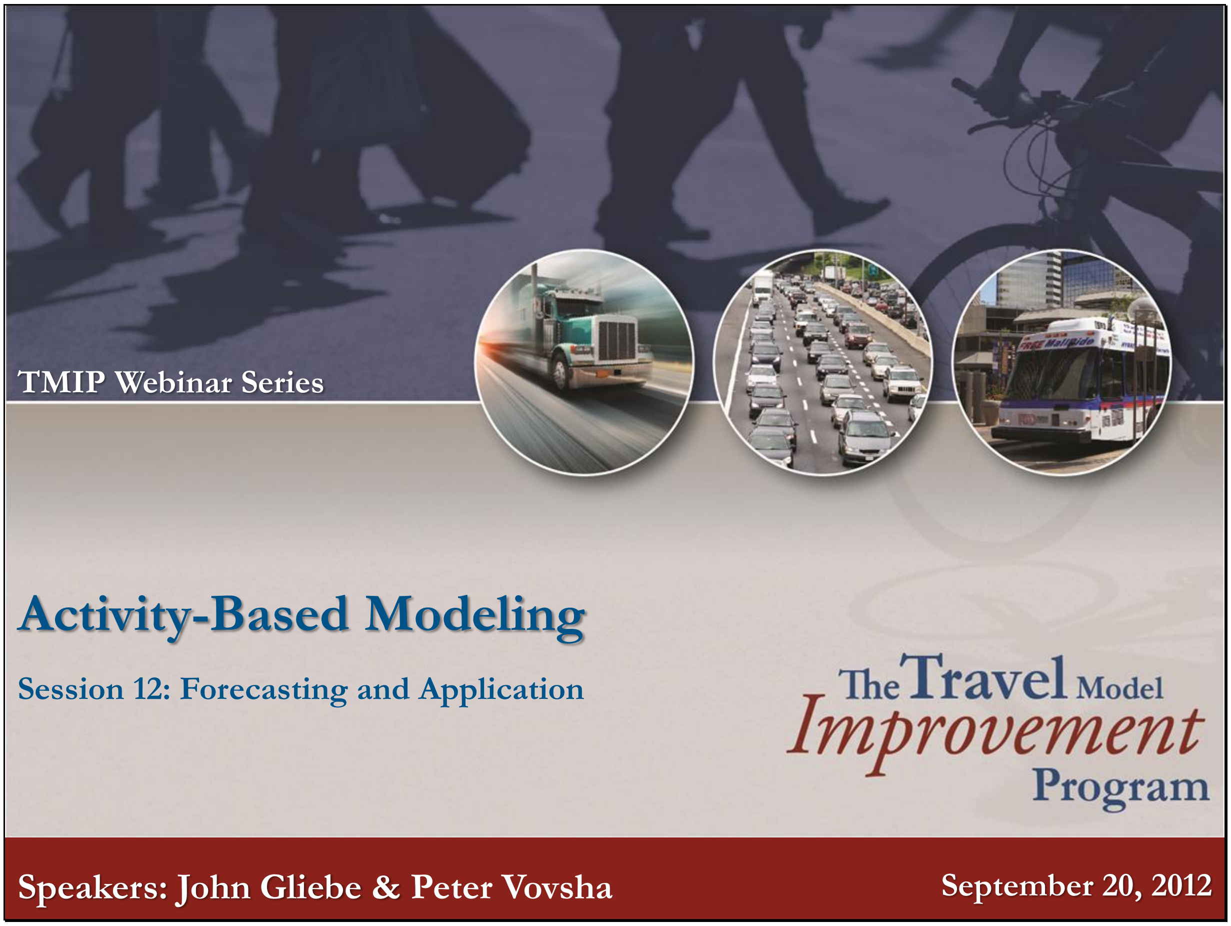
TMIP Webinar Series
Activity-Based Modeling
Session 12: Forecasting and Application
The Travel Model
Improvement
Program
Speakers: John Gliebe & Peter Vovsha
September 20, 2012

This series is and has been a collective effort between RSG & PB. It is largely built on our experience with many activity-based models in practice.

Your presenters for today are John Gliebe and Peter Vovsha. Maren Outwater actually prepared most of the content for this presentation, along with Peter and John. The slides at the end of the presentation showing the visualizations from the Atlanta Regional Commission activity-based model were developed by Joel Freedman and Ben Stabler (PB). We were also supported by Mark Bradley, who reviewed the presentation. The multi-media production for this webinar is being handled by Bhargava Sana.

2012 Activity-Based Modeling Webinar Series

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Today webinar will cover Forecasting, Performance Measures and Software. It is a natural follow up to the previous webinar on activity patterns. This is the final webinar in the series. We invite you to return to the TMIP webinar archives if you're interested in viewing and listening to any of the previous webinars in the series.

Learning Outcomes

- Steps involved in preparing an activity-based modeling system for forecasting
- Output measures produced with an activity-based modeling system
- Differences in alternatives analysis with an activity-based modeling system
- Hardware and software considerations for activity-based modeling applications

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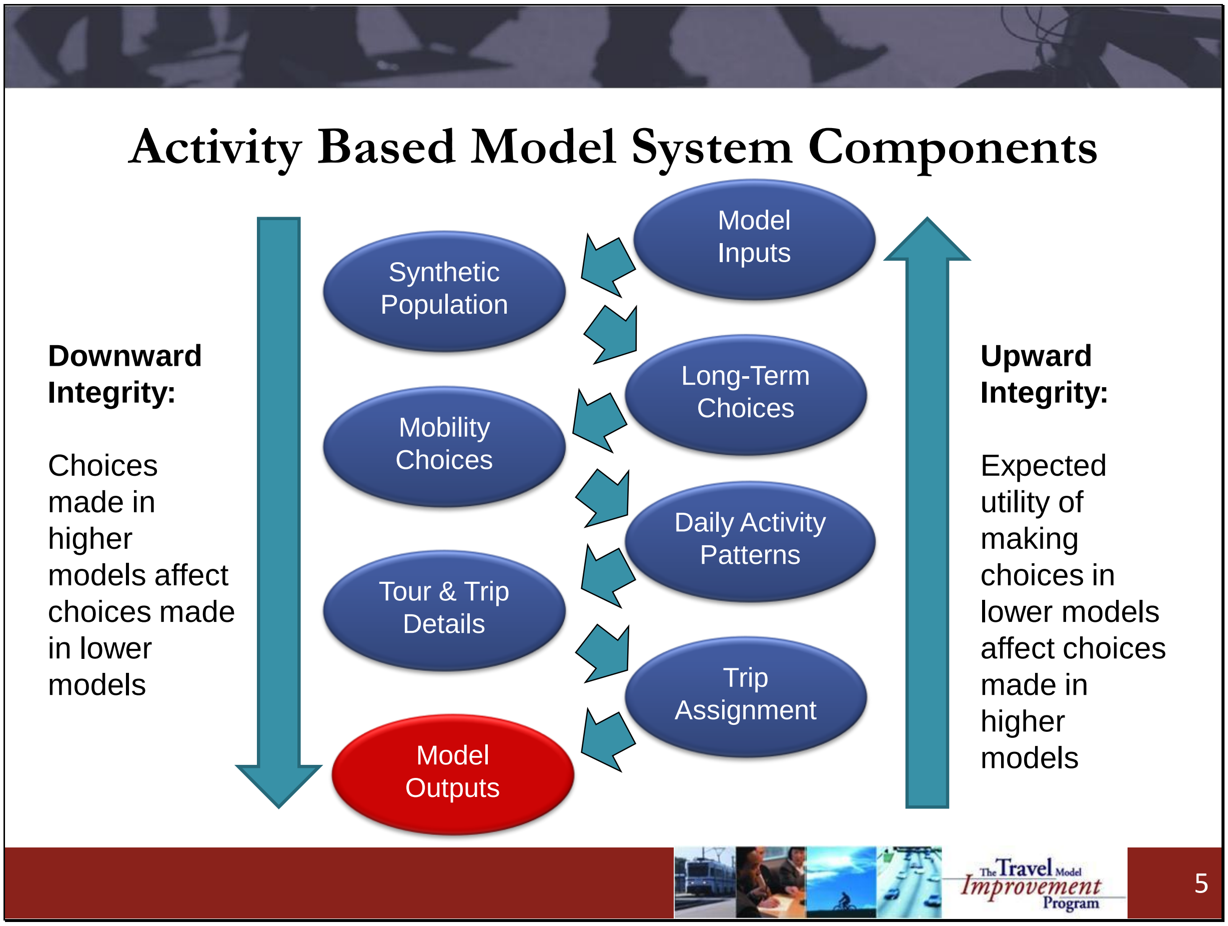
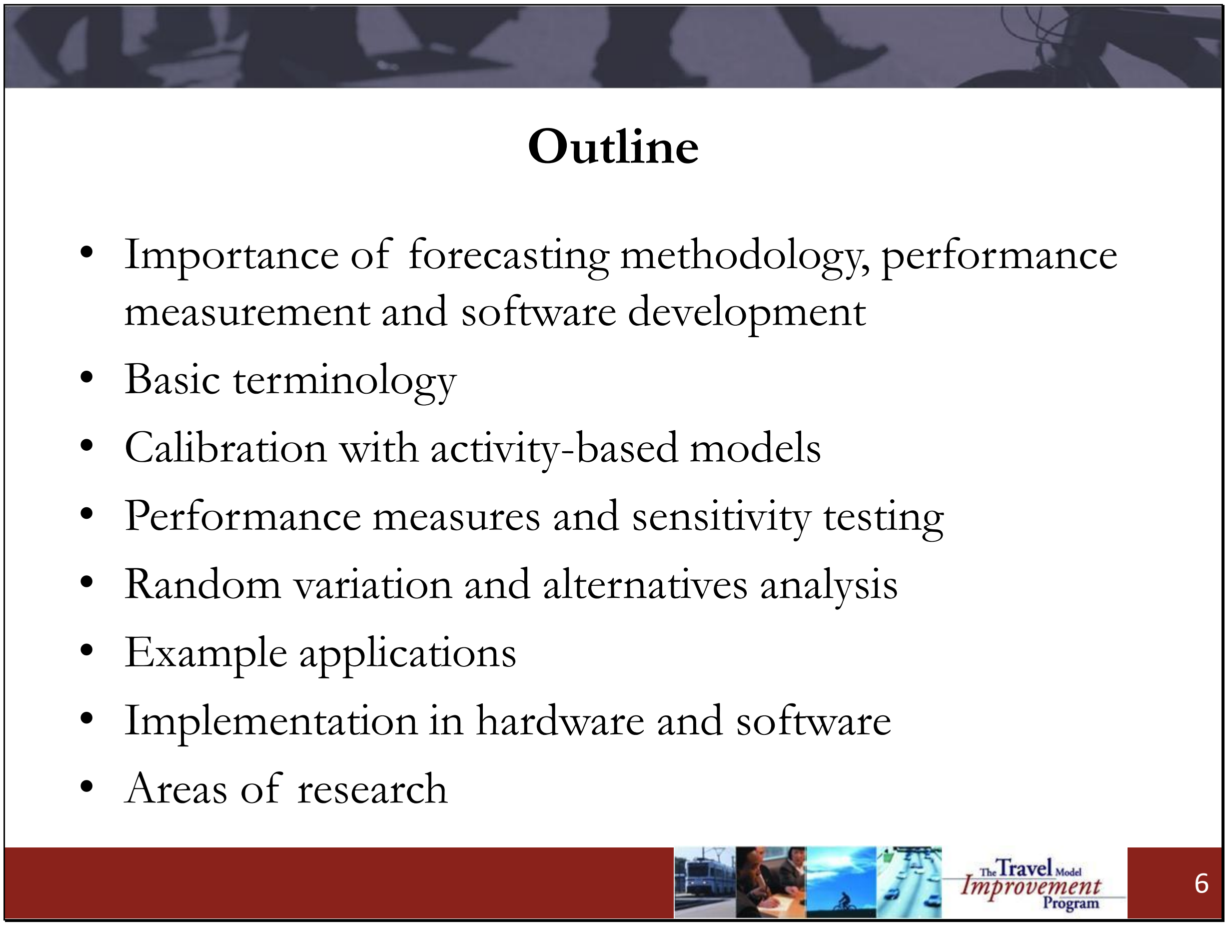
At the end of this session, participants should be able to answer the following questions:

- What are the steps involved in preparing an activity-based modeling system for forecasting?
- What output measures are produced with an activity-based modeling system?
- What are the differences in alternatives analysis with an activity-based modeling system?
- What are the hardware and software considerations for activity-based modeling applications?



Before going further, it is worth revisiting where we've been. This being the final webinar in the series, we have now covered all of the fundamental components of activity-based modeling system. This includes the creation of a synthetic populations and important model inputs, such as the treatment of space and accessibility; long-term and mobility choices; activity pattern generation; tour and trip details such as scheduling and time-of-day choices, and tour and trip destination and mode choices; and finally network assignment and its integration. Throughout this series, we've emphasized the integrity of these modules as a working whole. Downward integrity refers to choices made in upstream models conditioning the choices made in downstream models. Upward integrity is where the expected maximum utility of these downstream choices affects the probabilities of the choices made first, in the upstream models. Now we are ready to discuss model outputs in more detail.



In this session we will discuss various aspects of the forecasting process, highlighting the differences between activity-based models and trip-based models. We will begin by discussing the importance of methodology, performance measurement and software development. We will then define some basic terms with which you should be familiar to better understand forecasting with activity-based models. Next, we will talk about calibrating an activity-based model and the additional considerations that that entails. After that we will discuss performance measures and sensitivity testing and why this is where activity-based models reveal their true explanatory power. We will then discuss how to handle random variation across model runs, particularly as it pertains to alternatives analysis. We will review some example applications of activity-based model forecasts. We will discuss important hardware and software issues. Finally, we will spend a little bit of time discussing areas of research.

Important Differences in Activity-based Model Forecasting Practice

- A much richer array of output measures are possible
- Internal complexity requires new understanding of how to properly calibrate and validate activity-based models
- Are not just about trips–interpretation of daily patterns, tours, activity durations are important to comprehensible forecasts
- Use of simulation to produce forecasts–controlling and explaining random variation is important to producing consistent forecasts and communicating with decision makers
- Application software is needed to take advantage of more powerful analytical capabilities, but must be designed to handle greater computational loads

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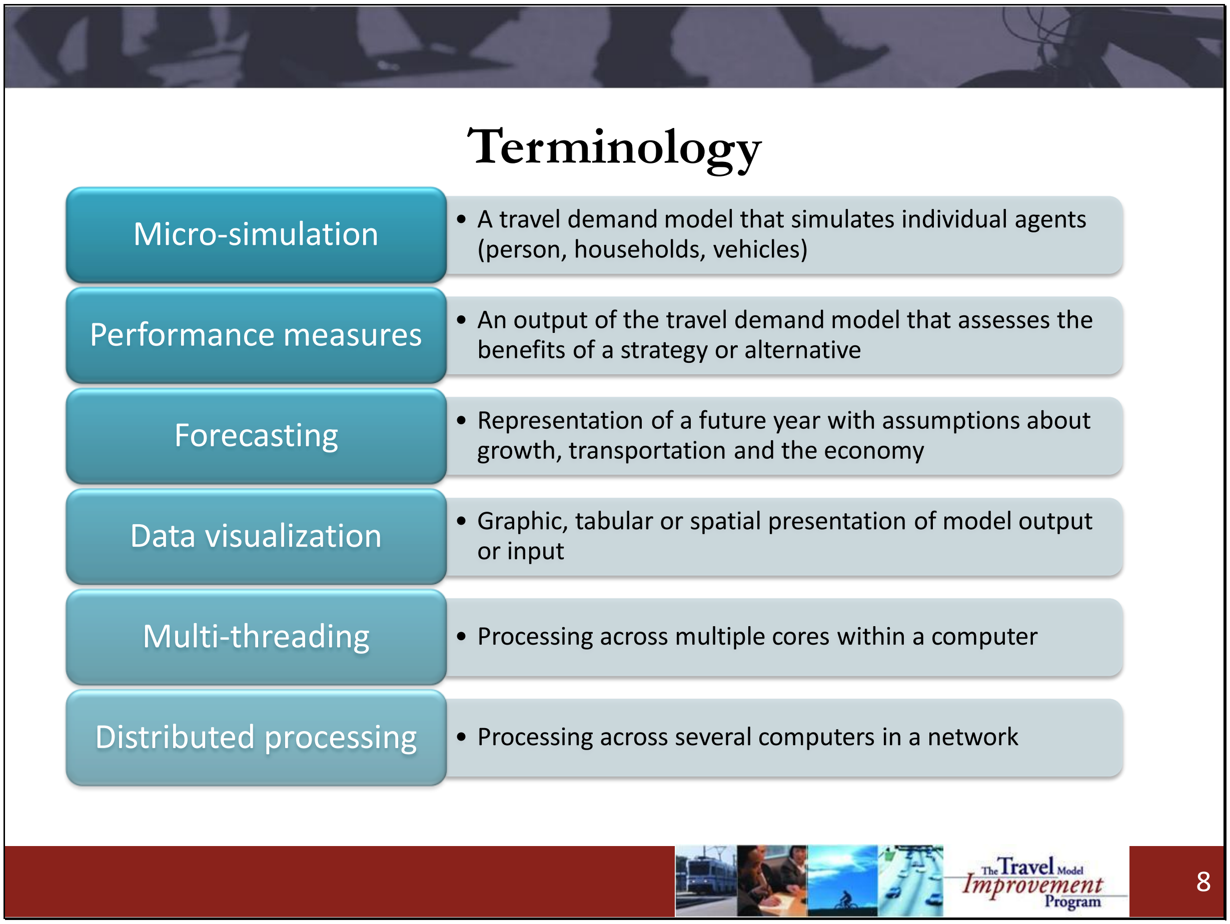
There are several themes that we'd like to emphasize today in order to convey the important differences between activity-based model and trip-based model forecasting practice. First, with activity-based models, a much richer array of output measures are possible, which you shall see later when we discuss performance measures. Second, the internal complexity requires new understanding of how to properly calibrate and validate activity-based models. This is because there are more model components and they have a larger number of interdependencies. In addition, activity-based models are not just about trips–interpretation of daily patterns, tours, activity durations are important to comprehensible forecasts. The use of simulation to produce forecasts makes it necessary to control and explaining random variation, which is important to producing consistent forecasts and communicating with decision makers. Finally, the added complexity of activity-based models means that new application software is needed, both to take advantage of more powerful analytical capabilities and to handle greater computational loads.



This slide defines some of the key terms as they are used in this presentation.

Micro-simulation in this sense refers to a travel demand model that simulates individual agents (person, households, and vehicles).

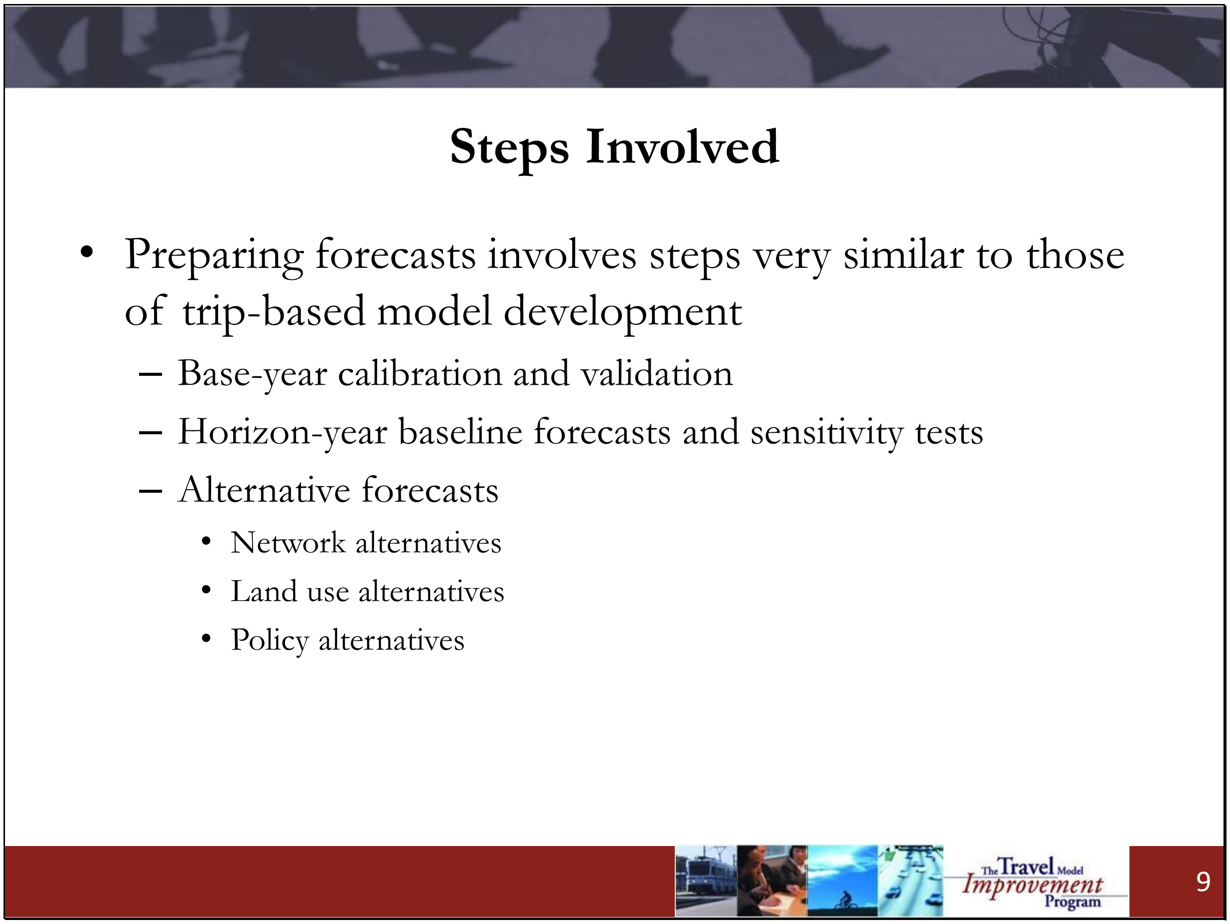
Performance measures are outputs of the travel demand model that may be used to assess the benefits of a strategy or alternative.

Forecasting refers to representation of a future year with assumptions about growth, transportation and the economy.

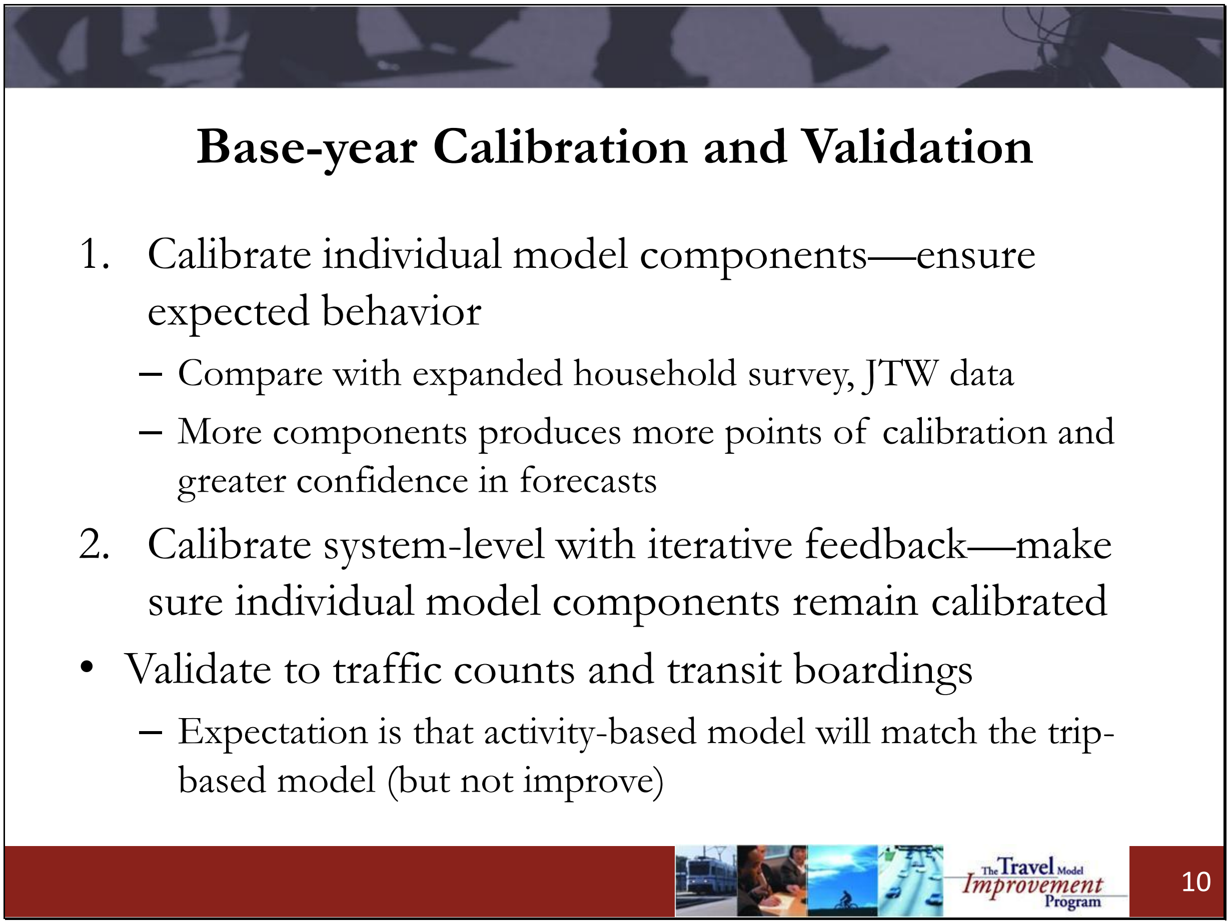
Data visualization includes graphic, tabular or spatial presentation of model output or input.

Multi-threading is processing across multiple cores within a computer.

Distributed processing refers to processing across several computers in a network.

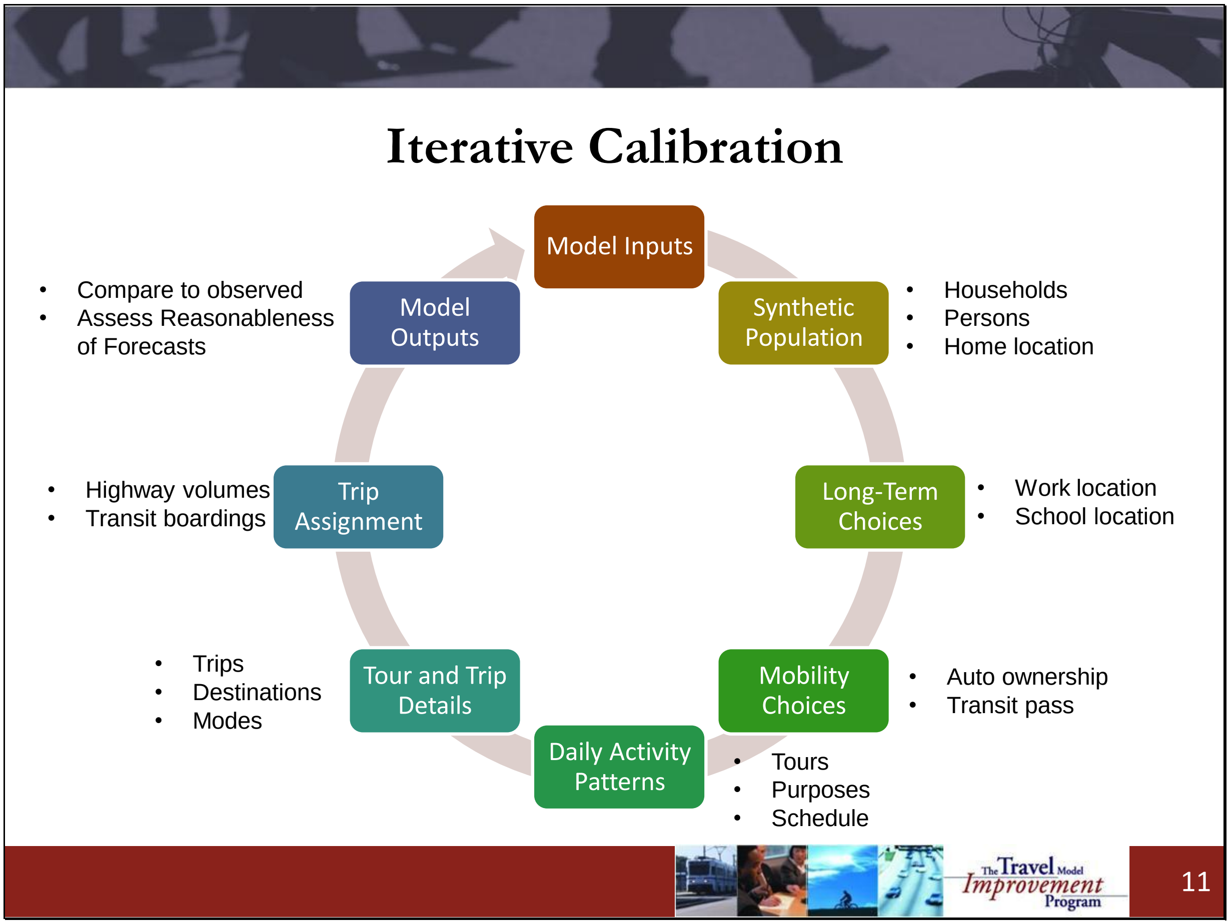


Preparing forecasts involves steps very similar to those of trip-based model development. We always start with the development of a calibrated and validated base-year model. As we are about to discuss, there are some similarities to trip-based model calibration and validation, but some important differences as well. From there, it is typical to create horizon-year baseline forecasts. When an agency first develops an activity-based model, it is common to compare the forecasting results to those of their trip-based model. This helps the agency to spot differences and to explain those differences. Some general sensitivity testing is also recommended—varying certain input assumptions, for example—to make sure that the model system responds as expected. Once an activity-based model is put into operation, there are potentially many different types of uses to which it may be applied. Starting out, an agency may want to try it out with some basic types of alternative analyses such as: network alternatives, land use alternatives, and various policy alternatives. It is important for an agency adopting a new tool to become comfortable with the way it behaves, to do any necessary fine tuning, and to know what to expect when it comes time for the next big long-range plan update, conformity analysis, or policy study.



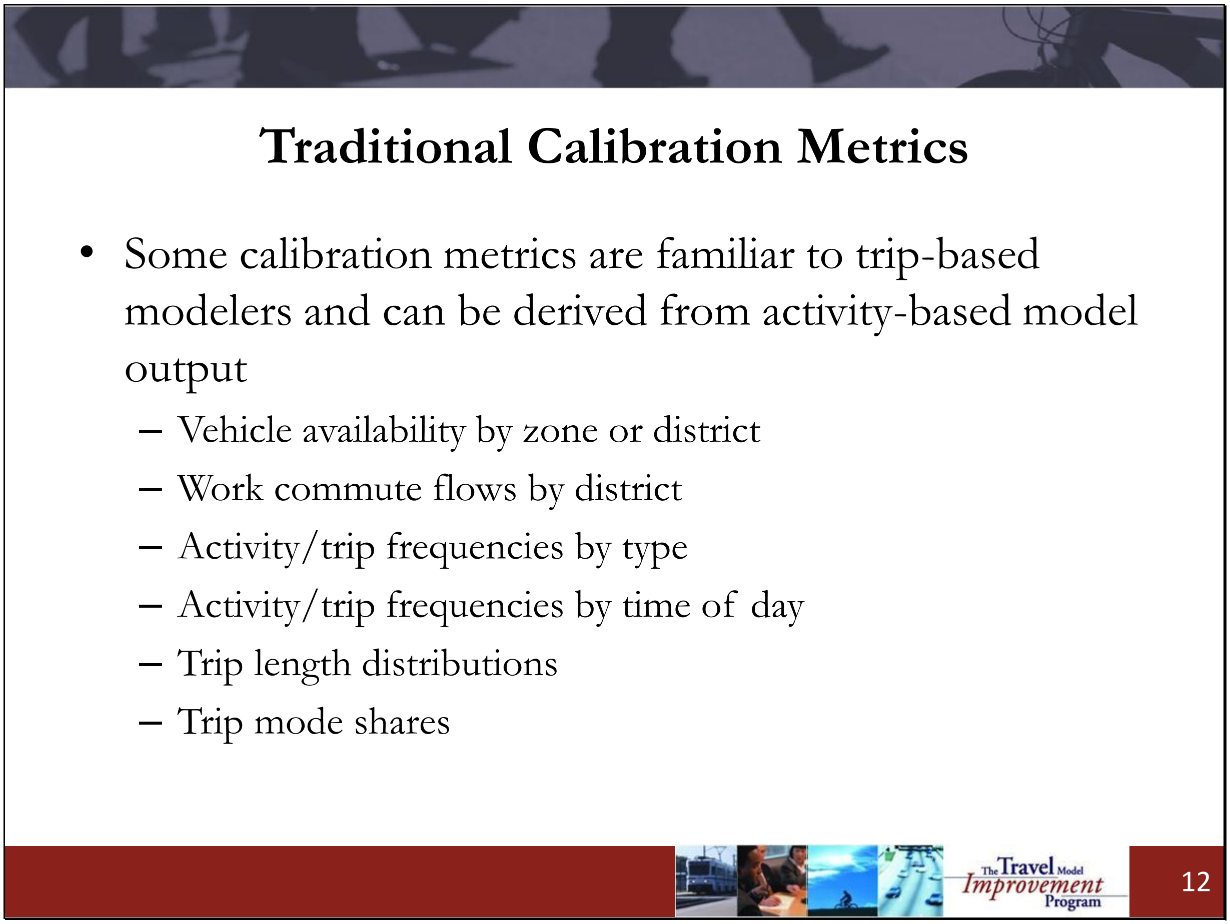
Base-year calibration and validation may be described by two basic phases. In the first phase, individual model components are calibrated while holding others constant. Typically, you would be estimating model components from household activity-travel diary data. The survey would be expanded and calibration target values set for all of the model system components. In addition, you may want to supplement the survey data with other sources, such as the Census's journey to work data, which should be a more comprehensive indicator of commuting trip lengths and spatial patterns. Another consideration is the activity-based model systems will have many more component modules than a 4-step model, so there will be more points of calibration. While this adds to the amount of time required for calibrating the model, it allows the model system to respond in more behaviorally consistent ways when applied to various scenarios that happen to deviate from the baseline.

The next phase of calibration is system-level with feedback. Here we want to makes sure that the individual model components remain in calibration, although there will usually be additional adjustments made. In general, we do not expect an activity-based model to do a better job of matching traffic counts or boarding counts than a trip-based model. If two models started from scratch, with no calibration, the activity-based model generally gives a more reasonable first pass results. But, usually the comparison is to an existing trip-based model that has already been (over-calibrated). It is typically easier to calibrate an activity-based model without extensive use of K-factors.



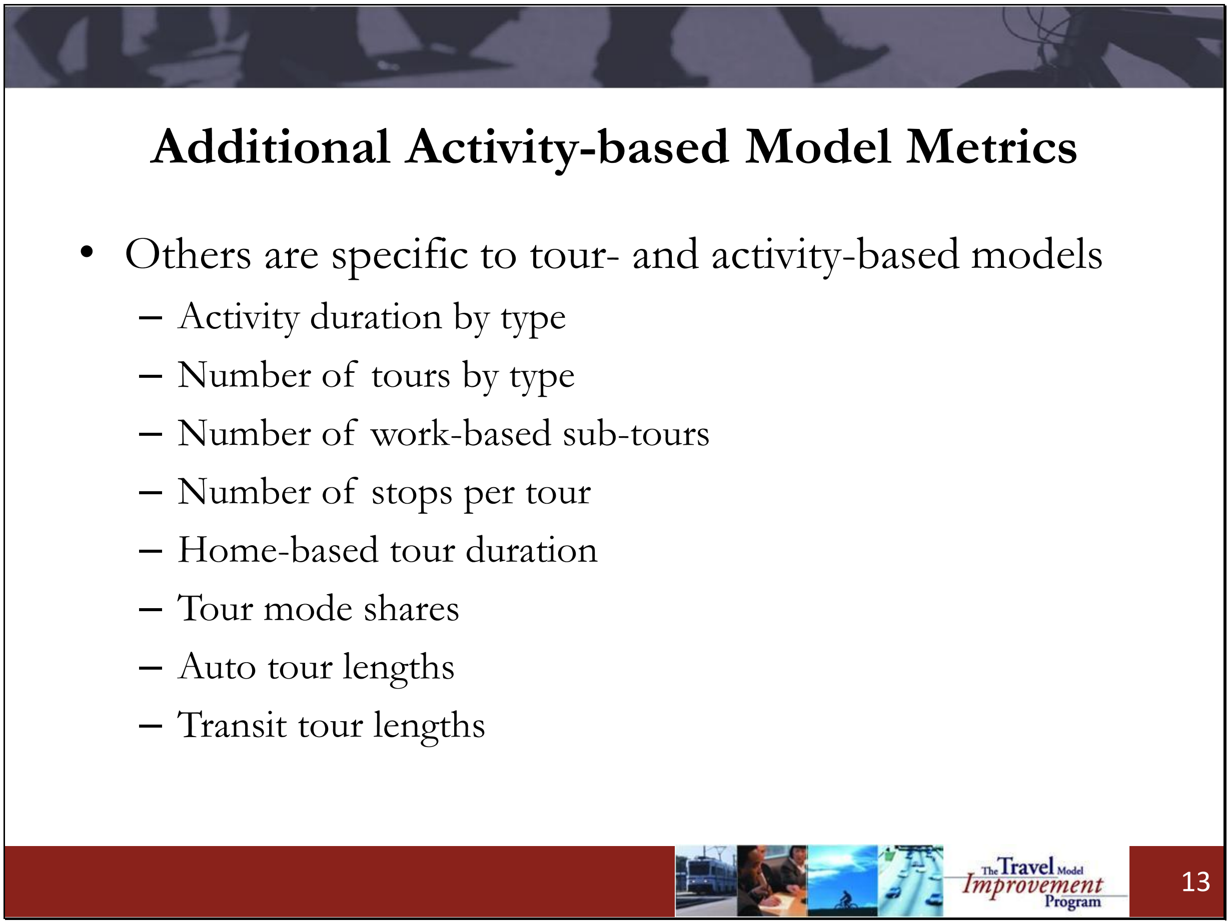
This figure illustrates the iterative calibration process that I just spoke of. It is also a good refresher for talking about activity-based model components. The synthetic population is the first thing to calibrate; however, this can be done essentially independently of the other model components, and the methods used in synthetic population generation software do the calibration for you, using marginal control totals. From there, we proceed down the model stream, first calibrating the long-term choice models, which condition the mobility choice models. Long-term workplace and school location choice are usually inputs to mobility models such as auto ownership, transit pass holding, and the like. The results of all of these long-term and mobility choices are inputs to the daily activity pattern choices and to models of tour and trip details—destinations, modes and time of day. We want to calibrate tour frequencies by purpose, destinations, modes, and time of day choices prior to calibrating trip-level characteristics. Trip frequencies, destinations and modes are typically the last models in the sequence to be calibrated.

Once we have gone through this sequence, we would then apply the entire model system and obtain assignment results. If we are at the stage of validation, we'd be making comparisons to traffic volumes and transit boardings. In addition, we may make some additional checks on the reasonableness of the activity-travel patterns being forecast. We'll discuss more of about reasonableness checks later in the presentation. Having gone through the process once, it is likely that some of the model components that we calibrated first will no longer be in calibration if we feed back the assignment skims. We will step through this process for at least one other iteration, and possibly multiple additional iterations, until we're satisfied that most of the calibration targets have been met and are stable.



Some calibration metrics are familiar to trip-based modelers and can be derived from activity-based model output. These include:

- Vehicle availability by zone or district;
- Work commute flows by district;
- Activity/trip frequencies by type;
- Activity/trip frequencies by time of day;
- Trip length distributions; and
- Trip mode shares.



In addition, however, tour or activity-based models require that an additional set of model predictions be calibrated against benchmark values. Typically, these include:

- Activity duration by type;
- Number of tours by type;
- Number of work-based sub-tours;
- Number of stops per tour;
- Home-based tour duration;
- Tour mode shares;
- Auto tour lengths; and
- Transit tour lengths.

How much time to calibrate?

- Activity-based models have many more components—and require more time to calibrate
  - Individual components
  - System-level calibration
- Activity-based models provide a better starting model
  - Fewer problems both in validation and in other types of scenario/sensitivity runs
  - Disaggregate population; linkages across persons, long-term and medium-term decision modules, activity generation and scheduling modules, tour-based linkages, daily pattern linkages, time of day consistency

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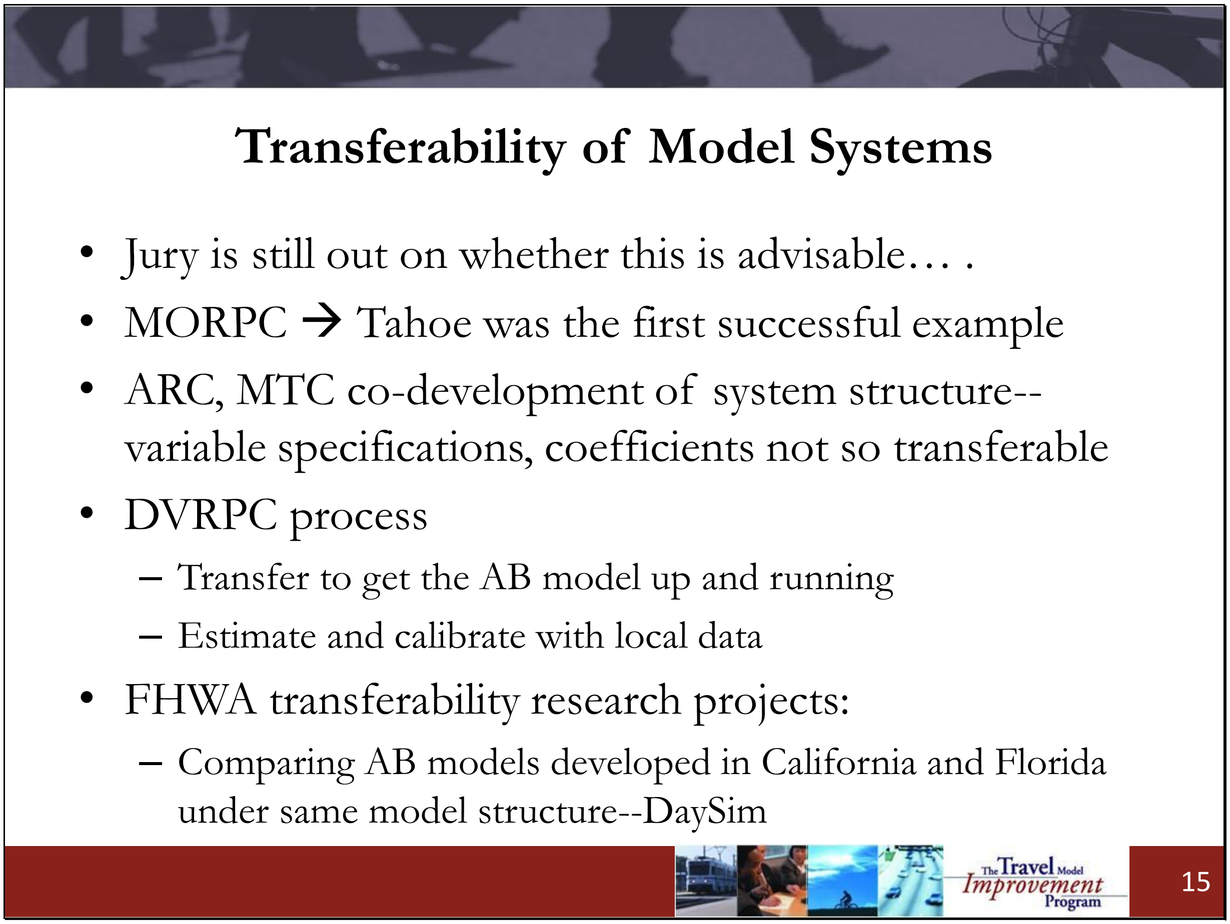
While activity-based models may take more time to calibrate because they have many more model components than trip-based models, practice has shown that they tend to result in fewer problems both in validation and in other types of scenario/sensitivity runs. This because you have more calibrated support points for forecasts. This is partially due to modeling a disaggregate population and partially due to all of the linkages between model components. So, investment in finer resolution and linked decisions pays off by putting the calibrated model in a better starting position.

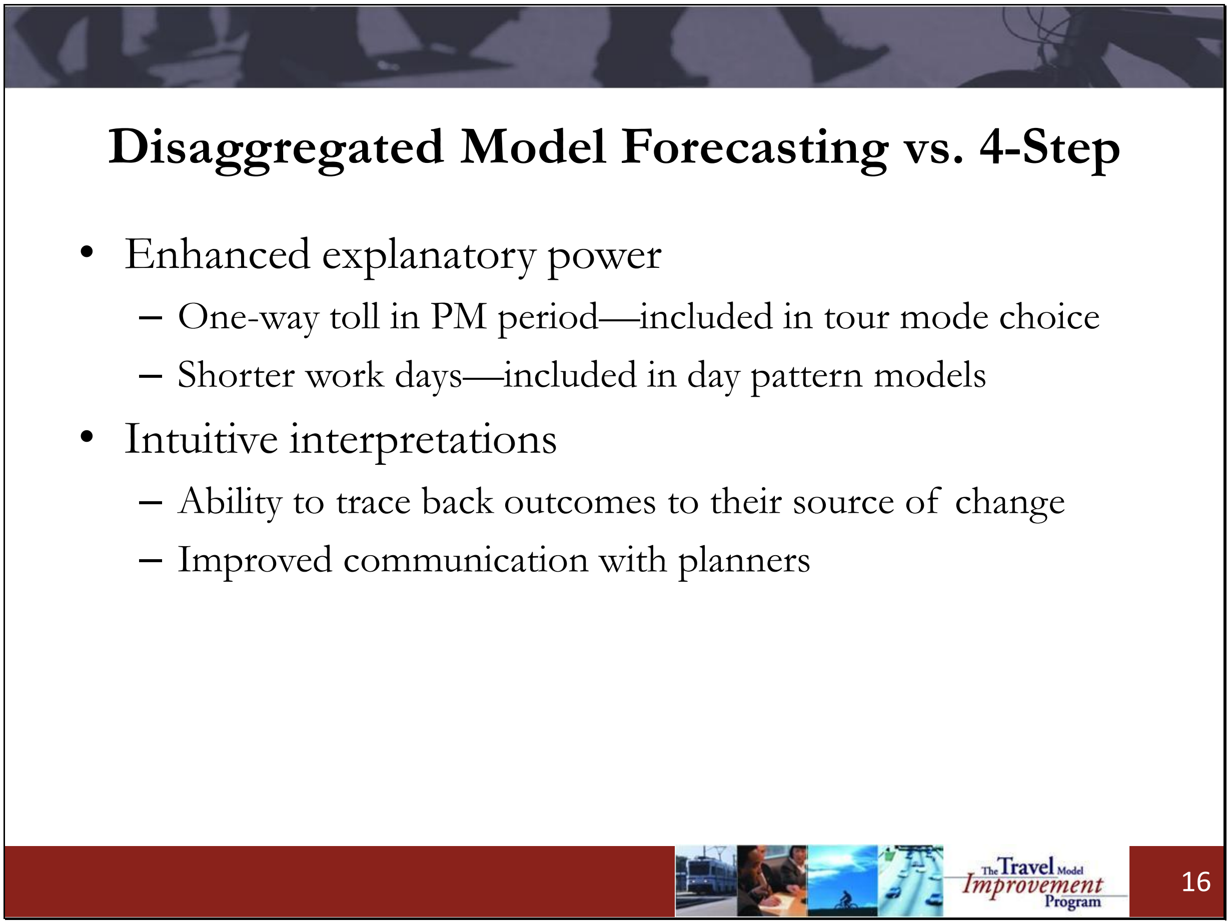


Transferring an activity-based model system from one region to the next has become a popular alternative to developing model components from scratch because it can get an agency up and running faster and presumably makes use of a model design and structure that has worked elsewhere. The “jury is still out” as to whether this is a good idea. The first successful example of this is probably the transfer of the Columbus, Ohio (MORPC) activity-based model to the Lake Tahoe region. This is a somewhat unusual case, given the characteristics of the Tahoe region as a resort area. The Atlanta Regional Commission and Metropolitan Transportation Commission (S.F.-Oakland Bay Area) is an example in which the CT-RAMP model structure was developed jointly for both regions, although it appears the model coefficients were not so readily transferred. As another example, the Sacramento model was transferred to the Fresno and North San Joaquin Valley region, which makes more sense because they are adjacent regions.

Commonly, the idea is to transfer an existing model to get it running and start to get the staff familiar with it, but then to recalibrate it using local data. In the recent case of the Delaware Valley Regional Planning Commission (Philadelphia area), the model transfer from the Puget

Sound Region (Seattle) has just begun, and the long-term plan is to re-estimate the model system in its entirety once a new household survey has been completed.

FHWA is quite interested in the issue of transferability and has a commissioned research on this. In the STEP project, comparisons are being made between several regional models of the DaySim framework have been developed for Sacramento, Shasta County, and Fresno, California as well as for Jacksonville and Tampa, Florida.



The true power of activity-based models tends to come out when doing disaggregated forecasts. For example, a trip-based model might not account for a one-way toll applied in the PM peak period, because it does not affect the AM Peak skims, whereas an activity-based model would model the travel impedances in both directions and predict a more appropriate response. Another example would be the ability to test travel demand management policies, such as shortened work days or work weeks.

In general, activity based models, being disaggregate representations of travel behavior, give the analyst the ability to trace travel behavior outcomes back to the source of their change. Of course, one needs to know where to look! And that's where training and familiarity come in. In addition, activity-based model facilitate better communication between modelers and planners because they can point to more intuitive explanations for changes in travel behavior.

Mobility and Equity Performance Measures

- Mobility
  - Trip length distributions
  - Mode shares
  - Travel times and costs
- Equity
  - ABM output looks like a full population household survey and can be expanded in any way to understand equity

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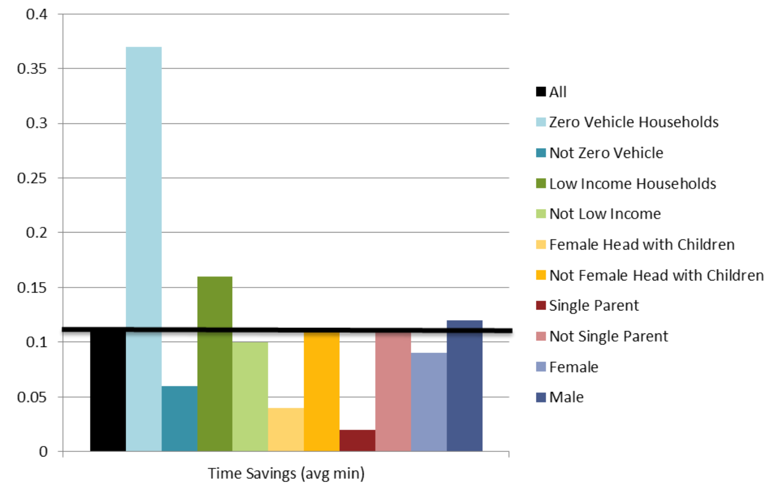
Traditional trip-based transportation system performance measures are still available in activity-based models. These include things like trip length distributions, mode shares, and link-based and OD-based travel times and costs. In addition, however, an activity-based model can do a better job of predicting impacts on individuals within the population. For example, this is especially useful when analyzing equity.

Let’s look at some examples. Here is an example of total daily travel time predicted by a Chicago regional model in which the data are summarized by household income group and by person types. Here you see the four income group levels in the black type with the black dot along the horizontal dashed line, and if you follow this you can see that total daily travel time (per capita) increases as you go up the income levels. In fact there is nearly a 20-minue difference from the lowest group to the highest group.

Similarly, this graph shows large differences in daily travel minutes for different person types. Full- and part-time workers have the highest values, followed by university students, driving age secondary school students, non-working adults, non-driving age students, retirees, and lastly pre-school age children.

Equity Analysis in San Francisco

- Travel time savings for different population groups compared against the average



Here is another example. Zero vehicle and low income households benefit from travel time savings where non-zero and non-low income households do not benefit. This may be due to the focus on transit investments and the fact the low income and zero-car households are more likely to happen in transit rich areas. Female head of household with children and single parent households do not have as much travel time savings as the average household. This may be because transit investments are serving work trips in transit rich areas, where female and single parent households are not traveling as much.

Environmental and Growth Performance Measures

- Environmental
  - Vehicle emissions at the source
  - Stationary emissions
  - Energy use
- Growth
  - Jobs-Housing Balance
  - Growth in centers

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Activity-based modeling can also help us evaluate environmental performance measures. This is because disaggregate modeling allows us to trace travel back to the household and individual sources and because it provides more precise estimates of travel demand by time of day. Because we are also modeling activity duration, we have better estimates of hot and cold starts. If an activity-based model is integrated with a dynamic traffic assignment (DTA) program, you can even get more precise estimates by facility type and time of day and trace vehicles. In fact, future activity-based models are expected to model vehicle usage by engine and fuel type.

For land use and growth management scenario testing, it is useful to test the impacts of proposals on activity-travel patterns. Activity-based models are designed to be sensitive to accessibility. This makes them more sensitive to commuting distances and modes, as well as discretionary trip making. For example, an activity-based model can capture the phenomenon of persons with reduced commuting times and costs taking advantage of this time by making additional discretionary trips.

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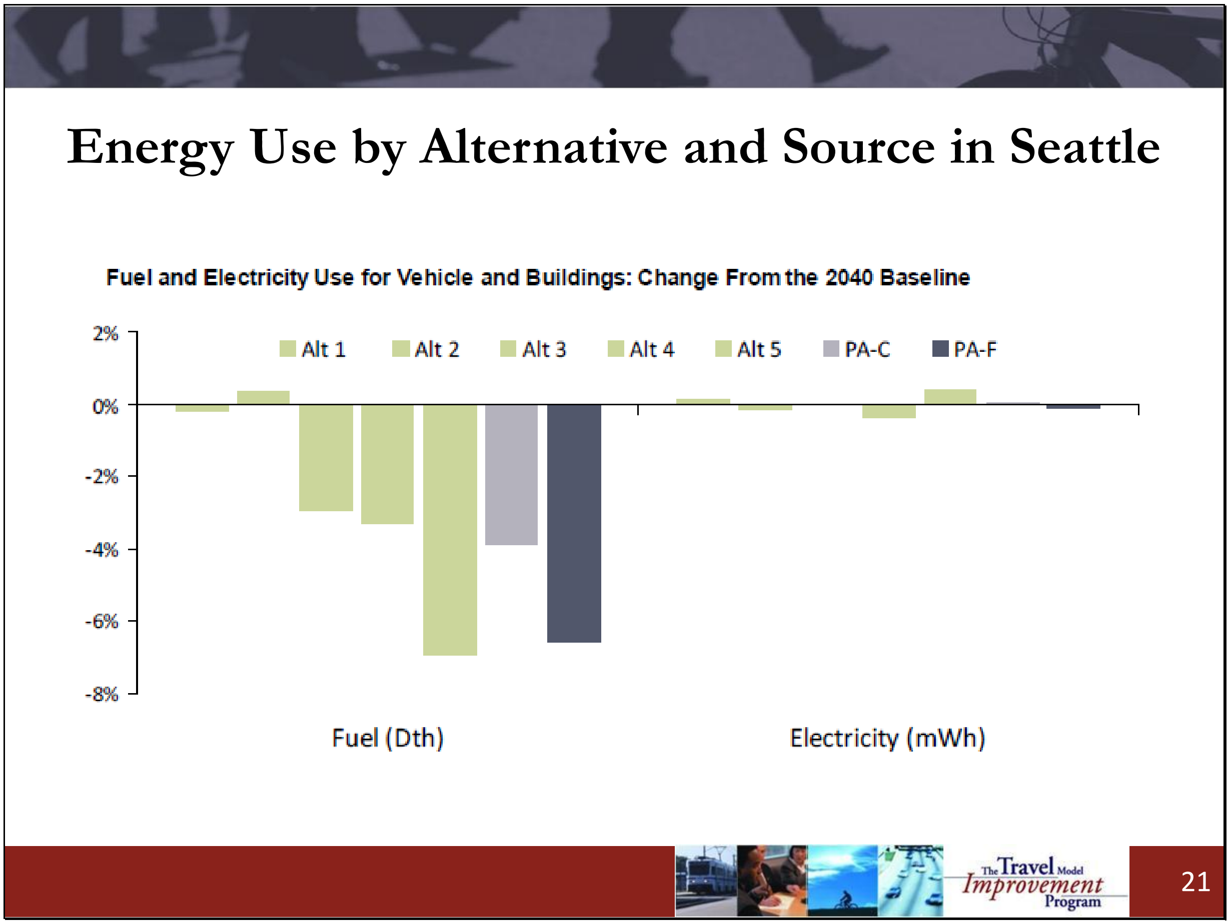
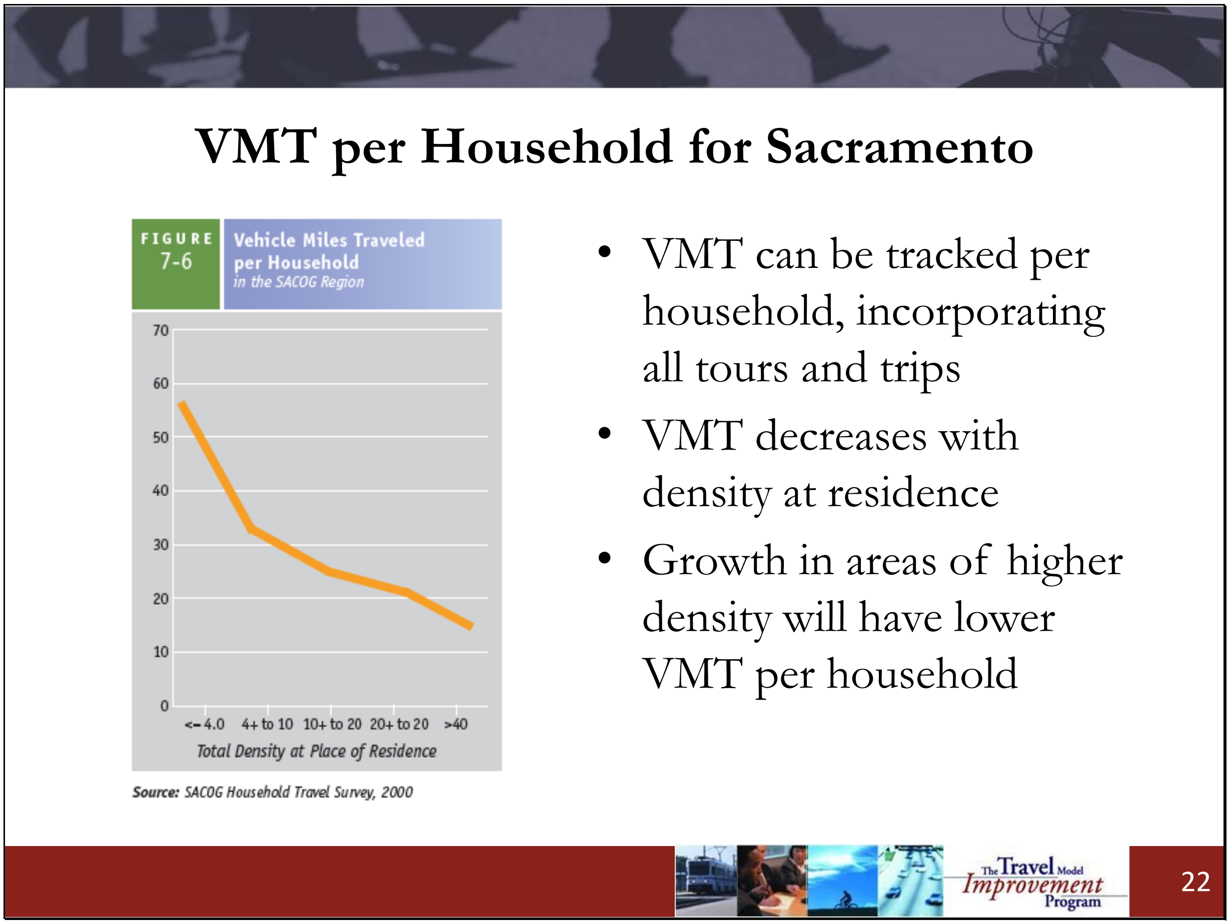


This is an example and a valuation of energy use by alternative and source that was completed as part of a long-range planning effort in Seattle. In this example, fuel and electricity use was estimated from the vehicle miles traveled produced by the travel demand forecasting model and from square footage estimates of buildings from the land use forecasting model. This comparison shows significant reductions in fuel consumption for several planning alternatives and very little change in electricity use from the buildings. This evaluation was designed to also account for electricity use from electric vehicles, but was not employed for these planning alternatives.



Another example shows vehicle miles traveled from the Sacramento activity based model on a per household basis. Tracking vehicle miles traveled on a per household basis is an advantage over trip-based models which can only track VMT on a link basis. This allows us to understand the source of vehicle miles traveled which is important because policies would affect households rather than links. In this example, the VMT with density at the household level and growth in areas of higher density will have lower VMT per household. Models that track VMT by link will show that VMT is higher in areas of higher density which is why it is so important to track VMT at the household level.

Economic and Life Performance Measures

- Economic Development
  - User benefits to low and high wage employment
  - User benefits to freight centers
- Quality of Life
  - Safety (crashes)
  - Health (active transportation)

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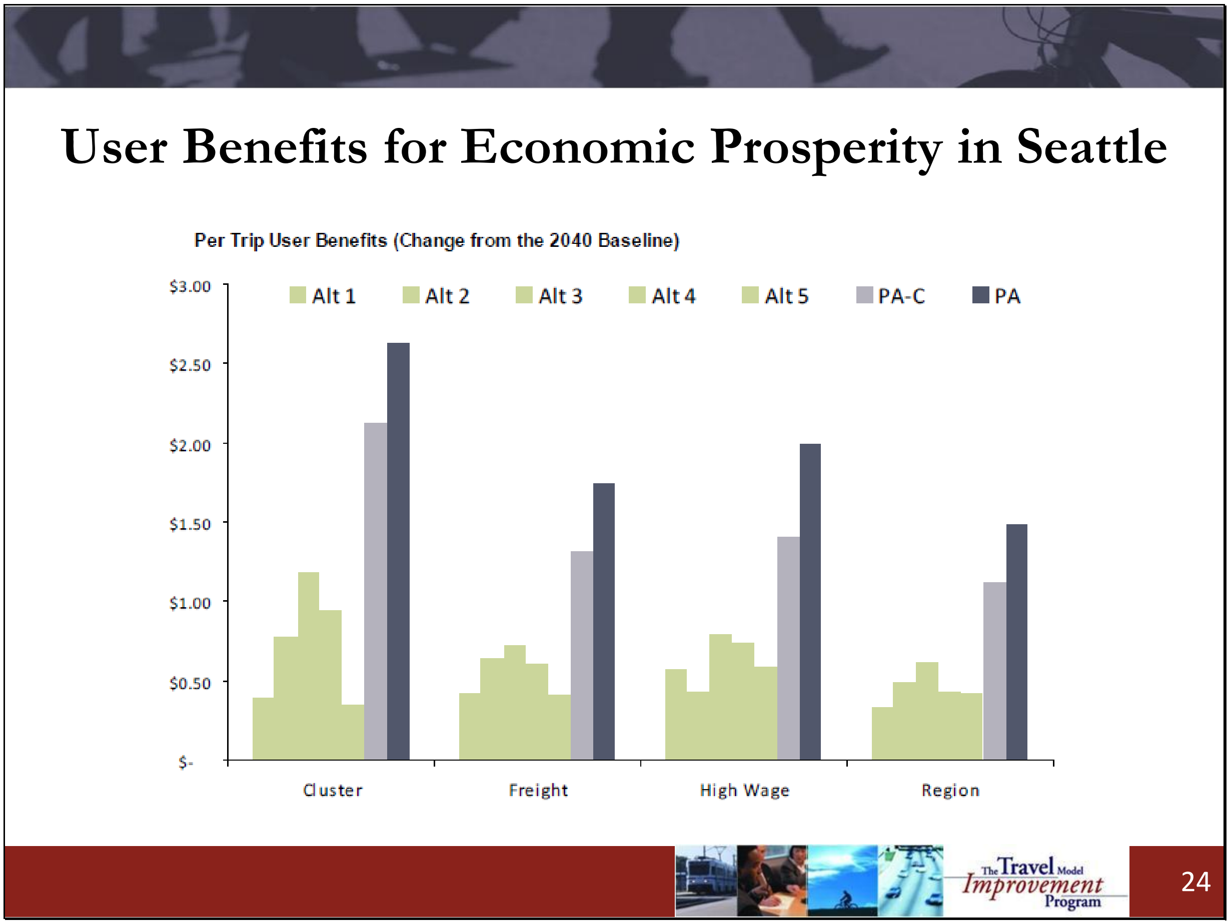
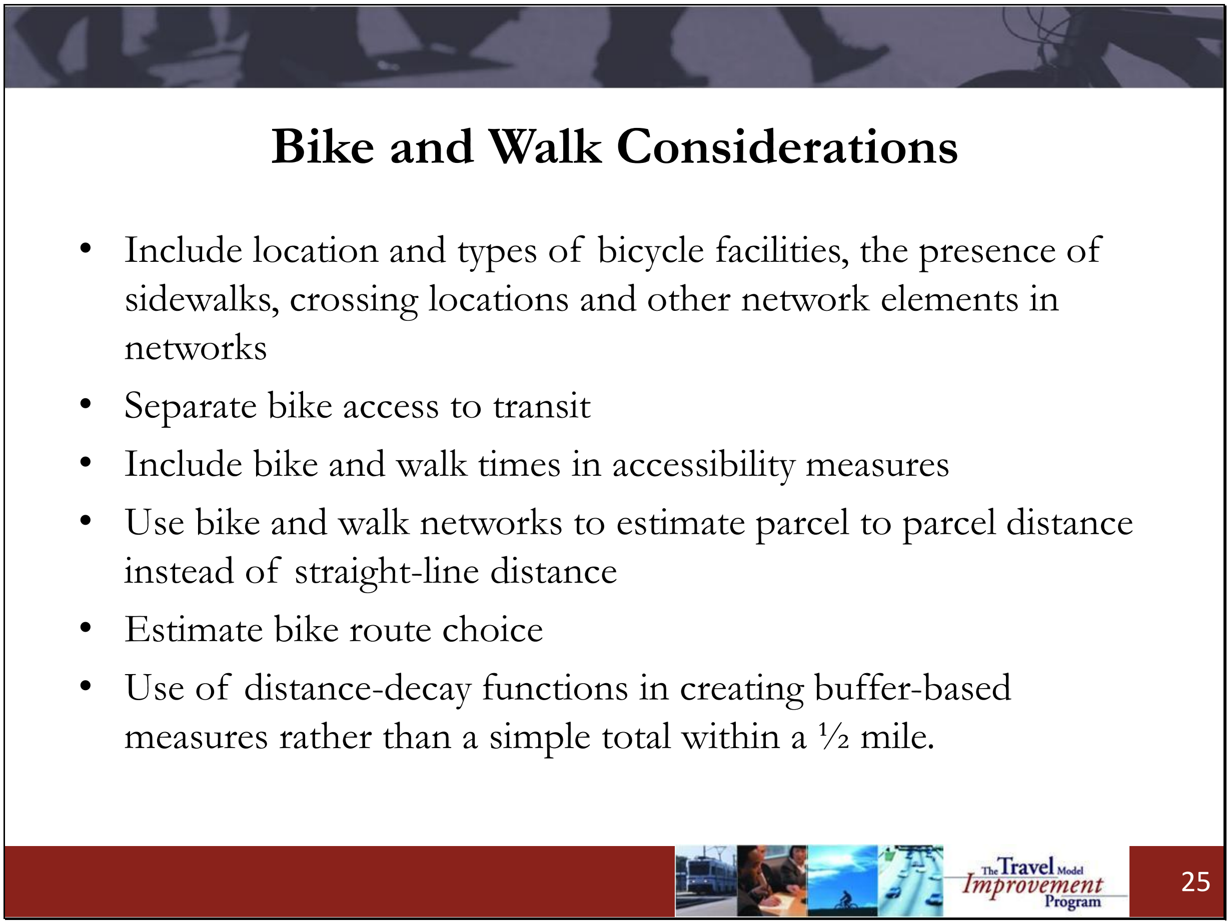
Another category of performance metrics describes economic development and quality of life. One common measure is the user benefits accruing to various economic sectors. One example of user benefits for economic development include user benefits to low- or high-wage employment sectors, which measures equity and potential for prosperity respectively. Another example are user benefits to freight centers. This measures freight mobility, which in turn is an indicator of the potential to attract more freight to these centers.

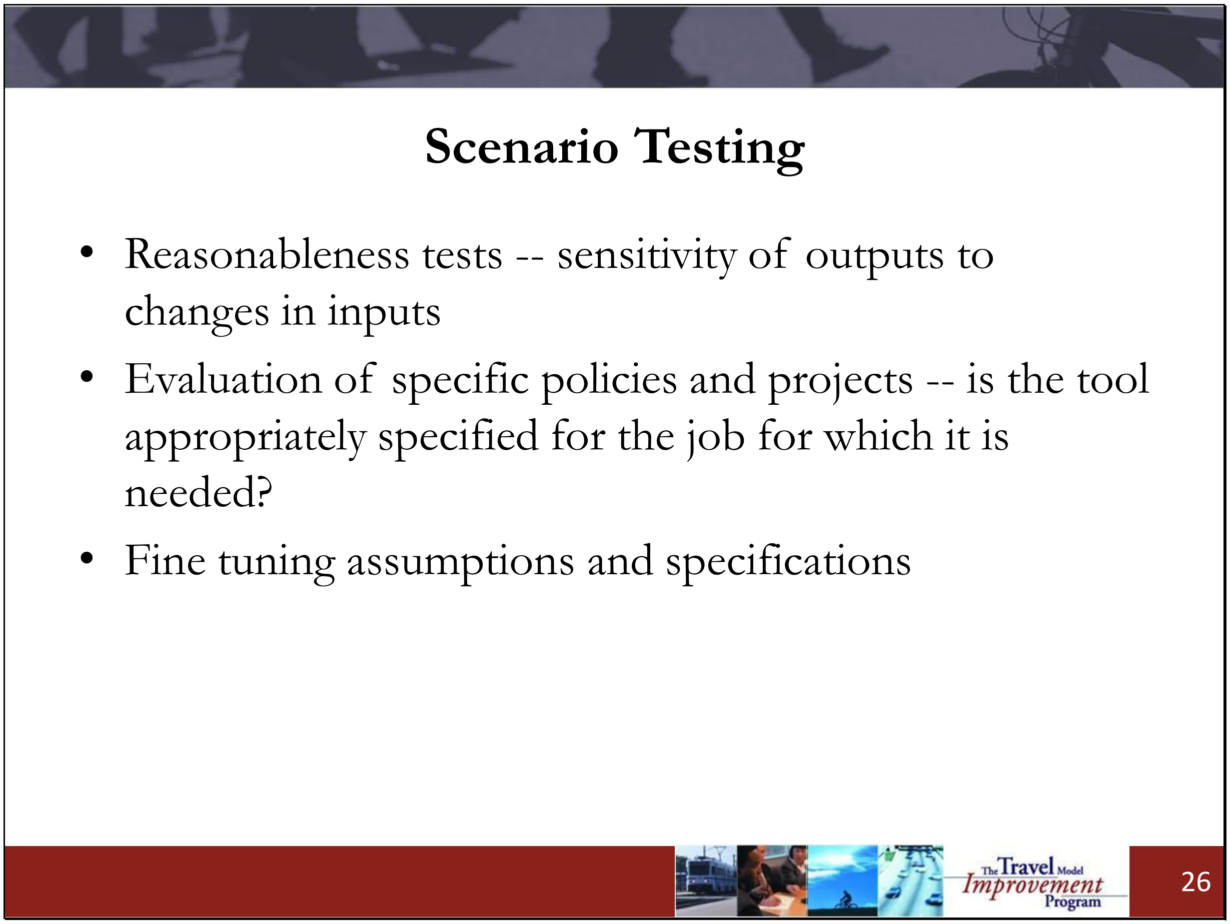
There are several ways to measure quality of life emanating from the transportation system. A measure of safety is the number and severity of crashes occurring on the roadway system. A measure of health is the number of non-motorized trips as an indicator of the number of people engaging in active transportation modes.



This graph shows these same economic prosperity measures and the extent to which different economic development plans produce user benefits. “Cluster employment” refers to those sectors that the regional economic development plan has identified as showing promise for economic prosperity. “Freight employment” covers those sectors that serve freight mobility and are therefore preferred for positive user benefits. High-wage employment benefits will attract more high-wage employment to the region. As you can see, there are seven alternatives and the last two which are the light and dark gray bars, respectively, would seem to confer the most benefits and are therefore the preferred alternatives.



Activity based models have several advantages for non-motorized travel over trip based models due to the additional spatial detail and the disaggregate nature of the models. Some considerations for modeling bike and walk trips that are on both the demand and supply parts of the modeling system. These include representing bicycle and pedestrian facilities in the networks, separating bike access to transit from walk access to transit, including bike and walk times in accessibility measures along with auto and transit times, representing walk and bike routes on the network from parcel to parcel instead of a more simplified straight-line distance estimate, including bike route choice model components, and using distance decay functions in buffer accessibility measures rather than a simple half-mile threshold. Any or all of these considerations can be included in the activity based modeling system to improve the accuracy of walk and bike trips.



Scenario testing is an important means to assess the reasonableness and appropriate use of activity based models. Scenario testing can include testing the sensitivity of outputs to various changes in the inputs as well as the evaluation of specific policies and projects. This can be useful to understand whether the activity based model has been appropriately specified to meet the needs of any specific planning application. Scenario testing can also be used to fine-tune the assumptions and specifications within the models. Sensitivity testing is often used to assess the reasonableness of specific policies before the model is used to evaluate the effect of a specific project which may be more difficult to interpret due to the complexity of the project details.

Parking Pricing Scenarios in San Francisco

- $3 charge into/out of NE Cordon during weekday peak periods
- $3 parking charge in Focus Area

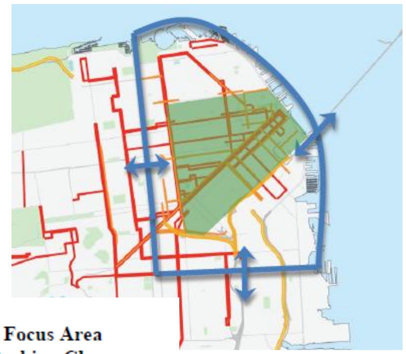


TABLE 1 Key results compared to a baseline scenario.

	Northeast Cordon Charge	Focus Area Parking Charge
Total Daily Charged Trips	250,000	145,000
Δ Total Daily Trips Citywide	~	-3%
Δ Peak Vehicle Trips to/from/within Focus Area	-14%	-22%
Δ Peak Vehicle Trips to/from/within NE Cordon	-12%	-12%
Δ Daily Non-Work Trips to/from/within Focus Area	~	-4%
Δ Daily VMT, Focus Area	-10%	-9%
Δ Daily VMT, Citywide	-5%	-3%
Δ Peak Period Transit Trips to/from Focus Area	+12,000	+15,500
Δ Peak Period Walk/Bike Trips to/from Focus Area	+6,000	-500

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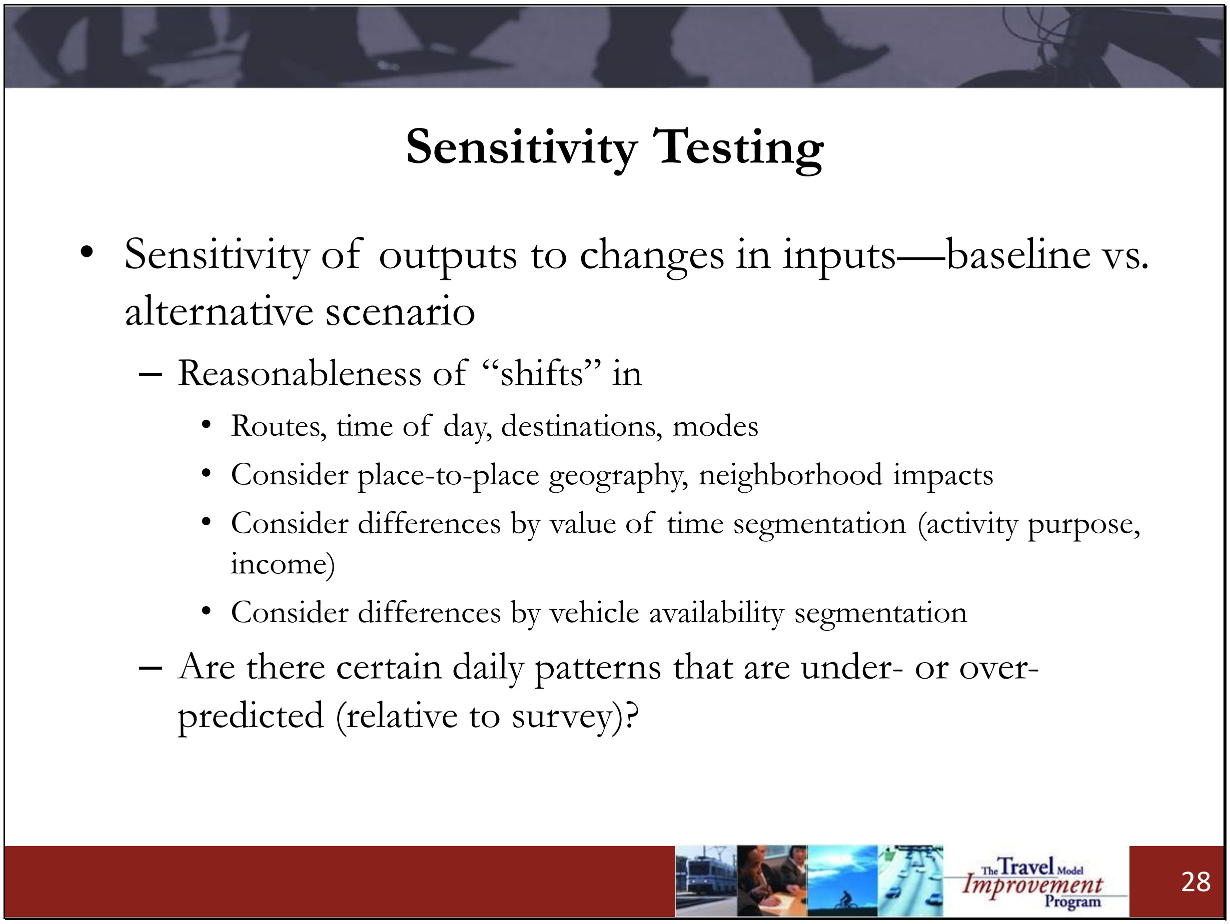
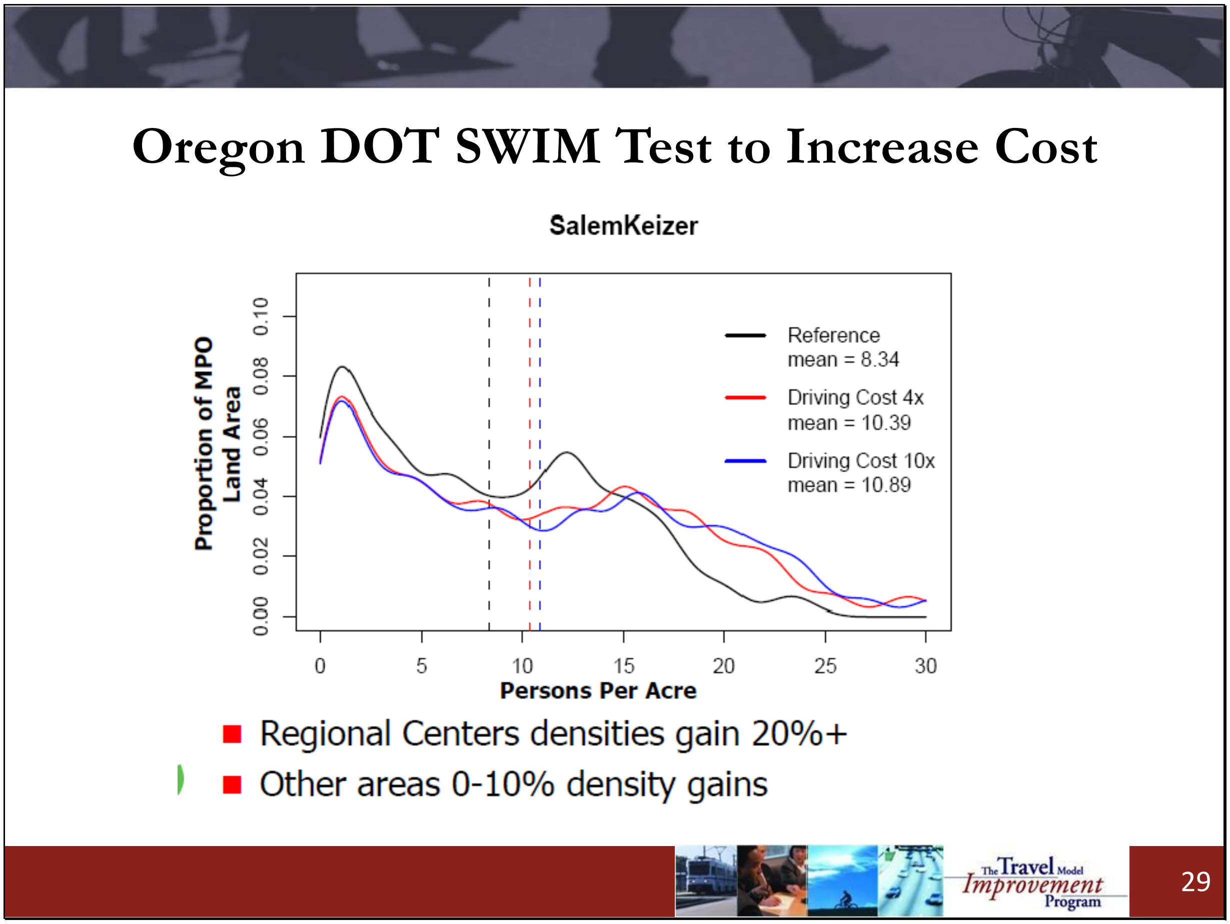
Scenario testing was used extensively to evaluate parking pricing scenarios in San Francisco. This example shows the results of a three dollar charge into and out of a Northeast cordon, shown here in blue, during weekday peak periods; compared with a three dollar parking charge in a focused area, shown here in green. The Northeast cordon charge reduced vehicle miles traveled citywide more than the focused area parking charge due to the broader coverage of daily trips that were charged. This scenario also increased walk and bike trips much more than the focused area scenario, but did not increase peak period transit trips as much. These parking pricing scenarios would be quite difficult to model using a trip-based model.



Sensitivity testing is the process of changing model inputs to evaluate the effect on outputs. Typically, we change model inputs using simple factors so that the outputs can be interpreted more easily. For example, a change in a bridge toll could be tested by doubling the current price rather than implementing a more specific evaluation of a dynamic or time of day cost structure on the bridge. Sensitivity testing can be used to assess the reasonableness of shifts in routes, time of day, destinations, modes, or locations. We can also summarize the reasonableness of model outputs with respect to value of time segments or vehicle availability segments of the population.

Reasonableness testing is as much art as science. Basically, one needs to consider the magnitude of the "shifts" produced by the model—shifts in route, time of day, O-D patterns, and mode—and assess whether they make sense and are similar to what has been observed in the past when such changes occur. For new policies—such as pricing—it would be ideal to look at places where pricing changes have occurred to get some idea of what to expect. In most cases it comes down to professional judgment and requires a high level of experience with modeling in general—not necessarily activity-based models.



This example from the Oregon statewide model shows a sensitivity test on driving cost which is four times the original input shown in red and 10 times the original input shown in blue. The results shown here demonstrate that regional center densities will increase 20% under the higher cost options and other areas will have density gains up to 10%. Are these results realistic? For example, if gasoline prices increased to $15 per gallon or $38 per gallon is this the change in land use density that we'd expect to see? How long would the land market take to adjust? These are difficult questions to answer when we have not experienced such costs.

Stability Across Scenarios

- Research indicates almost unequivocally that people maintain time budgets in daily life, which should remain stable across scenarios
  - Are average activity durations stable, reasonable?
  - Are the total amounts of time persons spend on out-of-home activities and travel stable, reasonable?
  - Is the ratio of travel time to activity-time stable, reasonable?
  - How does total household VHT change? Are there compensatory effects with household VMT?
  - Are the components of forecasted transit paths reasonable?
    - Walk access and egress distances?
    - Number of transfers?
    - In dynamic models, it is possible to miss connections?

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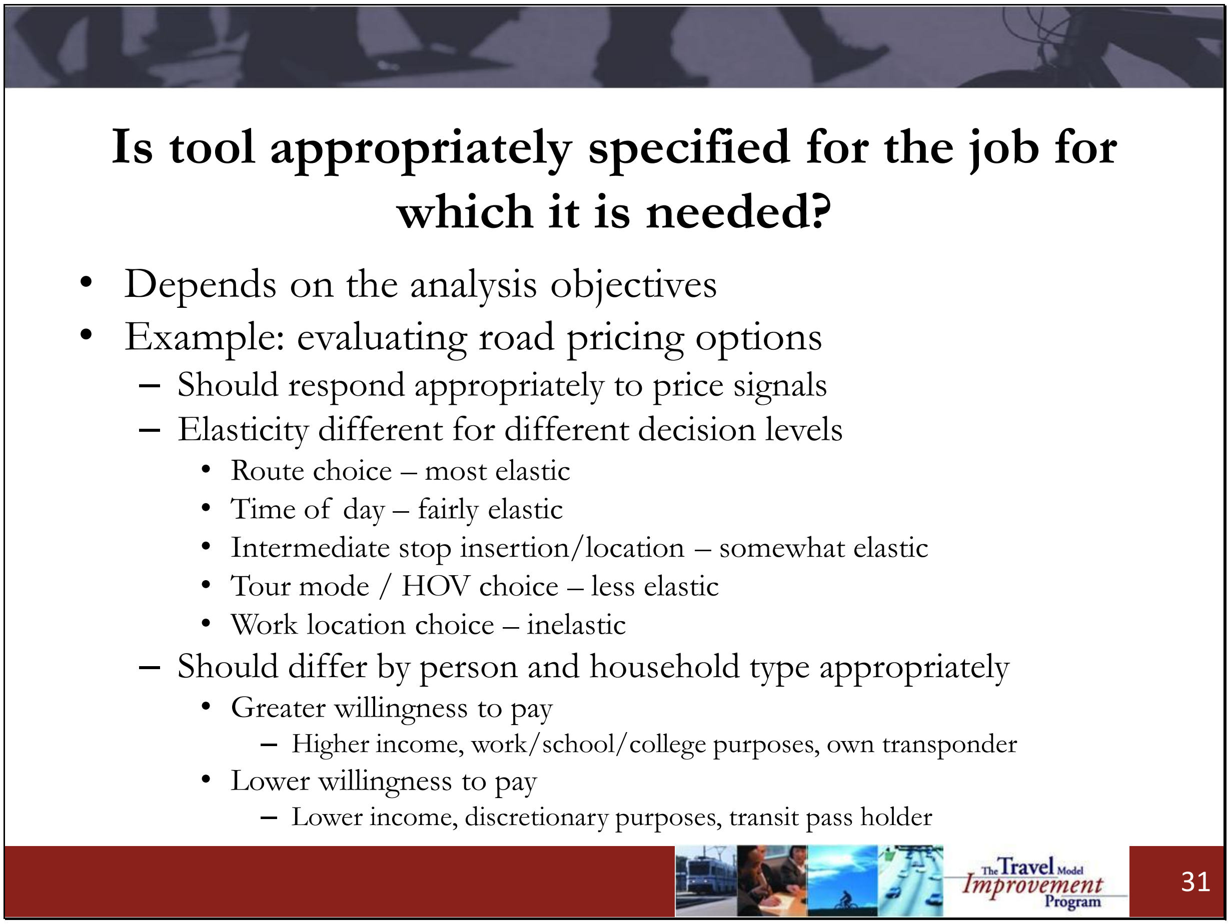
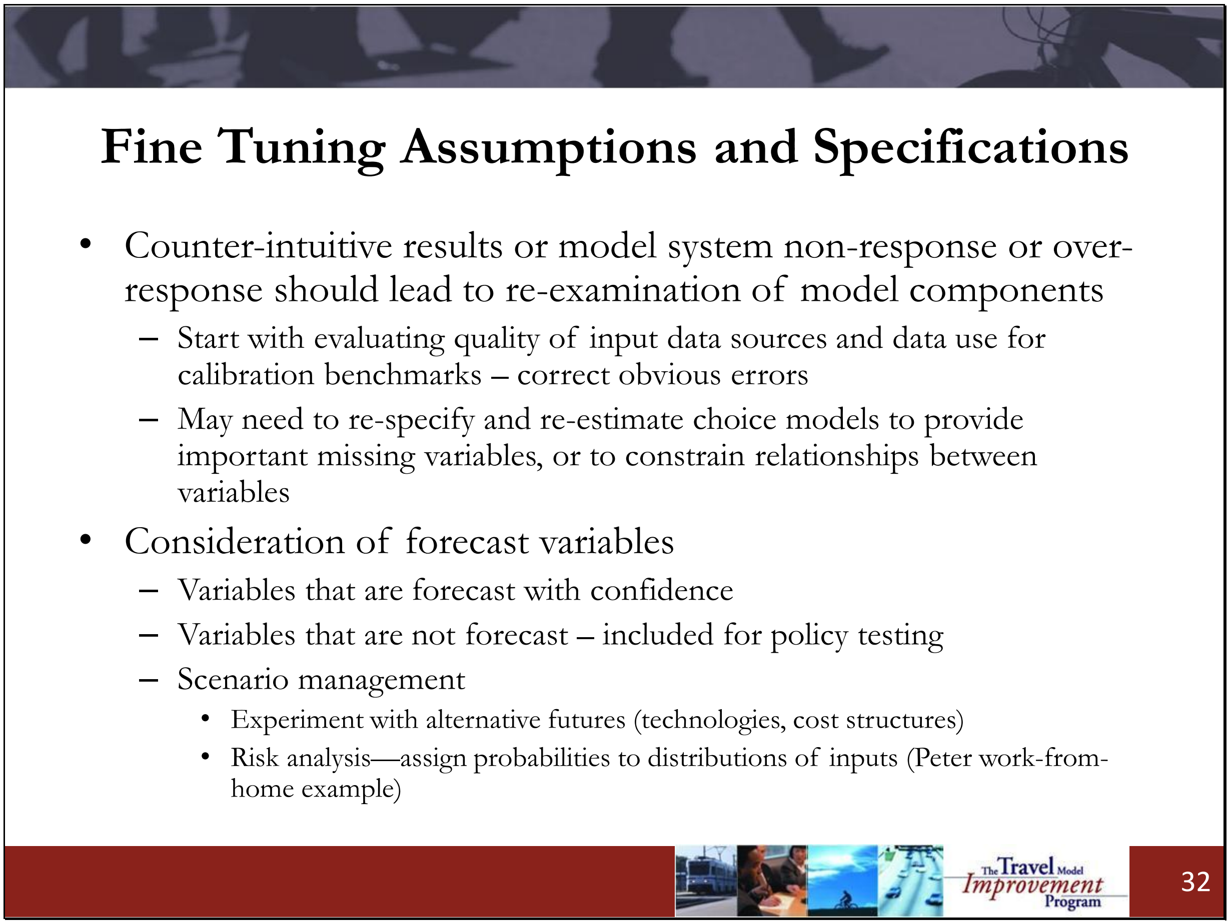
One issue in travel demand forecasting that can be better assessed in activity based models are the stability across scenarios. For example research shows that people maintained time budgets in daily life so that total amount of time spent on travel is about the same and increases in one type of travel will result in decreases in another type of travel. It is useful then to review forecasts of average activity durations to determine if they are stable and reasonable over time. The details of various scenarios like vehicle hours of travel or walk access and egress distances to transit can provide insights as to the stability across scenarios.



Travel demand forecasting models should be dynamic in the sense that they will be improved, assessed, and updated over time. In practice, travel demand forecasting models will typically be updated for a specific purpose which improves all aspects of the system needed for that purpose, but it may not cover all other purposes until there is a need. It is important to assess the reasonableness of the model specifications for a particular analysis. For example, evaluating road pricing options requires that the model responds appropriately to price signals and produce elasticities for route choice, time of day, intermediate stops, modes, and work location choice that are consistent with our expectations.



For each planning application, it is useful to fine tune assumptions and specifications in the activity based model as a result of sensitivity tests specifically aimed at understanding the model in the context of the specific planning application. Counter intuitive results or non-response should lead to changes in the assumptions or specifications of the model to correct these results. This can lead to changes in input data or assumptions or specifications for a specific choice model.

It is also useful to consider the confidence we have in forecast variables and whether we need these forecast variables for policy testing. Sensitivity testing can be used to including variables for policy testing that we may have less confidence in forecasting.

Alternative Analysis with Activity-Based Models

- Clear advantages in ability to summarize outputs by virtually any available household or person attribute, geographic stratification, or time of day
- Simulation of outcomes has theoretical advantages, but presents practical challenges in handling stochastic effects
- Doing away with trip-independence assumptions has clear theoretical advantages, but requires new ways of interpreting outcomes, taking into account intra-personal and inter-personal linkages; tour-level versus trip-level decisions

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Activity-based models have some clear advantages over trip based models because of their disaggregate data throughout the system. This allows us to summarize any household or person attribute along any geographic stratification or time of day. Trip based models are limited to summarizing outputs by the segments that are directly represented in the model. Simulating individual people has clear theoretical advantages but also presents a practical challenge in handling the stochastic effects and producing a slightly different outcome each time the model is run. Many have found that an alternative analysis is easier to understand and interpret if these stochastic effects are eliminated, but some people feel that the range of results from these stochastic effects is useful to understand.

Stochastic Variation

- Advantage: ability to portray a distribution of outcomes – more realistic – ability to portray risk
- Challenges:
  - Need to demonstrate that random variation does not swamp meaningful changes in policy variables
  - Non-technical decision makers may prefer a single number
  - Some analyses require analysis of comparative statics

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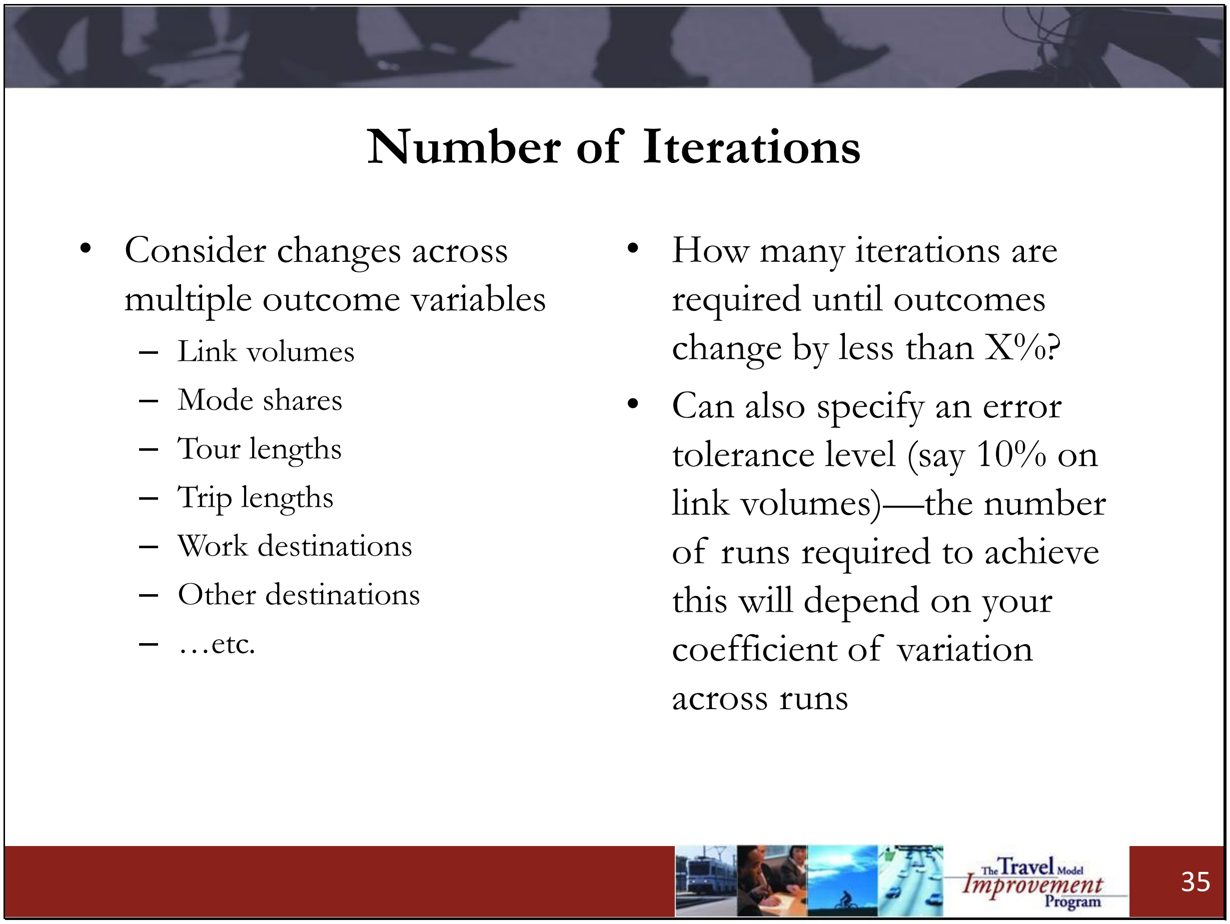
Stochastic variation has a clear advantage in portraying a distribution of outcomes and the uncertainty associated with these outcomes, which is more realistic than a single number. The challenge, however, is to demonstrate that this random variation does not overshadow meaningful changes in policy variables. Another challenge is that many decision-makers find this confusing and prefer a single number result that can be more easily interpreted and compared across planning alternatives. Note that methods have been developed, like random sequence synchronization, to minimize the random stochastic differences BETWEEN scenarios, which addressed the first challenge.



It is important to determine the number of iterations needed to achieve a desired level of confidence. The desired level of confidence may be for link volumes, mode shares, tour links, trip links, or destinations as well as other aspects of the modeling system. Sometimes iterations are determined by specifying an error tolerance level rather than a fixed number of iterations because this focuses on the desired results.

SFCTA Tests on Random Simulation Error

- Results are stable across 100 runs for all geographies
- More variation at TAZ level
  - 3% difference initially
  - <1% after 10 runs

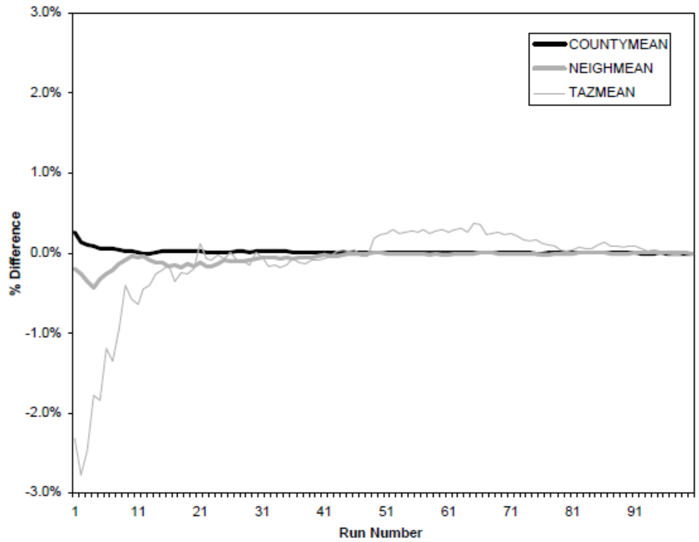


FIGURE 4 Trips per person (all levels), percent difference from final mean.

This example from San Francisco shows the random simulation error that occurred over 100 runs of the activity based model. The graphic shows that aggregated results at the county or neighborhood level have much less random simulation error then results at the traffic analysis zones level.

Strategies for Controlling Stochastic Variation

- Multiple demand system runs -- assignment performed on averaged trip tables
- Constraining random number sequences
  - Starting from same random number seed for same process
  - Saving random number sequences
- Freezing certain model components between runs
- Feedback and convergence through network integration (See Webinar #11)

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There are several strategies for controlling stochastic variation that can be deployed. This includes constraining random number sequences by starting from the same random number seed or by saving random number sequences to eliminate the random numbers used in the activity based model. Another strategy is to run the model multiple times and average the trip tables from these runs for use in assignment. A third strategy is to hold certain model components fixed between model runs. There are also feedback and convergence issues with integration of network models that was discussed in the previous webinar that should be considered.

Questions and Answers

The Travel Model Improvement Program

Speakers: John Gliebe & Peter Vovsha

Types of Activity-Based Model Applications

- New Starts
- Pricing studies
- Conformity
- Regional Transportation Plans
- Environmental Impact Statements

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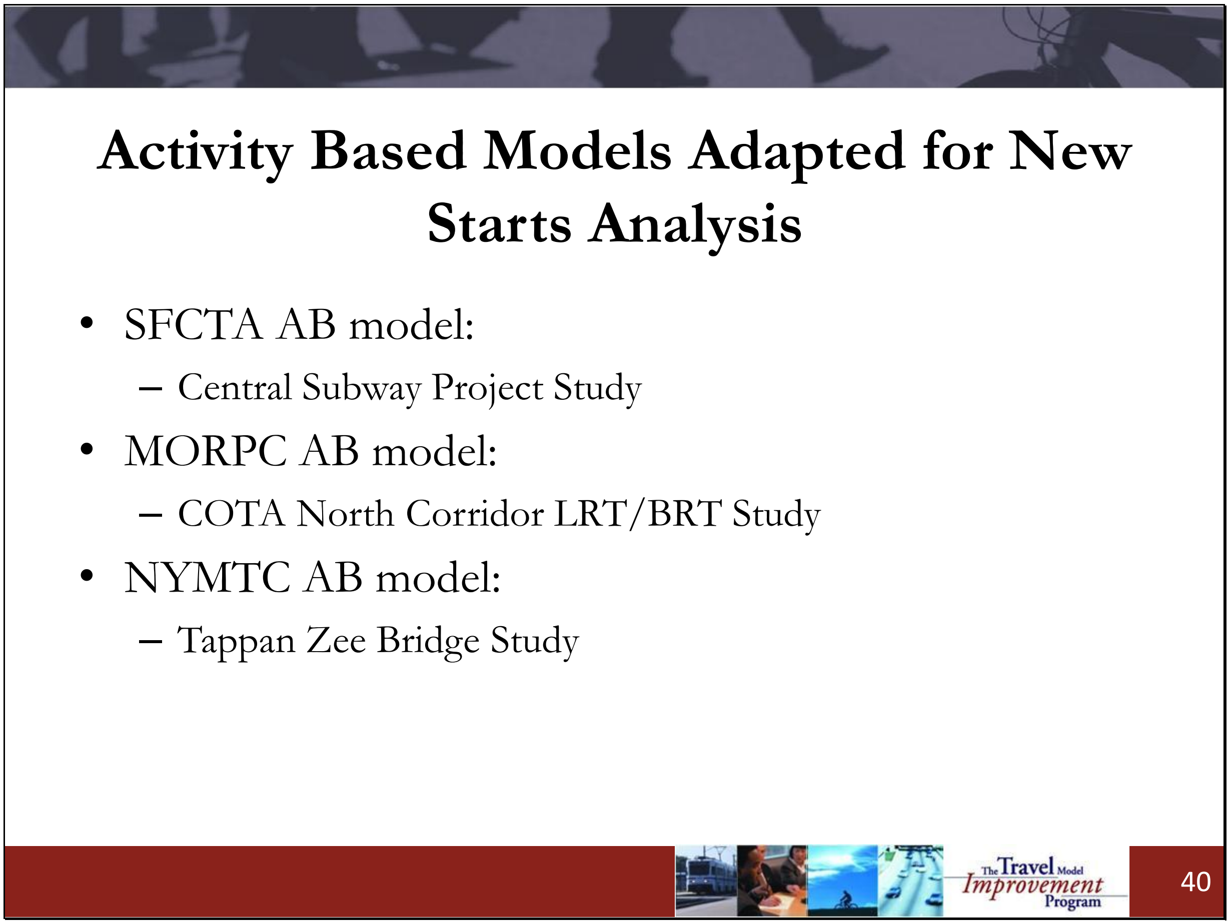
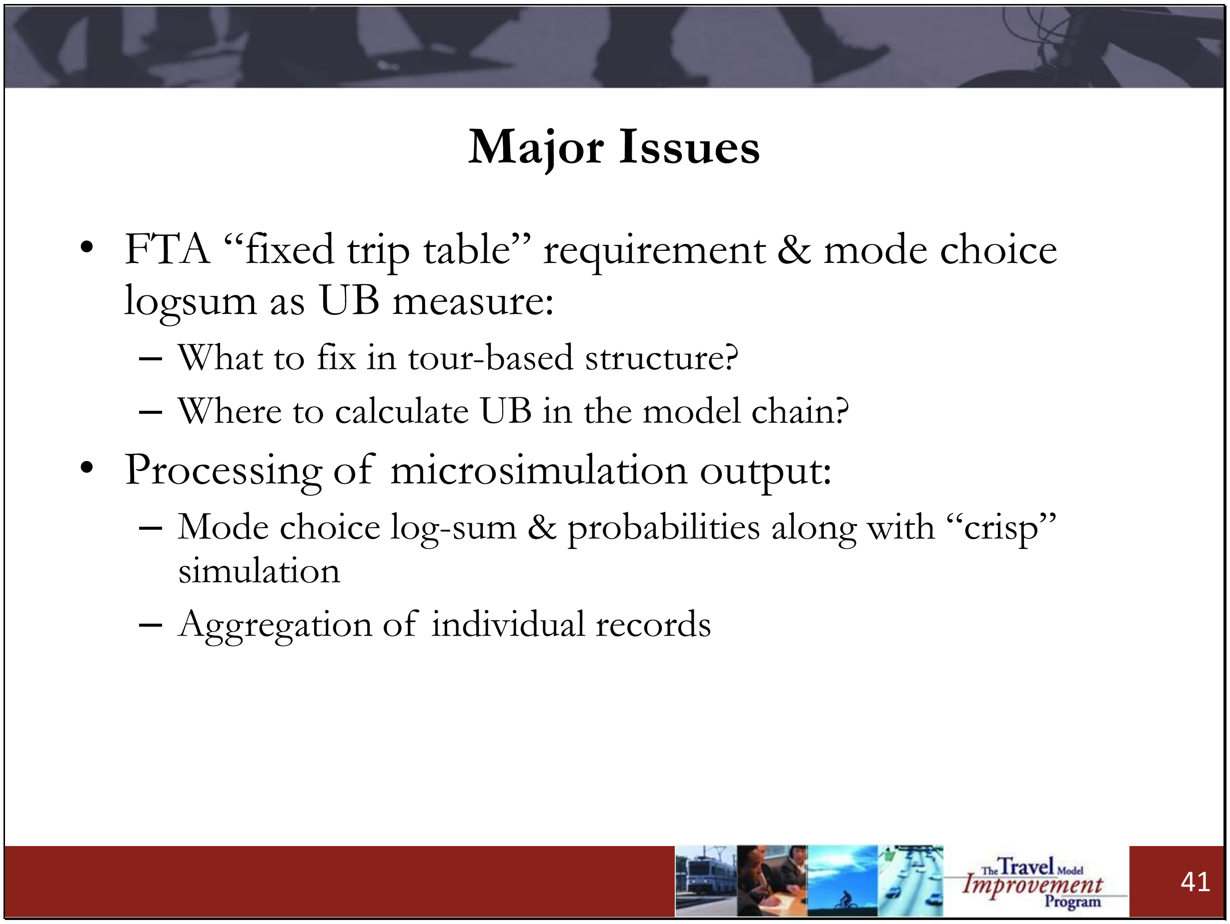
The next part of the webinar covers the types of activity based model applications with several examples, software platforms, and integration topics for model applications. There are many types of activity based model applications. I will cover four of the most common and show several examples. These include transit ridership forecasting for new starts applications, conformity analysis, forecasting of alternatives for regional transportation plans and the evaluation of forecasts for environmental impact statements.

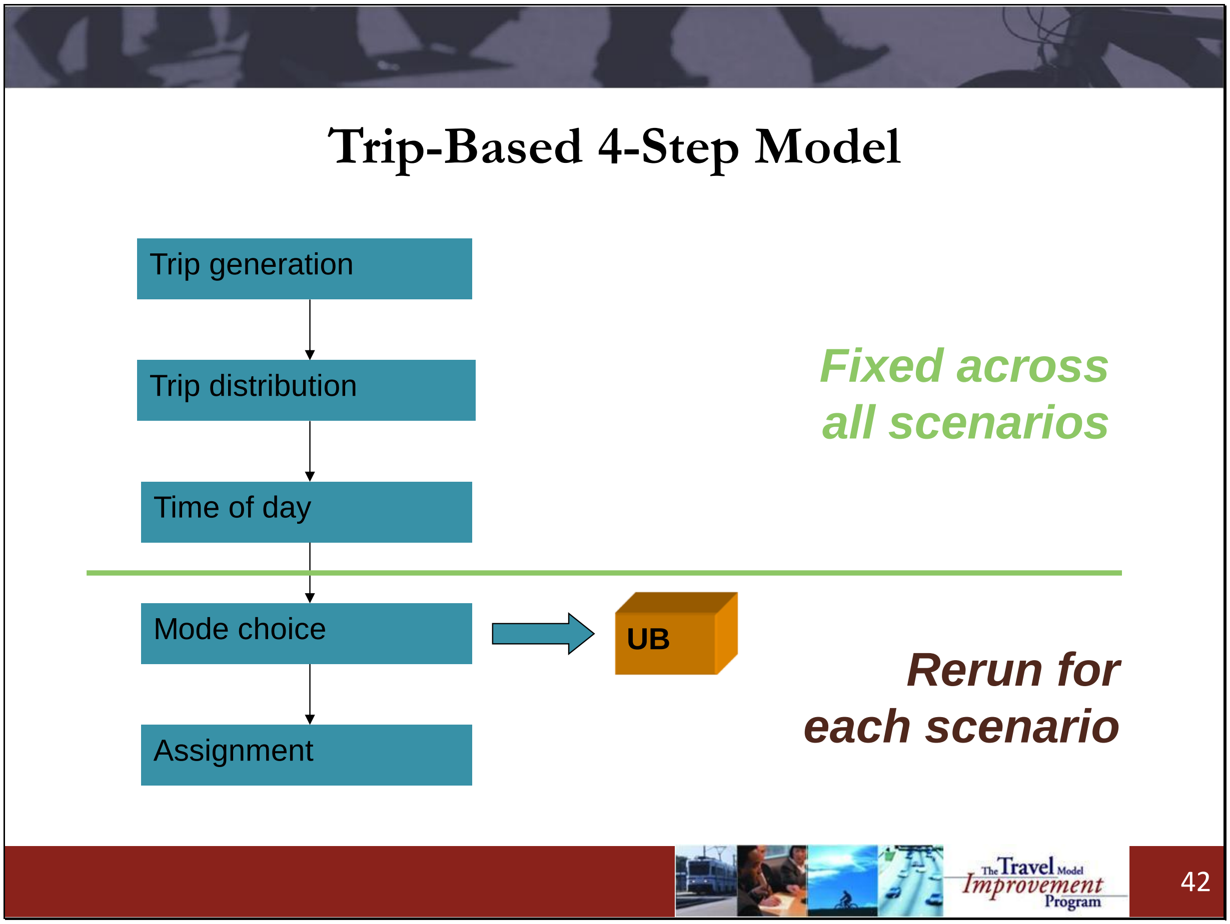


Current news starts modeling requires that the number of trips and their locations be fixed across alternatives and that highway skim values remain the same across alternatives. This requires adapting the activity based model so that outputs from the baseline model run can be used across all build alternatives allowing us to isolate mode choice differences. New starts applications should reuse random numbers generated in the baseline case for all build alternatives so that change is only attributable to the differences in utilities.

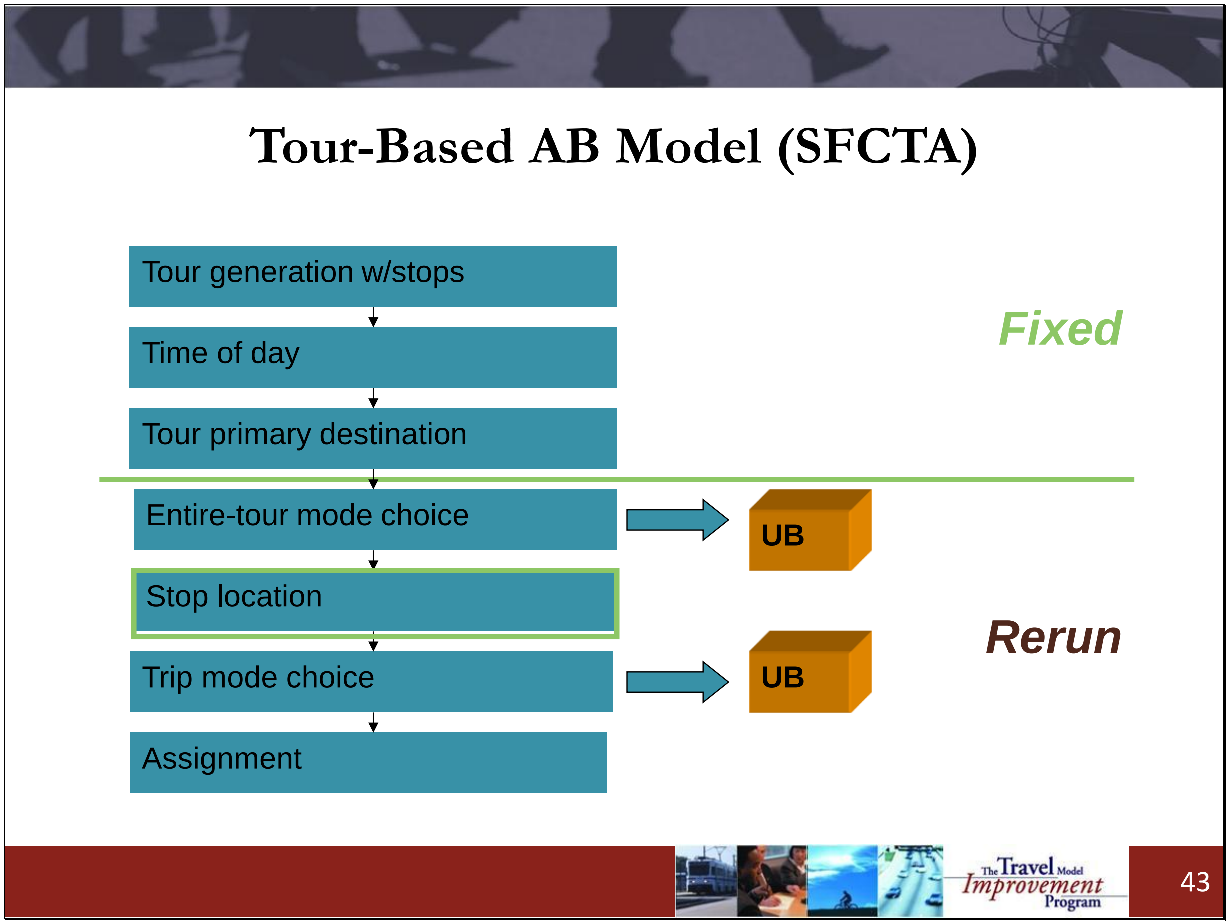


Applying activity based models for new starts applications involved fixing trip tables to ensure that mode choice and assignment results could be compared more directly across alternatives. New starts applications for activity-based models have explored interpreting tour and trip level outcomes in mode choice. Mode and destination choice at the tour and trip level need to be accounted for without double counting user benefits. This requires consistency in defining markets at the tour and trip levels. The simulation of individuals provides flexibility in defining market segments.

Current news starts modeling requires that the number of trips and their locations be fixed across alternatives and that highway skim values remain the same across alternatives. This requires adapting the activity based model so that outputs from the baseline model run can be used across all build alternatives allowing us to isolate mode choice differences. New starts applications should reuse random numbers generated in the baseline case for all build alternatives so that change is only attributable to the differences in utilities.



This is a reminder of the FTA process for a trip-based 4-step model. Current news starts modeling requires that the number of trips and their locations be fixed across alternatives and that highway skim values remain the same across alternatives. This requires adapting the activity based model so that outputs from the baseline model run can be used across all build alternatives allowing us to isolate mode choice differences. New starts applications should reuse random numbers generated in the baseline case for all build alternatives so that change is only attributable to the differences in utilities.



User benefits for new starts applications should be tabulated at the tour and trip levels. At the tour level individual trips are adequately represented directly when there is only one stop on the tour but with more than one stop there may be individual trips that are not adequately represented at the tour level in terms of user benefits. Also some models provide more detail at the trip level in terms of transit access or sub modes and these differences need to be recognized when summarizing user benefits at the tour level.

Once the user benefits have been calculated at the tour level, any additional user benefits that accumulate at the trip level can be assessed. It is important to know that if the build scenario results in a change in tour mode then the trip mode alternatives will be different and the outcome may be counter intuitive. For example improved transit service may result in a switch from auto to transit at the tour level and then auto is no longer included in the log-sum calculations of the build alternative and there would be a reduction in user benefits at the trip level even though transit service has been improved. It can be difficult to hold destination locations fixed in an activity based model when the intermediate stops are determined after the tour mode choice model so this needs to be accounted for in tracking user benefits at the trip level.

Transit User Benefits in San Francisco

- Tracking tour and trip benefits separately
- Retain sensitivity without a fixed distribution

Table 3. Tour and Trip User Benefits: IOS (baseline) to NCS (build)

	TOUR	TRIP	TOUR+TRIP
WORK TOUR TRIPS	388	2,098	2,486
SCHOOL TOUR TRIPS	187	483	670
OTHER TOUR TRIPS	132	1,528	1,660
WORKBASED TOUR TRIPS	-21	202	181
TOTAL	**686**	**4,311**	**4,997**

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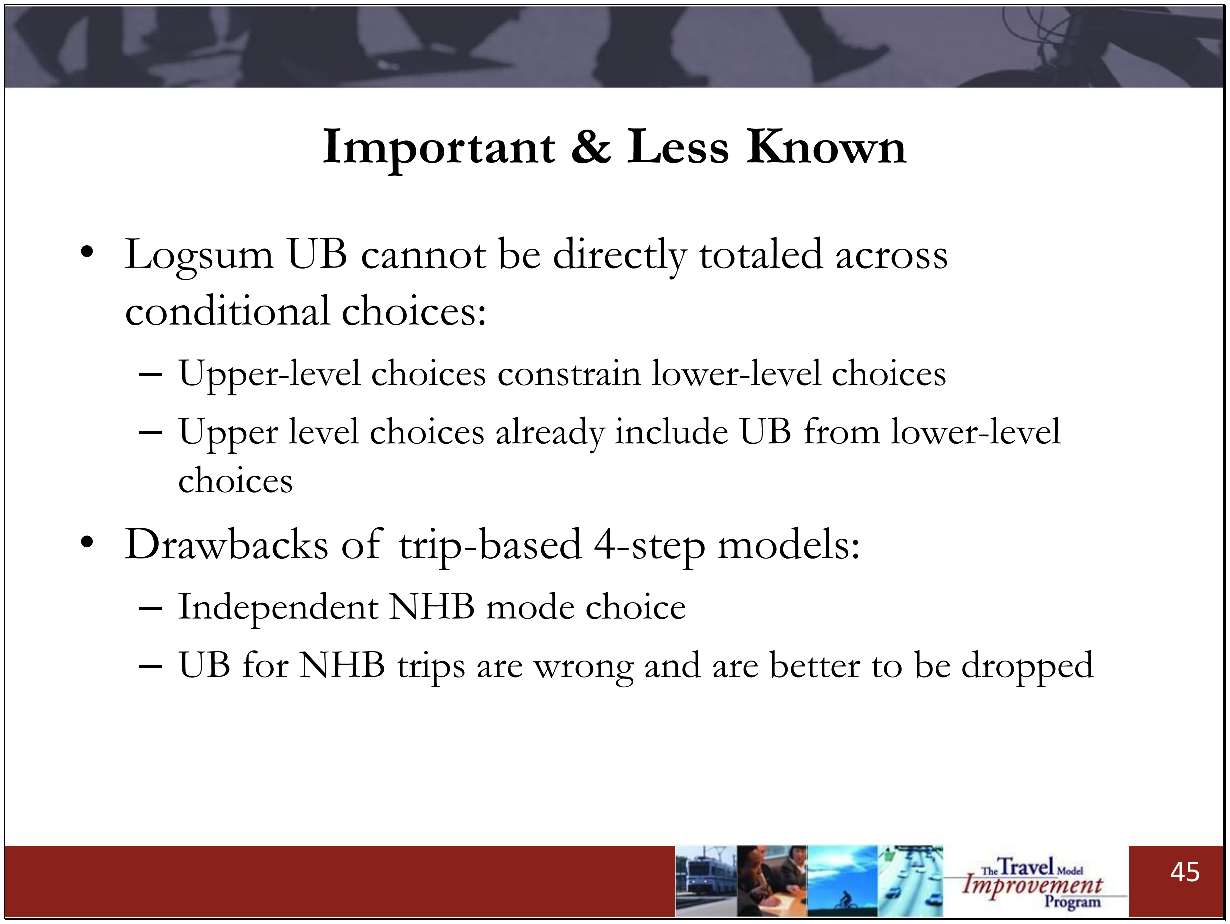
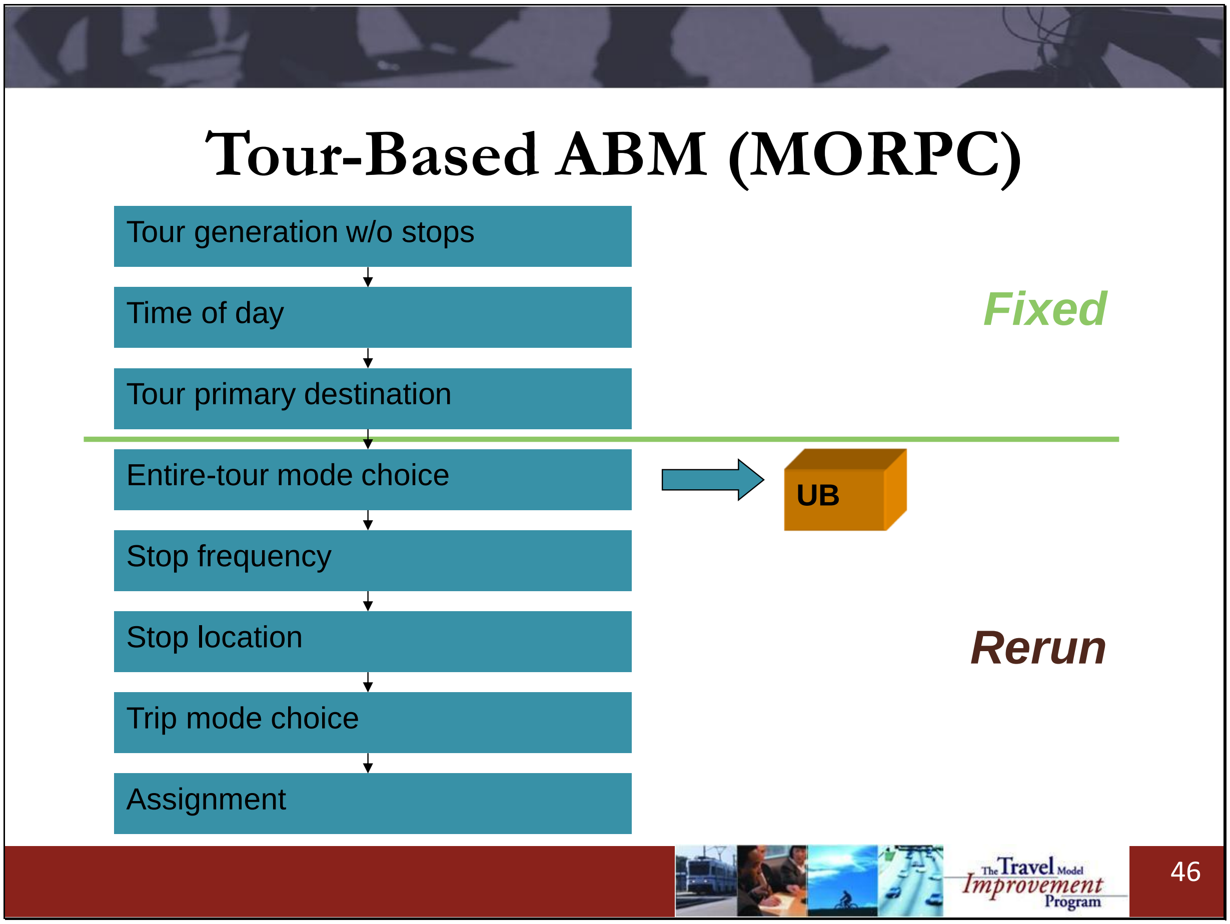
Here is an example of transit user benefits assessed in San Francisco for the new central subway project. This table shows the user benefits for the baseline scenario and the new central subway scenario by trip purpose separately for tours and trips. Most of the user benefits are accumulated at the trip level, but the tour benefits account for about 15% of total user benefits to account for some benefits that cannot be accrued at the trip level.

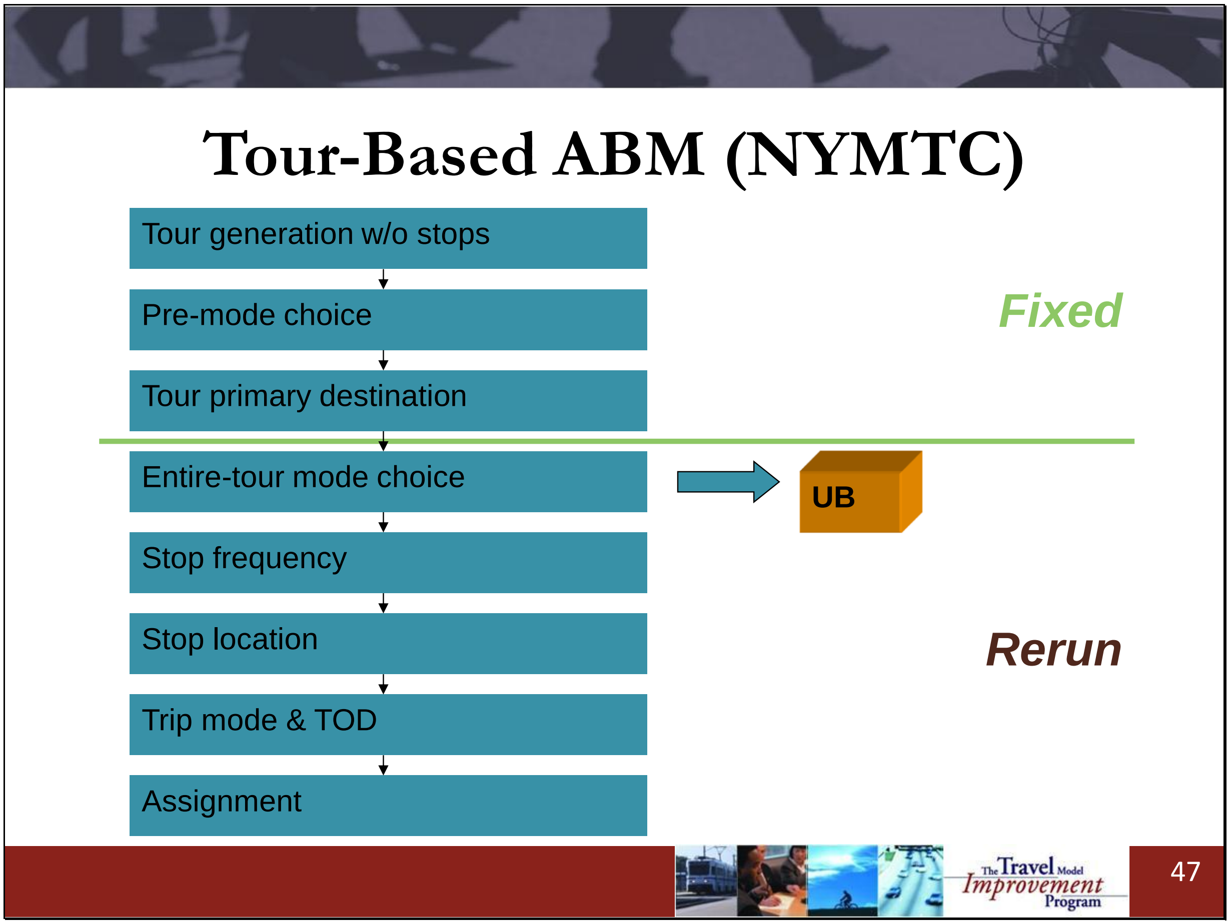
User benefits were negative for work based tours because FTA requires that that destinations be held fixed between the base and the build alternative. This causes complications for work-based sub-tours because work-based sub-tour mode choices are constrained by work tour mode choices. So, for example, if in the baseline a worker drove to work, they would select a destination for a work-based sub-tour assuming the availability of an auto. If in the build scenario they switch their tour mode to transit due to a transit improvement, their work-based sub-tour destination is fixed (and assumed availability of an auto), but may be very inaccessible now if they no longer have an auto mode available for the work-based sub-tour. This results in negative benefits.



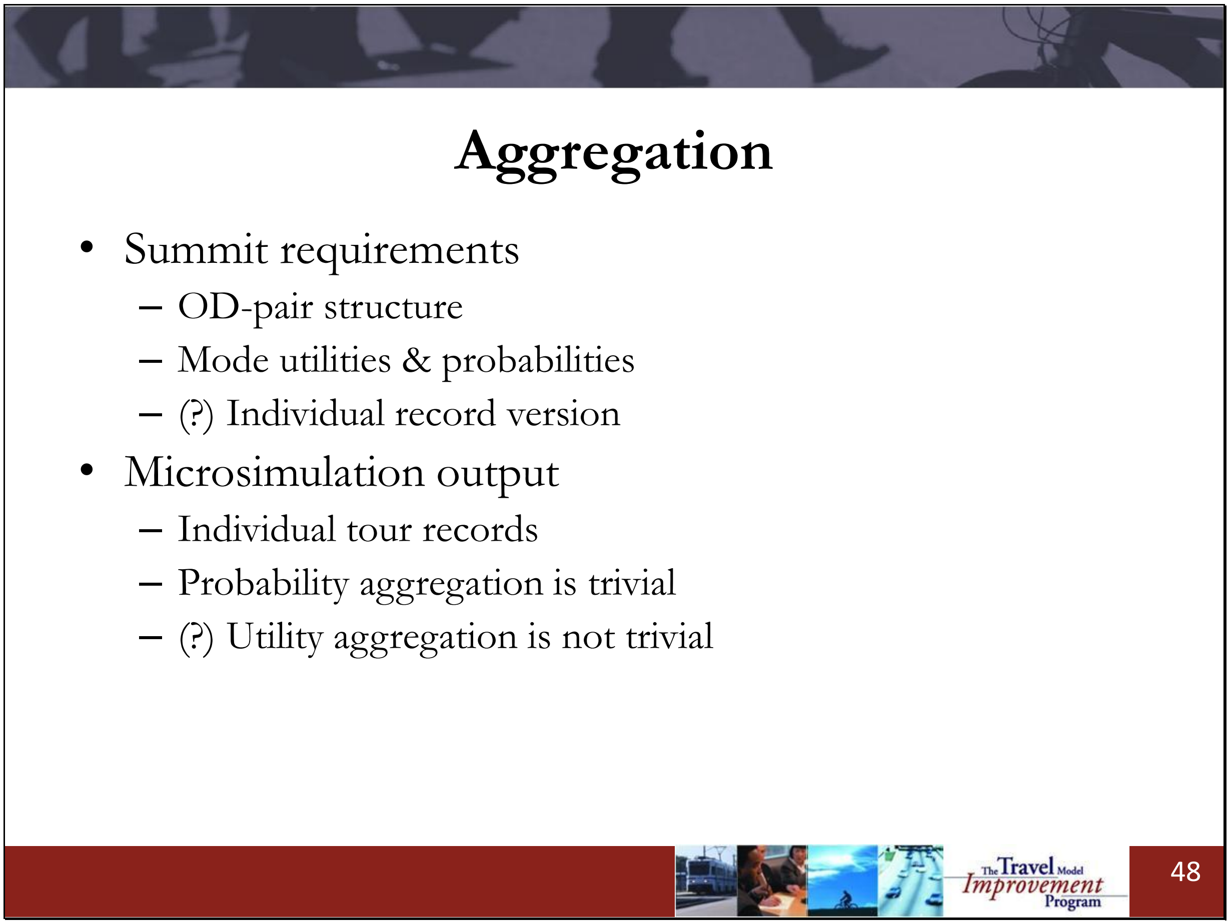
However, certain additional consideration should be taken into account. Log-sum user benefits cannot be directly totaled across conditional choices since upper-level choices constrain lower-level choices and upper-level choices already include user benefits from lower-level choices. In this regard, some drawbacks of trip-based 4-step models should be mentioned. These drawbacks include independent non-home-based (NHB) trip mode choice. User benefits for NHB trips are wrong and are better to be dropped.



A more theoretically consistent approach was adopted for the Columbus activity-based model where user benefits are derived at the tour mode choice level. The upper models are frozen across all scenarios while the lower portion of the model system is rerun for each scenario. It is assumed that the tour-level mode choice shift captures the most important part of the benefits.



Similar approach was adopted for the New York activity-based model where user benefits are derived at the tour mode choice level. The upper models are frozen across all scenarios while the lower portion of the model system is rerun for each scenario. It is assumed that the tour-level mode choice shift captures the most important part of the benefits. However, note the differences in the model structure and especially placement of the time-of-day choice.



The individual micro-simulation activity-based model output cannot be automatically processed by Summit. Summit is set to work with aggregate flows and loop over OD pairs rather than individual records. Several technical step have to be made to aggregate the model output into the Summit input form. These subroutines are run automatically for all activity-based models adapted for the FTA studies.

Utility Aggregation Problem

- Given a set of individual choices with known utilities and probabilities
- Calculate aggregate representative utilities that exactly replicate:
  - Aggregate choice probabilities
  - UB measure (logsum)
- Simple naïve solutions like averaging utilities are wrong

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Aggregation of utilities allows one to swap the original individual-record choice model output with a quasi-aggregate model that produces the same result for SUMMIT. Summit does not know that this is a MCSM model. For the SUMMIT program it looks like a conventional aggregate input.

Utility Aggregation Problem

Modes: $i = 1,2,\ldots,I$

Known individual:	Known aggregate:
$n = 1,2,\ldots,N$ $P_n(i)$	$P(i) = \dfrac{\sum_n P_n(i)}{N}$
	Unknown aggregate:
V_{in}	V_i

Let's introduce the following notation and given inputs. We have to calculate the unknown aggregate mode utilities.

Sufficient Conditions (MNL)

1. Probability replication:

$$\frac{\exp(V_i)}{\sum_{j=1}^{I} \exp(V_j)} = P(i)$$

2. Logsum replication:

$$\ln\left[\sum_{j=1}^{I} \exp(V_j)\right] = \left\{\sum_{n=1}^{N} \ln\left[\sum_{j=1}^{I} \exp(V_{jn})\right]\right\} \Big/ N$$

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I want to replace a set of individual choices with one aggregate choice (to eliminate index n). It is done through formulation of two logical conditions. First, we want to replicate mode probabilities. Secondly, we want to replicate the user benefits log-sum measure.

Equivalent Transformation

1. Probability replication:

$$\exp\left(V_i\right) = P\left(i\right) \times C$$

where $C = \sum_j \exp\left(V_j\right)$

2. Logsum replication:

$$\sum_{j=1}^{I} \exp\left(V_j\right) = C = \prod_{n=1}^{N} \left[\sum_{j=1}^{I} \exp\left(V_{jn}\right) \right]^{\frac{1}{N}}$$

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The first condition sets the expression for utilities with unknown constant scale. The second condition helps identify the scale. After the equivalent transformations and substitutions we obtain the expression for utilities.

Unique Solution

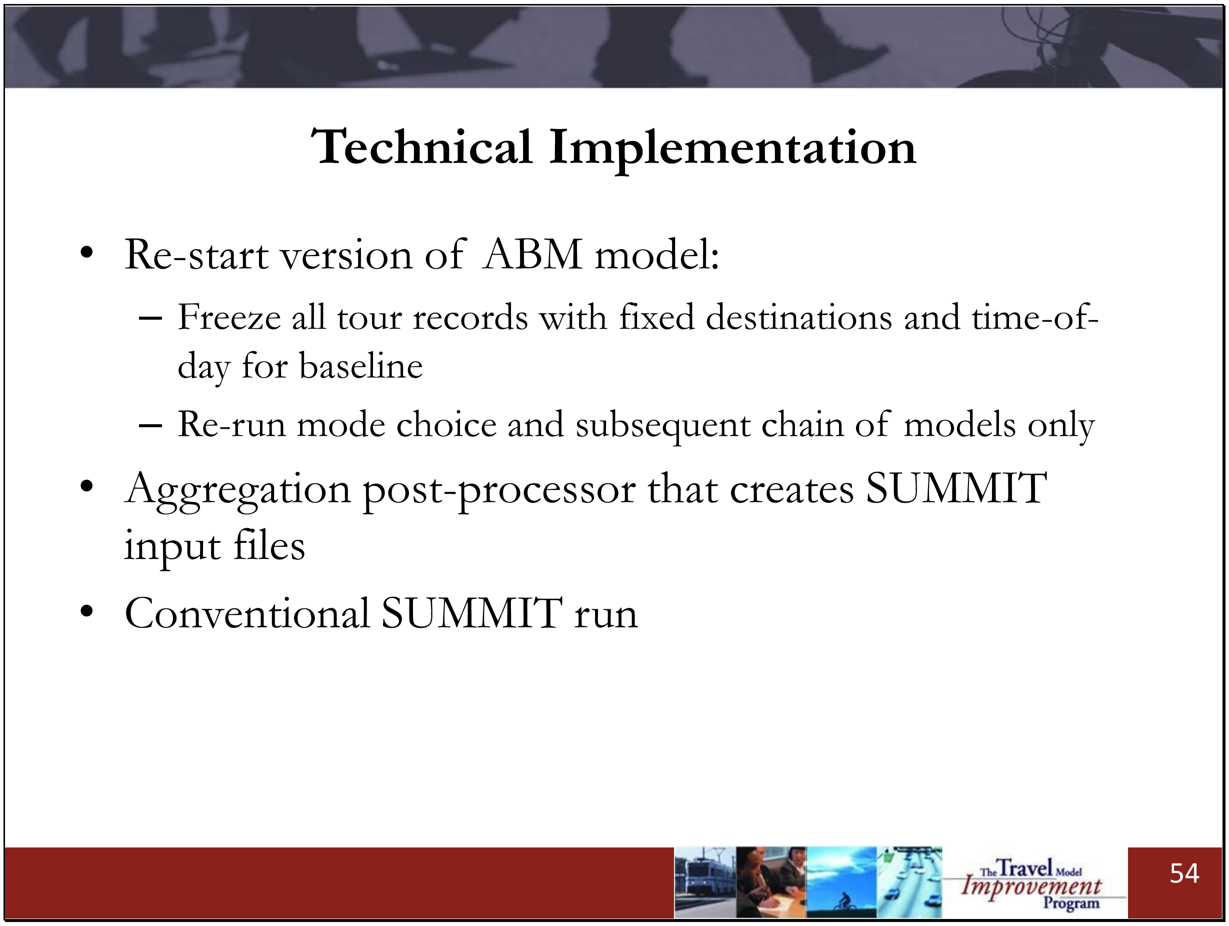
Substituting 2 to 1:

$$\exp\left(V_i\right) = P(i) \times \prod_{n=1}^{N} \left[\sum_{j=1}^{I} \exp\left(V_{jn}\right) \right]^{\frac{1}{N}}$$

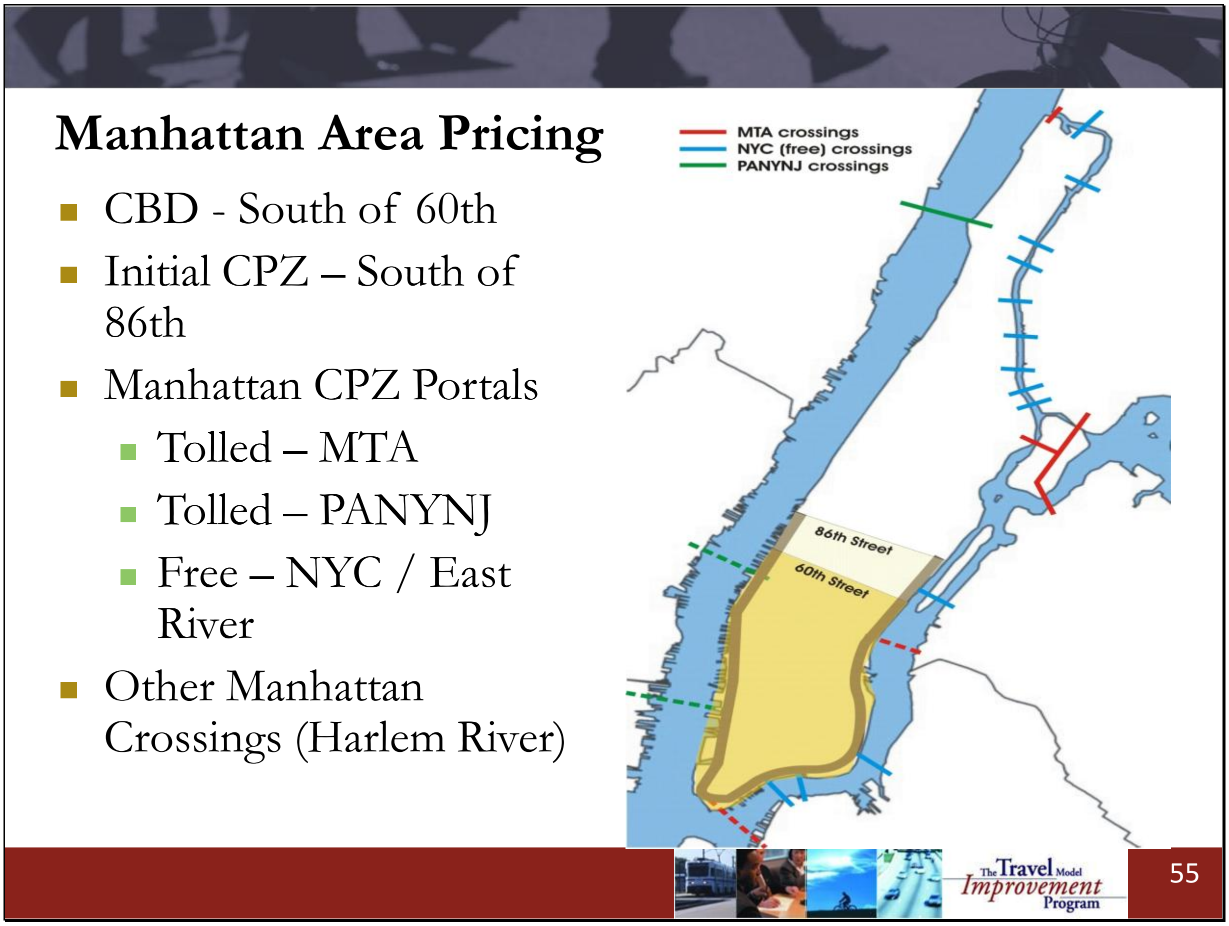
or equivalently:

$$V_i = \ln P(i) + \frac{1}{N} \sum_{n} \ln \left[\sum_{j=1}^{I} \exp\left(V_{jn}\right) \right]$$

The solution is unique and easy to calculate. It is also subject to interesting behavioral interpretations. In particular, what we created is an aggregate choice model counterpart to the disaggregate choice model.

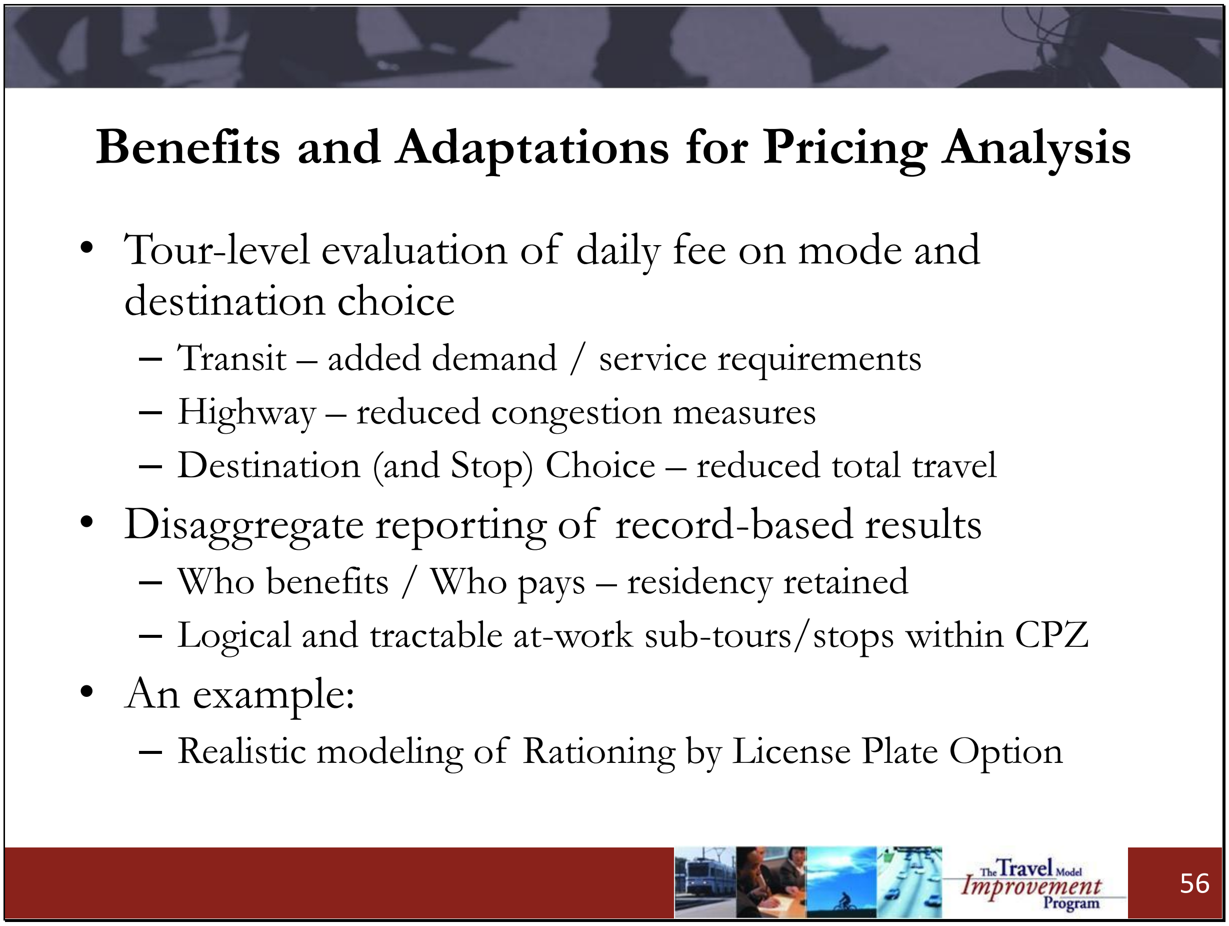


There have been new starts user benefits analysis for San Francisco and Columbus that involved post-processing of model results for use in FTA's SUMMIT program. Since the San Francisco activity based modeling platform is in the DaySim family of models, this post-processing could be used with other DaySim models. And since the Columbus model is in the CT-RAMP family of models, this post-processing could be used with other CT-RAMP models. This is a good example of how these model applications can be reused or adapted from place to place to the level of effort for future new starts model applications.

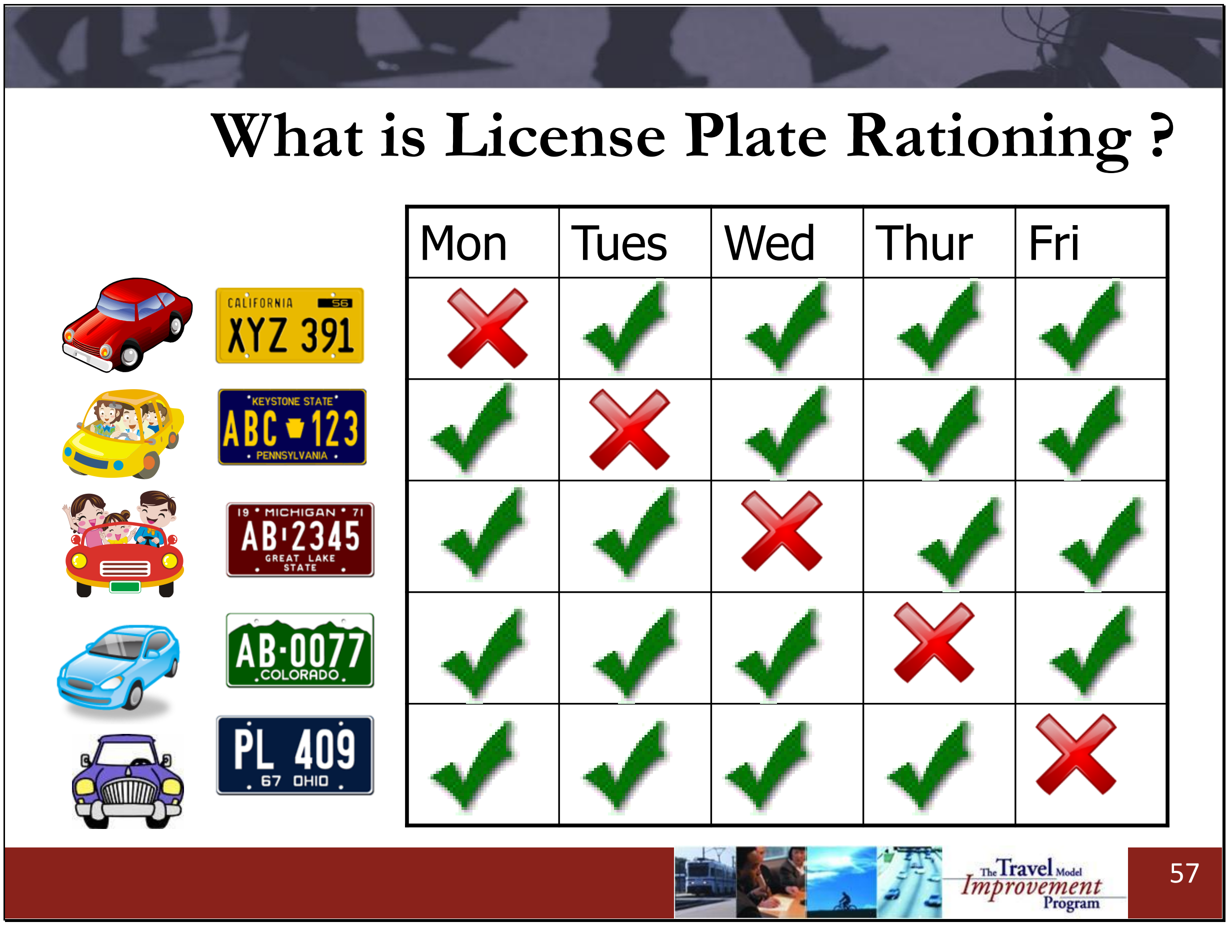


One interesting example of an application of activity-based model is the Manhattan Area Pricing Study. The pricing study included multiple options to model:

- **Type of Charge:** Fee (once a day),Toll (recurring)
- **Rate to be Charged:** Amount charged, Flat vs. variable time of day, 12 hour or 24 hour, Toll offsets (MTA or PA tolled crossings)
- Northern Boundary of CP zone: 86th St, 60th St
- **Policy for Trip Types:** Intra-Zone: Staying in the zone, Through trips - on FDR and Rt. 9A peripheral route, 2-way (inbound and outbound), 1-way (inbound only), Vehicle Type (auto, truck, and taxis)

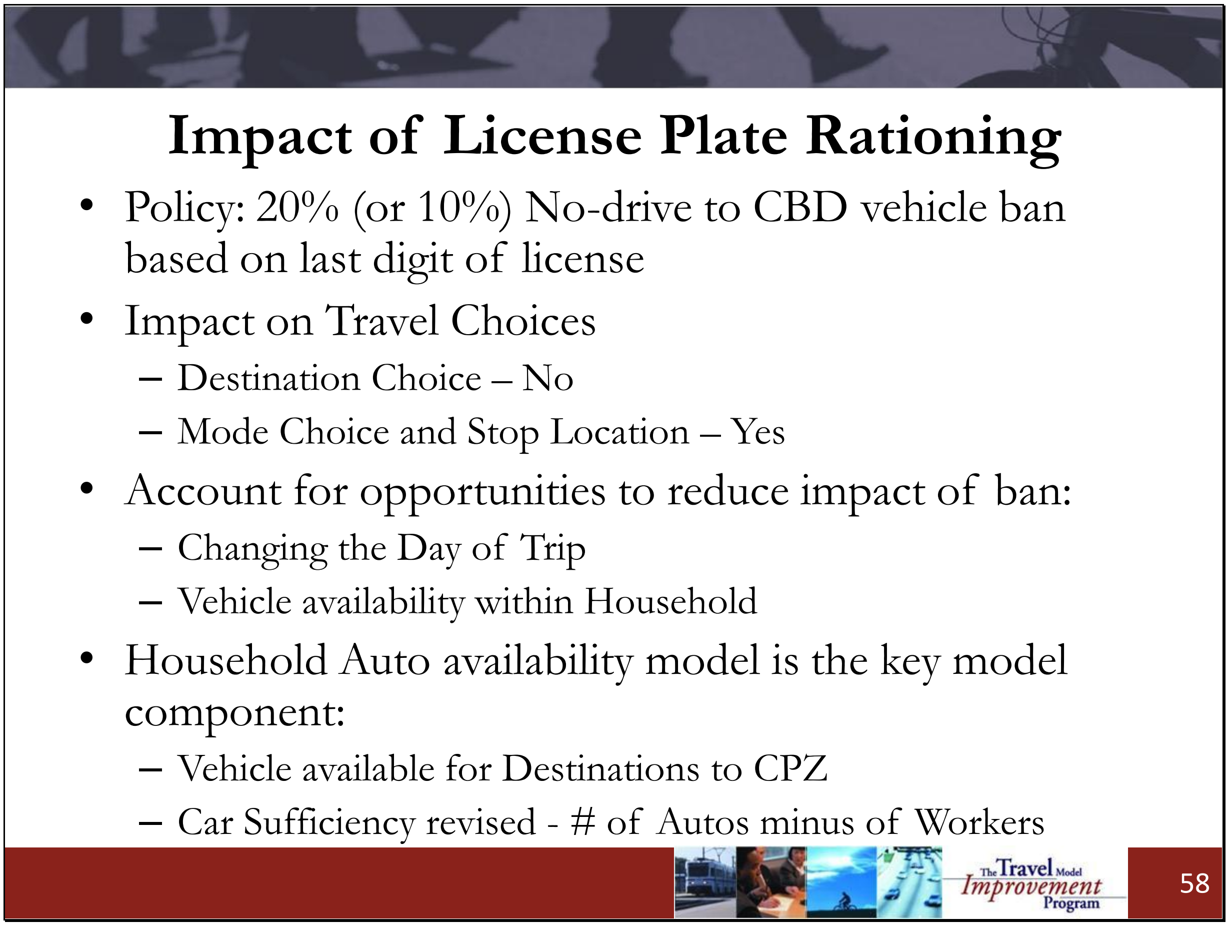


The activity-based model offers multiple benefits, but also requires some adaptations depending on the pricing form. Tour-level evaluation of daily fees on mode and destination choice require the added demand / service requirements for transit; measures of educed congestion on highways; and measures of reduced travel due to changes in destination (and stop) choices. Disaggregate reporting of record-based results allows one to analyze who benefits and who pays because the model keeps track of where travelers live. This is also logical and tractable for analysis of at-work sub-tours/stops within the Central Pricing Zone (CPZ). An example that we would like to discuss is the “Realistic modeling of Rationing by License Plate Option.”



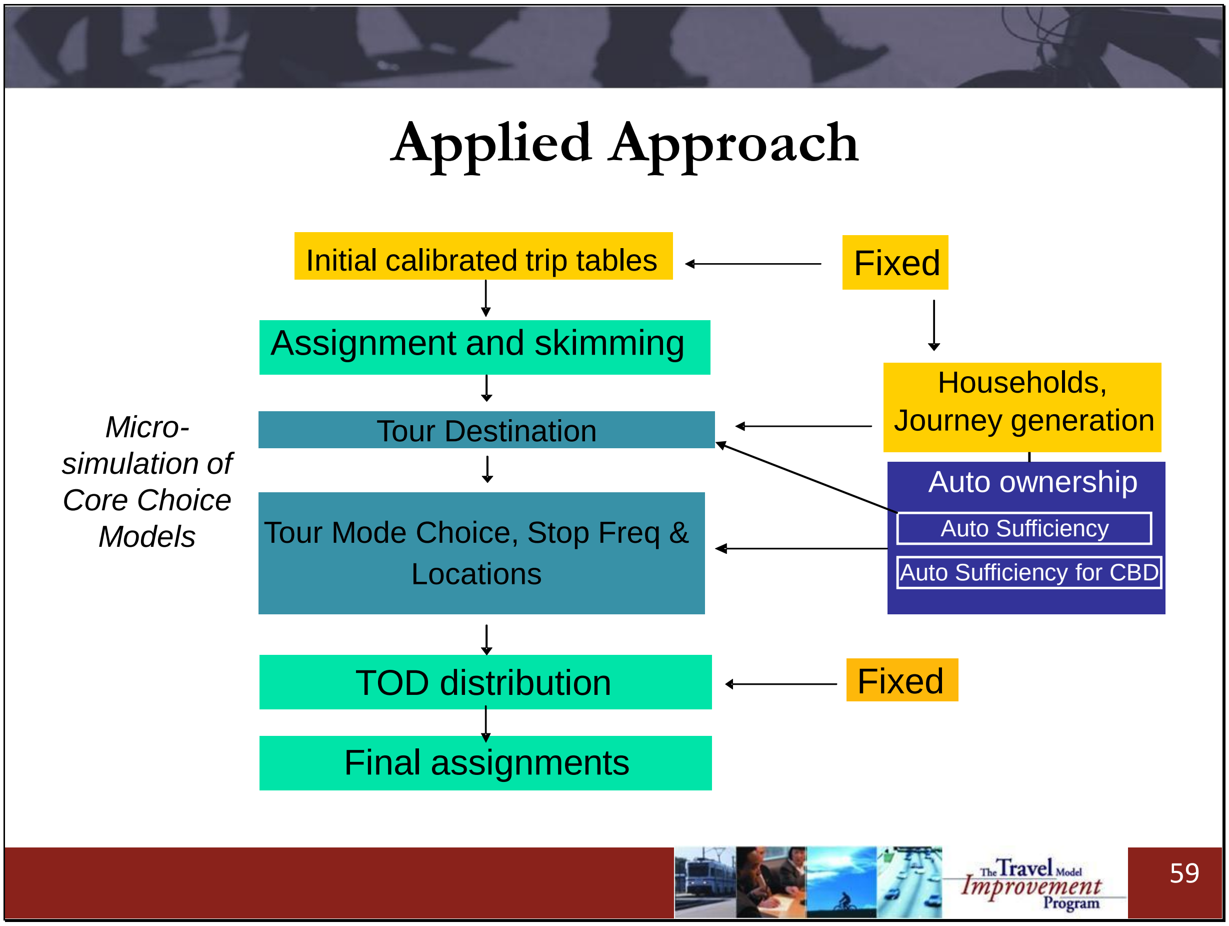
	Mon	Tues	Wed	Thur	Fri
XYZ 391	✗	✓	✓	✓	✓
ABC 123	✓	✗	✓	✓	✓
AB 2345	✓	✓	✗	✓	✓
AB 0077	✓	✓	✓	✗	✓
PL 409	✓	✓	✓	✓	✗

License plate rationing (LPR) is a policy where certain cars are prohibited from driving into the CPZ at certain hours and days based on the license plate number. An example is shown on this slide.



The impact of License Plate Rationing is one in which 20% (or 10%) of drivers are prohibited from driving in the CBD on certain days, based on last digit of license. LPR has affects travel choices such that there is no impact on the primary destination choice (usually work), but there are definite impacts on mode and intermediate stop location choices.

In modeling, we must account for opportunities to reduce the impact of ban, such as changing the day of trip and vehicle availability within household. The household auto availability model is the key component, because it determines whether vehicles are available for destinations in the CPZ. In addition, car sufficiency need to be revised to reflect the number of autos minus the number of workers.



The applied approach takes a full advantage of the micro-simulation structure and would not be possible with an aggregate 4-step model. Essentially, the car ownership sub-model adjusts car sufficiency for the corresponding tours and trips based on the LPR percentage. This affects all subsequent choices for the affected tours (mode, time of day, stop frequency, etc.).

License Plate Rationing – 20%
Auto Availability Model

Random #'s for tagging

HH#	Wkrs	Autos	Car Suff	a1	a2	a3	a4
1	2	3	1				
2	1	1	0				
3	1	2	1				
4	1	1	0				
5	2	4	2				
6	2	2	0				

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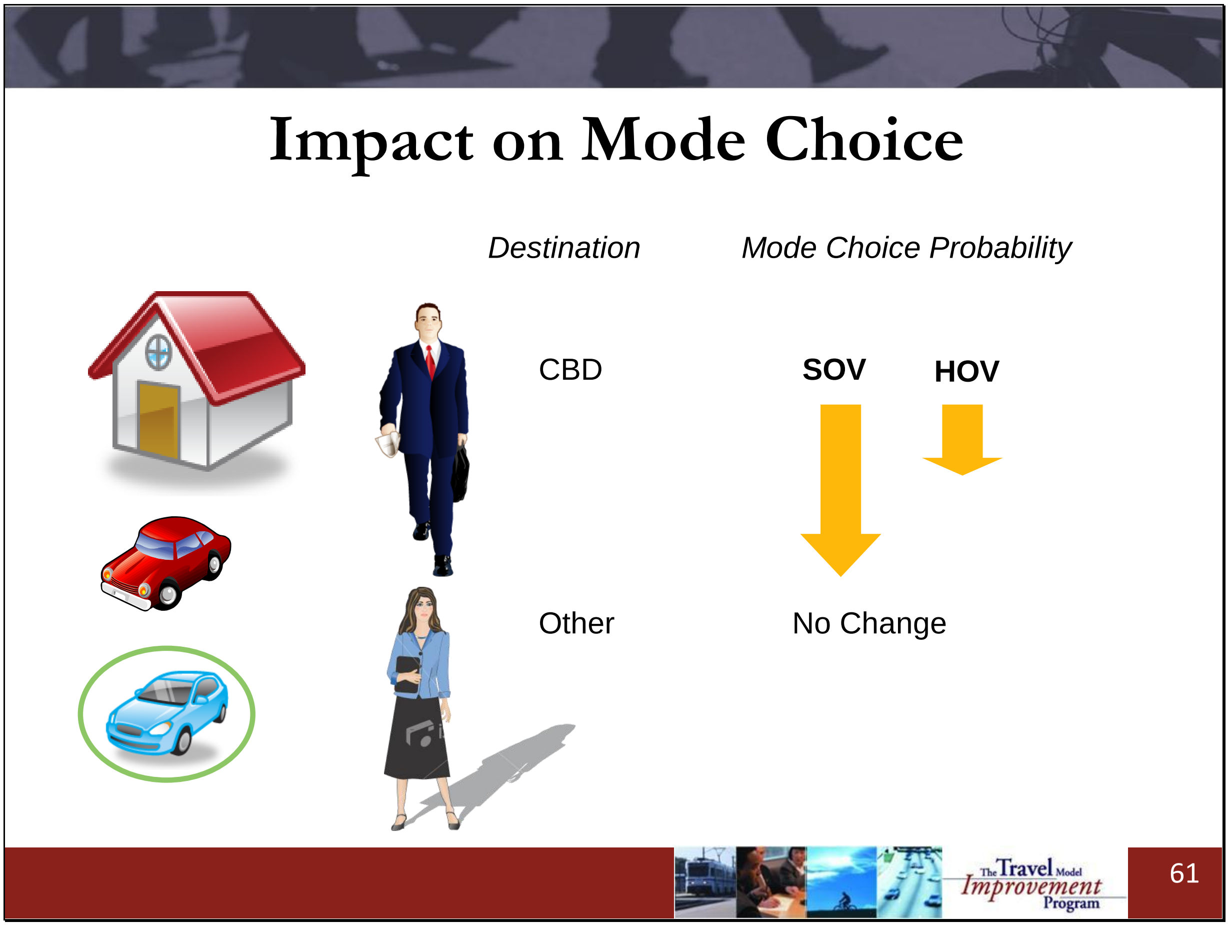
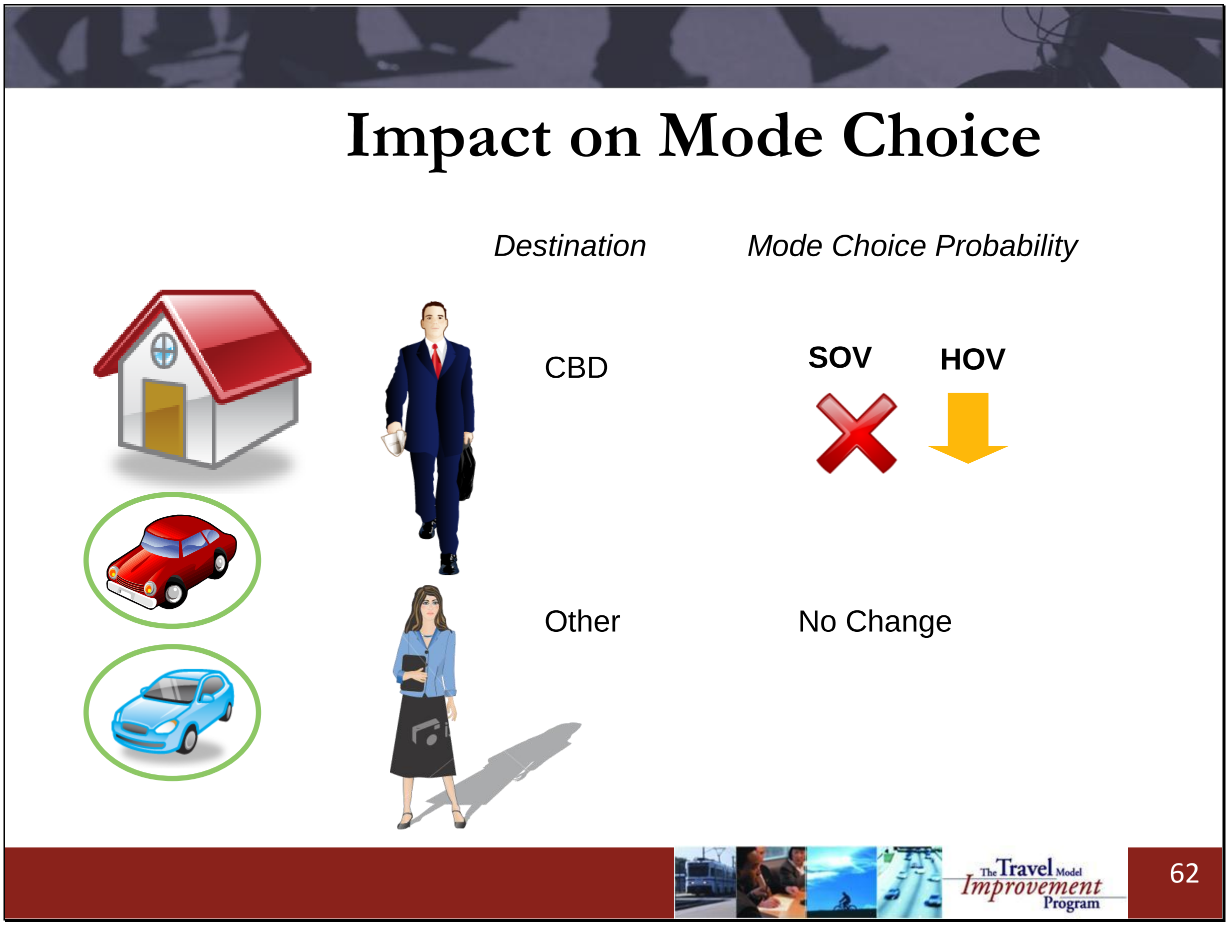
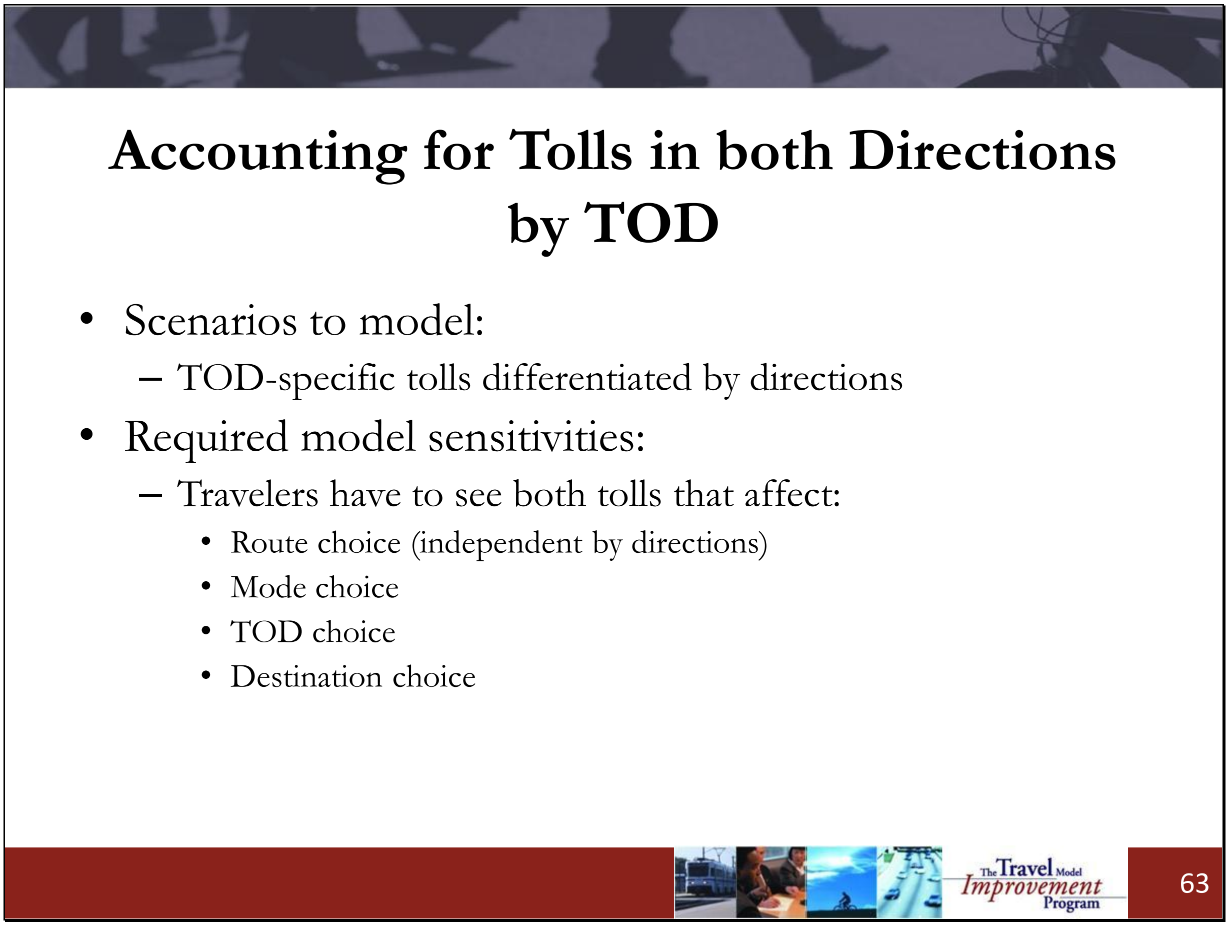
This example illustrates how the adjustments are made for individual records. Note that car sufficiency is calculated as a difference between the number of cars and number of workers. Some of the cars are randomly tagged as banned based on the LPR percentage.



Consider a household with two workers and two cars when one of the cars is subject to LPR. This would affect probabilities of the corresponding person to travel by SOV or HOV quite negatively (SOV might be reduced to practically zero).



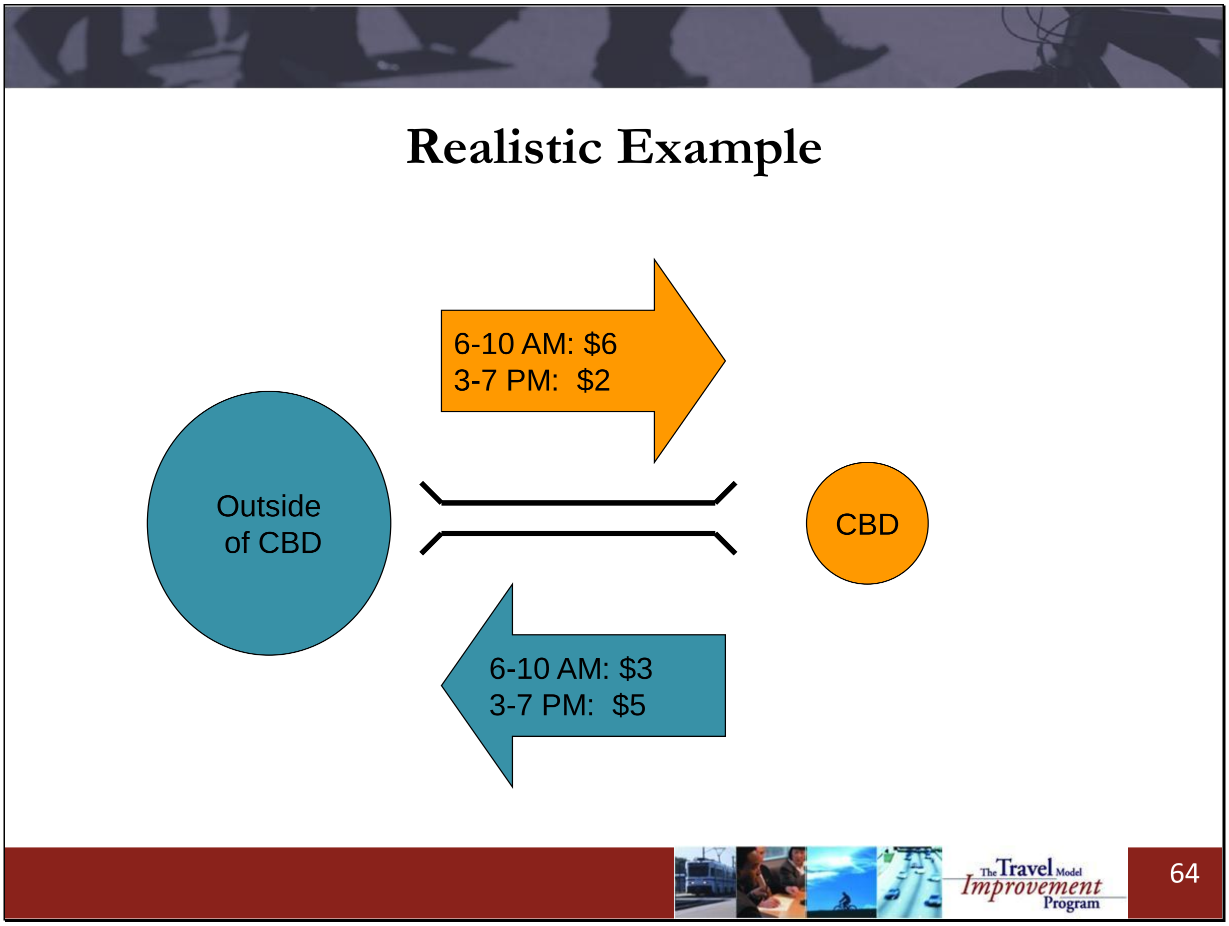
In this example, the first person would probably have to switch mode to HOV or transit, depending on their availability.



Let's put this discussion into a broader contest of pricing studies. A very important aspect that cannot be really addressed with a 4-step model is "Accounting for Tolls in both Directions by time-of-day." Scenarios to model include time-of-day-specific tolls differentiated by directions.

Required model sensitivities can be formulated as, "Travelers have to see both tolls that affect":

- Route choice (independent by directions);
- Mode choice;
- Time-of-day choice; and
- Destination choice.



Consider a realistic example where tolls are set by directions as shown in the slide. Tolls are high for travel to and from the Congestion Pricing Zone (CBD) in the corresponding peak periods.

True Tolls Paid by Commuters

Outbound time	Inbound time	Toll, $
Earlier than 6AM	Earlier than 6AM	
Earlier than 6AM	6-10AM ($3)	3
Earlier than 6AM	10AM-3PM	
Earlier than 6AM	3-7PM ($5)	5
Earlier than 6AM	Later then 7PM	
6-10AM ($6)	6-10AM ($3)	9
6-10AM ($6)	10AM-3PM	6
6-10AM ($6)	3-7PM ($5)	11
6-10AM ($6)	Later then 7PM	6
10AM-3PM	10AM-3PM	
10AM-3PM	3-7PM ($5)	5
10AM-3PM	Later then 7PM	
3-7PM ($2)	3-7PM ($5)	7
3-7PM ($2)	Later then 7PM	2
Later then 7PM	Later then 7PM	

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This setting of tolls results in a wide range of toll values paid by commuters depending on the time-of-day choice combinations as you can see on the slide. Tolls range from zero up to $11. How can we make this complicated reality modeled?

Modeling True Tolls & LOS

- With 4-step model:
  - Impossible to ensure any reasonable level of consistency across trip distribution, mode choice, and time of day choice
- With tour-based ABM:
  - It is still difficult to ensure a full consistency, but a much better job can be done

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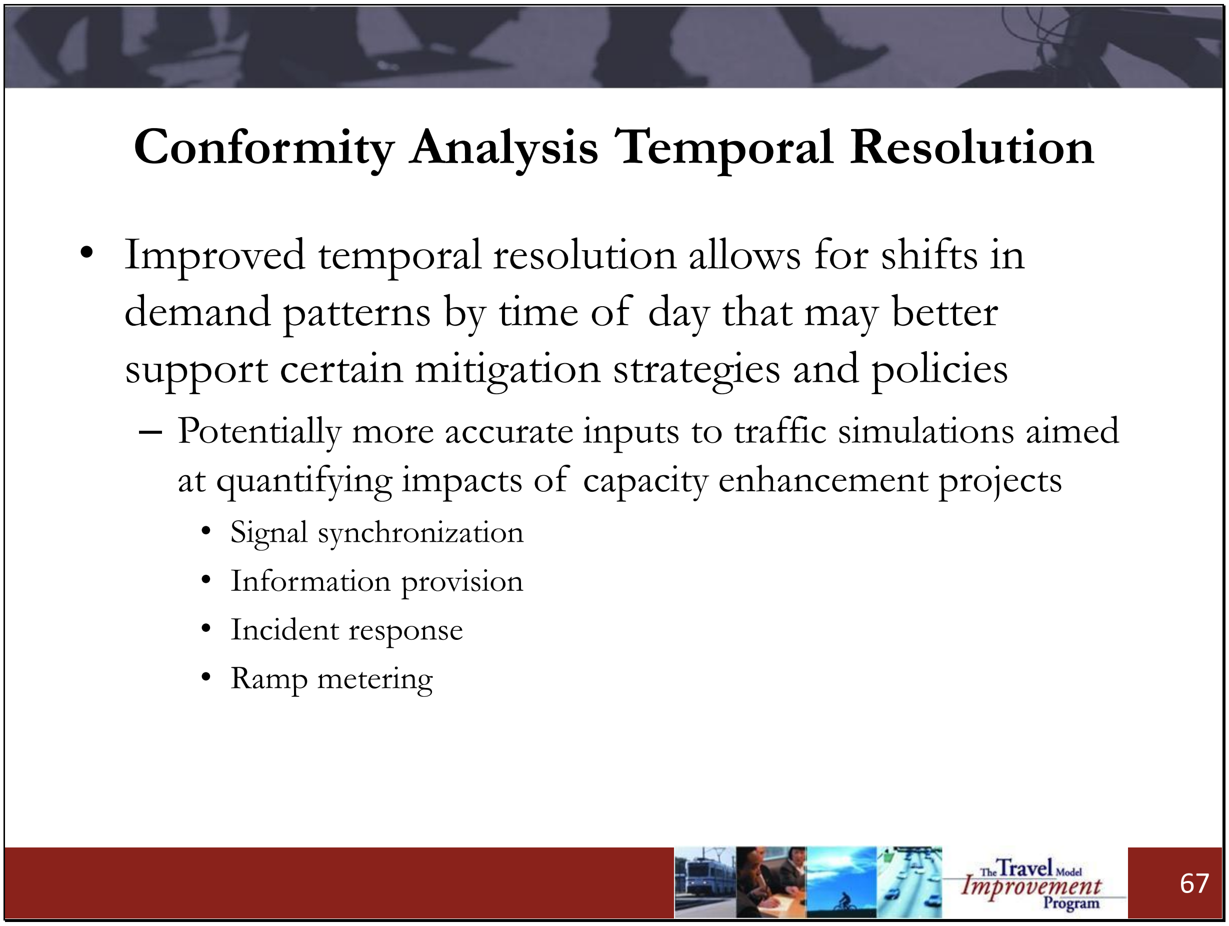
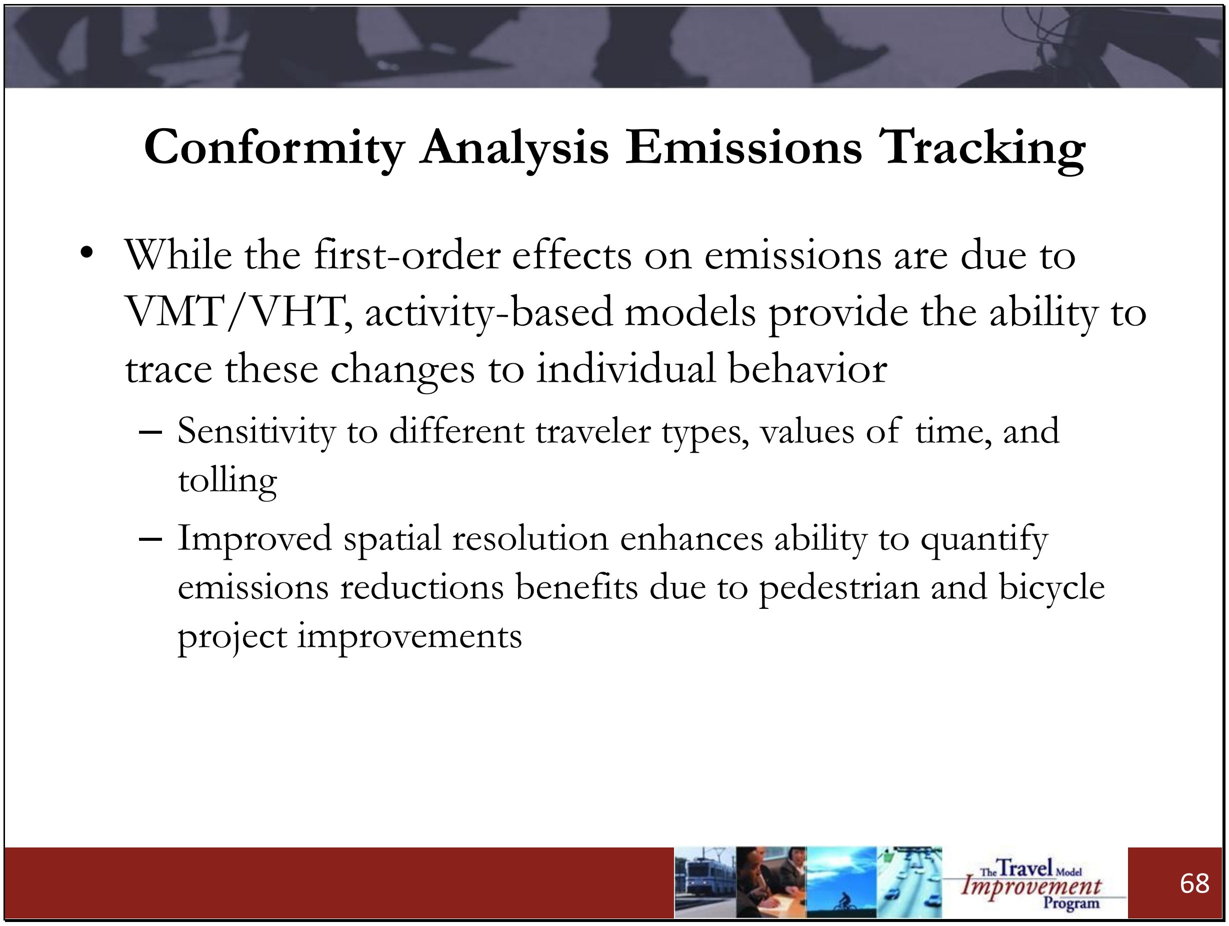
This is not simple but the activity-based model framework allows for much better behavioral realism. With 4-step model, it is impossible to ensure any reasonable level of consistency across trip distribution, mode choice, and time of day choice. With tour-based activity-based model, it is still difficult to ensure a full consistency, but a much better job can be done.



Conformity analysis is highly dependent on temporal traffic conditions and this additional level of detail within activity based models is more effective at analyzing certain mitigation strategies and policies. Many activity based models generalize these time periods when using an aggregate trip assignment methodology and so may lose some of the advantages for temporal resolution. If the activity based model is integrated with a traffic simulation model then these advantages can be retained and more accurate impacts of capacity enhancement projects will be available for conformity analysis. Some of the projects that may be difficult to quantify for conformity without this linkage to traffic simulation include ramp metering and incident response strategies.



One drawback of trip based models for conformity analysis has always been the inability to trace emissions back to the source. Activity based models allow the accumulation of the emissions at the household level in addition to reporting at the link level. It is important to report emissions for different traveler types or different values of time because this is how policies could affect traveler behavior. Another useful aspect of activity based models for tracking an

Some of the more important benefits to activity-based models are the additional performance metrics that one can produce. In some ways, regional transportation planning practices are driving this need for additional performance metrics. We have already mentioned some of these, and provided examples, but these are the metrics that are more commonly being required for RTPs. They include equity measures, often across household income categories but sometimes along other dimensions, emissions at the household level for policies around greenhouse gases and other pollutants, energy use of vehicles and buildings, user benefits for economic sectors, and induced travel.

Model Performance

- Model design drives computational performance—user requirements for computational performance constrain model design
- Custom software is needed to implement demand components of activity-based models
  - General purpose commercially available travel demand modeling software is not designed to handle all of the special decision structures, data pathways and accessibility variable calculations, and not designed to forecast using simulation methods
- Hardware and software considerations are a tradeoff
  - Distributed processing across many computers; additional computers reduces run times
  - Optimized software can reduce run times as well

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Why is activity-based modeling performance important? Model performance is a practical matter that agencies need to consider in order to provide information to decision-makers in a timely manner. For many years the model performance was not reasonable for practical applications of activity based models and hindered their adoption. Today, however, activity based model performance has improved and is well within the reasonable range for practical applications. That said, there are integrations with the land use and traffic or transit simulation models that are still beyond the realm of reasonable model performance and these integrated models will not be widely adopted until the computational performance improves. Fortunately there are many research programs and active software development working on these challenges. In addition the computational performance of activity based models continues to improve. Currently custom software has been developed to implement activity based models because general purpose commercially available travel demand modeling software is not designed to handle the decision structures or data pathways needed.

Hardware and software are often a trade-offs with activity based models where distributed processing and multi-threading can improve computational performance but require additional resources for hardware. There are activity based model applications running on single computers with reasonable computational performance and other activity based model applications that require significant hardware investments to achieve reasonable computational performance. Computational performance is directly tied to the size of the population for the region and the custom software being applied.

Custom Application Programs

- Many different ABM developers have created custom application programs for specific projects
- Typically free, open-source licensing, but code availability may be restricted to clients of developers and/or difficult to implement without developer assistance
  - Users pay for developer expertise and assistance in the development of data, model structures, parameters and calibration
  - Users may benefit by upgrades in subsequent applications for other regions

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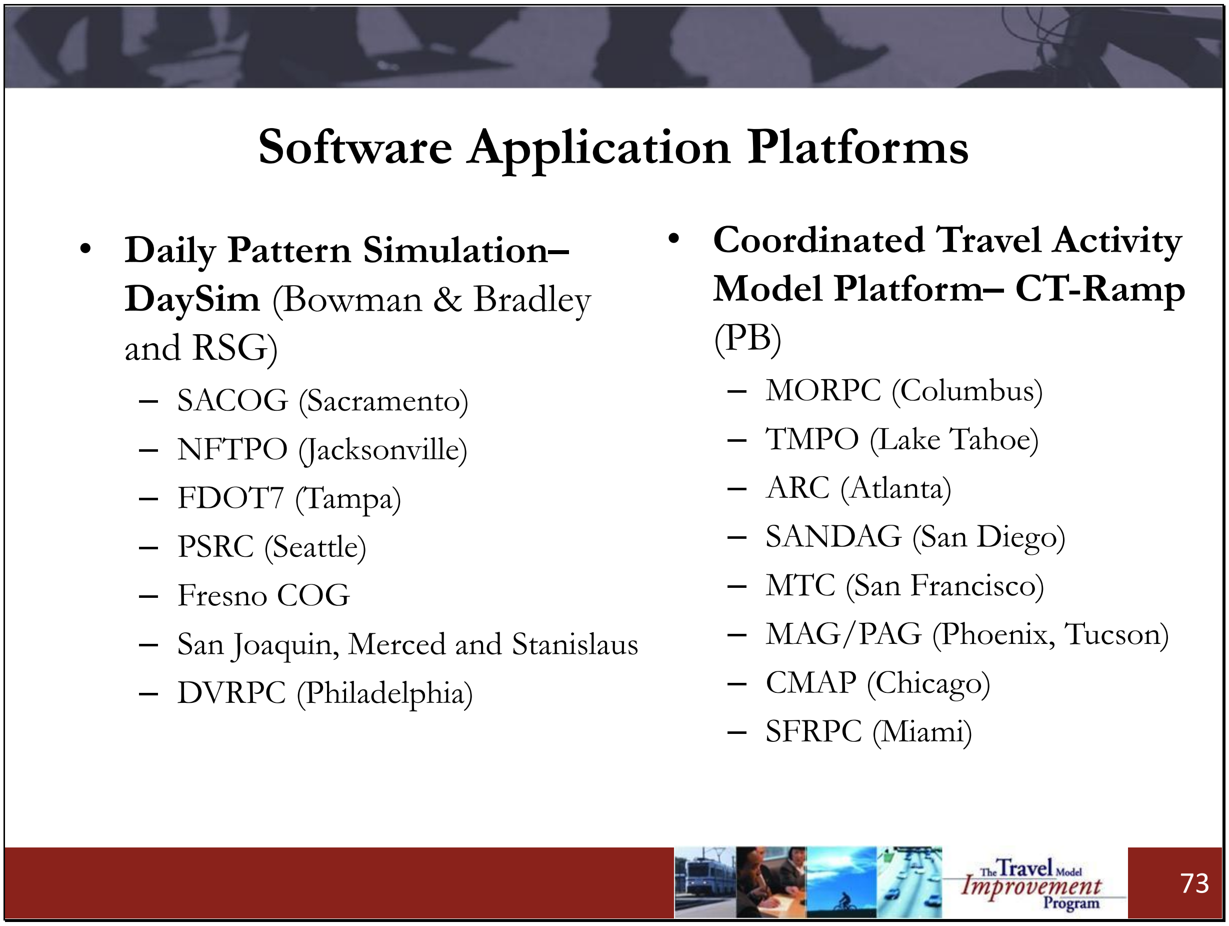
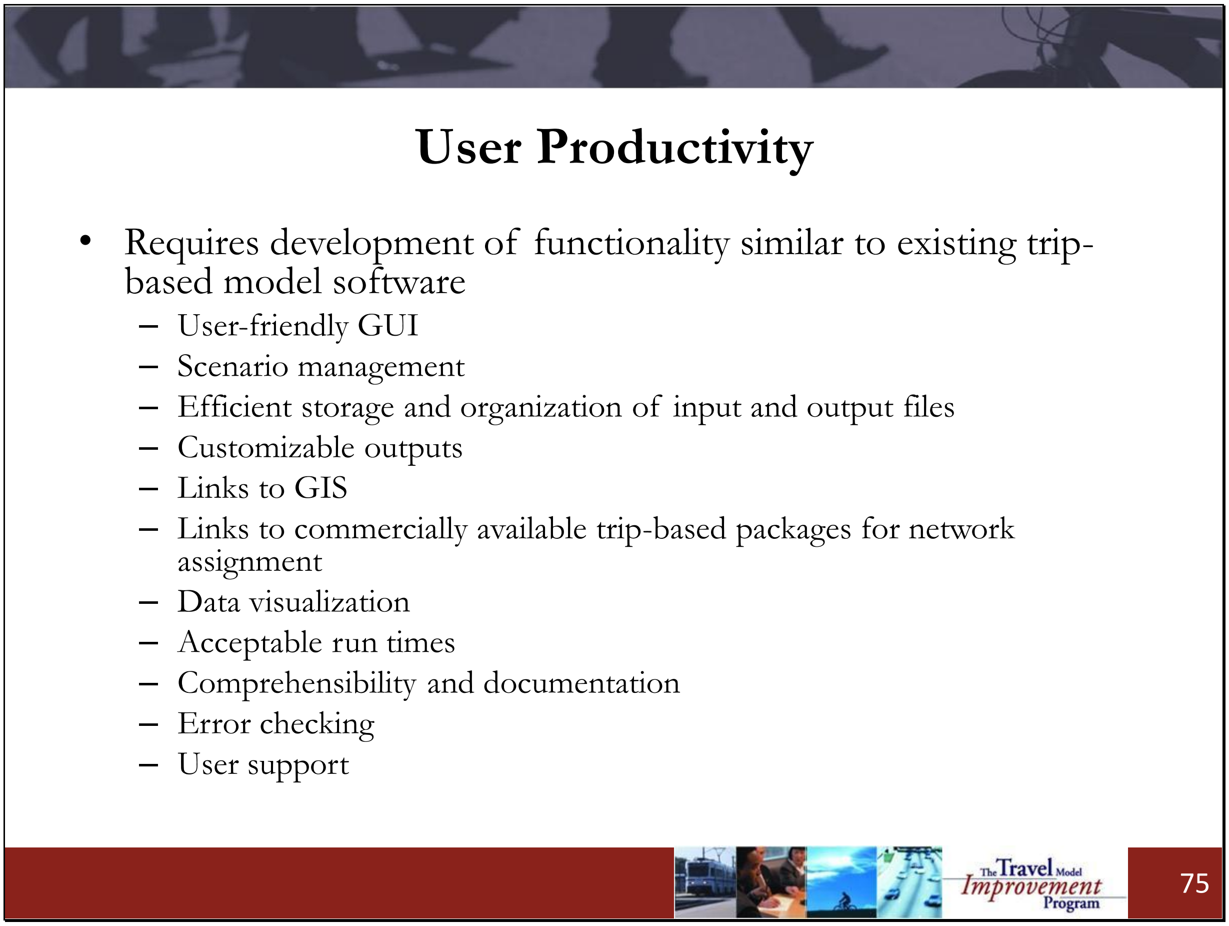
There are many different activity based model custom application programs developed for specific projects. Some of these have grown as subsequent projects have built upon earlier projects to produce more robust platforms. Many of these custom application programs are open source, and therefore freely available, but code may be difficult to interpret without developer assistance. Users of these platforms have contributed to the development of the software through individual projects and benefit from software improvements funded by other agencies if they choose to upgrade. Users are beginning to collaborate to take advantage of synergies for software development.



Consultant-developers with repeated experience in applying similar models in different locations have refined and branded their software platforms. There are two software platforms that are common in the U.S. One of these is the daily pattern simulation model called DaySim and is in use by eight MPO’s in the U.S. The other platform is the coordinated traveler activity model platform called CT-RAMP and is in use by seven and MPO’s in the US.

There are also teams of academic researchers that have branded their products and implemented or are now attempting implementations in select locations. These include custom software written by DRCOG and CS in Denver for the FOCUS model, SimAGENT developed by U. of Texas-Austin, U.C.-Santa Barbara, and Arizona State U. for SCAG in Los Angeles; SimTravel developed by ASU, UC Berkeley, and U. of Arizona for a FHWA research project with a case study in Phoenix; MatSim developed by ETH in Zürich and TU-Berlin for the Switzerland national model and several European cities; the ILUTE model developed by the University of Toronto and for Metrolinx; the Albatross model developed by Eindhoven University for applications in the Netherlands; and the DASH model developed by Portland State University and RSG for Portland Metro. These software applications demonstrate a wide variety of activity based modeling methodologies.



In addition to the custom software applications for activity based models, there are a series of additional software tools needed to provide functionality for the travel demand forecasting which system which is similar to utility tools used for existing trip-based model software. Even if these utility tools exist for trip based models, they require adaptation to integrate them with activity based modeling software. These are the types of user friendly functionality that users have come to expect with travel demand forecasting models.

Data Structures & Computational Requirements

- Greater complexity and resolutions leads to greater computational requirements
- Theoretical justification of system features is tempered with computational realities
- Model developers have experimented with and developed methods for getting as much out of an activity-based model system design as possible, while respecting computing budgets
  - System design compromises, simplifications necessary
  - Adding computational power—distributed processing

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Other factors influencing computational performance are the temporal and spatial resolutions and the complexity of the data and modeling structures. These structure and level of detail tradeoffs are determined during model design and not easily adjusted once the model is complete. Fortunately, software optimization continues to improve computational performance. Distributed processing and multi-threading are computational methods to reduce run time and have been quite successful in reducing run times for activity based models.

Run Times with Different Configurations

	ARC	MORPC	SACOG	SACOG
Households	1,760,000	610,774	1,250,000	700,000
Number of Global Iterations	3	3	10	10
Intra-household Interactions	Yes	Yes	No	No
Spatial Resolution	Zones	Zones	Parcels	Parcels
Run Times (hours)				
Without distribution/threading	146		33	
Households per hour per iteration	36,164		384,615	
Households per hour per iteration per processor	4,521		96,154	
With distribution/threading	16	36		16
Households per hour per iteration	330,000	50,898		437,500
Households per hour per iteration per processor	41,250			109,375
Specifications				
Hardware without distribution	8 processors, 16GB RAM, 1 computer		4 processors, 12 GB RAM, 1 computer	
Hardware with distribution	24 processors, 48GB RAM, 3 computers	3 computers		4 processors, 3.2 GB RAM, 1 computer
Software	CT-RAMP	CT-RAMP	DaySim	DaySim

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Intra-household interactions add a lot to run times (SACOG 96k households per hour per iteration per processor compared to ARC with 4.5k). This doesn't completely separate other software differences or the fact that SACOG has a finer resolution than ARC (parcels vs. zones) which requires much more programming. These statistics were derived from the CMAP strategic plan for advanced model development (June 2010).

Example of Model Design Tradeoffs: Fine-grained Spatial Resolution

- Includes micro-zones and parcels
- Potential explosion in point-to-point routing, memory utilization and access, and disk storage requirements
- Compromise through hybrid, hierarchical spatial unit processing schemes
  - TAZ routing of highway and transit vehicles
  - Micro-zone/parcel routing of walk and bike paths (SACOG example with run times)

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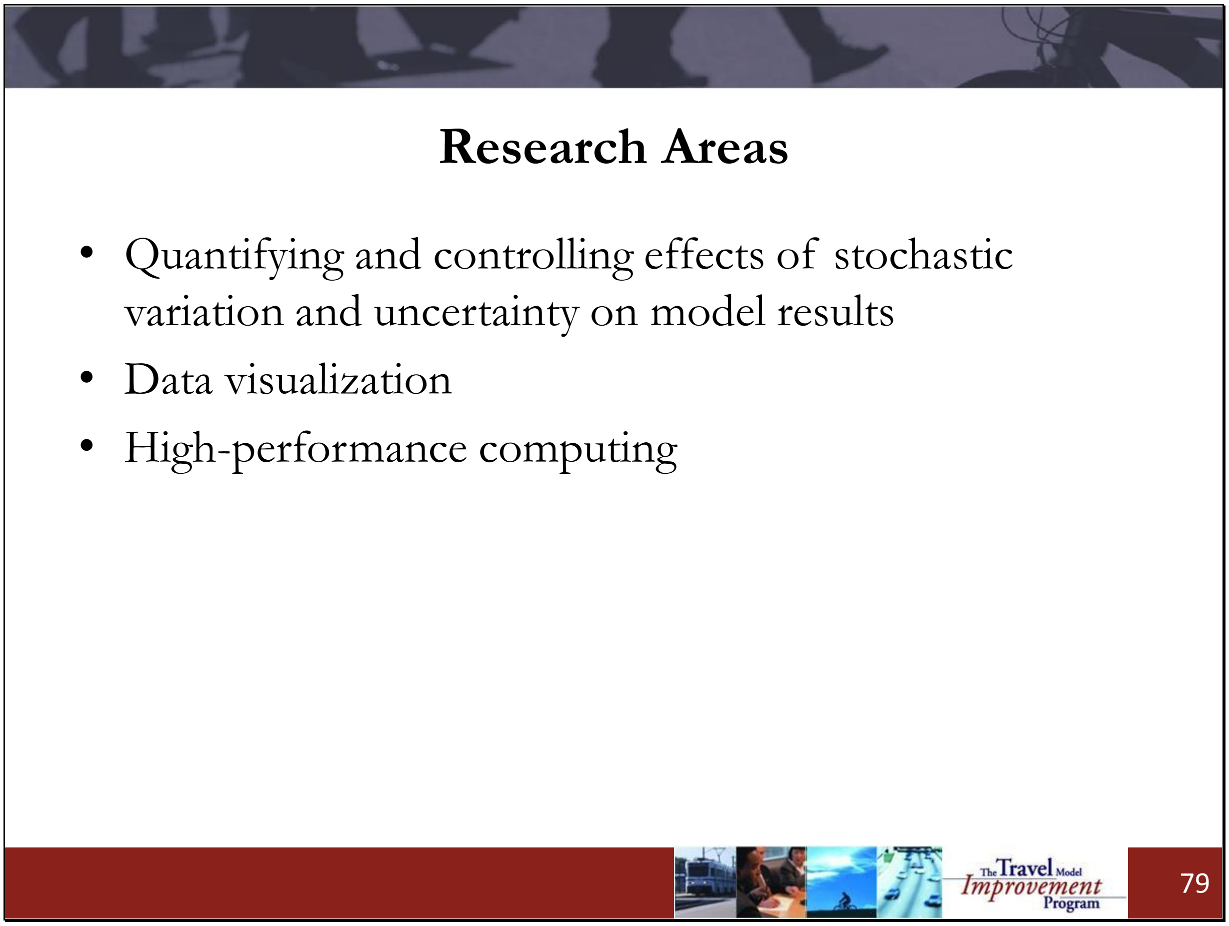
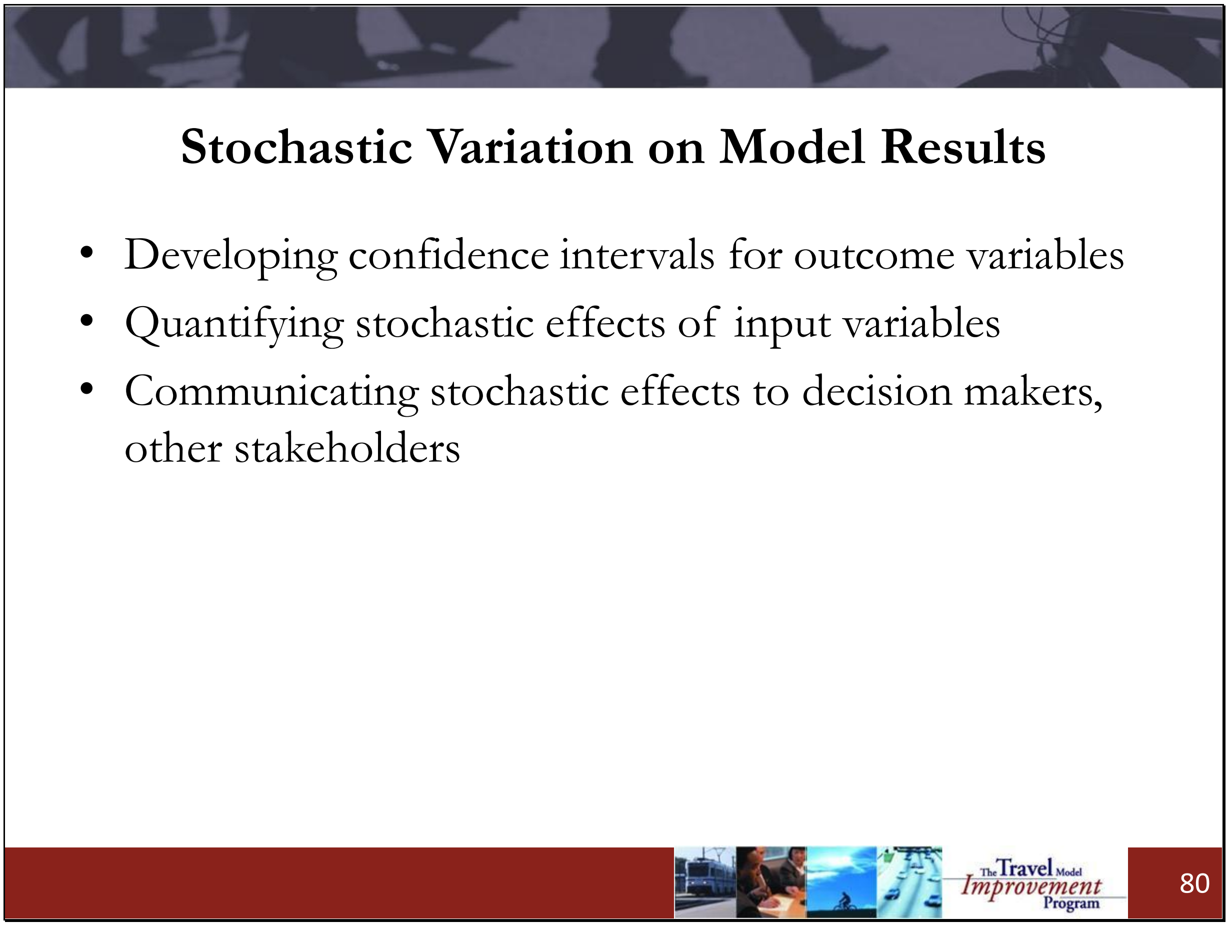
Here is another example of a model design trade-off where detailed spatial resolution is considered. Using parcel data as the most detailed spatial resolution has advantages from a land-use planning perspective but will increase run times slightly and increase data development and cleaning significantly. Use of micro-zones can significantly reduce data development and cleaning time and is useful from a transportation planning perspective but complicated from a land-use planning perspective.



There are several areas of research which are underway to support advances in activity based models. One area that we have already discussed is on quantifying and controlling effects of stochastic variation and uncertainty in model results. There are two other research areas, one on data visualization, and another on high-performance computing, that I will discuss.

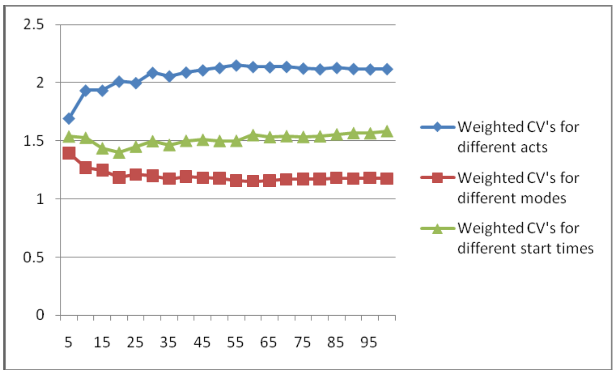


There are several challenges to assessing stochastic variation on model results: developing confidence intervals for outcome variables, quantifying stochastic effects of input variables, and communicating stochastic effects to decision-makers and other stakeholders. The primary challenge here is not one of statistics but rather one of interpretation and understanding. Many stakeholders may not understand how to interpret model results presented in a range, especially when comparing different alternatives.

Uncertainty using Albatross (Rotterdam)

- Stochastic variability is small (less than 5%)
- 25-30 runs are sufficient

- Confidence intervals are higher (around 28%)
- More than 100 runs are needed



	No of runs	Lower boundary	Upper boundary	diff lower from mean(%)	diff upper from mean(%)
Work	100	0.0135	0.0179	14.0967	13.7153
	50	0.0127	0.0189	19.9935	19.6144
	5	0.0059	0.0328	69.3383	69.2352
CarD	100	0.0090	0.0120	14.0818	14.0818
	50	0.0085	0.0125	17.8593	21.7428
	5	0.0048	0.0266	69.3135	69.3135
3am-10am	100	0.0119	0.0158	13.9691	13.8824
	50	0.0101	0.0151	19.8021	19.8021
	5	0.0035	0.0192	69.3054	69.3054

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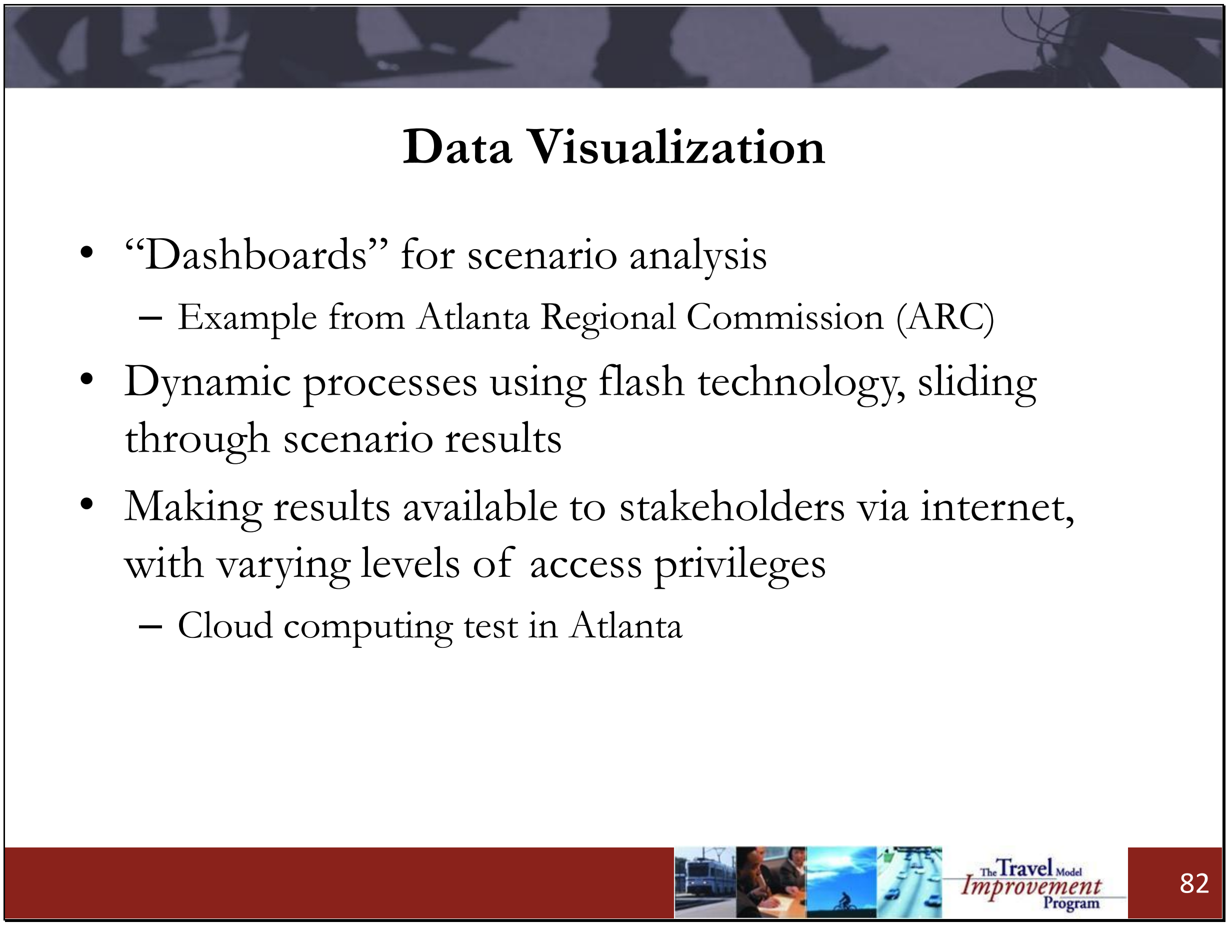
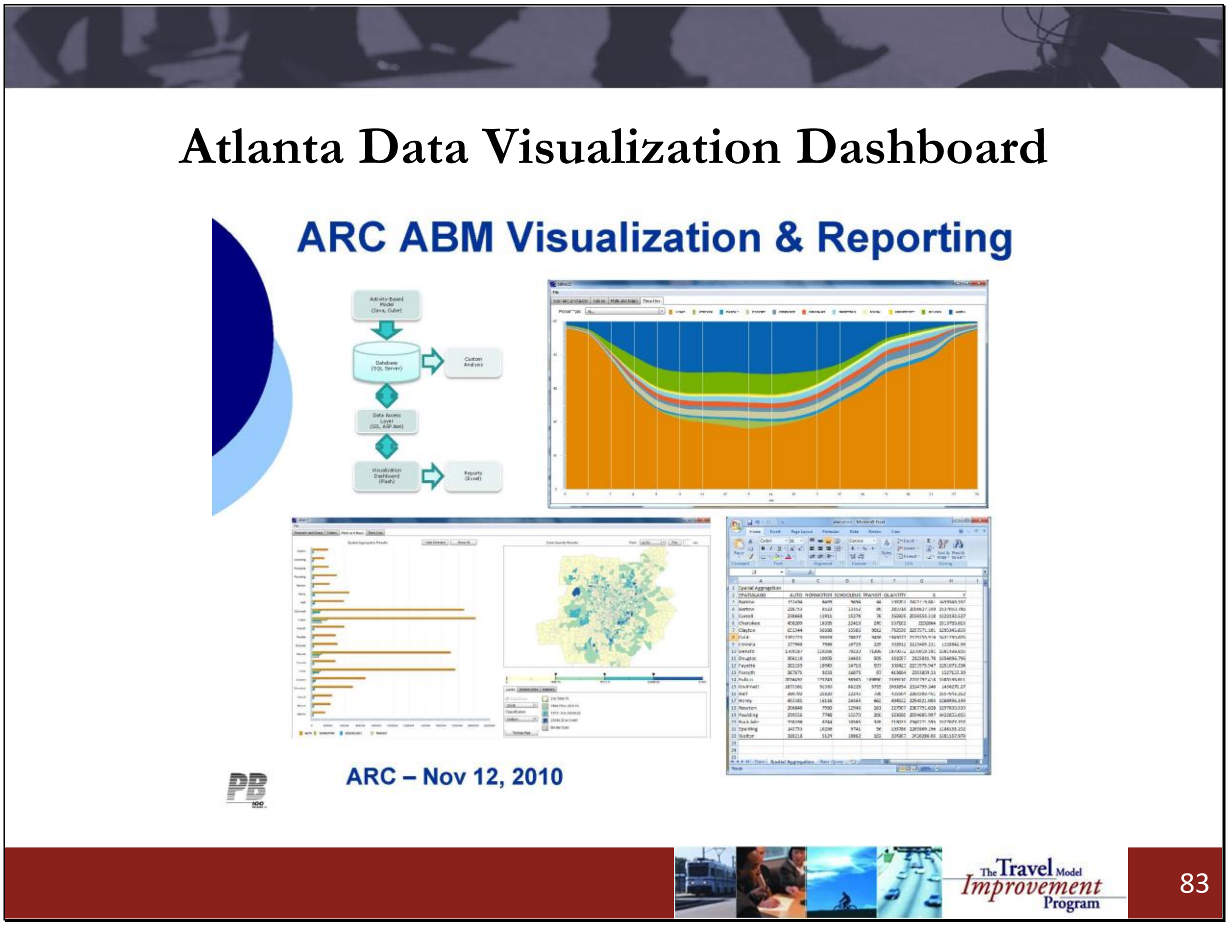
Here is an example of the measure of stochastic variability and confidence intervals for the Albatross model in Rotterdam (Netherlands). In this example, stochastic variability is quite small and 25 to 30 runs are sufficient. Confidence intervals, however, are much higher and require more than 100 runs to produce sufficient results.



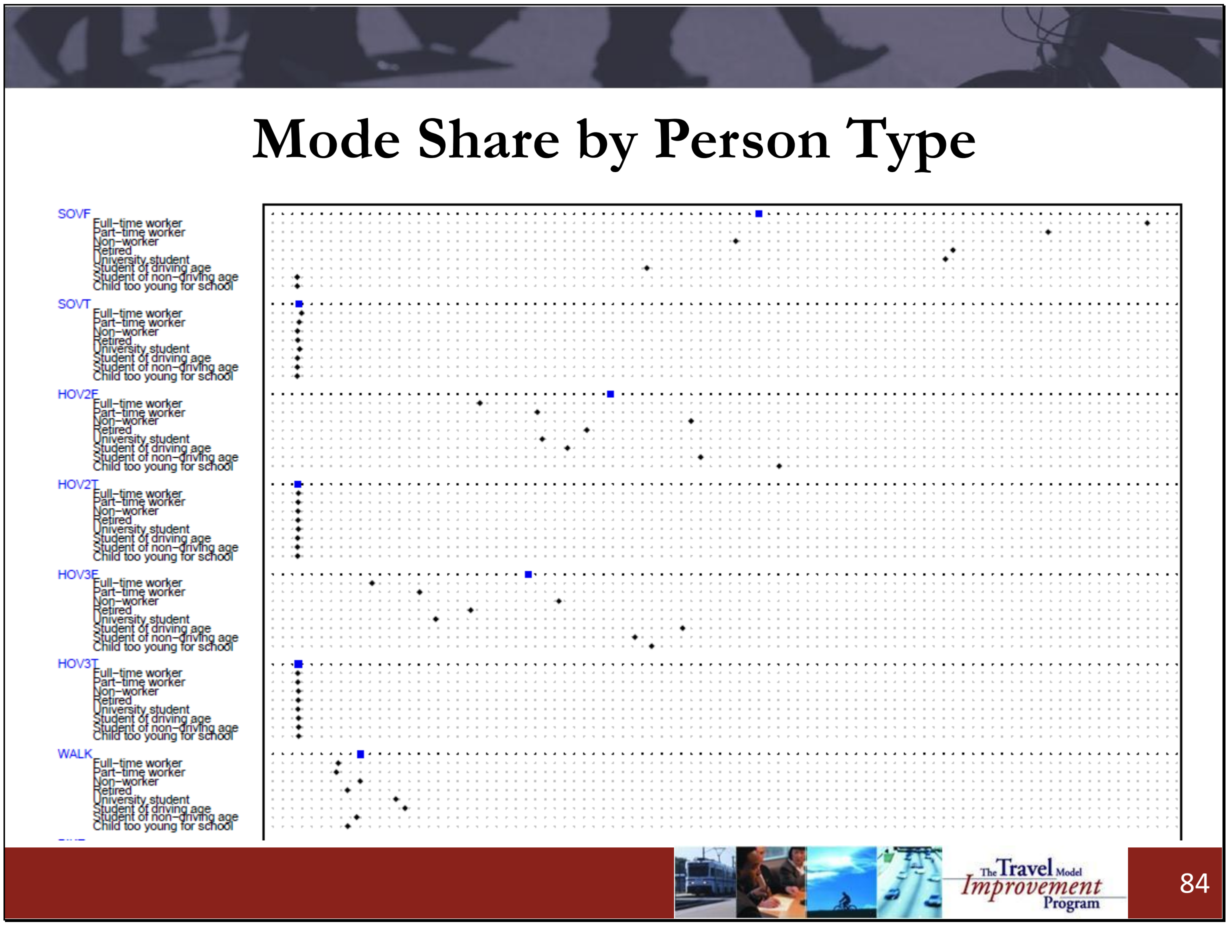
Given the abundance of model outputs, data visualization seems to be limited only by imagination and technology. For example, Atlanta has created a dashboard for scenario analysis to review model results. Atlanta has also been testing cloud computing and the benefits to the model user in terms of runtime and convenience.



Here is an example of the Atlanta data visualization dashboard. This dashboard contains four parts:

- Flowchart of the data structures;
- Timeline to show travel over the course of the day;
- Map and bar chart of zonal data; and
- Tabular summary of zonal data by County.

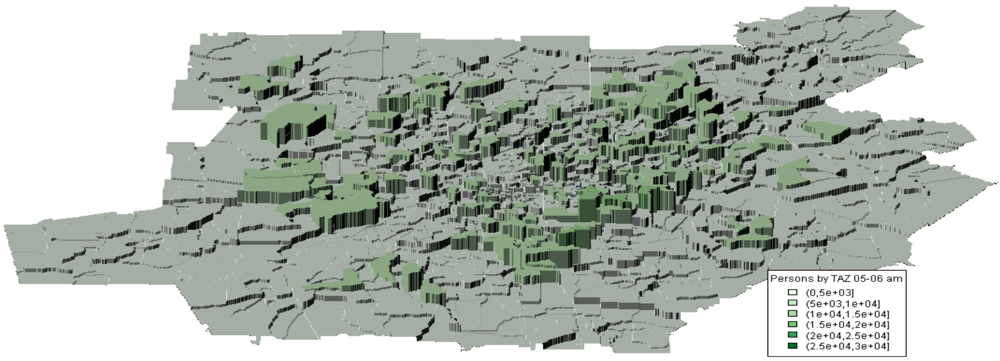
The dashboard combines flexibility with ease of interpretation to provide meaningful results.



This example shows a very detailed analysis of mode share by different person types. This type of summary based on individual (person-level) attributes is not possible with an aggregate 4-step model.

This is another example of a unique angle of analysis, the distribution of travelers by age for by mode. It is especially important and interesting to track for transit users and compare to the on-board transit surveys.

Persons By TAZ and Hour



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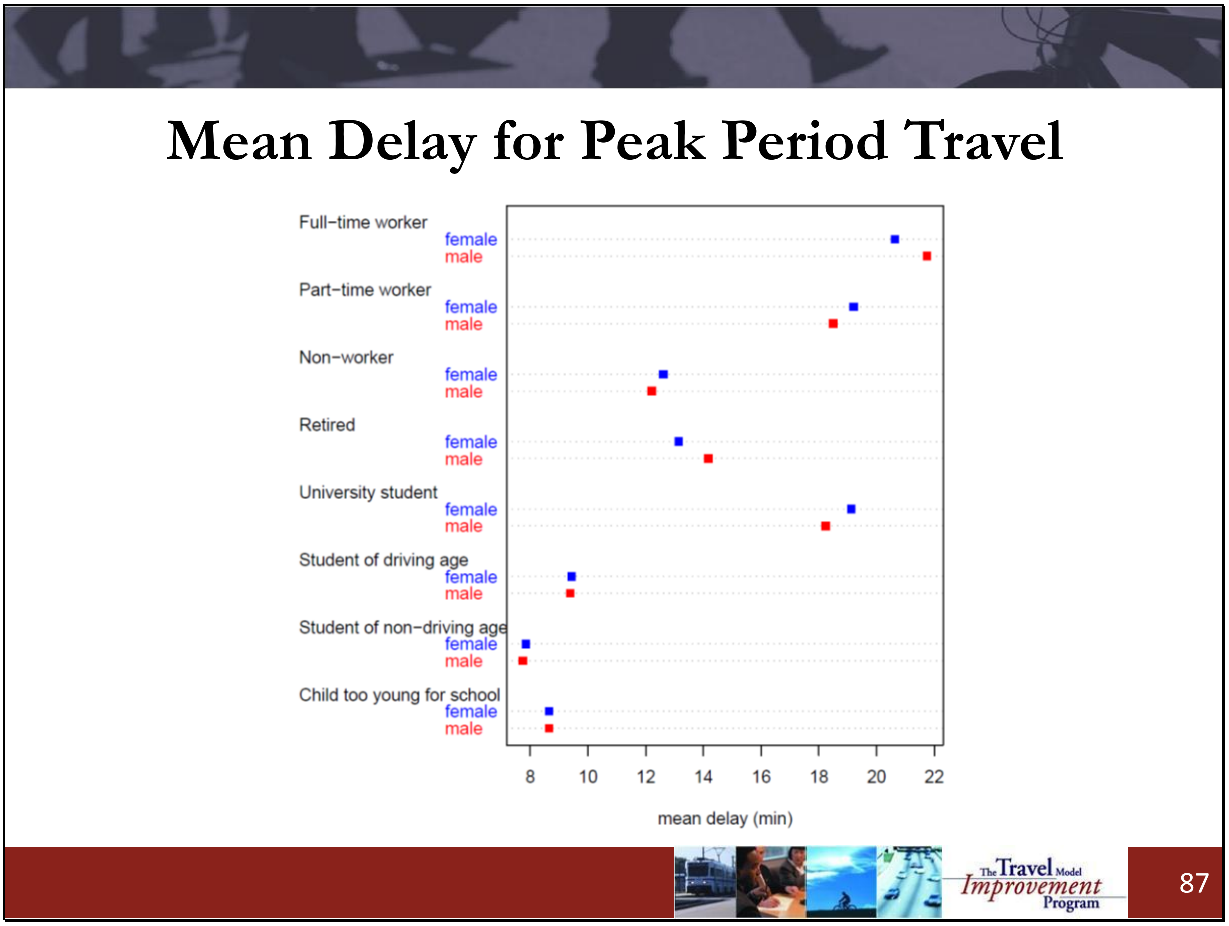
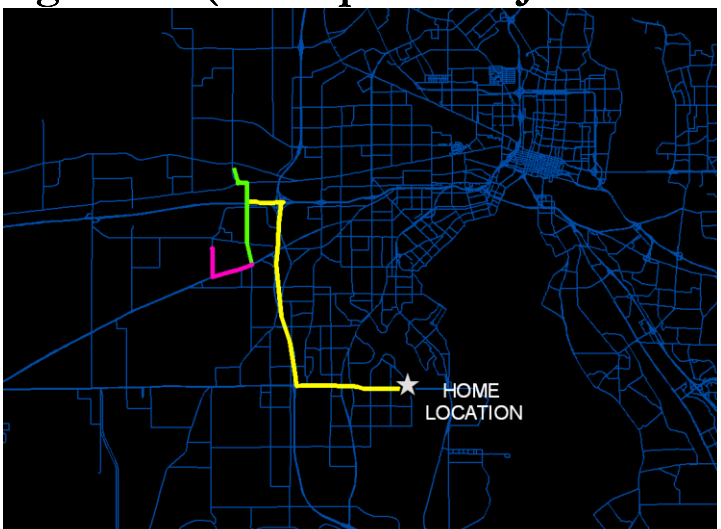
This is dynamic view on location of the regional population in Atlanta by hours of the day. Note that this is not a DTA representation of traffic flows, but rather persons located at activity sites.



This diagram shows those who experience longest delays relative to free-flow time. Not surprisingly, this would be workers who do the most traveling and are traveling during peak demand periods.

DaySim/Transims Tracks Individuals Through Assignment (Example from Jacksonville)



HHOLD	PERSON	ACTIVITY	PURPOSE	PRIORITY	START	END	DURATION	MODE	VEHICLE	LOCATION	PASSENGER	Start at home	Travel Time
21	1	2114110	0	9	0	2:49	2:48	1	0	8679	0		
21	1	211411	3	9	3:08	7:37	4:28	2	1	4024	2	TRIP 1	0:19
21	1	211412	6	9	7:45	10:20	2:35	2	1	4175	1	TRIP 2	0:08
21	1	211421	3	9	10:25	10:29	0:04	2	1	3740	1	TRIP 3	0:05
21	1	211422	0	9	10:48	12:23	1:35	2	1	8679	0	TRIP 4	0:19

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This example is from the Jacksonville SHRP2 C10 project. It shows traces of a tour in DaySim and Transims. This tour starts at home then travels to three different destinations. In this example, we track individual vehicles, but not people riding transit or walking. Nonetheless, the level of detail of the tour records provides insights on individual travel characteristics as well as supply-side constraints during this period.

High-performance Computing

- Advances in efficient data structures and algorithms (software engineering)
- Multi-threading
- Options for distributed processing
  - In-house LAN servers—large hardware investment, but local control
  - Leased time on remotely hosted networks (Argonne Labs)—more processors, no sunk cost in extra hardware; lack control over processing availability, software maintenance
  - Cloud computing—farming out processing tasks while software resides locally; may be public (enterprise-wide) or private (Google, Amazon) — more processors, no sunk cost in extra hardware

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High-performance computing is rapidly changing in our world and in our industry. Advances in efficient data structures and algorithms have opened doors for activity-based models and continue to evolve and improve. Multi-threading and distributed processing are becoming increasing important to achieve reasonable run times for activity-based models and provide more opportunities for integrating Activity-based models with land use and traffic/transit micro-simulation models. The options for distributed processing allow for local control on in-house servers, leased time on remote servers, or cloud computing where processing tasks are farmed out to public or private networks.

Summary

- Disaggregate representation of individuals provides summarization by any available attributes, enabling more sophisticated, higher-resolution analyses of transportation policy and investment alternatives
- Application of ABMs to alternatives analysis presents some challenges in how to present and interpret results vis-à-vis the expectations of policy makers and other agencies used to seeing trip-based model results

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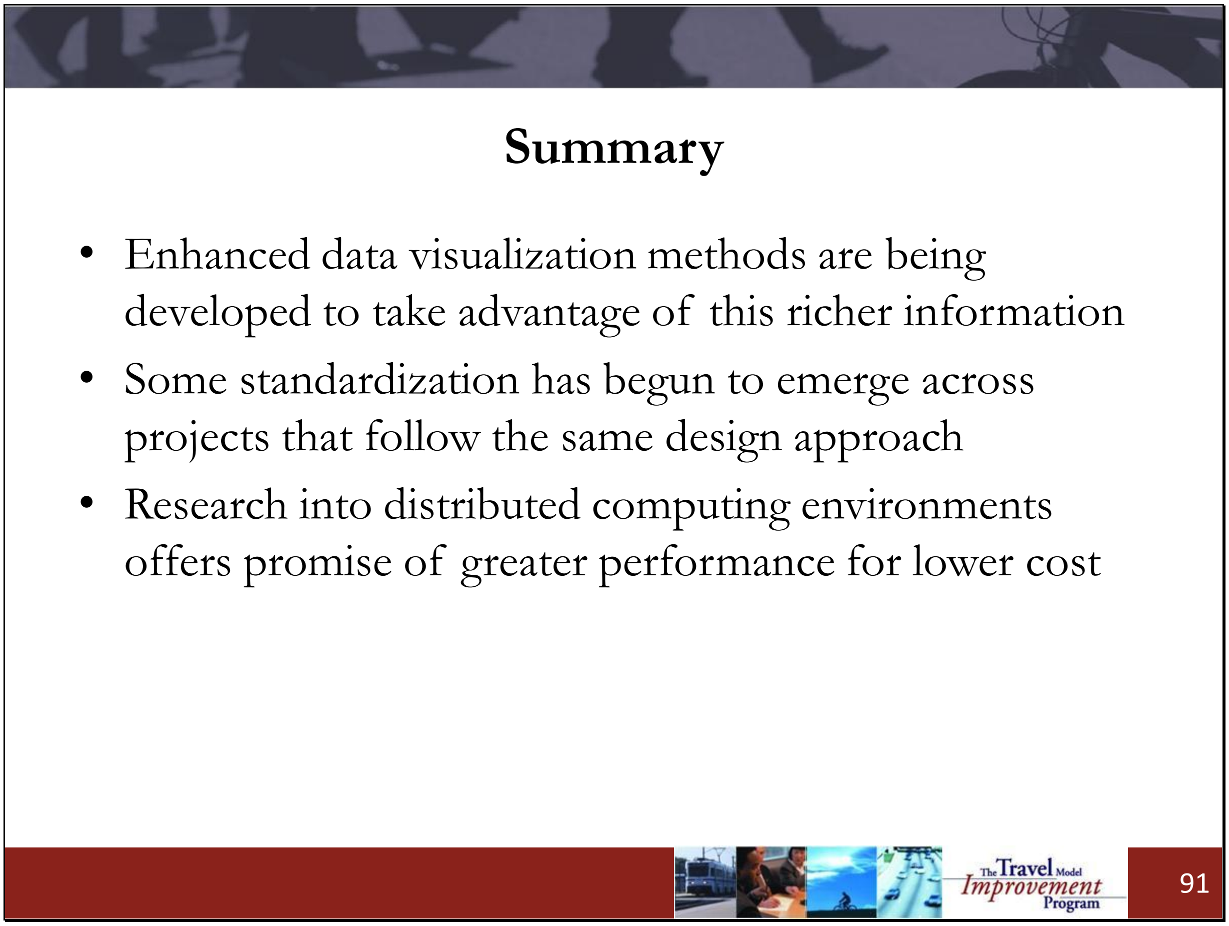
Activity-based models offer the potential for a much richer array of analysis types, depth and sophistication than previous trip-based methods. This is largely due to the disaggregate nature of the population and accounting for individual behavior, thus allowing for a better representation of smaller market segments, greater flexibility in reporting, and a wider array of performance metrics to inform decision-making. The applications of activity-based models are useful to improve our understanding of the transportation system. The stochastic nature of AB models requires some additional consideration on how to present and interpret a range of outcomes rather than a single outcome.



The mechanics and interfaces for activity-based models are improving with use and are expected to continue to get faster, better and cheaper as they become more common. The data visualization completed to date for these models have just touched the surface of the possibilities to mine and display the richer data contained in activity-based models. The coalescence of model designs around two approaches in the US has created software platforms that continue to evolve and improve and user communities that can work together for common goals. This type of sharing of information (which has been supported by FHWA in these webinars) will benefit users as well as those considering developing an activity-based model.

Questions and Answers

The Travel Model *Improvement* Program

Speakers: John Gliebe & Peter Vovsha

Section 12 Questions and Answers

Isn't the information on slide 18 referring to travel time differences mostly an academic and research question? How can it be used in a practical context?

John: That was the one where we looked at the travel time analysis in Chicago and looked at it by different income groups and different person types. In addition to research, the information is of interest in equity analysis. The information shows precisely how different subgroups in the population are affected by a particular scenario or plan and how that varies among income groups or specific types of people.

You mentioned that elasticity is different for different decision levels. How do you accomplish that if you use mode choice log-sums throughout the model?

John: If there's a change that affects mode choice at that level it will be reflected and percolate up to the upstream models. The effects will become attenuated somewhat. As you go up the model chain they become less. And down the model chain they become greater.

Have you found any systematic differences between user benefits from a four-step model and an activity-based model applied to the same area?

Peter: I'll be honest with you, we've never really implemented completely on this exercise, but I have something that came up very strongly when we discussed the results of this model with FTA. An activity-based model can better address span of service, when you consider alternatives which improve frequency for a wide range of hours. The four-step model overcomes all this and creates a very small additional benefit. A four step model has about 80% of trips falling into the peak period, and any improvement is not really proper. When you apply a four step model, you favor improvements of services in the peak period. However, only 60% of commuters make both legs in both the AM and PM peaks. If one leg is in the off-peak, lower frequency service can discourage them from making either trip by transit. This is overlooked by a four-step model.

Can an activity-based model system be executed or designed in such a way that it accounts for consolidation of activities, for example going to a shopping mall to consolidate multiple shopping trips?

Peter: This feature is very important, and is incorporated in the models. People frequently go for one period of time, and frequently entire families combine shopping activities. Those visits are a separate segment. It's not just shopping but a combined activity. By taking advantage of a finer level of spatial resolution we can portray accessibilities. A shopping mall might eventually be modeled not as a single TAZ or micro-zone but separate individual locations connected by pedestrian links. Any improvement in terms of accessibility making the locations more walkable, for example, would affect the choice of those activities.

John: You are typically choosing a primary purpose and destination of the tour, if you choose a zone or parcel in a shopping center, accessibility to other shopping opportunities is going to be very high, so you're likely to generate one or additional trips near that location. That's how it would evolve in the output, creating a cluster of trips in the area.

Has anyone used the results of an activity-based model for travel time reliability analysis?

Peter: Yes. It so far has not been part of the routine for what we do, but we have developed these methods and reported them in a research project. Travel time reliability is a very important factor. One method we've put in practice is to generate a series of scenario type tables rather than one, and see distributions of travel time and calculate standard deviations. The New York model currently has this in place.