ABSTRACT

In this research, we explore the impact on mobility and energy use of wide-scale deployment of fully autonomous, privately owned vehicles. Such vehicles have a potential range of impacts on travel times, costs, and transportation system performance depending on their operating assumptions and the level of urban demand. We studied the combination of multiple effects of CAV deployment for a small hypothetical city, and used a variety of policy approaches to investigate the long-term costs, demand, and energy use, demonstrating the range of possible impacts and exploring several potential optimization strategies.

METHODOLOGY

• POLARIS agent-based transportation simulator used to generate activities and vehicles
• Microscopic traffic simulator updated to account for passenger capacity improvements from empirical studies and microscopic traffic flow studies
• Introducing CAVs can change a range of penetration levels under a variety of configurations (e.g., passenger demand, energy costs, traffic reduction, etc.)
• Polymorphic features of household vehicle sharing for CAVs is a single household’s set of vehicles (in a multi-household model)
• POLARIS code generates and simulates demand heading vehicle trips for CAV-own users
• Autonomous vehicle energy model used to estimate the energy consumption from CAVs

CASE STUDY

• Vancouver, Washington, a 4,000-ha City
• Short trips (2015-CAVE only)
• Long trips (2014-CAVE 4, 2015-CAVE 4 and 5)
• 65,000 households
• 192,092 people
• 233,743 trips
• 2,897 vehicle locations
• 3,381 bike stops

POLARIS, AGENT-BASED MODEL

• The optimal transport model proposed
• The optimal transport model proposed for an individual household trip
• The optimal transport model proposed for an activity
• The optimal transport model proposed for an event
• The optimal transport model proposed for a trip

CONCLUSIONS AND POTENTIAL NEXT STEPS

• Full AVs have potential to disrupt traffic by induced demand and Zero Occupancy Vehicles (ZOV) travel
• In the absence of data, simulation with reasonable assumptions is best way to analyze possible outcomes
• Optimization model of household vehicle and ride-sharing developed and implemented in POLARIS
• Simulate people’s travel behavior changes in the presence of level 5 CAVs

• ZOV trips could
  • Increase SOV trips more than 35% (for low penetration rate) and 48% (for high penetration rate)

• Increase VMT by 50% and 55%, respectively

• Negate much of the gains in reducing fuel consumption due to baseline vehicle technology improvement

• Introducing SOV and ZOV trips can reduce impacts somewhat (2010.5% and 45.45%) and corresponds

• Results could vary by city and context, depending on their characteristics, as well as the assumptions used

• Future research efforts focus on analyzing additional scenarios for different regions, testing various regulations, improving performance and developing models for analyzing changes in energy consumption based on physical/network characteristics

• Next steps in current analysis
  • Comparison across different vehicle technologies levels
  • Impacts of CAV operational assumptions
  • Parametric exploration of ZOV assumptions
  • ZOV change, activity flexibility, capital discount for unused veh

**IMAGE:** [ Visualization of the impact of autonomous vehicles on travel times and costs. ]

**TABLE:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
<th>Total Trips</th>
<th>VMT</th>
<th>VHT</th>
<th>Avg. Speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-base</td>
<td>Impacts of level 4 CAV Fuel use (gallon)</td>
<td>475,149</td>
<td>1,666,635</td>
<td>44,300</td>
<td>23.4</td>
</tr>
<tr>
<td>2025-base</td>
<td>Impacts of level 5 CAV Fuel use (gallon)</td>
<td>64,428</td>
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**GRAPH:**

- **Bar Graph:** Comparison of travel times, costs, and energy consumption for different scenarios.
- **Line Graph:** Trend analysis of travel times and costs over time.

**EQUATIONS:**

- $\text{Fuel Use} = \text{Number of Trips} \times \text{Fuel Consumption per Trip}$
- $\text{Total VMT} = \sum (\text{VMT per Trip})$
- $\text{Total VHT} = \sum (\text{VHT per Trip})$
- $\text{Avg. Speed} = \frac{\text{Total VMT}}{\text{Total VHT}}$

**FIGURE:**

- **Figure 1:** Illustration of the impact of CAVs on traffic flow and transportation system performance.
- **Figure 2:** Graphical representation of the impact of ZOVs on travel times and costs.

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<table>
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<tr>
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<th>Description</th>
<th>Value</th>
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<tr>
<td>Level 4 CAVs</td>
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<tr>
<td>Level 5 CAVs</td>
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**FIGURE 2:**

- **Graph A:** Comparison of travel times and costs for different scenarios.
- **Graph B:** Comparison of fuel consumption and ZOV charge for different scenarios.

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**FIGURE 3:**

- **Graph A:** Comparison of travel times and costs for different scenarios.
- **Graph B:** Comparison of fuel consumption and ZOV charge for different scenarios.

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