AGENDA

1 Trends
2 Predictions
3 Policy Responses
For some years Michael Sivak, of the University of Michigan, has been monitoring vehicle ownership and distance driven in the US. His latest report shows that light duty vehicle ownership per person and per household both peaked in 2006, and that distance driven per person and per household reached their maxima in 2004. (Light duty vehicles are cars plus trucks with two axles and four tires.)

There has been some revival of distance driven per capita in recent years, but I would not expect any long term growth above the present plateau, given both time constraints on personal travel and speed constraints on the road network.
Trends

- Gasoline Prices
- GDP, Real Income Growth
- Household Formation
- Labor Force Participation
- Driving Age Population
- Licensing Regulations
- Non-Auto Mode Options
- Suburban & Urban Migration
- Congestion & Time Use
- Tele-Commuting
- Social Networking
- Internet Shopping
- Vehicle Ownership
- Goods & Services Delivery
- Autonomous Cars
- Shared Mobility Marketplace
VMT Trends
1970 to 2004 INCREASE
VMT Trends
2017 to 2040

Your Forecast

2040
15,350

1970
2004
12,100 VMT per capita

2012
13,200 VMT per capita

2040
Published Forecasts
17,100 VMT per capita
U.S. DOT
16,300 VMT per capita
Transportation Financing Commission
13,400 VMT per capita
U.S. Energy Administration
12,200 VMT per capita
Public Interest Research Group: High
8,200 VMT per capita
Public Interest Research Group: Low

VMT per capita will be 10% to 20% above its 2004 peak, suggesting a need to accelerate transportation investment to keep pace with population growth.
TNC Activity
Rapid Growth

Source: Uber
TNC Activity
Rapid Growth

Lyft Annual Completed Rides (Millions)

Lyft’s completed rides tripled from 53.3 million to 162.6 million. Lyft
What's Uber Displacing?
How people would travel if they weren't taking Uber or Lyft

60+% of TNC Trips Are New Vehicle Trips

Source: University of California, Davis Institute of Transportation Studies
Trend Effects on Transit
Evidence

New York

Chicago

Boston

Los Angeles

www.schallerconsult.com | 2018 TRB Presentation
Trend Effects on Transit
WMATA

WMATA «Understanding Rail and Bus Ridership» October 2017.
Trend Effects on Transit Evidence

Transit ridership fell in 9 of 10 largest markets in 2017. Researchers attributed the decline to ride-hailing services, cheap fuel, and the increase of car ownership, among other factors.

<table>
<thead>
<tr>
<th>DECREASE</th>
<th>INCREASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York -1.1%</td>
<td>Seattle +3%</td>
</tr>
<tr>
<td>San Francisco -1.3</td>
<td></td>
</tr>
<tr>
<td>Atlanta -2.6</td>
<td></td>
</tr>
<tr>
<td>Boston -3.1</td>
<td></td>
</tr>
<tr>
<td>Chicago -3.2</td>
<td></td>
</tr>
<tr>
<td>Washington, DC -3.4</td>
<td></td>
</tr>
<tr>
<td>Los Angeles -5.4</td>
<td></td>
</tr>
<tr>
<td>Philadelphia -7.3</td>
<td></td>
</tr>
<tr>
<td>Miami -8.7</td>
<td></td>
</tr>
</tbody>
</table>

Source: TransitCenter, National Transit Database

The Washington Post | Falling Transit Ridership Poses an 'Emergency' for Cities, Experts Fear | Faiz Siddiqui | 3.24.18
**AV Definitions**
Society of Automotive Engineers

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>Zero autonomy; the driver performs all driving tasks.</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.</td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.</td>
</tr>
</tbody>
</table>
Autonomous Delivery Technologies

Autonomous Drone
Sidewalk Delivery Robot
On-Street Robot
Autonomous Vehicle
Autonomous Trucking
Autonomous Delivery Technologies

Delivery Technologies Timeline - Past Events & Future Predictions

- In-tacart grocery delivery service begins operations
- Doordash restaurant delivery service begins operations
- AmazonFresh grocery delivery service begins operations

2012

- Otto completes first autonomous truck delivery with 50,000 cans of Budweiser
- Amazon launches same day delivery service: PrimeNow

2015

- Daimler tests freight truck platooning on Autobahn
- Matternet launches autonomous medical drone program in Switzerland

2016

- Daimler tests the first semi-autonomous semi-trailer truck on Nevada roads
- FAA issues regulations that allow use of commercial drones for deliveries
- San Francisco bans sidewalk robots

2017

- Daimler anticipates semi-autonomous freight trucks will become commercially available no later than 2018
- Nuro and Udely conduct on-street robot testing

2018

- San Francisco overturns ban on sidewalk robots
AV Predictions
AV Predictions

Potential Growth In Autonomous Vehicles as Percent of Vehicle Fleet

- Quarles & Kockelman (Conservative)
- Quarles & Kockelman (Aggressive)
- Litman (Aggressive)
- Trendline (high)
- Trendline (low)
- Litman (Conservative)
- Goldman Sachs

Legend:
- Qua: Quarles & Kockelman
- Lit: Litman
- Trendline (high)
- Trendline (low)

X-axis: Years from 2020 to 2040
Y-axis: Percent of Vehicle Fleet
AV Predictions

AV Technology Timeline - Future Predictions

- Baidu's Chief Scientist expects a large number of AVs on the road by 2019, mass production in full swing by 2021
- Ford's head of product development: Level 4 AVs on the market by 2020
- Fully autonomous vehicles (Level 5) could be ready by 2025, predicts Daimler chairman
- Truly autonomous cars to populate roads by 2026-2032, estimates insurance think tank executive
- Uber CEO hints at a driverless Uber fleet by 2030
- Institute of Electrical and Electronics Engineers predicts up to 75% of vehicles will be autonomous in 2040
- GM predicts that AVs could be deployed by 2020 or sooner
- Lyft co-founder predicts the phase out of private vehicle ownership in major U.S. cities by 2025
- Elon Musk told a gathering of U.S. governors, "Almost all cars will be autonomous [by 2027]."
AV Predictions
Tipping Point

95% of Passenger Miles by 2030
Delivered by Transportation as a Service (TaaS) in Autonomous Electric Vehicles (AEVs)

https://tonyseba.com | 2018 TRB Presentation
How will autonomous vehicles influence the future of travel?

Agencies dedicate a great deal of time and effort developing and using software tools to estimate future travel behavior. It’s not clear how people’s travel choices will change as autonomous vehicles (AVs) become more prevalent, nor is it clear how to best predict those changes.

Although little is clear at this point, it is clear that our existing models need to evolve. So our TP Think initiative tested how AVs might change the predicted outcomes of nine regional travel models from around the U.S. The results are shown for a scenario where AVs are privately owned and where half of trips are made as shared rides.
AV Tests
Travel Behavior Mechanisms

1. Decrease access time
2. Decrease parking costs
3. Decrease impact of lost in-auto time
4. Increase auto availability
5. Increase non-work trip-making
6. Increase auto occupancy
7. Increase freeway capacity
1. Decrease access time
2. Decrease parking costs
3. Decrease impact of lost in-auto time
4. Increase auto availability
5. Increase non-work trip-making
6. Increase auto occupancy
7. Increase freeway capacity
How will we use AVs?

Public and Shared

OR

Private and Mine
AV Tests – Regional Models
Vehicle Results

VEHICLES
RANGE OF RESULTS

- AV model results

PRIVATE AV OWNERSHIP
50% SHARED AVs

Vehicle Miles Traveled
Vehicle Trips
Average Vehicle Trip Length
AV Tests – Freeway Simulation
Northern California Case Study

**AUTOMATED VEHICLE FLEET PERCENTAGE EFFECT ON TOTAL NETWORK DELAY**

- Total Network Delay decreases as the automated vehicle fleet percentage increases.

**AUTOMATED VEHICLE FLEET PERCENTAGE EFFECT ON NETWORK AVERAGE SPEED**

- Network Average Speed increases slightly as the automated vehicle fleet percentage increases.

Note: The graphs illustrate the findings from AV Tests – Freeway Simulation for the Northern California Case Study.
“AV” Effects
Evidence

Research Findings: Chauffeur Experiment
(Harb et al., 2017)

• 13 San Francisco Bay Area subjects  
  Cohorts: 4 Millennials, 4 Families, 5 Retirees
• More auto travel
  – 76% increase in VMT
  – 22% of increased VMT were ghost trips
• Change in activity patterns
  – 94% increase in # longer trips (over 20 miles)
  – 80% increase in # evening trips (after 6 pm)
• Bimodal impact on miles walked
  – Half decreased (-28% on average), half increased (+49% on average)
• Virtually no biking, transit, TNC use in the sample
  Consistent across cohorts
  Retirees increase most
  Consistent across cohorts
  Retirees increase most
Heaven or Hell?

Source: NACTO, Blueprint for Autonomous Urbanism
Heaven or Hell?

Source: Bethesda Magazine
Policy Response
Depends on the desired outcome
Private Sector Motivation: Revenue
(Miles, Minutes, and Choices)
Public Sector Motivation(s): Complex

Increase mobility?

Improve safety?

Increase accessibility?

Promote equity?

Improve affordability?

Reduce environmental impacts?

Improve health outcomes?

Support placemaking and recreation? ....
Establish Community Priorities

Prioritize people over vehicles
“20 is plenty”
“Pavement for the people”

Support shared use of vehicles, lanes, curbs, land

Aim for public benefits via open data

Lead the transition to a zero-emission future

Engage stakeholders

Promote equity

Support fair user fees
Transit Market Assessment
Policy Response

Evaluate demand, then determine typology

Backbone  Crowd Sourced  Door to Door
# Market Assessment: Tailored Service

## Policy Response

<table>
<thead>
<tr>
<th>Backbone</th>
<th>Crowd-Sourced</th>
<th>Door-to-Door</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail</td>
<td>BRT/Bus</td>
<td>Small Bus</td>
</tr>
<tr>
<td>High density</td>
<td>High-Moderate density</td>
<td>Moderate density</td>
</tr>
<tr>
<td>Rail</td>
<td>BRT/Bus</td>
<td>Sharing/Pooling</td>
</tr>
<tr>
<td>High density</td>
<td>BRT/Bus</td>
<td>Low density with centers</td>
</tr>
<tr>
<td>Rail</td>
<td>BRT/Bus</td>
<td>Personal Vehicle</td>
</tr>
<tr>
<td>High density</td>
<td>BRT/Bus</td>
<td>Low density</td>
</tr>
</tbody>
</table>
## Autonomous Rapid Transit (ART)

### Policy Response

<table>
<thead>
<tr>
<th>Performance</th>
<th>20-passeneger vehicles</th>
<th>4-passeneger vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced travel delay</td>
<td>46%</td>
<td>49%</td>
</tr>
<tr>
<td>Improvement in travel time advantage over cars</td>
<td>34%</td>
<td>36%</td>
</tr>
<tr>
<td>Improvement in travel time advantage over BRT</td>
<td>33%</td>
<td>35%</td>
</tr>
</tbody>
</table>

Through TaxiBots (yellow) Passing Loading Bot at ART Station (red rectangles)
City friendly mobility as a service
An on-demand city-integrated urban autonomous transportation system
# Micro-Transit or Micro-Vehicles

Improved operational performance

<table>
<thead>
<tr>
<th>Performance</th>
<th>Traditional Vehicles</th>
<th>Micro Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay (seconds)</td>
<td>175</td>
<td>31</td>
</tr>
<tr>
<td>Fuel consumption (gallons)</td>
<td>422</td>
<td>187</td>
</tr>
</tbody>
</table>
Invest in High-Quality Transit
Prioritize trunk service in dedicated corridors
Prioritize Safety
Emphasizing safety of vulnerable users

- More frequent crossings
- Lower vehicle speeds
- Shorter stopping distances
- Designated Pick-Up/Drop-Off
- Shorter Crossing Distances
Allocate Public Space (and Time)
Consider separate facilities and/or road pricing or priorities
Allocate Public Space (and Time)
Curbside use, including passenger and commercial loading
Reallocate Land Used for Parking
Example: Twinbrook Metro Station
Reallocate Structured Parking
Policy Response

Reduced Parking Space
The New Metrics of Parking

Phase 1: Full Parking
Phase 2: Partial Parking
Phase 3: Partial Parking

Narrower Aisles: Perfect alignment and optimized spacing through parking technology
Stall Stacks: Flexible re-configuration of parking space - tight parking scenarios are conceivable
Smaller Stalls: The required parking footprint per car can shrink to a minimum
Prepare for Sprawl-Inducing Effects

Particularly reduced sensitivity to travel time