Benefits of Autonomous Vehicles

- Increased safety
- Reduced Traffic congestion
- Flexible mobility options
- Enhanced comfort and use of time
- Improved energy efficiency and emissions
Increased Safety: Pros

- Reduce the number of accidents (currently ca 94% human error)*

- Mitigate the severity of crashes that do occur

- Less loss of life, less injury

- Fewer traffic jams, because accidents are a major cause of congestion → fuel efficiency

- Smaller, lighter-weight vehicles possible
  - Because weight for safety systems (e.g. airbags, laminated glass) not needed → fuel efficiency

- Increased safety for pedestrians and cyclists → encourages more sustainable mobility

Increased Safety: Cons

Umm... none

Faster travel due to safer highway operation → Higher drag & fuel efficiency decreases at faster speeds

Can only prevent 1/3 of crashes if they drive like people*

- Only 1/3 could be avoided due to more accurate perception and less incapacitation
- For the remaining 2/3 they would need to be specifically programmed to prioritize safety over speed and convenience

* https://www.greencarcongress.com/2020/06/20200608-iihs.html
### CO₂ Increases with Driving Speed (Umweltbundesamt)

<table>
<thead>
<tr>
<th>Speed Limit</th>
<th>Average Speed</th>
<th>Kilometers Travelled</th>
<th>CO₂ Emissions per Kilometer</th>
<th>CO₂ Emissions in Million t CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>in km/h</td>
<td>in km/h</td>
<td>in %</td>
<td>in g/km</td>
<td></td>
</tr>
<tr>
<td>≤ 60</td>
<td>60²)</td>
<td>0,4</td>
<td>127,7</td>
<td>0,1</td>
</tr>
<tr>
<td>80 (Construction)</td>
<td>80²)</td>
<td>5,3</td>
<td>129,4</td>
<td>1,8</td>
</tr>
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<td>80</td>
<td>87,4</td>
<td>3,3</td>
<td>132,5</td>
<td>1,2</td>
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<tr>
<td>100</td>
<td>103,3</td>
<td>11,0</td>
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<td>4,3</td>
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<td>120</td>
<td>115,6</td>
<td>17,2</td>
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<td>7,4</td>
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<tr>
<td>130</td>
<td>118,3</td>
<td>7,4</td>
<td>164,8</td>
<td>3,3</td>
</tr>
<tr>
<td>No limit</td>
<td>124,7</td>
<td>55,5</td>
<td>175,4</td>
<td>26,2</td>
</tr>
</tbody>
</table>

¹⁾ Own Calculations
²⁾ Löhe (2016)
Increased Safety: Additional Side Effects

Fewer vehicle replacements
- Effect on landfills, fewer oil spills
- Less manufacturing required

Better use of land (smaller vehicles, repurpose land from parking)
Pros and Cons: Traffic Congestion

**Pros**
- Accidents, which are a common cause of congestion, will be reduced
- AVs can travel closer together, increasing utilization and capacity of the roads
- Less congestion leads to lower emissions

**Cons**
- “The Fundamental Law of Road Congestion”: the extension of most major roads is met with a proportional increase in traffic\(^1\)
  - Can we beat this by re-purposing roads (e.g. as bike lanes)?
- Increased traffic rather than parking: drive around in circles rather than pay for parking
  - 30% of the cars in congested downtown traffic are looking for parking\(^2\)

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2) https://www.reinventingparking.org/2013/10/is-30-of-traffic-actually-searching-for.html
Flexible Mobility Options: Pros

- Provides mobility options for people who are currently unable to drive
  - Don’t have a license, physical or age-related constraints, the elderly, disabled, teenagers, children
  - Gives this group more independence in their mobility
  - Reduces social isolation
- Enables easier car sharing
  - Higher occupancy per trip
  - Fewer vehicles in total: saves resources (material and energy) in manufacturing
Flexible Mobility Options: Cons

Cons:

- Additional trips that would not have been taken otherwise
  - +70% emissions due to additional travel by underserved populations*
  - -12% to -20% through higher occupancy in shared vehicles*

- Additional side effects:
  - Increases motorized travel, decreases ridership in public transit

* https://www.nrel.gov/docs/fy13osti/59210.pdf
Effects of Autonomous Driving on the Modal Split

Scenario 1
Privately-owned autonomous vehicles
- Use of privately-owned vehicles becomes more attractive
- New user groups

10% more kilometres with privately-owned motor vehicles
11% fewer kilometres with public transit

Scenario 2
A mix of privately owned AVs and shared robotaxis
- Moves individual trips with the car, public transit and cycling to the robotaxis

11% more kilometres with motorised vehicles (6% individual vehicles plus 5% robotaxis)
25% fewer kilometres with public transit

Source: Presentation by Kerstin Stark, DLR, at EcoSysHAF 2019
Enhanced Comfort and Use of Time

**Pros**
- Occupants can use their travel time for other activities (sleeping, work, social media, ...)
- Overall better travel experience and comfort level, more effective/pleasurable use of the time spent travelling

**Cons**
- More travel due to easier, more efficient travel
- People willing to commute longer distances
- Commuters currently on long-distance transit might switch to AVs
  - +50% emissions due to more travel*
  - Increased vehicle weight for luxury features (e.g. entertainment)

**Side Effects**
- Urban sprawl
- Revival of rural areas
Improved Energy Efficiency and Emissions: Pros

- 20% to -30% through optimized driving style (e.g. smoother acceleration & braking)
- 10% to -20% through optimized driving (in addition) with shared ownership
- 10% to -20% through platooning
- 20% through efficient routing
- 45% through lighter vehicles
- 4% through less time looking for parking
- 12% to -20% through higher occupancy in shared vehicles
Improved Energy Efficiency and Emissions: Cons

The rebound effect...

+70% due to additional travel by underserved populations

+30% due to faster travel

+50% due to more travel

Depends very much on HOW the autonomous vehicles are used.
Fuel Demand Depends on a Wide Range of Factors

- Private Ownership
  - Low Penetration Scenarios
  - Scenario change in total light-duty vehicle fuel demand:
    - Scenario 1: -5%
    - Scenario 2: 8%
    - Scenario 3: -1%

- Shared Ownership
  - High Penetration Scenarios
  - Scenario change in total light-duty vehicle fuel demand:
    - Scenario 4: -78%
    - Scenario 5: 217%
    - Scenario 6: -68%
    - Scenario 7: -87%
    - Scenario 8: -83%
Thank you

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