Breakout Session #1
Research to Examine Behavioral Responses to AVs

Organizers:
Chandra Bhat, University of Texas at Austin Center for Transportation Research
Kristin Kolodge, J.D. Power and Associates
Barbara Lenz, German Aerospace Center, DLR
Maren Outwater, Resource Systems Group
Ram Pendyala, Arizona State University
Yoram Shiftan, Technion
Joan Walker, University of California, Berkeley
Johanna Zmud, Texas A&M Transportation Institute
Liaison: Don MacKenzie, University of Washington

Invited Presenters:
Eric Miller, University of Toronto
Patricia Mokhtarian, Georgia Institute of Technology
Session Objective

To identify research needs and develop research approaches (both quantitative and qualitative) for gaining deep insight on behavioral responses to AVs in three priority areas:

(1) vehicle ownership and use choices,
(2) land use choices, where people choose to live and work, and
(3) activity and travel choices, what people do, how often, how they get there.
Session Product

A synthesis document describing a 3-5 year “research roadmap” of behavioral studies

(1) To identify priority areas of research and associated research questions, and
(2) To outline “best practice” research approaches to obtain deep behavioral insights and address questions of interest.
Agenda

Day 1
• PPTs to introduce three priority research areas, plus time use (1 hour, then break)
• Small breakout groups focusing on one of three priority research areas
  – Vehicle ownership and use: *How and at what rate will fully autonomous vehicles be adopted?*
  – Land use choices: *Where will people live and work with fully autonomous vehicles?*
  – Activity/travel choices: *How do daily activity/travel patterns change (activities, schedules, departure time, modes, destinations, with whom) with fully autonomous vehicles?*
  – Groups to discuss research approaches to answer the question – *template is provided.*

Day 2
• Continue small breakout groups
• Synthesize findings across groups working in same area
• Report back
• Strategy session on next steps
Template

• Priority Area: One of three
• Main Question: One of three

• Short-Term Information Needs to Address Question
• Medium-Term Information Needs to Address Question
• Identify One Research Objective (short-term or medium term)
• Primary Data Needs for Research Objective
• Methodology or Data Acquisition Plan for Research Objective
• Data Modeling or Analysis Approach for Research Objective
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(3) land use choices, where people choose to live and work, and
Main Research Questions

• How would Value of Time change under AV:
  • Population segments
  • How these change in VOT will affect our various choice dimensions

• **Auto use and ownership**
  • Personalized AVs vs ride sharing AV
  • Who are the early adopter of AV and sharing services, the different stages of automations
  • The factors affecting sharing

• **Activity and travel choices**
  • Induce activities
  • Destinations choices/opportunities
  • Alternative time use

• **Land use/location choices**
  • Will the changes brought by AVs be structural or they will just magnify/reduce effects that we have already been observing?
  • How much VOT is important above other factors?
What we know/Don’t know

• Behavior under AV can change a lot, we know very little.....
  • Would you send your child to school alone in AV?
• AV are so different than anything we have to know, difficult to predict
  • What is the value of SP studies?
• How would Value of Time change under AV
• Many mode already allow Multi tasking, what can we learn from them?
• Attitudes/preferences are changing
• The social factor: time alone, time with kids
• Destination choice – will people travel further away?
• Residential location choices are complex
Recommended Action Items/Research Needs

- Combination of different research approaches

- **Collect time use/longitudinal data**
  - Follow changes in perceptions/attitudes
  - Compare between places with different development/penetration
  - Longitudinal data from existing (Uber) and future evolving services

- Coordinate surveys with field experiments

- build upon existing survey instrument tools and leverage technology to collect data?
  - Using smartphone apps, new technology
Recommended Action Items/Research Needs

• Improve SP: virtual reality/gaming/movies

• naturalistic studies/Chauffer

• Qualitative data: interview people, focus groups
  • Better understand people motives and goals

• Need to collect more psychometric indicators

• Develop standard questions to include in various surveys/field experiments
Breakout Session 1: Research to Understand Behavioral Responses to AVs

Value of Travel Time

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2017 Automated Vehicles Symposium
San Francisco, CA, July 11, 2017
Some things we “know”

Some things we don’t know

How to study the things we don’t know
Some things we “know” (1)

- Ability to use travel time (TT) more meaningfully
  - Saves time

Fraunhofer IAO and Horvath & Partners (2016),
Some things we “know” (2)

- Ability to use travel time more meaningfully
  - Saves time, i.e., reduces the “disutility” (inconvenience, generalized cost) of travel
  - Which (unless priced or regulated out of reach) leads to more travel:

  ➢ More trips:

  **BEFORE:** “I don’t have time to go there because I have to do x”

  **AFTER:** “I can do x while I go there”
  OR “The time I saved by doing other things while traveling allows me to do x as well as go there”
Some things we “know” (3)

- **More travel:**

  - **More distant destinations:**

  BEFORE: “It’s a week night – let’s eat nearby”

  AFTER: place 50 miles away – we can do our last hour of work in the car on the way there, and watch our favorite TV show on the way back (as we would have done at home)
Some things we “know” (4)

- **More travel:**

  - **Shifts from other modes to car:**

    **BEFORE:** “A 45-min transit ride is better than a 30-min car drive because I can use the time productively”

    **AFTER:** “Even if the car drive becomes 45 min, I’m no worse off than I was on transit, because now I can use *that* time productively – and now I have all the advantages of the car (privacy, ubiquity...)”
Some things we “know” (5)

- **More travel:**

  ➢ **Greater tolerance of congestion:**

  **BEFORE:** “I’m willing to spend $x$ mins driving in congestion”

  **AFTER:** “Since I can now use the time more productively, I’m certainly not **LESS** willing to spend $x$ mins driving in congestion – indeed, I am willing to spend **MORE THAN** $x$ mins in congestion”
Some things we “know” (6)

● More travel:

➢ Longer commute distances:

BEFORE: “I’m willing to waste 30 minutes (each way) on my commute”

AFTER: “Since I can
  ❖ work productively
  ❖ eat, sleep, exercise

in the car, I’m willing to spend 1.5 hours (each way) on my commute –
and now I can live on the lake/in the mountains/by the shore!”
Some things we “know” (7)

- More travel (longer-distance):
  - More frequent/longer road trips
  - Stronger competition with air for short- and medium-distance trips
  - Mixed impact on hotel stays:
    - More stays because more/longer trips, partly counteracted by
    - Fewer stays because we can save a night by riding back in the car while we sleep
Some things we don’t know: (1)
Institutional and aggregate

- What will the regulation and pricing climate be?
- What will become of cost-benefit analysis of transportation alternatives?
- In addition to the impacts already suggested, what will
  - adoption by the mobility-limited (elderly, children, other non-“drivers”)
  - repositioning and other vehicle-only trips
  add to total distance traveled?
Some things we don’t know:  

Social

- How will social expectations for uses of travel time (TT) evolve?
  - Always-available
  - Fuzzy boundary between work and personal time
Some things we don’t know: (3) Individual (1)

- What are the motivations for TT use, and under what circumstances are they active (Circella et al., 2012; Cotte & Ratneshwar, 1999; Shaw et al., in progress)?
  - Decreases the burden of disliked travel/activity
  - Increases the pleasure of liked travel/activity
  - Increases productivity
  - Decreases time pressure
  - Decreases (or increases) stress
  - Reinforces self-identity
  - For its own sake
  - in short, increases subjective well-being
Some things we don’t know: (4)

Individual (2)

- What are the **disadvantages** of TT use, and under what circumstances are they active?
  - Interferes with the enjoyment of the trip
  - Makes an unpleasant trip even more unpleasant
  - Diminishes enjoyment of the activity (compared to doing it at another time)
  - Reduces the quality of what is accomplished
  - Fragments attention too much
  - Takes time away from preferred activities
  - Increases stress

  – in short, decreases subjective well-being
Some things we don’t know: (5)
Individual (3)

- Preference for vehicle...
  - customization / personalization / personification versus
  - sharing sequentially or simultaneously

- Who prefers which, under which circumstances, and how might it be evolving?

- Role and rigidity of constraints (physiological, monetary, coupling, household/child-care, capability, authority, operational)
We know a lot about the influence of travel time on travel choices (1)

- **Trip generation**
  - E.g., choice to telecommute = f(commute distance, etc.)

- **Destination choice**
  - TT traded off against destination attractiveness

- **Mode choice**
  - TT traded off against travel cost; other variables

- **Route choice**
  - Shortest path a common choice

- **Residential location**
  - Commute cost traded off against housing cost
We know a lot about the influence of travel time on travel choices (2)

- I.e. functional forms that work well, variation with other factors (e.g., Abrantes & Wardman, 2011)

- To some extent, we “just” need to know how the “weight” of travel time in those choices is changing

- However, other questions also arise, even in our familiar models
  - Choice set definition
  - **Shared ride with strangers** may be perceived very differently than a **private ride** (in own or hailed vehicle)
Some other questions of interest (1)

- Not all minutes are created equal: how can we quantify the value of travel time?
  - Do we have different standards for TT than for other time?
  - What is our reference point:
    - Zero expected value (therefore any positive benefit is a “bonus”)?
    - Full value we would receive for those same minutes if not traveling?
    - Maximum possible value?

Ben-Elia, et al. (esp. Lyons), (in press)
Some other questions of interest (2)

- How do the activities we engage in while traveling differ from our preferred (or, next-best) alternative?
  - I.e., to what extent are the activities we do while traveling an unconstrained choice (something we would have done anyway), versus “the best we can do, given that we’re traveling”?
  - To what extent are they entirely new activities that would not have taken place otherwise (thus replacing nothing, maybe not “creating time” at all)?
- More generally, what are the interactions of TT with non-TT (and the impacts on others)?

Ben-Elia, et al. (esp. Lyons), (in press)
Analysis tools

- Data collection platforms
  - Focus groups
  - Stated response surveys
  - Revealed preference surveys
    - Learn from current uses of travel time by passengers (Malokin et al., under review; in prep)
  - Smartphone apps
  - Social media?

- Data collection times
  - Cross-sectional
  - Continuous
  - (Eventually) longitudinal

Ben-Elia, et al. (esp. Lyons), (in press)
Analysis tools (2)

■ Nature of the data
  ● Qualitative – ask people; study the past
  ● Qualitative/quantitative – chauffeur study (Walker et al., in progress)

■ Models
  ● Theoretical models of destination, mode, residential location choices
  ● Time allocation models that account for travel time use (Pawlak et al., 2015)
  ● Account for heterogeneity

■ Disciplines
  ● Economics, psychology, sociology, anthropology, geography, urban planning, engineering, computer science, history, law, public health ...
In summary

- It appears (to some!) that the use of travel time will be undergoing a revolution with the advent of autonomous vehicles – in any case we have a lot to learn about it.

- Looking forward to the journey!

http://www.iamatechie.com/relax-your-car-is-on-auto-pilot/5454
Selected references


- **Shaw, Atiyya, Alex Malokin, Patricia L. Mokhtarian, & Giovanni Circella** (in progress) The pros and cons of travel-based multitasking: Who does it, and what do they get out of it?

- **Walker, Joan**, et al. (in progress) Chauffeur experiment.
Land Use Impacts of Autonomous Vehicles: Some Speculations

Eric J. Miller, PhD
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Director, Transportation Research Institute
University of Toronto

and

Yoram Shifton, Ph.D
Professor, Department of Civil and Environmental Engineering
Director, Transportation Research Institute
Technion, Israel Institute of Technology
Research Questions

• How will fully autonomous vehicles affect people's choice of where to live and work?
• Business location choices?

• What are the main characteristics of AV that will affect such choices:
  • VOT/Multi-tasking/Travel time budget
  • No need to park
  • Travel cost budget

• The larger impact on land use patterns
Potential Impacts/Questions

AVs

- Accessibility: travel time/cost/effort
- Multi-tasking
- Activity/travel choices
- Auto ownership
- Other?

Residential Choice

- No parking search
- Friendly to kids, elderly and disabled
- Travel time and speed
- Value of time
- Logsum of travel choices
- Participation in remote activities
- The willingness to accept longer travel distance
Autonomous vehicles

Auto ownership

Short term travel and activity behavior

Long term location choices
Related Literature

• No literature specific of AV impact on location choices
• Rich literature on land use and transport interaction
• Rich literature of the impact of accessibility on location choices
• Accessibility variables in residential choice models:
  • Walking distance to transit
  • Travel time to CBD
  • Travel time to work and shopping centers
  • In neighborhood proximity to shops and other activities
  • Work places in given travel time, etc.....
  • Parking availability
Typology of Approaches

Initial use in in auto ownership and travel choices:

- Stated Preference Surveys
- Virtual reality/Games/Simulators/movies
- Revealed Preference/Analog modes/naturalistic experiments
- Qualitative: focus groups, interviews, history of locations changes.....
- Data Needs?
Initial Considerations
Factors affecting residential location

- Residential location choices depend on so many factors in addition to transportation accessibility:
  - Neighborhood characteristics.
  - Dwelling attributes.
  - Schools.
  - Lifestyle.
  - Price / affordability.
  - “Community”:
    - Neighbors.
    - Local amenities.
  - ...

Accessibility

• Accessibility defined across so many modes, purposes, etc.
  • Although in so much of the US, the car is the only viable mode.

• AVs almost certainly improve accessibility for those who cannot currently drive: young, old, disabled.

• Still will need to locate services conveniently close to target users.

• ...
Dodging the hype

• For AVs to have significant impact on residential location they actually have to “deliver” in terms of:
  • Significantly faster travel times.
  • “Productive” within vehicle/trip environment (e.g., happy to work within the vehicle rather than at home or at work).
  • “Trustworthy” chauffeuring of children, etc.
  • Even if adopted, people may simply change travel behavior “in place” rather than move.

• Many of the claims for AVs are unproven at the moment (& arguably even quite dubious).

• We need, however, to study their potential impacts in case they come to pass.
Existing “models” (1)

- Numerous modes/services already provide a “driverless trip” from the perspective of the passenger, notably:
  - Commuter rail.
  - Conventional taxi.
  - Uber/Lyft, etc.

- What can we learn from responses to current and emerging services with respect to travel behavior & residential location?

- Certainly throughout history, people have “moved out” and de-densified as transportation technology has allowed them to do so:
  - Commuter rail lines.
  - Streetcar railways.
  - Subways.
  - Automobiles.

- People have always been willing to trade some travel time for more space, cheaper land, etc.

- A key question is whether AVs will really change the accessibility landscape or not, and, if it does, will it encourage even greater “sprawl”? 
Existing “models” (2)

- Telecommuting (“flat earth” hypothesis):
  - It has long been argued that modern ICT would “free” workers from the workplace and even from the “City”.
  - While this has happened to a certain extent, it has not revolutionized either commuting behavior or residential location choices.
  - This probably largely reflects the continuing need (for a wide variety of reasons) for people to still gather together in “work places”.
  - But it also arguably does not provide evidence for a strong desire to “flee the city” if able to do so.
Existing “models” (3)

• Indeed, we have seen a “return to the city”, particularly among younger people.

• Perhaps, rather than encouraging sprawl, AVs will encourage greater densification / urbanization, at least among younger generations:
  • No need to own a car.
  • Urban lifestyles.
  • Possibly freeing up land for parking (although, again, perhaps quite dubious that this will happen).

• We see these trends already; perhaps AVs will reinforce them.
Surveys

• In theory, one should be able to construct SP experiments to explore these issues.

• However, this surely would be very challenging to do:
  • High “dimensionality” of the problem.
  • Massive uncertainties.
  • Alternatives include both residential location alternatives & travel alternatives.
  • How to even pose the problem?
Understanding behavior better

• Maybe the starting point is to delve deeper into residential location preferences:
  • What do people really want and why?
  • What are the actual constraints on their current residential locations?
  • How do they view the location / travel tradeoff?
  • How does accessibility actually enter into their decisions & behaviors?

• As with just about all aspects of AVs, the “big question” is getting a more fundamental, deeper understanding of current behavior, preferences, decision processes. This would tell us much about how people can be expected to react in the face of new technologies & services.
Timeframe for change

- Regardless, residential location shifts are likely to take a long time to play out (indeed, AV impacts are likely going to be much longer-term than many advocates claim).
- So we have some time to conduct some fundamental research.
- But we should start now!
Policy implications

• Policies to prevent / discourage additional sprawl?
  • Road tolls.
  • Land development control (greenbelts, etc.)
    • Not a big winner to date in the US and elsewhere!
  • ...

• Using AV-based services to:
  • Solve “first/last mile problems”:
    • Support/preserve higher-capacity transit services.
    • Encourage people to “stay in place”.
  • Support densification, urbanization processes:
    • Evolving suburbs into mixed-use, somewhat higher density “cities” (without having to rip existing suburban developments apart and starting from scratch).
Employment & other activity locations

• How will offices, stores, etc. respond in a truly ubiquitous AV world?
  • Very hard to say.
• ...
Autonomous vehicles and potential impacts on activity-travel behavior

Chandra Bhat and Mark Bradley
Automated Vehicles and Transportation

Technology

Infrastructure

Traveler Behavior
Potential AV Impacts on Activity Participations and Travel

• Today’s mobility-constrained groups (including seniors and physically-challenged individuals) will have more mobility freedom and may generate more out-of-home (OH) participations and travel

• More generally, individuals may participate more in OH activities, and generate more trips (less need for trip chaining and more time freed up for leisure OH participation?)

• More empty trips? Depends on automobile ownership and use paradigm.
Potential AV Impacts on Location Choice

• Be willing to live farther away from the work place

• Choose locations for non-work activity participation that are farther away than current participation locations

• Lower parking hassles may imply more attraction to dense, attractive activity locations

• Be less likely to pursue activities (as a package) within a compact geographic footprint (i.e., potentially less incentive for activity chaining), or perhaps more activities within a compact geographic footprint if AV ride-sourcing is used.
Potential AV Impacts on Mode Choice

Automated vehicles combine the advantages of **public transportation** with that of **traditional private vehicles**

- Catching up on news
- Texting friends
- Reading novels
- Flexibility
- Comfort
- Convenience

What will happen to **public transportation**?

Also automated vehicles may result in lesser walking and bicycling shares (and less walking to/from parking and transit)

**Time** (congestion and reliability) less of a consideration ➞ **So, will Cost** be the main policy tool to influence behavior?
Potential Impacts on Mode Choice

- Driving personal vehicle more convenient and safe
- Traditional transit captive market segments now able to use auto (e.g., elderly, disabled)
- Reduced reliance/usage of public transit?

However, autonomous vehicles may present an opportunity for public transit and car sharing

- Lower cost of operation (driverless) and can cut out low volume routes
- More personalized and reliable service - smaller vehicles providing demand-responsive transit service
- No parking needed – kiss-and-ride; no vehicles “sitting” around
- 20-80% of urban land area can be reclaimed
- Chaining may not discourage transit use (that is, people can use a good public transit system to go to work even if they have to make a stop on the return home from work)
Central Role of Time Use

• Notion of time is central to activity-based modeling
  – Explicit modeling of activity durations (daily activity time allocation and individual episode duration)
  – Treat time as “continuous” and not as “discrete choice” blocks

• Activity engagement is the focus of attention
  – Travel patterns are inferred as an outcome of activity participation and time use decisions
  – Continuous treatment of time dimension allows explicit consideration of time constraints on human activities

• Reconcile activity durations with network travel durations (feedback processes)
Shared Autonomous Vehicles (SAV) vs. Private Ownership is a key issue

- **Private ownership**
  - Chauffeuring household members

- **Shared Autonomous Vehicles (SAV)**
  - Acquired by mobility providers (Uber, Lyft, car2go...)
  - Travelers purchasing transportation
    - $/trip
    - $/mile
    - $/minute
Potential Activity-Travel Impacts Based on Ownership/Use Paradigm

**PRIVATELY OWNED AV**
- High empty-vehicle-miles traveled
- Reduced AV owners’ value of travel time
- Cancel some/all network operation gain due to AV platooning
- Increased energy consumption (?)
- Increased congestion (?)

**SHARED AV**
- Subsided fares for social inclusion (?)
- Lower empty-vehicle-miles traveled
- Fares control value of travel time
- Network operation gain due to AV platooning
- Reduced energy consumption
- Less congestion
About auto ownership and use paradigm*

* Based on a forthcoming paper by Lavieri et al

- Two forms of adoption were considered:
  - AV ownership and
  - AV sharing.

- Individuals were grouped into one of four different categories:
  - interested in AV ownership,
  - interested in AV sharing,
  - interested in both options, and
  - not interested in AV adoption.
Data

- Survey with 1800 individuals in the Puget sound Region

- AV interest
  - Not interested in AV sharing or AV ownership (68.5%)
  - Interested in AV sharing only (7.6%)
  - Interested in AV ownership only (8.5%)
  - Interested in AV sharing and AV ownership (15.4%)

- 51% reside in low-density neighborhoods

- 12% reside in zero-vehicle households and 39% resided in one-vehicle households

- 14% used a ride-sourcing service at least once in their lifetime

- 9.2% used a car-sharing service at least once in their lifetime
# Concerns about Autonomous Cars

<table>
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<th>Type of concern</th>
<th>Not concerned</th>
<th>Somewhat unconcerned</th>
<th>Neutral/does not know</th>
<th>Somewhat concerned</th>
<th>Very concerned</th>
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<tbody>
<tr>
<td>Equipment and system safety</td>
<td>6.9%</td>
<td>4.4%</td>
<td>22.2%</td>
<td>26.9%</td>
<td>39.6%</td>
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<tr>
<td>System and vehicle security</td>
<td>8.4%</td>
<td>5.0%</td>
<td>26.2%</td>
<td>26.8%</td>
<td>33.7%</td>
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<tr>
<td>Capability to react to the environment</td>
<td>6.2%</td>
<td>3.2%</td>
<td>18.9%</td>
<td>22.8%</td>
<td>48.9%</td>
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<tr>
<td>Performance in poor weather or other unexpected conditions</td>
<td>6.3%</td>
<td>4.3%</td>
<td>21.5%</td>
<td>26.5%</td>
<td>41.4%</td>
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<tr>
<td>Legal liability for drivers or owners</td>
<td>6.4%</td>
<td>4.2%</td>
<td>24.3%</td>
<td>27.4%</td>
<td>37.7%</td>
</tr>
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</table>
4. BEHAVIORAL FRAMEWORK
Individual preferences for ownership and sharing AVs

- **Lifestyle**
  - Green Lifestyle
  - Tech-savviness

- **Present Choices**
  - Use of carsharing (binary)
  - Use of ridesourcing (binary)
  - Vehicle Ownership (count)
  - Household location density (binary)

- **Future Intention Based on Current Interest**
  - Interest in AV
    1) sharing
    2) owning
    3) both
    4) none

**Sociodemographics**
Lifestyle Variables

- Green lifestyle

- Frequency of transit usage
- Importance of a walkable neighborhood and being close to activities in choice of home location
- Importance of being close to public transit in choice of home location
- Importance of being within a 30-minute commute to work in choice of home location
Lifestyle Variables

- **Tech-savviness**

  - Smartphone ownership
    - Do not have and do not plan to buy a smartphone (28%)
    - Do not have but plan to buy a smartphone (4%)
    - Have a smartphone (68%)
  
  - Frequency of usage of smartphone apps for travel information
  
  - Frequency of usage of GPS
Policy Implications

- Results show:
  - **Individuals with green lifestyle preferences and who are tech-savvy** are more likely to adopt car-sharing services, use ride-sourcing services, and embrace autonomous vehicle-sharing in the future.
  - **Younger and more educated urban residents** are more likely to be early adopters of autonomous vehicle technologies, favoring a sharing-based service model.
  - **Individuals who currently eschew vehicle ownership, and have already experienced car-sharing or ride-sourcing services**, are especially likely to be early adopters of AV sharing services.
  - Most effective way to move **AV adoption toward a sharing model** (rather than an ownership model) is to **enhance neighborhood densification**.
  - Will new mobility options reduce bicycling, walking, and the use of public transportation (PT) services?
Modeling Implications

- Need to consider latent (and stochastic) psychological constructs to obtain “true” estimates of the effects of current residential and mobility choices on future AV-related choices.

- Travel behavior community: There is a need for a better understanding underlying psychological motivations and preferences.
  - The cursory attention we have paid to psychological underpinnings in our current modeling approaches will not suffice as we move into a new transportation era of innovative mobility-technology services.

- Need a better understanding of the individual observed attributes that characterize factors such as being green and tech-savvy.
Research To Examine Behavioral Responses to AVs

Examining Vehicle Ownership and Use

Johanna Zmud, Texas A&M Transportation Institute
Barbara Lenz, German Aerospace Center, DLR
AVS 2017
Research Question

How and at what rate will fully autonomous vehicles be adopted?

Will Car Ownership Survive Shared AVs?
“By 2025, private car ownership will all but end in major cities”

“By 2030, 95% of miles traveled by on-demand autonomous vehicles owned by fleets”

“By 2050, shared mobility will account for 80% of the market”
Framework for Viewing Future Under Uncertainty

- Fully Autonomous
  - Personal Automation
  - Personal Vehicle
- Semi-Autonomous
  - Business as Usual
  - Shared Mobility
- Driver
  - Shared Automation
  - Shared Vehicle

Texas A&M Transportation Institute

DLR
Will Shared AVs Really be the end of car ownership?

<table>
<thead>
<tr>
<th>Fully Autonomous</th>
<th>Personal Automation</th>
<th>Shared Automation</th>
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<tbody>
<tr>
<td>Semi-Autonomous</td>
<td>Business as Usual</td>
<td>Shared Mobility</td>
</tr>
<tr>
<td>Driver</td>
<td>Personal Vehicle</td>
<td>Shared Vehicle</td>
</tr>
</tbody>
</table>
People Like to Own Cars

- Fully Autonomous
  - Easily dominant mode of transportation
  - Huge percentage has never used

- Semi-Autonomous
- Driver
  - Personal Vehicle
  - Shared Vehicle
### Shared Automation Deploys Before Personal Automation

<table>
<thead>
<tr>
<th></th>
<th>Fully Autonomous</th>
<th>Semi-Autonomous</th>
<th>Driver</th>
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</thead>
<tbody>
<tr>
<td><strong>At least 2030</strong></td>
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<tr>
<td><strong>As early as 2020</strong></td>
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<td><strong>Policy</strong></td>
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<tr>
<td><strong>Market demand</strong></td>
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<td><strong>Deployment speed</strong></td>
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<td><strong>Near Perfect Operations</strong></td>
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<tr>
<td><strong>Early applications route constrained</strong></td>
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</tbody>
</table>

- Personal Vehicle
- Shared Vehicle

**Notes:**
- At least 2030 refers to the earliest deployment time for fully autonomous vehicles.
- As early as 2020 refers to the earliest deployment time for semi-autonomous vehicles.
- Near Perfect Operations imply that once deployed, these vehicles operate nearly flawlessly.
- Early applications route constrained refers to the initial deployment of vehicles being limited to specific routes or areas due to safety or regulatory reasons.
How Will People Behave?

- Fully Autonomous
- Semi-Autonomous
- Driver
- Personal Vehicle
- Shared Vehicle
Critical Questions Going Forward

• What is the uptake of shared mobility?
• Who are early adopters of shared AVs?
  • Is adoption based on the pull of market demand or on the push of supply?
• How do increasing levels of automation influence car ownership?
  • Who buys new?
  • Who buys used?
• How likely is it that people will give up their personal vehicles to use shared AVs?
• What happens to public transit and cycling?
• How are purchasing / usage trends transformed by the passage of time?
Barbara’s public transport slides here
How to Measure Behavioral Responses to AVs and SAVs?
How to Tackle Behavioral Complexities

Research Challenges
• People like cars
• Lack of experience
• Speed of technology deployment
• Varying regulations
• New industry landscape

Methods/Solutions
• Attitudes and preferences
• Virtual reality
• Leverage pilots
• Tracking studies
• Qualitative methods