How New Technologies and Autonomous Vehicles May Change Public Transportation

2016 Transit CEO’s Seminar

Steven E. Polzin, PhD.
Sunday, January 31, 2016
CENTER FOR URBAN TRANSPORTATION RESEARCH

- Established 1988 by Florida Legislature
- Home of the National Center for Transit Research
- Applied research – Policy focus
- Technology transfer / training
- Education
- Multi-disciplinary (Anthropology to Zoology)
- “Real world” experience
- Housed in USF’s College of Engineering
- 180+ active research projects
- $14 million in 2015
- over $5 million federal
- 35 full-time research faculty
- 20-50+ student researchers
Outline

• Introduction to technology changes
• The context
• Impacts of technology changes
  – Vehicle ownership
  – Location decisions
  – Sharing travel
• Transit’s Response
• Discussion
We are in Perhaps the Most Transformational Period in Transportation Since the Development of Personal Vehicles

Demographics
Economics
Technology
Governance
Culture/values
The 2015-2019 APTA Strategic Plan

• Key challenges and opportunities over the next four years:
  – Safety and Security,
  – Resource Advocacy,
  – Workforce Development,
  – Demographic Shifts and Technological Innovation in Public Transportation.
Technology

- Powerful global positioning satellites
- Ubiquitous wireless communication capability
- Powerful portable computing
- Powerful web computing capability for pathfinding and scheduling optimization
- Sophisticated sensors
- Artificial intelligence/machine learning

Integrated with new materials, designs, propulsion systems, etc.
Transportation Network Companies (TNC)

TNC – a company that leverages smart phone apps to hail livery services. Sometimes referred to as e-hailing or ridesourcing. Not Ridesharing

Offers real time information on arrival, electronic payment, electronic customer feedback. Perceived as cleaner, more convenient and safer than taxis. Generally lower cost and more quickly available than traditional taxis.
Automated/ Connected Vehicles
Automated Vehicles Relieve the Occupant of Driving
Environmental Considerations
Transportation Safety
Environmental Considerations
Impact on travel demand by mode
Unintended Consequences
Economic and Employment Impact
Transportation System Capacity
Transportation Stakeholders
Personal Mobility
Transportation Infrastructure
Land Use

Consequences

Travel Behavior

UBER

Google Car

NCTR at CUTR
Everything Affects Transportation and Transportation Affects Everything

- Legal Political Governance Context
- Land Use & Infrastructure
- Demographics
- Economy
- Technology
- Environment
- Culture and Values

Transportation
Disclaimer: “Prediction is very difficult, especially if it's about the future.”

Nils Bohr, Nobel laureate
Very smart people have very different opinions on the pace of implementation, market acceptance, and impacts of technology on transportation.

Hey Watson, When did you say automated vehicles will be here? And what will the impacts be?
Hype Cycle for Emerging Technologies

Source: Gartner (August 2014)
The Public is Being Bombarded with Stories on Autonomous Vehicles

Cop pulls over Google self-driving car - going 24 in 35 mph zone
CNN November 13, 2015

Will your driverless car kill you so others may live?
Los Angeles Times, 2015
The Business World Is Being Rocked by Technology Deployed for Transportation

Uber Valuation Put at $62.5 Billion After a New Investment Round
- GM $53.6 B 12-11-2015
- Ford $54.09
- Tesla $29.08

GM is Investing $500 Million in Lyft to Develop Self-Driving Cars
January 2016

Toyota Chief Shifts to Self-Drive: Akio Toyoda, once a skeptic, steers automaker into autonomous vehicle race.
WSJ, January 2016

Google, Ford in Talks on Self-Driving Car Partnership
December 2015

Transportation as a Service Envisioned as Massive Global Market Opportunity

Uber
Google
Apple
Ford
Chrysler
GM

Transportation is 17% of Household spending + time value + plus commercial spending
Consensus? Thoughts

• Some safety benefits evident by mid 2020s
• Some capacity impacts (incident reductions benefits) by late 2020’s
• Sufficient market penetration for some dedicated high capacity exclusive lanes in high volume corridors in 2040s
Providing Transportation

The transit industry
(moving people, building places)

The technology and financial interests
(logistics and dollars)
Technology Implementation is Not Easy

August 13, 2015
How are We Doing Implementing New Technologies for Transportation?

What Lessons have We Learned?

- Next Generation Air Traffic Control
- Positive Train Control
- Red Light Cameras
- VMT Fees for Vehicle Use
- Electronic Toll Collection
- Smart Card Fare Systems
- Automatic Passenger Counting Systems
- Real Time Transit Information
- Smart Signal Systems
Factors that Influence Travel Behavior

Technology Enables:

- Real time information
- Electronic payment
- Trip planning
- Trip scheduling
- Navigation/trip tracking
- Electronic hailing
- Trip aggregating /ride matching
- Dynamic pricing
- Electronic satisfaction feedback
- Automated driving
Factors that Influence Travel Behavior

Traditional Travel Decision Making
(4-Step Process)

1. Number of Trips Made
   (trip generation vs. communication)

2. Destination Choice (trip distribution impacted by better knowledge of choices)

3. Mode Choice
   - Drive personal traditional car
   - Ride in my automated car
   - Hail automated car
   - Ride with family/friend
   - Taxi
   - Ridesourcing, e-hailing, Uber, Lyft, Sidecar
   - Ridesharing - Carma, eRideShare
   - Carsharing
   - Personal bike
   - Bikesharing
   - Transit
   - Transit Alternatives/Feeders “microtransit”, Bridj, Leap, MetroBee, TransLoc
   - Walk

4. Path Assignment (Choice assisted by real time information)
“I couldn’t get my autonomous car to back down the boat ramp.”

“I got dropped off by my TNC car service but they said I couldn’t carry any fish home in their vehicle.”
Impacts of Technology is Highly Dependent on Three Key Decisions

- Live/Work Location Choices
- Vehicle Ownership
- Shared Occupancy Mode Choice
The Vehicle Ownership Decision

- Average car driven about 10,000 to 12,000 miles per year
- About one hour per day at an average of 30 mph
- About 13+ million new vehicles purchased by households annually
- Households own about 215 million vehicles
- Avg. life of 17 years and 163,000 miles before scrapping
- Households responsible for about 2.25 trillion VMT annually
- U.S. vehicle fleet valued at over 2 trillion.
Ownership Not Just a Mobility Decision

Functional transportation

Transportation plus?

Ego
Investment
Image
Hobby
Entertainment
Envisioned Cost Structures Imply Possible New Institutional Roles

Governing/Providing Mobility

- Public Transit?
- Government
- Family
- Self
- Community
- Private sector
Personal, Private Sector, or Government Ownership of Vehicles?

Mobility Services Center
Single Payment Plan – Bundled Mobility Services – Govt. Vouchers Accepted

Transit passes - Bikes - Motorcycles - Autonomous vehicles - TNC Vouchers, Amtrak HSR Tickets – One Low Monthly Fee
Modification to the
Second Amendment to the U.S. Constitution

A well regulated militia being necessary to the security of a free State, the right of the People to keep and bear arms shall not be infringed.

Adopted December 15, 1791

Amended June 20, 2021
It remains to be seen what share of households would be willing to relinquish one or more vehicles.
Key Decisions

Live/Work Location Choices
What is the Value of “Freed Up” Time and How do We Spend the Savings?
Land Use Impacts

Drive till you qualify becomes nap till you qualify?

More house and less garage?
Land Use Impacts

Without having to own and park a car I can afford the urban lifestyle.

After a day at the office and a nap on the ride home I can enjoy the great outdoors.
It remains to be seen how travelers will react to the ability to be “passengers” during their vehicle travel.
Key Decisions

Sharing vehicles **sequentially** versus sharing vehicles **concurrently**

**Shared Occupancy, Mode Choice**
Do Travelers Want to Share a Ride?

The Demise of Carpooling?

![Graph showing the trend of commuting market share over time. The line for Drive Alone shows an overall increase from 1975 to 2015, while the line for Carpool shows a decrease.](image-url)
Tidbits on Carpooling

• Work trip auto occupancy is approximately 1.13.

• Approximately half of the passengers riding with commuters are other work commuters and half are persons carrying out other activities (go to school, go to daycare, etc.)

• For every 100 vehicles commuting to work about six have a fellow commuter, approximately half are fampools.
Impact on VMT Scenarios

**1950–2050 U.S. VEHICLE MILES TRAVELED**

- **Historical**
- **Forecasted**

**AVO**

- **Vehicle Miles Traveled (VMT)**

- **Forecasted VMT, < 1**: More cars on the road than people
- **Forecasted VMT, = 1.2**: Car can drive your parents and take the kids to practice
- **Forecasted VMT, = 1.67**: Status quo occupancy AVO = 1.67
- **Forecasted VMT, = 2**: Carpooling and ride-sharing takes off

Note: (a) Discounted 25% from U.S. BTS total VMT for 1995, 2001, 2009, 2014 (assumed to be commercial miles), (b) Multiplied by NHTS occupancy rates applied 2009 rate to 2014 numbers.

Source: U.S. BTS data, NHTS data, U.S. Census data, KPMG Analysis

Low occupancy and lots of deadhead miles

Today

Lots of shared use offsetting deadhead miles
Will a generation, many of whom haven’t shared bathrooms or bedrooms or phones or televisions or dorm rooms, share small vehicles with strangers?

It remains to be seen how accommodating of vehicle sharing travelers will be and what the cost benefits and time penalties will be.
So What Does this Mean for Transit?
The Competition is Coming

$2.25 Lyft Line Rides. That’s Right.

Lyft Line competing openly with SFMTA transit in San Francisco

Source: Charlie Youakim, Passport
The Grades Are In

In Chicago

Source: Charlie Youakim, Passport
The Grades Are In

In Los Angeles

Source: Charlie Youakim, *Passport*
The Grades Are In

In New York City

Source: Charlie Youakim, *Passport*
The Competition is Coming

Source: Charlie Youakim, Passport
The Rise of The Rideshares

Uber: >3m riders/day in North America
NYC (MTA): 9m riders/day
Chicago (CTA): 1.6m riders/day
Boston (MBTA): 1.3m riders/day
San Francisco (SFMTA): 700k riders/day
DC (WMATA): 900k riders/day

1 Based on internal Passport estimates. Uber reported 1m riders per day in Dec 2014.

Source: Charlie Youakim, Passport
How Disruptive?

Self-driving buses will be a big part of the transit puzzle
Roberto Baldwin, @strngwys
January 2016

What Will Happen to Public Transit in a World Full of Autonomous Cars?
From the Atlantic, CITYLAB
January 2014

Driverless Cars: What Could Possibly Go Wrong?
by Robert Hutchinson
Harvard Business Review
January 2016

Autonomous Vehicles' Disruptive Potential for Transit
Surface Transportation News #147
January 2016

Urban Transit’s Uncertain Future
NOVA NEXT
January 2016
http://www.pbs.org/wgbh/nova/next/tech/urban-transits-uncertain-future/
Perceptions of the Impact on Public Transit are Emerging

- Insurance industry, labor, etc. won’t let this happen.

- Emerging technologies will undermine auto ownership and complement transit in first-mile/last-mile services - supporting transit use.

- Transit will be reduced to very high volume fixed guideway operations.

- The public transit industry will morph unto a mobility service provider.

- Shared rides in autonomous vehicles will become the new public transit.
Transit’s Strategic Response?

1. Strive to understand/monitor the impact of technology on travel behavior

1. Leverage the emerging modes/services to complement transit

2. Leverage the emerging technologies within transit operations

3. Be at the table in preparing for and adapting to new technologies

4. Advocate for transit’s goals/strengths

5. Acknowledge the uncertainty and adapt long-range planning to mitigate risk
1. Strive to Understand/Monitor the Impact of Technology on Travel Behavior

   a) Auto ownership, cost and use trends

   b) Acceptance of evolving modes: bikeshare, carshare, TNCs, microtransit, etc.

   c) Impacts of new services on travel and transit
Emerging Insights into Behavior Impacts

• In a survey of over 10,000 bikesharing members found that 40% reduced their automobile use as result of bikesharing and 39% of bikesharing members reduce the amount that they use public transit as a result of bikesharing (Shaheen et al 2012).

• Buck et al. (2013) corroborated this shift away from public transportation, reporting that 35% casual users and 45% of annual members of Capital Bikeshare in Washington DC replaced a public transit trip with bikesharing.

• As of March 2015, the number of Uber vehicles in New York overtook the number of medallion cabs (Licea et al 2015).

• As of January 2015, the taxi market in San Francisco was about $140M per year, while Uber’s gross revenues in the same city were approximately $500M per year and growing at a rate of 200% per year (Blodget 2015).

• Ride-hailing may be substituting for both transit and driving trips (Rayle et al 2014).
Emerging Insights into Behavior Impacts

• Beware these business concepts and characteristics are changing rapidly.

• The early case study data is often limited to a few, not necessarily typical markets.

• Early findings reflect early adapter behaviors and may not apply to the broader market.
2. Leverage the Emerging Modes/Services to Complement Transit

a) Paratransit services
b) First-mile, last-mile
c) Guaranteed ride home
d) Co-branding/integrated marketing
e) Integrated traveler information
f) Etc.
3. Leverage the Emerging Technologies within Transit Operations

- Safety features/driver assist
- Productivity/capacity features
  - platooning, preferential treatments
- Convenience/reliability features
  - customer information, fare payment, wi-fi, etc.
3. Leverage the Emerging Technologies within Transit Operations

USDOT Pilot Deployments

- University of Michigan Buses
- CV 5.9GHz V2V and V2I
- 5 Collision Avoidance Systems
- 2 Transit Specific
Automated or Piloted Vehicles

Challenges a fundamental cost factor (operator labor) in transit delivery

• Technologies could break the dependency on expensive infrastructure and exclusive right-of-way as prerequisites to allowing autonomous operation.

• Capture the benefits of congestion free operations while sharing the ROW/travel way investment.
Automated or Piloted Vehicles

Removes the criticality of having large vehicles to amortize driver labor over

• Enables higher frequency smaller units of capacity
• Enables lower cost (smaller scale) infrastructure
• Enables greater flexibility in fitting infrastructure in built environments.
Public Transit as a Technology Deployment Opportunity

• New technologies with unique features or special maintenance, safety, training, etc. often benefit from deployment in a professional/institutional environment (like a transit agency)
  – Policy/image motivation
  – Controlled professional environment
  – Economy of scale to amortize training, fixed capital, etc.
  – Vehicles have high use which enables rapid experience accumulation
4. Be at the Table in Preparing for and Adapting to New Technologies

a) Be at the table.

b) Acknowledge the potential impacts and commit the industry to a constructive path forward.

c) Education and training.
5. Advocate for Transit’s Goals/Strengths

a) Some markets will still need high capacity vehicles – transit’s space efficiency
5. Advocate for Transit’s Goals/Strengths

a) There is not enough curb space to accommodate high volumes with small vehicles (especially with shared ride coordination).
5. Advocate for Transit’s Goals/Strengths

b) some users will need the mobility subsidy inherent in today’s transit

- 70ish% operating subsidy
- 100% capital subsidy

= ≈ 80% non user subsidy of travel costs.

Mobility options priced over current user fare costs will impact many travelers.
### Cost of Mobility Options

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Auto Capital and Operating Cost (business)</strong></td>
<td>$0.54/mi., $0.575 in 2015</td>
</tr>
<tr>
<td><strong>Variable Cost (moving and medical)</strong></td>
<td>$0.19, $0.23 in 2015</td>
</tr>
<tr>
<td><strong>Out of Pocket (charitable, by statue)</strong></td>
<td>$0.14</td>
</tr>
<tr>
<td><strong>BLS Consumer Expenditure Survey</strong></td>
<td>$0.44/ vmt, $0.26/ pmt</td>
</tr>
<tr>
<td><strong>Transit Fares</strong></td>
<td>~ $0.24/mi</td>
</tr>
<tr>
<td><strong>TNC (Uber, Lyft)</strong></td>
<td>~$0.65-2.00/mi</td>
</tr>
<tr>
<td>(sequentially shared vehicle, not concurrently shared ride)</td>
<td></td>
</tr>
<tr>
<td><strong>Automated Vehicle (shared ride)</strong></td>
<td>~&lt;$0.20-?????</td>
</tr>
</tbody>
</table>

*Source: IRS*

Auto owners “feel” $0.14 per mile costs in mode choice decision.
Ability of Transit Patrons to Procure Private Sector Mobility Services

• On average between 2009-2013 total expenditures (capital and operating) per passenger mile of transit service delivered equaled $1.04. Fares covered $0.24.

• Based on NHTS 2008 data 38.5% of transit passengers had household incomes below $20,000.

• Based on 2007 APTA onboard survey summaries, 34.9% of transit passengers have household incomes below $25,000 (2004 $).
Access to Smart Phones and Banking Relationships

- Data indicates that 8% of the adult population does not have cell phones and 32% of adults do not own smartphones. (http://www.pewinternet.org/2015/10/29/technology-device-ownership-2015/)

- Onboard survey data suggests that 27% of St. Louis and LA Metro bus passengers do not have a smartphone as of 2013. While 33% of LA Metro rail passengers do not own a smartphone as of 2013.

- The Federal Reserve indicates that 7.7 percent of households in 2013 had no formal banking relationships (bank account). Alternative accommodations would be required for these patrons to utilize app enabled mobility services – these jeopardize the security benefit of not having anonymous travelers.
5. Advocate for Transit’s Goals/Strengths

c) Some travelers will still need door-to-door assistance.
6. Acknowledge the Uncertainty and Adapt Long-Range Planning to Mitigate Risk

Low Risk Decision
- Near-term impacts/benefits
- Lower cost
- Reversible/redeployable
- Similar examples from which to gauge impacts

High Risk Decision
- High cost
- Not reversible
- Dependent on longer-term impacts
- Original/rare situation
Planning Challenges?

None of the MPOs most likely to be planning for self-driving cars have incorporated them into their most recent RTPs. Of the twenty-five largest MPOs, only Philadelphia’s Delaware Valley Regional Planning Commission mentions autonomous vehicles at all.

- There is a great deal of uncertainty about what technologies will prevail, how much and when they will penetrate the market, whether regulation will hinder or support deployment, what the direct impacts will be on capacity or safety, and how consumers will respond.
- Driverless cars and their potential impacts are too far removed from decisions about whether and how to invest in and maintain transportation infrastructure.
- Vehicle automation is just one of a number of radical changes that could influence regional transportation over the next 30 years. Staff also mentioned changes in federal transportation funding, 3D printers, improvements in telecommunications, and the impacts of and policies to address climate change as potential game-changers.

Risk Averse Planning

• Focus on near term benefits
• Test option’s robustness (ability to perform in various future scenarios)
• Use uncertainty or risk analysis
• Invest in adaptive infrastructure
Integrating Smart Technology with Dumb Infrastructure
A Path Toward Success

Policy makers and industry professionals with input from the public should strive to find ways for the positive benefits of technology to be realized without ego, greed, self interest, lust for power, or incompetence denying the public the full benefits of new technologies.
Contact Information

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