# Potential Energy Impacts of Automated Driving

## an overview of our research results

Jean Chu, Ph.D.

Toyota Motors North America R&D

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# 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*

> **Bloomberg**
>
> Markets
>
> ## Automated Cars May Boost Fuel Use, Toyota Scientist Says

# 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****."*[1]

[1]https://jalopnik.com/this-toyota-scientist-is-wrong-about-urban-sprawl-and-s-1607281124

…and now, almost 5 years later,
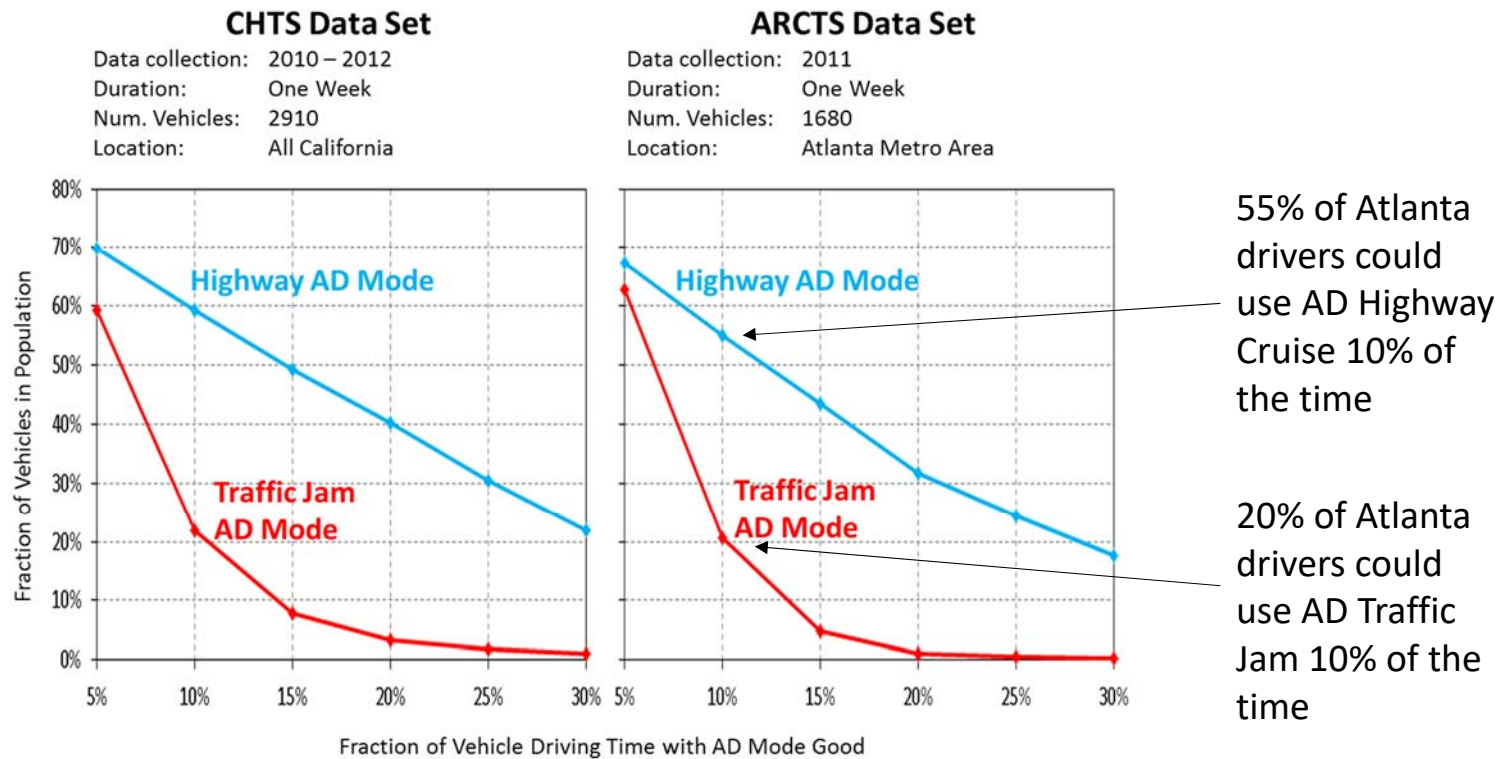who was right????


# 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[2]

[2]Method 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

Highway AD Mode

Traffic Jam AD Mode

Fraction of Vehicles in Population

Fraction of Vehicle Driving Time with AD Mode Good

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)

Preliminary, non-validated results
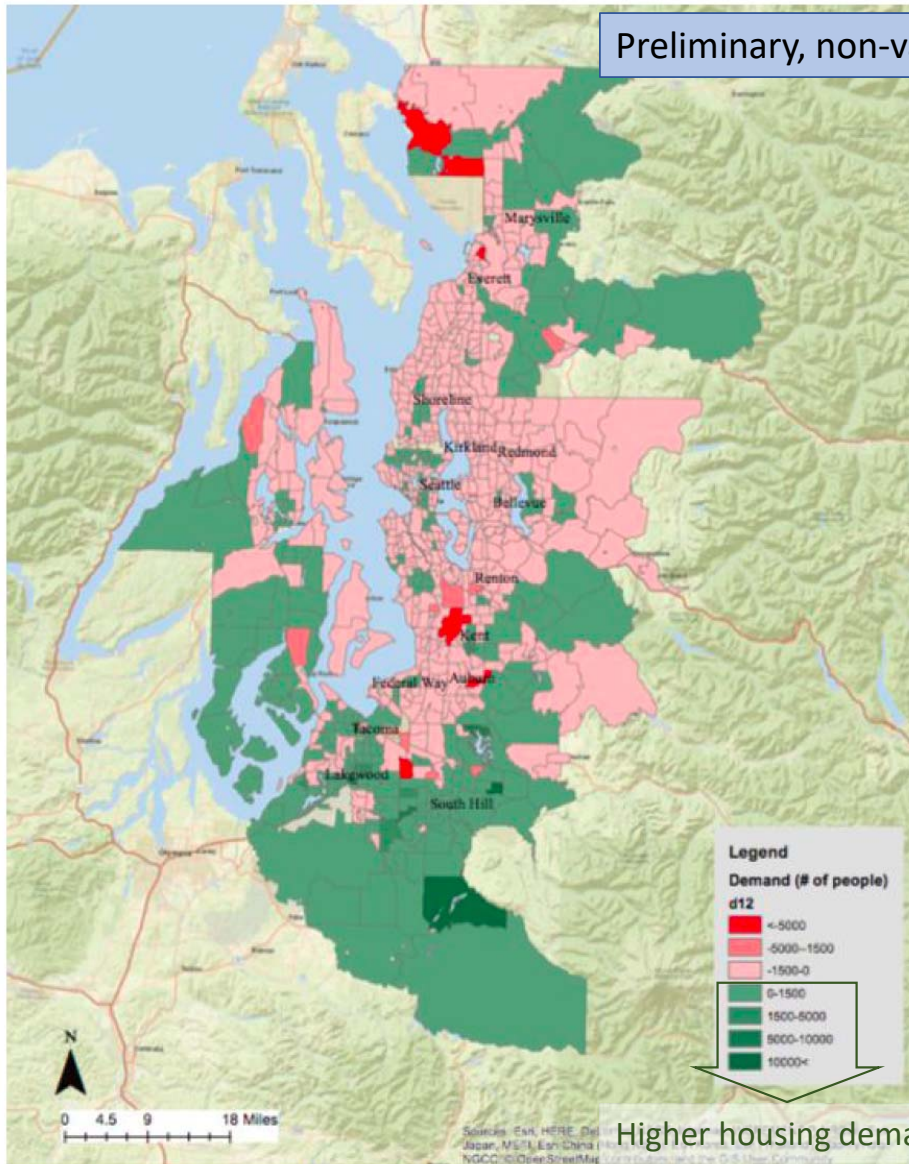
**Change of demand after introducing *Magic Carpets* (approximating high-level automated vehicles) replacing the personal vehicle.**

*[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?
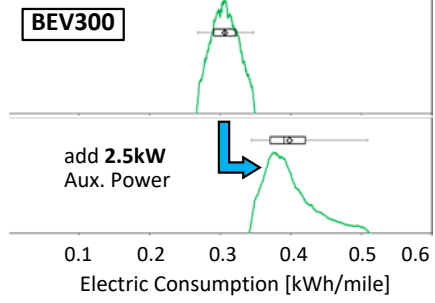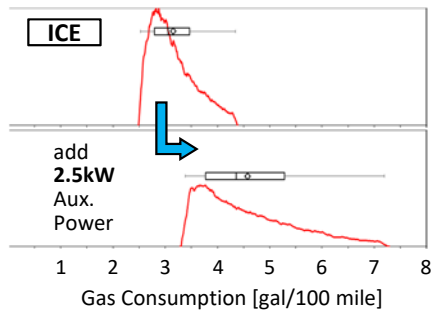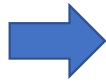
Autonomous Vehicle ⧧ Electric Vehicle

# Q3: What could be the impact of power consumption in AD system on vehicle energy efficiency?

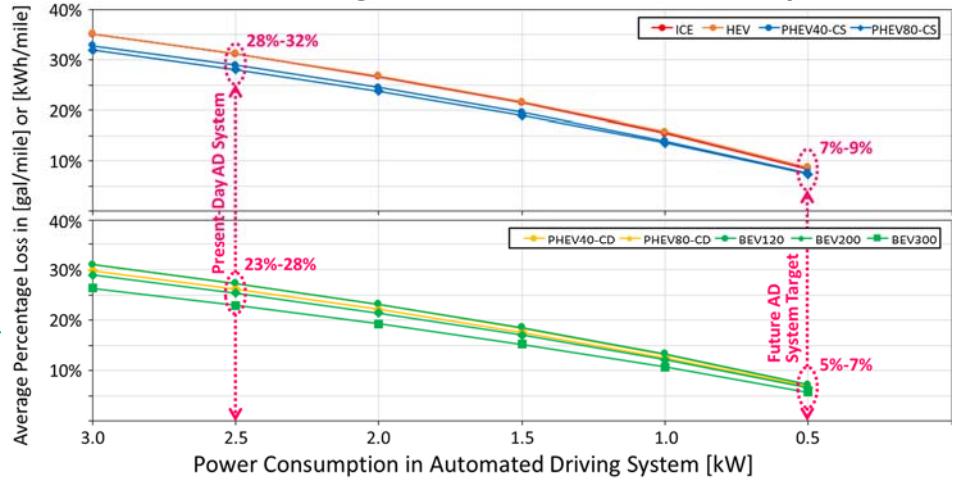## A3: Reduction in efficiency and driving range could be significant[4]

[4]Modeling the Effect of Power Consumption in Automated Driving System on Vehicle Energy Efficiency for Real-World Driving in California, Hamza, Willard, Chu, Laberteaux, Transportation Research Record, 2019

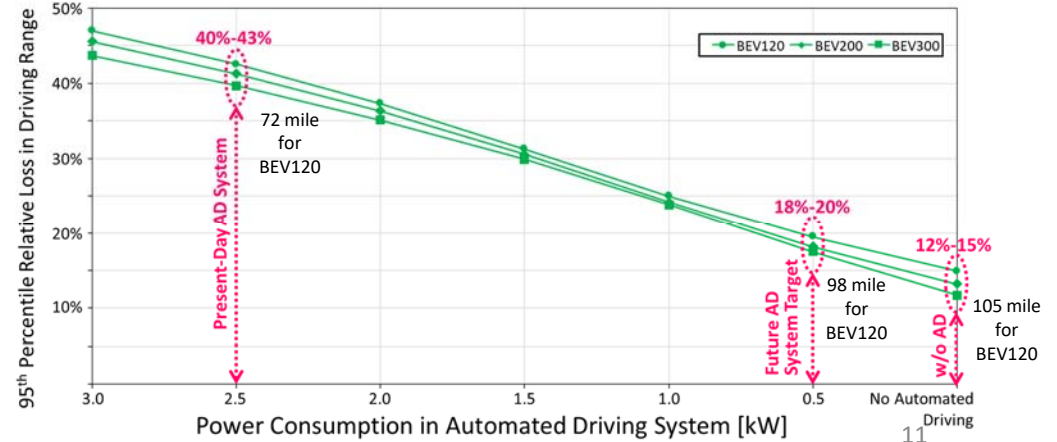# Impact of Power Consumption in Automated Driving System



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.