Potential Energy Impacts of Automated Driving
an overview of our research results

Jean Chu, Ph.D.
Toyota Motors North America R&D

May 6th, 2019
ACEEE Forum on Connected and Automated Vehicles: Energy Impacts
What Will be the Impacts of AD?

5 years ago in July, at Automated Vehicle Symposium...

My colleague, Ken Laberteaux, predicted that,

without policy changes, in the US, Level 2+3 Automated Driving will likely:

- Increase highway speeds (mostly via reduced congestion and accidents)
- Increase automobile Vehicle Miles Travelled
- Increase commute distances (with roughly same commute time as today)
- Less likely (vs Level 4/5) to provide new vehicle ownership models and usage cases
What Will be the Impacts of AD?

The next day 5 years ago, on Jalopnik.com blog...

This Toyota Scientist Is Wrong About Urban Sprawl And Self-Driving Cars

“Ken Laberteaux is a senior principal scientist for Toyota North America, and he's convinced that self-driving cars will increase pollution, exacerbate urban sprawl, and ruin our families. I'm pretty sure there's something in there about killing kittens too, but I may have missed it in his haze of pessimistic, contrarian bull****.”

1https://jalopnik.com/this-toyota-scientist-is-wrong-about-urban-sprawl-and-s-1607281124
...and now, almost 5 years later, who was right????

We don’t know for sure.

But we are making progress.
Q1: Which drivers would benefit most from low-complexity, Level 2 AD?

A1: The highway drivers, living in the distant suburbs

²Method for Gauging Usage Opportunities for Partially Automated Vehicles with Application to Public Travel Survey Data Sets, Laberteaux, Hamza, Berger, Brown, Transportation Research Record, Volume 2625, 2017
Partial AD Availability Preliminary Results

CHTS Data Set
- Data collection: 2010 – 2012
- Duration: One Week
- Num. Vehicles: 2910
- Location: All California

ARCTS Data Set
- Data collection: 2011
- Duration: One Week
- Num. Vehicles: 1680
- Location: Atlanta Metro Area

55% of Atlanta drivers could use AD Highway Cruise 10% of the time

20% of Atlanta drivers could use AD Traffic Jam 10% of the time

Far more Atlanta drivers (at least 2.75X) will have use for AD Highway vs AD Traffic Jam (with heaviest users in exurbs)
Q2: Which regions would benefit most from higher-complexity, Level 4-5 AD, personally-owned vehicles?

A2: The distant suburbs\(^3\)

\(^3\)Preliminary results from a Toyota R&D collaboration with U-Washington Prof. Don MacKenzie’s Lab were presented at 2019 Transportation Research Board Annual Meeting (Paper No. 19-05259)
Change of demand after introducing *Magic Carpets* (approximating high-level automated vehicles) replacing the personal vehicle.

*Assumed same cost per mile as current personal vehicle, but half of the travel time cost. Housing cost remains unchanged.*

Housing demand shifts to the surrounding suburban zones in south and northeast, where people are likely to drive with long commute time.
So, if AD on personally-owned vehicles is likely to benefit long-distance commute and increase Vehicle Miles Travelled, can we at least expect AV to be more energy efficient or electrified?

Autonomous Vehicle $\equiv$ Electric Vehicle
Q3: What could be the impact of power consumption in AD system on vehicle energy efficiency?

A3: Reduction in efficiency and driving range could be significant\(^4\)

Present-day power consumption of AD system (~2.5 kW) could shorten the electric driving range by 1/3 and increase fuel consumption by up to 32% compared to same vehicle model with no AD system.
We don’t have all the answers to the future, but what can we say now?

• While automated driving makes driving easier and more convenient, people are likely to live further and drive (or be driven) more

• AD system could have non-trivial impact on energy efficiency and electric driving range, which could be particularly unfavorable for short-range BEV

But still, there are much more we don’t know yet.