Automated vehicles – Game changer for urban mode choice?

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Studies expect strong impact of automation on urban transport – especially for shared systems

Up to +12% VMT resulting from additional trips with an AV made by people with mobility constrains\(^1\)

-67% \textbf{Vehicles} in an autonomous „on-demand“ system \(^2\)

-90% \textbf{Vehicles} in a shared autonomous vehicle system \(^4\)

+4% bis +8% VMT resulting from willingness to longer trips and better capacity utilization \(^3\)

-94% \textbf{Parking space} in an autonomous system with efficient public transport \(^6\)

Up to +90% VMT in a shared autonomous vehicle system without efficient public transport \(^6\)

-80% \textbf{Cost/ Mile} with a shared autonomous vehicle fleet\(^5\)

Will people change their mode choice given new automated options? An SP-experiment on mode choice and time use...

Imagine that all of the following modes of transportation are available for your trip. The trip duration and the trip cost are as presented below.

Please mark which of the following transportation modes would you choose.

<table>
<thead>
<tr>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
<th>Option 4</th>
<th>Option 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode of transport</td>
<td>Walk</td>
<td>Bicycle</td>
<td>Public transport</td>
<td>Private AV (SAV)</td>
</tr>
<tr>
<td>Trip duration</td>
<td>1 h 09 min</td>
<td>22 min</td>
<td>15 min</td>
<td>16 min</td>
</tr>
<tr>
<td>Access / egress time</td>
<td>2 min</td>
<td>5 min</td>
<td>10 min</td>
<td>2 min</td>
</tr>
<tr>
<td>Waiting time</td>
<td>10 min</td>
<td>2 min</td>
<td>5 min</td>
<td>2 min</td>
</tr>
<tr>
<td>Ridesharing</td>
<td>no</td>
<td>no</td>
<td>up to 11 min</td>
<td>no</td>
</tr>
<tr>
<td>Costs</td>
<td>Available time: no</td>
<td>Available time: no</td>
<td>Available time: up to 11 min</td>
<td>Available time: up to 11 min</td>
</tr>
<tr>
<td>Available time: Total trip time:</td>
<td></td>
<td></td>
<td>Available time: Total trip time:</td>
<td>Available time: Total trip time:</td>
</tr>
<tr>
<td>1 h 09 min</td>
<td></td>
<td></td>
<td>10 min</td>
<td>11 min</td>
</tr>
<tr>
<td>24 min</td>
<td></td>
<td></td>
<td>30 min</td>
<td></td>
</tr>
<tr>
<td>18 min</td>
<td></td>
<td></td>
<td>18 min</td>
<td>21 min</td>
</tr>
</tbody>
</table>

Private fully automated vehicle (AV)

(Shared) automated vehicle (SAV)
Mode choice preferences depend on the residential location – today and tomorrow

Urban / City (>100k)

Suburban / Town (>20k)

Rural / Village (<20k)

future situation

current situation
Users anticipate primarily trend towards shared car usage, but hardly at the expense of PT usage...
Do preferences also depend on other spatial characteristics, such as availability of a parking option?

<table>
<thead>
<tr>
<th>Region</th>
<th>Urban / City (&gt;100k)</th>
<th>Suburban / Town (&gt;20k)</th>
<th>Rural / Village (&lt;20k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking Availability</td>
<td>![Parking Symbol] 49%</td>
<td>![Parking Symbol] 23%</td>
<td>![Parking Symbol] 14%</td>
</tr>
<tr>
<td></td>
<td>![No Parking Symbol] 51%</td>
<td>![No Parking Symbol] 77%</td>
<td>![Parking Symbol] 86%</td>
</tr>
</tbody>
</table>
Available parking space at the residential location and at the destination location both play a role, even assuming a car picking you up at the place you are at …
...however, availability of parking at the residential location is more important for mode choice.
While changes in mode choice are overall relatively small, usage shares of automated options depend on trip distances!

Modal split in future scenario
no differentiation by residential locations
Private automation: time to relax while driving?

- SP-experiments of the survey were used to estimate different choice models
- Focus: changes in mode choice and travel time perception (value of time, VOT)

- Travel time perception in AV:
  - <10 km: 87% current travel time
  - > 10km: 79% current travel time

- Estimates used for scenario simulations
  - for the city of Brunswick
  - using the agent based transport demand model TAPAS

- Generally: Scenarios show only small implications for mode choice, perceived travel time & accessibility within the city of Brunswick
Time for relaxing? Let’s have a look at trips within Brunswick for an example...

Perceived travel time savings of 2+ min apply to only ¼ of the car trips – automated or not!

* FIF-scenario with shared and private automation.
Respondents do not perceive AV and SAV as game changer for urban mode choice; Study results show preferences today and tomorrow strongly depend on residential location and parking situation

- Comparably small usage of AV as well as SAV
- SAV and AV preferred rather for shorter distances, PT for longer trips

**Why?**
- Short trip distances = higher use of active modes of transportation; parking issues; small time savings due to short trips

**Generally:**
- Advantages of reduced access and egress times using AV and SAV not valued highly
- PT substitution by SAV not seen, usage in cities relatively low

**But:**
- Caution when anticipating behavioral change
- First/ last mile solutions were not considered (mitigating potential for decrease in PT attractiveness)
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Further readings:

Survey:
Steck et al. (2018): How Autonomous Driving May Affect the Value of Travel Time Savings for Commuting, TRR.
DOI:10.1177/0361198118757980

Scenario simulations:
DOI: 10.1016/j.procs.2018.04.083
Backup for discussion
The survey on time use and mode choice in a nutshell

• Online survey, 485 respondents (representative sample for Germany by age (> 18) and gender)

• Combination of revealed and stated preference (SP) methods

• 2 SP experiments, based on a reference trip:
  • Current mode choice: foot, bike, pt, car
  • Future mode choice: automated instead conventional private car, (shared) VOD

• 8 choice situations per participant / time with different trip purposes: work / shopping / leisure / long distance

• Analysis: estimation of choice models with different complexity / goals; for simulation a MNL

• Results: mode choice parameters, value of travel by transport mode with differentiation by distance, income (, trip purpose)
Accessibility analysis of shopping locations:
Number of shops within 10 minutes perceived travel time

Only minor changes for short distance trips,...
Accessibility analysis of working places:
Number of places within 10 minutes perceived travel time

...but substantial increases when looking at wider ranges.
Changes in mode choice are relatively small and depend on trip distances!

**Modal split in future scenario**

- **Walk**
  - < 5 km: 29%
  - 5 to < 10 km: 29%
  - 10 to < 15 km: 30%
  - 15 to < 20 km: 32%
  - ≥ 25 km: 30%

- **Bike**
  - < 5 km: 5%
  - 5 to < 10 km: 14%
  - 10 to < 15 km: 10%
  - 15 to < 20 km: 18%
  - ≥ 25 km: 28%

- **PT**
  - < 5 km: 14%
  - 5 to < 10 km: 14%
  - 10 to < 15 km: 23%
  - 15 to < 20 km: 56%
  - ≥ 25 km: 46%

- **AV (Car)**
  - < 5 km: 11%
  - 5 to < 10 km: 28%
  - 10 to < 15 km: 28%
  - 15 to < 20 km: 5%
  - ≥ 25 km: 14%

**Changes in modal split compared to today's mode choice**

- **Walk**
  - < 5 km: -10%
  - 5 to < 10 km: -5%
  - 10 to < 15 km: 2%
  - 15 to < 20 km: 4%
  - ≥ 25 km: 0%

- **Bike**
  - < 5 km: -4%
  - 5 to < 10 km: 2%
  - 10 to < 15 km: 0%
  - 15 to < 20 km: -2%
  - ≥ 25 km: -5%

- **PT**
  - < 5 km: 1%
  - 5 to < 10 km: -2%
  - 10 to < 15 km: 2%
  - 15 to < 20 km: -4%
  - ≥ 25 km: 8%

- **AV (Car)**
  - < 5 km: 39%
  - 5 to < 10 km: 32%
  - 10 to < 15 km: 50%
  - 15 to < 20 km: 14%
  - ≥ 25 km: 14%
Simulating the effect of automation on the city of Brunswick with the demand model TAPAS

- Basis 2010 and 2030 following German federal transport forecast (VP 2030):
  - population
  - fleet composition and size
  - transport mode costs except VOD 0.6 €, shared VOD 0.3 € (current cs price + update)

- Scenarios 2030
  - Modification of vehicle fleet and car ownership
    - Penetration rates adopted from IFMO-Project: very optimistic, German-wide
    - Reduction of car ownership resulting from VOD following Renewbility III
  - Adjustment of mode choice following survey estimates of VOT

Demand generation: TAPAS; traffic assignment: SUMO
### Scenario definition with respect to automation and fleet

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Abbreviation</th>
<th>Penetration Rate 44% PAV (DEU)</th>
<th>VOD (City)</th>
<th>VOD Shared</th>
<th>Fleet Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basis 2010</td>
<td>Basis_10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basis 2030</td>
<td>Basis_30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private fully automated vehicles</td>
<td>PVA</td>
<td></td>
<td>✔️</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOD w/o fleet reduction</td>
<td>VOD_konst</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>VOD w fleet reduction</td>
<td>VOD_red</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Shared VOD w fleet reduction</td>
<td>VOD_shared_red</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Combined automation w VOD w fleet reduction</td>
<td>combi_VOD_red</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
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</tr>
</tbody>
</table>
Integration of VOT changes in the TAPAS mode choice

- TAPAS uses MNL for mode choice, estimated on geocoded region specific data set
- Travel time and egress / assess times amongst parameters

- Different time perception for automated than manual driving considered via time adjustment
- No direct comparison between manual and automated driving possible
- Comparison via public transport:

\[
a = \frac{VOT_{\text{normal}}}{VOT_{PT1}} \quad b = \frac{VOT_{\text{automat}}}{VOT_{PT2}} \quad c = \frac{b}{a}
\]

<table>
<thead>
<tr>
<th>VOT_{\text{normal}}</th>
<th>VOT_{PT1}</th>
<th>VOT_{\text{automat}}</th>
<th>VOT_{PT2}</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=10 km</td>
<td>8,03€/h</td>
<td>8,46€/h</td>
<td>3,52€/h</td>
<td>4,28€/h</td>
</tr>
<tr>
<td>&gt;10 km</td>
<td>10,44€/h</td>
<td>8,42€/h</td>
<td>4,82€/h</td>
<td>4,9€/h</td>
</tr>
</tbody>
</table>

- Additional assumption: the existence of a „ramp-up time“, no anticipated time saving within the first five minutes

\[
t_{\text{automatisiert}} = \begin{cases} 
  t_{\text{normal}} & |t_{\text{normal}} \leq 5\text{Min} \\
  5\text{Min} + c_{\text{dist}} \times (t_{\text{normal}} - 5\text{Min}) & |t_{\text{normal}} > 5\text{Min}
\end{cases}
\]
Integration of automated driving in TAPAS mode choice

- Automated vehicles
  - Modification of the travel time (starting from the fifth minute as presented) → “perceived travel time”
  - Access and egress time = 0 min

- Vehicle-on-demand (VOD, automated Carsharing)
  - Introduction of a new mode
  - Costs and trip purpose parameter estimates of a conventional car sharing (combination of private car and public transport)
  - Age parameter estimates adapted to car sharing in Berlin
  - Usage conditions: (age ≥ 20 years, driving license = true)
  - Access time = 2 min

- Shared VOD
  - Half of the price of the VOD offer
  - Waiting time = 5 min

- None of the new modes addresses new person groups!