Modelling the impact of automated driving -
Private autonomous vehicle scenarios for Germany and the US

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Outline

- Introduction
- Model scheme
  - Vehicle Technology Diffusion Model
  - Travel Demand Model
- Results
- Conclusion and Outlook

Introduction

- Motivation:
  - Market entry of highly and fully automated vehicles (AVs) within next years
  - AVs in private vehicle fleet and new mobility concepts (shared AVs)
  - Impact of autonomous driving on travel demand
    (VoTTS, new user groups)

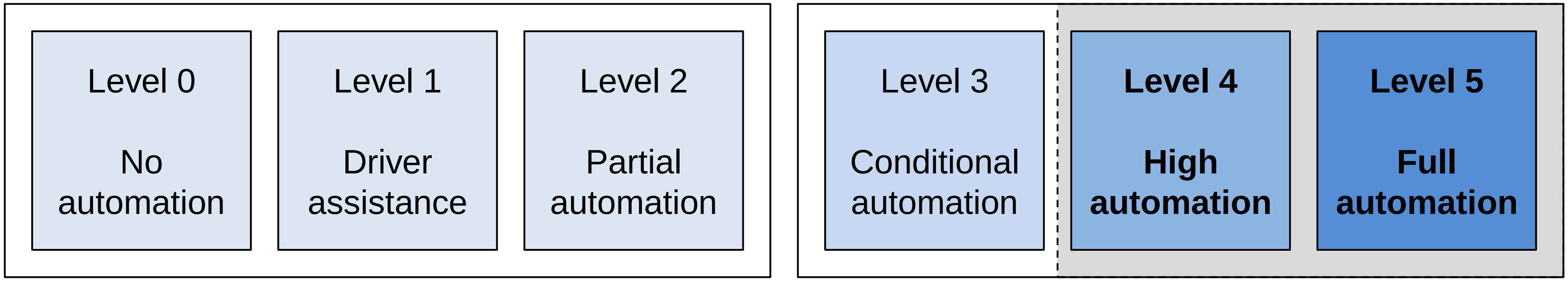
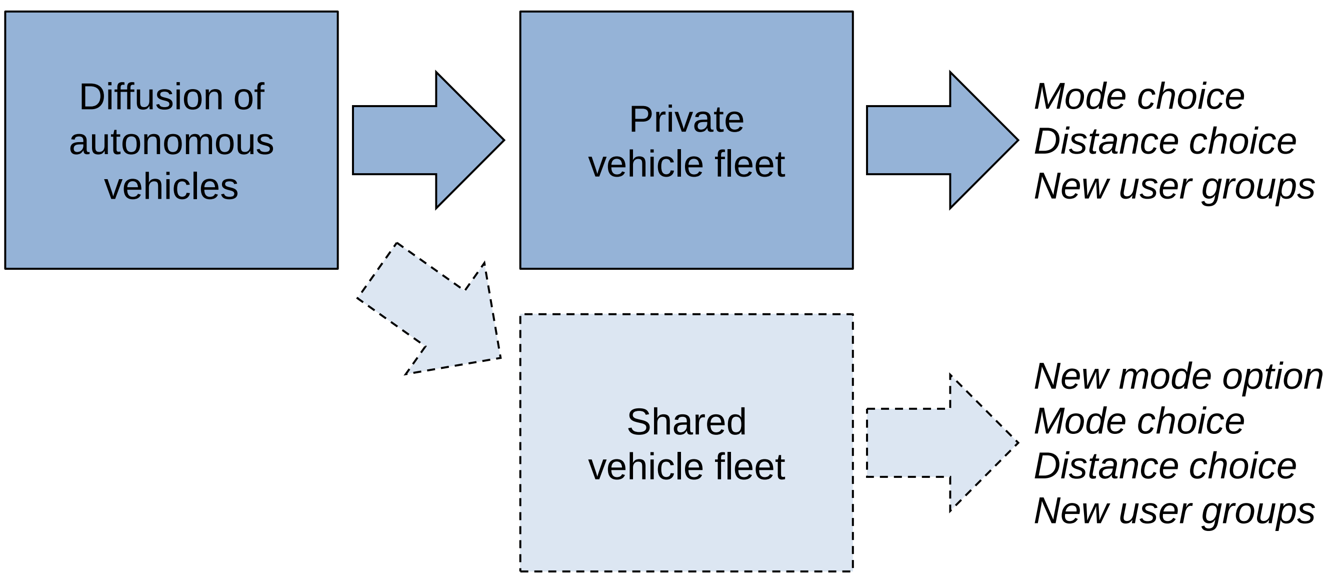


Figure 1: Levels of automation (SAE n. d.)

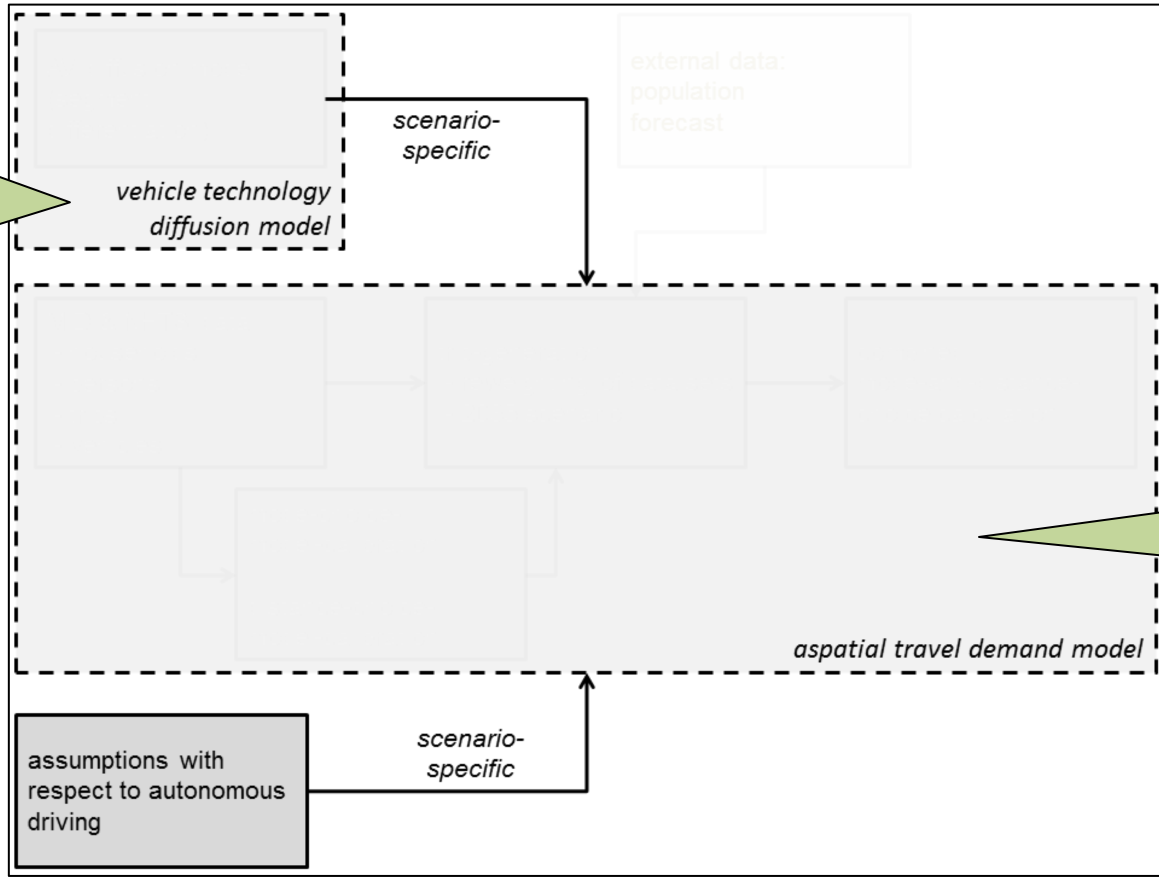
Introduction

- Topic of this study:
  Introduction of Level 4 and Level 5 vehicles into the private vehicle fleet,
  Impact on travel demand, comparison of two scenarios in Germany and the US
- Basis for a subsequent study of new mobility concepts with shared AVs



Methodology: Overview

AV diffusion rates for car segments



Impact on travel demand

Figure 2: Overview of model scheme

Methodology: Vehicle Technology Diffusion Model

- Estimation of number of newly registered AVs per year
- Differentiated by car segments (specific for the national car market: Germany: small/compact/medium/large, US: small/pick-up/medium/large)

- s-shaped market-take-up
- Differentiation of initial diffusion rates, years of introduction and growth rates

- Number of newly registered AVs P_t in year t :

$$P_t = P_\infty * a^{b^t}$$

With:

P_∞ *maximal number of newly registered AVs (with the assumption of a maximum 95% rate of AVs);*

a *quotient of the initial rate of newly registered AVs in the year of introduction;*

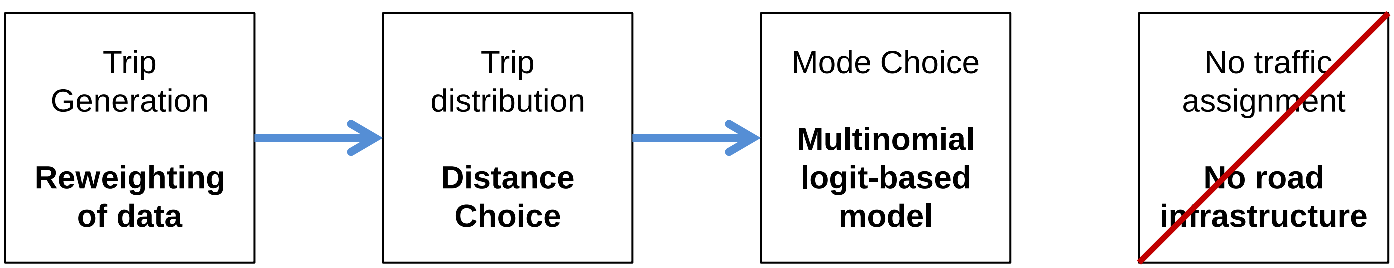
b *factor of growth;*

t *number of years since introduction.*

Methodology: Aspatial Travel Demand Model

- Macroscopic and highly aggregated travel demand model (no traffic-analysis-zones)

- Input:
  - NHTS (US) and MiD (Germany) data (household travel surveys) (household, person, trip, vehicle data sets)
  - Socio-demographic forecasts, Studies of valuation-of-travel-time-savings



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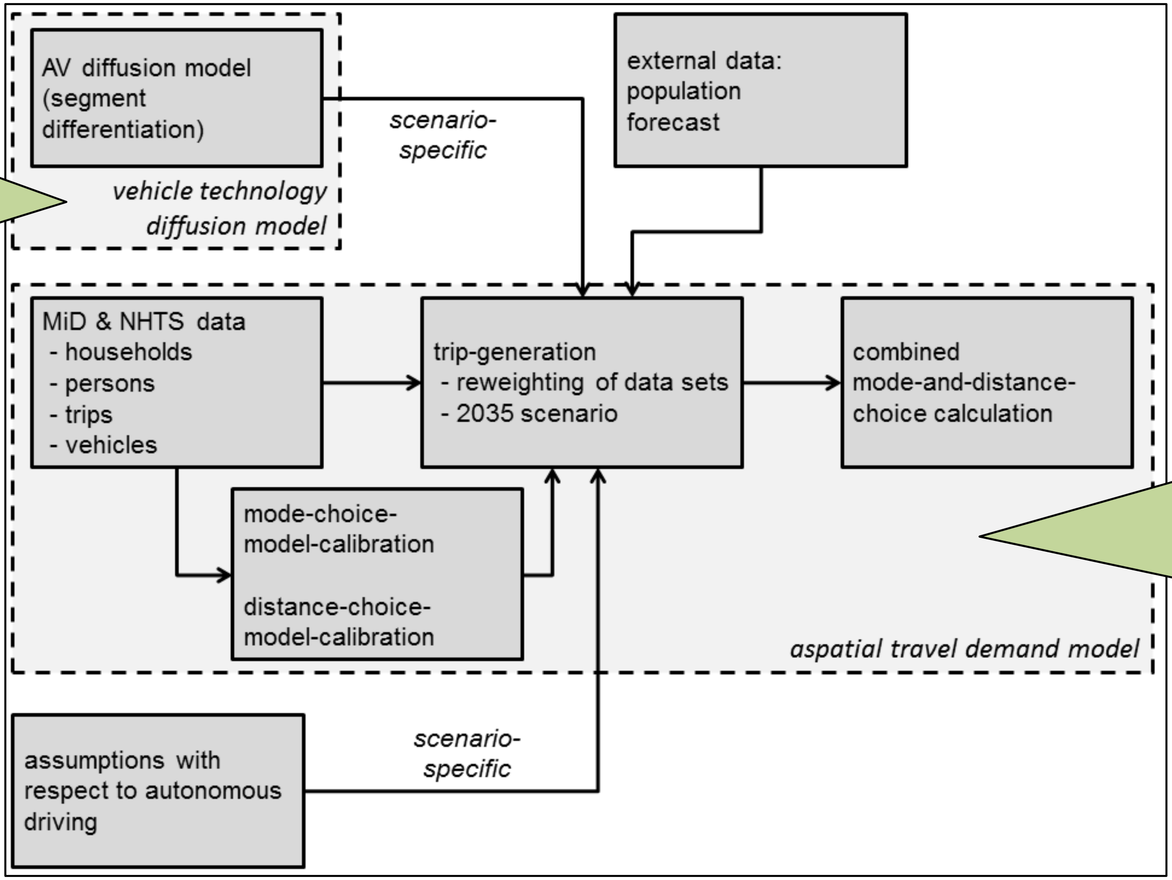

Figure 2: Overview of model scheme

Impact on travel demand

- **Trip tables (summarized weights)**
- **Mode/distance probabilities**

Methodology: Scenarios

	trend scenario 2035	extreme scenario 2035
Market introduction of AVs (differentiated by car segments) - Level 4 - Level 5	 2025-2030 2030-2034	 2022-2025 2025-2028
reduction of value-of-travel-time-savings	reduction of 25% from the 11th minute of driving on	
reduction of access and egress times to and from AVs	reduction of access and egress time from 5 minutes (GER) resp. 4 minutes (U.S.) to 3 minutes	
car availability of mobility-impaired-people	prioritized distribution of AVs to match the car-availability-ratio of non-mobility-impaired people	
car availabilty of other household members	all household members can use a household-owned AV	
car availability of teenagers	minors from 14 years on can use a household-owned AV	minors from 10 years on can use a household-owned AV

Table 1: Overview of scenario assumptions

- Two scenarios for US and Gemany
- Differentiated by AV diffusion rates and assumptions of user groups

Results: Fleet size

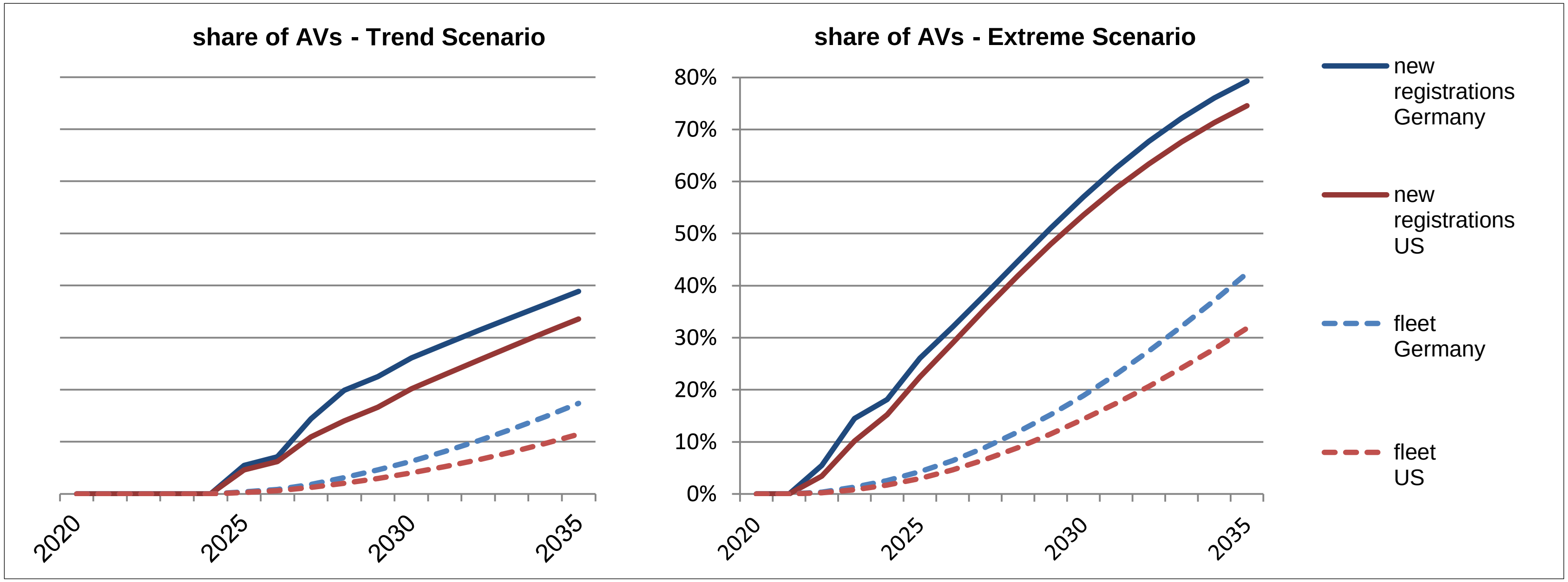

Figure 3: Share of AVs in the fleet and on newly registered vehicles (share as sum of Level 4 and Level 5 vehicles of all car segments) (own scenario calculation)

- Higher AV share in the extreme scenario and
- Higher AV share in Germany than in the US

Results: Impact on travel demand

	US			Germany		
	reference scenario 2035	*trend scenario 2035*	*extreme scenario 2035*	*reference scenario 2035*	*trend scenario 2035*	*extreme scenario 2035*
Increase in vehicle mileage - change to reference scenario		**+3.4%**	**+8.6%**		**+2.4%**	**+8.6%**
Modal share car driver (based on number of trips)	65.6%	66.9%	69.4%	45.1%	46.1%	48.8%
Change compared to reference scenario - Absolute		+1.3%	+3.8%		+0.9%	+3.7%
Change compared to reference scenario - Relative		+2.0%	+5.7%		+2.1%	+8.2%
Modal share public transport (based on number of trips)	2.6%	2.4%	2.2%	8.6%	8.3%	7.7%
Change compared to reference scenario - Absolute		-0.2%	-0.4%		-0.2%	-0.9%
Change compared to reference scenario - Relative		-6.3%	-17.6%		-2.8%	-10.6%

Table 2: Overview of the impacts of private AVs on vehicle mileage and modal share

- Moderate increase in vehicle mileage due to new user groups, modal shifts and distance choice

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Results: Impact on travel demand

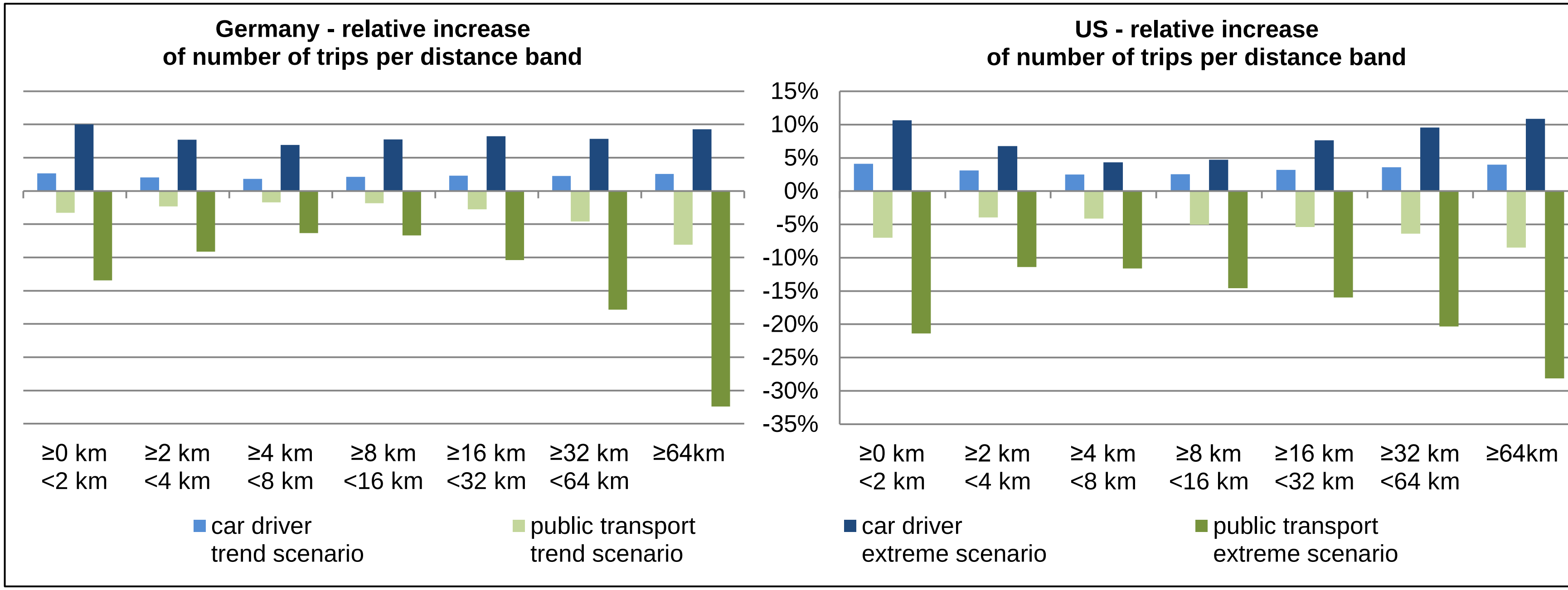

Figure 4: Increase of number of car driver and public transport trips differentiated for distance bands

- Higher increase of trips as car driver for very short and long distance trips
- High rate of decreasing public transport trips for very short and long distance trips
- Stronger effect to the distance travelled in the extreme scenario

Results: Sensitivity analysis

	US		Germany	
	trend scenario 2035	extreme scenario 2035	trend scenario 2035	extreme scenario 2035
	Change compared to reference scenario		Change compared to reference scenario	
Differentiation of the **value-of-travel-time-savings**				
VoTTS -0%	+2.0%	+2.6%	+1.4%	+4.9%
VoTTS -25% (original scenario value)	+3.4%	+8.6%	+2.4%	+8.6%
VoTTS -50%	+5.1%	+15.7%	+3.5%	+12.7%
Differentiation of the **road traffic travel speed**				
velocity +0% (original scenario value)	+3.4%	+8.6%	+2.4%	+8.6%
velocity +2%	+4.2%	+9.3%	+3.3%	+9.5%
velocity +5%	+5.4%	+10.4%	+4.6%	+10.7%
velocity +10%	+7.2%	+10.8%	+6.6%	+12.5%

Table 3: Sensitivity analysis for the value-of-travel-time-savings (VoTTS) and for the differentiation of system velocity

- Uncertainty of decrease of VoTTS and capacity restraint effects
- Higher dependence on change of VoTTS in US than in Germany
- Higher dependence on change of system velocity in Germany than in US

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Conclusion and Outlook

- Aggregated models for vehicle technology diffusion and travel demand
- Combining of different models

- Introduction of AVs into the private vehicle fleet leads to a moderate impact on travel demand
  - New user groups
  - Mode shift
  - Distance choice

- Next step: Modelling the introduction of new autonomous mobility concepts (autonomous car sharing & autonomous pooling)
  - Estimation of fleet size, properties of supply and spatial differences
  - Estimation of impact on travel behaviour, in particular mode choice

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