

# **Modeling the New Mobility: Integrating Autonomous Vehicles, the Sharing Economy and the Impacts of E-Commerce into a Model Framework**

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# TRANSPORTATION (PLANNING) ENTERING ERA OF GREAT UNCERTAINTY

- Weekly or even daily announcements on:
  - the progress of Autonomous Vehicle (AV) testing (passenger shuttles and trucks)
  - AVs will remake our cities, freeing up land currently dedicated to parking
  - the sharing economy (and car-sharing specifically) will lead to enormous reduction in household vehicle ownership (with ride-sourcing and shared AV fleets to finish the job)
  - E-commerce will so dominate the retail sector that personal shopping (even for groceries) will become a thing of the past, so downtown retail centers and particularly suburban malls will need to be repurposed
- While skepticism over many of these claims is warranted, at the same time it is true there are relatively few tools available to examine the impact of new technology on transportation at the regional scale
- Ideally, new model approaches will be developed and integrated with scenario planning approach (for instance testing the impact of low vs. high AV penetration)

## CAR-SHARING/RIDE-SOURCING

- While ride-sourcing (Uber, Lyft) perhaps studied more than car-sharing, car-sharing was first to be integrated into practical travel models
  - Proximity to car-share lot embedded in car ownership model and mode choice model (TransLink since 2012)
  - On-going investigation into joint auto ownership and car-share membership model (TransLink, PSRC, Metrolinx)
  - Other planning agencies adding questions about car-sharing and ride-sourcing to household travel surveys to allow further research and ultimately model integration
- Biggest challenge with respect to ride-sourcing is anticipating long-term cost of ride (relative to taxi and transit), which partly depends if AVs can operate in urban environment
- Worth considering that proliferation of specific new mobility option is not inevitable; government policy (and subsidy) matters
  - Ride-sourcing still not legal in Metropolitan Vancouver
  - Car2Go completely ceased operations in Toronto in 2018 in response to new regulations (though ZipCar remains)

## E-COMMERCE

- Studies in San Francisco and New York have focused on increase of courier shipments (shifting away from USPS) and impact on local traffic
- Much more research needed on whether this at-home activity (on-line shopping) is a pure substitute for household shopping trips (some or all) or whether it is effectively additional induced travel (made by third party couriers)
  - Time-series analysis of recent household surveys could determine whether decline in shopping trips can be observed at regional scale since 2000
- In 4-stage models, the impact (if one is observed) could be handled through minor trip rate reduction and increase of truck demand (though few of these types of models explicitly model light trucks/vans)
- The impact on ABMs is more complicated, as any reduction in personal or household level maintenance activity frees up time for discretionary travel
  - Developing a direct linkage to commercial vehicle model would be a challenge
  - As with other rapidly changing technologies, the biggest challenge is “recalibrating” relationships observed today to future year conditions when technology has matured

# AUTONOMOUS VEHICLES

- According to proponents (working from best case scenarios)
  - Households will no longer own cars but rather subscribe to shared AV fleet
  - Highway capacity will be increased dramatically
  - Urban areas revitalized as parking is repurposed
  - Travel time will be productive (will significantly reduce the perceived impedance of distance)
  - Etc.
- Key to the more optimistic scenarios is that AVs are shared (SAVs), akin to micro-transit, rather than privately-owned (PAVs) and running with 1 or 2 household members at most (and often running around empty – 0 person trips)
- Research (Meyer and Shaheen; Fagnant and Kockleman; Thomopoulos and Givoni; Litman) suggests a PAV-dominated future will actually be worse than today due to hyper-congestion and more urban sprawl, though accidents would be reduced
- Stated preference survey (Ryerson's 2016 consumer survey on AV adoption in GTHA) strongly suggests PAV future more likely than SAV future
  - Privacy and convenience of PAV outweigh lower costs attributed to SAV

# CHALLENGES IN MODELING NEW MOBILITY

- Rapid changes in the environment, especially car-sharing
  - New car-share firms might enter market with new offerings (EVs) while others fail relatively quickly
  - This all occurs far too quickly to be captured in 5-year (at best) survey cycles
  - Some future alternatives are radically different from today's offerings making SP surveys of limited value
- More than ever before, past performance (long-term trends) and current data does not automatically provide useful guide to the future.
- Scenario planning is useful under such conditions of high uncertainty:
  - Eliminate car-sharing and replace with shared AV fleet (transit marginally impacted)
  - Shared AV fleet effectively replaces suburban transit but medium and high income HHs shift to PAVs (and auto sufficiency is no longer relevant in model stream)
  - Conversely, AVs never crack the urban context challenge and are restricted to highway use (special managed lanes) leaving a very mixed auto fleet in place
  - Shopping becomes in-home activity and discretionary travel increases

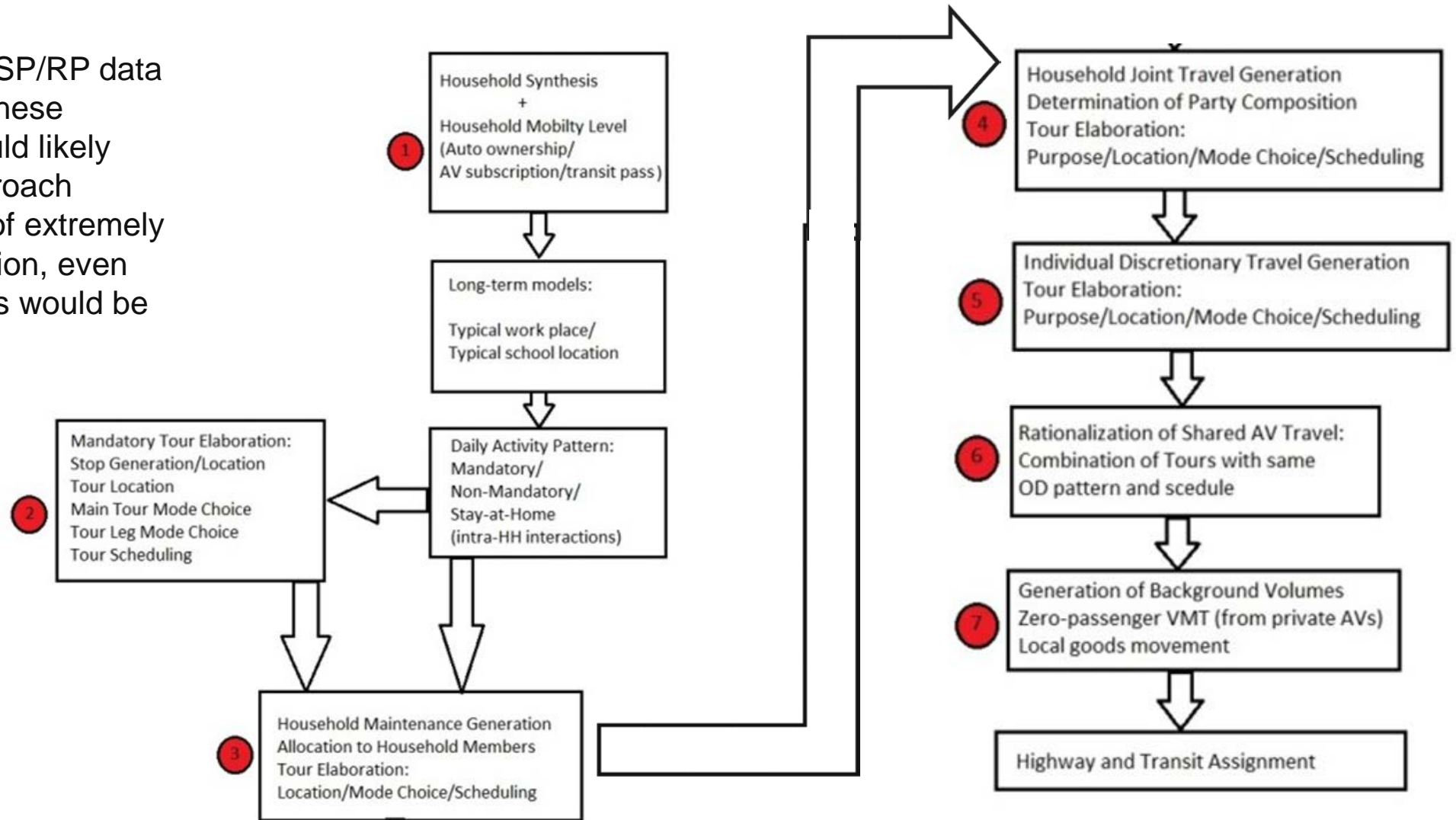
## UPDATES TO MODEL FRAMEWORK TO REFLECT NEW MOBILITY

- Biggest single change would be to auto ownership/sufficiency models, then cascading down to long-term choices, tour generation and mode choice
- Tour rates likely to increase in PAV-dominated future (and tours will be longer)
- E-commerce likely to reduce shopping tour activity (with subsequent increase in courier VMT) and potential shift to discretionary travel
- Potentially shifting to half-tour mode choice in AV-dominated future, as tour consistency no longer must be maintained
- Revising commuter rail park-and-ride models to eliminate (or strongly reduce) the impact of parking supply at specific stations
- Fleet composition (AV vs. non-AV) could impact assignment
- Auto occupancy (both PAV and SAV) will need to be established, potentially removing a certain % of SAV tours prior to assignment
- Developing a method to calculate zero-passenger VMT, i.e. AVs with no passengers, which is of particular concern in PAV-dominated future




# IMPACT OF NEW MOBILITY TECHNOLOGY ON MODEL STRUCTURE

- Assuming data (SP/RP data were available, these components would likely require new approach
- Under scenario of extremely high AV-penetration, even long-term models would be impacted



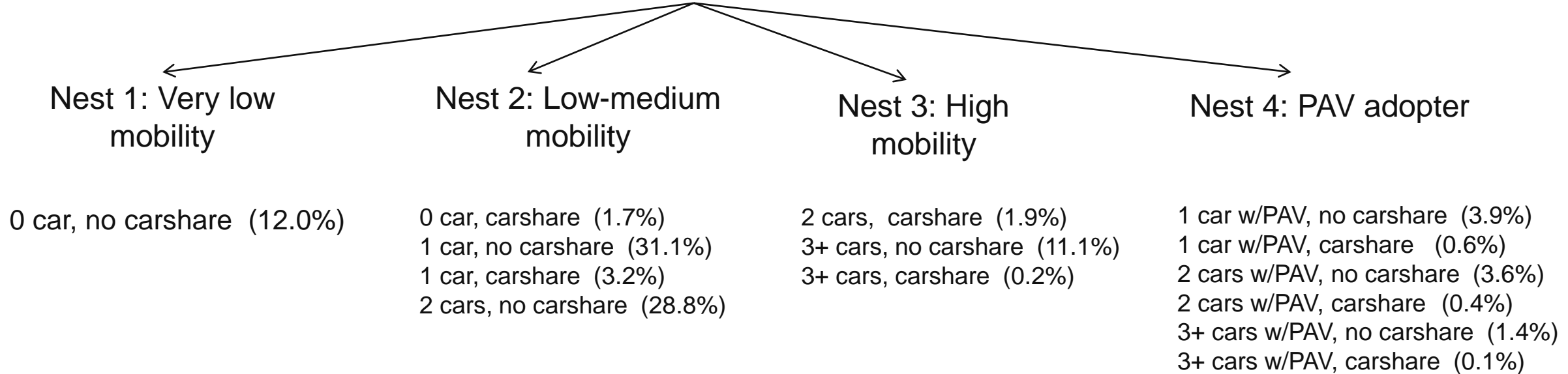
Note that this simplified process diagram does not include any feedback loops.

 = Significant Update or New Component to Incorporate AVs

## FIRST STEP: DEVELOPING HOUSEHOLD MOBILITY MODEL

- Transportation Tomorrow Survey is extensive household survey for GTHA (160K HHs)
  - Did not ask about car-share membership (currently available in region)
  - Did not ask about attitudes or propensity towards owning/renting AVs
- Ryerson University conducted consumer survey with SP questions on AV adoption
  - Personal survey with only a few household attributes captured, though attempts made to ensure consistency with TTS 2016
  - Question – If you are purchasing a new vehicle, how much more would you be willing to pay for it to be available as a fully driverless car as opposed to a conventional car ?
  - Five income ranges (and “would not buy driverless car”)
  - Cost curve (predicting incremental cost of AVs in near term) developed, resulting in 10.6% of respondents with a strong likelihood of purchasing AVs when available.
  - In addition, car-share membership was asked on survey.
- Combining the two surveys allowed for development of household mobility model:
  - Alternatives are combination of 0, 1, 2, 3+ autos (with 0/1 PAV in the HH), as well as indicator of household car-share membership

# HOUSEHOLD MOBILITY MODEL – ALTERNATIVES IN NESTING STRUCTURE



Nesting parameter (theta ) = 0.972

Numbers in parentheses represent observed share of each alternative in data set (N=162,670 HHs)

# HOUSEHOLD MOBILITY MODEL – COMPONENTS OF UTILITY

## Car ownership variables

0 car ASC	-2.27
2 car ASC	-0.89
3 car ASC	-4.44
0 car – very low income	3.19
0 car – low income	2.09
0 car – HH in Car2Go catchment	0.81
0 car – HH within 500 m of ZipCar lot	0.40
0 car – HH in Toronto	1.08
0 car- HH in Hamilton	0.72
0 car - HH in high density zone	1.82
0 car – child in HH (binary)	-0.81
1 car – very low income	1.24
1 car –low income	1.09
1 car - HH in high density zone	1.74
2 cars- 4+ HH size	0.73
2 cars – each worker in HH	0.73
3+ cars – high income	0.44
3+ cars - 4+ HH size	0.73
3+ cars – each worker in HH	1.48
3+ cars – HH not located in Toronto	1.05

## Car-share membership variables

Car-share ASC	-1.01
Car-share – each child in HH	0.31
Car-share – HH in Hamilton	-0.53
Car-share – HH in Halton	-0.53
Car-share – HH in Durham	-0.28
Car-share – HH in high density zone	0.43
Car-share – 4+ HH size	-0.49
Car-share – HH in Car2Go catchment	0.26
Car-share - HH within 500 m of ZipCar lot	0.12
Car-share – Head house age 46-64 (binary)	-1.25
Car-share – senior in HH (binary)	-2.11
Car-share – HH is “complex” (binary)	-1.50
Car-share – 2+ workers in HH	0.30

Model R-square = 0.42

## Private AV variables

PAV propensity ASC	-2.20
PAV – HH in Toronto (outside Car2Go boundary)	0.30
PAV -senior in HH (binary)	-0.43
PAV – very low income	-0.64
PAV – very high income	0.46
PAV – missing income	-0.07
PAV – HH in high density zone	0.28

## Interaction terms

0 car & car-share	-0.56
1 car & car-share	-0.63
2 cars & car-share	-1.26
3+ cars & car-share	-1.89

Reference categories are 1 auto, no car-share and no PAV in HH

# Questions?

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