

*TIGER 21 Naples & Miami, FL*

# Driving Change – Autonomous Vehicles’ Big Impact

National Economic Education Delegation

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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
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- **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

**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



**ATOYOT**



WAYMO



**HONDA**



**Audi**



**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**

**Cruise launches driverless robotaxi service in San Francisco**

**Argo AI is testing fully driverless vehicles in Miami and Austin**




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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

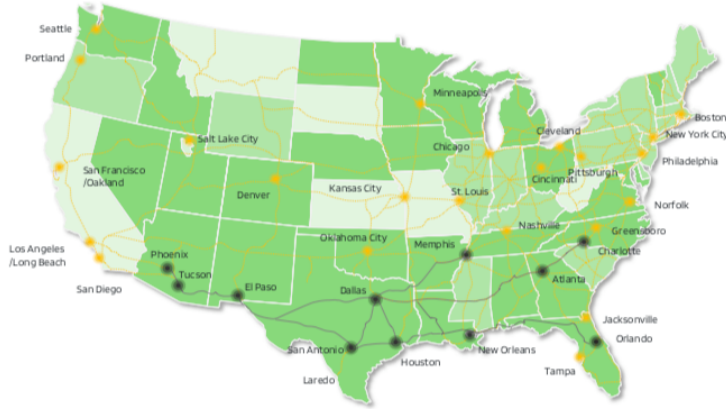
- **Long haul trucking is likely the first place we will see it adopted.**
  - Reduces costs associated with drivers.
  - End run around limits on hours of driving.
- **Where does it stand?**
  - Lots of trials underway.
  - TuSimple – actively building a long haul network.
  - Waymo – focused more on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

- 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

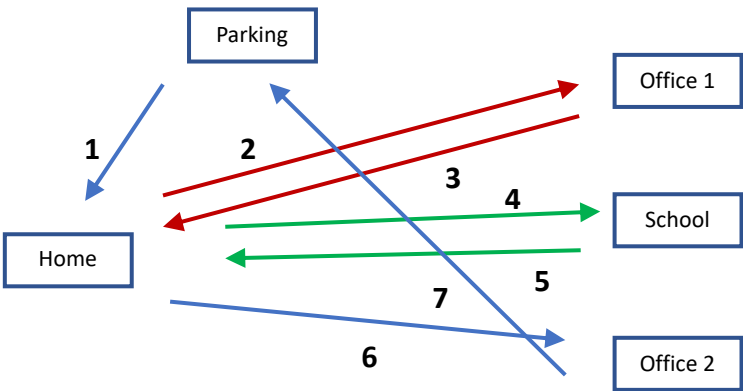





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# Two Adults and a Child: Morning Miles



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**
- **Insurance: product liability**
- **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: \$9,666 (2021)
  - Cost per mile will fall: \$0.64 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.

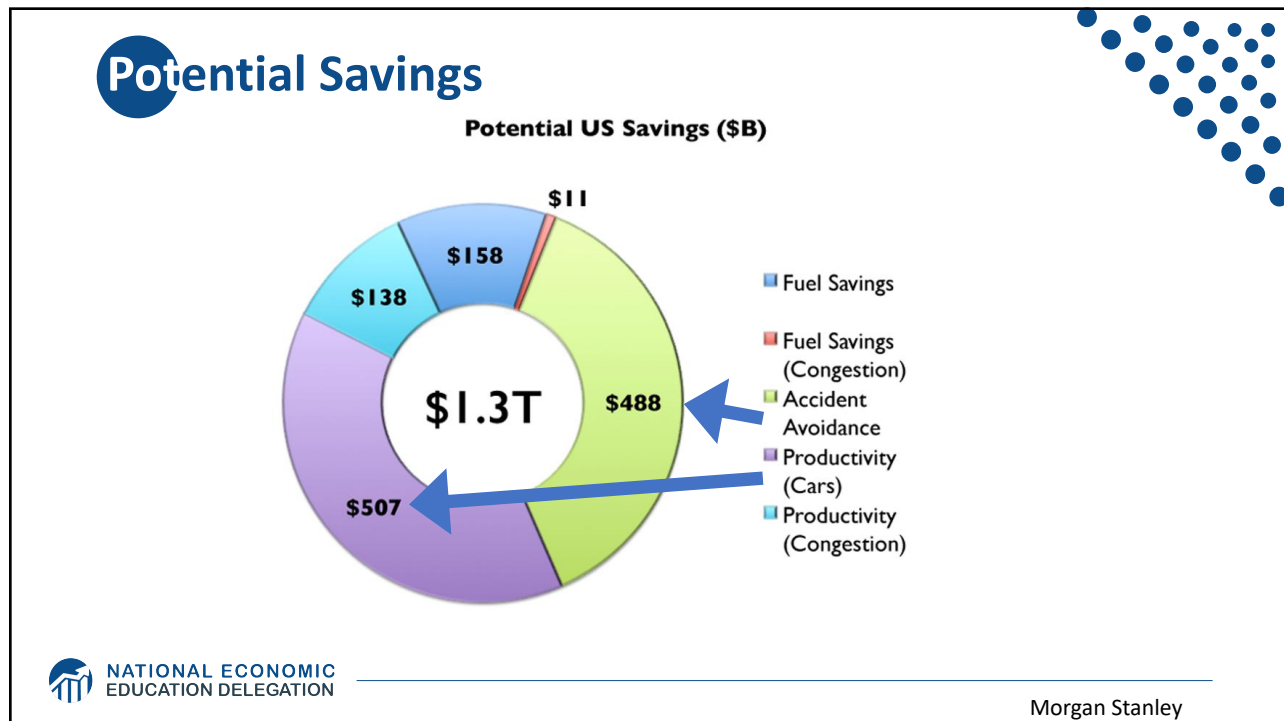
## Economics Drives Transition: Public

- **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

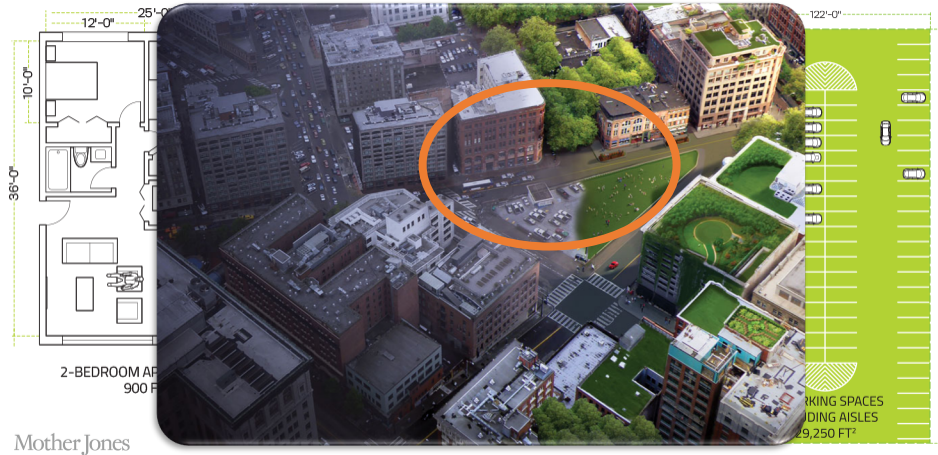
- **Mobility and equity considerations**
  - Elderly/disabled/impooverished
- **Safety:** only way to reduce traffic fatalities is by coordinated effort
- **Productivity:** reduced congestion
- **Environment:** speed transition to electric vehicles

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

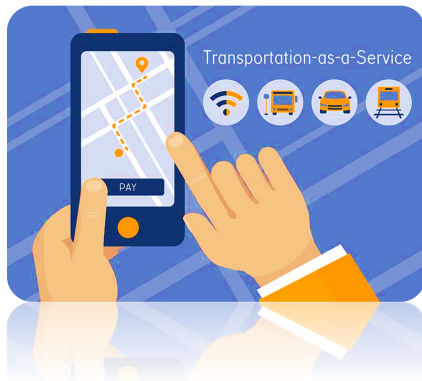
Potentially dramatic improvements in infrastructure planning and maintenance -  
Data sharing and integration



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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...

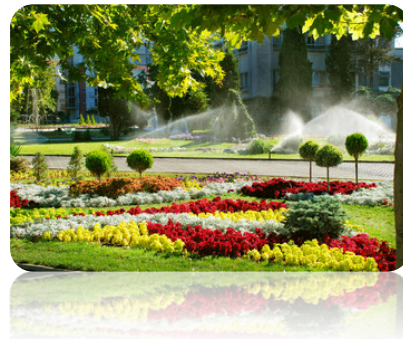


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## Parking

- **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
- Certain residential properties
- Apartment complexes
- Infrastructure technology
- Gas stations/body shops(?)



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**Thank you!**

## Any Questions?

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