Future Mobility Technologies
Autonomous and Connected Vehicles

presented by

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Overview

- Public and private sector leaders want to understand the impacts of connected and autonomous vehicles (CAV)
  - Analysis frameworks are emerging
  - Market research is evaluating attitudes
  - Uncertainty in forecasts is a challenge
- Modelers want to represent CAVs
  - Vehicle choice and use models
  - Strategic models
  - Activity-based and 4-step passenger models
  - Supply chain and tour-based freight models

Analysis Frameworks Emerging

Analysis frameworks need to be grounded in empirical data and sensitive to traveler preferences future mobility technologies. Both are advancing rapidly.

Technology market penetration

- Availability in market place, pricing, various ownership/service models
- Enabling, supporting technologies (e.g., fueling, parking)
- Rates of adoption correlated with socio-demographics

Effects of new technologies on transportation system performance

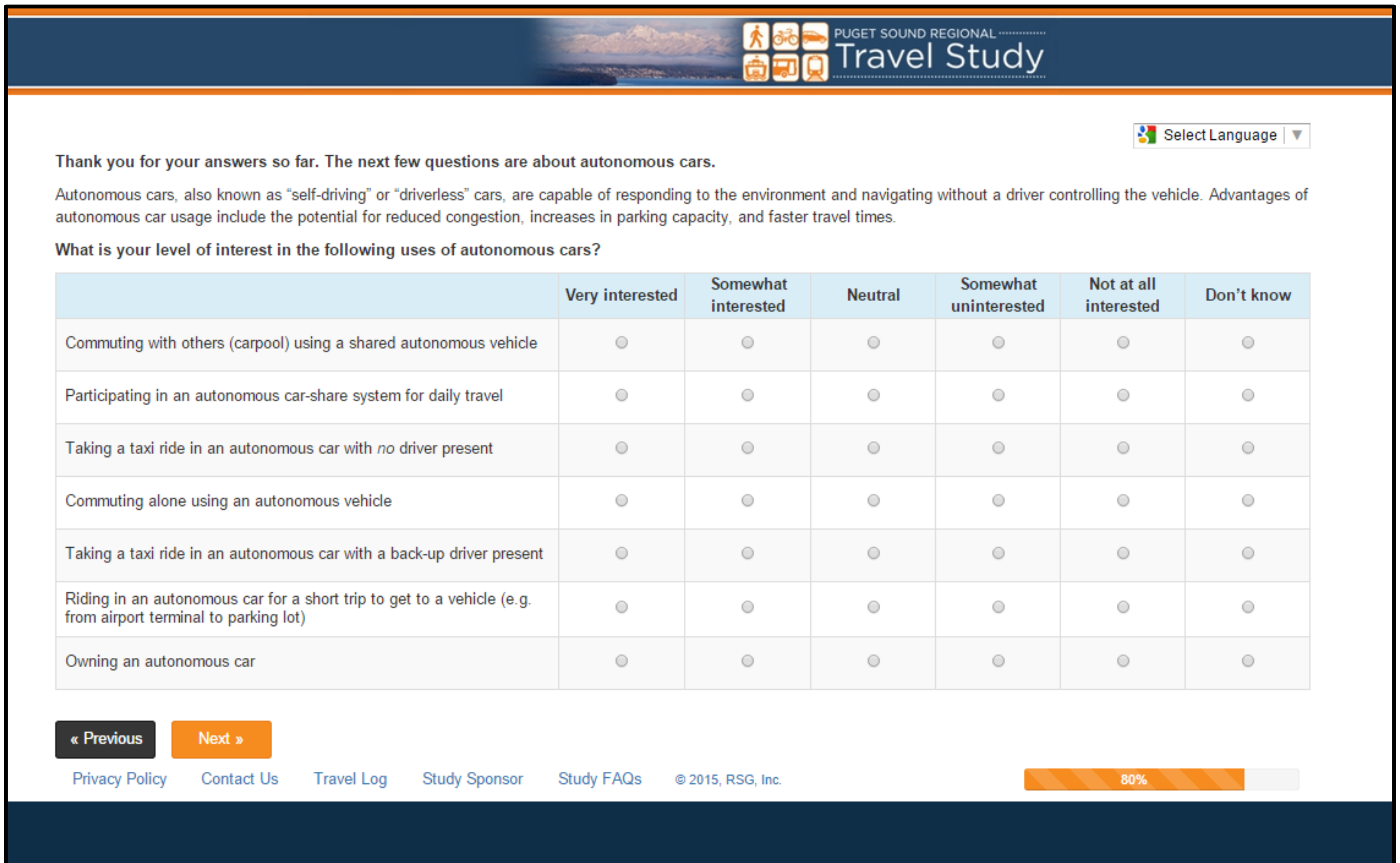
- Energy consumption
- System capacity, reliability
- Safety

User response to technology through purchase, activity-travel patterns

- Perceived utility, lifestyle changes
- New patterns … unintended side effects?

Traveler's Attitudes Toward New Technologies

*Puget Sound residents' attitudes about **autonomous vehicles** in 2015.*



PUGET SOUND REGIONAL
Travel Study

Select Language

Thank you for your answers so far. The next few questions are about autonomous cars.

Autonomous cars, also known as "self-driving" or "driverless" cars, are capable of responding to the environment and navigating without a driver controlling the vehicle. Advantages of autonomous car usage include the potential for reduced congestion, increases in parking capacity, and faster travel times.

What is your level of interest in the following uses of autonomous cars?

	Very interested	Somewhat interested	Neutral	Somewhat uninterested	Not at all interested	Don't know
Commuting with others (carpool) using a shared autonomous vehicle						
Participating in an autonomous car-share system for daily travel						
Taking a taxi ride in an autonomous car with *no* driver present						
Commuting alone using an autonomous vehicle						
Taking a taxi ride in an autonomous car with a back-up driver present						
Riding in an autonomous car for a short trip to get to a vehicle (e.g. from airport terminal to parking lot)						
Owning an autonomous car						

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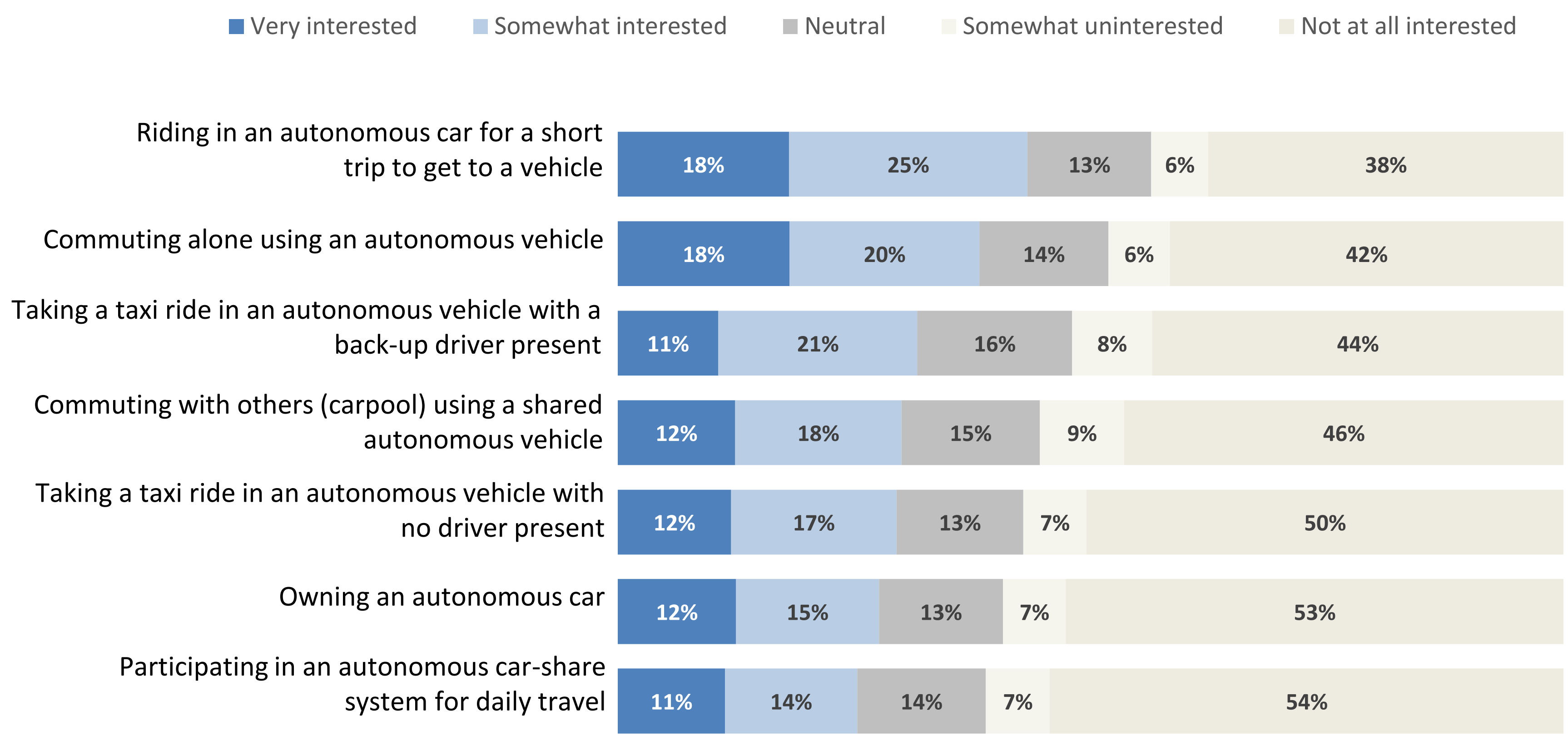
80%

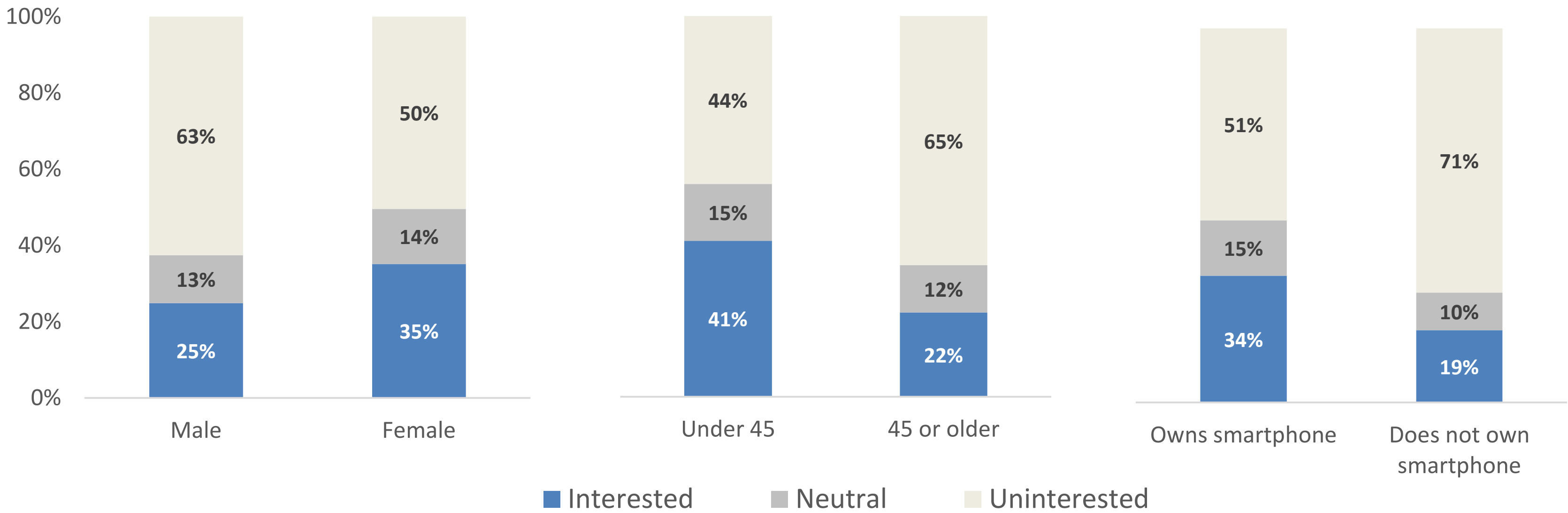
Interest in Autonomous Vehicles Depends on Usage and Ownership

In Puget Sound, 25-43% interested in using AVs; 44-61% not at all interested.



Demographics Also Have Significant Impact on Interest in AVs

Demographics of “interested” people: Under 45, Female, Smartphone user

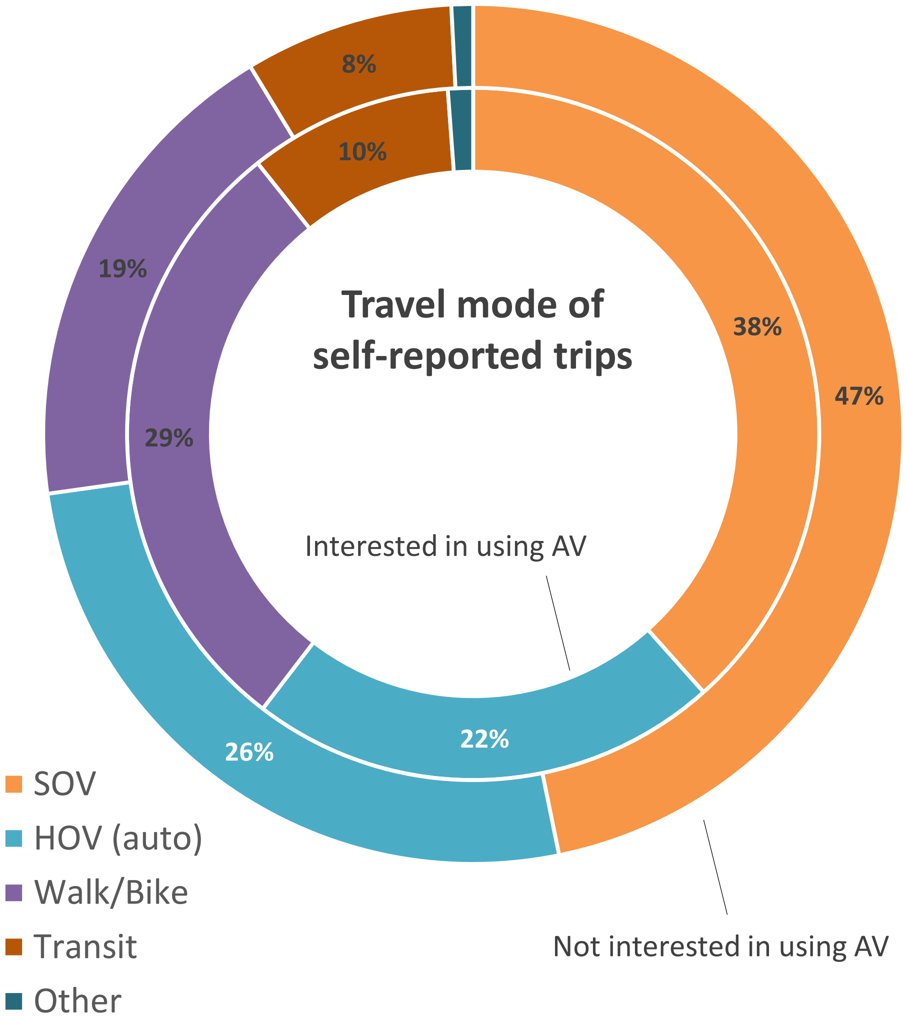


Vehicle Ownership Plays a Small Role

People who do not own a vehicle are less likely to be interested in owning AV and not any more interested in using AV otherwise.

People with at least one hybrid or electric vehicle are more likely to be interested in owning AV but not significantly more interested in general usage.

“AV-interested” People More Likely to Currently Walk, Bike, Use Transit



*People who value **living near transit** are more likely to be interested in using AVs*

*Enrollment in **car-share** program correlates with interest in using AVs (not so interested in owning)*

*Interest in **carpooling** in AV with non-household members correlates with current carpool habits*

Vehicle Ownership and Use Models are Expanding to Include New Technologies

There have been several major efforts to develop vehicle choice models that are being used to support policy analysis and product development.

California Energy Commission's DynaSim Model

- Light duty vehicle ownership and use forecasting model
- Originally built in 1990s, updated for each forecasting cycle
  - New RP/SP survey data
  - Re-estimated choice models reflecting new vehicle options and changing preferences
- Current 2016/2017 update
  - Survey of 3,500 households, 2,000 commercial establishments, 500 PEV owners
  - Initial assessment of consumer response to AV options (focus groups only)
  - Vehicle choice model representing 8 fuel types (e.g., gasoline only, gasoline hybrid electric [HEV]) and 11 vehicle types (e.g., small car, van).

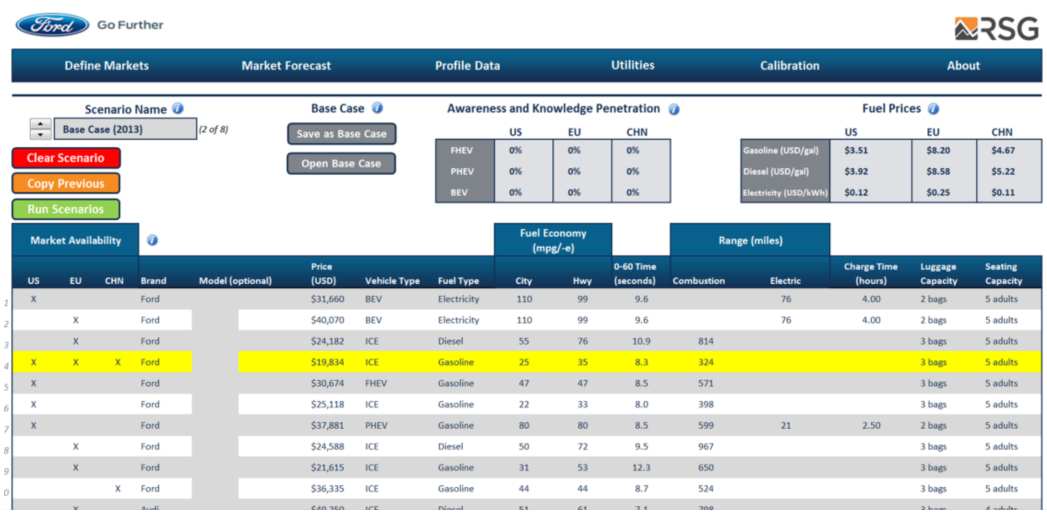
Vehicle Type/Fuel Type Choice Models Help Manufacturers Meet Emissions Mandates

Johnson Controls (*world's largest automotive battery manufacturer*)

- Global vehicle battery forecasting model
- Vehicle type choice models estimated using RP/SP survey data

Ford Motor Company

- Global vehicle choice simulator to support electrification program



General Motors

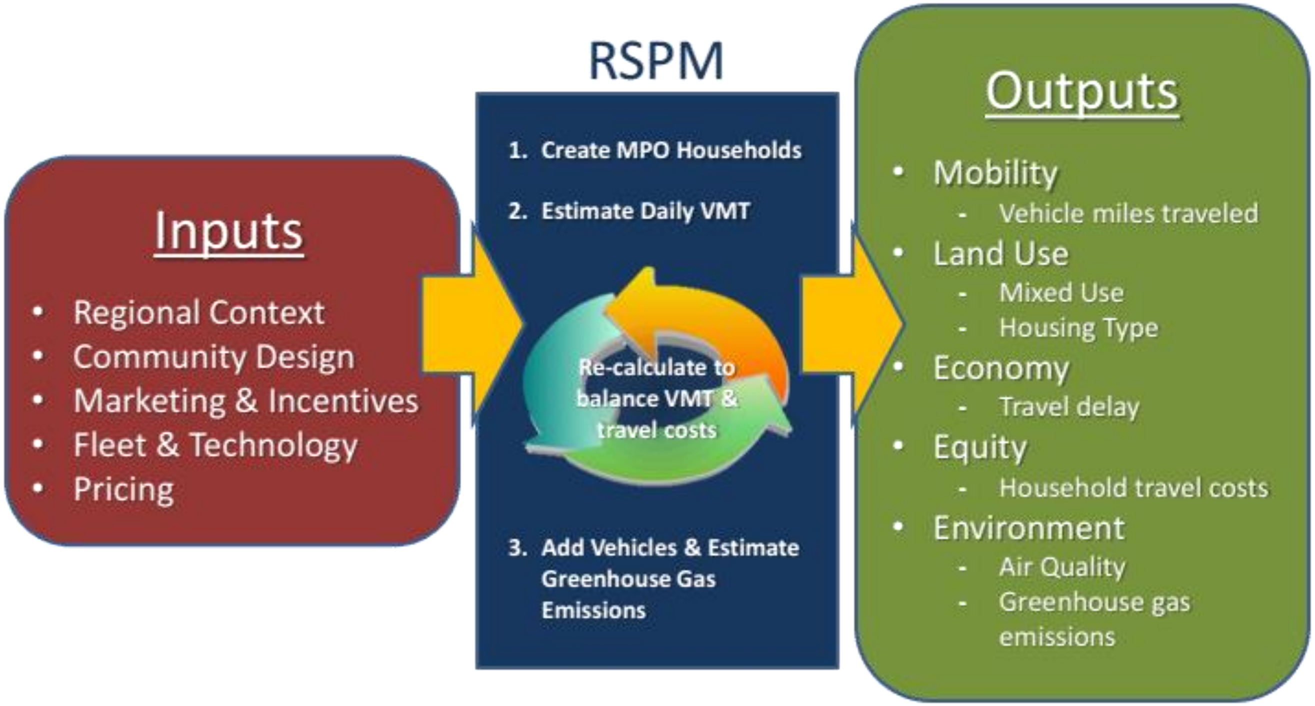
- AV adoption and use forecasting model

Strategic Planning Models Used to Model GHG/Energy Use and Vehicle Fleet Dynamics

Aggregate models with fast run times are ideal for rapid scenario planning to obtain area-wide outcomes and test assumptions

Regional Strategic Planning Model (RSPM)

- Developed by Brian Gregor, Oregon System Analytics
- VisionEval open source project (FHWA, Oregon DOT sponsors) by OSA, RSG



Strategic Planning Models Adapted to Predict Automated Vehicle Ownership, Service Usage

Atlanta Regional Commission (ARC)

Adapted RSPM to predict automated vehicle ownership and shared automated vehicle usage – **input assumptions**.

Pricing

- Own vs. car share
- Financing
- Insurance and registration
- Cleaning
- Parking

Usage

- Service life of vehicle in miles
- Non-revenue mileage/repositioning

Features

- Travel comfort and convenience
- Occupancy

Strategic Planning Models Used to Predict Automated Vehicle Impacts

Delaware Valley Regional Planning Commission (DVRPC)

- Rapid Policy Assessment Tool (RPAT) and Impacts 2050 models
- Assumptions from *The Eno Center for Transportation's Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations* report (Fagnant, 2015)

	Adoption Rates		
	10%	**50%**	**90%**
VMT Increase	+2%	+7.5%	+9%
Crash Reduction per AV	0.5	0.75	0.9
Number of AVs in U.S.	12.7 million	63.7 million	114.7 million
Annual Savings per AV	$2,960	$3,320	$3,900

Activity-Based Models Used to Predict AV Vehicle Ownership, Usage, Latent Demand

TMIP Assessment of Integrated ABM and DTA for Exploratory Modeling and Analysis of Future Scenarios for Connected and Autonomous Passenger Vehicles (ongoing)

- Market penetration and use of AVs
- **Disutility of in-vehicle time** in AVs
- **Car-sharing** and **ride-sharing** usage level
- Households could change their **escorting/chauffeuring behavior**
- Changes in **parking behavior** at the destination could include:
- Generation of **empty vehicle trips**
  - e.g., AVs being used for driverless pick-up/drop-off trips, ridesharing service vehicles searching for and picking up passenger, driverless trips to remote parking locations
- New trips could be generated as a result of latent demand

Early Experiments with Activity-Based Microsimulations – Simple Assumptions

METROPOLITAN TRANSPORTATION COMMISSION (SF BAY AREA)

- Base year scenario
- Additional research by Michael Gucwa, PhD student, Stanford

Link Capacity Increases

- Platooning, signal optimization, safety enhancements
- +50% to +200% freeways; +20% to +80% arterials

IVT Parameter Modifications

- Lower disutility of travel time
- Various levels in Gucwa's research

Results

- 3% to 5% in VMT (4% to 8% in Gucwa's research)
- Little increase in total trips; somewhat lower fixed guideway transit trips due to improved travel times, primarily on Bay Area bridge crossings

Early Experiments with Regional Activity-based Microsimulations – Additional Factors

ATLANTA REGIONAL COMMISSION

- 2040 scenario

Assumptions

- Link capacity increases (+100%)
- IVT parameter modifications (-50%)
- Increase fuel efficiency (71% applied to auto operating costs)
- Eliminate parking costs (assume AVs park in outlying free spaces)

Results

- Total trips decrease 0.8% and 2.6% depending on factor combos
- Trip lengths increase up to 20%
- VMT increases 3.6% to 24%
- Transit trips decrease 1 to 42% (parking cost elimination had greatest impact)

What About Freight Vehicle/Fuels and Automated and Connected Vehicles?

FHWA BAA and SHRP 2 C20 programs have funded the development of models featuring detailed supply chain simulations and tour-based simulations of urban commercial vehicle movements that could be used for this purpose.

Long-Distance Trucking

- Virtual truck trains
- Ability to continue driving without mandatory driver safety breaks
  - Improved supply chain reliability
  - Shorter supply chain response time

Urban Areas

- Congestion and safety benefits similar to passengers
- Use of PEVs for small and medium trucks – reduce diesel and GHG
- Small package pick up and delivery
  - Possible use of smaller AVs and aerial drones

Anticipating Computational Challenges

Microsimulation of activity-patterns and modeling dynamic responses may require programming enhancements. Agencies are collaborating to build the next generation of modeling platforms.

Northwest Institute for Advanced Computing at Pacific Northwest National Laboratory (PNNL), Puget Sound Regional Council, and RSG

- Improve computational performance of DaySim (TourCast)
- **2016:** 7x speed up achieved by improving memory management (.NET) and parallel execution to fully utilize all available machine processors
- **2017:** improve distribution of model tasks across multiple computers

5-Agency “ActivitySim” Consortium

- San Diego Association of Governments, Metropolitan Transportation Commission (SF Bay Area), Atlanta Regional Commission, Puget Sound Regional Council, and San Francisco County Transportation Authority
- Multi-year project to develop common activity-based modeling platform using professional software engineering designed to optimize speed

Future Mobility Method Development

- Traditional marketing research methods are useful for predicting technology diffusion—better grounding for assumptions
- Strategic planning models can be practical tools for rapidly testing assumptions prior to more granular analysis/modeling
- "True" model parameters are evolving with technology and demographics
- New response alternatives and travel patterns will emerge, depending on how technologies, services, and policies co-evolve
- Freight/commercial use of new mobility technologies needs attention

Future Mobility Method Applications

- Current work with activity-based and 4-step modeling systems is at an early proof-of-concept stage
  - Acknowledging uncertainty and lacking empirical data, modelers “push the boundaries” of existing modeling systems under a range of plausible and even extreme assumptions
  - Useful for revealing deficiencies in existing tools
  - Using data inputs outside the value ranges used to estimate parameters may lead to unreliable results
- For regional traffic microsimulations and dynamic response models, computational advances should anticipate enhanced behavioral models

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