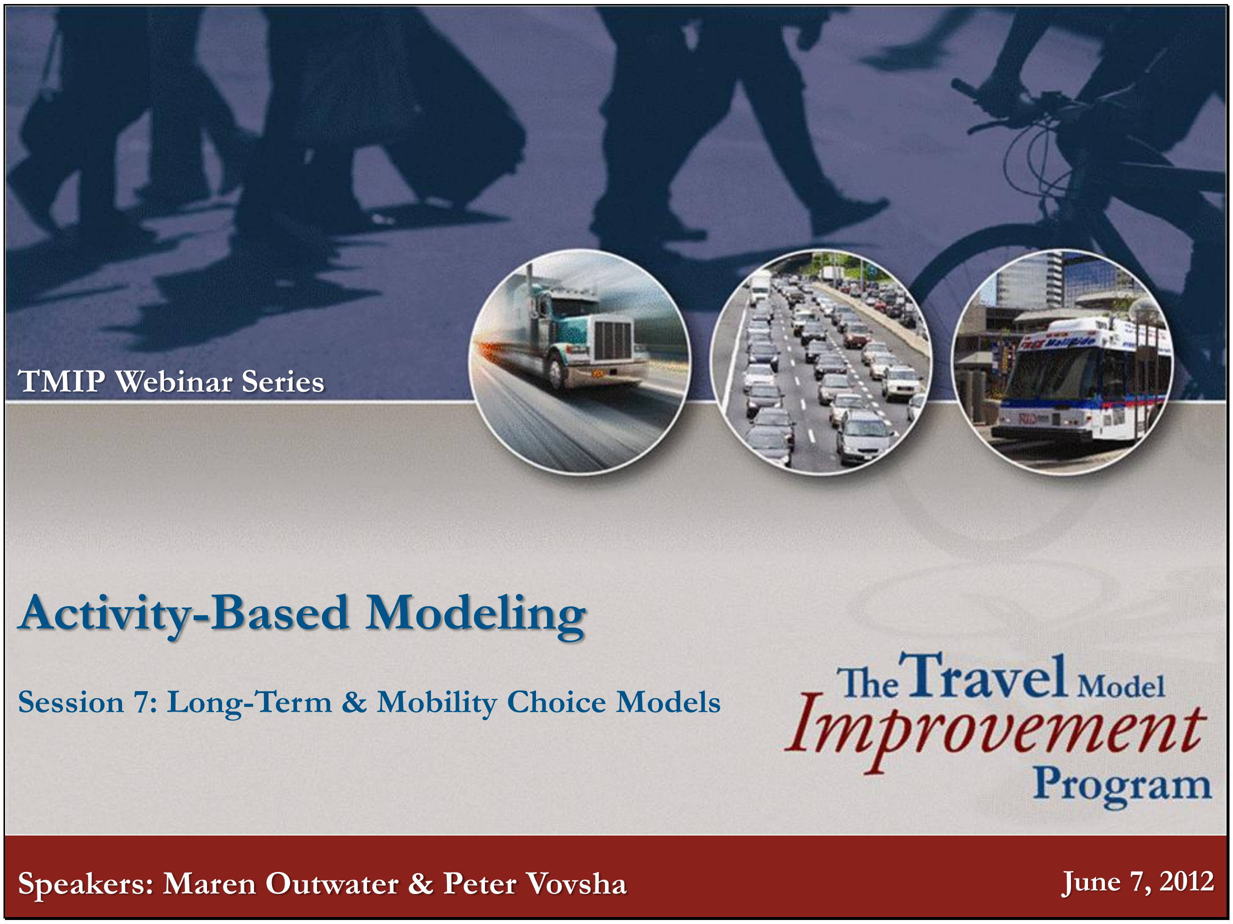
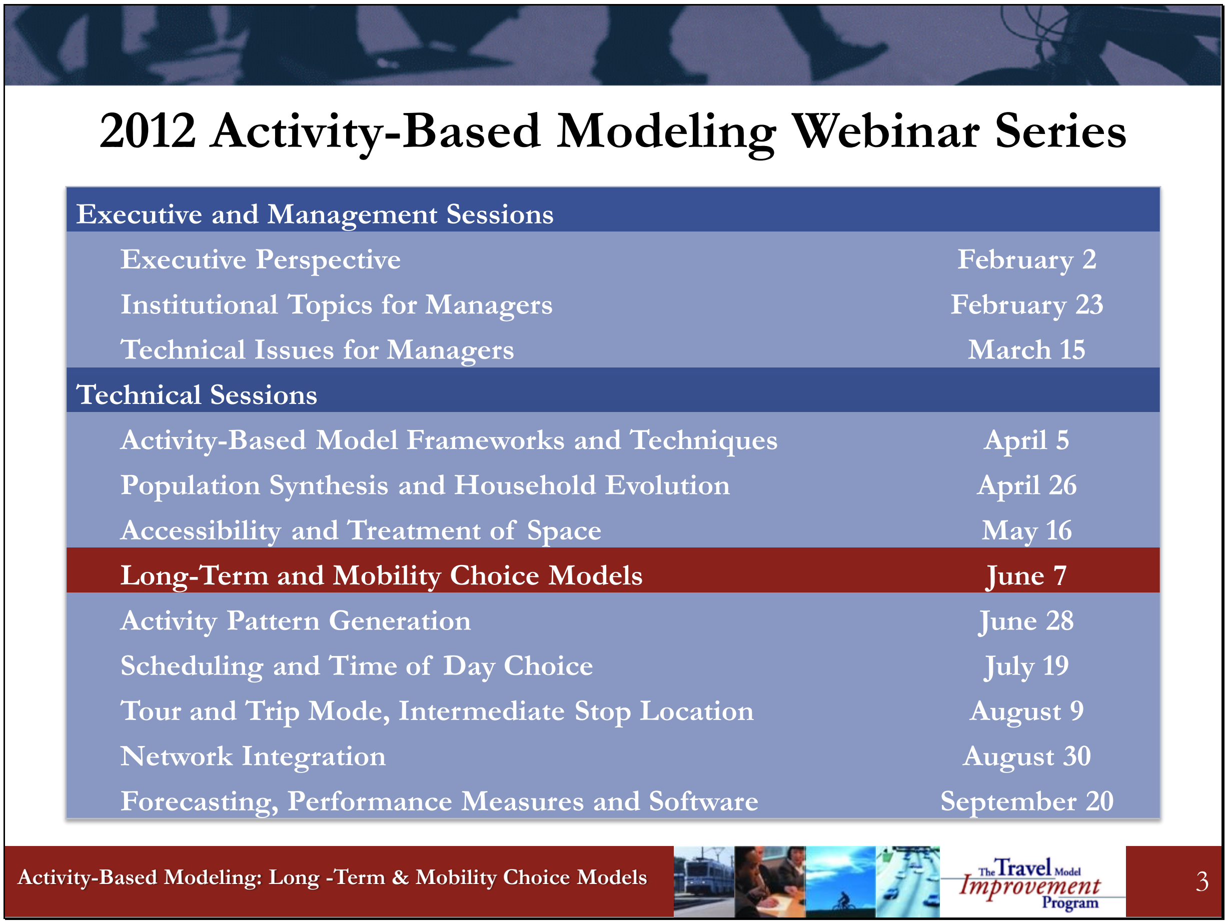

TMIP Webinar Series
Activity-Based Modeling
Session 7: Long-Term & Mobility Choice Models
The Travel Model Improvement Program
Speakers: Maren Outwater & Peter Vovsha
June 7, 2012

Resource Systems Group and Parsons Brinckerhoff have developed these webinars collaboratively, and we will be presenting each webinar together. Here is a list of the persons involved in producing today's session.

- Maren Outwater and Peter Vovsha are co-presenters. They were also primarily responsible for preparing the material presented in this session.
- Stephen Lawe is the session moderator.
- Content development was also provided by Nazneen Ferdous, John Gliebe and Joel Freedman. John Bowman provided some content and served as a reviewer.
- Bhargava Sana was responsible for media production, including setting up and managing the webinar presentation.



For your reference, here is a list of all of the webinars topics and dates that have been planned. As you can see, we will be presenting a different webinar every three weeks. Three weeks ago, we covered the sixth topic in the series—Accessibility and Treatment of Space.

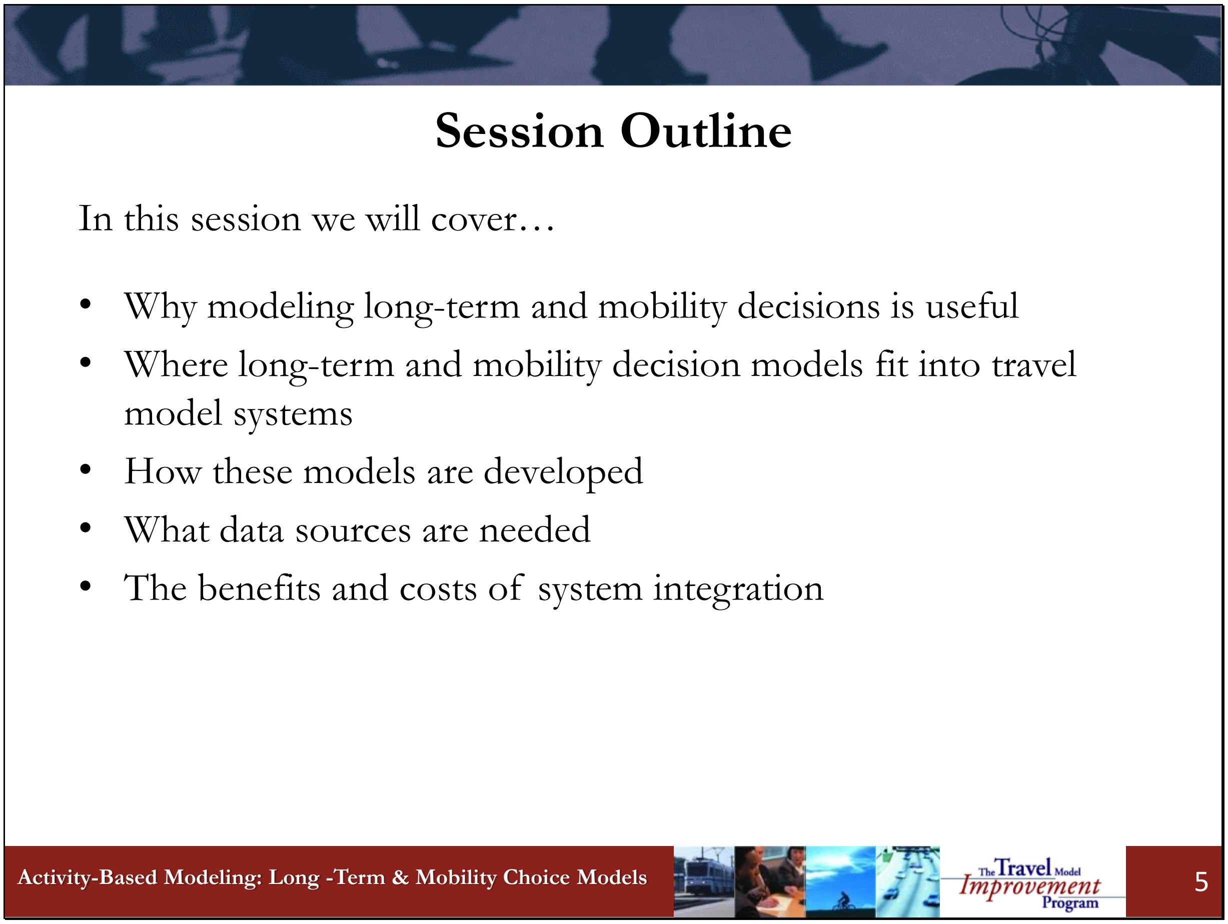
Today’s session is the fourth of nine technical webinars, where we will cover the details of long term and mobility choice models. In today’s session, we will prepare participants for developing long term and mobility choice models and discuss which models are important for different types of planning studies. In three weeks, we will cover activity pattern generation models.

Learning Outcomes

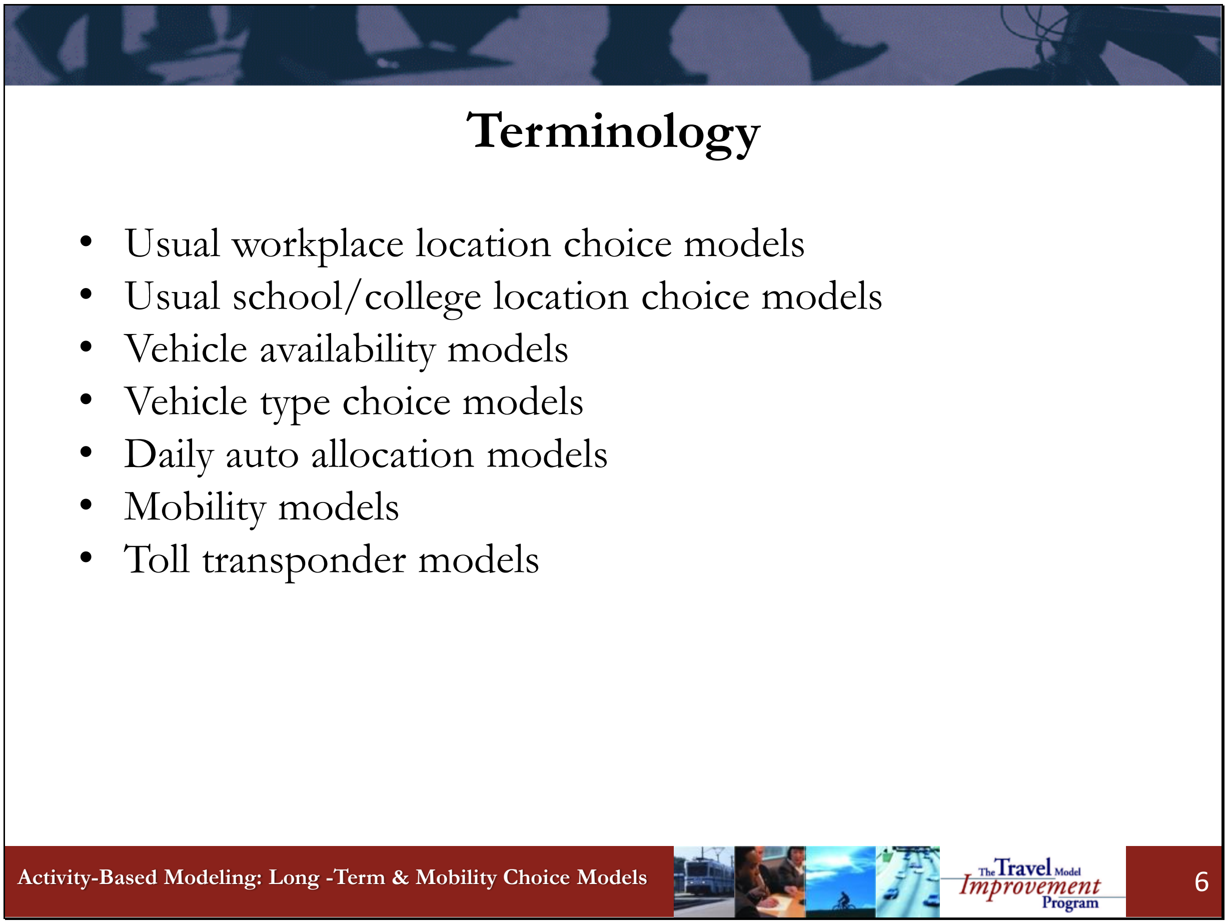
By the end of this session, you will be able to:

- Determine which long-term and mobility decisions are important to model
- Describe how long- and mobility decision models are integrated into the activity-based model system
- Consider the benefits, costs and key challenges of modeling long-term and mobility decisions

This session covers a long term and mobility models for activity-based modeling systems. Today we will be determining which long and medium-term decision models are important for different types of policy studies and for different types of transportation alternatives. We will also describe how long term and mobility decision models are integrated into the larger activity-based modeling system so that you can understand the context of how these models work with other modeling components. The long and medium-term decision models are at the top of the hierarchy of the activity-based modeling system and incorporate feedback from several of the downstream model components. Another important topic for today is the benefits, costs, and key challenges of modeling long and medium-term decisions. Most activity based models in use today include a limited set of long and medium-term choice models but many of those under development are including an expanded list to provide greater sensitivity for the travel demand models.



In this session, so we will cover why modeling long and medium-term decisions is useful to provide added sensitivity in the models to policies and transportation investments under consideration. We will present information on where long and medium-term decision models fit into travel modeling systems and describe how feedback is used to represent accessibility measures and travel times and costs for these long and medium-term choice models. We will also cover how these models are developed in practice as well as several new areas of research that are being considered for these models. We will touch on what data sources are needed for model estimation, application, and validation. It is useful to note that most of the data sources required by these models are provided by the synthesized population and by the accessibility and log some measures discussed in the previous two webinars. Lastly, we will present some of the advantages and disadvantages of network integration within the context of the activity-based modeling system.

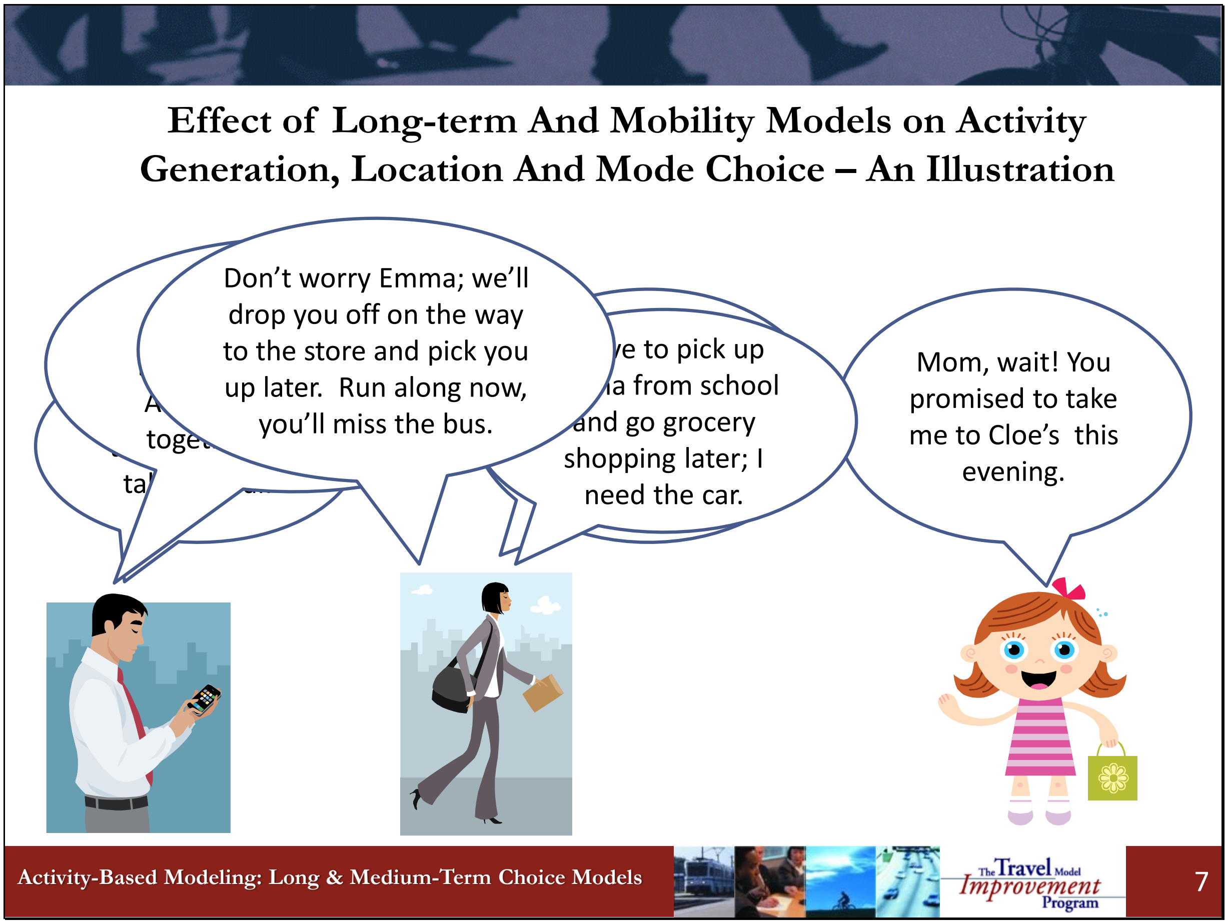


Before we begin, I would like to cover a few terms that we will be using in this webinar.

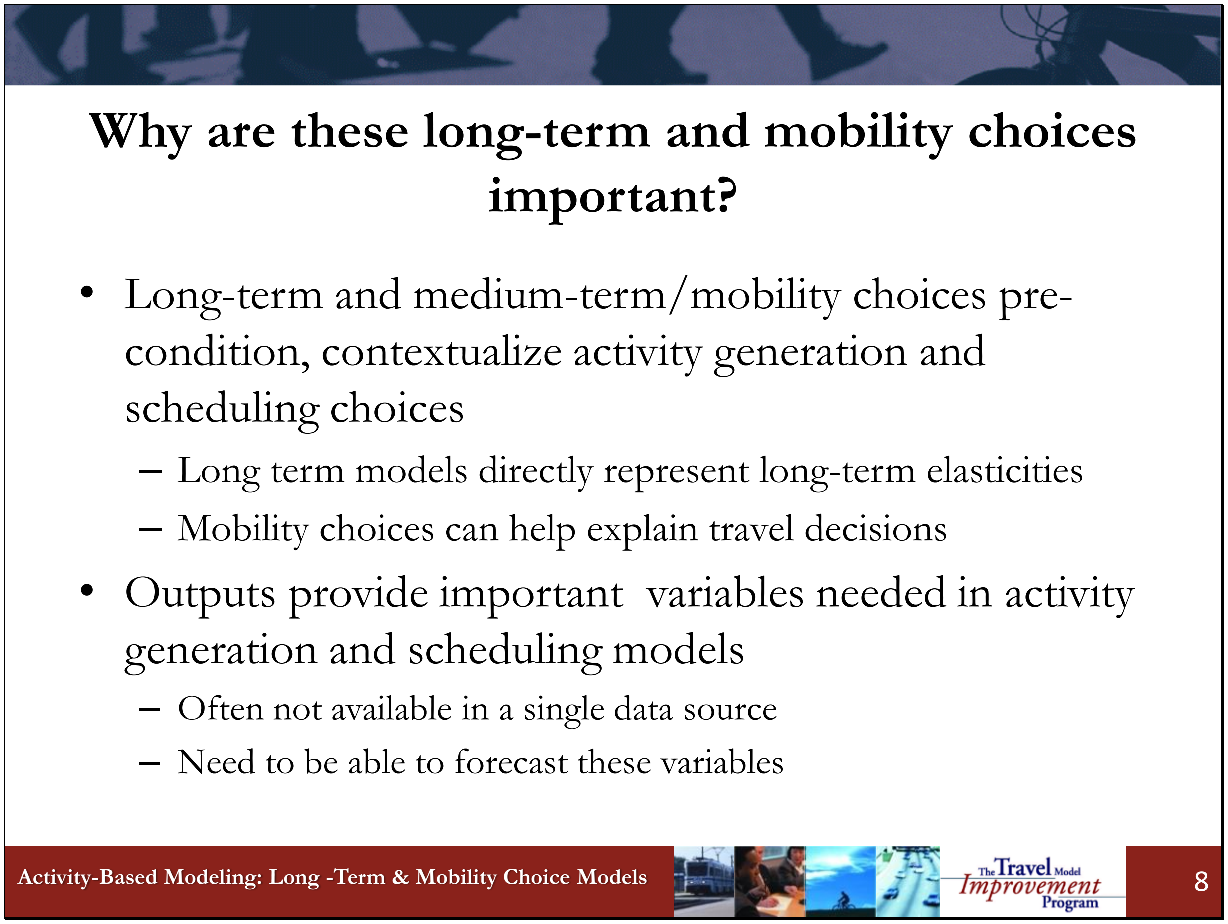
- Usual workplace location choice models are used to determine the workplace that you visit most often during a week. A separate process can be used to identify the workplace that you visit on a given travel day.
- Usual school or college location choice models are used to determine the location of the school or college that you visit most often during a week. Again, a separate process may be used to identify the specific school location you visit on a given travel day if it is different from the usual location.
- Vehicle availability models describe the number of vehicles available to a household. In this context, vehicles may include passenger cars, SUVs, pickup trucks, and motorcycles. The term availability is used here to identify any vehicles that are owned, leased or borrowed on a long-term basis and readily available in working order for travel by members of the household. This is a departure from the prior use of the term auto

ownership models to provide a broader consideration of vehicles that may be available for use by household members.

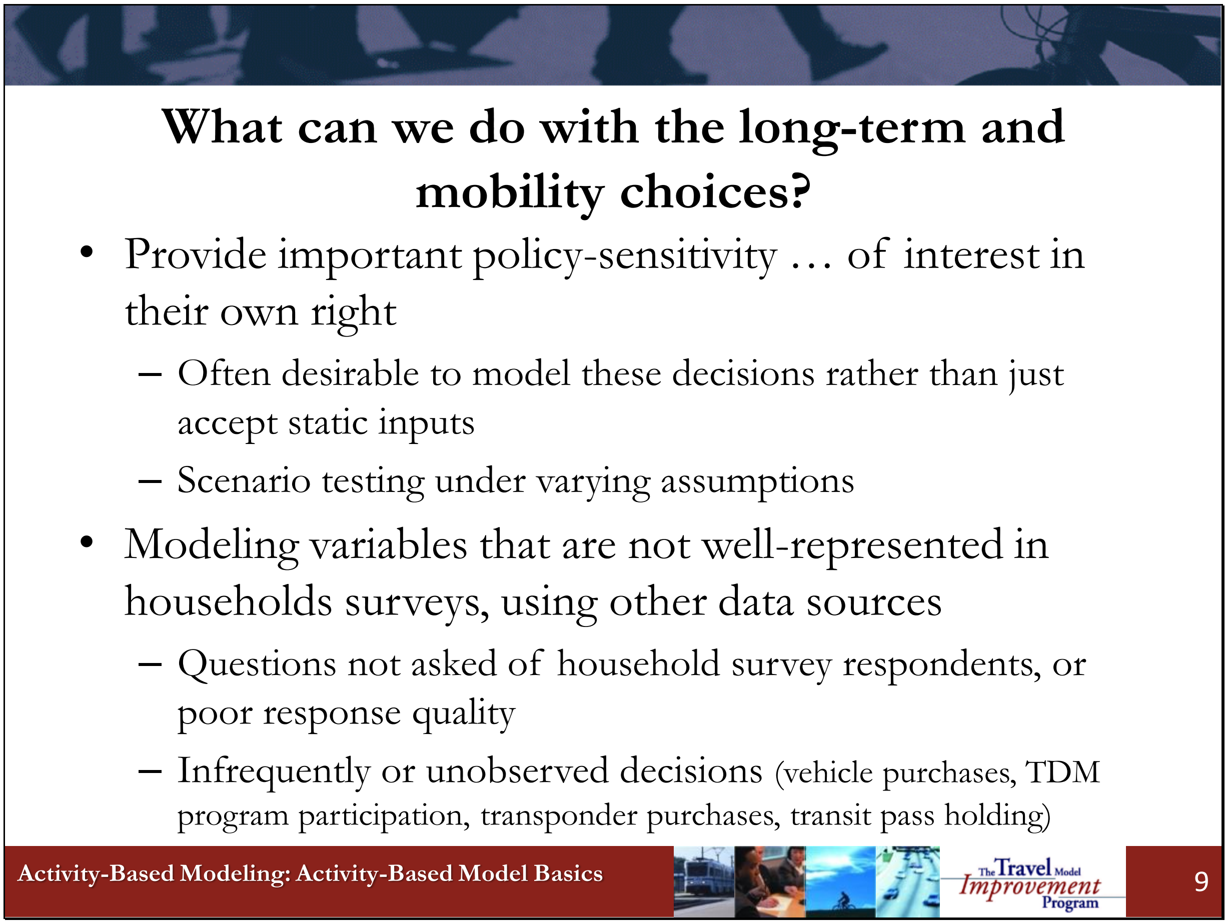
- Vehicle type choice models predict the make, model and fuel efficiency of vehicles in the household. These models are important for estimates of fuel consumption and emissions.
- Another type of vehicle choice are auto allocation models that assign a particular vehicle in the household to an individual member of the household. This is used to estimate vehicle miles traveled, fuel consumption and emissions from a particular vehicle.
- Mobility models for personal and worker mobility cover a wide range of topics that are used to enhance sensitivity of the travel models. These can include models to identify drivers licenses, transit passes, work duration, work schedule, and the usual mode of travel for members of the household. These can also include bike ownership models and models to calculate subsidies for transit passes, parking, and other travel offered by employers.
- Toll transponder models are used to estimate the number of toll transponders that a household has purchased for the purposes of obtaining discounted tolls and a means to pass toll booths at a higher speed.



Long and medium-term mobility models are intended to capture choices that a household or members of the household are making regarding longer-term decisions such as buying a car and medium-term decisions such as whether to buy a transit pass or a toll transponder. These decisions are longer-term because they affect travel choices over the course of the year, as well as influencing travel choices on a day-to-day basis. This illustration shows a three person family with one car considering trade-offs between individual activities and what modes can accommodate these activities. Each person in the family has different needs at different times, so they sort out who will use the car at which times and for which purposes.



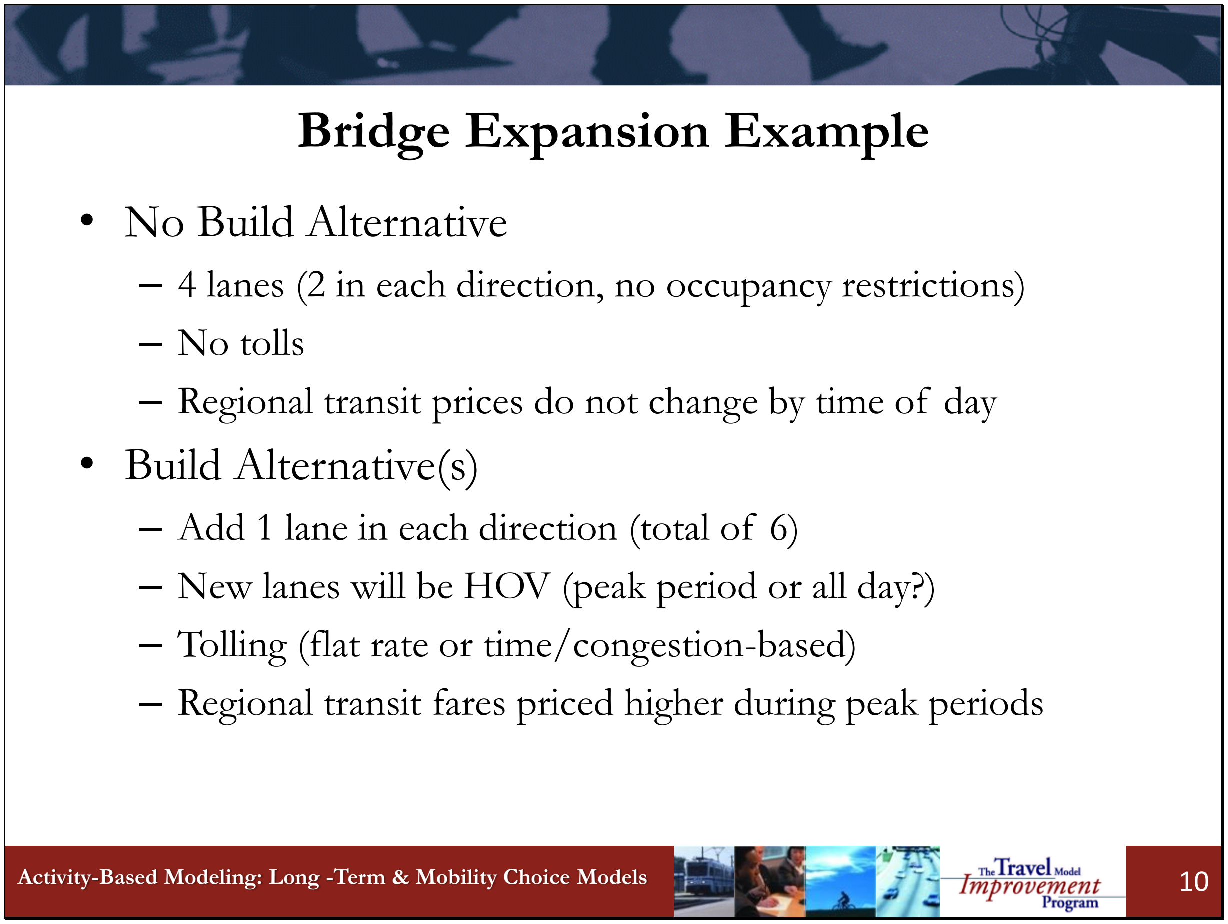
Why are these long-term and medium-term mobility choices important? Primarily, it is because they directly influence other travel choices like mode and activity scheduling. More recent activity based model development has recognized the usefulness of these variables in the daily activity pattern and mode choice modeling components. In addition, we recognize the usefulness of providing a model to estimate the probability of these choices, so that we can represent the influence of various policies and programs affecting these choices. For example, travel demand management strategies, such as flex time and telecommuting, provided by many employers will influence workers activity schedules and mode choice. In addition, pricing strategies will impact workers differently if employers are subsidizing aspects of their travel. Usual work and school location choice models reflect long-term decisions for workers and students that may be different than the short-term decisions made about going to a meeting, or a seminar at a different location on a given day. In addition, these models recognize the growing trends to work at home or take classes online, either on a permanent or occasional basis. Again, these decisions are made in a long-term context or within the travel model on a day-to-day basis to recognize that different factors influence these decisions differently. The use of these mobility choices within the activity generation, scheduling, and mode choice models has improved the explanatory nature of these travel demand elements. Lastly, these models provide an ability to forecast changes in these variables as a result of transportation investments and policies in the future.



After developing these long-term and medium-term mobility choices we are able to test different scenarios, such as travel demand management program participation and demonstrate the changes in performance of the system. Many decision makers are interested in understanding the influence of toll transponders, transit passes, and fuel efficient vehicles on travel demand and the environment. These models allow that sensitivity.

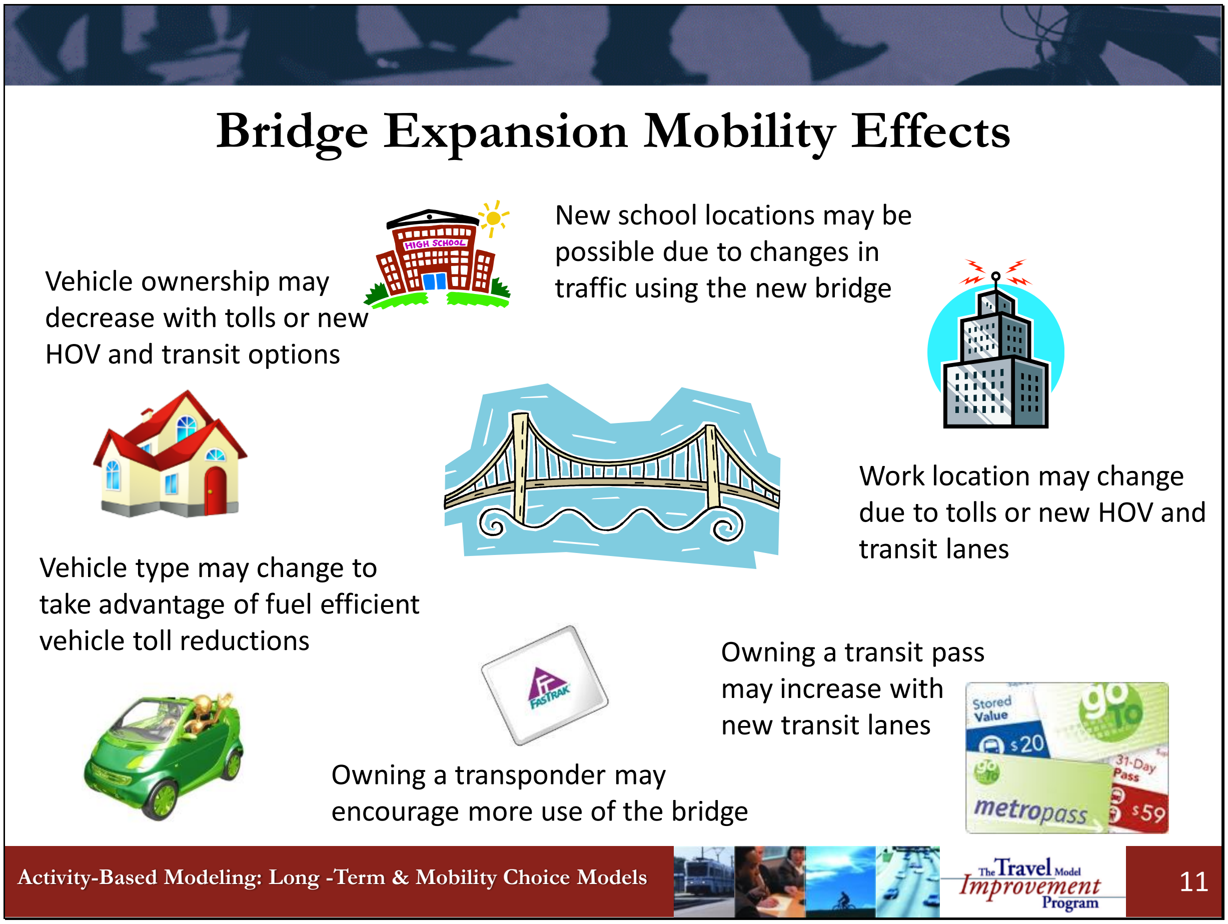
One challenge in developing these models is that many of these variables are not well-represented in older household surveys, and so other data sources may be needed to develop these models. The good news is that many newer household surveys are including questions about these mobility choices, so that they can be readily included in the activity-based modeling system. An example would be asking questions about whether someone has an alternative work schedule (like working four 10-hour days) or what their usual mode to work is. Some areas have surveys that were designed specifically to evaluate a particular program like the travel demand management program and so may be useful in developing some of the mobility choice models.

Since many of these models are quite new, we don’t yet understand whether parameters are transferable or whether behavior is similar in different areas.



Let’s consider a transportation planning and policy project that might be faced by an MPO or DOT and how long-term decision making and mobility fits into the picture. We used this example in the population synthesis webinar and will discuss how future topics will be affected by this bridge expansion example.

For this scenario analysis, we will be considering a number of alternatives: a no-build alternative and a various configurations of the build alternative. In the no-build alternative the bridge has 4 lanes (2 in each direction), there are no tolls, and the transit fare stays the same all day. In the various build alternatives, there are 6 lanes on the bridge. In some alternatives the two additional lanes will be HOV lanes all day, while in other alternatives the two additional lanes will be HOV lanes only during peak periods. In addition, in some build alternatives there will be a new toll that is the same across the entire day, while in other build alternatives there will be a toll that will be only applied during peak periods, or when certain levels of congestion occur. Finally, in the build alternatives regional transit fares will be higher during peak periods.



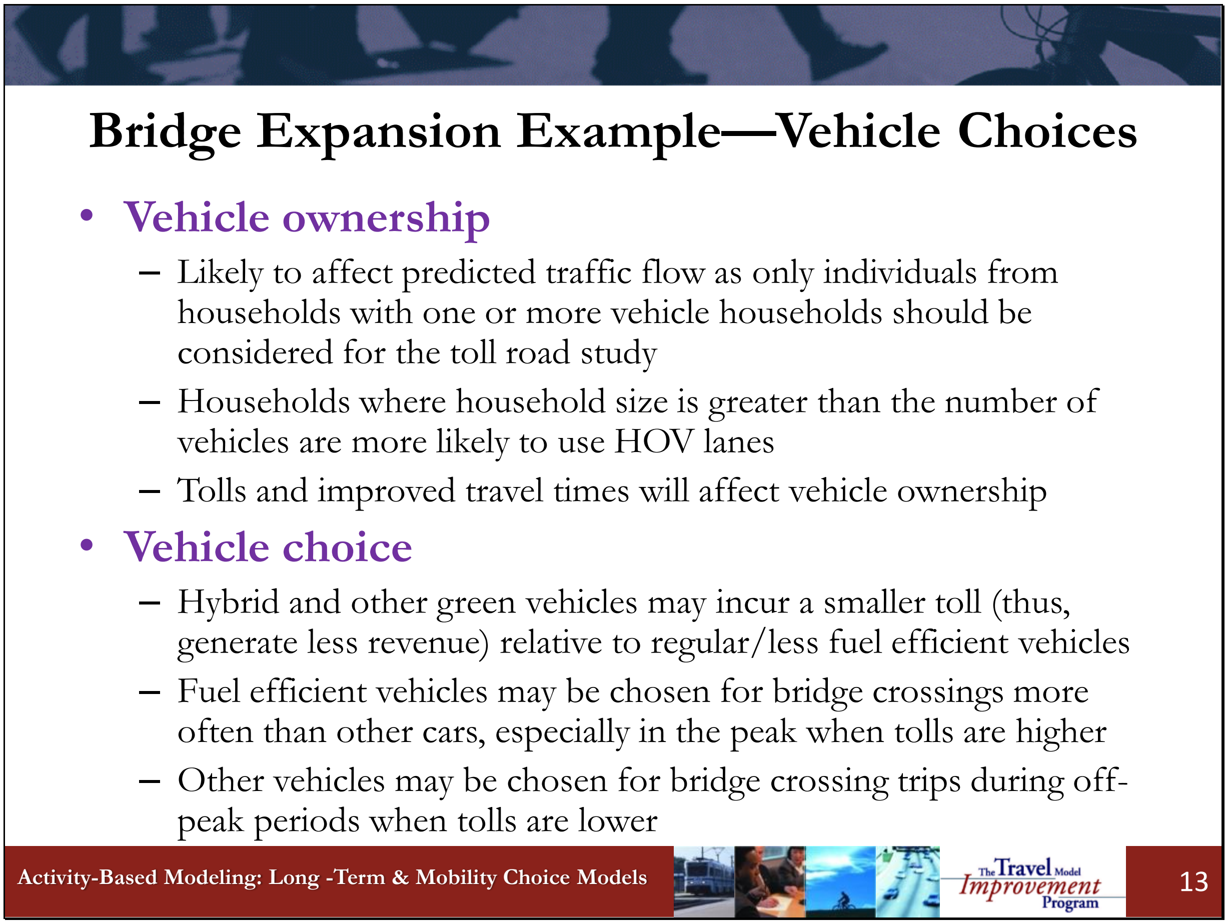
The bridge expansion example will have varying effects on the long-term and medium-term mobility choice models. For example, vehicle ownership may decrease with tolls, and vehicle type choice may increase if fuel efficient cars are offered discounted tolls. If someone owns a transit pass they may increase their transit use across the bridge to take advantage of the carpool lanes and the free passage. If someone owns toll transponder, they may be more likely to cross the bridge on a regular basis. It is also possible that work locations may change over time as people decide that paying a toll five days a week to get to work doesn’t fit within their transportation or household budget. Less likely, but still possible, school locations may also change if they are across the bridge and a toll is required. Work and school locations are also affected by tolls that are higher in the peak period because workers and students are often required to travel at this time.

Bridge Expansion Example—Location Choices

- **Workplace location choice**
  - Work location is likely to affect expected traffic volume on the new road and projected toll revenue
  - Tolls and improved travel times will affect location choices for workplaces
  - Accurate prediction of telecommuters will ensure that toll revenue for peak period is not over estimated
- **School /college location choice**
  - Location of school/college is likely to affect HOV lane use (e.g., parents may drop their children off to school on the way to work)
  - Tolls and improved travel times will affect locations choices for colleges, possibly schools as well.

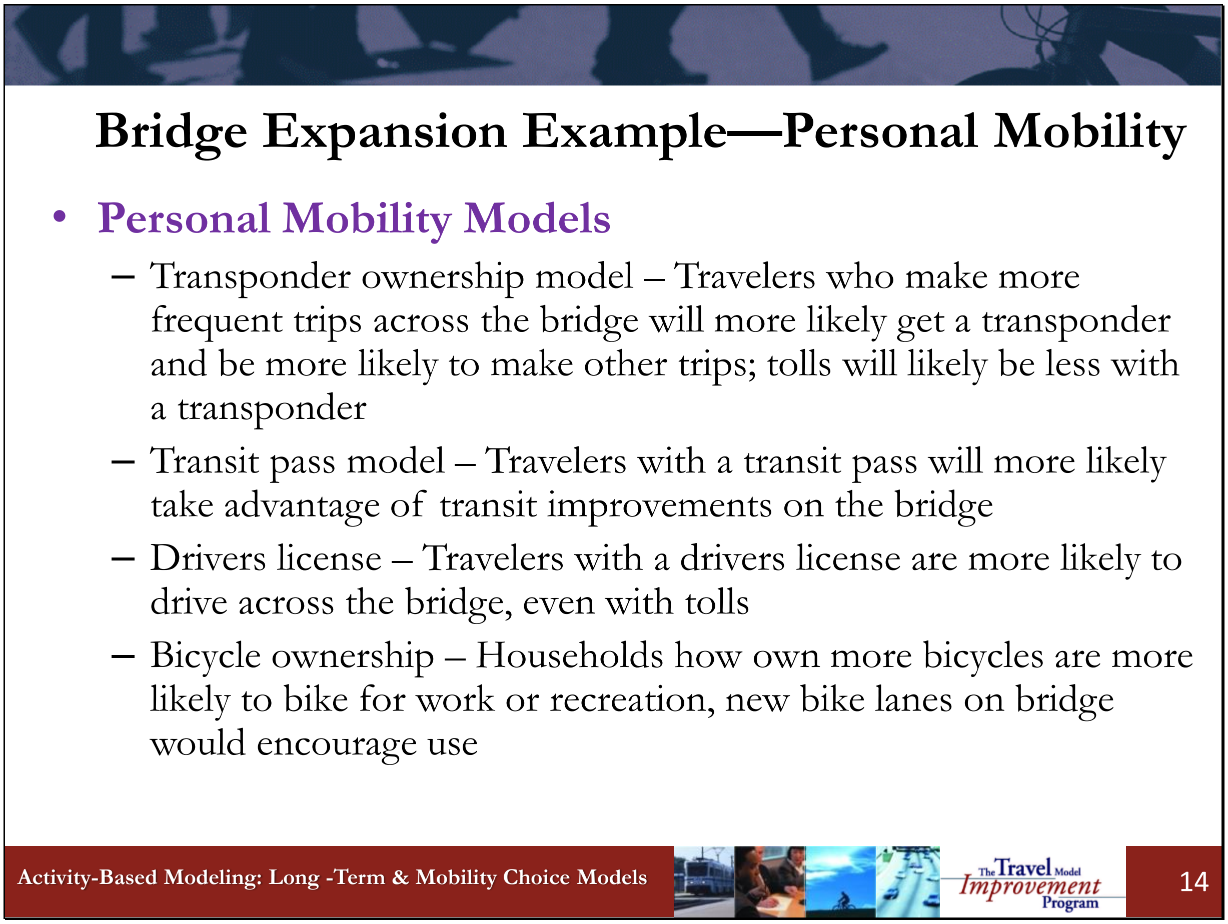
There are likely going to be other indirect effects of the new toll bridge, if traffic volumes are spread throughout the day and travel times improve as new workers can consider work locations across the bridge. Other workers may consider telecommuting as a viable option, rather than pay the toll. These shifts will be different for higher and lower income families and those who have work schedule flexibility to travel outside the peak period.

School location may be less impacted by a bridge expansion example, but college locations may be influenced in much the same way as work locations. Private schools, though, represent an element of school location that may be influenced by a bridge expansion.



The bridge expansion example may also affect vehicle choices in the household. As the price for travel increases on the toll bridge, lower income households may choose to reduce car ownership in favor of alternative modes such as transit. Higher income households may appreciate the improved travel times on the bridge and over time purchase additional vehicles. Households with more people may choose to take advantage of carpool options.

Some toll bridges are considering offering discounted tolls for hybrid or other green vehicles, which may increase the use of these vehicles as well as the purchase of these vehicles. People may also choose to use fuel efficient vehicles during peak periods when tolls are higher and to use other vehicles during off-peak periods when tolls are lower.



The bridge expansion example also affects some aspects of personal mobility directly and other aspects indirectly. For example, transponder ownership may increase significantly if transponders offer a discount for frequent use. Travelers who are considering transit as an option, may be more likely to purchase a transit pass to take advantage of the transit improvements on the bridge. The bridge expansion example may have indirect and smaller impacts on drivers licenses and bicycle ownership.

Bridge Expansion Example—Worker Mobility

- **Work Mobility Models**
  - Usual work arrival and departure times – Lower off-peak tolls may encourage travelers to work longer hours or to adjust arrival or departure times to avoid peak periods
  - Work schedule flexibility – Lower off-peak tolls may encourage travelers to work fewer days or work different hours if they have some schedule flexibility at their workplace
  - Parking Subsidy – Employers may offer subsidies for parking at work that encourage driving, especially if bridge tolls improve travel times
  - Travel Subsidy – Employers may offer general travel subsidies that could be used to pay for tolls, encouraging driving across the bridge instead of other modes
  - Transit subsidy – Employers may offer subsidies for transit passes, encouraging use of transit on the bridge

There are also a series of worker mobility models that will be affected by improvements on the bridge. For example, tolls that are lower during off—peak periods may encourage workers to travel in off-peak periods by working longer hours or by shifting work hours. Workers may also choose a work schedule that involves longer work hours for fewer days, such as a 10 hour, four-day workweek, or a nine-hour nine-day two-week work schedule.

Employers who have travel demand management programs may offer employees subsidies for transit passes, parking, or other travel. These subsidies can influence travelers decisions by reducing costs for specific alternatives. Some employers offer parking or travel subsidies as part of an overall benefits package rather than to influence a mode shift. In the context of the bridge expansion example, these subsidies can influence modal shifts especially if one mode is subsidized and another is not.

Summary of Mobility Model Decisions

	Household Decision	Person Decision	Worker Decision	Student Decision
Location Models			Workplace Location Work at Home	School/College Location
Vehicle Models	Auto Ownership Bike Ownership Toll Transponder	Auto Allocation Driver's License		
Personal Mobility		Transit Pass	Transit Pass	
Worker Mobility			Usual Work Times Work Schedule Usual Mode Pay to Park	

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There are many types of mobility decisions in the activity-based modeling system made by different agents. Household decisions include auto ownership, bike ownership, and toll transponder ownership because these can all be used by any member of the household. Personal decisions include which auto to use for each trip and whether to obtain a drivers license or a transit pass. The auto allocation choice could be considered as a medium-term decision, if the auto is driven primarily by one person most of the time. If the auto is shared among two people, then the auto allocation choice becomes a shorter term decision where the auto may be used by different people throughout the day. These types of shorter-term decisions are made within the context of the daily activity and travel models rather than as part of the long-term and medium-term mobility models.

Another example of this is our workplace and school or college location choice models where the usual workplace and school or college locations may be chosen as part of the long-term decisions and the workplace and school or college locations for a particular day may be chosen as part of the daily activity and travel decisions. Here, we may have someone who works downtown typically, but on the day of travel goes to a business meeting in another city. The long-term workplace location downtown is modeled as a long-term choice, and the short-term workplace location in the other city is modeled as part of the short-term daily activity pattern.

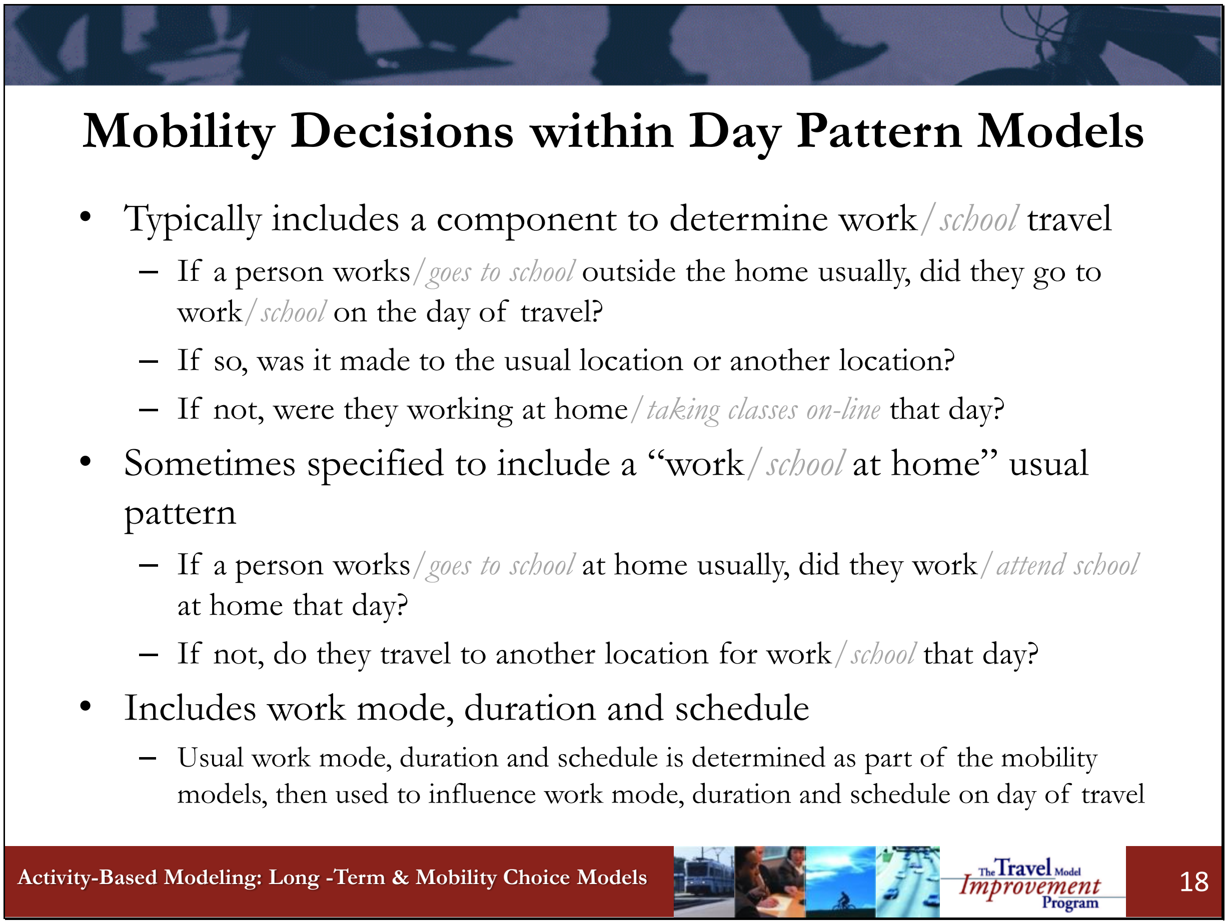
A third example of this is our work duration, work schedule, and usual mode models. These can be included as both long-term mobility models and as short term activity travel models. Again, the purpose of separating these choices is to identify the characteristics involved in a long-term choices separately from the characteristics involved in the short term choices and to recognize the differences between them.

The last set of mobility of models include those that involve travel demand management programs such as flex time, telecommuting, and subsidies for transit passes, parking, and other travel.

Design Decisions for Each Model Component

- Identify a variable of interest (e.g., locations of work activities)
- What are the theoretical motivations behind the outcomes? (e.g., reduce personal transportation costs, maximize household welfare, personal schedule flexibility)
- How should this variable be used in other model components?
  - As a pre-condition (e.g., given auto availability or usual workplace…)
  - As a covariate (e.g., holds a transit pass, participates in a cash-out parking program)
  - … different roles in different models
- Other model components might provide similar functionality
  - Day pattern models
  - Land use models
  - Population synthesizers

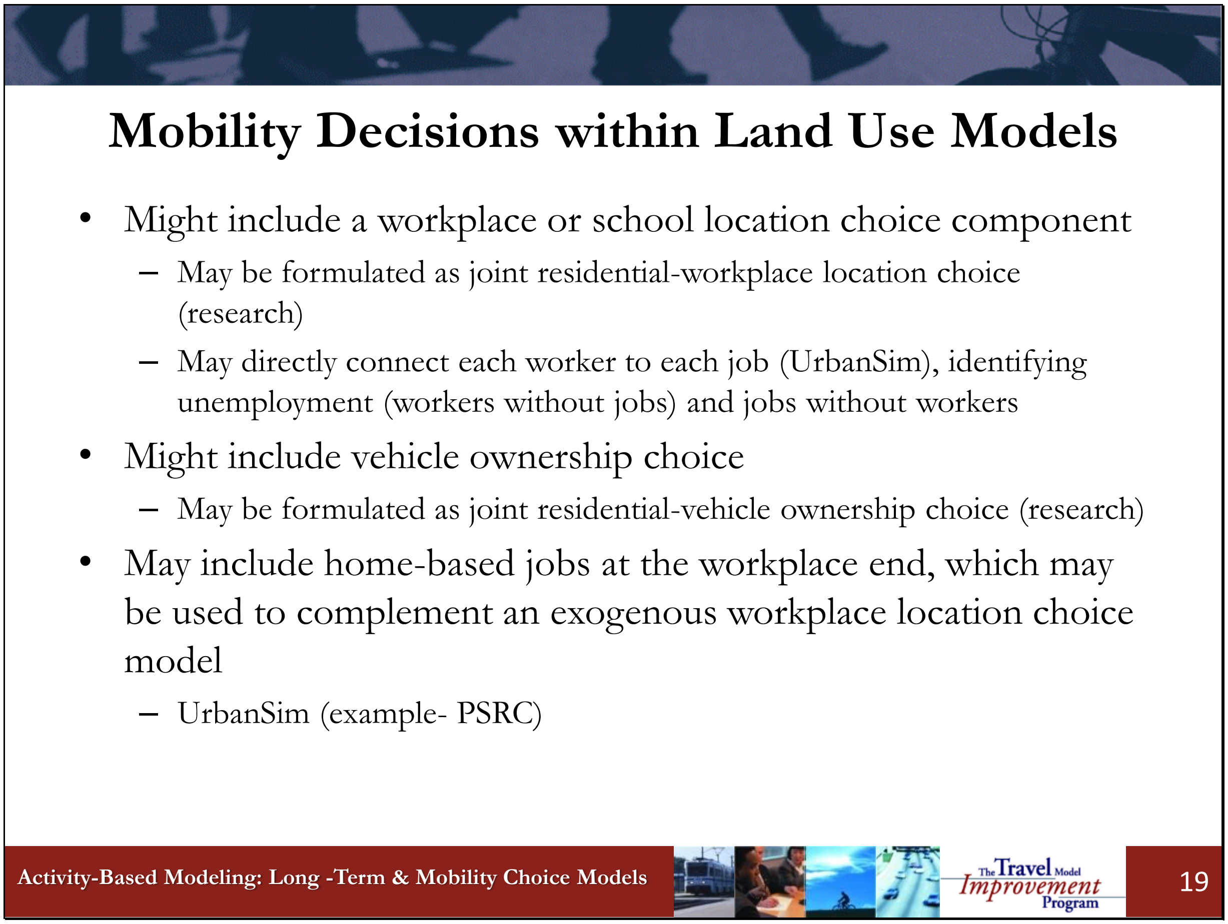
The mobility models have a series of design decisions that will affect the model components, model structure, and sensitivities in these models. The first part of my talk has focused on which models, or choices should be represented in the modeling system. This part focuses more on design decisions within each modeling component. These include identifying the choice to be made or the variable of interest such as the locations of work activities. Most of the long-term and medium-term mobility models are structured to produce a single variable for input to the activity pattern and travel models, such as whether someone owns a transit pass. It is also necessary to identify the variables that will impact this choice and these should include as many of the policy sensitivities desired in the modeling system. An example of the variables that would affect owning a transit pass are person type (workers, students), age, income, time and cost to work. Another aspect of design is how it will fit within the modeling system. This could be as a direct input, as a pre-condition, or as a combined decision with another variable.



As I mentioned before, mobility decisions may be embedded within day pattern models and as long-term choices, or represented in one or the other. This is true for work and school location choice models. If the mobility decisions are included as long-term choices then questions about usual patterns of travel to work and school locations are needed in the household travel survey to distinguish these usual patterns from a daily pattern collected as part of the travel diary.

This is true also for work-at-home patterns representing people who work at home full-time, or students who are enrolled in online colleges. Current household surveys capture people who stay at home rather than go to work or school, but may not capture whether they work or attend classes at home as a substitute for going to work or school.

Another more recent expansion of mobility models is in the area of usual work mode, duration and schedule to distinguish this from the daily work mode, duration and schedule. For example, I may take transit to work every day except on a day where I need to visit a client. So I have a transit pass and take transit regularly, but on my day of travel I choose to take the car and go to work as well as to visit the client and then return home. The reason I take my car is because the client is not in a transit area but my regular workplace is in a transit area, so the factors for these two destinations are different. We are still modeling an average day of travel, but can account for those who deviate from their typical work schedule with this additional information.

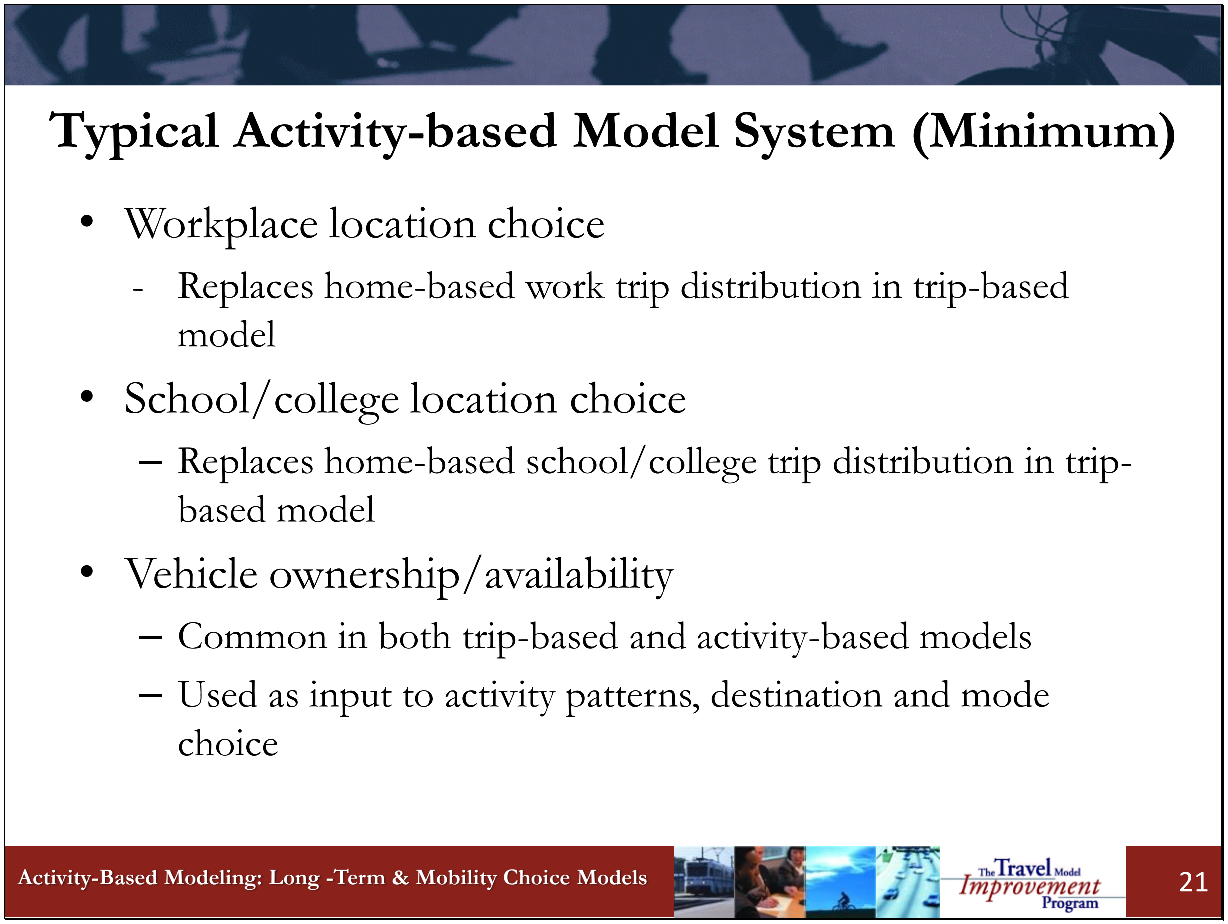


Some land-use models have components of mobility decisions built within them, such as workplace or school location choice. There are several reasons one may choose to build these mobility decisions into the land-use model instead of the travel model. First, this offers the opportunity to formulate a joint residential and workplace location choice model, which has been researched, but not put into practice. Second, a disaggregate land-use model can directly connect each worker to each job and each student to each enrollment. One example of a workplace location choice model like this is at PSRC in Seattle, where each worker chooses a job and workers without jobs represents unemployment and there are also potentially jobs without workers. In this example, the micro-simulation will match new workers to open jobs each year and relocate some workers to available jobs. One benefit of this approach is that there cannot be more workers than jobs at a location. Another area of research is in joint residential and vehicle ownership choice models. The benefits of these models are not yet well understood, or whether the additional complexity offers significantly better results. Home based jobs can also be included in the land-use model to represent home-based businesses or services provided to homes.

Mobility Decisions within Population Synthesizers

- Might include household automobile ownership, person driver's license holding, work-at-home, etc.
- May be a controlled population attribute, but more likely uncontrolled
- Advantages
  - Easy to add other variables, subject to availability in PUMS or comparable source
  - Don't need to create another model component
- Disadvantages
  - Assumes that households/persons of the same type will make similar choices in the future
  - Does not account for important policy and cost variables that influence these decisions
  - Can't do scenario analysis

A third option for mobility decisions is to include them within the population synthesizer. These might include auto ownership, driver's licenses, or people who work at home. These are most likely to be included as uncontrolled population attributes, but could be controlled if desired. The advantages of including these decisions in the population synthesizer are that it is easy and doesn't require a separate model component. The disadvantage is that the population synthesizer is not sensitive to policies or cost variables that influence these decisions and scenario analysis will not be possible. As a result, most current activity-based models do not include mobility decisions within population synthesizers.

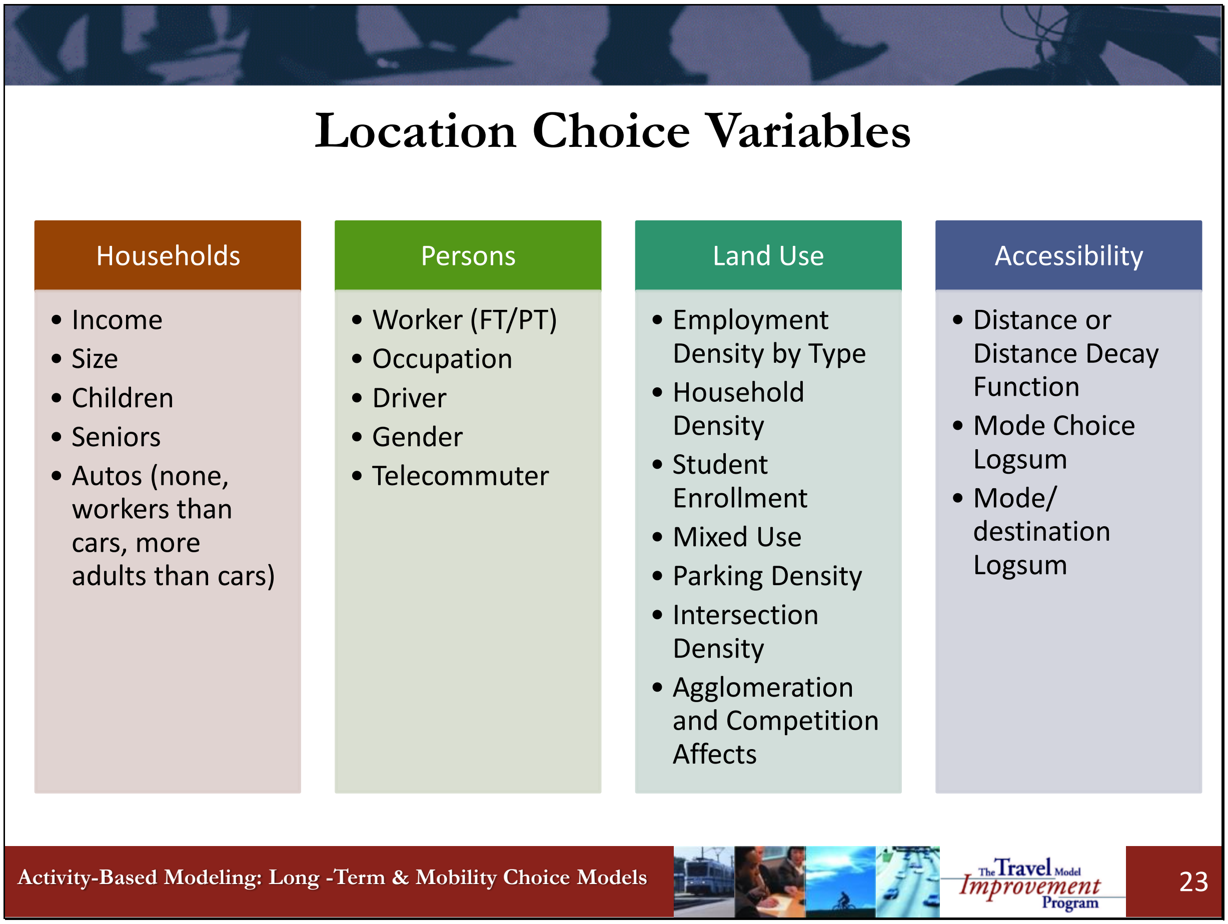


There are three mobility decisions that are included in the activity-based modeling system, at a minimum, but these are quickly changing to include many additional decisions. The workplace location choice model replaces the home-based work trip distribution in a trip-based modeling system. The school and college location choice model replaces the home-based school and college trip distribution in nature-based modeling system. The vehicle availability choice model is common to both work based and activity-based models except that there are many additional accessibility measures and log sums that may be possible in the activity-based model version.

Workplace Location Choice

- Spatial resolution - Zone, micro-zone or parcel
- Formulation as destination choice with size variables
- Usual workplace location (mobility model) and day-of-work location (day pattern)
- Work at home
  - Home-based businesses (full-time work at home)
  - Telecommuters (part-time work at home)
  - Work at usual workplace and work-at-home in same day
- Advanced methods match workers to jobs
  - Employment industry
  - Work flexibility

Workplace location choice models can be estimated, calibrated, and validated at different spatial resolutions, including zones, micro-zones, or parcels. Workplace location choice models can identify usual workplace location, day of work location, and work at home situations.



Workplace location choice models may contain a variety of household, person, and land-use characteristic variables as well as accessibility measures from the travel models. These variables are also potential variables for school and college location choice models, as well as location choice models for primary and intermediate stop locations within the activity-based model.

Segmentation of Workers and Jobs by Occupation
(Example from Phoenix and Tucson)

- Workers classified by 5 occupation categories (2008 NHTS)
  - Sales, marketing
  - Clerical, administrative, retail,
  - Production, construction, farming, transport
  - Professional, managerial, technical
  - Personal care or services
- Jobs classified by 2-digit NAICS codes (26 categories)
- 26 to 5 correspondence used to segment the size variables by 5 categories

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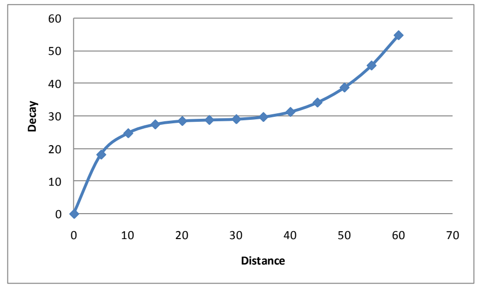
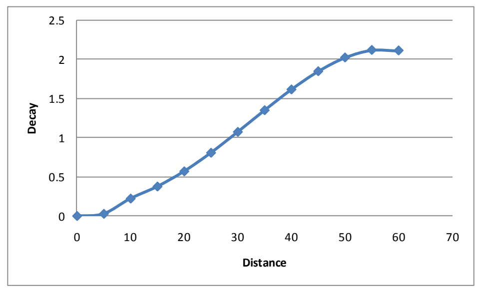
Workplace location choice models can be developed to segment workers and jobs in the same occupation. This example from Phoenix and Tucson shows 5 occupation categories in the 2008 NHTS, which are correlated to the 26 categories of jobs by NAICS codes. In this way, you will prevent salesmen from taking jobs in the manufacturing industry and someone in the manufacturing industry from taking a retail job. This requires including occupation in the synthetic population. Ideally, employment would also be classified by occupation rather than by industry, since occupation and industry are weakly correlated.

Distance Decay Function

- Linear combination of elemental distance (D) functions:
  - LN(D)
  - $D^{0.5}$
  - D
  - D^2
  - D^3
- Great degree of flexibility in describing various non-linear effects

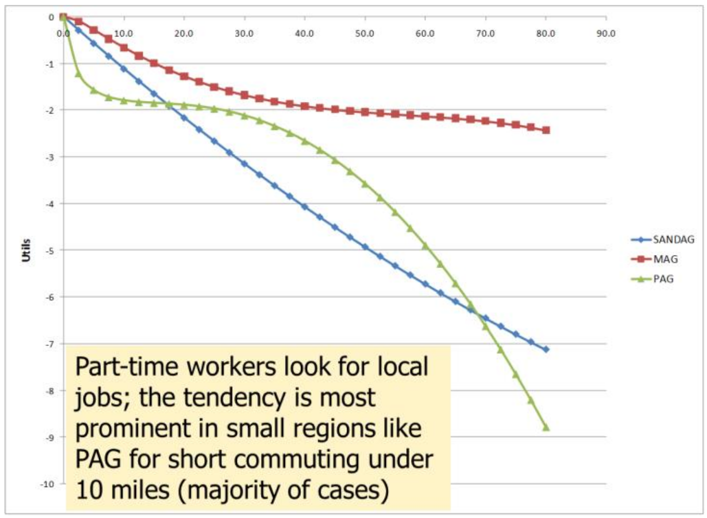




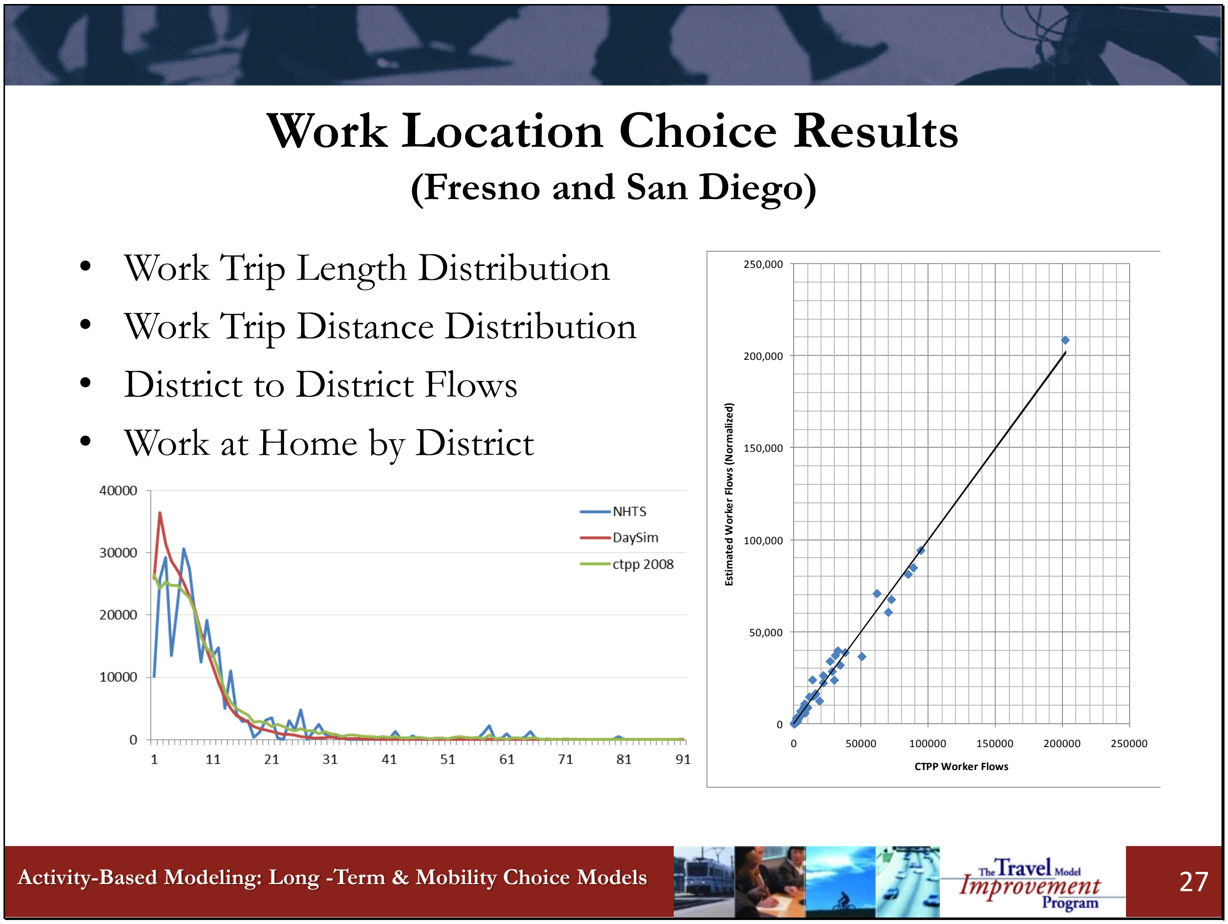
Another potential variable in any of the location choice models is a distance decay function. This reflects a non-linear relationship between distance and the location of interest (work or school).

Distance Decay Function Impacts

- Baseline worker case (male, full-time, medium income)
- Main impacts on top of the baseline found in San Diego, Phoenix and Tucson
  - Female
  - With preschool child under 6
  - Without preschool child under 6
  - Part-time
  - Low income (<$50K)
  - High income (>=$100K)



The impacts of the distance decay function vary based on the population. In this example, part-time workers look for local jobs; this tendency is most prominent in smaller regions like Tucson and for shorter commutes (under 10 miles). Low-income workers look for local jobs and are less specialized in occupation; the tendency is less prominent in small regions like PAG. High-income workers do not look for local jobs; for MAG high-income workers could not be distinguished from medium-income workers (baseline). These distance decay functions were estimated from survey data in San Diego, Phoenix and Tucson.



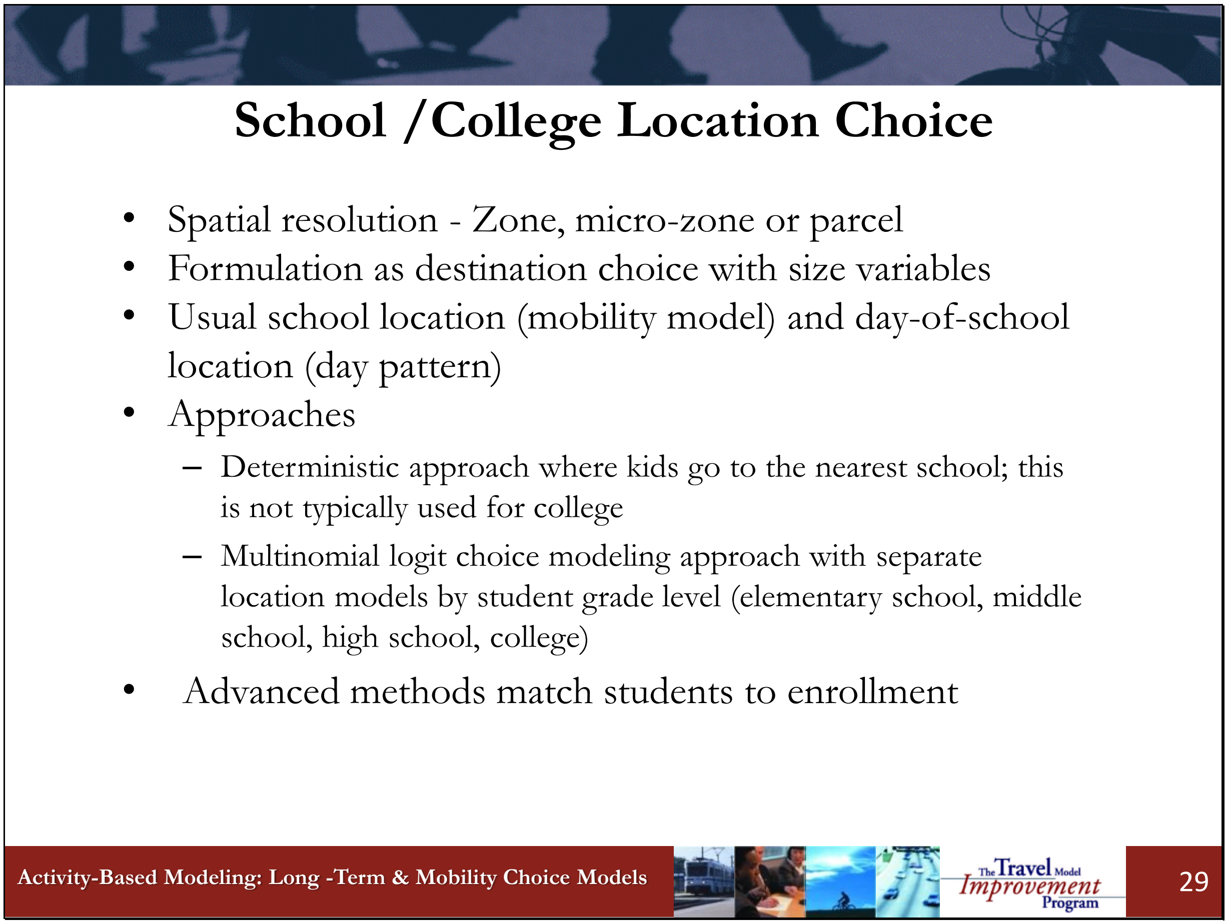
The results of a typical work location choice model may look similar to those from a trip-based model for work trips. These include work trip length and distance distributions and district to district flows. The work-at-home element is typically not included in a trip-based model but is useful to calibrate in the mobility models. The example on the left shows a typical validation of the work trip length distribution in Fresno and the example on the right is a district to district chart.

Work at Home

- Work at home is rapidly growing because of
  - Communications technology
  - Structural shifts in occupation and industries
- Will these trends continue?
  - Is there a saturation point? If so, what is it?
  - Can models forecast or back-cast the rise in this trend or are the factors changing?
- There are potentially significant impacts on congestion
  - Which makes this an effective policy lever
  - Sensitivity tests may help to evaluate these impacts

Work at home is a rapidly growing segment because of significant increases in communications technology, providing reasonable video capabilities in the hands of everyone. There has also been some cultural shifts in some industries to allow telecommuting, either part-time or full-time. So, the real question is, will the trends continue? Is there a saturation point? If so, what is it? Can the models recognize the changes in the trend?

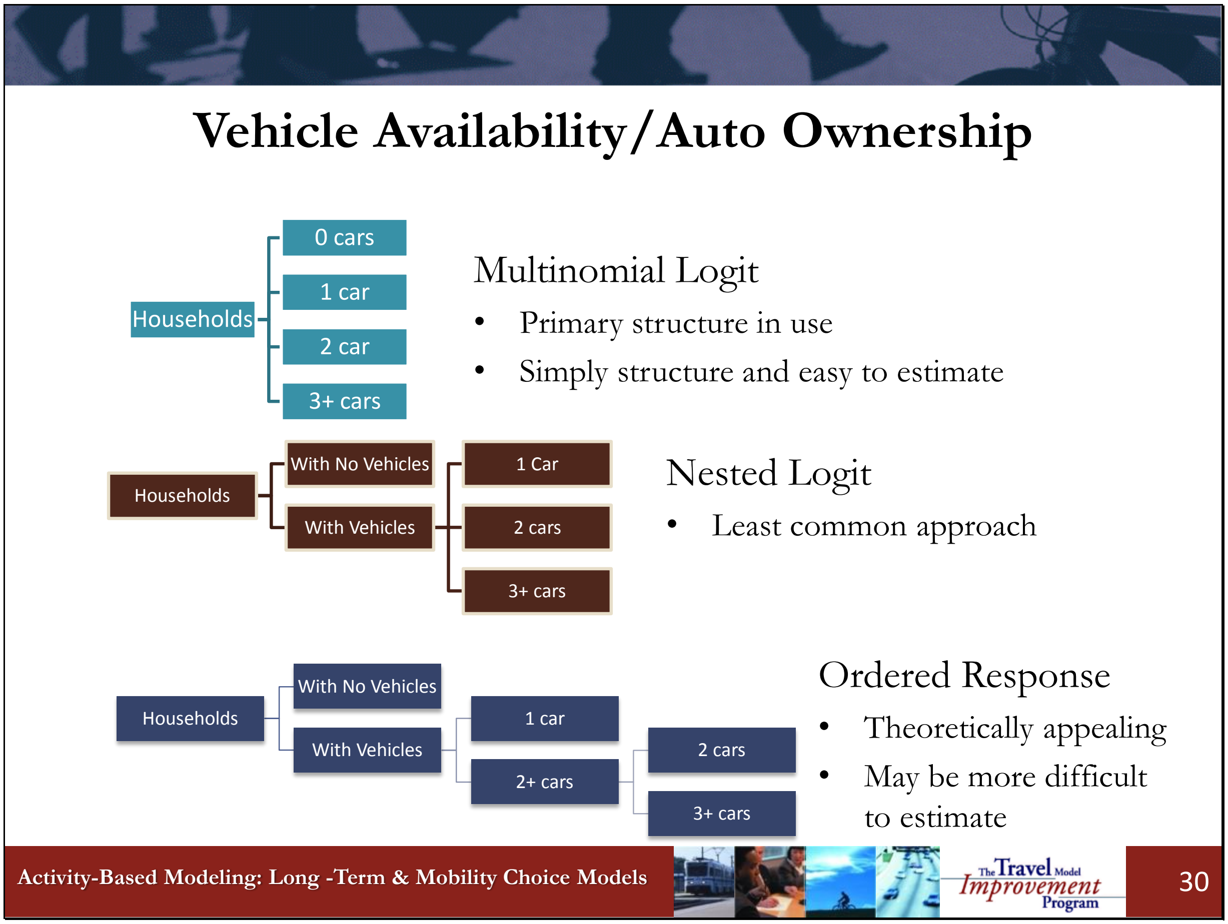
Workers who work at home can have significant reduction in congestion, if these work trips are in congested areas. Regional agencies may allow this option, but have not typically set policies to encourage this option as a valid trip reduction program. Many current work-at-home models focus on changes in travel times and costs and may not be sensitive to other aspects of the trends in work-at-home like improvements in telecommunications and employer’s willingness to let workers work at home.



The school and college location choice models follow many of the same features as the work location choice models in terms of spatial resolution, formulation, and integration with the activity-based model. Some models use actual school locations at parcels, but the advanced practice to match students with enrollments directly has not been done in practice. This is primarily because current practice of using multinomial logit models has worked well and because the student-enrollment market is smaller than the worker-job market.

Some of the more recent methods to include long-term location choice models for usual schools or colleges along with short-term choice models for daily travel to school and colleges are just coming into practice. For example, Sacramento, Seattle, and Philadelphia are adopting this approach in their models under development.

Many existing models separate school locations by grade level and to elementary schools, middle schools, high schools, colleges, and some even include preschools. In the public school setting, models can adopt a deterministic approach to send kids to the closest school. This often doesn’t work for private schools or colleges, where a multinomial logit choice model is more practical. The choice between these methods should be determined by the student requirements for each school (i.e. are students required to live in a district?).



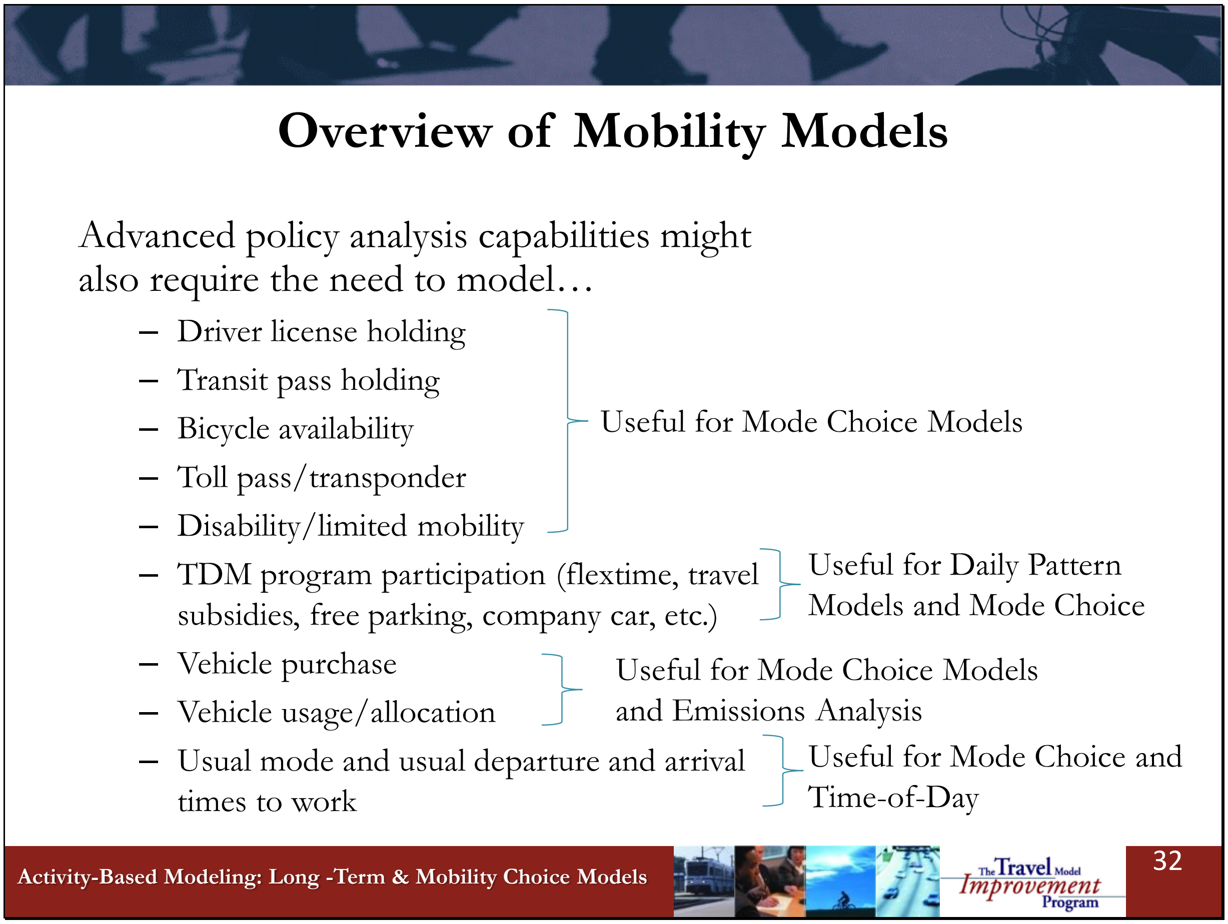
Vehicle availability or auto ownership models are typically developed in a multinomial logit form, but other forms have been tested and researched. The most common multinomial logit form has four alternatives beginning with zero car households.

A nested logit model could be used to separate households with and without vehicles and then estimate the number of vehicles for those households with vehicles, but this is more difficult to estimate and less theoretically appealing than an ordered response.

A third alternative form is an ordered response model where households are separated into those with and without vehicles initially and then separated into one car and more than one car households and finally separated into two car or three or more car households. Ordered response models have been used in practice, but are more difficult to estimate than multinomial logit models. Most agencies can develop multinomial logit models for vehicle availability, unless there are issues with estimation or calibration using this process, whereby another approach can be considered.

Questions and Answers

The Travel Model *Improvement* Program



I have focused this discussion mostly on the commonly used mobility choice models, but there are many additional models under consideration were under development at several MPO's around the country. The most important mobility models for mode choice are driver license holding models, transit pass holding models, bike ownership or availability models, toll transponder models or limited-mobility models. The travel demand management program participation models are quite useful for input to daily activity pattern models as they affect scheduling for work trips directly. Some of the travel demand management program models are also quite useful in mode choice. Another category of models under consideration or under development are vehicle purchase or usage models that predict the type of vehicle a household made by and which vehicle is used by which person in the household for which trip. These models support the estimation of emissions and can also influence mode choice. In addition, there are models to estimate the usual mode to work, along with the arrival and departure times to work, which inform the actual mode and schedule for a worker on the day of travel. These may change, of course, if the work location on the day of travel changes or if other locations on the day of travel are not typical, like if I need to go to the doctors on the way home.

Role of Mobility Attributes

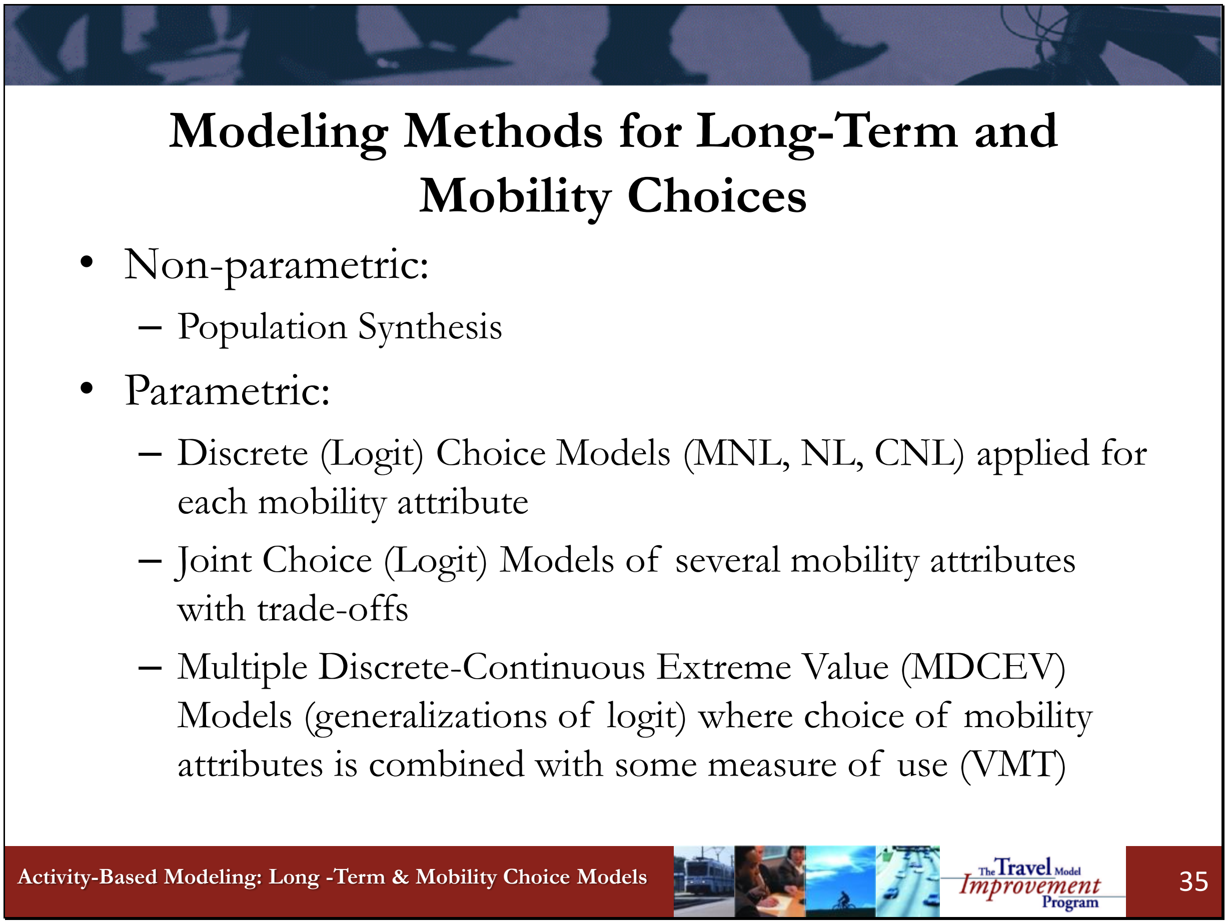
- Add behavioral realism and ***explanatory power*** to subsequent models of travel choices
- Endogenous interdependent mobility attributes enhance ***integrity & consistency*** of the model system (e.g. car ownership × transit pass)
- Mobility attributes are frequently determined by ***commuting needs***; then, they dictate travel behavior for other trips
- Provide ***policy-sensitive*** variables for certain scenarios like new transit (multimodal) pass, discounts, employer-provided parking
- Allows ***variation*** in individual mobility attributes to avoid aggregation bias

The purpose of these additional mobility models is to predict attributes of mobility that help explain the behavior of other travel choices and to provide sensitivity to specific policies of interest. These policies are often employer policies, so are naturally focused on commute travel. One popular example are commute trip reduction programs, which can include transit passes, flex time, carpool parking spaces, and other subsidies to discourage travel in single occupant vehicles during the congestion peak periods of travel.

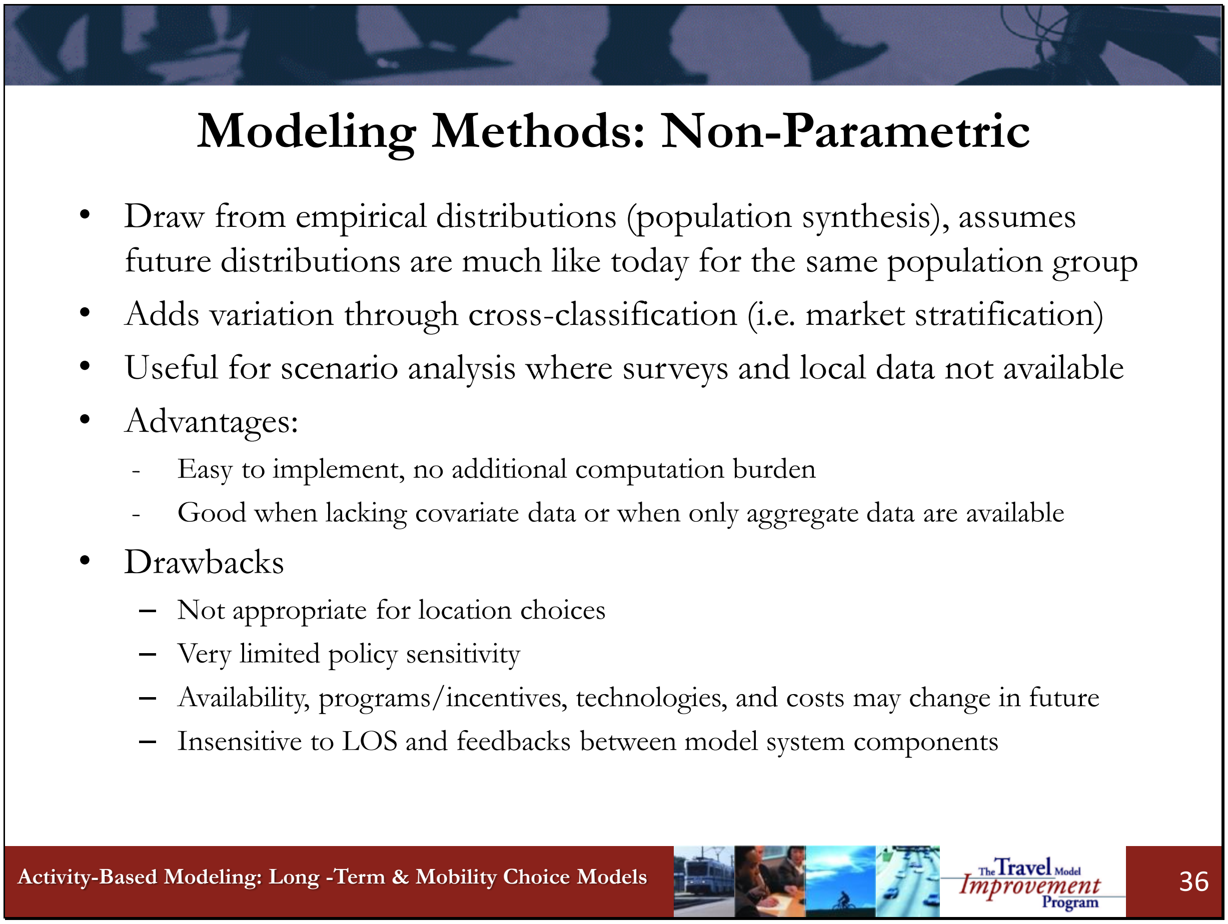
Example: Travel Demand Management Programs (TDM)

- Different types of programs
  - Flexible hours
  - Telecommuting
  - Carpool/vanpool
  - Parking subsidies
  - Subsidized transit passes
- Different incentive structures
- Level of participation
  - Which employers and which workers (match to employers)
  - Which programs
  - Modeled based on industry type, location, size
  - Assumed through scenario analysis

Travel demand management programs have been in place for many years in some cities, but are often not well represented in trip-based models and included as a long-term choices in some activity-based models. Current long-term choice models can represent different types of programs and different incentive structures, but may not adequately represent the level of participation, either by employers or employees. There is still much work to be done.



There are quite a few different models that have been developed for modeling long-term and mobility choices, although multinomial logit choice models is still the most commonly used method. We will describe each type and provide some examples of mobility models.



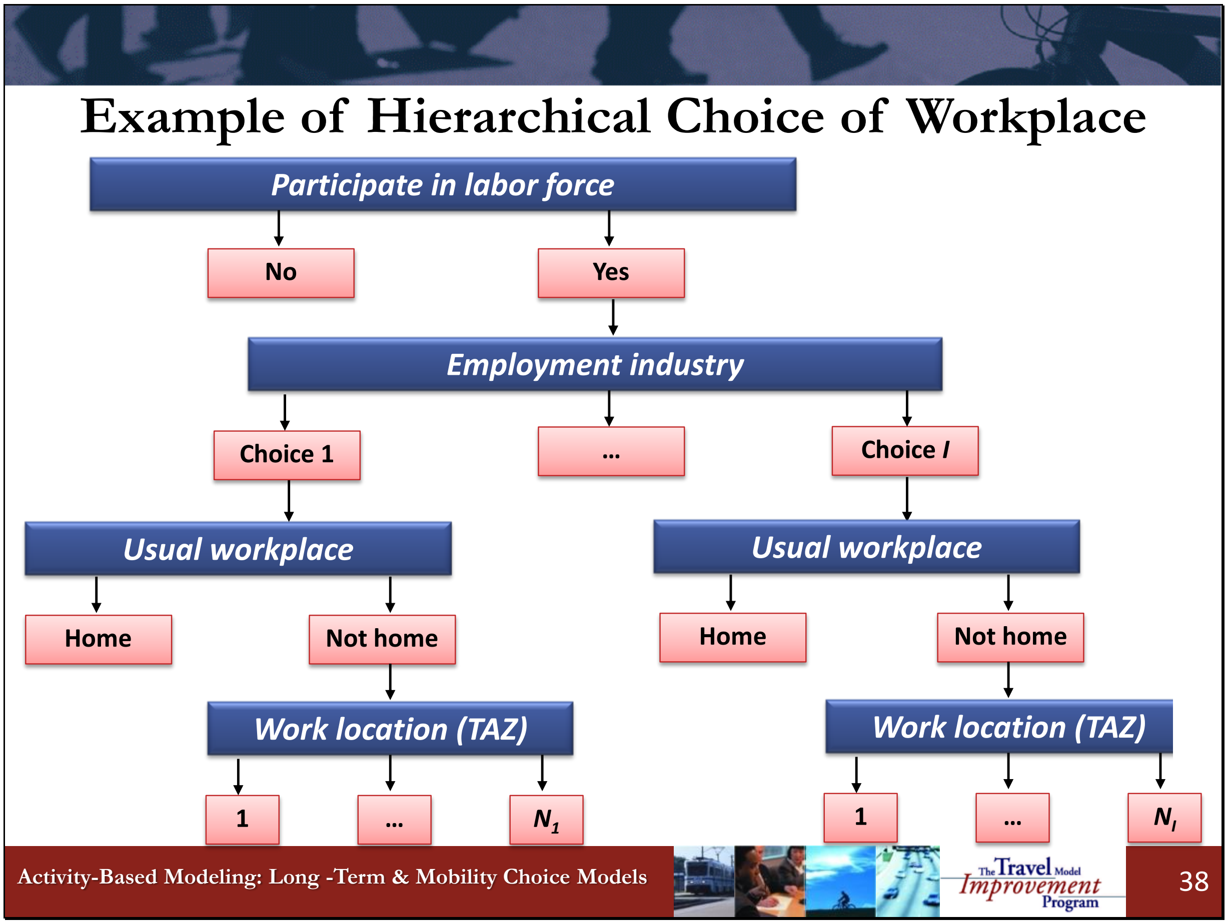
The second half of this webinar will focus more on the methods used in modeling long-term and mobility choices and on providing a few examples of these models in practice.

There are several nonparametric modeling methods, including population synthesis, which I mentioned earlier, or assuming future distributions are similar to today. Both of these lack sensitivity to transportation investments or policies. Some sensitivity may be incorporated through the use of cross classification models, but the dimensionality will be limited to the number of variables that can be included. These methods are very easy to implement and fast to run, but do not take advantage of the disaggregate data or accessibility measures available within that activity based modeling system. Another drawback of these methods are that they can't be used for location choice models. Since one primary objective of including these models in the system is to provide sensitivity to transportation investments and policies, the use of the non-parametric modeling methods is not recommended.

Modeling Methods: Parametric – Discrete Choice

- Flexibility to consider many variables
- Parameterization enables sensitivity and scenario testing of availability, preferences, programs/incentives, technologies and costs
- Can represent hierarchical or ordered choices of different mobility attributes with trade-offs with
- Sensitive to level-of-service and feedback
- Alternative-specific constants can be adjusted to form future scenarios
- Drawbacks:
  - Requires data assembly, special (local) surveys, model estimation and calibration
  - May need additional, exogenous data inputs (for example, workplace stratification by company size or work schedule flexibility)

Most of the long-term choice models in use today are based on discrete choice methods with all the advantages and disadvantages that come along with them. These models are flexible in terms of modeling structures and variables and can represent non-measurable variables through the alternative-specific constant. They also provide a sound economic backbone to the analysis and are sensitive to transportation investments and other policies. The drawbacks of discrete choice models are the data necessary for estimation and calibration, which may be a limiting factor for some of the modeling components.



Discrete choice models can be seen as a series of hierarchical choices--either as sequential model components where as nested, or as simultaneous model components. In this example, the initial choice is whether to participate in the labor force, or to get a job and then to choose an industry. Once an industry is chosen, the next choice is whether to work at home or outside the home and finally to choose a workplace location. If this model were a nested model, it would have four levels or it could be developed as four individual multinomial logit models. Current practice for long-term choice models is to develop a sequential set of multinomial logit models because the estimation process is more straightforward.

Ordered Choices of Car Ownership

$$y_q^* = \beta' x_q + \varepsilon_q, \quad y_q = k \quad \textbf{if} \quad \theta_k < y_q^* < \theta_{k+1}$$

Where

q = An index for household

$y_q{}^*$ = The latent propensity of household's vehicle/car ownership level

y_q = Observed household's vehicle/car ownership level

k = An index for the number of vehicle/cars in a household (k = 0, 1, 2, 3)

x_q =A vector of exogenous variables

β = A corresponding vector of coefficients

ε_q = An error term (standard normal or Gumbel distributed)

θ_k = The lower bound threshold for vehicle ownership level k

y_q =0 (No car) y_q =1 (1 car) y_q =2 (2 cars) y_q =3+ (3 or more cars)

$\boldsymbol{\theta_0} = -\infty$ $\boldsymbol{\theta_1}$ $\boldsymbol{\theta_2}$ $\boldsymbol{\theta_3}$ $\boldsymbol{\theta_4} = +\infty$

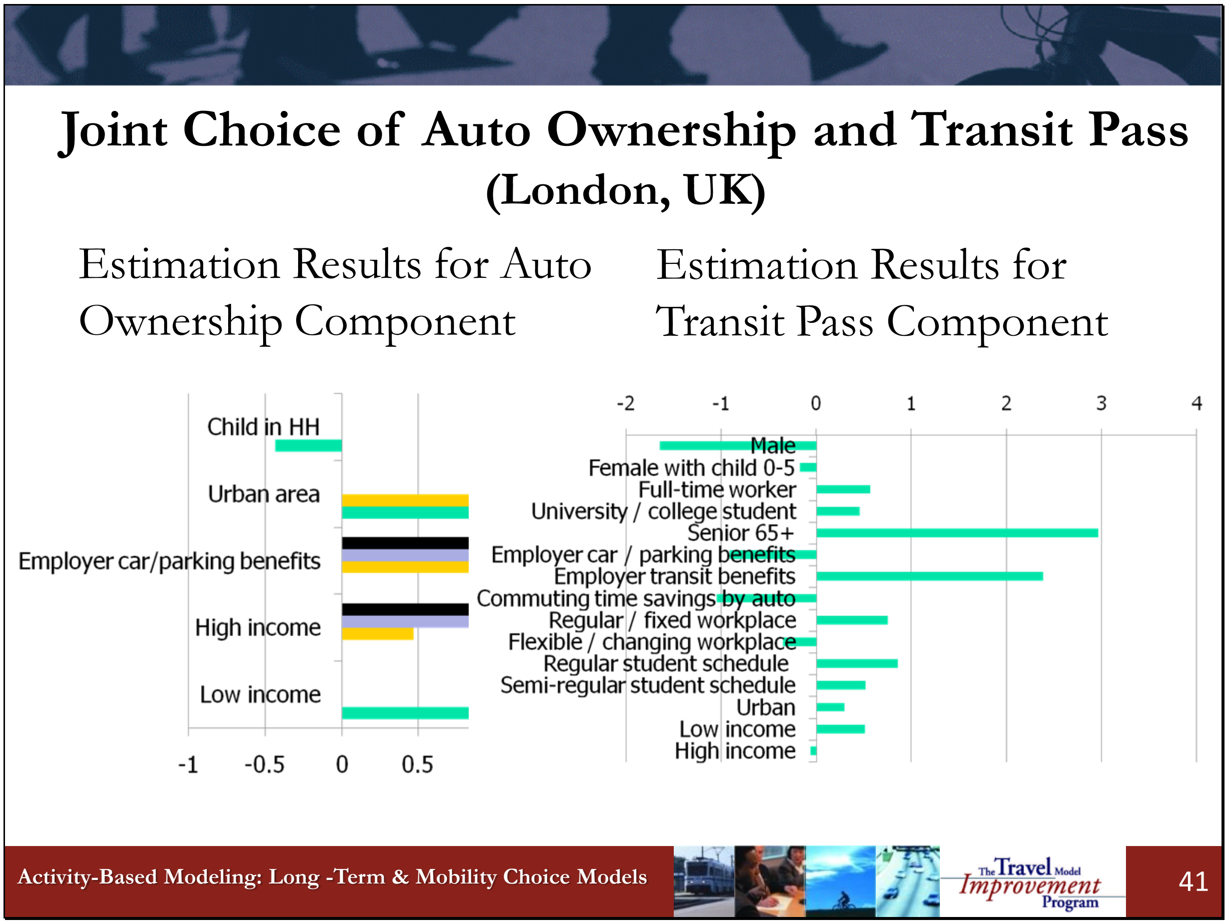
$\boldsymbol{y^*{}_q} \longrightarrow$

Here is an example of an ordered choice in modeling household vehicle ownership level.

Joint Multi-Dimensional Choices

- Theoretically appealing to represent inter-related choices
- Examples:
  - Residential location and workplace location
  - Residential location and school location
  - Workplace location and auto ownership
  - Residential location and workplace location and auto ownership
  - Auto ownership and transit pass holding
  - Auto ownership and reserved / subsidized parking at work

Another aspect of long-term choice models is the potential to represent joint choices. This is theoretically appealing because many choices cannot be sequentially determined and are in reality jointly determined by people. For example, does one choose their workplace based on where they live or choose their residence based on where they work? When someone is young, they may choose their workplace first, and then lived nearby, but as one gets older, they may choose their home first, and then get a job nearby. In addition, some families may choose their residence first, and other families may choose their workplace first. Having a joint choice for residential and workplace location would solve this problem. Nonetheless, these multidimensional choice models are more complicated to estimate and apply and may therefore be less practical to include. If an agency sees a need to represent these joint choices in order to improve the explanatory power of the model, then the additional complexity will be worth it.



One example of a joint choice model was developed in London to predict the joint choice of auto ownership and transit pass holding. This first chart shows the results of the auto ownership component for different population segments. Households in urban areas and with low income are more likely to have no cars and those with employer parking benefits or high income are more likely to have more cars, as expected. Also, households with kids are less likely to have no cars. The second chart shows the results of the transit pass component of the model, with seniors and people with employer transit benefits most likely to have a transit pass and males least likely to have a transit pass.

Challenging to Sort out Causality in Multi-dimensional Choices

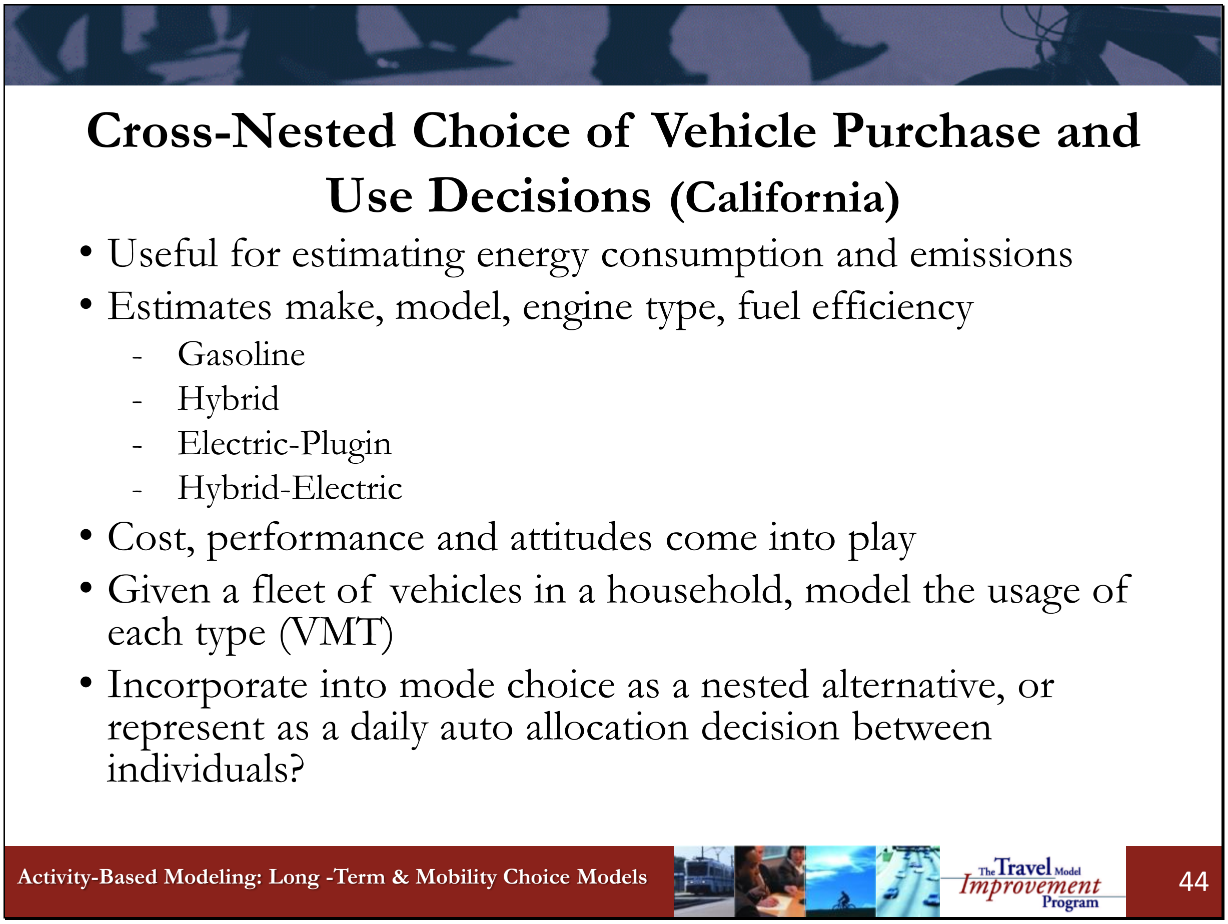
- Self-selection bias:
  - E.g., Do people choose to own a car because they prefer to live in the suburbs, or do they prefer to live in the suburbs because they enjoy driving and it is difficult to maintain a car in the central city?
- Ordering of decisions:
  - E.g., Did a household move to the neighborhood because of a new job, or did the workplace choice follow the choice of residence… or was school location/quality the deciding factor?
- That’s why joint choice is preferable but might result in infeasible dimensionality

One of the bigger challenges in multidimensional choices is how to sort out endogeneity issues. For example, do people choose to own a car because they live in the suburbs or do they live in the suburbs because they want to own a car. These types of self-selection biases can be difficult to sort out. In a set of sequential models, these decisions must be ordered and it may be challenging to determine an order that works for all people. Nonetheless, the practical needs for activity-based modeling require a sequential approach, so the ordering of decisions should be set to represent local conditions as much as possible.

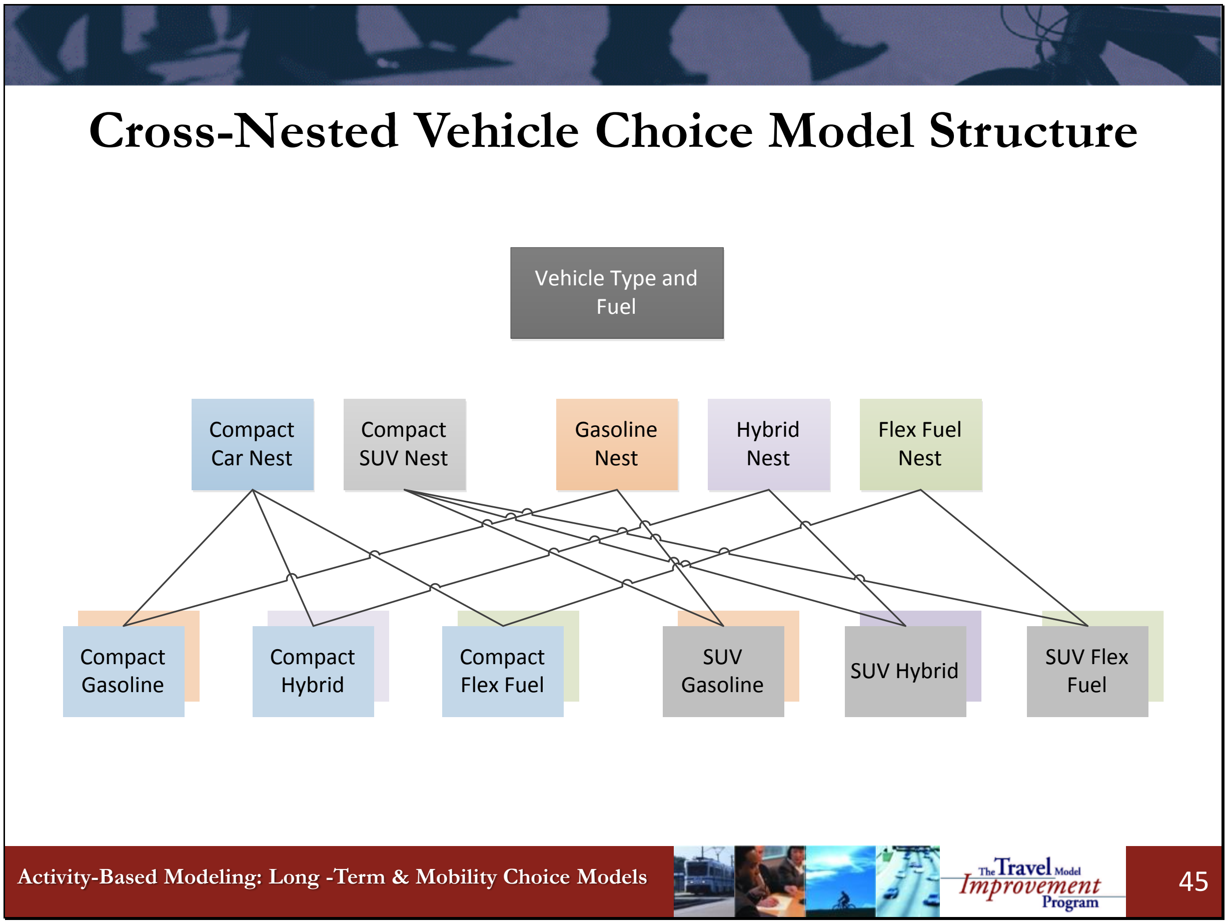
Cross-Nested Logit Model

- A member of the Generalized Extreme Value (GEV) family of (logit) models and is consistent with random utility theory
- Allows flexibility to assign alternatives to several nests and capture mixed interactions across alternatives (generalization of NL)
- The CNL model is appealing to capture complex situations where correlations cannot be handled by the NL model

Cross-nested choice models is a form of random utility model that allows flexibility of assign alternatives to nests across alternatives. The cross nested modeling structure is appealing because it can capture more complex situations where correlations among alternatives can be acknowledged.



An example of a cross-nested model is for vehicle purchase and use decision models, typically used for estimating energy consumption and emissions. These models estimate make, model, engine type, and fuel efficiency of new vehicles. Typically, the cost and performance of the new cars are included as well as attitudes of the buyers for certain makes and models, as well as price ranges and features. The vehicle purchase decision is clearly a long-term choice and the vehicle use decision may be both a long-term and a short-term choice, depending on whether each person wants to drive their own car or whether people share a car or whether people swap cars for different purposes. This example is of a vehicle choice model developed for the California Energy Commission.

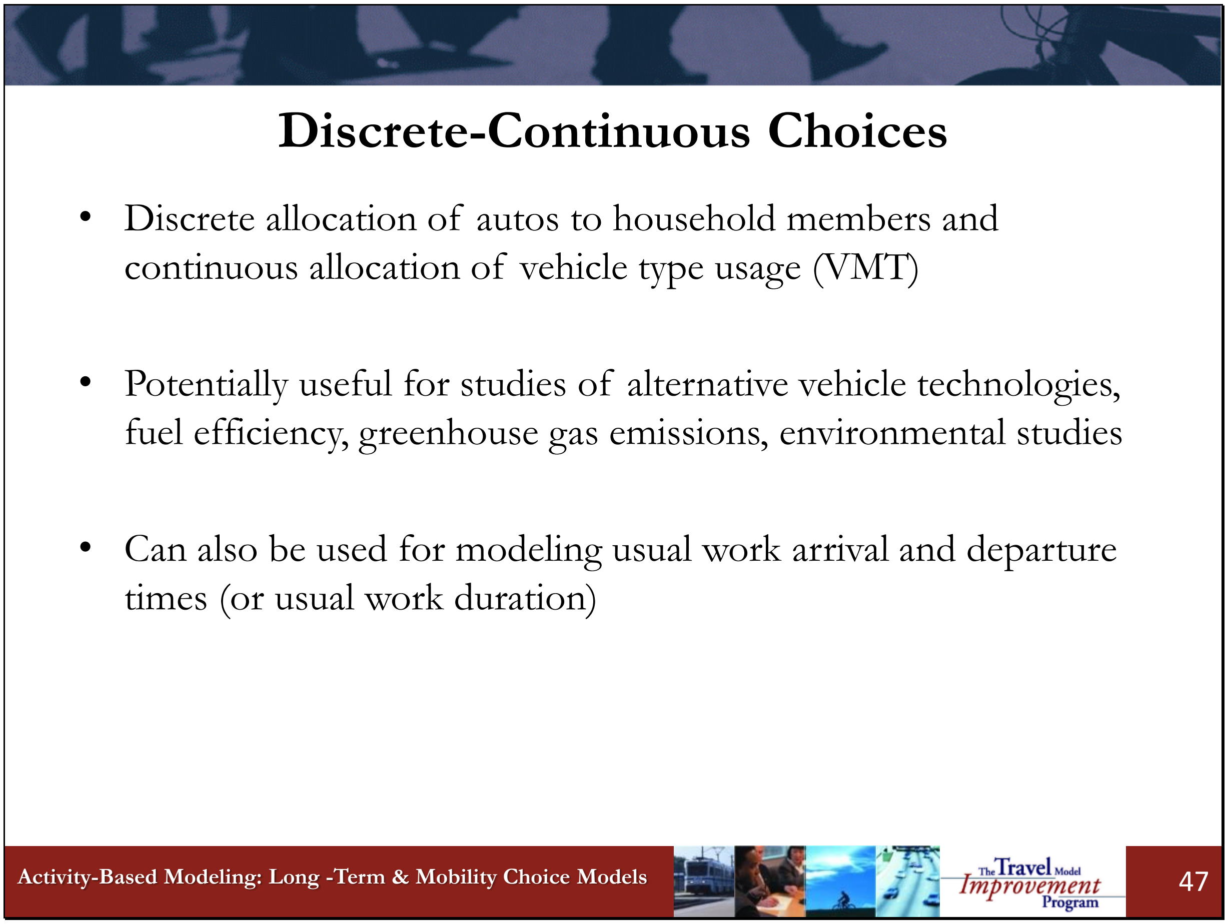


Here is the cross-nested vehicle choice modeling structure developed for the California energy commission to identify initially the type of car and then the fuel efficiency of the car. The cross nests allow for different types of cars and fuel efficiency types at each level.

Compare Nested (NL) and Cross-Nested (CNL) Logit Vehicle Choice Models

	NL (fuel)		NL (vehicle)		CNL	
Nesting parameter	no mixture	mixture	no mixture	mixture	no mixture	mixture
Standard Gasoline	0.68	0.81	-	-	0.4	0.59
Flex Fuel/E85	0.76	0.88	-	-	0.08	0.08
Clean Diesel	0.82	1	-	-	0.8	1
Compressed Natural Gas	0.9	1	-	-	0.97	1
Hybrid-electric	0.56	0.45	-	-	0.46	0.33
Plug-in Hybrid-electric	0.74	0.88	-	-	0.6	0.79
Full Electric	1	1	-	-	1	1
Subcompact car	-	-	0.9	0.63	0.81	0.21
Compact car	-	-	0.72	0.57	0.53	0.23
Mid-size car	-	-	0.71	0.59	0.48	0.20
Large car	-	-	1	1	1	1
Sport car	-	-	1	1	1	1
Small cross-utility car	-	-	0.77	0.79	0.65	0.68
Small cross-utility SUV	-	-	0.61	0.69	0.37	0.27
Mid-size cross-utility SUV	-	-	0.75	0.65	0.66	0.34
Compact SUV	-	-	0.68	0.48	0.15	0.16
Mid-size SUV	-	-	0.77	0.67	0.6	0.20
Large SUV	-	-	0.76	0.81	0.4	0.45
Compact van	-	-	1	1	1	1
Large van	-	-	0.63	0.88	0.47	0.87
Compact pick-up truck	-	-	0.71	0.76	0.39	0.46
Standard pick-up truck	-	-	1	1	1	1

This table is based on the same cross nested legit vehicle choice models presented above, but shows a comparison with traditional nested logit models developed for fuel types, as well as vehicle types. This example demonstrates how the cross-nested model structure can provide a more complete picture than the nested model structure.



Another aspect of the long-term choice models is whether to include discrete, continuous choices for different model components. In this context discrete allocation of autos to household members could be combined with continuous allocation of vehicle type usage. Most often, however, the long-term choices will be modeled as discrete choices since they by definition are not changing over time. Discrete, continuous choices may be useful for studies of alternative vehicle technology, fuel efficiency, and greenhouse gas emissions.

Benefits and Costs of System Integration

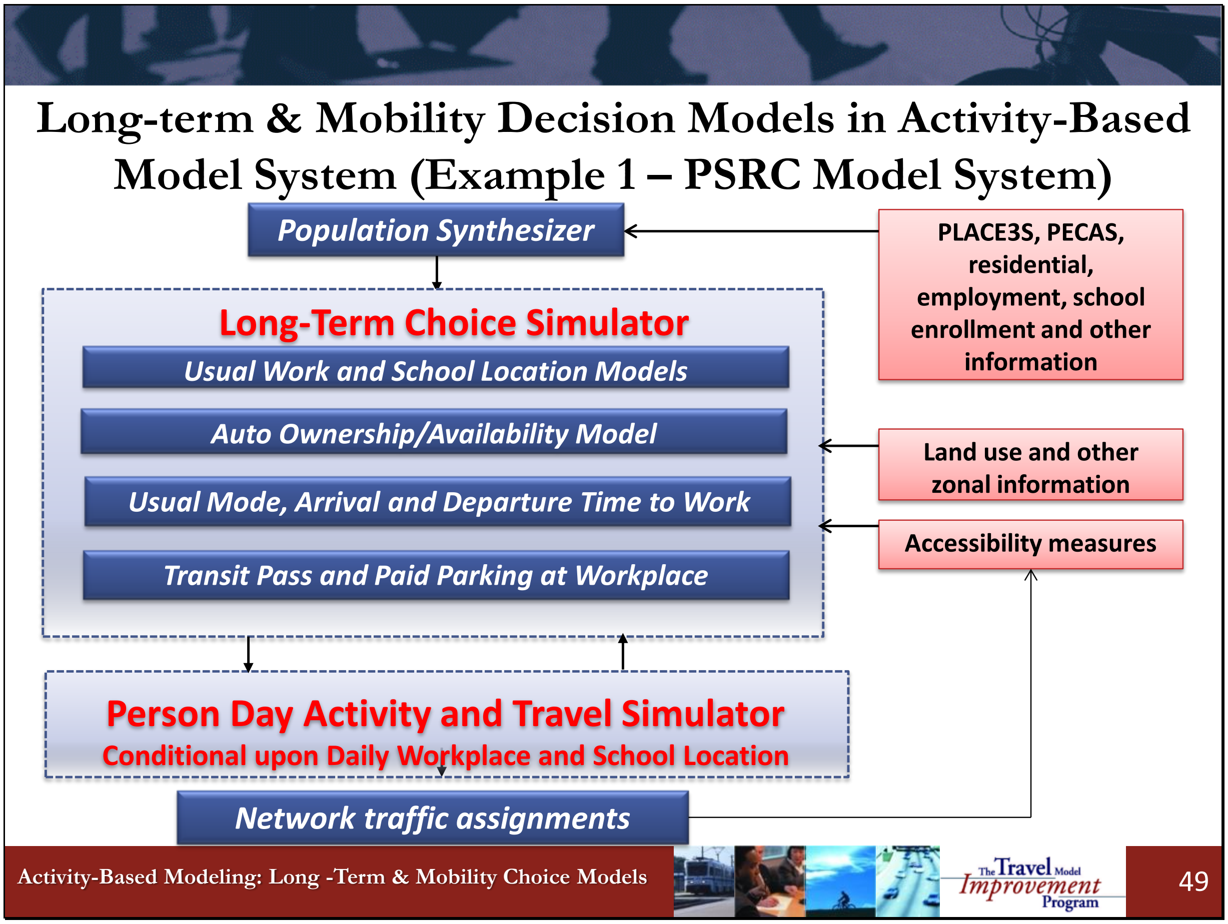
Benefits

- Long term choices are affected by transportation investments
- Long term choices are sensitive to pricing and demand management policies
- Long term choices have different characteristics and elasticities than short-term choices
- Long-term choice have strong impact on daily travel choices

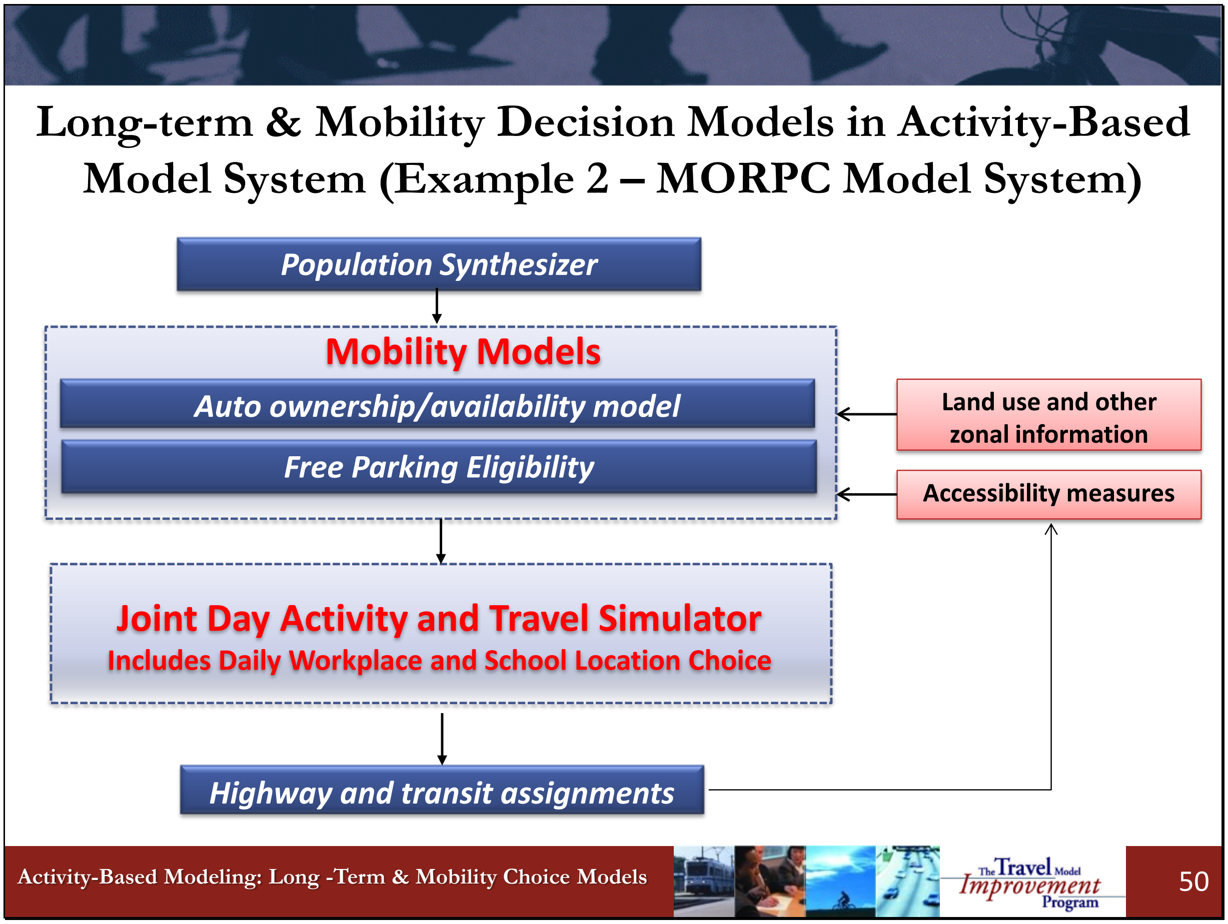
Costs

- More choice dimensions in the model system and more complex causality linkages
- Feedback loops for accessibility add run time to the process

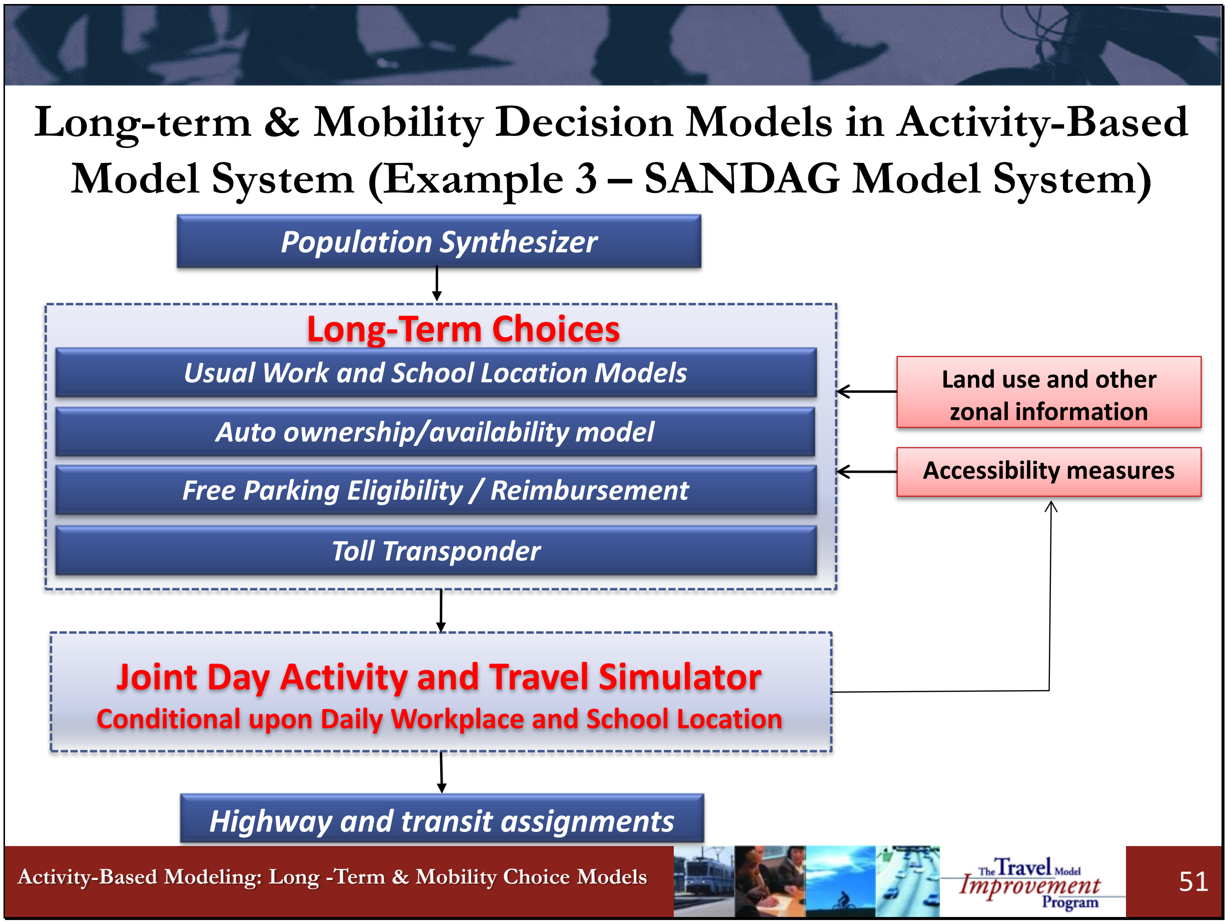
There are many aspects of integrating the long-term choice models within the activity-based modeling system to consider. The benefits of integration are that long-term choices are sensitive to transportation investments and policies such as pricing strategies and demand management programs. Another benefit is that long-term choices can be represented with different characteristics than short-term choices. There are costs to including long-term choices as separate modeling components because they add runtime and complexity to the process. In addition, the feedback between travel times, costs, and accessibility should be equilibrated with other downstream model components. There is a trend to add more long-term choice models and hence more sensitivity indicating that these benefits outweigh the costs.



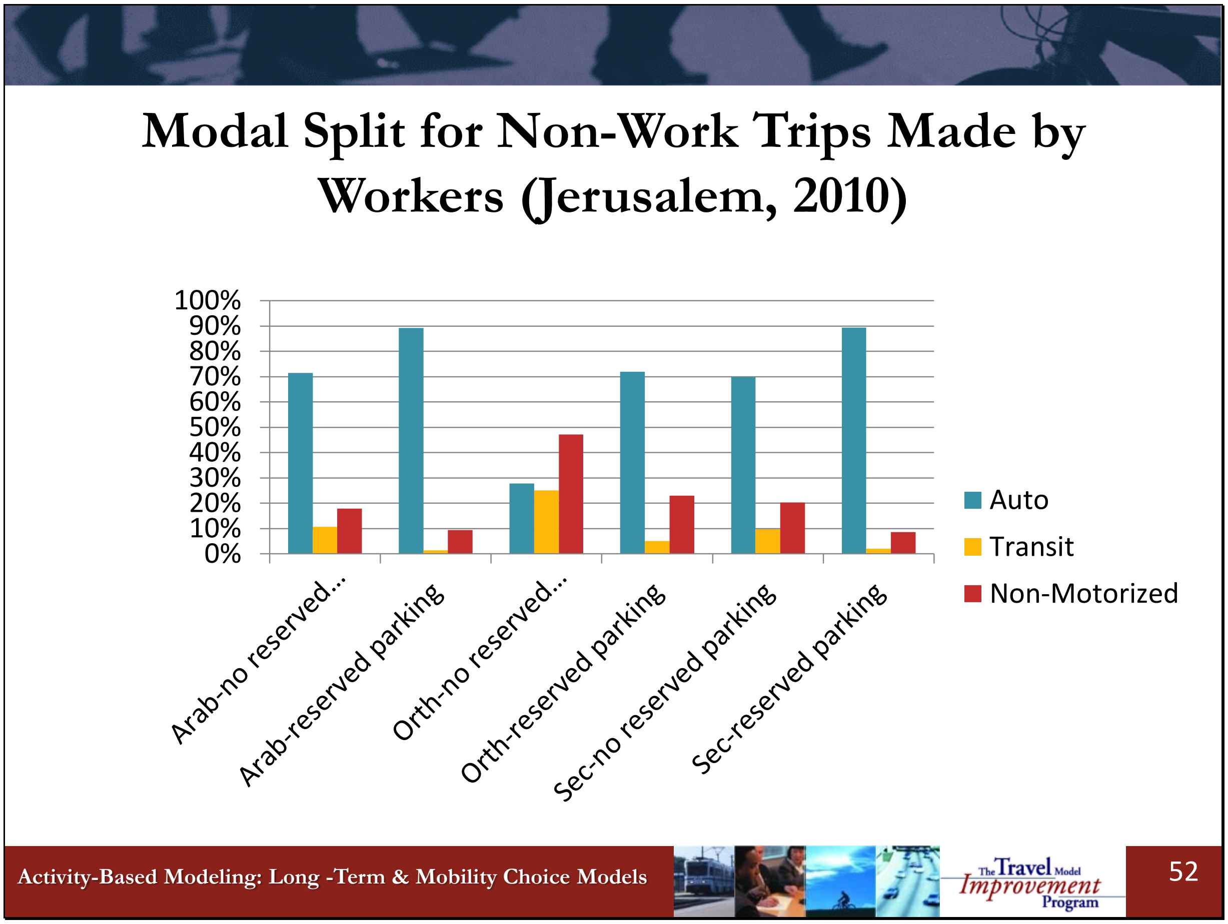
The long-term choice models are one element of this full activity-based modeling system as demonstrated in this example from the Puget Sound Regional Council in Seattle. In this example, PSRC includes usual work and school location choice models in two places: as long-term choices and as part of the person day activity pattern models. The long-term choice models also include auto ownership models, usual mode to work models, arrival and departure time to work models, transit pass models, and paid parking at workplace models. The number of long-term choice models has been growing steadily over time to incorporate various aspects of long-term choices and to provide more explanatory power for the travel demand models.



Another example of how long-term mobility choice models can be incorporated within the activity-based modeling is in Columbus at the mid-Ohio regional planning commission. In this example, the workplace and school location choice models are embedded within the joint daily activity and travel simulator. The long-term choices represented are the auto ownership and free parking eligibility models.



Another example of how long-term mobility choice models can be incorporated within the activity-based modeling is in San Diego. In this example, the workplace and school location choice models are long-term choices, along with transponder ownership and free parking eligibility models.



This is a unique although simple analysis that we first implemented in Jerusalem, Israel as part of the ABM development project. The population in Jerusalem for this analysis was broken into three groups: Arab, orthodox Jewish, and secular Jewish since they are characterized by very different travel behavior. In each group, workers were broken into two subgroups; those who have a reserved or paid parking at work and those who don't. For each subgroup, modal split was calculated with respect to the non-work trips. There is a strong correlation between reserved parking at work and car orientation in modal split for non-work trips, although seemingly these choices are unrelated. This is a strong manifestation of modality captured by mobility attributes.

How Modality is Formed

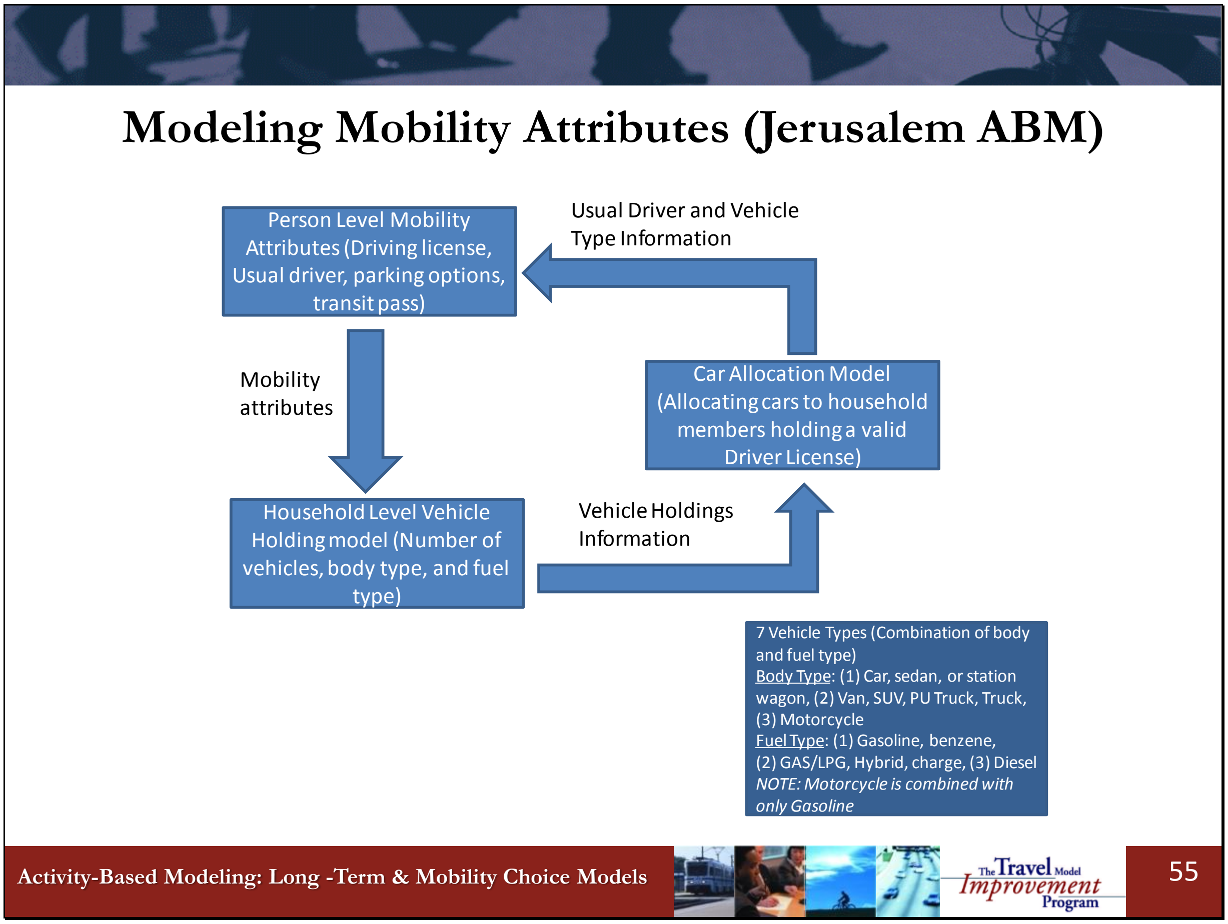
- Commuting to work/school is the most frequent trip:
  - Mobility attributes (car ownership, transit pass) are largely defined by commuting
  - Modality style is formed
- Mode choice for other trips is largely driven by mobility attributes and modality:
  - Inclusion of this sub-model in the model system enables this important linkage of mode choice decisions across different trips made by the same individual

Commuting to work/school is normally the most frequent trip made by workers and students. Mobility attributes (car ownership, transit pass) are largely defined by commuting conditions. Also, modality style is largely formed by commuting. Further on, mode choice for other trips is largely driven by mobility attributes and modality. Inclusion of this sub-model in the model system enables this important linkage of mode choice decisions across different trips made by the same individual. This important effect cannot be incorporated in a conventional 4-step model.

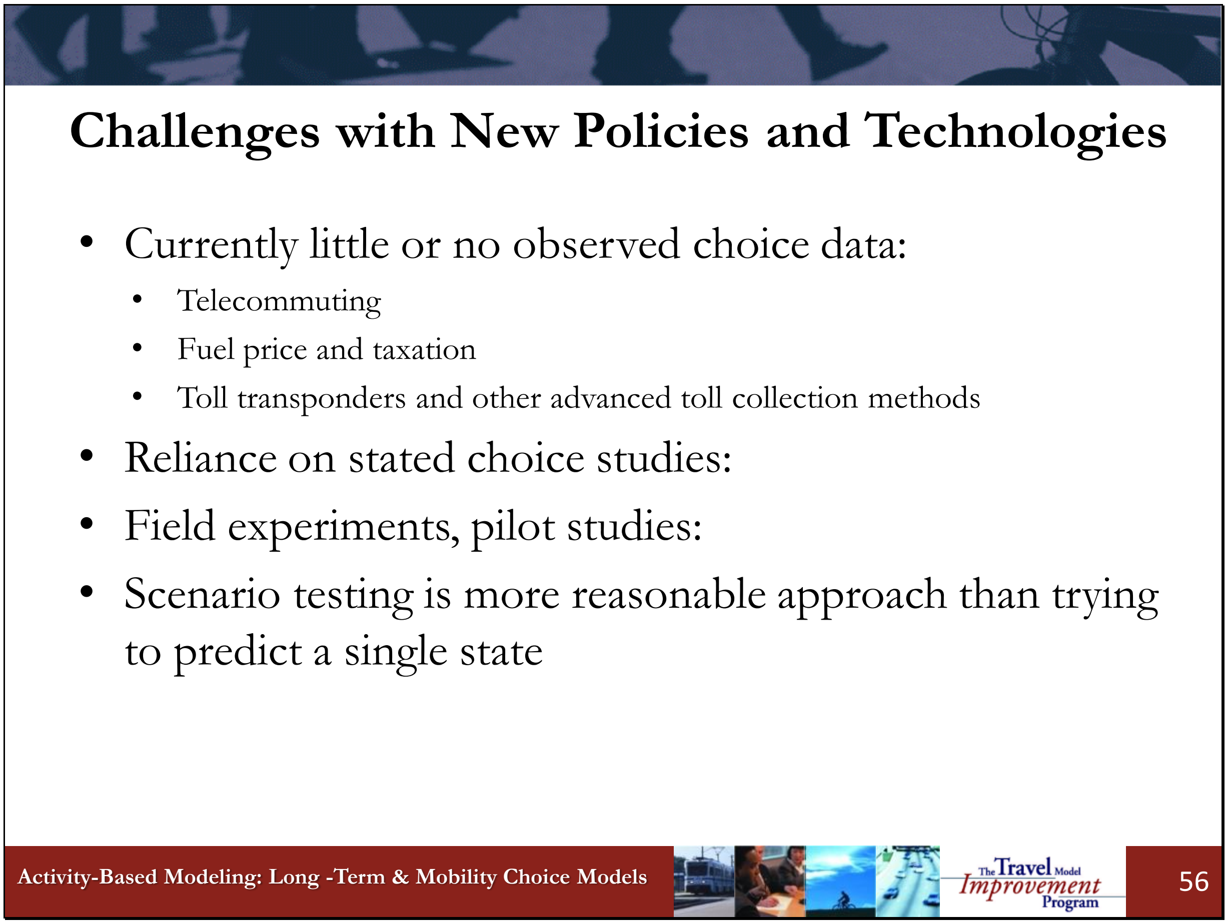
Approach to Forecasting

- Jerusalem ABM has a special extended sub-model for mobility attributes:
  - Modeled with interactions and trade-offs between different mobility attributes
  - Sensitive to socio-economic, demographic, and travel variables
  - Allow for scenario analysis, policy levers, and dynamic trends through adjustment of alternative-specific constants

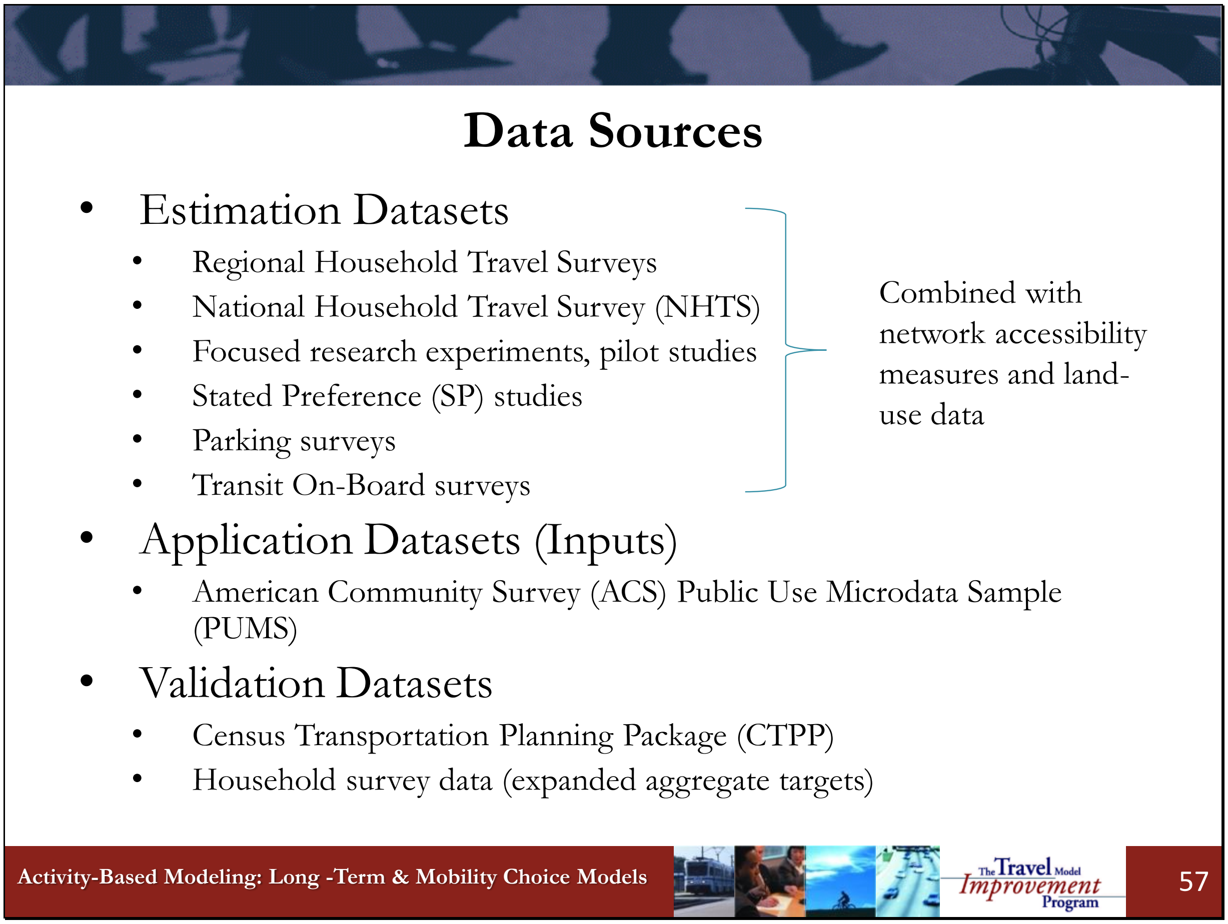
The Jerusalem ABM includes an example of a special extended sub-model for mobility attributes with more details included and somewhat more sophisticated model structure applied. Mobility attributes are modeled with interactions and trade-offs between different attributes. The system is designed to be sensitive to socio-economic, demographic, and travel variables It allows for scenario analysis, policy levers, and dynamic trends through adjustment of alternative-specific constants.



The Jerusalem model for mobility attributes includes three sub-models applied iteratively with inter-linkages between them rather than sequentially. The first model represents a joint model of many mobility attributes applied for each person in the household separately including a role of a usual driver of car (i.e. person need in a car). The second model ingrates person needs within the households with respect to number of cars and car type by body and fuel (7 car types). The third model allocated cars to usual driver within the household. These three models are iterated several time to integrate the associated choices.



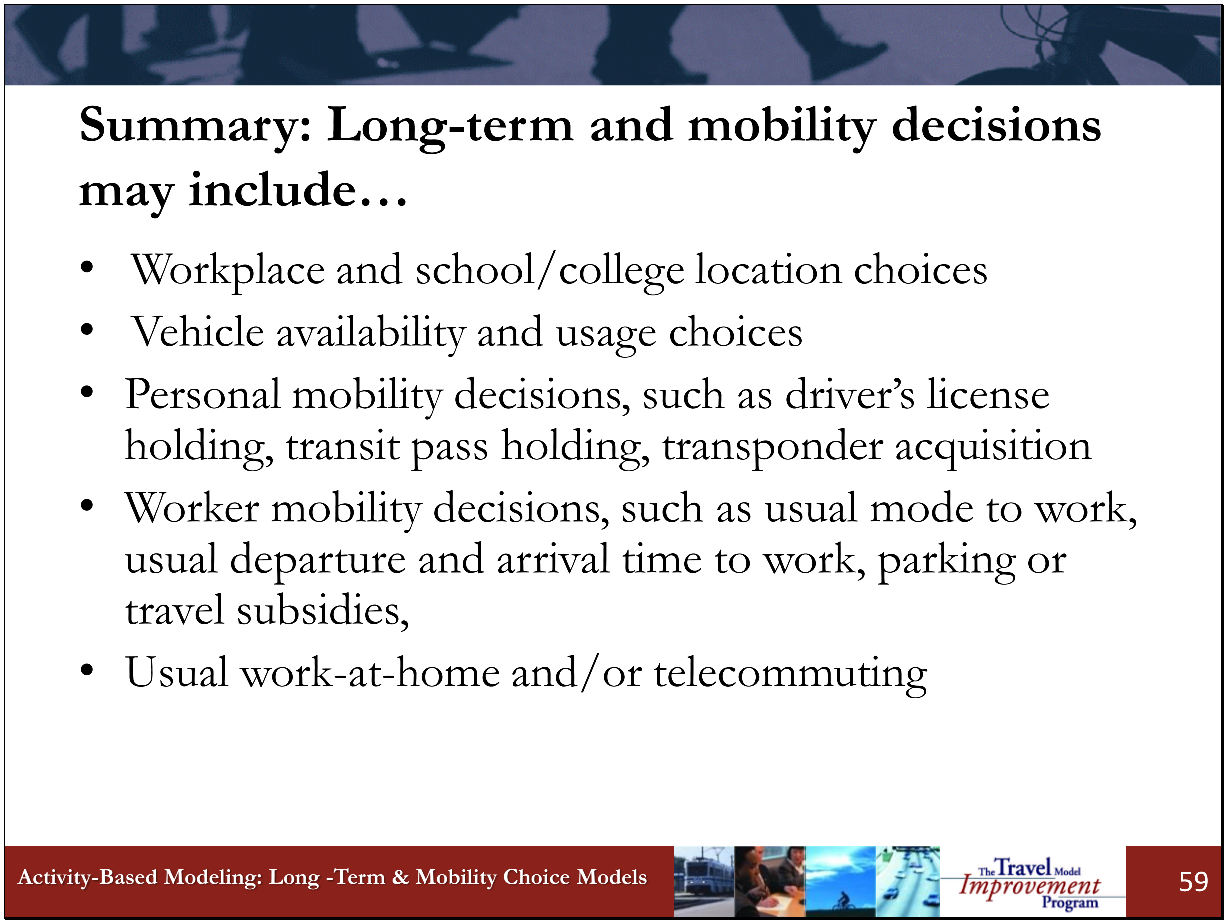
A challenge in developing models to address new policies and technologies is that there are no observed choice data sets by definition, and so stated preference surveys are needed to evaluate the trade—offs for these models. In some cases, field experiments and pilot studies of implementations or demonstrations of these new policies and technologies can provide insight on travel behavior for these choices. For example, we have collected before and after surveys in Seattle and Atlanta on travel with and without tolls in specific corridors. These surveys also included questions about workplace locations and auto ownership and could be used to evaluate the sensitivity of these choices to pricing.



Most of the data required by the long-term mobility choice models will come from the activity-based modeling. Additional data for estimation of these choice models is required and would typically come from a local household survey data set or the national household travel survey (NHTS), or other focused, stated preference experiments. These surveys would need to be supplemented with network accessibility measures and log-sums in a similar way to the travel demand choice models. In addition, questions about usual mode, departure time, arrival time for work trips and usual work and school locations are needed to estimate these long-term choice models, and these questions may not have been included in past surveys if these long-term choice models were not envisioned as part of the process.

The data required for application and validation are very similar to data required by the rest of the activity-based modeling system and include the American Community Survey PUMS data set and census transportation planning package. In addition, specialized surveys that are collected for travel demand management programs may be quite useful in validation.

There are quite a few emerging practices in the long-term mobility choice model area as demonstrated by the many choices that are being considered or are under development in activity based models around the country. In addition, there is investigation into multidimensional choice structures and other econometric methods in research settings. And, as is the case in many areas, these models are changing to reflect new and emerging policies and technologies. Another area that has received considerable discussion is modeling household budgets, which really drives cost decisions for transportation.



We have covered a wide range of possible long term and mobility decisions that could be included in the activity-based models. They include the most commonly used models for workplace and school location choices and vehicle availability models, as well as newer models under consideration at many MPOs for personal and worker mobility decisions.

Summary: Long-term and mobility decisions are important to activity-based modeling because they…

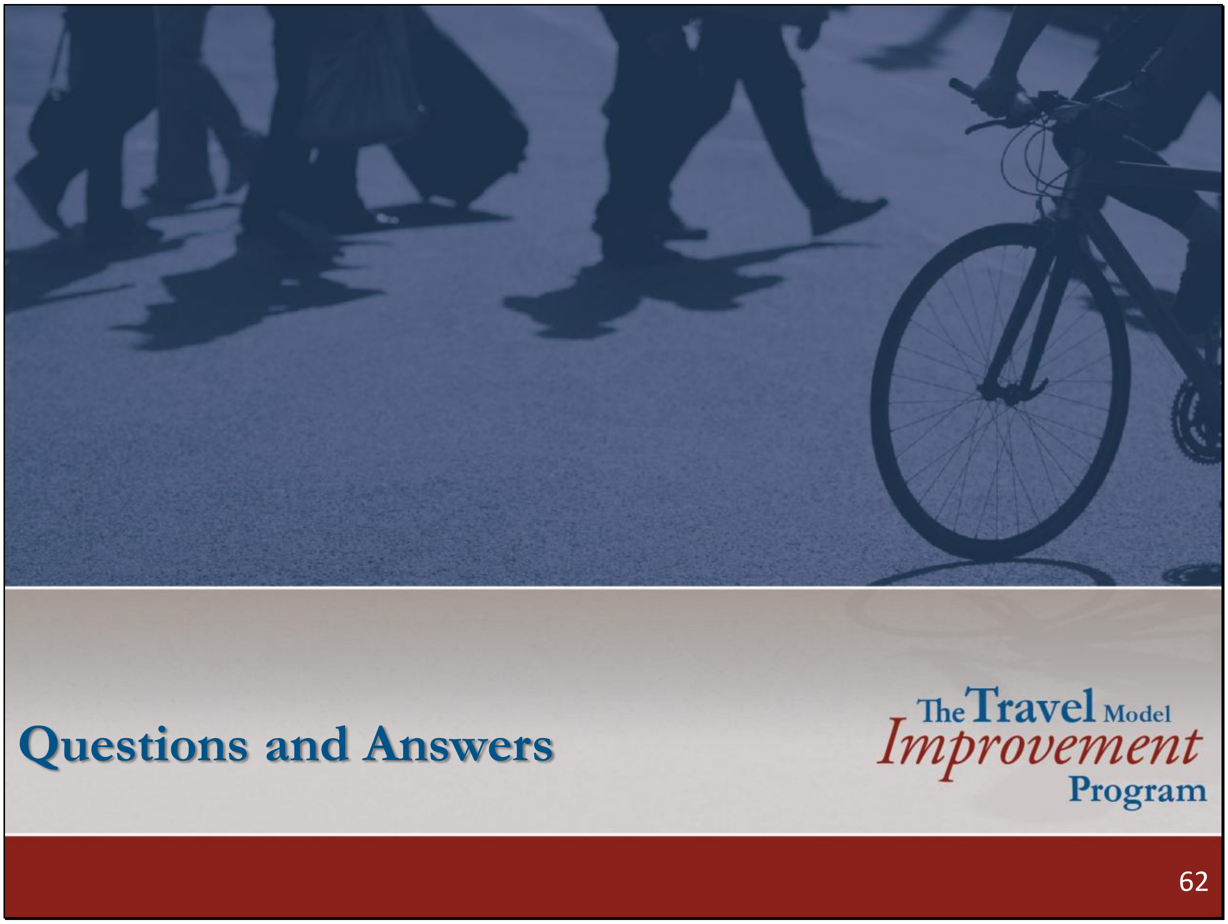
- Create important policy variables are needed for forecasting, often not found in household survey data
- Pre-condition, contextualize many activity generation and scheduling decisions as well as choice of modes
- Enable scenario analysis on household and person decisions that tend to be longer-term in nature
- Enable analysis of TDM policies such as pricing, subsidized parking or transit pass, etc., that are difficult to model otherwise

These mobility decisions are important because they add explanatory power to the travel models and provide sensitivity for policy variables of interest to MPOs. These include travel demand management programs, pricing strategies, and the influence of transportation investments on longer-term choices for work and school.

Summary: Long-term and mobility decision models are integrated into activity-based model systems in various ways

- These are design decisions that reflect how the model will be used and the perspective the analyst:
  - Still variation from ABM to ABM but some convergence of approaches is observed
- Models vary in complexity, with parametric, discrete choice models providing more flexibility, and sensitivity, but requiring richer data sources and (marginally) more computation

These long-term and medium-term mobility decisions can be integrated into the activity-based travel modeling system in several ways; we have discussed advantages and disadvantages of various approaches to consider. In addition, we have talked about a series of alternative modeling formulations that have been considered for mobility models that have been used in various other venues and in research settings. These may represent the next generation for mobility models.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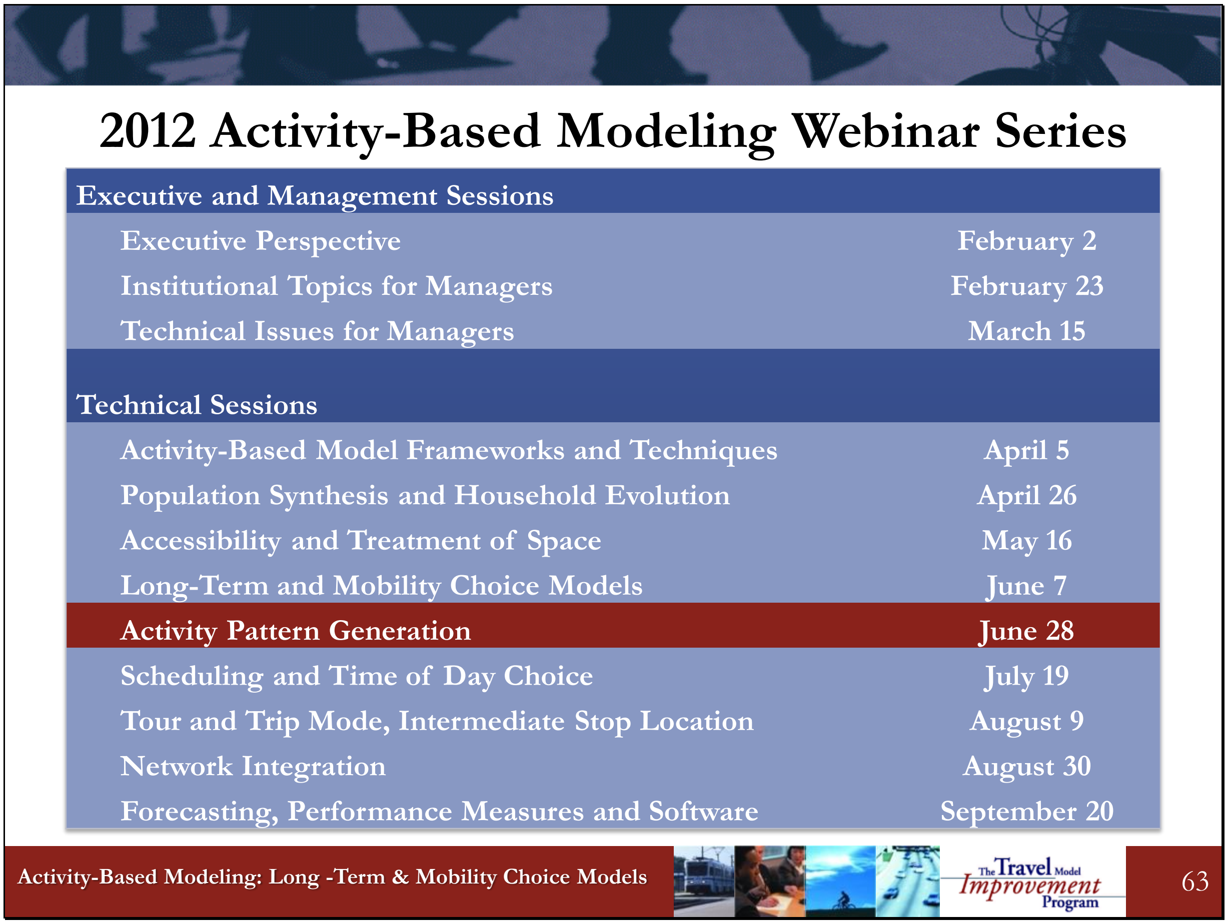

Once again, here is the schedule for the webinar series. Our next webinar, three weeks from today, will cover activity pattern generation models.

Thank you!

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Session 7 Questions and Answers

Can you estimate dynamic decisions; for example a worker who spends the day at a site visit instead of their usual workplace?

Maren: Yes, we can do that. We first need to identify what the usual workplace location is, which is done as a long-term choice. Then in the context of the daily travel decisions, a model reflects whether the worker goes to a different location on a particular day, influenced by the context of other decisions and factors including travel conditions. We know the probability of workers not attending their regular workplace during a typical day, which we gather from survey data.

Peter: Multiple days of survey is useful to glean such data. But we also gather regular workplace from the recruitment questionnaire and then observe actual behavior cross-sectionally from travel diary information (from just one day). GPS data is also being collected across multiple days, and imputation can be used to determine the frequency of workers attendance at the actual workplace versus non-usual workplace such as client visits.

Can you describe how you handle very large employers, such as Microsoft or Boeing, and how the types of employees can be very different for those large employers?

Peter: Our ability to model these employers depends upon the scale of the models developed and the availability of data. For example, some of the larger employers in a region have commute programs with observed data on the types of workers and their commuting habits that can be used to model long and medium term mobility decisions. Since the model is applied at the individual level, the structure allows for individual attributes to be used in the workplace location decision. In NY, a large-scale establishment survey is being conducted, and 700 major employers in NY are being surveyed in order to observe whether there are unique attributes of major employers (such as much longer commute lengths). Major employers may also allow more telecommuting than smaller employers, which is why data would be helpful.

How do you calibrate the models if you don’t have local data? Are national defaults available?

Maren: Local data is required for calibration of work and school location choice models, because trip lengths and commute patterns are very different across regions (due to differences in urban forms). Census data can be used to calibrate work location choice.

Are the decay functions being applied differently across different regions? Which ones fit best?

Peter: The distance decay functions are important components of the workplace location choice model, because there are certain non-linear affects with respect to individual attributes and how distance is perceived. Some workers are much less sensitive than others to commute distance. As for statewide models, the individual attributes are still relevant, but the coefficients would be different. The same coefficients should not be transferred, but the mechanics are transferrable.

How are transaction costs handled in the model, such as traveler information?

Maren: There are a few examples of incorporating real-time information into mobility decisions, for example, comfort, reliability, real-time information, station amenities into mode choice models.

Are any of you familiar with GPS data used in California or other states, and is it being used in model estimation?

Peter: Yes, SCAG collected GPS survey data, and at the statewide level for Caltrans, and for SFCTA in San Francisco. It is being used, primarily to identify the under-reporting bias in household surveys. A smaller household sample includes GPS data, and that data is analyzed to determine the aspects of trip under reporting (frequency, length, etc) and then the main survey is adjusted to correct for the under-reporting. Also the following surveys were 100% GPS (or close to it): Cincinnati, Cleveland is starting soon, and Jerusalem, Israel. When you compare the quality and quantity of data between GPS and non-GPS data, GPS surveys are very cost-effective. The quantity and quality of travel data is much higher in GPS surveys.

For the ABMs that were developed for San Joaquin Valley – do they use both parameteric and non-parametric methods? Do ABMs use both parametric and non-parametric methods?

Maren: San Jouquin Valley's population synthesizer is largely non-parametric, while all of the long-term, mobility, and daily travel models are parametric. In any model, there are often combinations for both parametric and non-parametric methods. In a non-parametric approach, we try to apply probabilities to discrete groups of people (market segments), which reflect observed distributions but do not vary according to covariates. For example, an auto ownership model that is driven entirely by constants is just a way of using logit math to calculate a probability distribution that can be easily specified by a non-parametric distribution. It is generally always advantageous to use parametric models so that we can reflect changes in outcomes due to changes in continuous input variables. But it is not always possible to do so – for example, there may be cases where we don't observe enough cases where we can estimate a parametric model.