, 81% saving time, 77% safety (n=8.500)(2016 Observatoire Cetelem automotive survey)**, less fuel consumption (72%), fewer emissions (64%), less congestion (52%)** (Schoettle & Sivak, 2014)

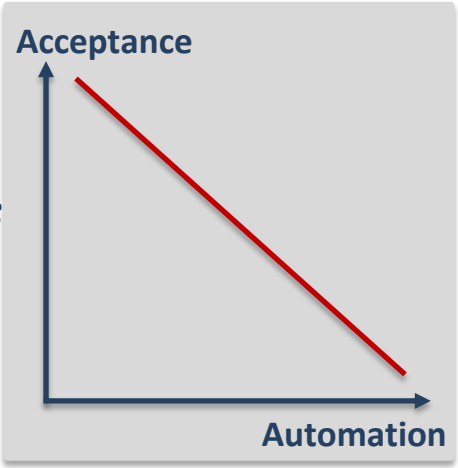
Men feel more comfortable travelling in automated vehicle than women (n=27.801) (Eurobarometer Survey on Autonomous Systems, 2015)

Elderly people have lower willingness to pay for Avs (difficulties to learn how to use them, lack of trust) (Kockelman, Bansal, & Singh, 2015)

High-income countries uncomfortable with data transmission to insurance companies, tax authorities or roadway organizations and most concerned about software issues and more likely to be negative rather than positive than people from low-income countries (n=5.000) (Kyriakidis et al., 2014)

AV Acceptance: Current Knowledge

- **Degree to which specific system is enjoyable and fun declines with higher levels of automation** (Rödel, Stadler, Meschtscherjakov, & Tscheligi, 2014)



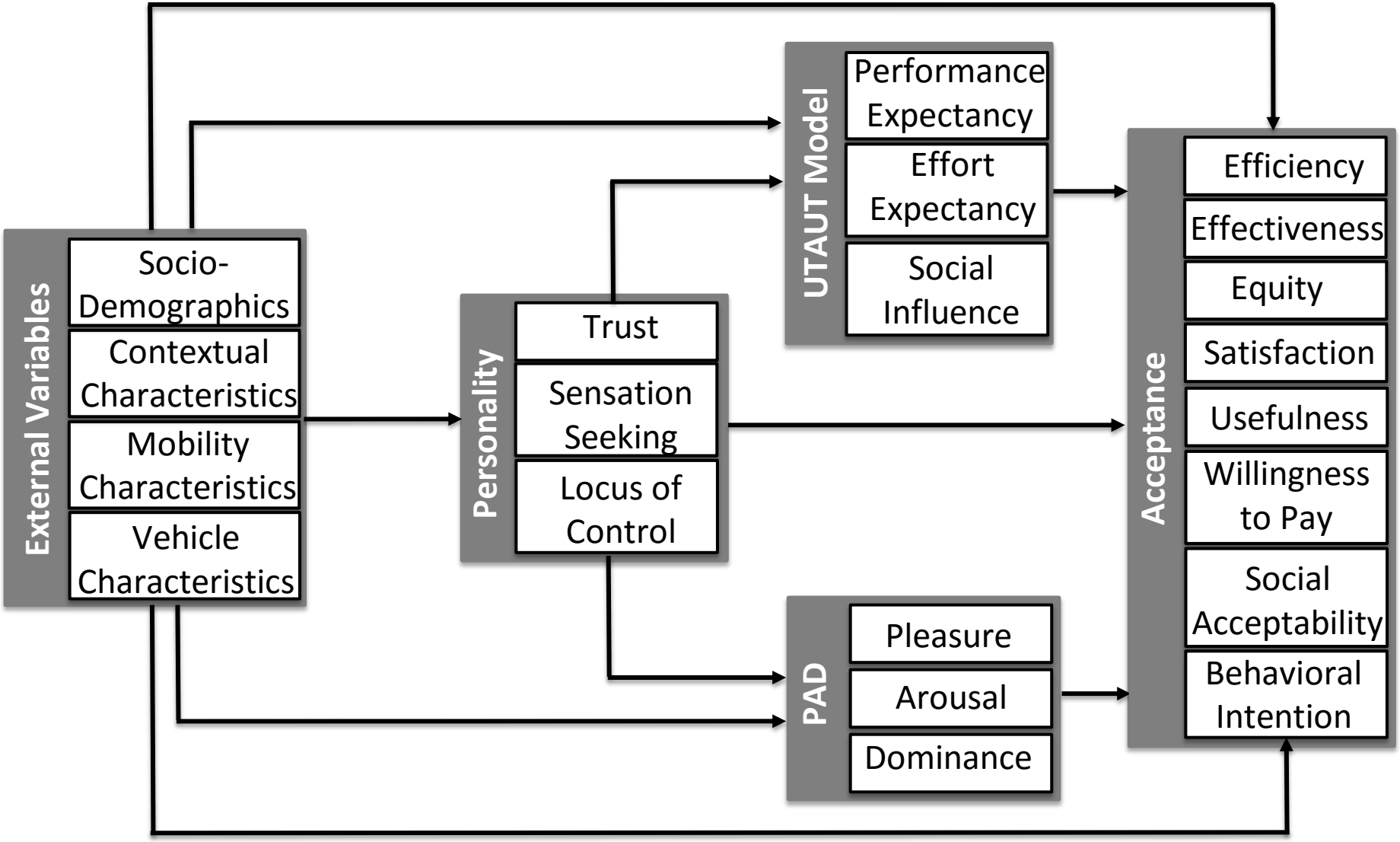
- **Manual driving is considered the most fun part of driving and full automation as the least enjoyable mode** (Kyriakidis et al., 2014)
- **Lack of trust in fully automated vehicles, manual or partial automation preferred** (Bazilinskyy et al. 2015)
- **75% of respondents wanted to talk or text with friends and look out of window in fully automated car** (Kockelman et al., 2015)

- **The higher the level of automation, the higher the willingness to rest/sleep, watch movies or read in fully automated car** (Kyriakidis et al., 2015)

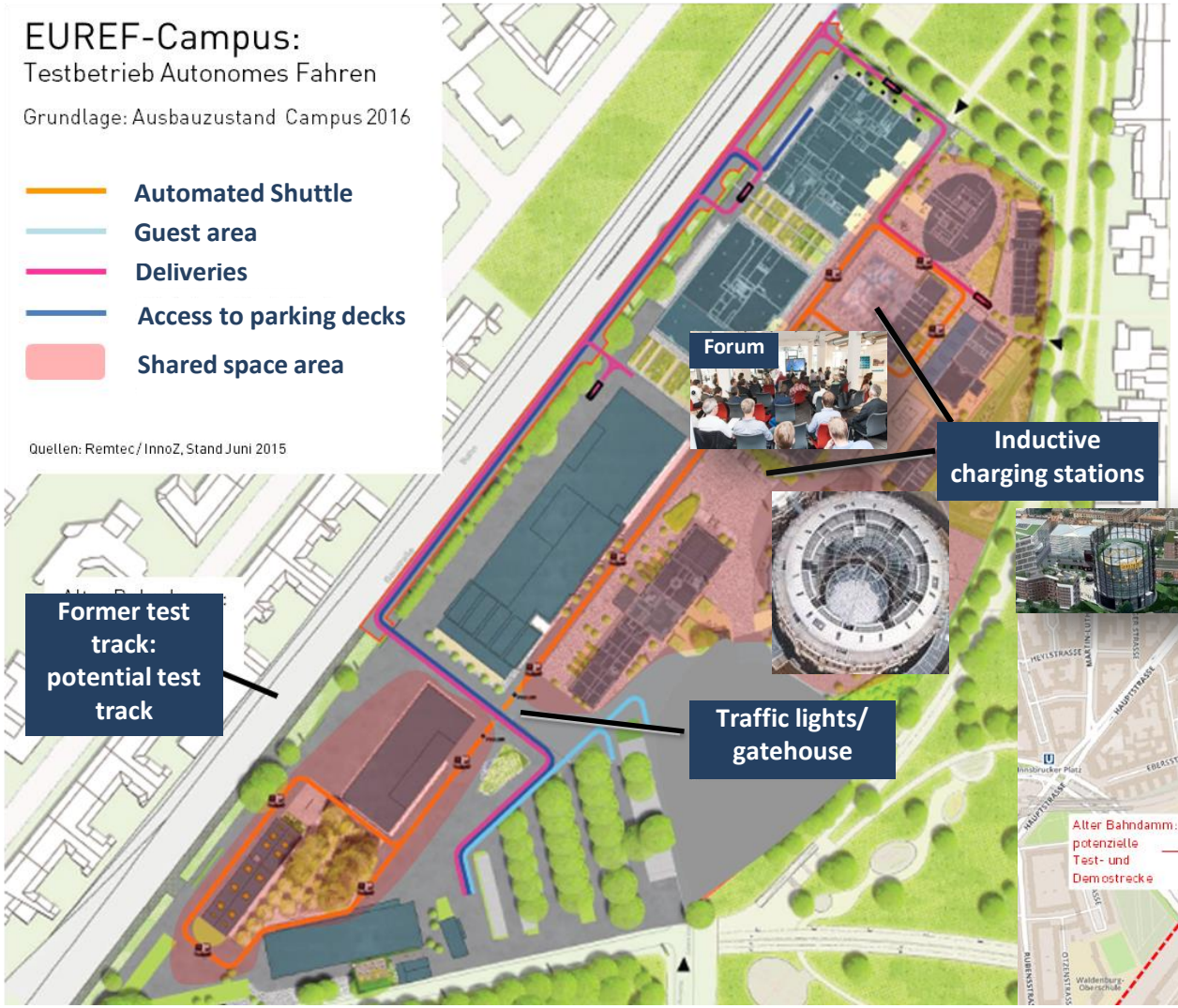
Literature Review

- **People currently using ACC show higher willingness to pay**
- **50% of respondents (n=347) would prefer family, friends, or neighbors to use automated vehicles before adoption**
- **Respondents with negative attitude towards automated driving prefer to have manual vehicle control (n=8862)** (Bazilinskyy, Kyriakidis, & De Winter, 2015)
- **AVs preferred on long freeway journeys (67%), traffic jams (52%), on rural roads (36%) and city traffic (34%)** (Continental Mobility Study 2013) **or when being impaired by alcohol, drug or medication (71%)** (Payre, Cestac, Delhomme, 2014)

4P Acceptance Model



Living Lab EUREF Campus: Automated Driving in the City



Different phases

- **Phase 1**
  - Automated valet parking and use of automated vehicles on EUREF-campus
- **Phase 2**
  - Automated shuttle transport
  - Last mile delivery
- **Phase 3**
  - Use of automated vehicles beyond EUREF-campus
  - Complete integration into automated carsharing fleet

WEPods project

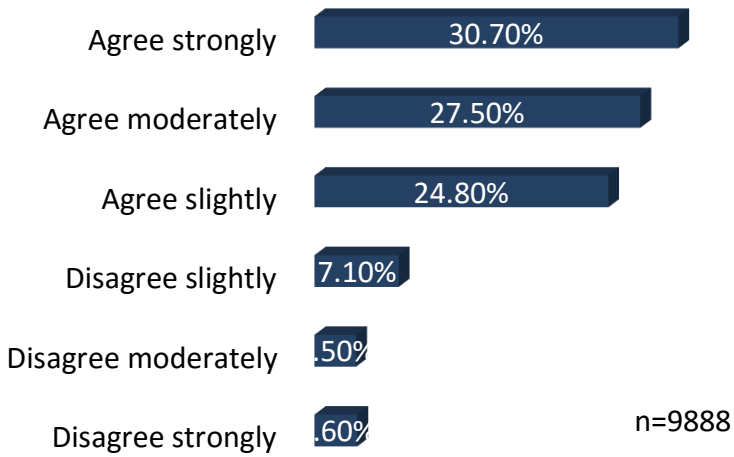
- Dutch Consortium
  - Vision, Radar, Laser,…
  - Safety by low speed
  - Two shuttles (6 seat)
    Using EasyMile EZ10 platform
- Route: Wageningen University – Ede/Wageningen railway station
- Track length: approx. 9 km
- Booking via smartphone app
- Operational: Mid 2016

Paper II: Validation by Online Survey

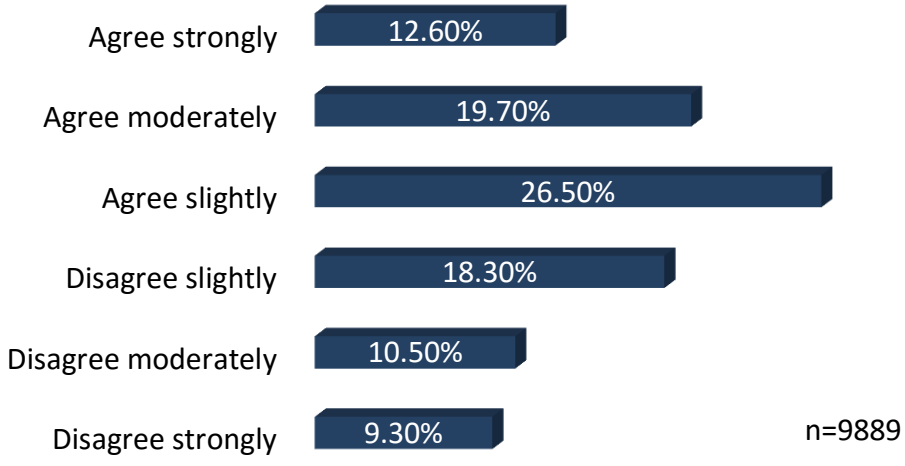
Paper No	Title/Content	Status	Planning/ Timing	Research Questions	Research Objectives	Methods
II	Why Users will Accept and Use Driverless, Pod-Like Vehicles: Results of an International Crowdflower Survey with 10,000 Respondents	In process	01/08/2016: Submission to TRB ~01/09/2016: Submission to higher-impact journal	1. To what extent is 4P acceptance influenced by variables as identified by the 4P Acceptance Model? 2. To what extent does 4P acceptance change within and between subjects?	Validation of 4P Acceptance Model	Data collection: Online Survey (n=10,001) Data analysis: Descriptive statistics, frequencies, Pearson-product moment correlation coefficients, Multiple hierarchical regression

Acceptance for driverless 4P vehicles high

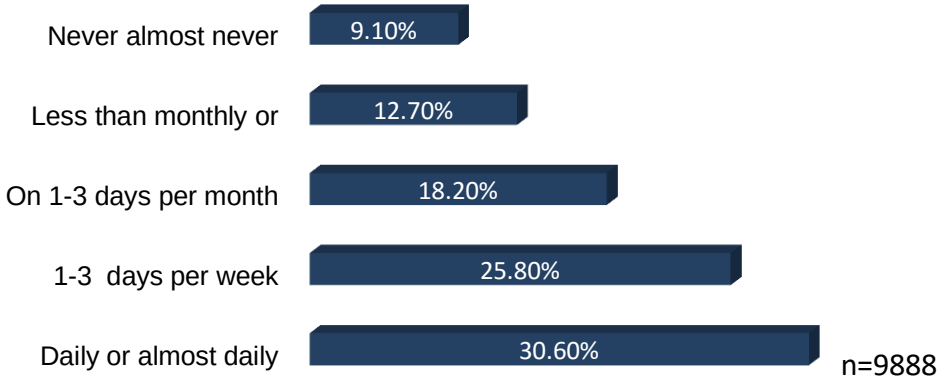
I would use a 100% electric driverless vehicle from the train station or some other public transport stop to my final destination or vice versa.



Even if it were more expensive than my existing form of travel, I would prefer driverless vehicles to my existing form of travel.



Please indicate how often you intent to use a driverless vehicle when it is on the market.



Stepwise Multiple Regression Analysis of 4P Acceptance

Predictor Variables	R^2	B	ß
Performance Expectancy	0,506	1,628	0,711
Trust	0,570	0,326	0,328
Personal Distance	0,602	0,213	0,217
Perceived Enjoyment	0,623	0,146	0,176
Effort Expectancy	0,636	0,166	0,167
Mobility-related Innovativeness	0,643	0,098	0,102

$p<0,001^*$

- Utilitarian motives may dominate affective, symbolic factors (sharing versus owning)
- Extension of model by relatively neglected factors (e.g. personal distance)
- Strong role of trust
- Mobility-related innovativeness and urban life
- Identification of determinants of perceived enjoyment

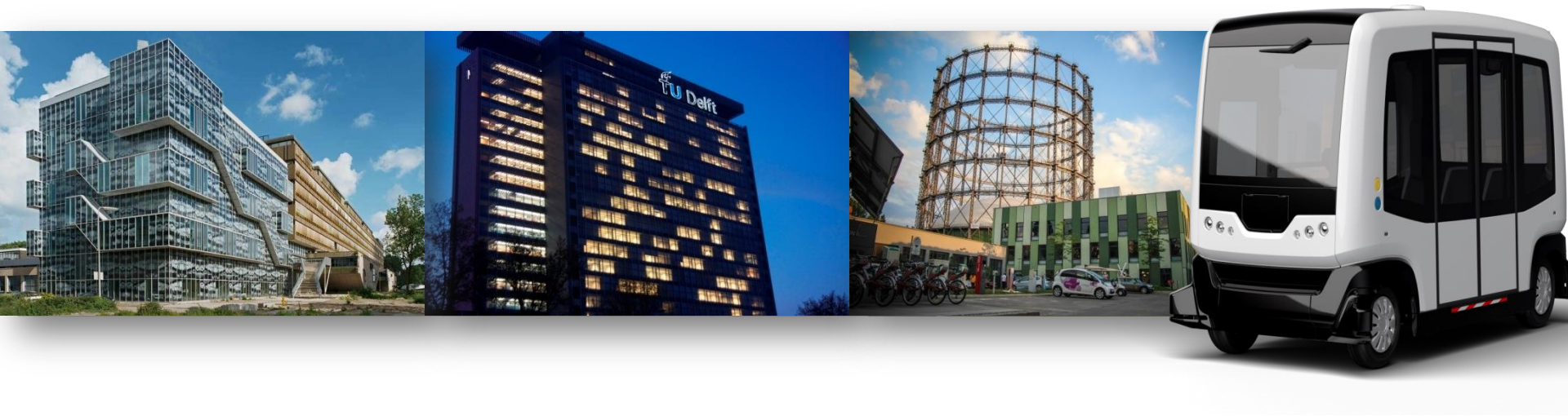
Conclusions

- Many studies about public‘s perception of Avs but critical research questions need to be addressed
- Public is generally positive about Avs
- Identification of „right“ contingencies may result in large-scale adoption
- No common definition of acceptance, no systematic representation of drivers of acceptance
- 4P Acceptance Model as status quo of user acceptance on automated vehicles
- Empirical validation of 4P Acceptance Model needed (WEpods, Living Lab EUREF-Campus)
- Push/pull factors: promote acceptance from higher level; involve key stakeholders

Open Challenges

- Access to test fields with real vehicles on public roads in mixed (national) environments
- Establish common definition of acceptance
- Uniformity of measurement across research settings
- Definition of acceptance that can be used to predict actual acceptance and adoption
- Relation to HR research???

Thank you!



Sina Nordhoff, PhD Researcher
TU Delft, Civil Engineering and Geosciences
Department Transport & Planning
s.nordhoff@tudelft.nl