Autonomous Vehicle Adoption and Traffic Flow

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Introduction

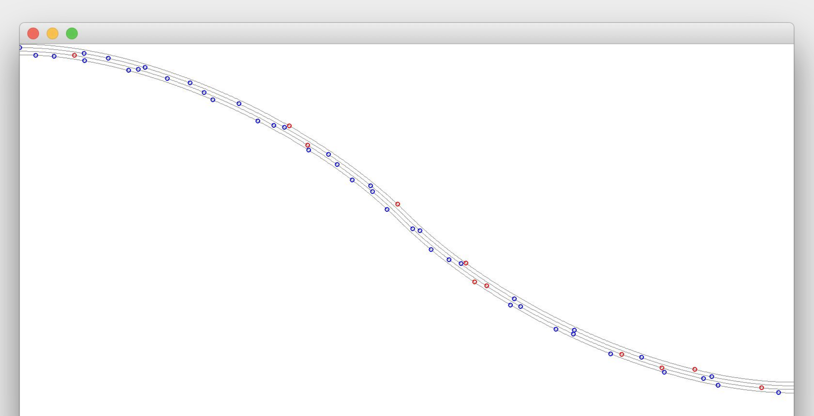
The adoption of new vehicle technology such as seat belts and airbags has been historically slow—on the order of decades (Litman, 2017). It is likely that autonomous technology will follow a similar trend, and the next twenty to thirty years could see a mixture of autonomous cars and human-driven cars on the road. Thus, the problem arises of how to integrate the two and facilitate simultaneous operation. This presents the following research question: "**How can simulations of a metropolitan freeway be used to investigate the traffic flow impact of different autonomous car adoption strategies?**"

Research Methodologies

This research focuses on using quasi-experimental computer simulations to investigate the problem of shared highway use between autonomous and human-driven vehicles.

Simulation Overview, Assumptions, Hypothesis and Experiment Variables

Four-lane, 4 km highway, no interchanges



Vehicle Behavior Assumptions:

- IDM - **I**ntelligent **D**river **M**odel
- MOBIL - **M**inimizing **O**verall **B**raking decelerations **I**nduced by **L**ane changes
- Time gap: 1.2s - 2.0s
- Average speed: 97 kph - 115 kph
- Maximum acceleration: $1.75\ m/s^2$ - $2.25\ m/s^2$

Autonomous Assumptions:

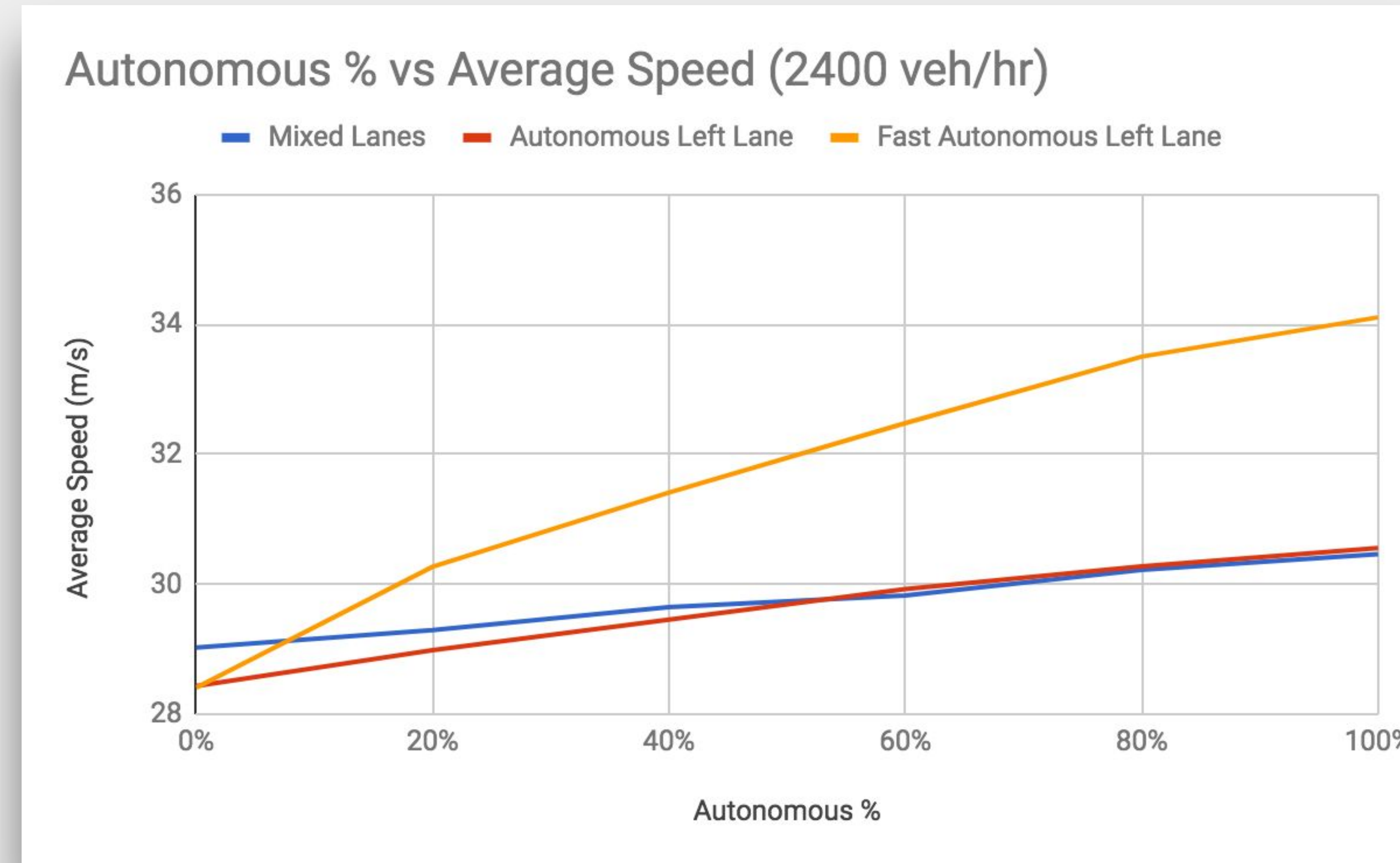
- Consistent behavior
- Comfortable acceleration
- Altruistic lane changing
- Less frequent lane changing
- Higher safe maximum speed when allowed

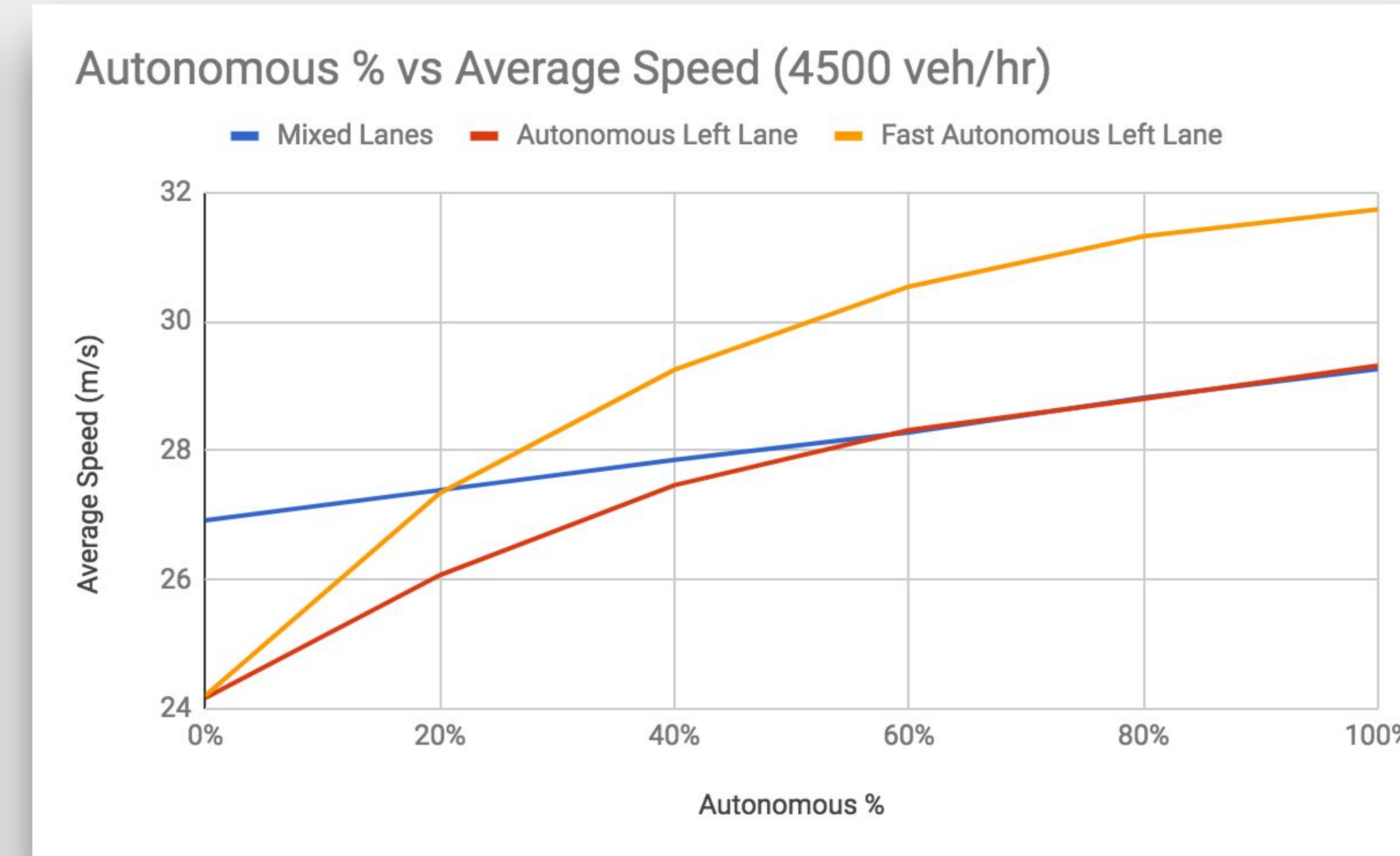
Hypothesis: Introducing autonomous vehicles into mixed roadways will increase overall traffic speed and decrease braking induced speed oscillations. Adding an "autonomous only lane" will increase traffic speed with medium percentages of autonomous vehicles. Allowing autonomous vehicles to travel faster in this lane will increase traffic speed with medium and high percentages of autonomous vehicles.

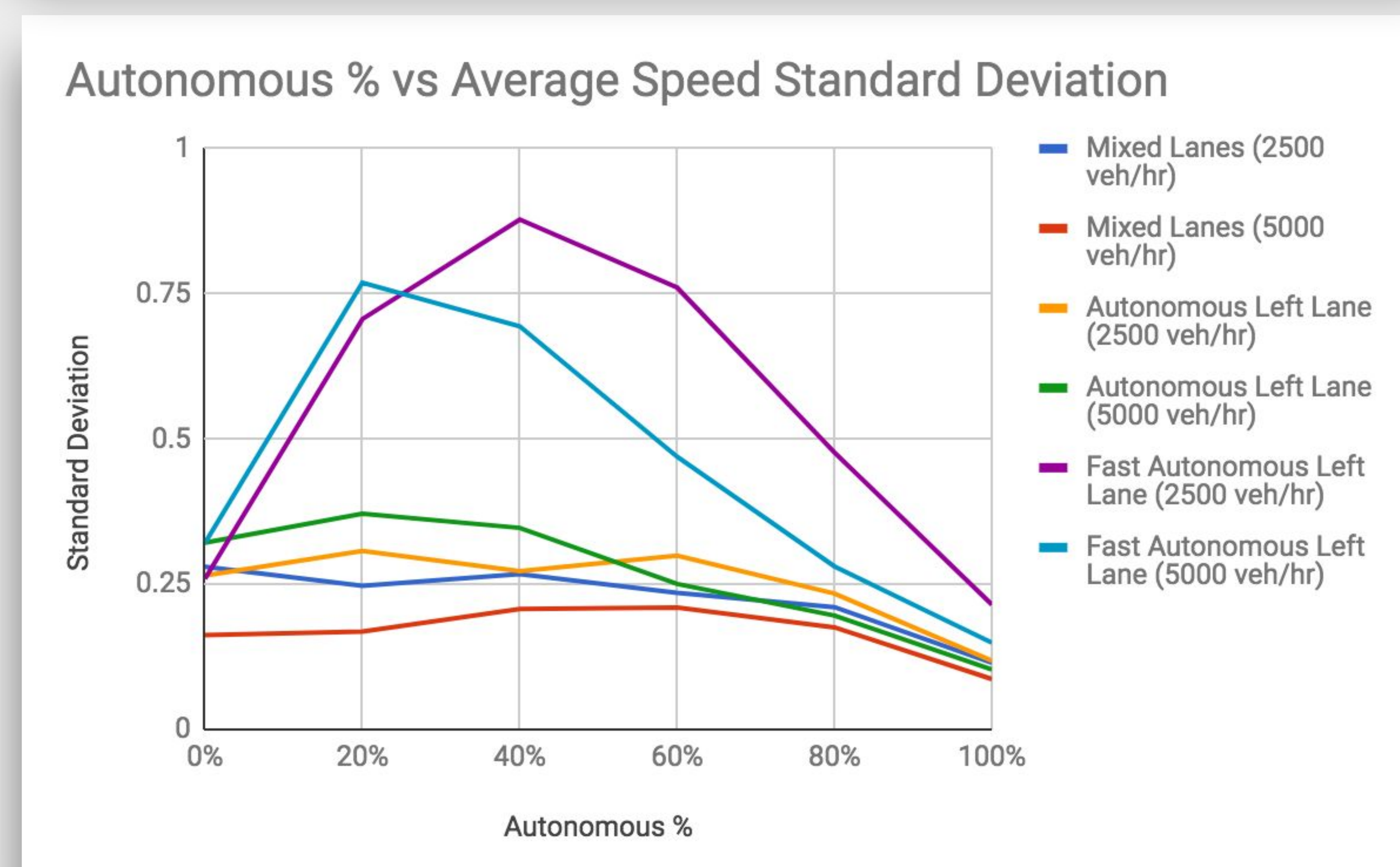
Experiment Variables:

- ***Lane configuration:*** Mixed lanes, an "autonomous only" left lane, and an "autonomous only" left lane with maximum speed increased 30%
- ***Vehicle flow:*** Lighter 2400 vehicles/hour and busier 4500 vehicles/hour
- ***Autonomous vehicle percentage:*** Increased from 0% to 100% by increments of 20%

Data and Analysis







Percentage of Autonomous Vehicles: With a vehicle flow of 2400 veh/hr on a mixed roadway, average speed increases 1.47 m/s from 0% autonomous to 100% autonomous. With a vehicle flow of 4500 veh/hr, average speed increases 2.34 m/s.

Autonomous Only Left Lane: Average speed is negatively affected when the autonomous vehicle percentage is low. However, allowing autonomous vehicles to travel faster in this lane increases average vehicle speed considerably.

Oscillations: When the percentage of autonomous approaches 80% and greater, the standard deviation of average speed drops to nearly half in almost all cases. This points to less variation in average speed over time, and less repeated slowing down and speeding up.

Conclusions, Implications and Next Steps

In summary, increasing the number of autonomous vehicles on the road will speed up traffic and help lower braking induced speed oscillations. Additionally, adding an autonomous only lane or lanes will be beneficial when a greater percentage of vehicles are autonomous. The vehicles will be able to travel faster safely, but the lanes will not go unused.

This research is important because it highlights the challenges urban planners and policy makers will face as autonomous technology continues to develop. The benefits the technology offers are clear: safer and faster roads. But the question is whether the infrastructure will be able to keep up quickly enough to take advantage of what autonomous vehicles have to offer.

Further research in this area could include modeling the nuances of highway driving, including merges and lane closures. Additionally, research could be extended to include city driving. Finally, there is the question of interconnecting autonomous vehicles to share data, and what role that plays in affecting traffic flow.

References and External Links

References:

Bansal, P. (2017). *Forecasting Americans' long-term adoption of connected and autonomous vehicle technologies*. Retrieved from http://www.caee.utexas.edu/prof/kockelman/public_html/TRB16CAVTechAdoption.pdf

Kesting, A., Treiber, M., & Helbing, D. (2007). General lane-changing model MOBIL for car-following models. Transportation Research Record, 1999. https://doi.org/10.3141/1999-10

Litman, T. (2017). *Autonomous vehicle implementation predictions*. Retrieved from https://www.vtpi.org/avip.pdf

Treiber, Martin, Hennecke, Ansgar & Helbing, Dirk (2000). Congested traffic states in empirical observations and microscopic simulations. *Phys. Rev. E, 62*, 1805-1824.

External Links:

- ***Project Github Repository:*** github.com/dardeshna/traffic-simulation/
- ***Raw Simulation Data:*** goo.gl/SPby6B