Behavioral Considerations for Integrated Modeling in an Era of Disruptive Emerging Transportation Technologies

Ram M. Pendyala, Professor and Interim Director
School of Sustainable Engineering and the Built Environment

MARG

TOMNET Transportation Center
Teaching Old Models New Tricks
http://tomnet-utc.org | http://mobilityanalytics.org

ASU Ira A. Fulton Schools of Engineering
Arizona State University

Acknowledgements

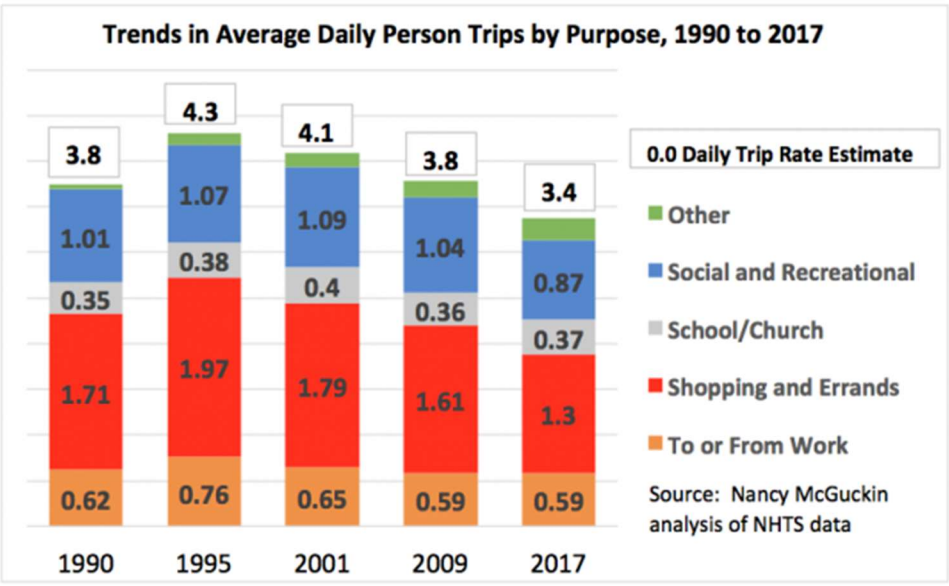
ASU Ira A. Fulton Schools of Engineering
Arizona State University

- ASU Team
  - Xuesong Zhou, Associate Professor
  - Sara Khoeini, Assistant Research Professor
  - Shivam Sharda, Denise Capasso da Silva, Irfan Batur, Tassio Magassy, Taehooie Kim
- Chandra Bhat, The University of Texas at Austin, and team of outstanding students

Acknowledgements

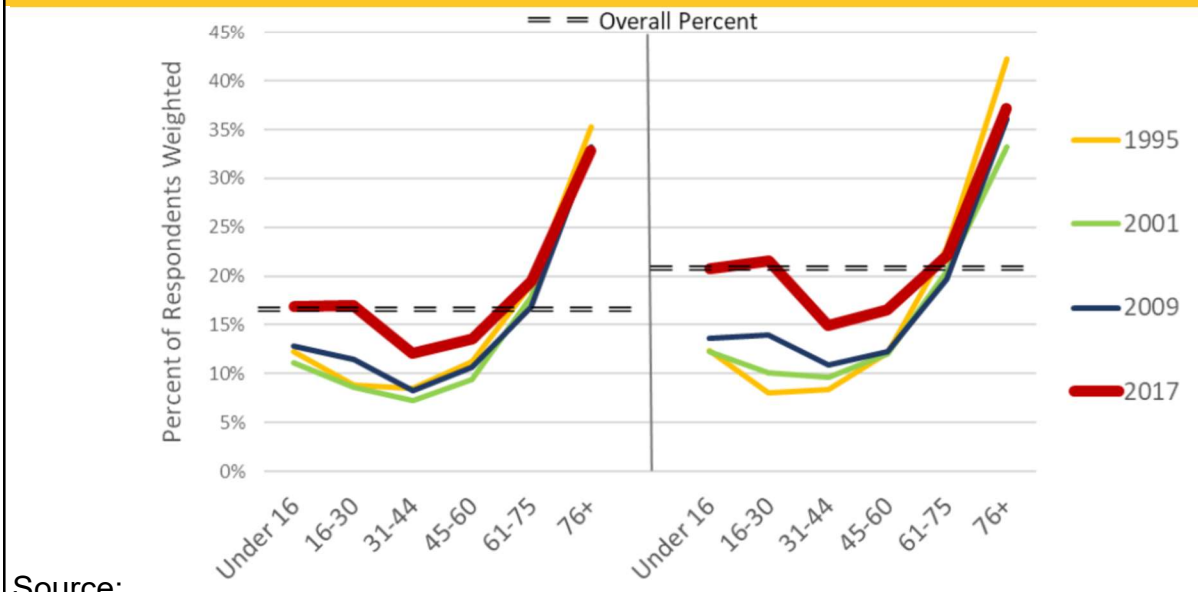
- TOMNET Team
  - Patricia L. Mokhtarian, Georgia Tech
  - Giovanni Circella, Georgia Tech and UC Davis
  - Deborah Salon, ASU
  - Michael Maness, University of South Florida
  - Fred Mannering, University of South Florida
  - Cynthia Chen, University of Washington
  - Daniel Abramson, University of Washington
  - Abdul Pinjari, Indian Institute of Science, Bangalore
  - **and many fabulous students!**

What is Going On With Travel Demand?

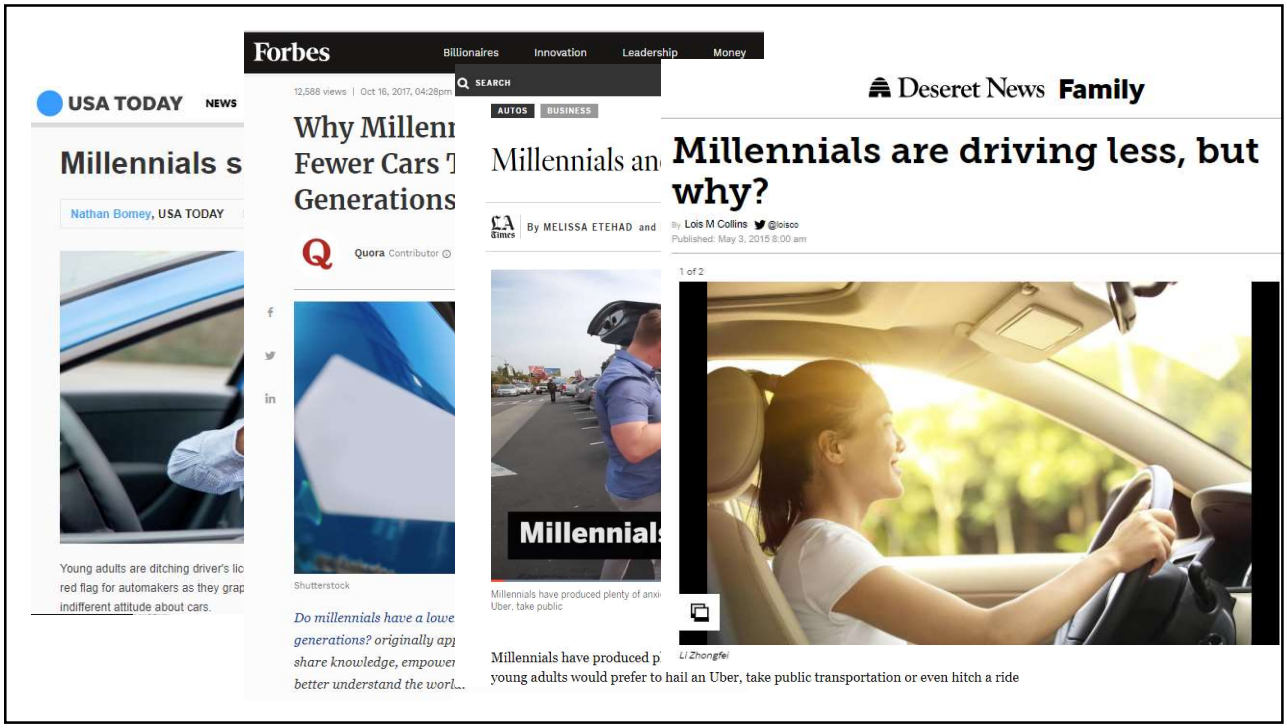


Disruption due to Socio-demographic shifts, attitudinal shifts, e-commerce, and IoT

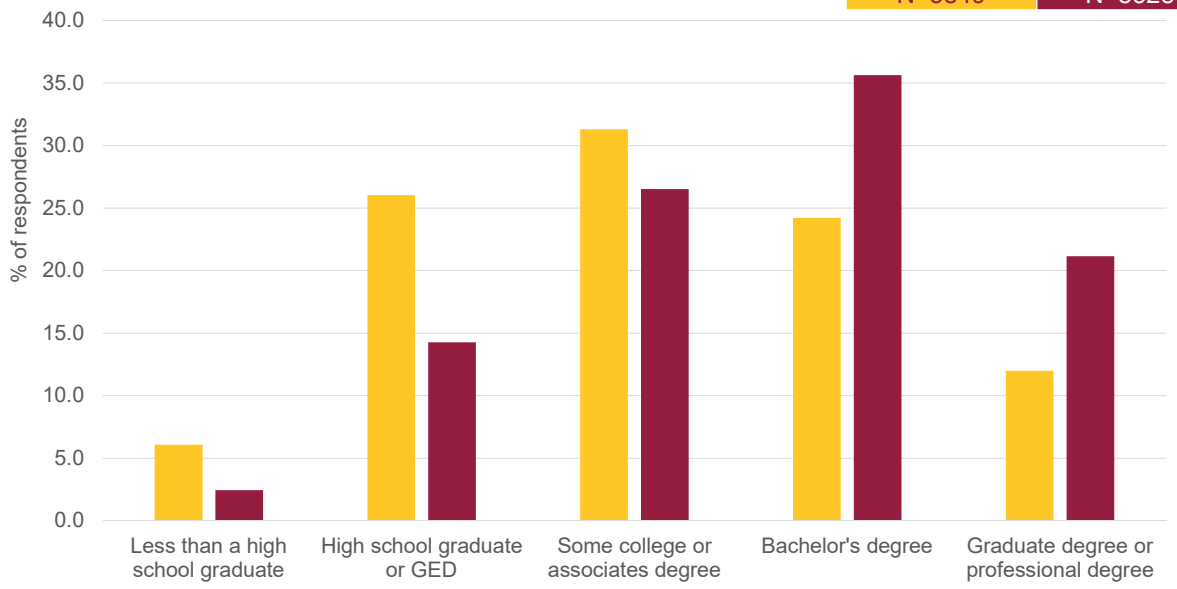
Percent of People Reporting ZERO TRIPS



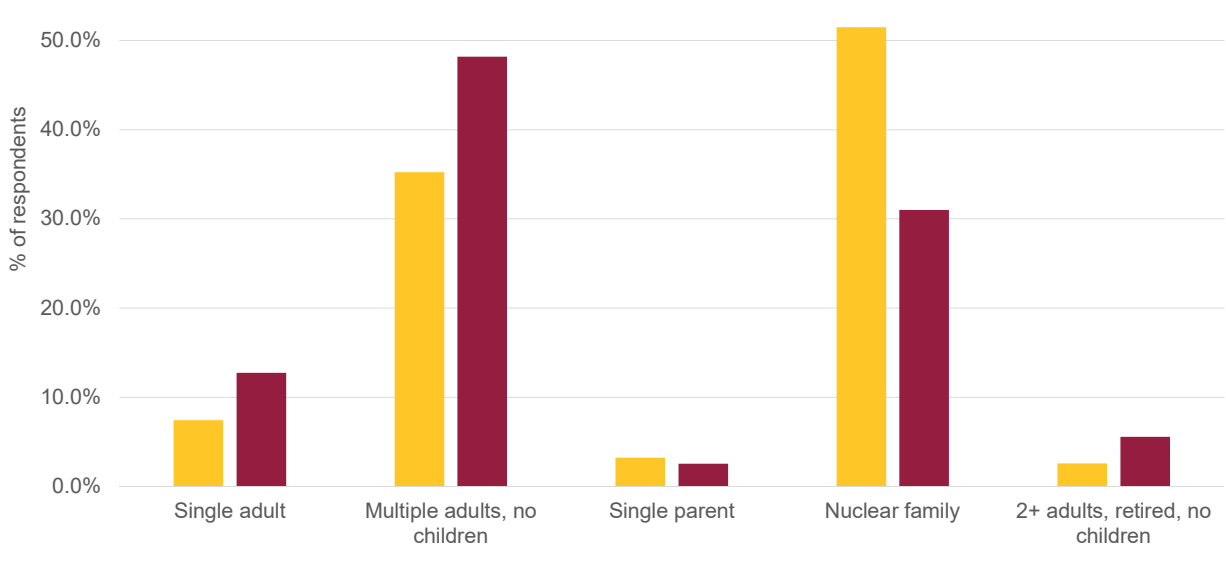
Source:
McGuckin, N. (2018)



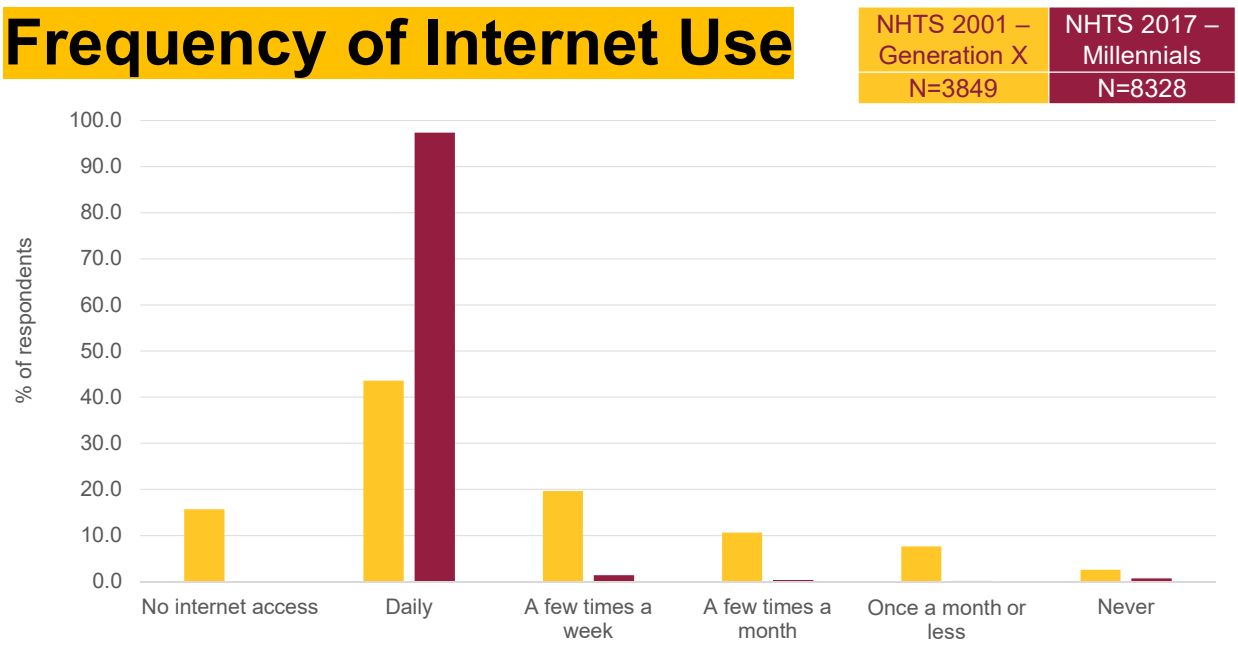
Educational Attainment



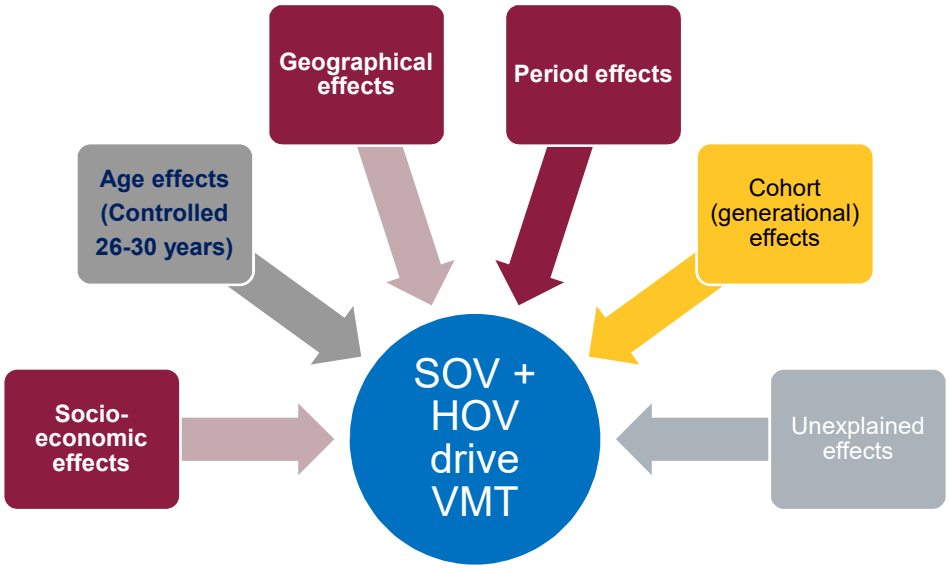
Household Structure



Frequency of Internet Use



Framework



Summary and Conclusions

Vehicle Miles Traveled is lower for Millennials, but the size of the generation (cohort) effect is tiny (less than 0.3%). VMT differences are largely due to socio-economic and demographic characteristics. The period effect is actually greater than the generation effect.

Huge UNEXPLAINED portion of person VMT variance!

Menu Search **Bloomberg Businessweek** Sign In Subscribe

April 25, 2019, 2:00 AM MST

Millennials Tried to Kill the American Mall, But Gen Z Might Save It

Source: https://www.bloomberg.com/news/articles/2019-04-25/are-u-s-malls-dead-not-if-gen-z-keeps-shopping-the-way-they-do

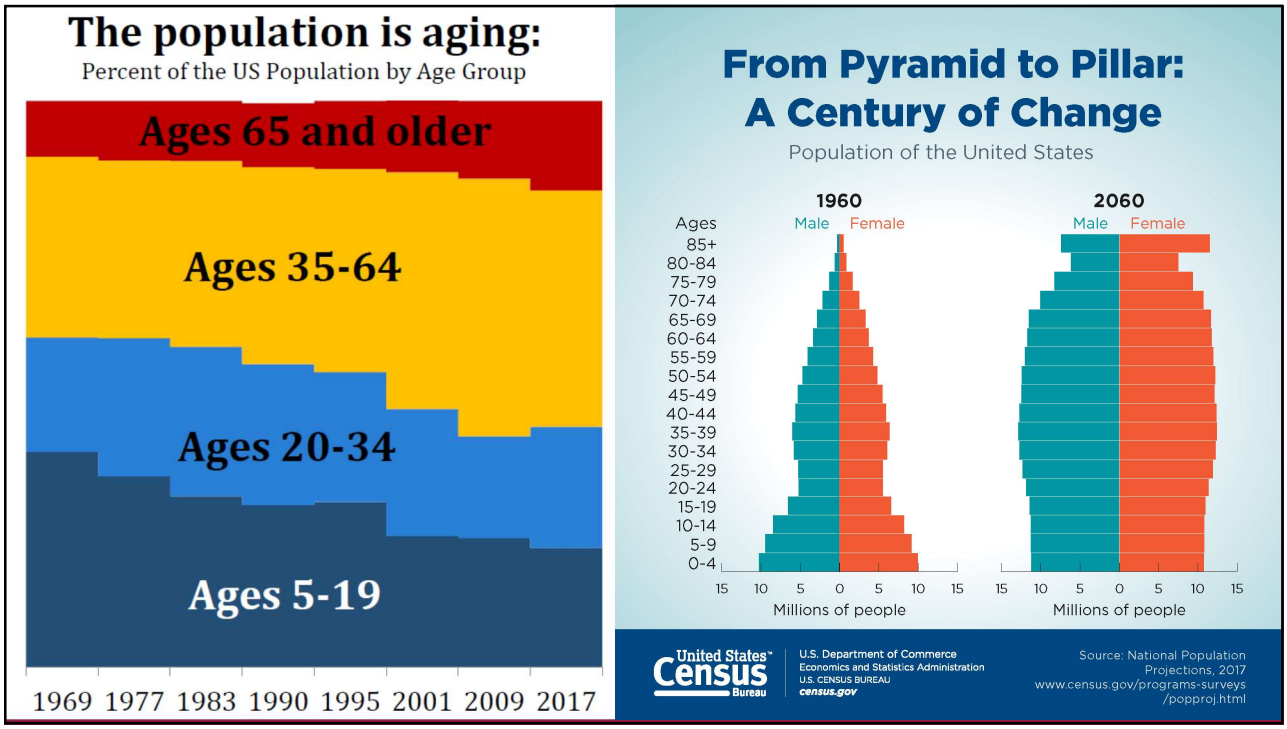
NEWS › NATIONAL

Is the era of the shopping mall over? Not quite. An unexpected generation is reviving them

Posted: 9:24 AM, May 13, 2019 **Updated:** 7:16 AM, May 13, 2019

By: Jade Jarvis

Source: https://www.abcactionnews.com/news/national/is-the-era-of-the-shopping-mall-over-not-quite-an-unexpected-generation-is-reviving-them



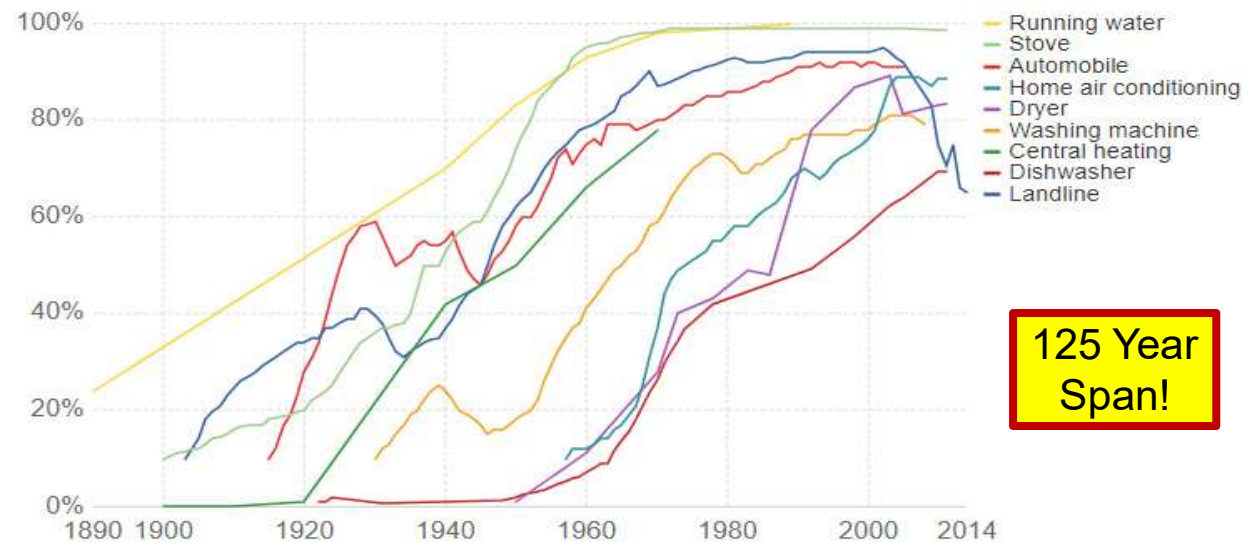
The Future of Mobility

ASU Ira A. Fulton Schools of Engineering
Arizona State University

- Connected vehicles
  - V2V and V2I configurations
- Automated vehicles
  - Various degrees of automation
- Autonomous vehicles
  - Truly driverless
- (Shared/Hailed) Mobility Services (TNCs)
  - On-demand
- Electrification
- No Travel – Virtual and Delivered!

MARG

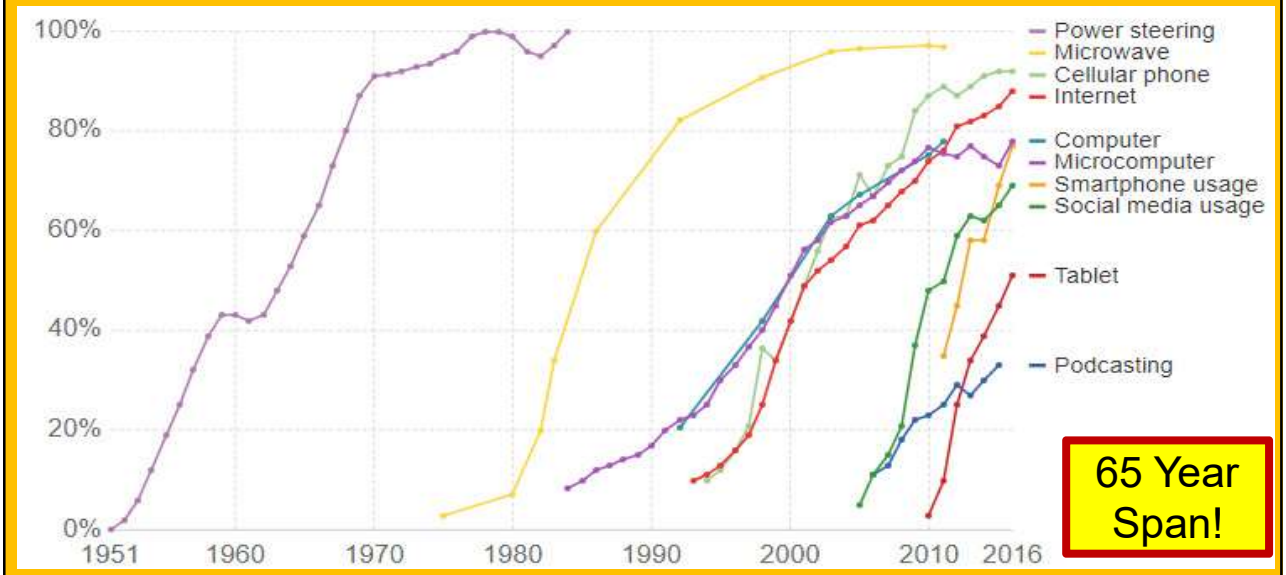
Technology Adoption



125 Year Span!

https://www.visualcapitalist.com/rising-speed-technological-adoption/

Technology Adoption

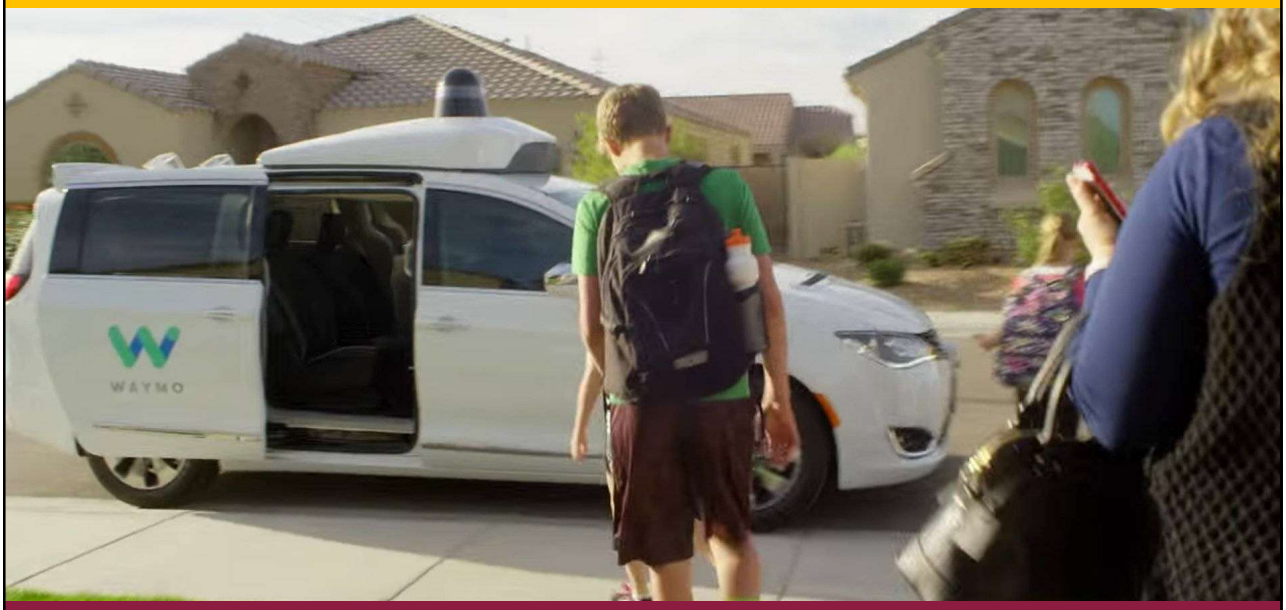


65 Year Span!

https://www.visualcapitalist.com/rising-speed-technological-adoption/

Waymo Now Giving Self-Driving Car Rides to the Public in Phoenix

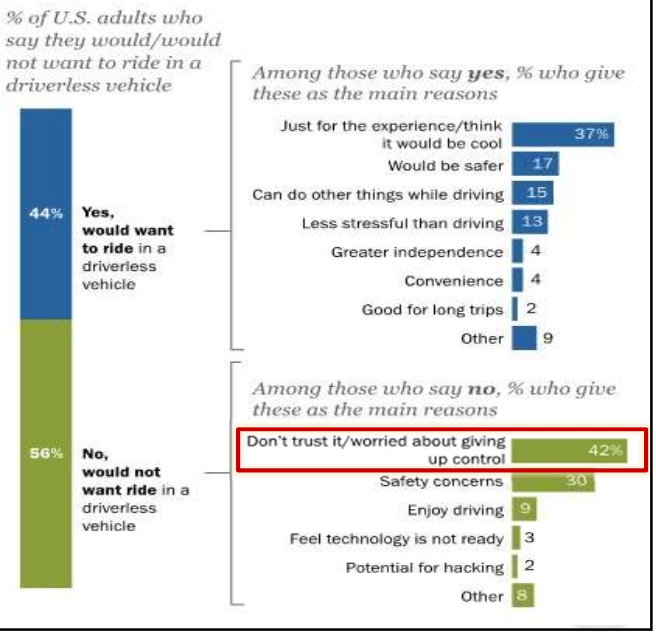
Average Joes are about to get a crack at riding in the company's autonomous minivans.



http://www.thedrive.com/tech/9644/waymo-now-giving-self-driving-car-rides-to-the-public-in-phoenix

AV adoption

Slight majority of Americans would not want to ride in a driverless vehicle if given the chance; safety concerns, lack of trust lead their list of concerns



Source: http://www.pewinternet.org/2017/10/04/automation-in-everyday-life/pi_2017-10-04_automation_3-05/

How a Self-Driving Uber Killed a Pedestrian in Arizona

By TROY GRIGGS and DAISUKE WAKABAYASHI UPDATED MARCH 21, 2018

A woman was struck and killed on Sunday night by an autonomous car operated by Uber in Tempe, Ariz. It was believed to be the first pedestrian death associated with self-driving technology.

What We Know About the Accident

fear about riding in a fully autonomous vehicle

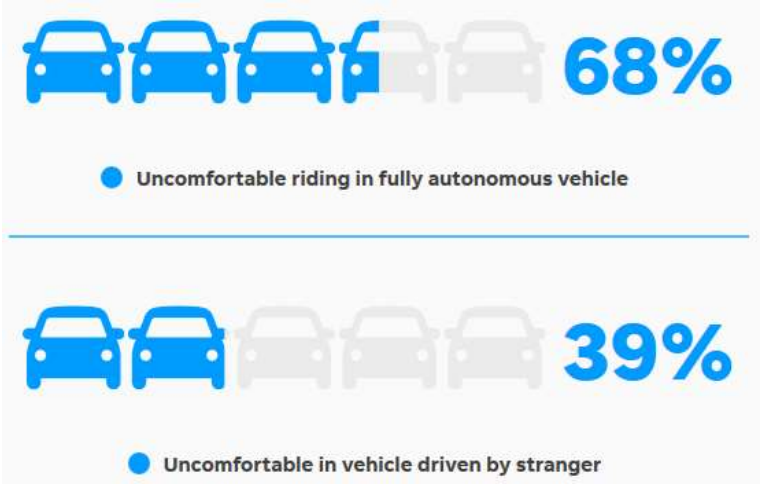
78% early 2017 ➡ **63%** early 2018 ➡ **73%** may 2018

survey taken few weeks after the Uber fatal accident in Tempe, AZ

Sources:
https://newsroom.aaa.com/2018/05/aaa-american-trust-autonomous-vehicles-slips/
https://www.bizjournals.com/phoenix/news/2018/05/22/aaa-survey-fear-of-self-driving-cars-rises.html

ASU Ira A. Fulton Schools of Engineering
Arizona State University

Consumers not ready for full autonomy



Source:
https://www.freep.com/story/money/cars/general-motors/2018/10/16/fighting-keep-humans-not-robots-drivers/1601286002/

Ira A. Fulton Schools of Engineering
Arizona State University

Consumers not ready for full autonomy

Source:
https://www.freep.com/story/money/cars/general-motors/2018/10/16/fighting-keep-humans-not-robots-drivers/1601286002/

Ira A. Fulton Schools of Engineering
Arizona State University

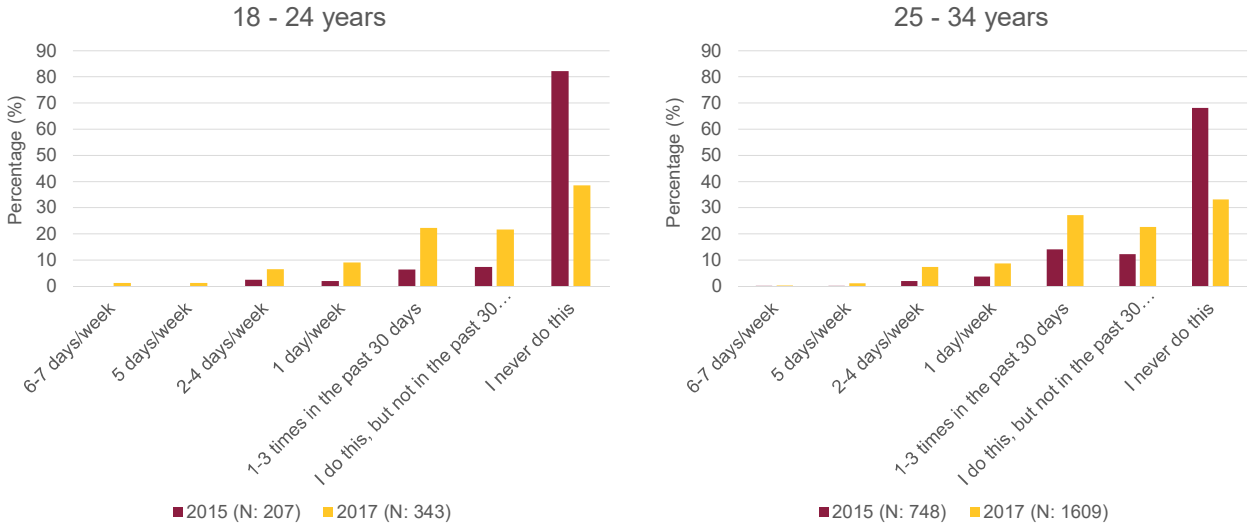
Question:

How do we control a system in which the most important agent doesn't wish to be controlled?

Ira A. Fulton Schools of Engineering
Arizona State University

Evolution of Ride-hailing Frequency: Age 18-34 years

Observed Heterogeneity in Evolution – Puget Sound Regional Travel Survey

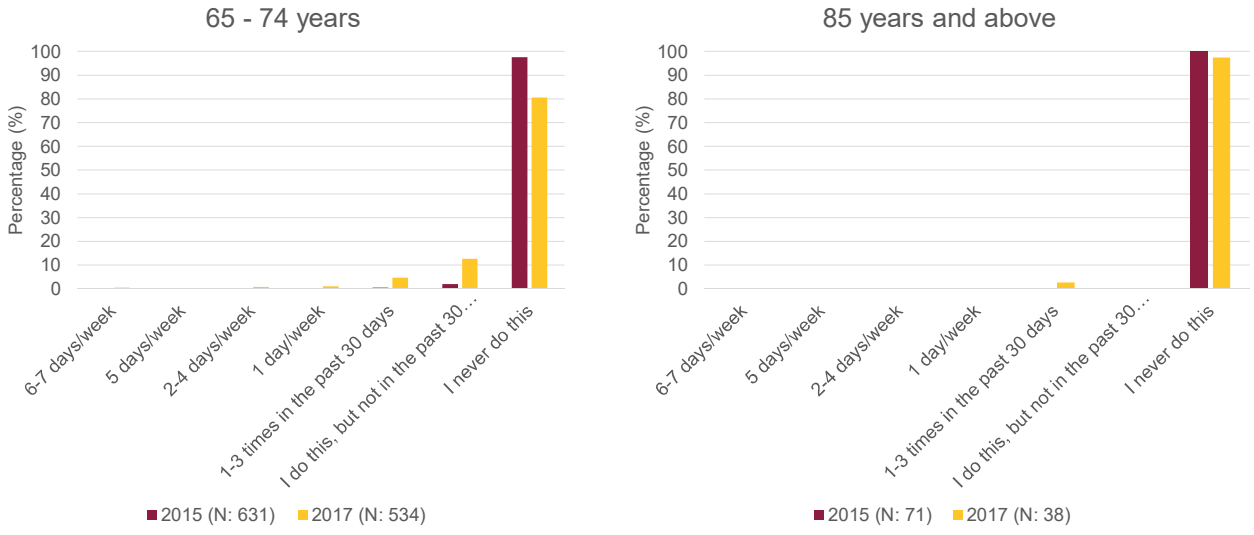


Puget Sound Regional Household Travel Survey, 2015 and 2017

24

Evolution of Ride-hailing Frequency: Age (65 to 74 and ≥ 85)

Observed Heterogeneity in Evolution – Puget Sound Regional Travel Survey



ASU Arizona State University

Puget Sound Regional Household Travel Survey, 2015 and 2017

25

Modeling Approaches

1 Electrification
2 Sharing
3 Automation
4 Deliveries

Scenarios & Parameters → Models & Simulations → Fake Forecasts

So little is known about the future →

Behaviors Defined by Attitudes, Perceptions, Preferences, Values, and Evolutionary Dynamics

How Will Emerging Technologies Impact VMT?

Ira A. Fulton Schools of Engineering
Arizona State University

Vehicle Ownership and So Much More!

Pros

- May ***replace a drive-alone trip*** with Uber + transit, or other combo (solves transit's first- and last-mile problem)
- May ***eliminate a personally-owned car*** (separately good), reducing unnecessary trips

Neutral

- May ***replace a kiss-and-ride or PNR trip***
- Or ***replace some other drive-alone trip***

Cons

- May ***displace a transit trip*** (not only increasing VMT, but undermining transit)
- May ***replace one carpool trip*** with multiple single-rider AV trips
- ***Makes travel easier, cheaper*** → may generate new trips
- ***Time saved*** (e.g., for parents using Shuddle for their children) may be used to generate new trips
- On-demand vehicles ***cruising, deadheading***

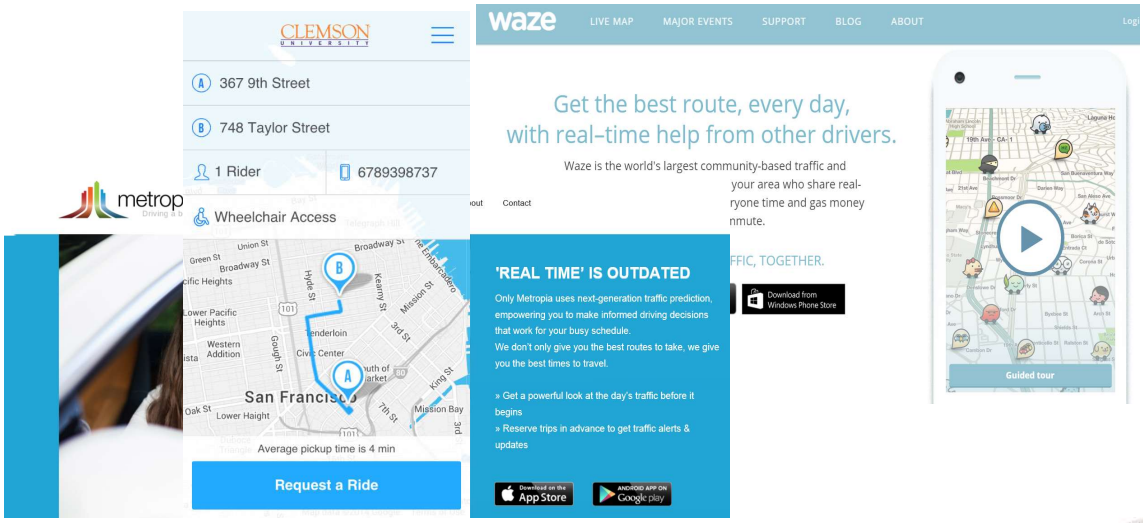
MARG

Source: Patricia L. Mokhtarian, Georgia Tech

The "I" Era in Transportation

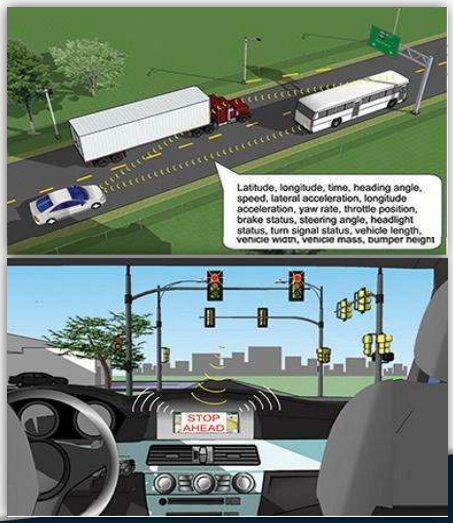
- Information (real-time, predictive, and personalized)
  - A focus on information provision and data collection
- Individual
  - A focus on individual agents
- Integrated
  - Addressing the built environment – travel demand – network supply nexus
- Intelligent
  - A user responsive, adaptive, and flexible multimodal transportation system
- Innovative
  - Big data to monitor and optimize complex adaptive system performance

App-Empowered Connected Travelers

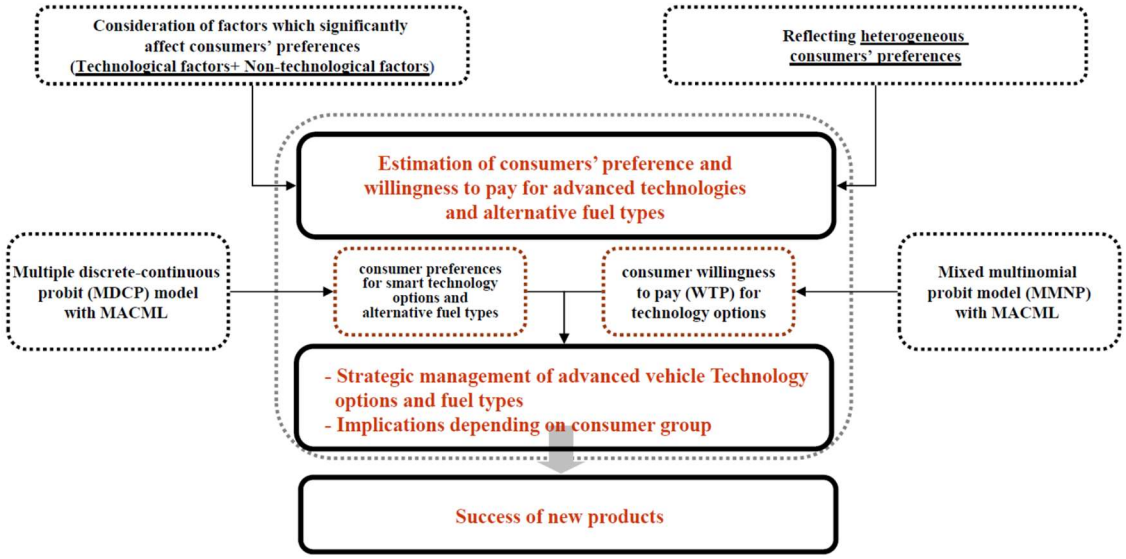


Connected, Shared, and Autonomous Agents

- Connectivity:
  - Among vehicles of all types
  - Among vehicles and a variety of roadway infrastructures
  - Among vehicles, infrastructure, and wireless consumer devices
- Enables **real-time activity/trip planning** (across spectrum of choices)
- Integrated models for era of connectivity and real-time information



A Consumer Adoption Modeling Framework

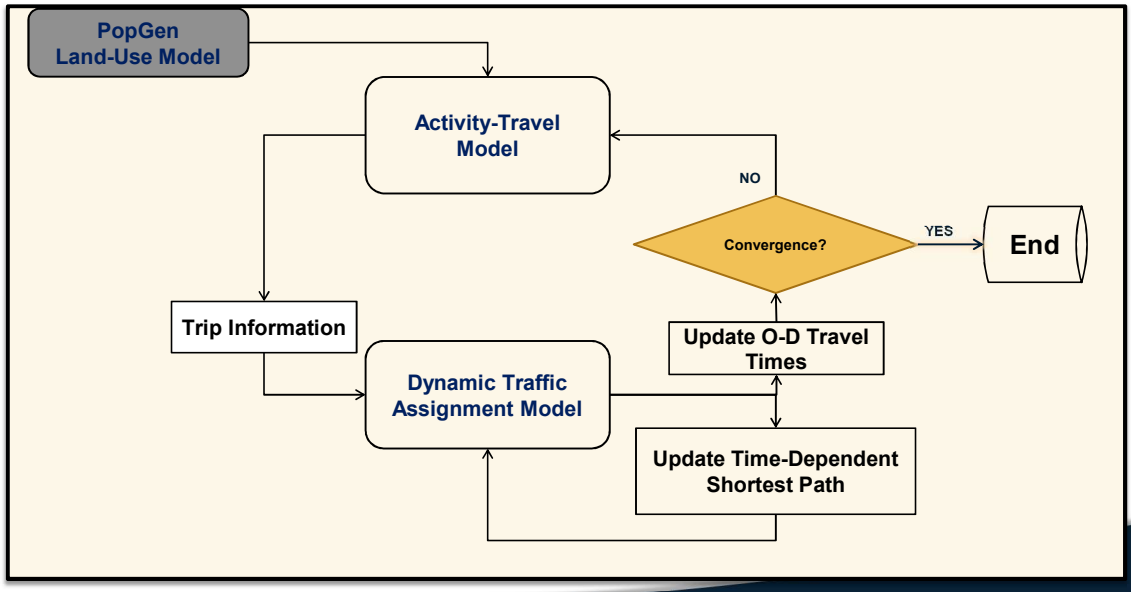


MMNP Model of Smart Vehicle Options

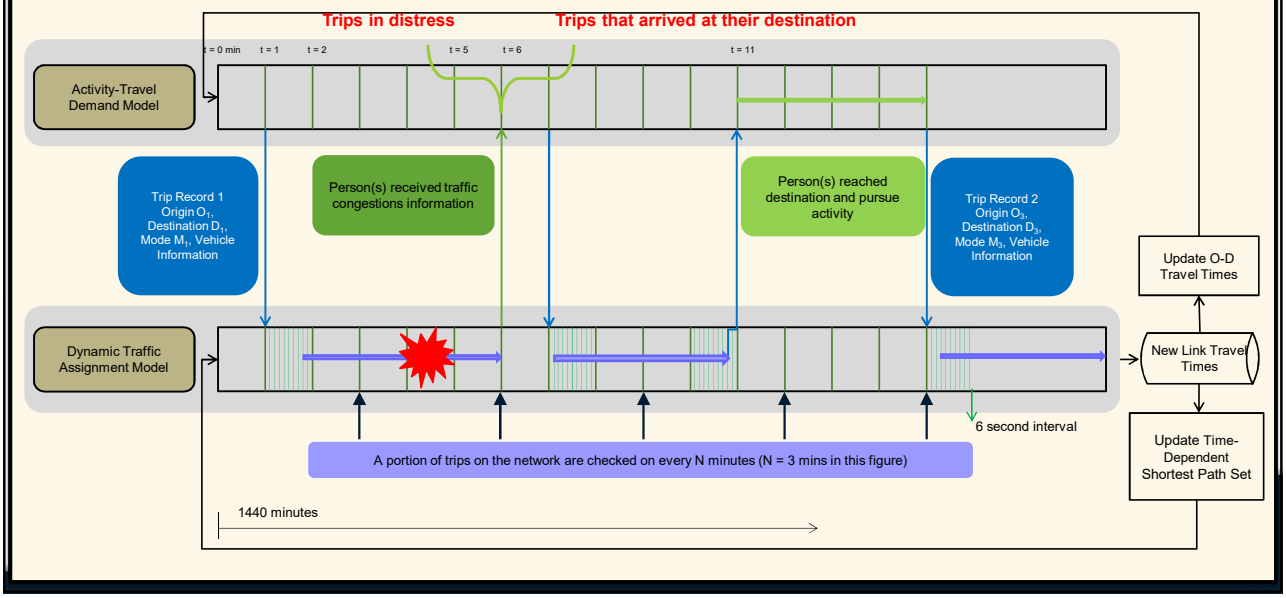
- Marginal willingness-to-pay (MWTP) computed for each attribute
  - Amount of money required to maintain a consumer's current level of utility when one unit of an attribute is changed
- Also compute relative importance (RI) of option based on worth of each attribute
- Assuming deterministic portion of utility (V_{nj}) may be divided into price-dependent component and non-price dependent component:

$$MWTP_{x_{jk}} = -\frac{\partial U_{nj} / \partial x_{jk}}{\partial U_{nj} / \partial x_{j,price}} = -\frac{\beta_k}{\beta_{price}} \qquad RI_K = \frac{part-worth_K}{\sum_k part-worth_k} \times 100$$

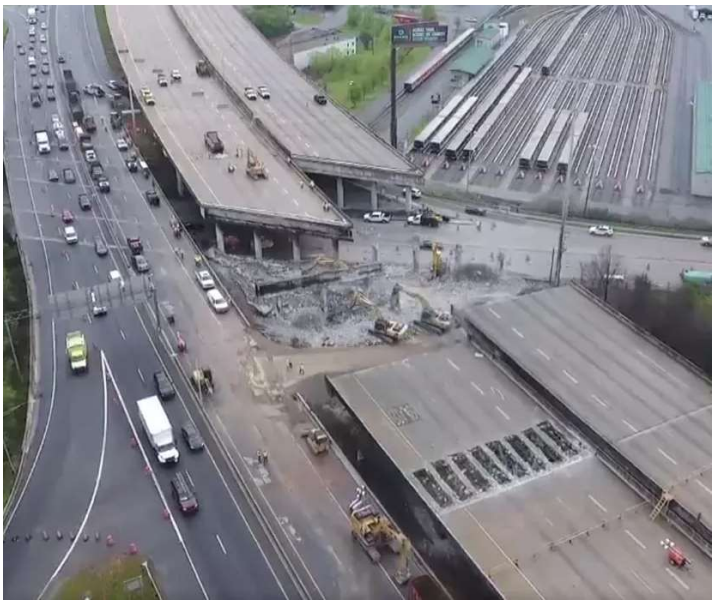
Level 0 Model Integration - Classic Sequential Paradigm



Level 4 Model Integration: Pre-trip + Enroute Traveler Choices



Need Data on Behavioral Adaption



Collect revealed preference data during events in the real world

I-85 Bridge Collapse, Atlanta 2017

Realizing Behavioral Change That LASTS

- The *Spitsmijden* reward-based travel demand management strategy
  - Assess the effectiveness of incentives in reducing morning peak period vehicular traffic volumes
- October 2006: 7:30 – 9:30 AM commuters on Dutch A12 motorway
- 14 week experiment
  - 2 weeks “pre-reward” period
  - 10 weeks “reward” period
  - 2 weeks “post-reward” period
- 340 participants
  - 232 selected monetary reward (€3 - €7 per day)
  - 108 selected Yeti smartphone (earn credits to keep smartphone at end of experiment)

Realizing Behavioral Change That LASTS…

Alternative	Total (%)	Prereward Period (%)	Reward Period (%)	Postreward Period (%)
Driving before peak hour (base)	34.2	23.4	37.2	24.9
Driving during peak hour	25.9	46.8	20.0	45.7
Driving after peak hour	17.5	13.3	18.7	13.9
Using carpool or carshare with family or friends	5.3	4.4	5.5	4.4
Avoiding peak hour by using public transportation	10.3	4.7	11.7	6.6
Avoiding peak hour by using bike	3.0	4.5	2.9	1.5
Working from home	3.8	2.9	4.0	3.0

… is proving elusive!

Transport Controls and Behavior

- Let's collect the data we need to understand
  - attitudes, behaviors, adoption and adaptation, and evolutionary dynamics…
- Take advantage of live experiments in the real-world
- Reflect behavioral evidence in transport models
- Acknowledge and accommodate high degree of uncertainty

It's all about the human!

Thank you

Ira A. Fulton Schools of Engineering
Arizona State University

Ram M. Pendyala
pendyala@asu.edu

MARG