

TIGER 21 Chicago, IL

Driving Change – Autonomous Vehicles’ Big Impact

National Economic Education Delegation

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April 12, 2022



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National Economic Education Delegation

- **Vision**

- One day, the public discussion of policy issues will be grounded in an accurate perception of the underlying economic principles and data.

- **Mission**

- NEED unites the skills and knowledge of a vast network of professional economists to promote understanding of the economics of policy issues in the United States.

- **NEED Presentations**

- Are **nonpartisan** and intended to reflect the consensus of the economics profession.



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Who Are We?

- **Honorary Board: 54 members**

- 2 Fed Chairs: Janet Yellen, Ben Bernanke
- 6 Chairs Council of Economic Advisers
 - Furman (D), Rosen (R), Bernanke (R), Yellen (D), Tyson (D), Goolsbee (D)
- 3 Nobel Prize Winners
 - Akerlof, Smith, Maskin

- **Delegates: 651+ members**

- At all levels of academia and some in government service
- All have a Ph.D. in economics
- Crowdsource slide decks
- Give presentations

- **Global Partners: 48 Ph.D. Economists**

- Aid in slide deck development



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Available NEED Topics Include:

- **Coronavirus Economics**
- **Climate Change**
- **Economic Inequality**
- **Economic Mobility**
- **US Social Policy**
- **Trade and Globalization**
- **Minimum Wage**
- **The U.S. Economy**
- **Immigration Economics**
- **Housing Policy**
- **Federal Budgets**
- **Federal Debt**
- **Black-White Wealth Gap**
- **Autonomous Vehicles**



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Credits and Disclaimer

- **This slide deck was authored by:**
 - Jon Haveman, NEED
- **This slide deck was reviewed by:**
 - Ronald Fisher, Michigan State University
 - William F. Fox, University of Tennessee, Knoxville
- **Disclaimer**
 - NEED presentations are designed to be nonpartisan.
 - It is, however, inevitable that the presenter will be asked for and will provide their own views.
 - Such views are those of the presenter and not necessarily those of the National Economic Education Delegation (NEED).



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Outline

- **Where does the AV path lead?**
- **Transition**
- **Policy/Planning Issues**
- **Major Economic/Development Changes**



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Autonomous Taxonomy

SAE AUTONOMY LEVELS

HUMAN

LEVEL 0
Human driver is in complete control. Maybe the car shifts its own gears, if you, you know, have fun.

LEVEL 1
Driver must be ready to take over at any time. Features like adaptive cruise control, parking assist with automatic steering, lane keeping assist, in any combination.

LEVEL 2
Automated system is doing most of the driving, including steering, braking, and accelerating, but human must be alert and ready to take over at any time.

LEVEL 3
In specific situations and environments, like highway driving, the car is in complete control. Human driver can read or text or whatever if they want.

LEVEL 4
The car can drive itself independently in most environments, with some exceptions for weather or unusual environments. Human may still need to take over at times.

LEVEL 5
All robot, all the time. Humans just along for the ride and, ideally, to tell the car where to go. No restrictions where the car can drive.

ROBOT

WAYMO

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JALOPNIK

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Growth Path

The self-driving vehicle revolution

An illustration of potential growth

2015 **2020** **2030** **2050**

Era 1:
Fully autonomous vehicles (AVs) being developed for consumers

Era 2:
Consumers begin to adopt AVs

Era 3:
AVs become the primary means of transport

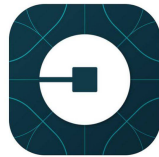
McKinsey & Company

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40+ Corporations Working On Autonomous Vehicles



WAYMO



TESLA



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WHEN?

What do the headlines say?



NVIDIA to introduce level-4 enabling system by 2018



First autonomous Toyota to be available in 2020



Volkswagen

Volkswagen expects first self driving cars on the market by 2019



Audi

Audi to introduce a self-driving car by 2020



TESLA MOTORS

Elon Musk now expects first fully autonomous Tesla by 2019, approved by 2021



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WHEN?

What is possible?

- **By 2025 (?)**
- **Potentially 95% of VMT by 2035.**
 - Last 5% may be very difficult to achieve.
- **Is this possible?**
 - Horses to cars: 10 years – early 1900s
 - But adoption of EVs is so slow!
 - Adoption of AVs will be rapid.



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Waymo's self-driving cars are now available on Lyft's app in Phoenix

Hyundai plans to launch a free robot taxi service in California

Singapore's self-driving cars can now be hailed with a smartphone

NuTonomy joins forces with 'the Uber of Southeast Asia'

Cruise to offer free robo-taxi rides in S.F. for the public — without backup drivers




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Waymo is in New York!



Waymo

New York City

Waymo driving territory

Image courtesy of Waymo

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Trucking – Highly Fertile Ground

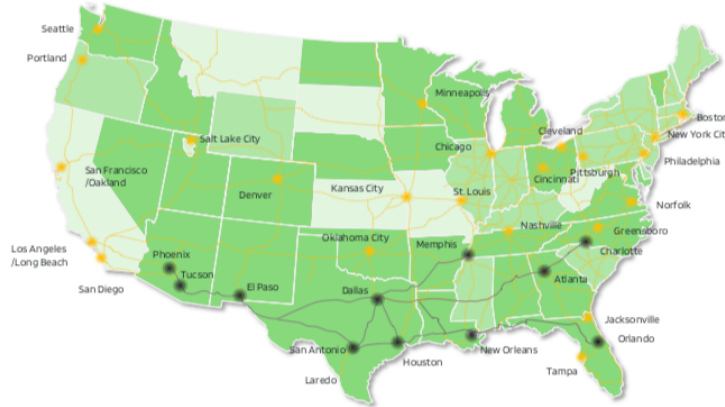
- **Long haul trucking is likely the first place we will see it adopted.**
 - Reduces costs associated with drivers.
 - End run around limits on hours of driving.
- **Where does it stand?**
 - Lots of trials underway.
 - TuSimple – actively building a long haul network.
 - Waymo – focused more on last mile/local delivery.

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TuSimple Current and Future Routes (Level 4)



44 states
allow autonomous semi-truck testing

26 states
allow autonomous semi-truck commercial deployment

50 states
cohesive AV operations framework laid out in US DOT 4.0 AV Regulations

AFN Network Expansion PlansTM

- Current Routes
- Future Expansion Plans

Regulatory Landscape

- L4 Autonomous Commercial Operations
- L4 Autonomous Testing
- In Progress



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What will the future look like?



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This:



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But, will it be:





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Hell

- **Primarily individual private car ownership**
 - Much as today.
- **Internal combustion engines**
- **Why Hell?**
 - Dramatically increased VMT and pollution.
 - Potentially increased congestion.
 - Parking

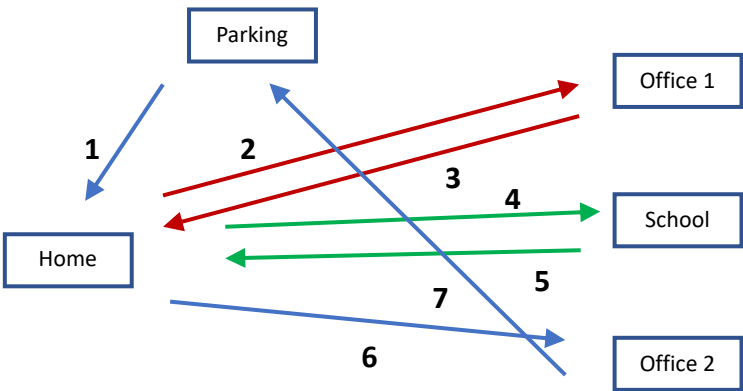





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Two Adults and a Child: Morning Miles



And this is just the morning.....



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Heaven



- **Vehicle ownership will be very limited**
 - Private ownership for those with specialized vehicle needs.
 - Fleet ownership will serve everybody else.
- **Engines: electric**
- **Not clear when we will get there, but this is the likely model.**
 - 2030 for widespread adoption in many regions.



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Why is this Heaven?

- **Not only autonomous, but:**
 - Shared
 - Connected
 - Green
- **Far fewer cars in existence.**
 - Better resource utilization.
- **VMT could go up or down, but more productive than in Hell.**
- **Congestion effects – unclear, but likely reduced.**
 - Right-sized vehicles, platooning, sharing, V2V communication
- **Minimal need for parking.**



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Economics Drives Transition: Private

- **Adoption dividend for private individuals**

- Eliminate car ownership
 - Ave annual cost of owning a car: \$9,561 (2020)
 - Cost per mile will fall: \$0.59 to \$0.19
- Repurpose your garage
 - \$50,000 from transition to bedroom

Average Costs Per Mile

Miles per Year	10k	15k	20k
Average Cost	82¢	64¢	55¢

- **Time recovery**

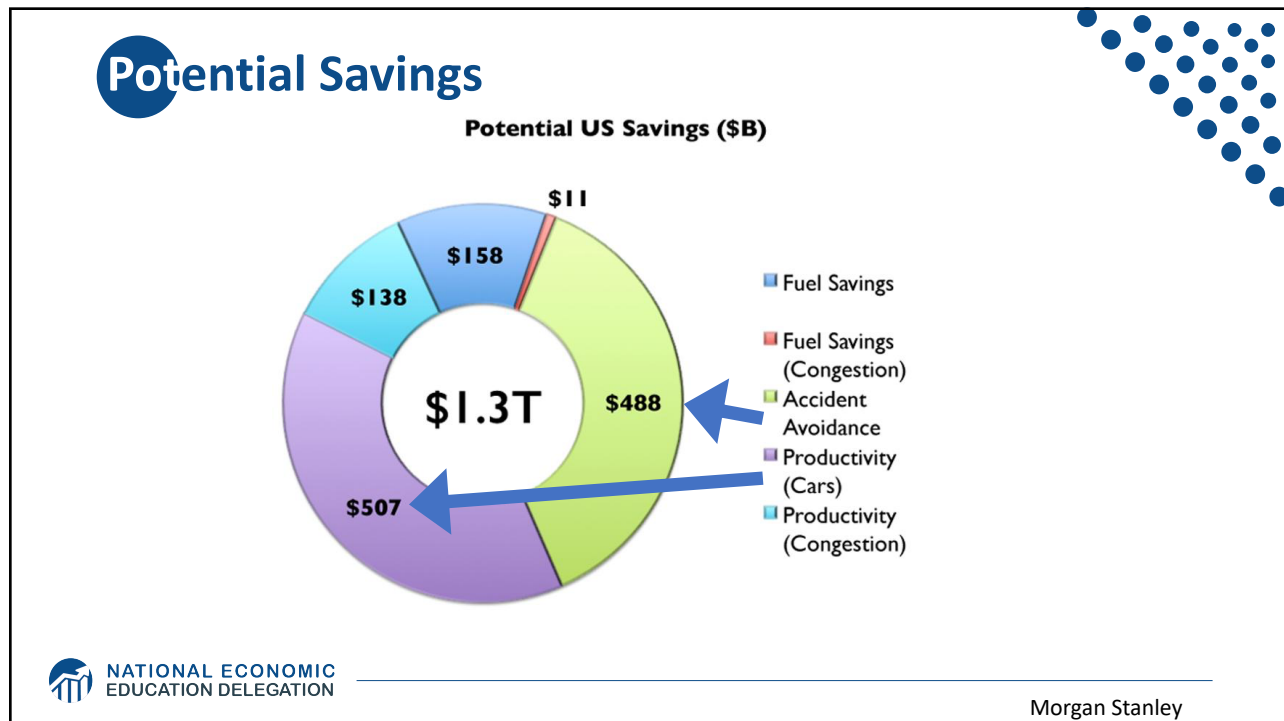
- 50% of the King County workforce has a commute in excess of 30 minutes.

Economics Drives Transition: Public

- **Economic and social costs associated with human drivers are enormous:**

- ACCIDENTS:
 - Drive 25% of congestion.
 - Result in 40,000 deaths.
 - And 2 million injuries.
 - 90+% caused by human error.
- Increased productivity from not driving.
- Costs of human drivers estimated at up to \$1.3 TRillion each year





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Encourage Change

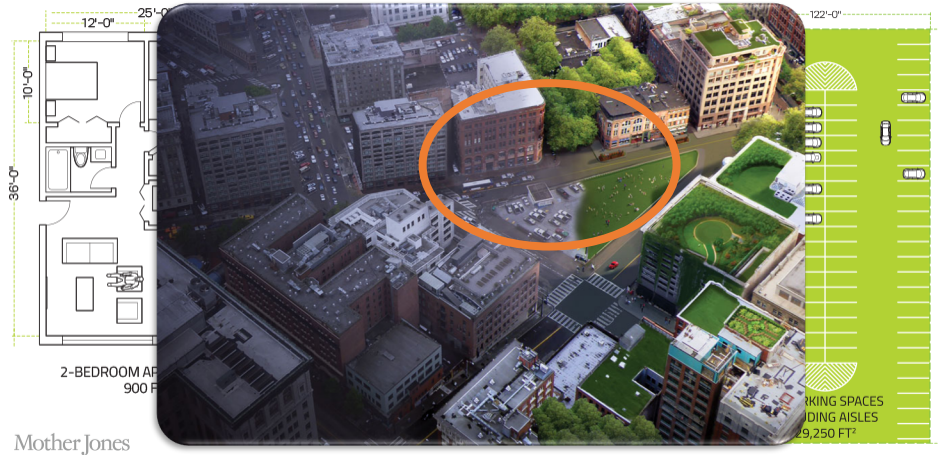
- **Mobility and equity considerations**
 - Elderly/disabled/impooverished
- **Safety:** only way to reduce traffic fatalities is by coordinated effort
- **Productivity:** reduced congestion
- **Environment:** speed transition to electric vehicles

These are all societal benefits that come about too slowly if the private market is left to itself.

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Environment



Environmental Implications Depends: Heaven or Hell

- **Improved resource utilization**
- **More efficient travel**
 - Right sized vehicles
 - Optimized routes
 - Reduced congestion
 - No searching for parking
- **Increased VMT**
- **Cleaner technologies**
 - Electric
 - Lighter vehicles
- **Energy use of onboard electronics**
 - Weight and functional
- **Increased urban sprawl**

Bottom line: push governments at all levels to embrace and to implement policies deterring private vehicle ownership and zero passenger miles

What Changes Will This Bring?

- Disposable income
- Government finances
- Transportation demand
- Infrastructure
- Housing
- Public transportation
- Employment
- Parking

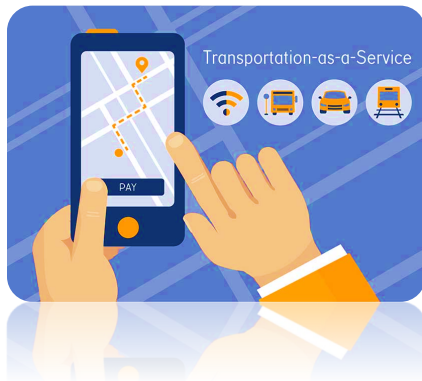
Potentially dramatic improvements in infrastructure planning and maintenance -
Data sharing and integration



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Public Transportation



- **Ambiguous implications for public transportation**
- **Demand may:**
 - Shrink because of low cost of TaaS
 - Grow because last mile problem is solved
- **Extensions may be added through contract with TaaS company**



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Employment

- **Massive job displacement/relocation (Millions!):**
 - Drivers of all varieties: truck, taxi, delivery...
 - Car production jobs, car parts production jobs
 - Gas station, vehicle repair, and body shop
 - Police and fire
 - Health care workers
 - And so on...

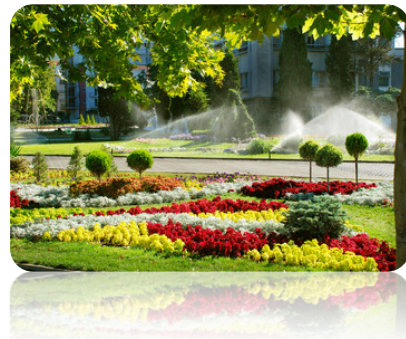


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Parking

- **Greatly reduced demand for parking lots.**
- **Service providers will own parking lots in strategic places.**
- **Street parking will largely be a thing of the past.**
 - More green space in cities
- **Shopping mall and apartment parking?**
 - Converted to housing?



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Freeing Up Urban Space from Parking

- **Los Angeles: 14% of incorporated land area**
 - 200 Square miles
- **San Francisco: 275,450 on-street parking spaces**
 - Enough to parallel-park a line of cars 60 miles longer than California's entire 840-mile coastline
- **Nationwide: (estimate) 500 million spaces**
 - That's larger than Delaware and Rhode Island combined.
 - Could be as many as 2 billion (add in Connecticut and Vermont).



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Summary of Change

- **Massive employment upheaval.**
- **Local government finances will look very different.**
- **Housing will be easier to build and more plentiful.**
- **Parking conversions will be commonplace.**
- **Demand for transportation infrastructure will likely decline.**
 - Transportation infrastructure technology will be a booming business.
- **Demand for public transportation may well decline.**
- **Coming likely sooner rather than later!**



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Potential Problems and Concerns

- Expansion of the electric grid to provide sufficient capacity.
- Mining for rare earth minerals for batteries.
- Hacking of autonomous vehicles for nefarious purposes.
- Competition in service provision in some markets.
- And many more...



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Investment Opportunities

- Parking lots/garages
- Transportation technology
- Certain residential properties
- Apartment complexes



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Thank you!

Any Questions?

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