Major Changes in Transportation
- the future leans towards electric & shared

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Eric Shimizu, PE, PTOE
Electromobility and Resiliency PIC

ehs@dksassociates.com
The future of transportation is anyone’s guess

Here’s mine…
Vision
Disruptive Transportation Technologies

1. Cost-effective Energy Storage
2. Smart sensors
3. Accessible data/data analytics
Overview

1. Background
2. Electromobility
3. Shared Mobility
4. Conclusion
Walking
Horses
Steam Locomotives & Electric Trolleys
Cars & Airplanes
Cars rule the world?

- 1900: 25,000
- 1920: 8,000,000
- 1950: 50,000,000
- 1970: 200,000,000
- 1990: 500,000,000
- 2002: 530,000,000
- 2010: 1 Billion

Average speed in London 2016: 11.8mph
Average speed in London 1916: 17mph
Impacts

- Safety
  - 33,561 highway deaths in 2012
  - 5.615 million crashes in 2012
  - Leading cause of death for ages 4, 11-27

- Mobility
  - 5.5 billion hours of travel delay
  - $121 billion cost of urban congestion

- Environment
  - 2.9 billion gallons of wasted fuel
  - 56 billion lbs of additional CO₂

Data Sources:
2011 Annual Urban Mobility Report, Texas Transportation Institute (Feb 2013)

Note: Over 35,000 highway in 2015
The Real Cost of Vehicle Ownership

AAA released the results of its annual “Your Driving Costs” study, revealing a 1.96 percentage increase in the yearly costs to own and operate a sedan in the U.S. The average costs rose 1.17 cents per mile to 60.8 cents per mile, or $9,122 per year, based on 15,000 miles of annual driving.

- **Fuel**: 1.93%
  - Average cost: 14.45¢ per mile
- **Maintenance**: 11.26%
  - Average cost: 4.97¢ per mile
- **Tires**: No change
  - Average cost: 1¢ per mile
- **Insurance**: 2.76%
  - Average cost: $1,029 per year
- **Depreciation**: 0.78%
  - Average cost: $3,571 per year

AAA has published “Your Driving Costs” since 1950. That year, driving a car 10,000 miles cost 9¢ per mile, and gasoline sold for 27¢ per gallon.

For more information on AAA’s Your Driving Costs study, visit NewsRoom.AAA.com
Outline

1. Background
2. Shared Mobility
3. Electromobility
4. Conclusion
1. Background

2. Shared Mobility
   - MaaS
   - Micromobility

3. Electromobility

4. Conclusion
From 2010 to 2019, center city drive alone commutes increased by approximately 6,000 while all other modes grew by approximately 82,000 commutes.
Transport/Mobility as a Service (TaaS/MaaS)
Car Share & Microtransit
Ride Hailing
Bike Share
Electric scooter share

Lime-S electric scooters

Bird electric scooters
Micromobility

SHARED MICROMOBILITY RIDERSHIP GROWTH FROM 2010–2019,
IN MILLIONS OF TRIPS

Source: NACTO

Source: https://nacto.org/shared-micromobility-2019/
Micromobility vs. Ridehailing

Total trips since launch for Uber, Lime and Bird

Data: Axios research; Chart: Naema Ahmed/Axios
Transition Timeframe

» Speed of TaaS adoption

<table>
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<tr>
<th>TRILLIONS OF PASSENGER MILES</th>
<th>YEARS</th>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
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<td>TaaS miles</td>
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Reduced parking demand?
Reduced transit demand?
Pick-up & Drop-off Zones
“The Birds”?

The 2018 remake of Alfred Hitchcock’s “The Birds”
Mobility Hubs
Overview

1. Background
2. Shared Mobility
3. Electromobility
4. Conclusion
Energy Storage

Lithium Ion Batteries
Battery Electric Vehicle (BEV)
Electric Pickup trucks

F-150 Lightning
Battery Electric Bus
Medium/Heavy Duty Vehicles

- XL Hybrids Ford F-150 upfit
- Workhorse E-GEN step van
- Thomas Built C2 Jouley
- Proterra EV bus

Source: Puget Sound Clear Air Agency
Electric Motorcycles

E-motorcycles
Electric Bicycles

E-bikes
## Microcycles

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>BRAND/MODEL</th>
<th>RANGE</th>
<th>TOP SPEED</th>
<th>WEIGHT</th>
<th>PRICE</th>
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</thead>
<tbody>
<tr>
<td>Segway</td>
<td>Segway miniPRO</td>
<td>14 miles</td>
<td>10 mph</td>
<td>28 lbs.</td>
<td>$600</td>
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<tr>
<td>E-Unicycle</td>
<td>Uno Bolt</td>
<td>25 miles</td>
<td>22 mph</td>
<td>45 lbs.</td>
<td>$1,500</td>
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<tr>
<td>Scooterboard</td>
<td>InMotion Technology</td>
<td>7.5 miles</td>
<td>15.5 mph</td>
<td>22 lbs.</td>
<td>$700</td>
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<td>E-Unicycle</td>
<td>Onewheel+</td>
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<td>19 mph</td>
<td>24.5 lbs.</td>
<td>$1,500</td>
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<td>E-Skateboard</td>
<td>Boostedboard (2nd Gen.) Dual+</td>
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<td>22 mph</td>
<td>15 lbs.</td>
<td>$1,500</td>
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<td>Hoverboard</td>
<td>EpikGo Classic</td>
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<td>12 mph</td>
<td>20 lbs.</td>
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<td>Solowheel Xtreme</td>
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<td>14 mph</td>
<td>26 lbs.</td>
<td>$1,800</td>
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EV charging infrastructure

Residential

Workplace

Fleet

Public
EV charging infrastructure

Charging Categories: Fleet
Charging Categories: Public

EV charging infrastructure

Commercial
Destination
Right-of-way
EV charging infrastructure

Charging Categories: Public

West Coast Electric Highway

Tesla Superchargers
Charging Categories: *Shared Mobility*
Dynamic Inductive Vehicle Charging
More Electric Vehicles with more range

EV Range and Buyer Choice

Models by style and range available through 2020

Source: https://i.redditmedia.com/5tehvhm0F-i_XCOag7o2eWSCrd2KHFE6YTWC2NQsJg.png?s=2a353cffdd3c128a26f40c01c9e16641
1. Background

2. Electrification

3. Shared Mobility

4. Conclusion
Adoption timeframe

1900: Easter Parade on Fifth Avenue, New York – Can you spot the car?

1913: Easter Parade on Fifth Avenue, New York – Can you spot the horse-drawn carriage?
Adoption timeframe

- **Electrification**
  - Hybrid: Toyota Prius, 1997
  - Electric: Tesla Roadster, 2008

- **Shared Mobility**
  - Carsharing: Zipcar, 2000
  - Ride Share: Uber, 2010
  - Doodless Bike Share: Mobike, 2016

- **Connected Vehicles**
  - V2V: Application, 2011
  - Teslas Autopilot Hands-free, 2015

- **Autonomous Vehicles**
  - AV with Expensive Premiums, 2020
  - South Korea Hyperloop, 2021

- **Other Technologies**
  - Drone Delivery: Flirtey Australia, 2013
  - AV Truck Platoon, 2020-2030s

**Synergistic Effect**
- India, Norway & Netherlands end sales of fossil fuel cars, 2030
- Britain & France end sales of fossil fuel cars, 2040
- China announces plans to end sales of fossil fuel cars, 2017
- Uber & Lyft use autonomous vehicles for rideshare, 2021

Conclusions

1. Propulsion
2. Vehicle Ownership
3. Intermodal & Multimodal
4. Revenue Disruption
5. Recommendations
“General Motors believes the future is all-electric. We are far along in our plan to lead the way to that future world.” - Mark Reuss, head of product, GM

1. Propulsion:
   - Electricity will dominate traction power.
   - Initiate by regulations, sustained by economics.
   - New technology will eliminate range anxiety.
   - Petroleum & automotive industries disrupted.
   - Significant environmental benefits.
2. Vehicle ownership:

- Personal vehicle ownership will decline, replaced by autonomous mobility as a service (MaaS).

- Individual car ownership will be limited to older generations, rural and exurban residents and to automobile hobbyists.
3. Multimodal & Intermodal:

- Multiple travel modes per trip in urban areas.
- More walking, bicycling, motor-assisted “microcycles”
- More ride-hailing & car sharing
- New modes like E-VTOL & Hyperloop
- Fewer drive-alone trips, but VMT might grow(?)
- Intercity MaaS to compete with air, rail and bus
- Rural areas will change more slowly than cities/suburbs.
4. Public vs. private transportation:

- Private/public transportation to blend.
- Autonomous Maas will disrupt public transit as it has to the taxi industry.
- Local transit routes with infrequent service will decline.
- Transit to partner with commercial MaaS providers for transit-dependent populations & connections.
- Competition for curb space with ride hailing vehicles.
5. Revenue disruption:

- Road user fees to replace gas taxes.
- Cities need to replace revenue from reduced violations, parking and taxes.
1. Design Multimodal Streets
   - Eliminate on-street parking
   - Expand sidewalks
   - Include EVSE infrastructure
   - Prioritize curb space for shared mobility use
   - Add bicycle & microcycle facilities
2. Reconsider Parking

- Eliminate parking requirements for new development
- Pre-purpose future structured parking by planning the conversion of new parking structures for housing and employment
- Re-purpose existing parking facilities for new uses like EV charging, TNC layover and product distribution
- Include pick-up & drop-off facilities
3. Facilitate Micromobility

- Create safe space on our streets for bikes and scooters.
- Build connected and ubiquitous protected bike lanes
- Deploy more scooter and bike parking, and lots of it
Recommendations

4. Facilitate Electromobility
   • Masterplan EVSE infrastructure
   • Require EVSE for new construction
Recommendations

5. Develop Smart Grid
   - Bi-Directional EV Charging
   - Distributed Energy (Solar, Wind)
   - Energy Storage