TMIP Webinar Series

Activity-Based Modeling

Session 2: Institutional Issues for Managers

The Travel Model Improvement Program

Speakers: John Gliebe and Rosella Picado

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2012 Activity-Based Modeling Webinar Series

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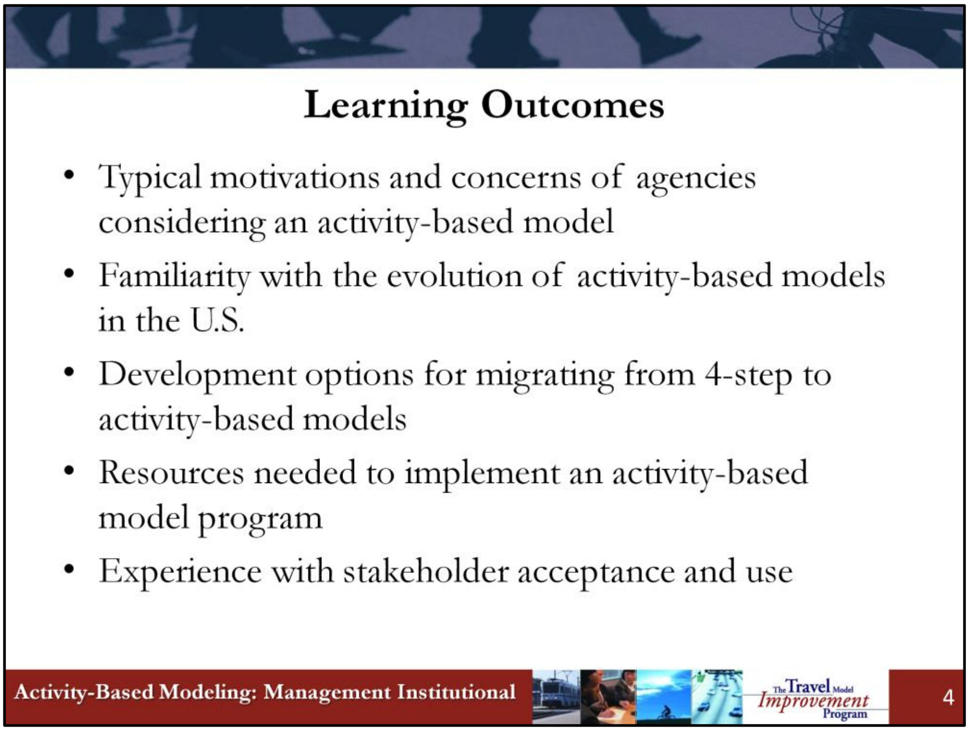
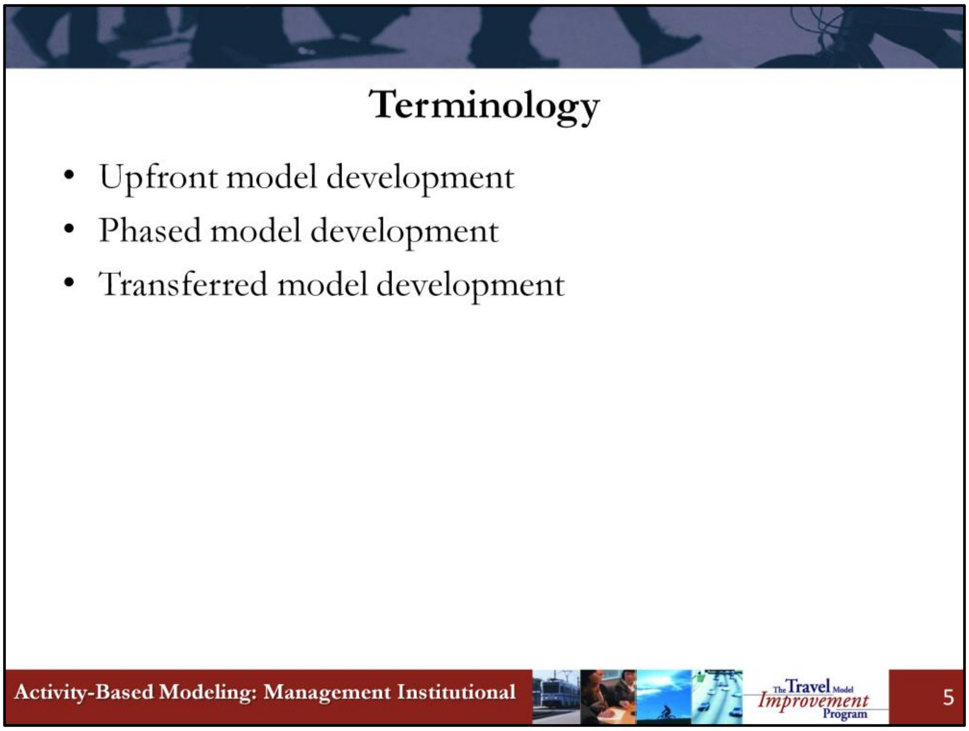
For your reference, here is a list of all of the webinars topics and dates that have been planned. As you can see, we will be presenting a different webinar every three weeks. Three weeks ago, we attempted to provide a somewhat high-level executive view of activity-based modeling. Today, we will be covering the second in topic in the series—Institutional Topics for Managers. Our objective is to get into a bit more depth on the issues that we have found to be important to the people we have talked to in our work in activity-based model development. Today we will be talking about what it takes to transition between a trip-based model operation and one that relies primarily on an activity based model. We will be talking about development time and costs, resource allocation, and issues related to productivity.

So, in this webinar we will try to stay away from the more technical issues surrounding activity-based modeling. As you can see by the schedule, there will be plenty of technical detail in the remainder of the series.



Our audience today is composed of modelers from public agencies, consulting firms and academic institutions. We also know that there are managers of various levels among you. Our goal in this webinar is to provide you with more of the institutional context for how travel demand modeling has evolved to the point where we are today in which there seems to be a growing demand for more advanced modeling tools. Accordingly, at the end of this webinar you should have a good understanding of the motivations and concerns that public agencies have when contemplating moving to an activity based modeling system. To begin to address some of those concerns, it is helpful to review how activity-based models have evolved over the last decade or so in different parts of the U.S. To make things a little more concrete, we'll discuss the various options that some agencies have followed in developing their activity-based modeling systems. Resource requirements are always an important issue, and we will share with you some examples of what some agencies have invested in consulting fees, data development, hardware and software, and staff resources. Finally, we will discuss some of the experiences to date of users of these systems, including project use and potential use by stakeholders.

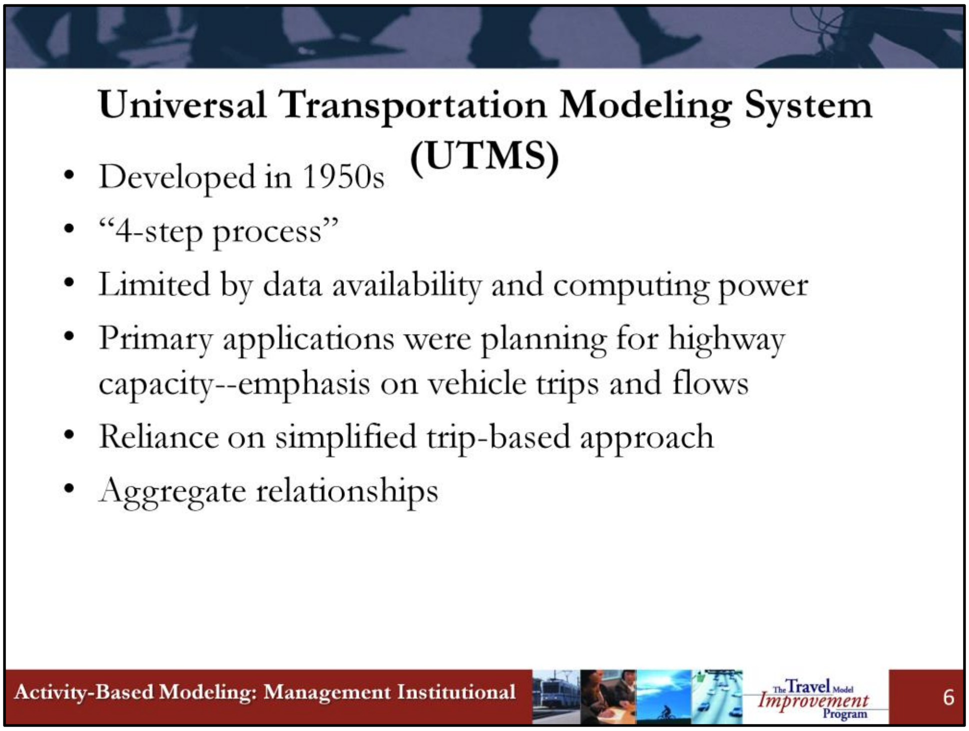


Upfront model development refers to a situation in which money is budgeted to develop a new model system in one shot, usually from a single RFP.
This could also be done with an interim milestone in mind, in which case multiple RFPs may be issued. In both cases, the agency intends to use the new activity-based model once the development process is completed. In the interim, it is compelled to continue using it’s extant trip-based model.

Phased model development refers to a strategy in which the agency gradually replaces parts of its existing trip-based model system with new components that will eventually be part of the final activity-based model system. The agency can use the new “hybrid” mode system while new components are being developed.

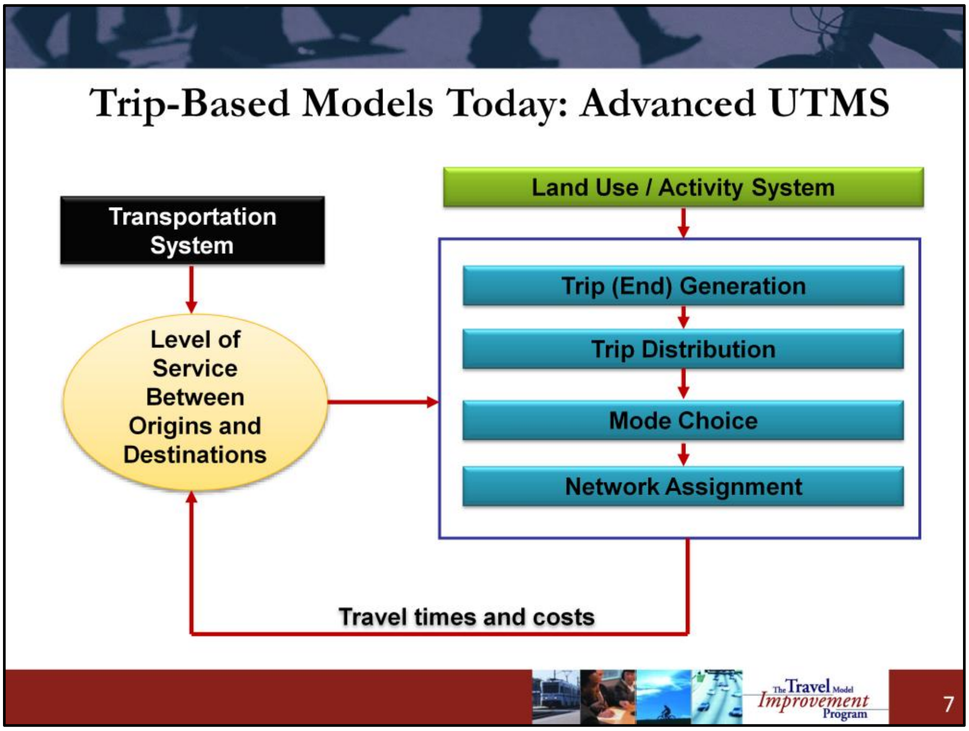
Transferred model development refers to a strategy in which an agency borrows the specifications and software developed for another region. This is then followed by calibration and validation using local data. This allows the agency to get started fast.

We will discuss these three strategies in more detail later in the webinar.



In order to provide context for our discussion, let's step back in time and review how we got here. Travel demand models were first used in the U.S. during an era in which the Interstate Highway System was being planned. It was an era of suburban expansion and a post-war baby boom. Consequently, the focus on modeling efforts in those days was highway capacity planning. Needless to say, computing power was not nearly what is today, so the process that was developed, which became the UTMS, was necessarily simple. It was based on the prediction of aggregate trips being generated from zones, composed of aggregations of households and businesses, distributed between zones, and assigned to a network to determine how well the network would perform.

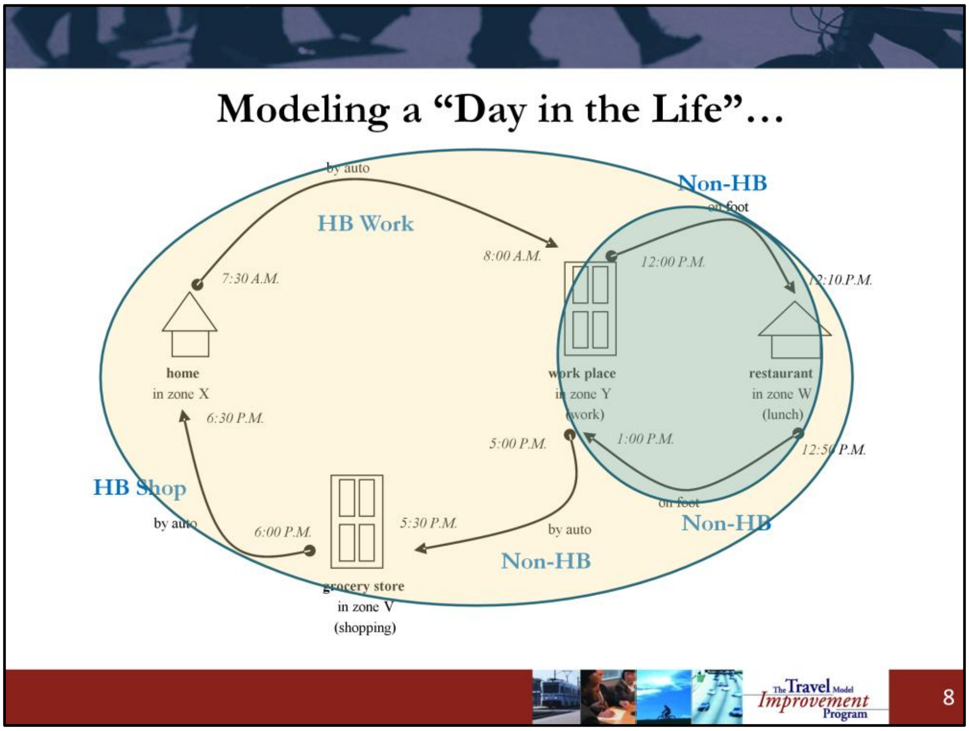
Some of the difficult questions that transportation planners face today—greenhouse gas emissions, travel demand management, congestion pricing, transit-oriented development and environmental justice—had not yet emerged as important topics in the early days of travel demand modeling.



The trip-based models of today are really just advanced version of the UTMS process. Here you see what many of us know as the familiar 4-step process, consisting of trip generation, distribution and mode choice. Over time, the profession has added explicit representation of transit and, in some places, pedestrian and bicycle travel modes. With the introduction of discrete choice models to the profession, models based on utility theory and estimated from individual observations were an early improvement, although in the end they are still applied to aggregations of trips rather than to individual travelers. In addition, trips are assigned to networks that typically represent peak and off-peak travel periods, which provides some differentiation between level of service conditions during different parts of the day.

Another major improvement is the feedback loop in which travel times and costs are fed back turned into skims tables and fed back into trip distribution and mode choice. This has long been standard practice in the U.S. It is interesting and relevant to point out here that feedback loops were mandated as the result of legal challenges and became a recommended best practice for consistency for air quality modeling. As many of you know, when a particular interest group or faction opposes a proposed action based on a forecast, they challenge the methods used to produce the forecast. In the case of feedback loops, critics rightly pointed to the need for consistency between the travel times being produced by the network assignment process and the representation of travel times and costs being input to the demand models.

So, we've got feedback loops now. This system is pretty good, right?



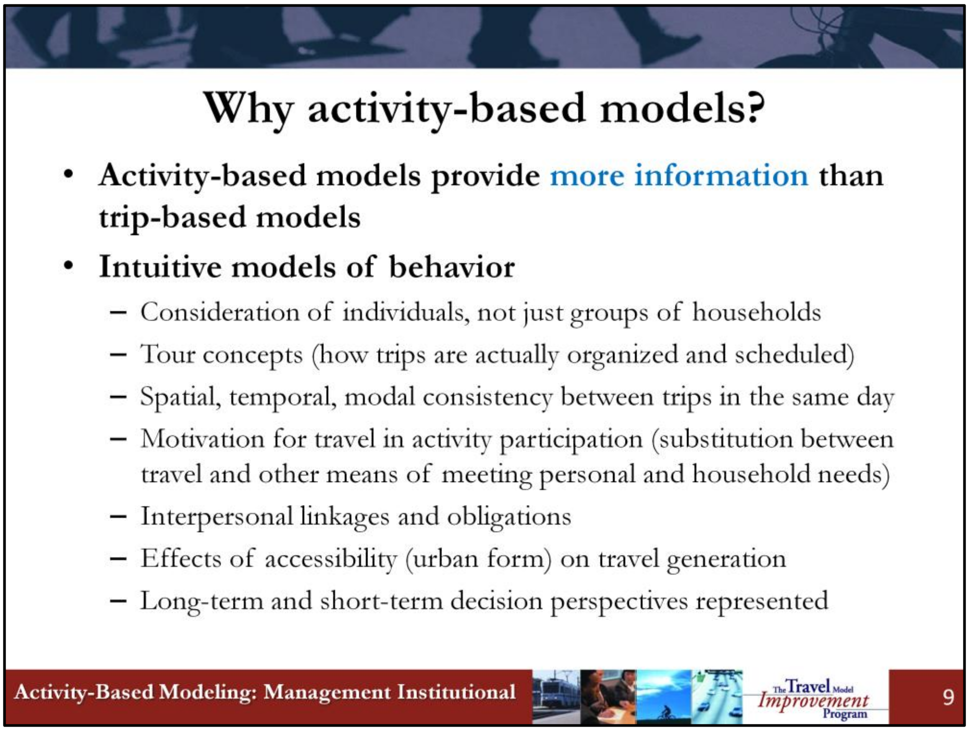
Let's consider how people really travel. Here we've depicted an individual who goes to work at 7:30 a.m., arriving at 8. Around 12 noon, this person walks to lunch and then returns to her work place at 1. She leaves work at 5 p.m. and stops at the grocery store before going home.

The way this would typically be represented in the trip-based modeling world would be the following. (Step through HB work, HB shop, and three Non-HB trips). The HB-Work and HB-Shop trips are in the AM and PM Peak periods. One of the Non-HB trips is in the PM Peak, and two Non-HB trips are in the off-peak period. We know their modes and trip lengths. That's about it.

One question that transportation planners typically struggle with is how to explain to stake holders in your area the impact of particular project, plan or policy on "non-home-based" trips? What does a non-home-based trip mean to them?

A trip-based model assumes that all of these trips are independent of one another. It does not account for the fact that all of these trips are actually part of one large daily activity pattern, anchored around a mandatory work activity. A trip-based model does not account for the fact that trips are chained into tours (advance slide) and that there is actually a work-based sub-tour within the larger tour (advance slide).

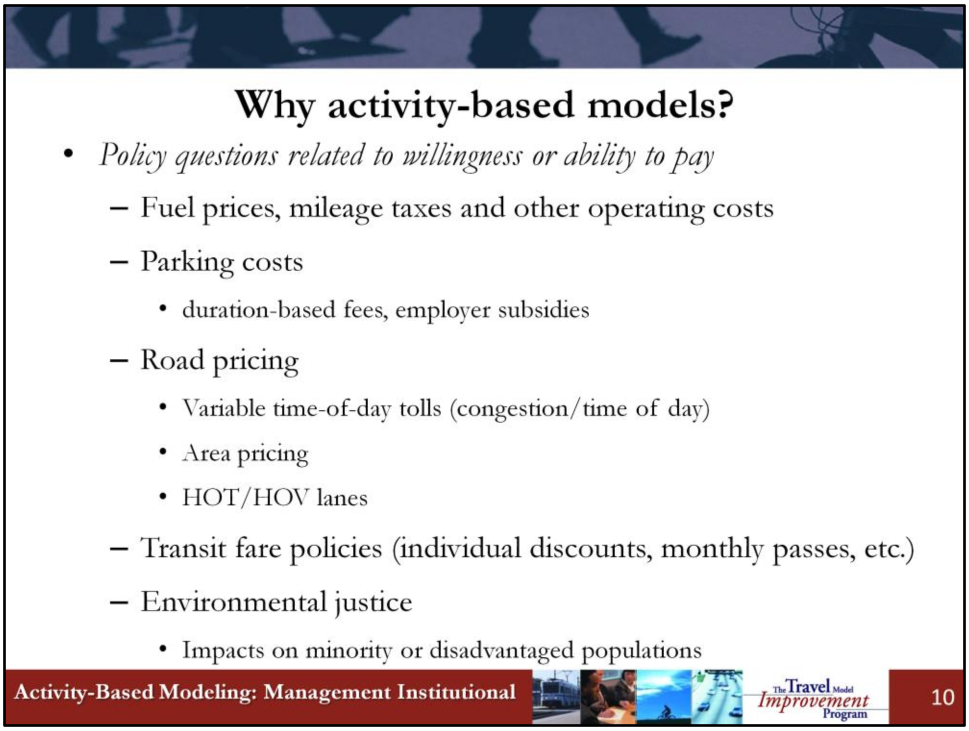
It also does not account for the fact that, because this person walked to lunch, they do not have their car available to get back to the office. Further, a trip-based model would not recognize that this person needed to arrive at work at 8 a.m. and therefore, did not have the time to drive her son to school since his school is in the opposite direction. So, he has to take the bus. Nor would a trip-based model recognize that this worker needed the car for work on this particular day because her planned agenda included a big grocery shop after work. The trip-based model would also not recognize that persons who work in this location are likely to go out for lunch



All of the additional information that an activity-based model takes into account are important, because in real life trips are not independent from one another and people do not respond to changes in transportation system level of service changes or policies as if they were. In real life, trips are organized into tours that make them interdependent. People plan activities at the end of the day that cause them to make certain travel decisions at the beginning of the day. Mode choices may be somewhat constrained by household linkages and obligations, such as taking care of children. The opportunities presented by surrounding land uses may induce people to make more or fewer discretionary stops. And in the long-run, people do make choices of where to live, work, go to school, and whether and what types of vehicles to own that are at least partially based on the transportation environment.

From a technical perspective, this comes down to accurately representing the actual alternatives available to people in their activity-travel choices. What is really in their choice set? What are their real short- and long-term elasticities?

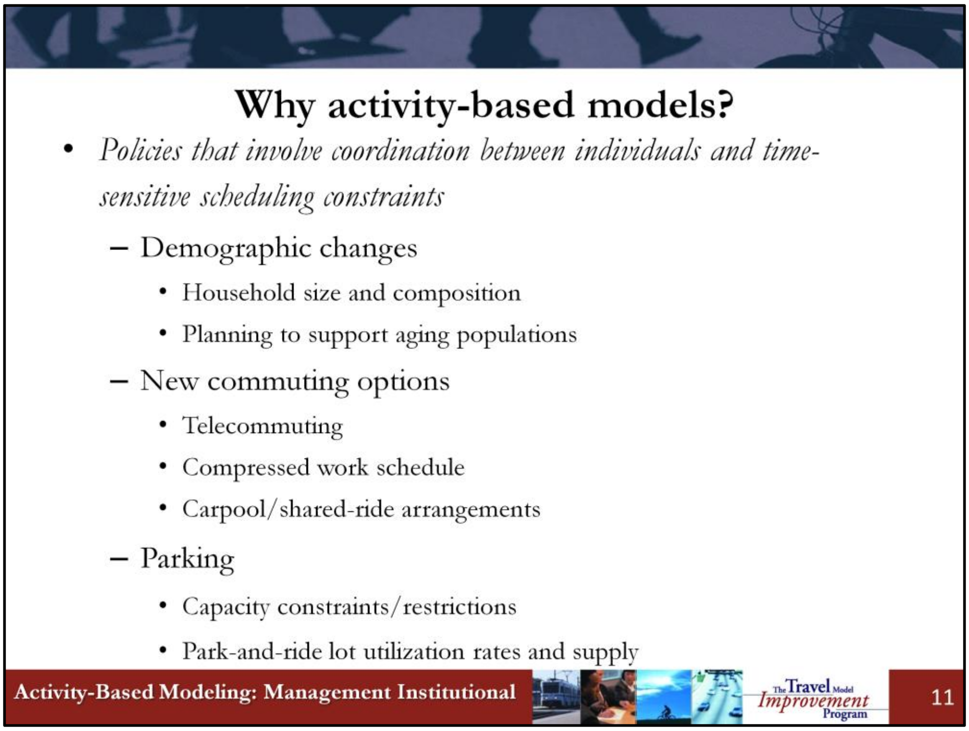
But as I said earlier this presentation is not intended to be technical. We will cover the finer points of choice sets and elasticities in future webinars.



Instead, let's talk about policies. How can we better estimate people's response to changes in travel costs? For example, how can we better estimate change in VMT as a function of gasoline prices? If gas prices this summer reach a new all-time high in the U.S., will people take more transit? Travel less frequently? Make shorter trips? Car pool? Buy more fuel efficient cars? … or forego family vacations and eating out? If high prices persist, will some people choose to work closer to their residences? These are all legitimate responses that we observe in data, or at least anecdotally.

These same set of responses are relevant for other policy examples, too. This slide also lists a number of policies related to how people value their time when faced with changes in travel costs—road pricing, transit fares, environmental justice.

Trip-based models typically do not do a good job of capturing the multi-faceted response of real people, because the basic unit of analysis is the individual trip. Important contextual information is simply not there. In addition, trip-based model make aggregate-level predictions for households of a certain type, but are unable to distinguish between individuals within households. Consequently, they tend to do a poor job of portraying how individuals value their time.

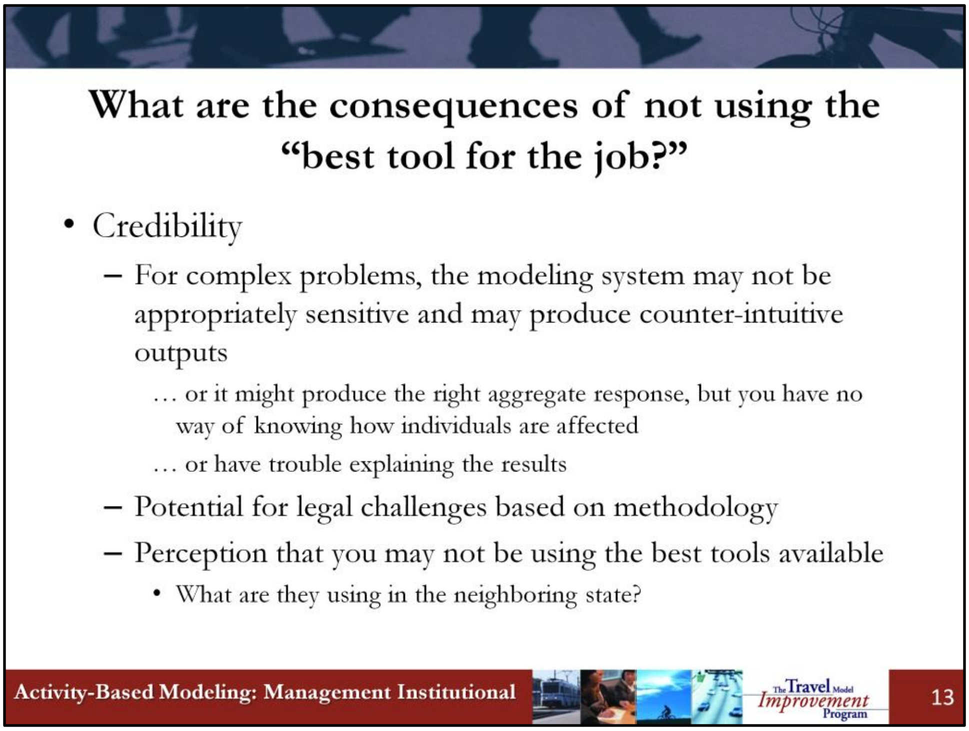


In addition, because activity-based models represent individual decision makers and operate at a finer temporal resolution, they are better suited for analyzing policies that require coordination between individuals and time-sensitive scheduling of activities. As such, they provide more information for the analysis of policies related to demographic changes, travel demand management and related commuting options, and time-sensitive issues related to the availability of parking at different times of day.

In reality, many policies involve both time and scheduling trade-offs along with user willingness to pay to obtain better level of service. The technical nuances of these trade-offs are something that we will explore in more detail in future webinars.

Are activity-based models always the best tool for the job? Not necessarily. For problems that are relatively narrowly defined and for which the likely range of transportation system user responses is expected to be limited, then a good trip-based model is probably just fine. Deciding whether and how much to extend roadway capacity in a corridor might be one example.

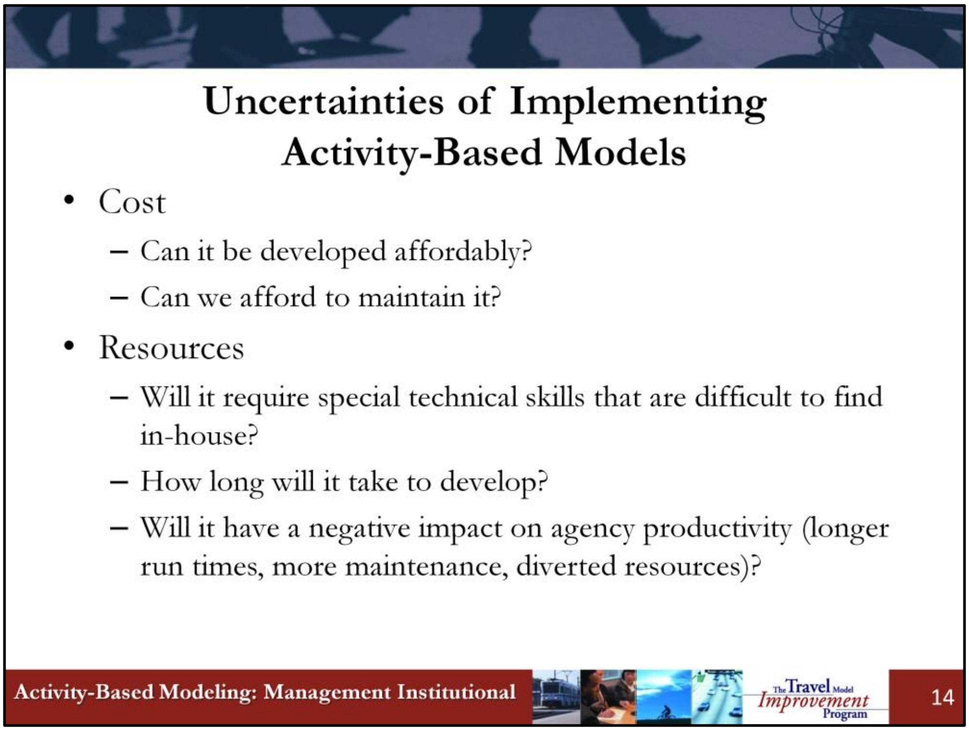
On the other hand, if you are charged with analyzing policies or plans that involve somewhat complex policies in which user may be considering multiple options for trading off time and money, then a tool that allows you to model that range of responses is probably what is needed.



What are the consequences of not using the "best tool for the job?" In a word, it comes down to credibility. It is important to use a model that is appropriately sensitive. Your trip-based model might be producing the an appropriate aggregate response, but you may have trouble explaining it and may be unable to show the impacts on individuals.

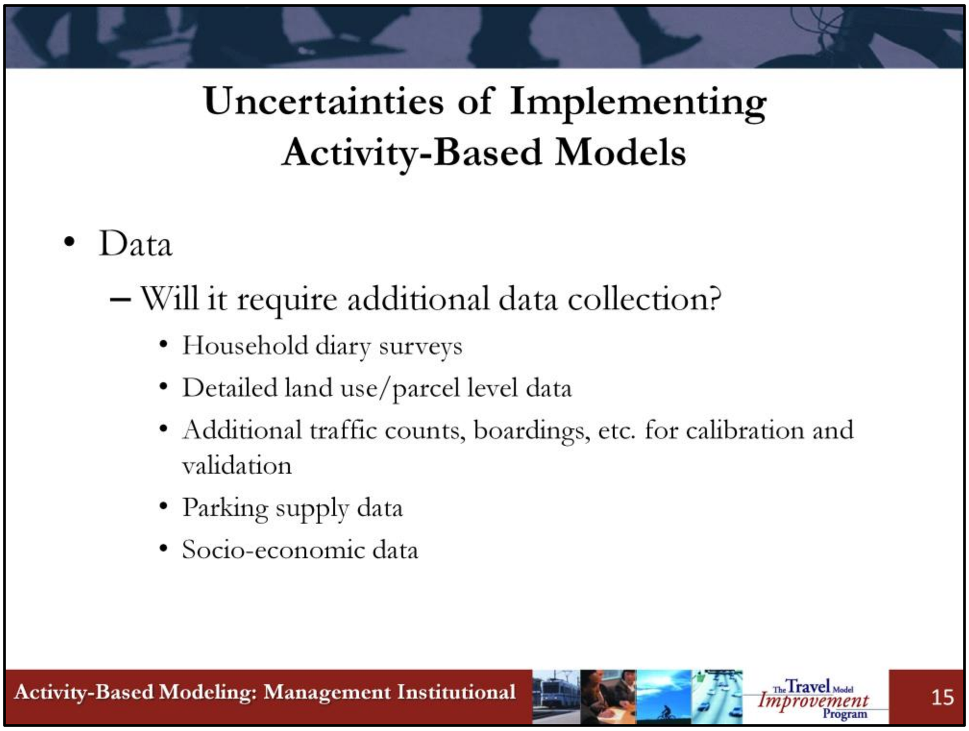
As we discussed before, in this business, there are frequent challenges to the credibility of the methods used to make forecasts—especially when large investments are at stake, or controversial policies. So that may be a concern.

Finally, although it may be unfair in many cases, there is always the risk that some parties may perceive your agency as not using the best tools available and therefore a little behind the times.

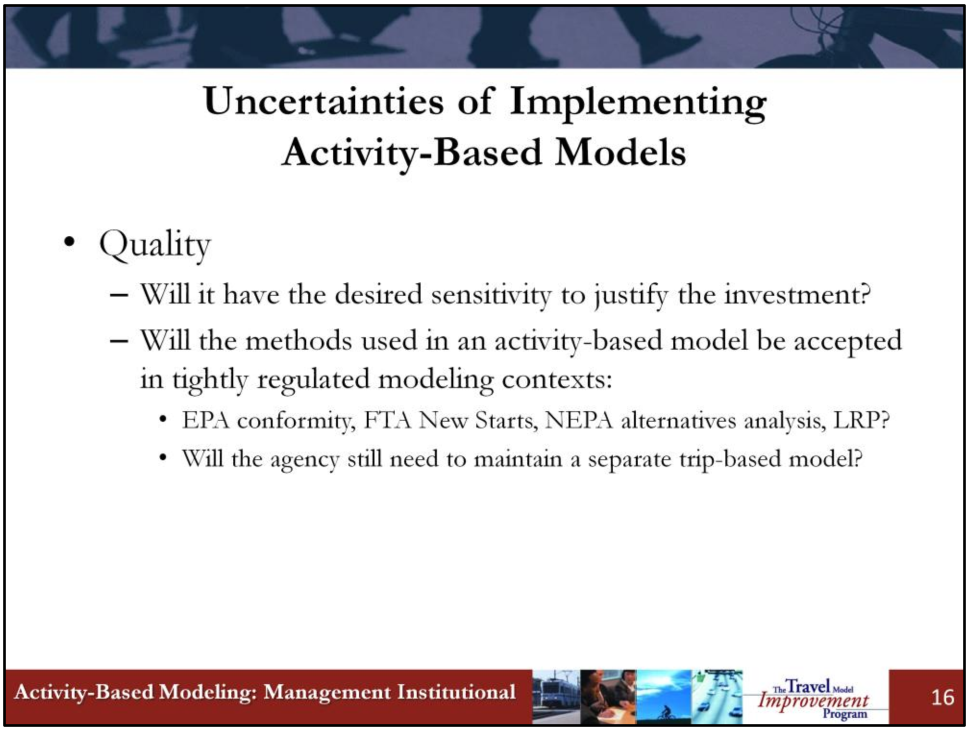


With all of these reasons to consider moving to an activity-based modeling system, there remains a great deal of uncertainty as to what it might take to implement such a system. The most important objective of this presentation is to remove some of this uncertainty.

Typically, people are most interested in how much it will cost, not only to develop but also to maintain. They often express concern on the effect if will have on staff resources—whether they will have the right skill set in-house to run the model or become dependent on a consultant. They want to know long will it take to develop an activity-based model, and how will it affect agency productivity.

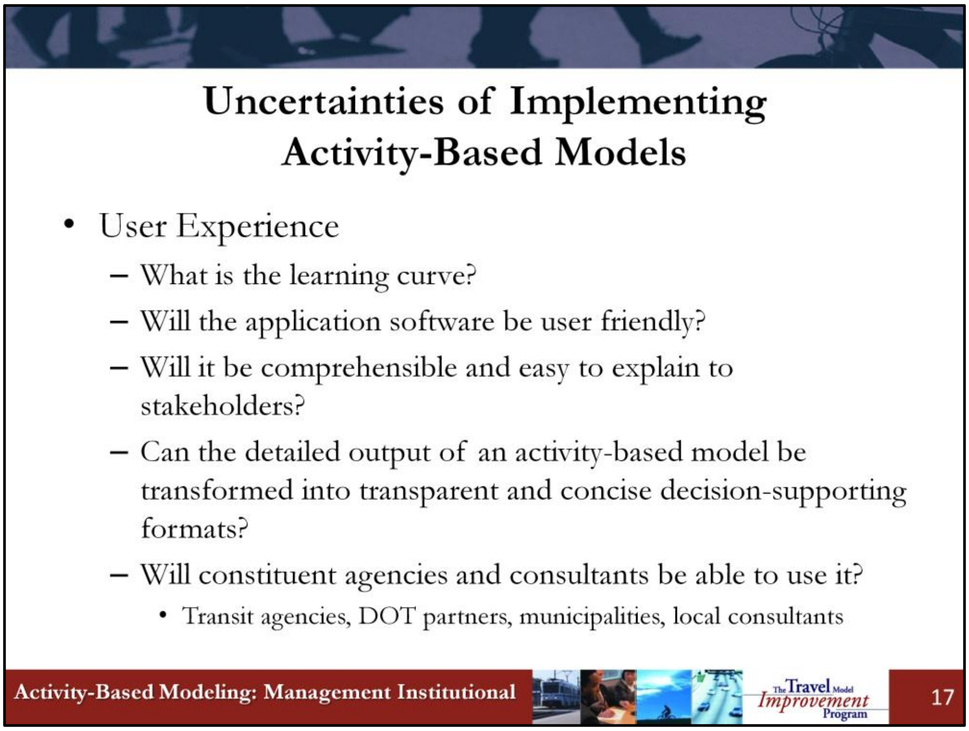


Our models are only as good as the data used to develop them. Given all the information that activity-based models are supposed to provide, people naturally expect that a good deal more data must be required. In fact, much of the data required is similar to what has been collected for trip-based models, though the level of detail might be greater as activity-based models may be more sensitive to the accuracy of inputs. In household surveys, activity-based models use more of the information that is already in the survey diaries.



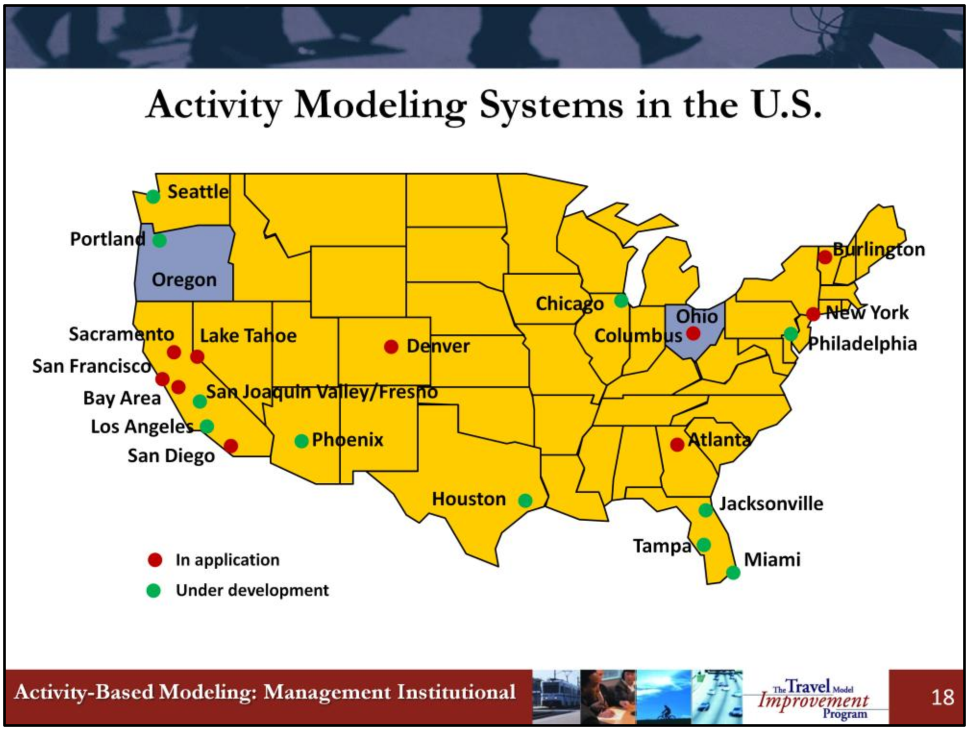
A lot of people also wonder an activity-based model is really as good as advertised. Will the performance justify the investment?

Most agencies have many years of institutional knowledge in honing their trip-based modeling skills and refining the models for a variety of important work products, such as conformity analysis, New Starts applications, NEPA studies, and long-range planning. Understandably, they'd like some confidence that an activity-based model will perform well under these tightly regulated scenarios. Naturally, they also wonder if they will need to maintain a trip-based model as a backup and, if so, can they afford to maintain two model systems.

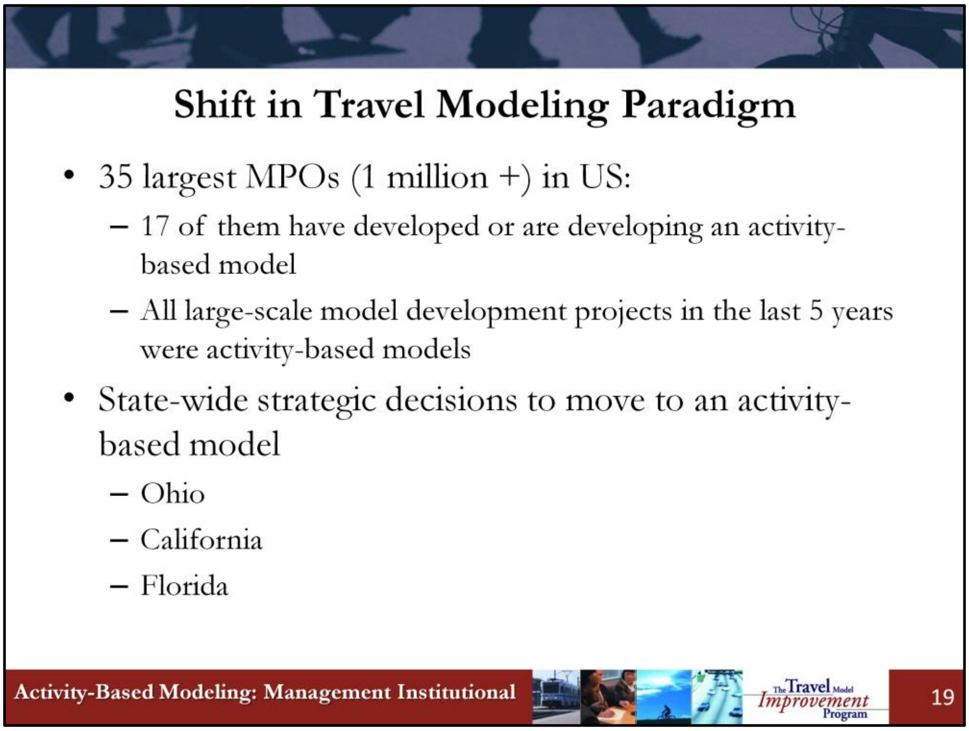


In addition, there is the user experience on a day-to-day level. What is the learning curve? Will it be easy to use? Will we be able to explain the model and its outputs to stakeholders?
For modelers who are used to seeing trip-level outputs, such HB-work trips, HB-Other trips and Non-HB-trips, there is uncertainty in not knowing what the output be like when travel behavior is expressed in terms of activities and tours. If there is so much more information and output, will this require sophisticated data mining skills? What software tools have been developed to help?

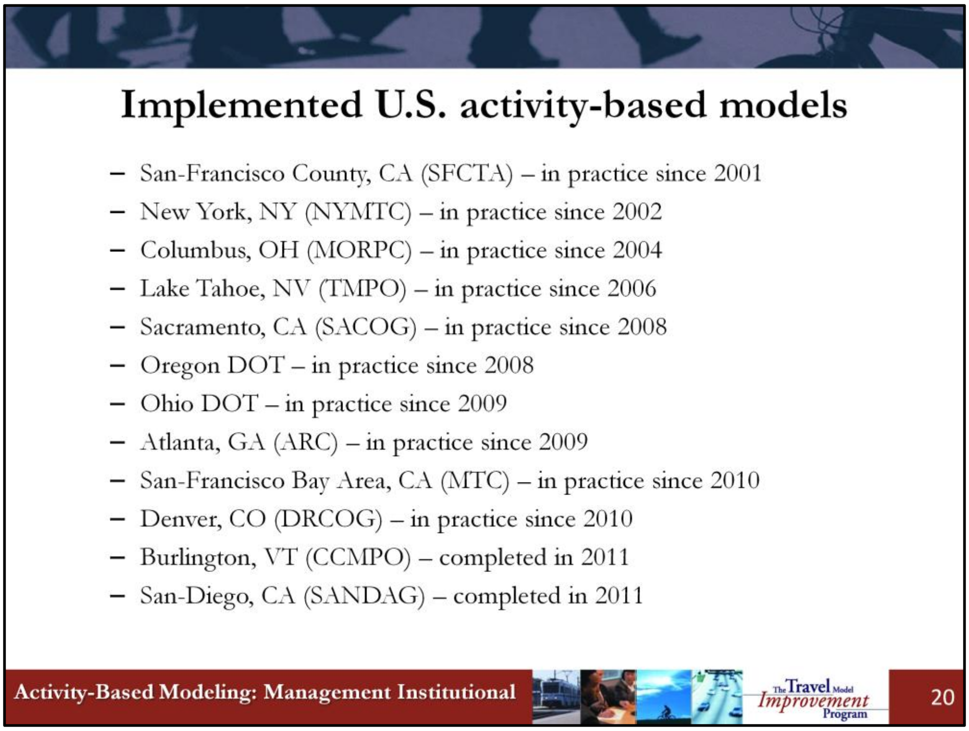
Finally, DOTs and MPOs often serve the modeling needs of constituencies composed of transit agencies and municipalities. In addition, there are often local engineering consultants who have used their models for years in traffic impact studies and similar work. Will they be able to use the new activity-based model, or will they insist on sticking with the trip-based methods which with they are most familiar?



The answers to these questions may be found by talking to modelers in regions that have already adopted activity-based modeling systems. This map shows locations in the U.S. where activity-based models have been developed. As the map key indicates, red dots are locations where a model system has been finished and is known or thought to be in operation. In some cases, these might be quite recent. The green dots indicate locations where model systems are now under development. Interestingly, there are two states shown here in blue—Oregon and Ohio—that developed activity or tour-based components for their statewide modeling systems. It is also interesting to note that all of these systems have been developed within the past 12 years.



To give you some statistics, of the 35 largest MPOs in the U.S., 17 have already or are in the process of developing an activity-based modeling system. In the last 5 years, all of the large model development projects have been a move towards an activity-based modeling platform. In addition, at least three states have decided to encourage the development of activity based modeling systems for the larger MPOs within their states. This includes Ohio, where the success of the Columbus model has inspired confidence in its transferability to other large cities in the state. In California, SB 375 introduced sweeping changes in the way transport planning agencies analyze transportation and land development, mandating the development of activity-base models for the largest MPOs in the state. Florida is another recent convert, in which FDOT has begun to support development of activity-based models in its larger metro areas.

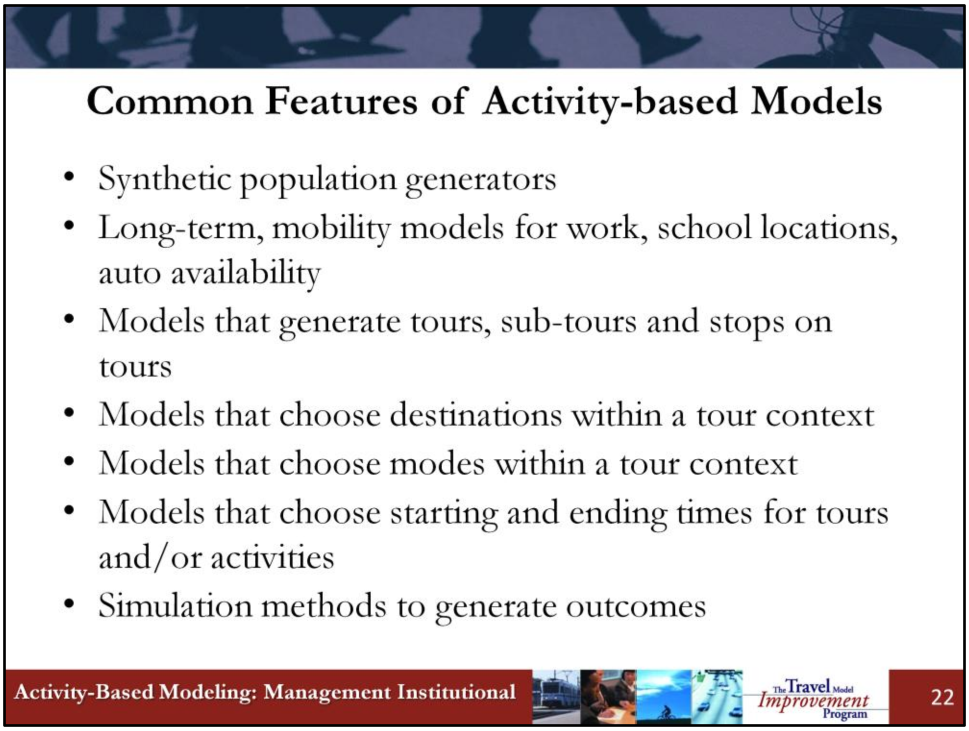


Here is a list of the known activity-based modeling projects that have been implemented in the U.S. The development of the early pioneers—SFCTA and NYMTC actually started in the 1990s, Some of these projects have long development histories, while others benefitted from the work done on the early models. One example of this was the MORPC model, developed for Columbus, which provided the basic model structure and software for the Lake Tahoe model. As you can see, some of these model systems were only recently completed.

Models currently under development in the U.S

- Seattle, WA (PSRC) – started in 2008
- Portland, OR (Metro) – started in 2008
- Los-Angeles, CA (SCAG) – started in 2009
- Phoenix, AZ (MAG) – started in 2009
- Chicago, IL (CMAP) – started in 2010
- Miami, FL (SERPM) – started in 2011
- Houston, TX (HGCOG) – started in 2011
- Jacksonville, FL (NFTPO) – started in 2011
- Tampa, FL (FDOT District 7) – started in 2011
- Philadelphia, PA (DVRPC) – started in 2012

Here is a list of some of the known activity-based modeling projects now underway. As you can see, the number of new activity-based model development projects that have been started within the past 3 to 4 years is about the same as the number of projects that were completed between 2000-2010. So, the pace of development is accelerating.



You might be wondering what the features are of these various activity-based modeling systems and how they differ from each other. The design features of the various modeling systems will be covered in exquisite detail in future webinars. The webinar schedule shows that we have 9 webinars devoted to various aspects of activity-based model design, behavior, performance other interesting issues. For today, however, it is sufficient to consider the common features that have become fairly standard across the various at a somewhat high level. Interestingly, some standardization of model components has occurred, although variable specifications and certain structural elements differ quite a bit between systems. This slide shows the common feature of activity-based models in use today in the U.S.

These features include:

Synthetic population generators

Long-term, mobility models for work, school locations, auto availability

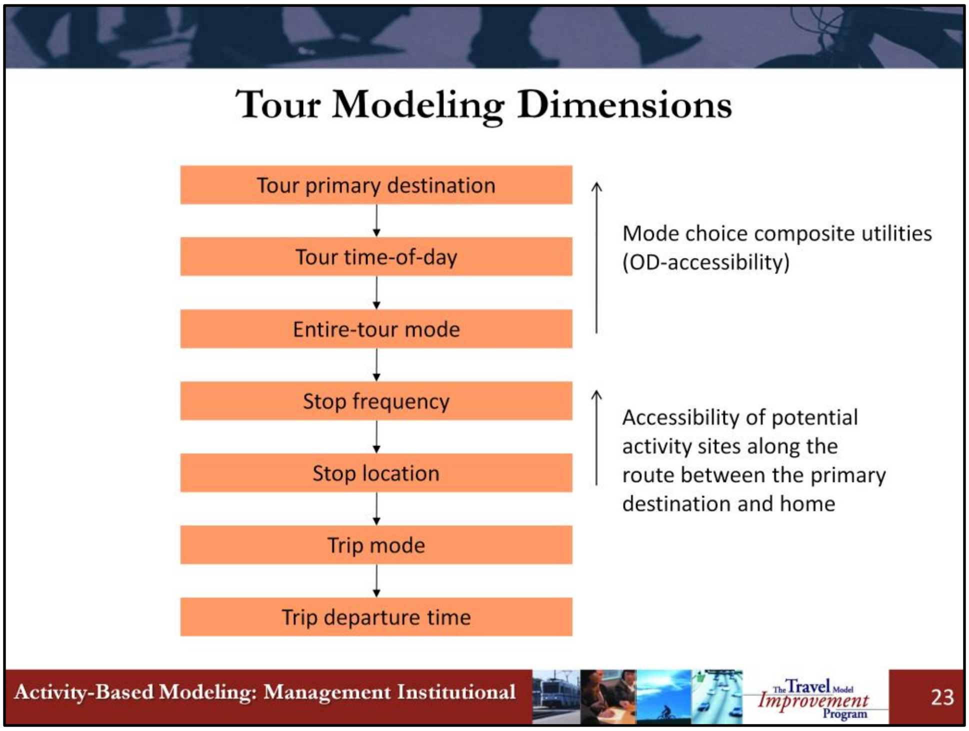
Models that generate tours, sub-tours and stops on tours

Models that choose destinations within a tour context

Models that choose modes within a tour context

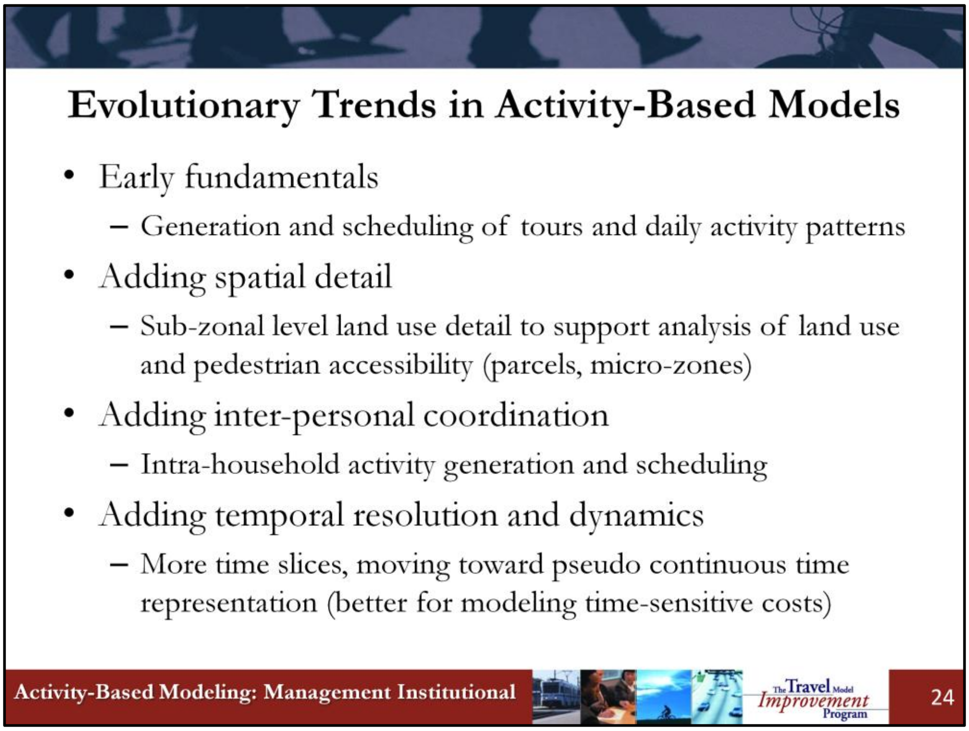
Models that choose starting and ending times for tours and/or activities

Simulation methods to generate outcomes

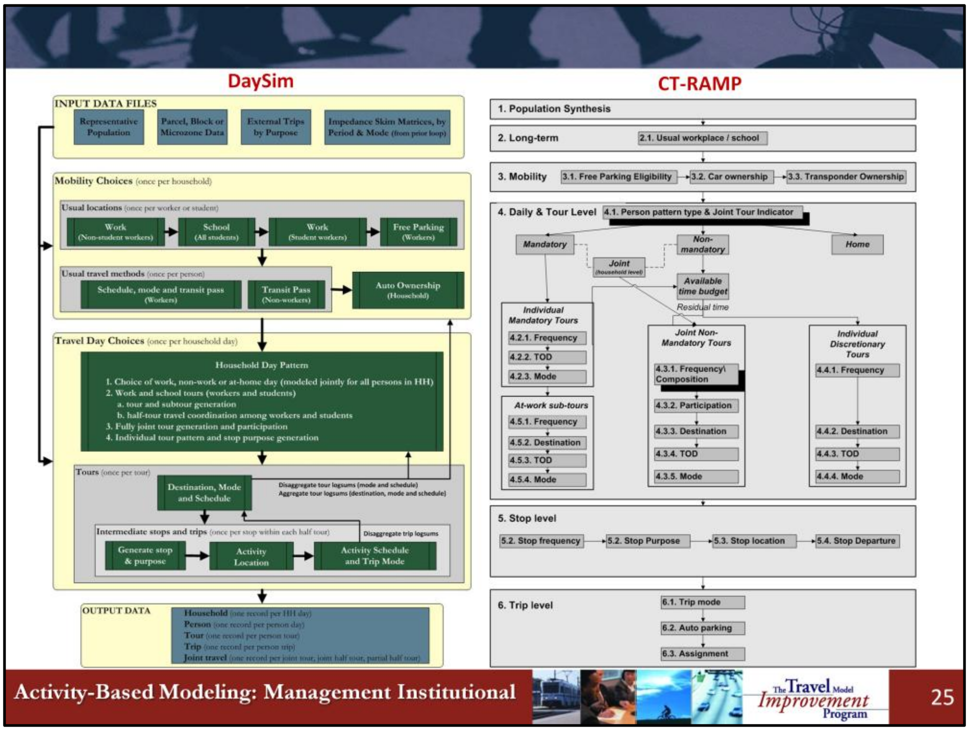


A central concept in these models is the notion that travel episodes are organized into tours and that people first make decisions about destinations, modes and timing in consideration of the entire tour, based on expectations of what they want to do. Trip-level decisions are conditional upon tour-level choices. It should also be noted that this diagram shows a particular sequence of decisions (destinations, time of day and mode) at the tour level, and at the trip level (stop frequency, location, mode and time of day). These sequences may vary from one modeling system to the next and sometimes even within the same modeling system for different contexts. The important takeaway is that tour-level choices condition trip-level choices.

The other important piece of information is found on the right side of the graph. The accessibility values of potential downstream choices are fed back up the model chain and used as predictors of upstream choices. This type of vertical integrity is another comment feature of activity-based models, at least the ones most commonly used in practice.



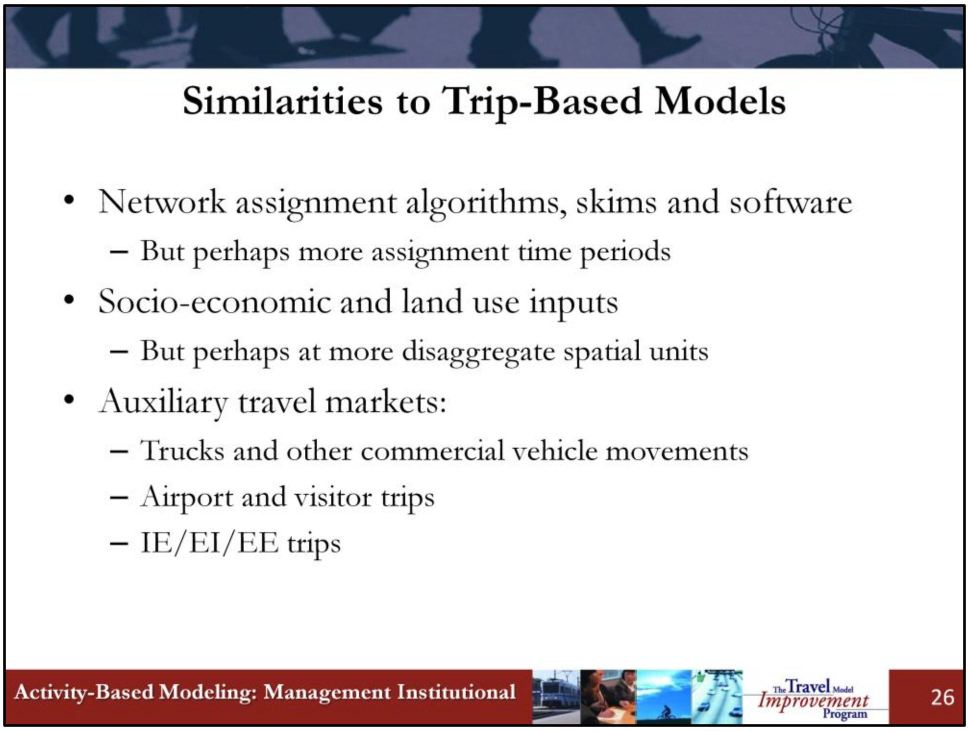
Trends in activity-based models have evolved from an initial set of models that implemented activity and tour-based concepts that we now consider to be fundamental to activity-based modeling platforms. Over the years, developers of these models have refined their designs in different ways. Some have added spatial detail to support the analysis of land use impacts on transportation accessibility, its effects on discretionary stop making, and to provide higher resolution analysis of pedestrian movements. Other model developers have focused on the dynamics within households and have explicitly modeled some of the sub-decisions that people make when coordinating drop-off and pick-up arrangements, scheduling around children, and joint activity participation. Even more recently, model developers have begun to move toward finer temporal resolution in order to better reflect time sensitivity to changes in travel costs over the course of the day.



This slide shows recent flow diagrams for the two most common activity-based modeling frameworks in the U.S. In recent, years these systems have been branded with the names “DaySim” (shown on the left) and “CT-RAMP” (shown on the right). We won’t cover the details of each model system today—that will be explored in subsequent webinars. I put them side by side like this because I wanted to point out how these two modeling systems are becoming increasingly similar. Both systems share the common features we just discussed, including a few items, such as free parking eligibility, that are non-standard, but necessary for analyzing TDM policies.

DaySim (left) was first implemented in Sacramento utilizing a very detailed parcel-based representation of land use, which was a departure from predominately TAZ-based systems. The earliest implementation of the models now known as CT-RAMP (right), the Columbus, Ohio model, focused on explicit modeling of interactions between household members. This came at a time when other activity-based modeling systems were modeling individual activity patterns, with interaction between household members more of a correlated attribute rather than a hard constraint. In a recent specification in Seattle, however, we now see joint activity generation and scheduling being added to the DaySim model. And in a recently completed version of CT-RAMP in San Diego, a more detailed spatial unit of analysis was implemented called micro-zones (though not shown in this diagram).

To be sure there are differences in the fine details of model structures and specifications, but it does appear that a common vision of functionality has begun to emerge.

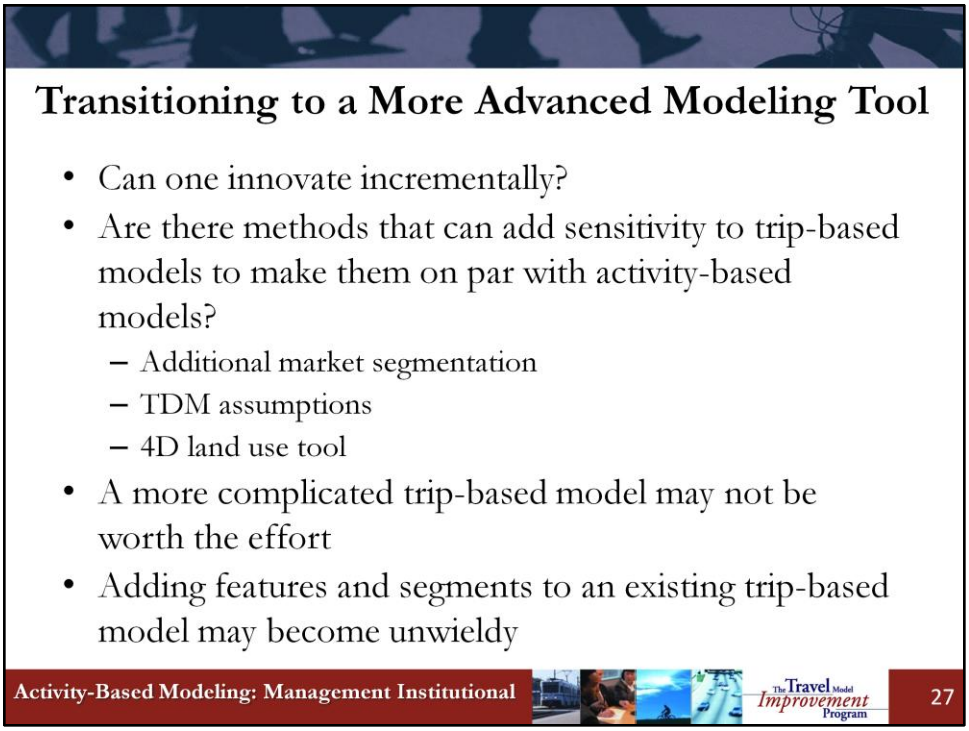


It is also important to highlight what activity-based models have in common with trip-based models. To start, agencies implemented activity-based models should expect to use the same commercial travel demand modeling packages for network assignment and scenario management. The one difference might be using more highway and transit assignment periods in order to take advantage of the temporal resolution reflected in the activity-based model outputs.

Socio-economic inputs and land use data should be quite similar, but some activity-based modeling systems require that they be maintained a more disaggregate spatial resolution. Once again, we are talking about a parcel-based system or micro-zones.

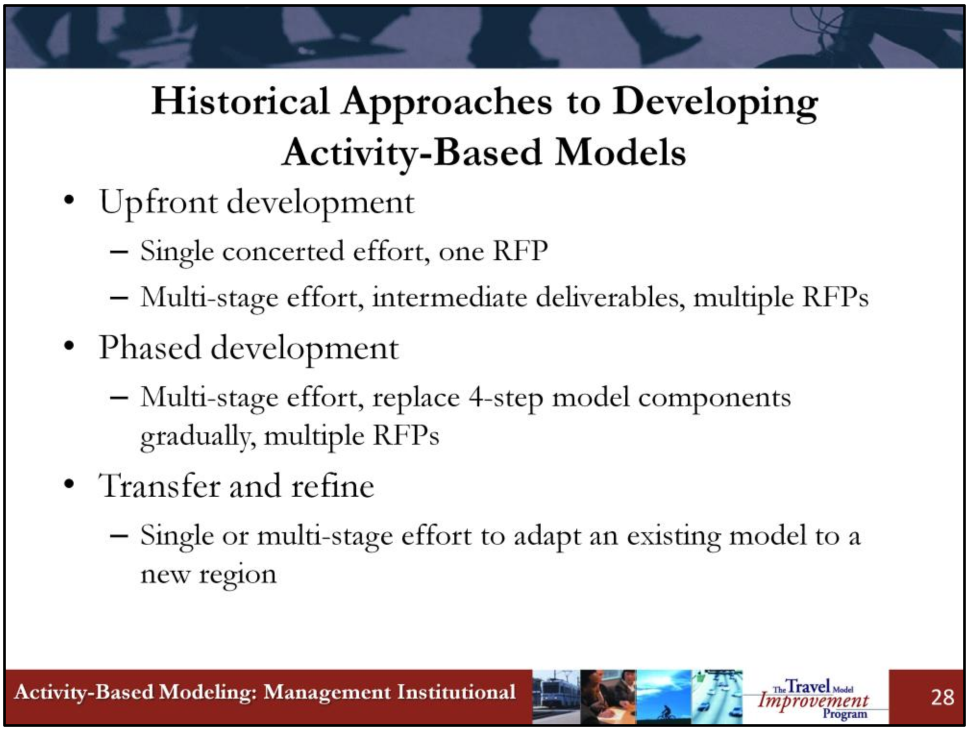
Activity-based models of the kind we are covering here are focused on resident travel. Public agencies considering the move towards an activity-base modeling system should be prepared to maintain truck and other commercial vehicle movement models, just as they did for their trip-based model. Similarly, Internal-External trips will be need to be generated and distributed through a separate process, probably the same one used for the trip-base model. Likewise, airport and visitor trips are not typically covered in an activity-based modeling system for an urban area.

While it is possible to develop activity-based commercial travel models and even tour-based visitor models, those represent completely separate models and processes.



Given the set of available activity-based model features and how they might interact with other system components, what are the options for an agency interested in transitioning from a trip-based model system to an activity-based model system? Can one innovate incrementally by gradually replacing trip-based model components with tour-based model components? Or might it be possible to add sensitivity to an existing trip-based modeling system so that it behaves more similarly to an activity-based modeling system? Some agencies have experimented with adding components to their trip-based modeling systems to do just that. One strategy is of course to add more market segments—either in terms of trip purposes, or socioeconomic segments at an attempt to explain more variation. One example might be to make assumptions on a certain percentage of trips being affected by travel demand management policies based on historic participation rates. Another example would be the 4-D-plus post-processing tool, which was tested out by SACOG prior to their usage of their activity-base model. The 4-D process (density, diversity, design and destinations) was intended to adjust trip generation rates according to these four dimensions of land use.

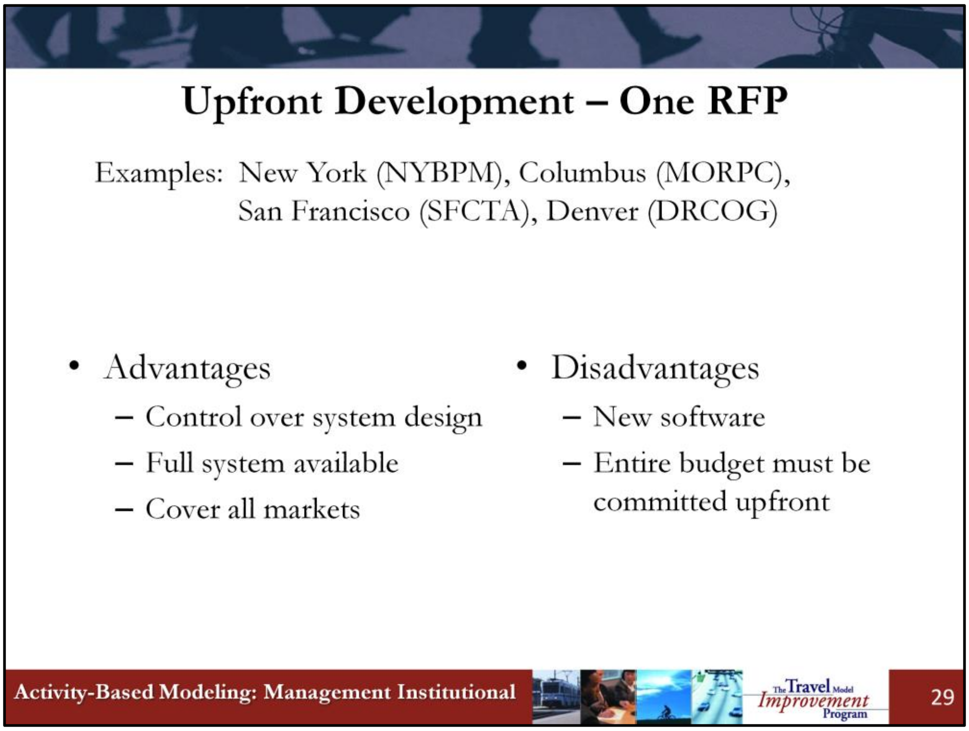
At some point, however, it may become apparent that adding these features costs time and money. Moreover, it may produce a complicated modeling system that does not do everything that an activity-based model could do, has lengthy run times, and requires excessive storage of trip tables and skim matrices.



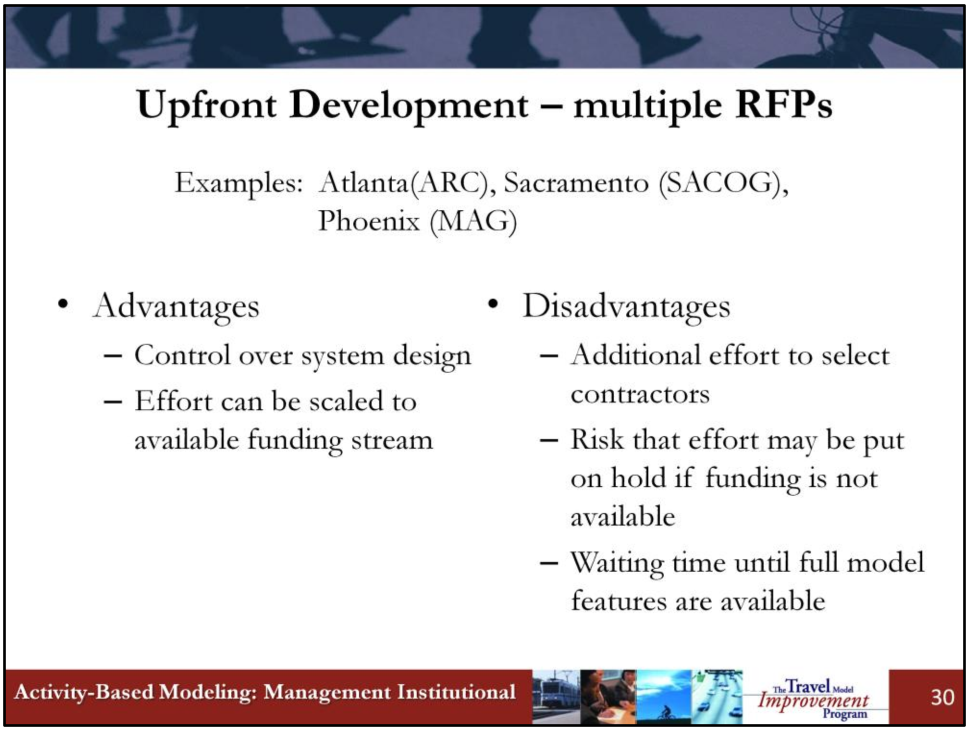
This slide list three generalized approaches for the development of activity-based modeling systems. The first is to develop the model through a single large effort through one RFP. A variation on this might be a multi-stage effort in which the first RFP takes the development process up to a certain milestone, and then another RFP issued (or even a third) in order to complete the next stage in the project. Here the trip-based model is being used as usual while the agency waits for the activity-based model to be ready for use.

This differs from a phased approach in which the activity-based model gradually replaces certain trip-based model components over time. Here two model systems are not being maintained. Rather, the trip-based model is being phased out.

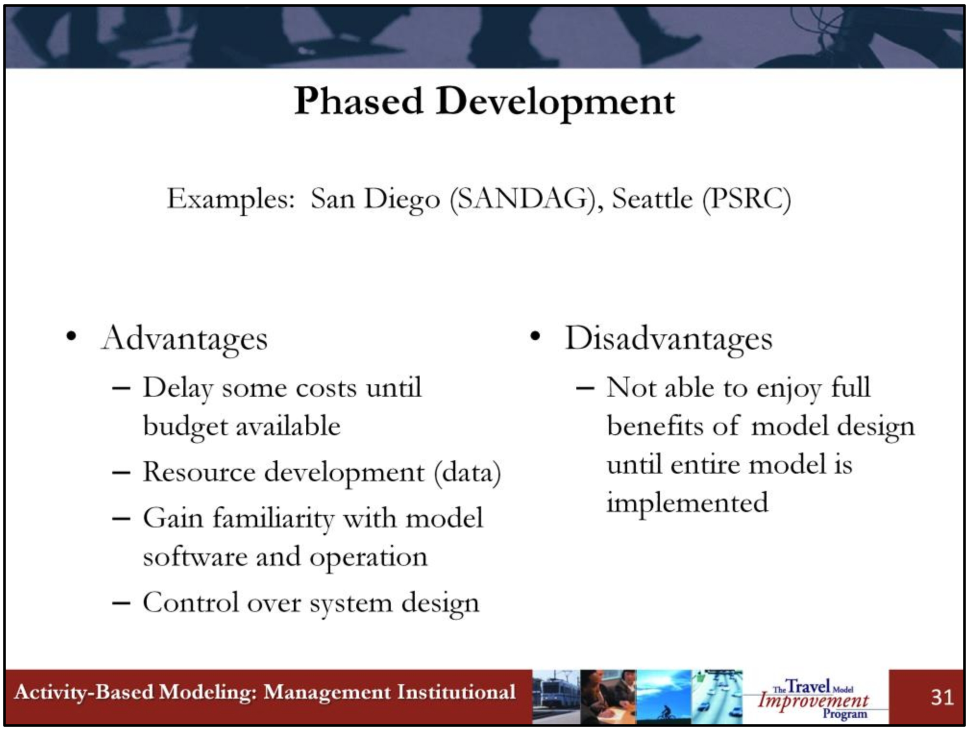
A third approach is to transfer an activity-based model developed for another region and to refine it as needed for the new location. This could be a single or multi-stage effort, though it is like to involve multiple stages if the region is large and complex in its transportation system.



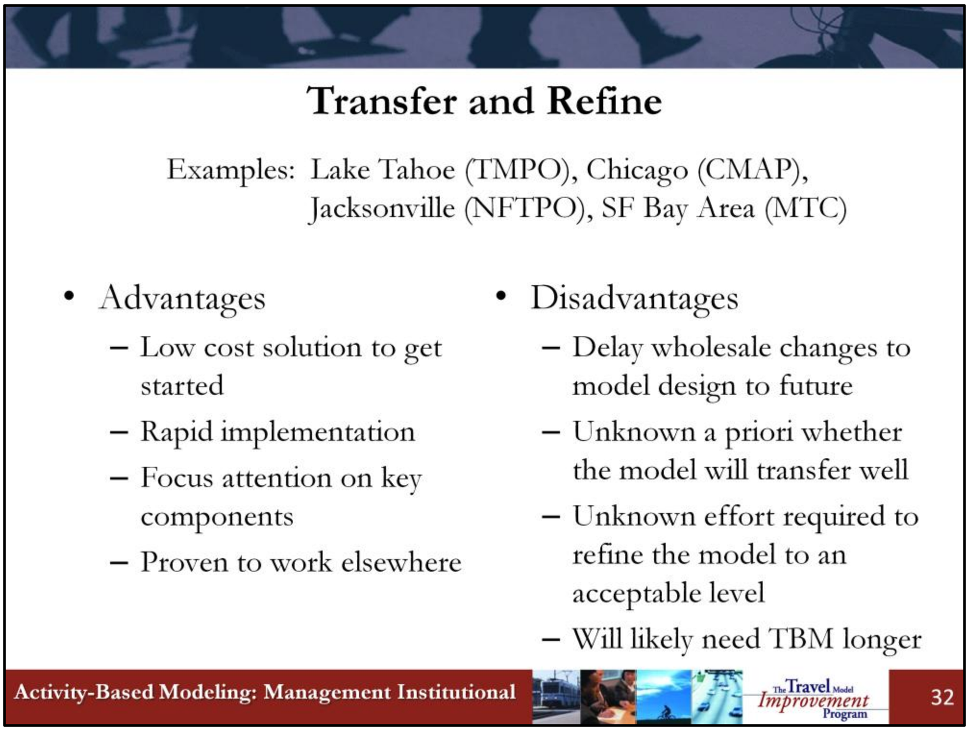
This slide shows the approach taken by most of the early adopters of the activity-based models. In upfront development with a single RFP, there needs to be a large enough budget committed to the project to pull it off in one contract. Because the model is not being transferred from elsewhere there is control over the system design, but also some risks in developing a new mode structure and application software. Once the work has been completed, however, the agency has a working model that covers all of the relevant travel markets intended in the original design. This is not to say that additional features and refinements might not be added later. In the case of SFCTA, for example, even though they have used their CHAMP model for close to 10 years now, they have frequently made modifications to certain model components, either for project-specific requirements, such as New Starts or tolling analysis, or just for the sake of efficiency. In that sense, the SFCTA modeling program is similar in its model update approach to agencies in similar-size market areas that run trip-based models.



This approach is one followed by some agencies that are committed to developing an activity-based model, but might need to stretch out the process over an extended period of time in order to synchronize funding availability, or perhaps in order to buy time to collect new data. In these cases, there is clearly a disadvantage to having to issue multiple RFPs, though some agencies may be faced with little choice. Typically, these agencies will maintain their trip-based model until the activity-based model is ready for use.



Phased development is another option, which can help an agency spread costs and risks over more time. At the same time, it enables modelers to get become familiar with some of the new model components. The main disadvantage to this approach is of course delayed gratification. The agency won't be able to fully realize the benefits of their activity-based model design until all of the components are in place. In the case of both SANDAG and PSRC, the two agencies began by replacing trip generation components in their trip-based model with the activity pattern and tour generation components.



If an agency wants to get started in activity based modeling, transferring a model from another region is quick way to get started at a reasonably low cost. Listed here are examples of MPOs that have or are in the process of developing models, based on specifications developed in other regions. Thus far, it has seemed to work well and partially mitigated concerns over transferability of parameters and structures. Nevertheless, an agency could be expected to follow-up the initial transfer with model calibration and validation based on local data. Depending on agency needs and the results of sensitivity testing, there may need to be follow-on contracts issued to refine or redesign certain model components. This is more likely to be the case in larger, more complex metro areas, particularly those with large-scale transit systems.

Questions and Answers

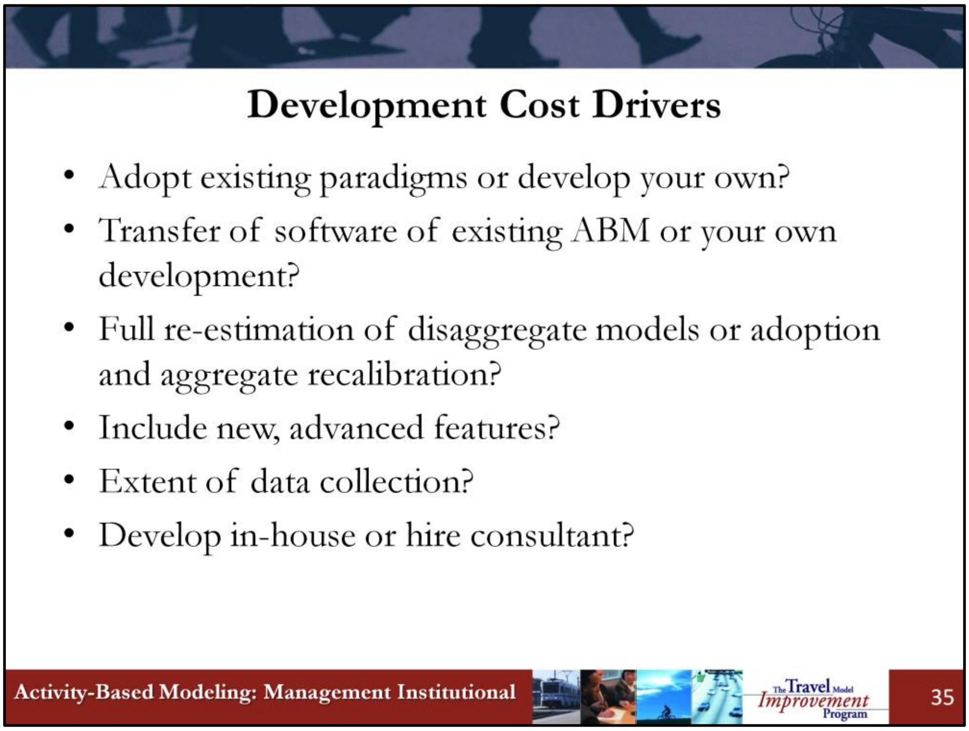
The Travel Model Improvement Program

Resources Needed to Develop and Maintain Activity-Based Models

- Budget
- Development timeline
- Agency
- Software
- Hardware
- Data
- Funding mechanism

Let's now talk about the resources required to develop and maintain activity-based models.

Read the list verbatim.



One of the first questions that gets asked is, how much will it cost to develop the model? There are several factors that affect the cost of a new model.

The first aspect to consider is whether your are comfortable with the paradigms that are currently into practice. If you disagree with the foundational theory of the existing models, then part of your development costs will include investing in the time that it takes to bring a new approach into practice.

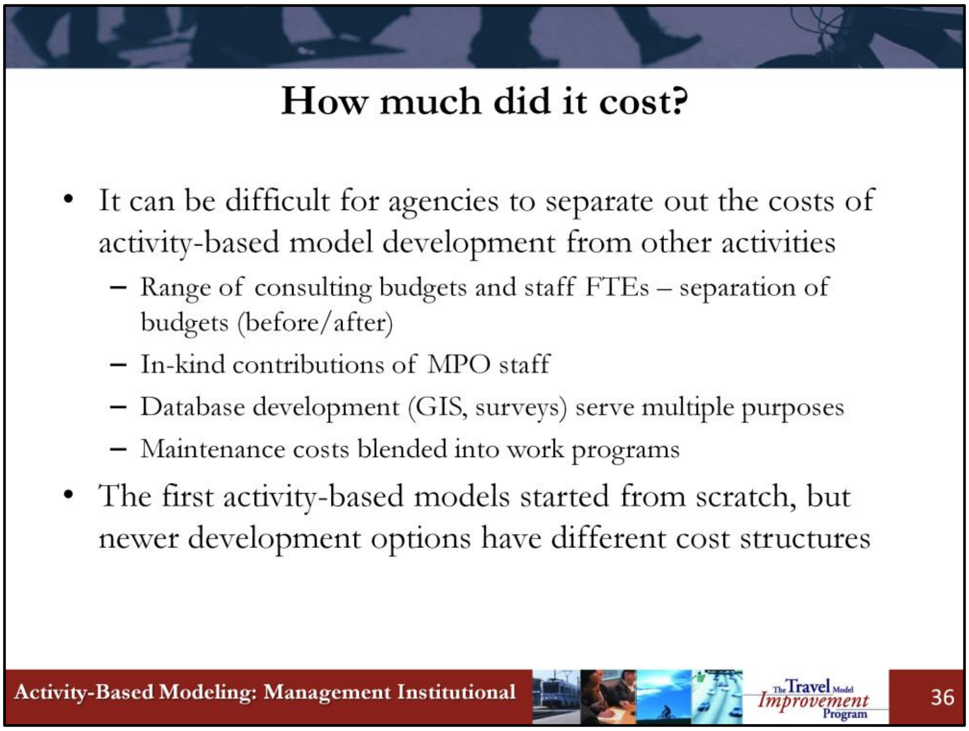
A second importance consideration is whether to adopt existing software, or to develop your own? Generally speaking, agencies would prefer that the software be written in a language that their staff is already familiar with. Current ABMs are written in various object-oriented programming languages, such as Java or C++. None of the current models is a completely scripted solutions; that is, they do not run completely in the same commercially-available transportation planning packages that run trip-based models. Developing new, well-tested and debugged programs is very costly and time-consuming. Some of the software on which current ABMs runs is publicly available and free, and it is modular so that even if you choose not to transfer the model itself, the software can be adapted to work with a new model.

Assuming that one chooses to transfer an existing model, a third important consideration is whether to re-estimate all of the individual models, to re-estimate some and recalibrate the rest, or just to recalibrate. Re-estimation is attractive because it offers the opportunity to adapt the models more fully to the local conditions, but depending on the extent of re-estimation it can be a large effort. A model that is transferred and only partially re-estimated can be calibrated to meet local conditions, and this typically takes less time that re-estimating all the models.

Another aspect of transferring an existing model is whether to take as is, or to include some additional features in the model. These additional features typically respond to some specific need of the agency, such as refining how the model deals with road pricing, or with various aspects of transit services. They may also be related to addressing specific populations or travel markets that may not have been important in the original model, such as visitors, seasonal residents, or special event travel.

Will the new model require new data? Many regions already plan to conduct travel behavior surveys every 10 to 15 years, so a relatively recent survey may already be available. If it isn't, then the cost of a new survey may need to be included in the cost of developing the activity-based model.

Lastly, there is the question of whether to develop the model in-house, or to hire a consultant to do it. To date the experience in the United States has been that consultants have taken primary responsibility for developing activity-based models. But as we will see, there have been several instances of agency staff taking an active, hands-on role in developing parts of the model.



Everyone wants to know how much it will cost to develop and maintain an activity-based model. In talking to various agencies that have implemented these models, it can be difficult to pin the answer to an exact number. While consulting costs are usually known, the budgets range widely because models have been developed under so many different arrangements. In some places, MPO staff have contributed a lot to model development, particularly in developing data. In terms of ongoing maintenance and operations, the staff responsible for the activity based model often have a range of other responsibilities. In addition, some the work on land use and survey data development as well as network coding and enhancements serve multiple purposes, including making improvements to the trip based model while the activity based model is under development.

In addition, more recent activity-based model development projects have tended to cost a little less than early ones. This is primarily due to the ability to transfer model components from one region to the next.

Development Cost – Sacramento Example

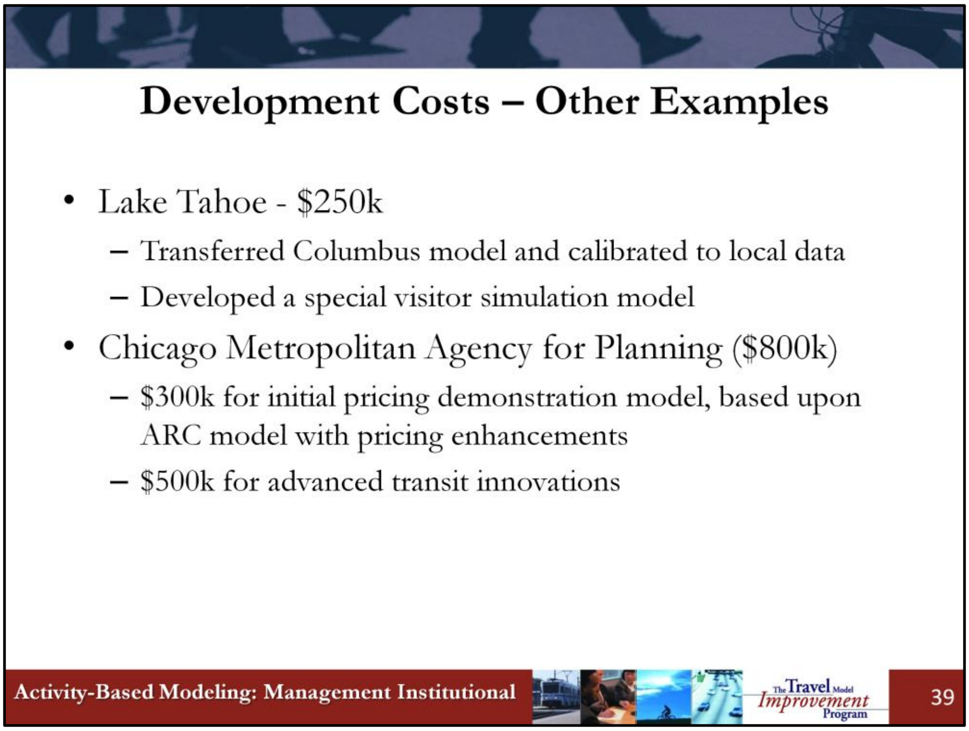
- $849,000 in consulting fees over 11 years
  - Initial development costs $514,000 to get to calibrated model in 2008
  - 2011 Model enhancement costs $335,000
    - Enhanced temporal resolution
    - Tolling/pricing analysis capabilities
- SACOG staff prepared land use parcel database over 5 years, a significant effort shared with other agency staff

Activity-Based Modeling: Management Institutional — The Travel Model Improvement Program — 37

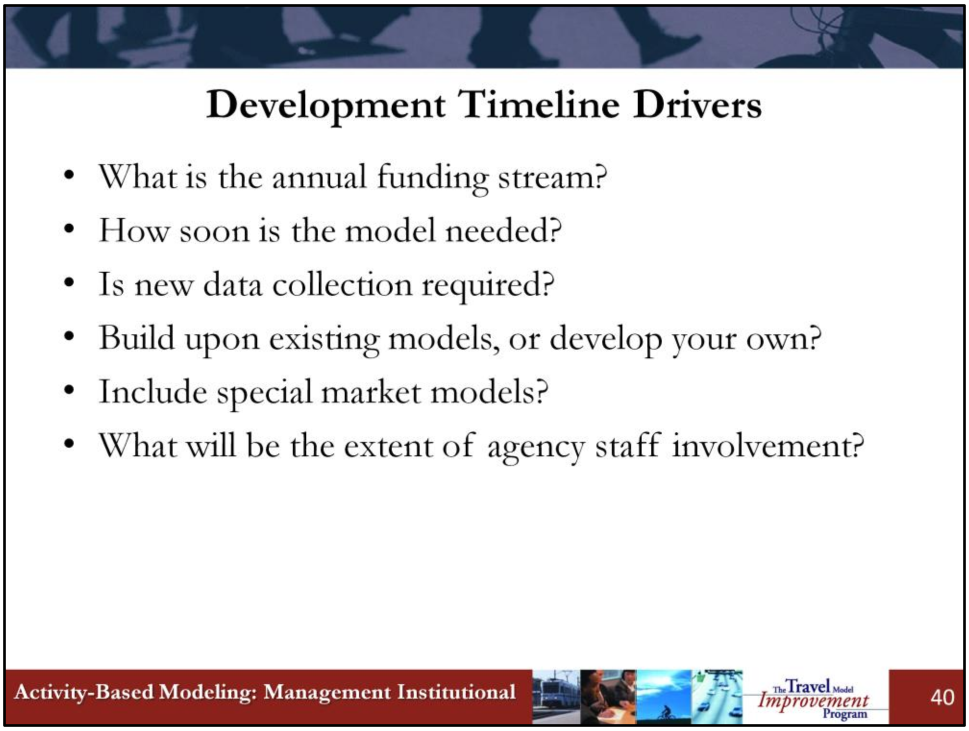
The SACOG model is one of the first to go into implementation. The model was paid for primarily through a combination of grants obtained over the span of several years. The total consulting fees are $849K, of which $514K represents the development cost of the initial model, and $335K the cost various modeling enhancements undertaken recently.

One significant contribution of agency staff to the development of the SACOG model, not accounted for in the consulting fee, was the development of a land use parcel database.

San Diego is a more recent model. It has been developed in four strategic annual phases, all with the same consultant. The consulting fee includes significant software development, as well as the development of a series of sub-models, such as simulation of airport passengers and cross-border travel, special events, a visitor model, and an external travel model. Total consulting fees are $1.2M, equally distributed over 4 years. The phase 1 models were funded with a grant from Caltrans, and partly for this reason these models were designed to result in a fully-functioning system by the end of this phase.



This is an example of the costs that might be expected in a "Transfer-Refine" development strategy. The initial cost to get the model in place are generally low. Depending on the region's needs, following the initial transfer there may be significant costs for enhancing the model. The first example is Lake Tahoe. The cost of transferring the Columbus, Ohio model to Lake Tahoe and recalibrating it to local data was $250K in consulting fees. This fee includes the cost of developing a new visitor travel simulation model. Note that no model re-estimation was undertaken. The second example is the transfer of the Atlanta model to Chicago, which took place in 6 months and cost $300K in consulting fees. The model was first implemented as a road pricing demonstration tool, so it included some enhancements over the ARC model, but also some simplifications, most notably the use of static skim matrices. Recently CMAP agreed to fund $500k in enhancements, some to fully interface the model with their existing networks but most of it devoted to transit modeling enhancements that go well beyond the state of the practice, and for that reason not typical of transit modeling elsewhere.



Let’s turn now to the time that it takes to develop a new model. Key aspects that play a role in the development timeline are listed in this slide. They include:

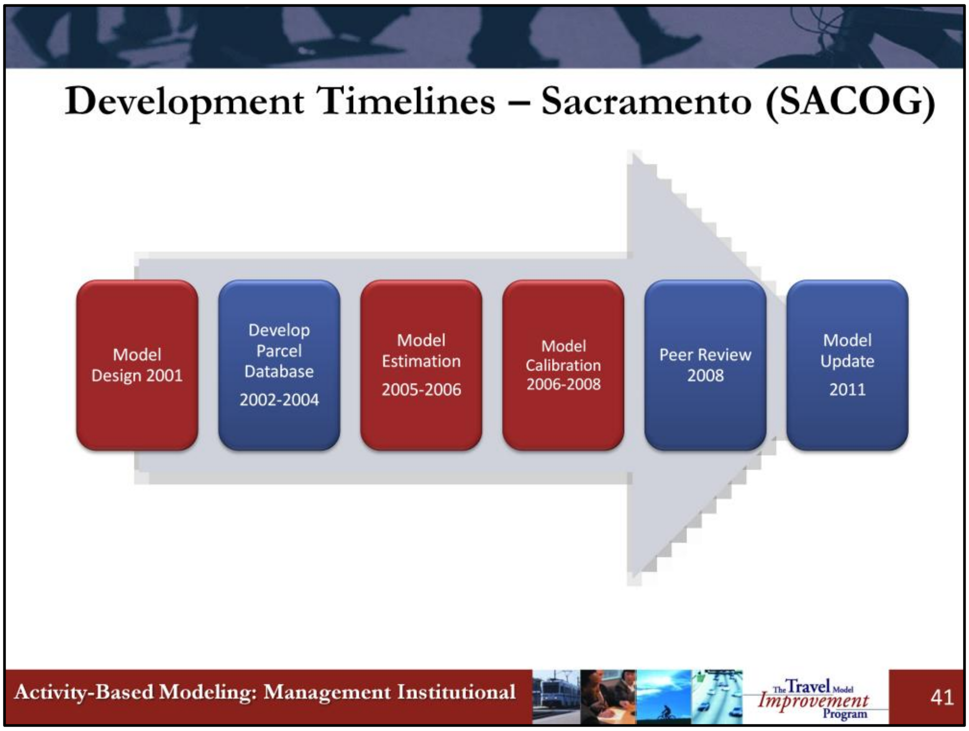
Annual funding stream: can the agency secure sufficient funding upfront to develop the model in one go, or will the model development pace need to be adjusted to fit the availability of funds?

Is there a pressing, immediate need or desire to have an activity-based model in place? Agencies need to schedule their model update cycles to fit the cycles of regional transportation plans and other activities. A model that is expected to be used to support an upcoming RTP may need to be developed on a faster track than when this external pressure is not present.

Will new data collection be required? The time needed to design, conduct, and analyze a household travel behavior survey may need to be accounted for in the schedule for developing the model.

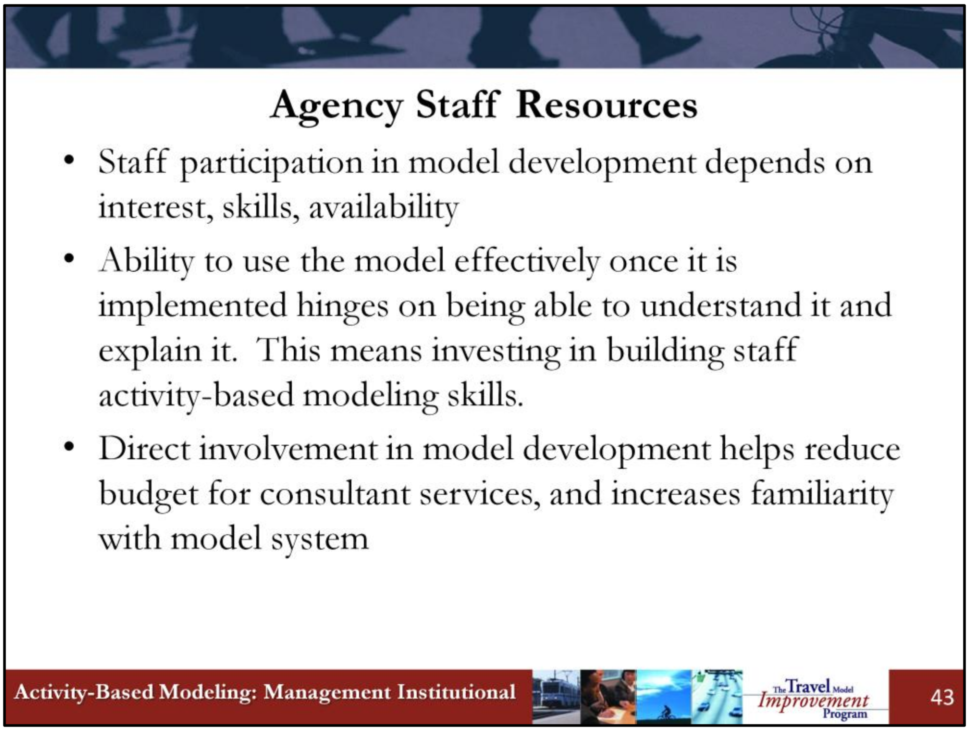
The specific features desired in the final model also play a role in how long it takes to develop the model. A model transfer without any changes to the model structure can be performed in 6 months, but additional time is required to re-estimate certain model components, add or refine model features that are important for the region, and include simulation models of special trip markets, such as air passengers, visitors, and others.

Last but not least is the extent to which agency staff can contribute to the model development. Some agencies may be able to take responsibility for developing certain model components, thus effectively complementing the consulting staff.

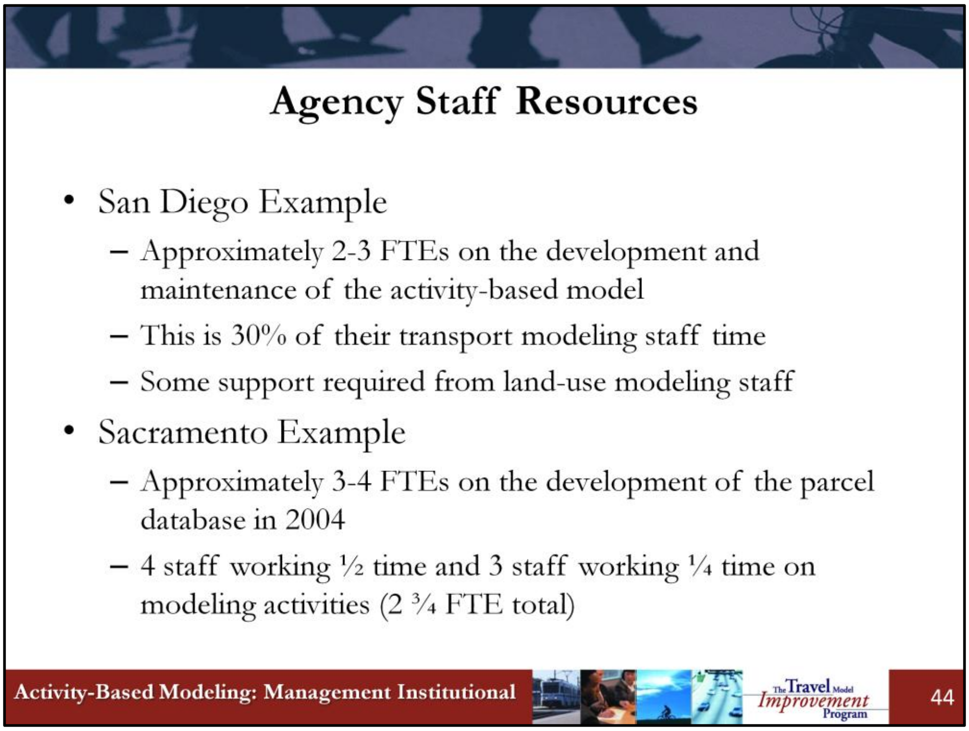


This timeline was developed from information given to RSG by SACOG through a study commissioned by the Association of Metropolitan Planning Organizations. It chronicles one of the first activity-based models. The impetus for the development of the SACOG model came from the MPO staff. After the initial design, there was a two-year period in which agency staff developed an extensive parcel-based land use database. This was followed by a 3-year period of pure model development: model estimation and calibration, as well as development of the application software. The model has been in use since 2008. Various enhancements were undertaken in 2011.

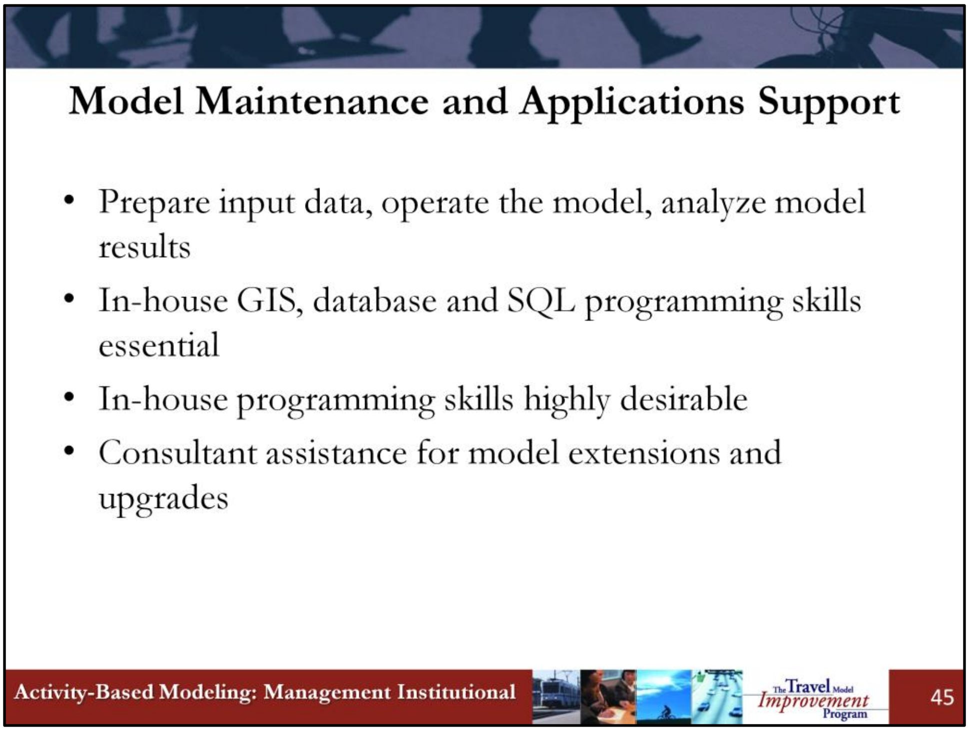
This example is a more recent model, started in 2009 and scheduled for completion this year. The SANDAG activity-based model took advantage of substantial work that the agency had invested in developing a micro-zone system and network GIS management tools developed for the trip-based model. The model development was planned as a phased update. Phase 1 of this model was funded with a grant from Caltrans, and so it was tailored to result in a fully-functioning model, with some AB-like components such as a population synthesizer, residential and workplace location models, and a day pattern model, working together with the trip-based distribution and mode choice models. There have been 3 subsequent phases, each devoted to a specific subset of models.



How much or how little agency staff participates in model development activities largely depends on their interest, their skills and their availability. The end goal is for the agency to be able to own the model and use it effectively. For this to happen, it helps to take advantage of the model development process to get agency staff familiar with the model. Some of the desired skills include a good understanding of the core modeling techniques, in particular discrete choice modeling and simulation, some familiarity with the programming language on which the model is built, and familiarity with database querying software. It helps to plan for multiple practical, days-long training sessions as the model is developed to build familiarity with the model over time. Comprehensive staff training is one of the lessons that agencies that have gone through this process cite as key to success and return on their investment.

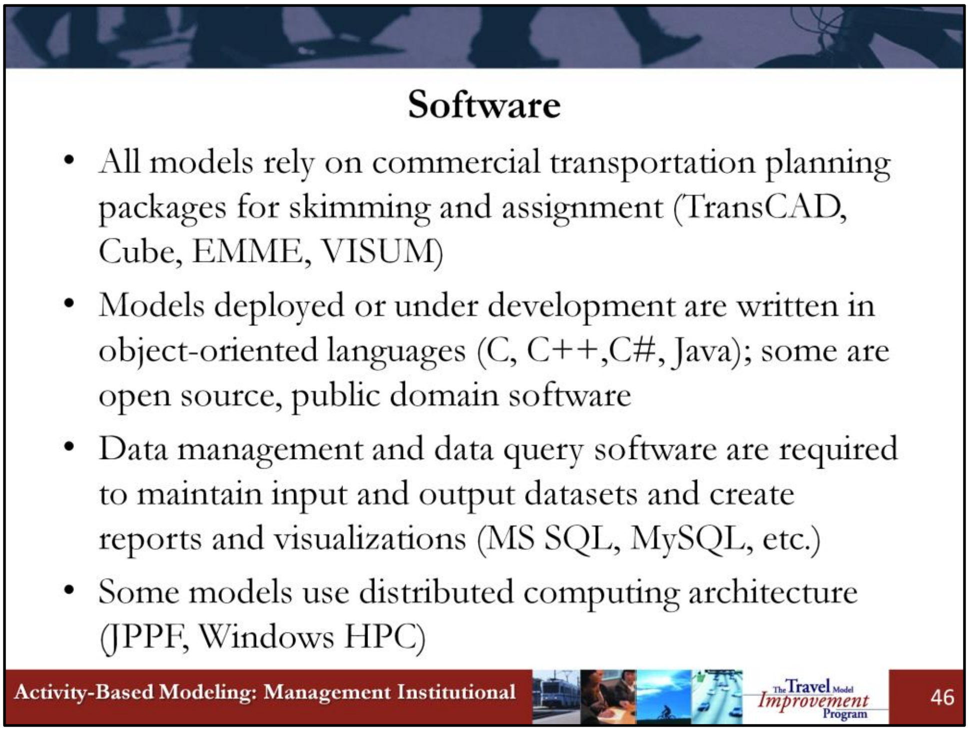


These two examples show the extent of agency staff involvement during the development of the San Diego and Sacramento models. Both agencies provided substantial staff time to support and complement the consultants' work.



Like a trip-based model, activity-based models require maintenance and support activities. Preparation of network scenarios, for example, is typically identical to the work done to run alternatives on a trip-based model. In an activity based model there tends to be more attention paid to land use representation at a disaggregate level. This is especially true of the models which operate at a parcel or micro-zone level.

In addition, because these programs make use of some data structures and model forms not typically found in commercial software, they have been developed in customized application packages that often rely upon external back-end databases. This, coupled with the opportunity to query disaggregate outputs in numerous ways to develop project- and policy-specific performance measures, has made staff scripting and programming skills even more important. That is, it is often necessary to know more than just the commercial package macro and scripting languages to be able to fully exploit the model.



Activity-based models have various software requirements. They rely on the same commercial transportation planning packages used for trip-based models for certain functions, such as network skimming and assignment, and sometimes for running special market models. So licenses to run your package of choice are still required. The core demand components of an activity-based model are written in programming languages which may or may not be familiar to an agency's staff. Some of the ABM software implementations are free; they are distributed by the developers as open-source software. This includes the software that runs the CT-RAMP family of activity-based models, and is expected to be the case for the work on activity-based models that is being funded by the SHRP C-10 project. Other specialty software may also be required to support database management, visualization tools, and distributed computing solutions.

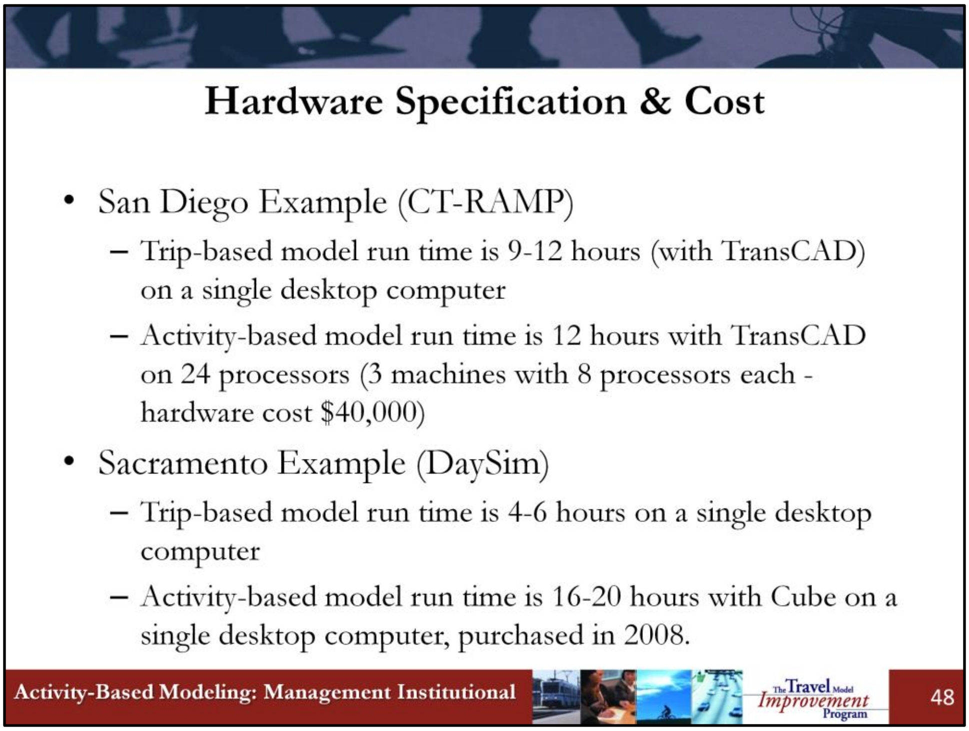
When it comes to software, the issue for agencies is not so much the licensing costs, which in many cases are zero, but the need to have staff fluent in these types of software tools. Other software issues to think about are related to providing remote access to the agency's servers to third party users (partner agencies, consultants working on behalf of the agency). Remote access and/or cloud computing solutions are more critical for large regions, where multiple, powerful servers are required to complete a model run in less than a day.

Hardware Specification and Cost

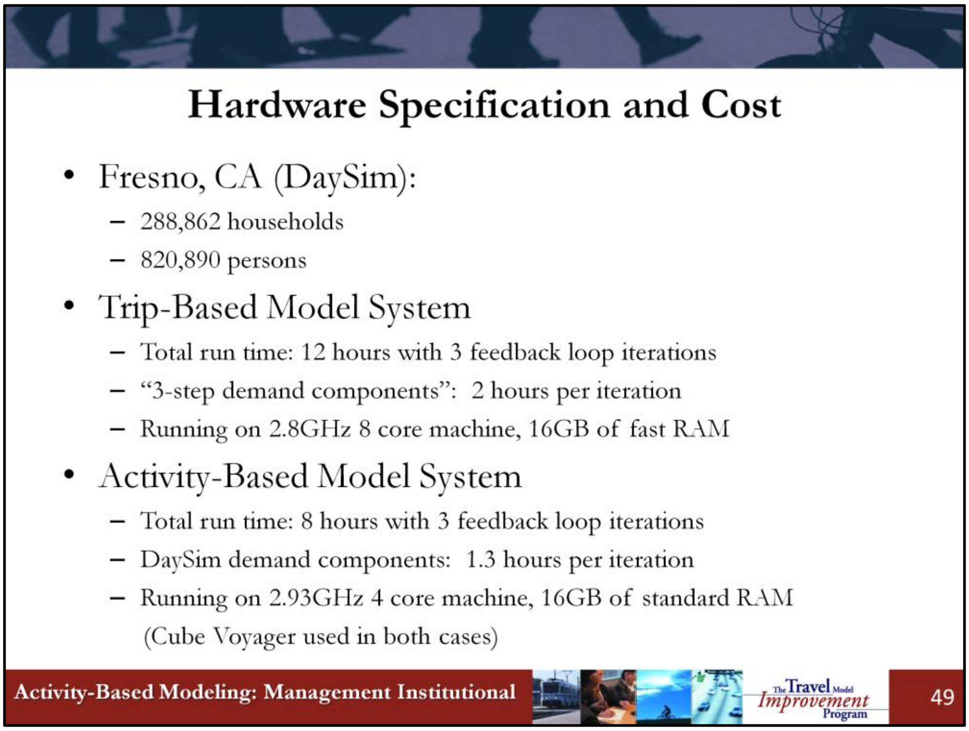
- Most important driver of run time is the size of the model population
- Number of network assignment periods and feedback loops is also important
- Tradeoff between run time and hardware cost – more and faster processors reduce run time, but increase server costs
- Some models use distributed processing, splitting the computation time among several computers
- Other hardware includes backup systems and model run archiving capacity

In a trip-based model run time is approximately proportional to the square of the number of zones; add zones and the run time grows exponentially. In an activity based model, run time is proportional to the size of the population; fortunately when you add population the run time increases linearly. The key message though is that populous regions incur longer run times, all else equal, than smaller regions.

How much to spend on computers to run the model is directly related to how fast you'd like the model to run. Most, if not all, models can be configured to run on a single, multi-processor computer. Most everyone would like to see their model complete a run in less than 12 hrs or approximately overnight; start the model when you leave for the day and have the results ready for you when you come back the next day. The way to achieve these run times in a large region is to deploy as many processors as needed to achieve the desired run times, either on a single computer or distributed over multiple machines. And as you all know, the more powerful the computer needed, or the more computers needed per model run, the higher the cost of the hardware. The good news is that computers continue to get faster and faster, and less and less expensive over time. Also ABM developers continue to come up with strategies to optimize the software, sometimes achieving significant improvements in run time performance.



This slide shows two comparisons of run time performance between trip-based and activity-based models. SANDAG achieves approximately the same performance with their activity-based model as they do with their trip-based model. It should be noted that the SANDAG trip-based model operates on the same micro-zone transit access framework that the activity-based model does. In Sacramento, the activity-based model takes approximately 4 times as long as the trip-based model, but it operates at a parcel level while the trip-based model operates at a far more aggregate traffic-analysis zone level. In both cases, the activity-based model provides a far more detailed representation of travel demand than the trip-based model, so in many ways the models are not really comparable.



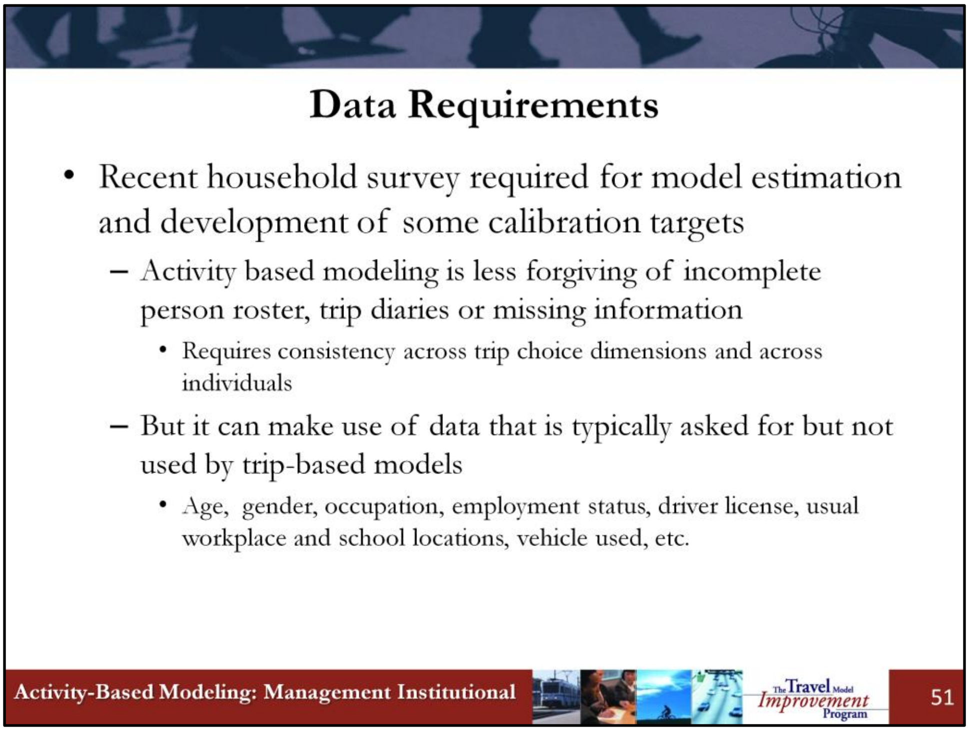
An activity-based modeling system does not necessarily have to be slower than a trip-based modeling system. In this particular case of a new DaySim model being developed for Fresno, California, the activity-based modeling system runs faster than the trip-based model, on a machine that's actually slightly slower (fewer cores, slower RAM)

Data Requirements

- Data requirements are the same or similar to those of trip-based models
- Some optional model features call for additional data collection:
  - Parcel or micro-zone population and land use inventories
  - Parking availability, transponder ownership, transit pass ownership
  - Highway and transit operations data for multiple time periods

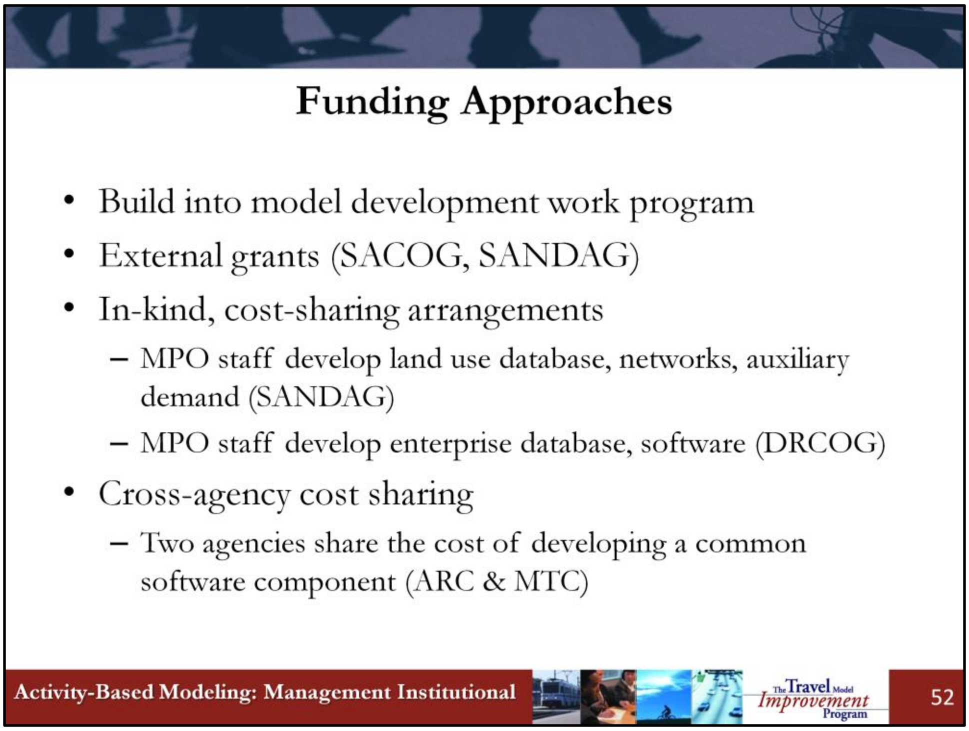
Another often-voiced concerned about activity-based models is that they are data hogs. In fact, an activity-based model can be developed with the exact same data that are used to develop trip-based models: a household travel survey, transit on-board survey, traffic counts, transit boardings, census summary data, employment data, and origin-destination or intercept surveys when available, for example.

Some optional model features call for additional data collection. Models that operate at the parcel or micro-zone level require detailed land use inventories. Models that account for mobility attributes like parking availability and cost at the place residence or place of work, transponder ownership, or transit pass ownership require data on who has access to these facilities and it impacts their travel choices. Agencies that wish to model highway or transit operations in great temporal detail need to be prepared to maintain a larger set of network attributes in their databases, for example.



Household travel behavior surveys are the backbone of all model development, and as mentioned previously, activity-based models use the same household surveys that trip-based models do. Nonetheless, it must be mentioned that an activity-based model is less forgiving of incomplete or inaccurate information. The main issue is that the model requires completeness and consistency across all individuals in the household and across the trip choice dimensions. For example, if joint travel among household members is a feature of the model, then the survey used to estimate the joint travel components must be able to show which household members travel together. Often times people report that they traveled with other household members, but their reported trip schedules or destinations do not coincide.

While activity-based models are more demanding of the data, they also use more of the data that is reported in these surveys. Person attributes are rarely used in trip-based models, yet are common and powerful explanatory variables in activity-based models. Activity-based models care about long term choices such as usual work place and school locations, in addition to short term choices – did you travel to work or school on the survey day? The ABM can track which person in the household uses which vehicles, which potentially can be used for analysis of fuel consumption and adoption of new vehicle technologies.



Last but not least, where to find the money to pay for all this?

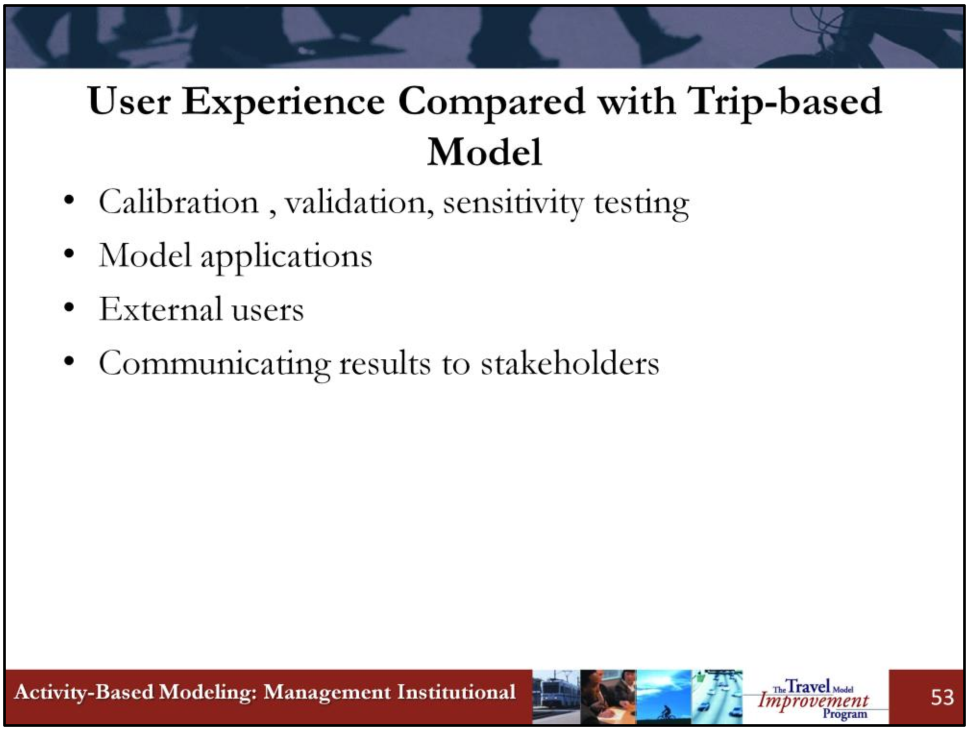
The most common approach is to funding it via the agency's ordinary work plan, at least by partially diverting some funds that would have otherwise been invested in improving the trip-based model. Thus, one opportunity to introduce an activity-based model is when your trip-based model is due for a major overhaul.

A second approach has been to fund it via external grants. SACOG and SANDAG were both able to secure grants from Caltrans to fund part of their activity-based model program.

A third option has been to fund the development partially with in-kind services performed by agency staff. In this way the funds go to pay for your staff's time, rather than for consulting fees.

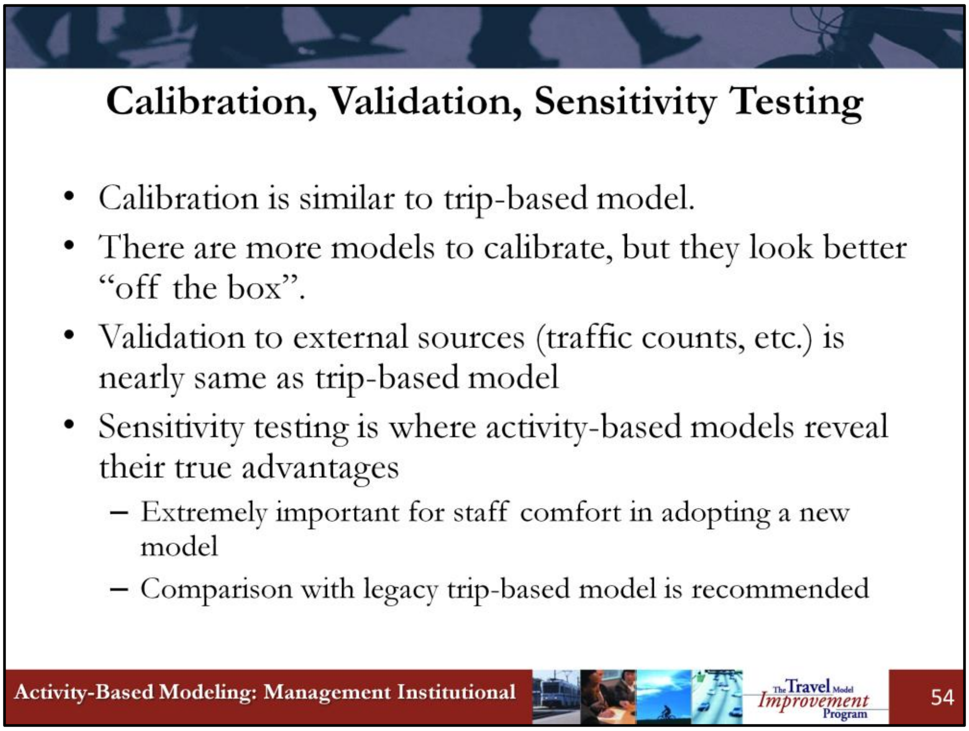
A fourth option that has become feasible now that multiple agencies share a common modeling framework is to jointly fund part of the model development.

The importance of a local champion and early success for securing continuing funding cannot be overstated. In this respect, it may be more important for the long term success of the program to start small and demonstrate the usefulness of the model with some early applications, than to spend years and years developing the most advanced, custom-built tool possible.



In the 10 year or so that activity-based models have been in practice, what has been learned in terms of user experience? From the perspective of the user, how are these models different from trip-based models? We are going to talk about four aspects of this user experience:

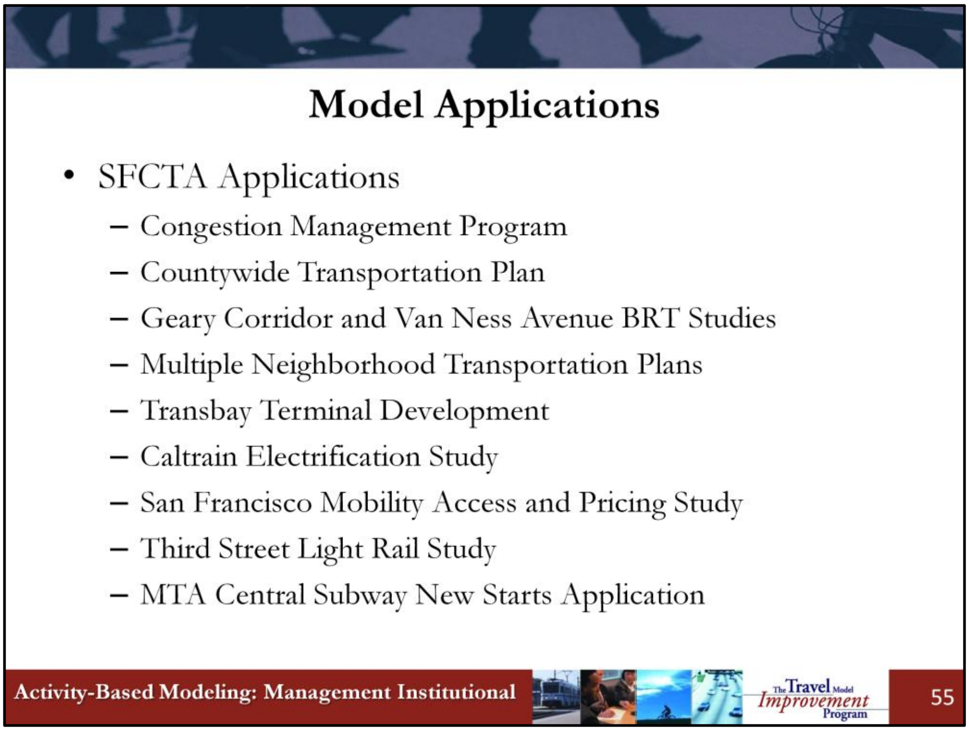
Calibration, validation and sensitivity testing
Using the model to support project work and agency reporting requirements
Interfacing with third-party users (partner agencies or consultants working on behalf of the agency)
Communicating results to stakeholders – planners, managers, other local, state or federal agencies, and the public at large



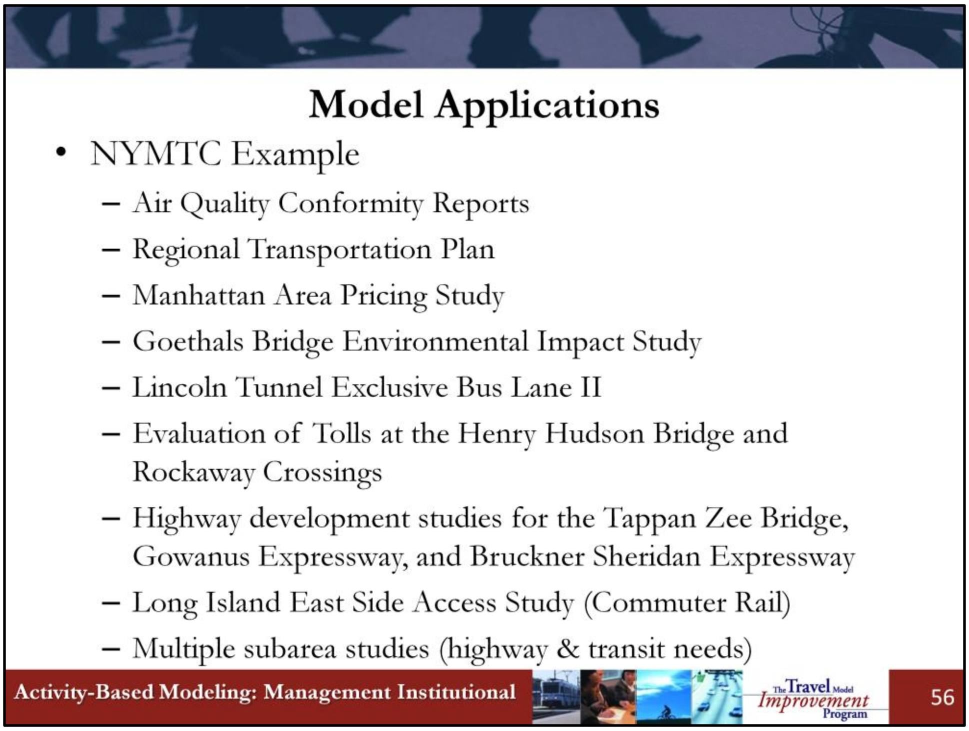
Calibrating an activity-based model is similar to calibrating a trip-based model. The goal of calibration is to get the model to meet certain aggregate targets, and this is done by interatively changing some model parameters and re-running to model to gauge their effect on the aggregate results. The main difference of course is that in an activity-based models there are more models to calibrate. The good news is that when the model has been developed with local data, they often look quite good already prior to any calibration, so less work is often required to achieve the desired targets.

Model validation, which is generally understood as comparing the model results to data independent of those used to calibrate the model, is nearly the same as a trip-based model. In the vast majority of cases the only truly independent data sources are traffic counts and transit boardings counts, so that validating the model essentially entails comparing the estimated boardings and volumes to these counts. The real work of course is troubleshooting – what to do when the model does not match well -- which requires a good understanding of the model at hand.

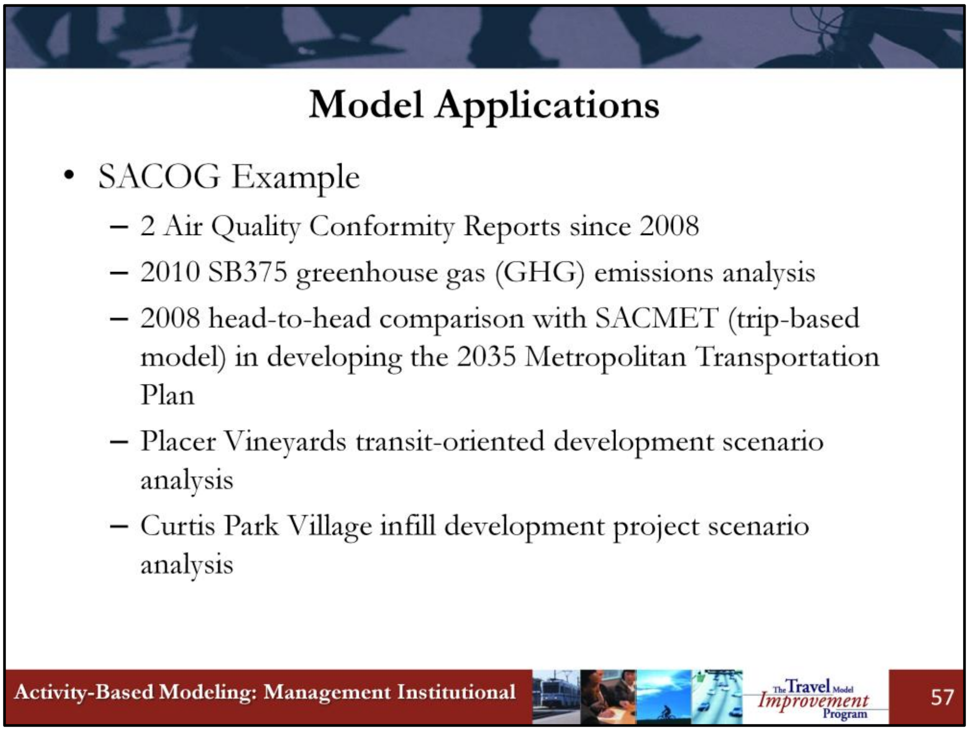
Where the activity models truly shine is in sensitivity testing. Sensitivity tests are highly recommended, not just for the developers to verify that the model works as intended, but to increase confidence among the staff and stakeholders that the model provides reasonable and relevant answers.



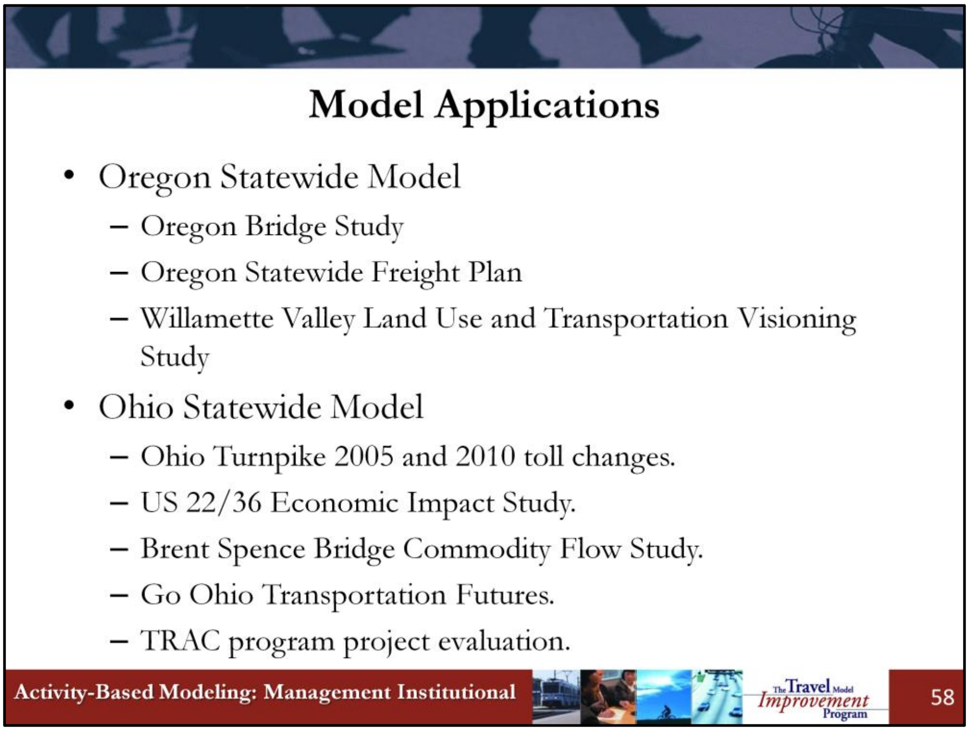
You would think that with nearly 10 years of activity-based models being implemented and in application that there would be a long list of projects that have been performed with these models. If you think that, then you are absolutely right. This slide shows a sample of the projects and studies that have been performed with the SFCTA ABM, which you may recall was the first operational model in the United States. Since 2001 SFCTA has used their model to develop their congestion management program and countywide transportation plan, to perform multiple transit studies include BRT on key arterial roadways, the Third Street light rail rail study and more recently the analysis of alternatives for the Central Subway, which supported their FTA New Starts Application. One of the pioneering studies performed with the SFCTA model was the San Francisco Mobility Access and Pricing Study, which examined alternatives for charging for auto access into the San Francisco central business district.



The New York Best Practice Model is another example of an early model -- in operation since 2002. The BPM has been used extensively to support multiple projects and studies for several agencies in New York City, as well as air quality conformity and the regional transportation plan. This slides shows a small sample of BPM applications. One of the most highly visible transportation studies in the country, the Manhattan Area Pricing Study, was performed with the NYBPM. But it has also supported the types of projects that may be more common in other large metropolitan areas, including various toll studies, multiple subarea studies that examined local road and transit needs, and various transit projects, including the Tappan Zee Bridge New Starts alternatives analysis.



The SACOG activity-based model has been in operation since 2008 and already has multiple projects and interesting applications “under its belt”. The model has been used to prepare two air quality conformity reports since 2008, and the emission analysis called for by California’s SB-375 regulation. One of motivators for developing an activity-based model in Sacramento was to study alternative land uses and formulate a long term land use strategy. Two of the applications listed here, Placer Vineyards TOD scenario analysis and the Curtis Village infill development scenario analysis exemplify these types of land use analyses.



The two statewide activity-based models have been largely absent from our discussion thus far, but they too have been put to good use. SWIM, the Oregon Statewide model, or TRANUS, its precursor, have been instrumental in supporting various statewide studies. The Oregon Freight Plan, for example, examined the impact of various economic scenarios on freight movements across the state. The Ohio Statewide model also has been used to study various projects of regional significance, such as the economic impact of the proposed US 22/36 highway on the eastern side of the state, and a study of commodity flows over the Brent Spence bridge, which spans the Ohio River at Cincinnati.

External User Experience

- Municipalities, local consultants, transit agencies
- May be initial resistance to adopting a new tool
  - Lack of familiarity, skepticism
  - Concerns: hardware/software costs, productivity, staff abilities/training
- Keys to success are same as for internal staff
  - Training and documentation
  - User-friendly interface

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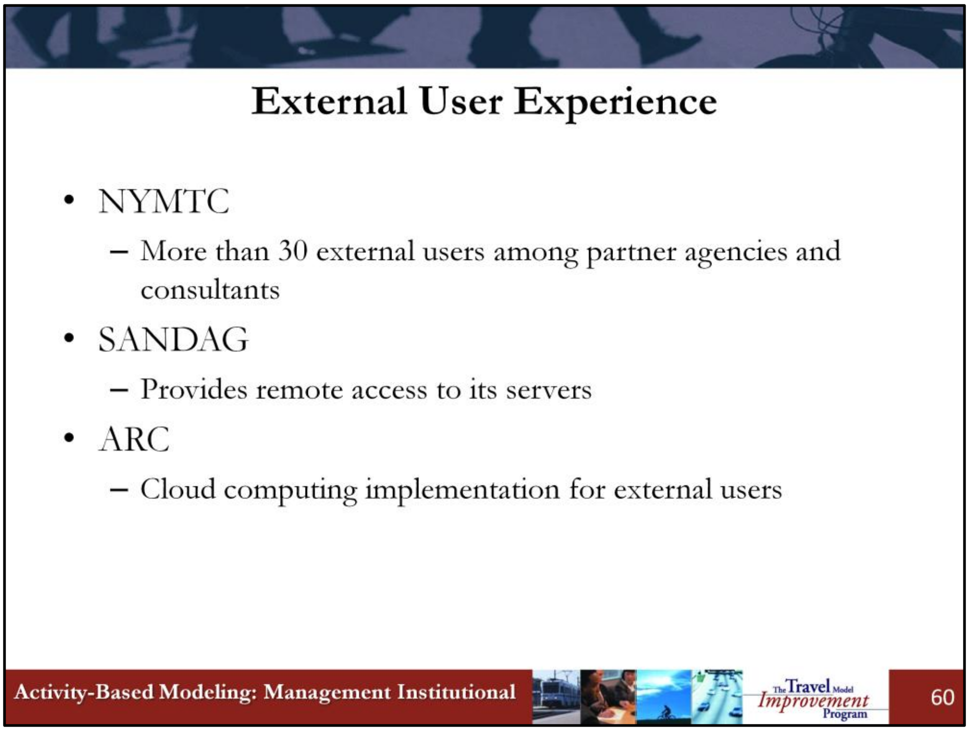
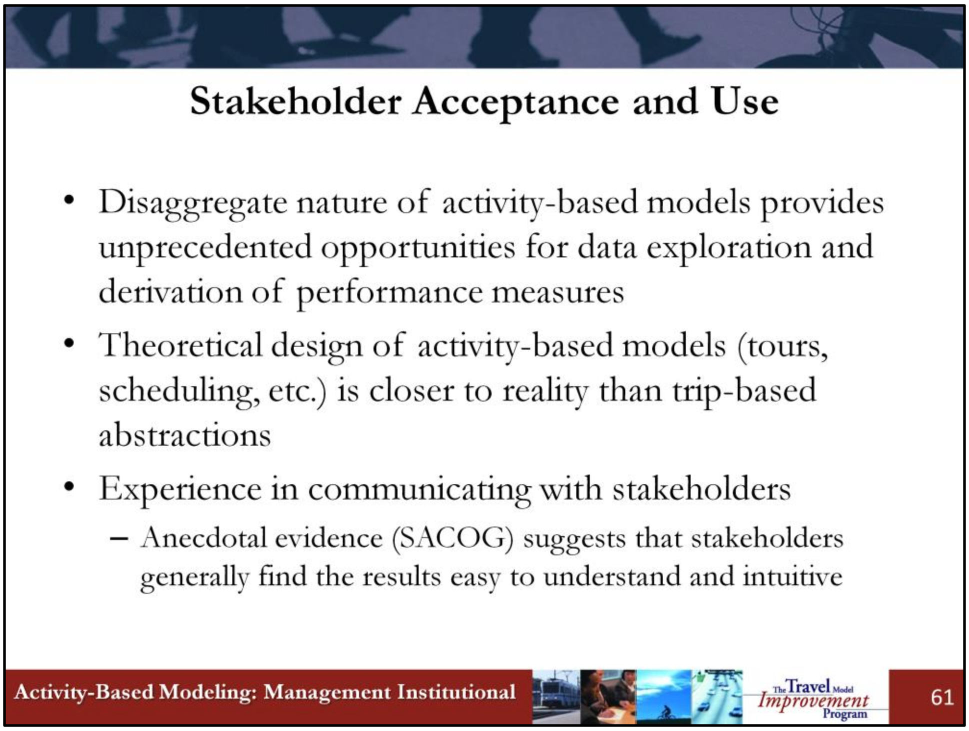
Travel demand models have multiple constituencies. The agency that developed and owns the model often times makes it available to other municipalities, transit agencies, and consultants acting on behalf of these institutions. Making sure that all these external users are comfortable with and able to use the model is a key step in the process of ensuring that the model is useful and relevant for a variety of stakeholders. As is often the case with new technologies, there may be resistance to adopting the model for a variety of reasons, including lack of familiarity, skepticism about claims that it is in fact a better tool, and concerns about the cost and time required to bring staff up to speed. The keys to success are hands-on training, extensive documentation that covers the model fundamentals as well as its operations, and user-friendly ways to interface with the model, both while preparing input data and scenarios and when analyzing its outputs.



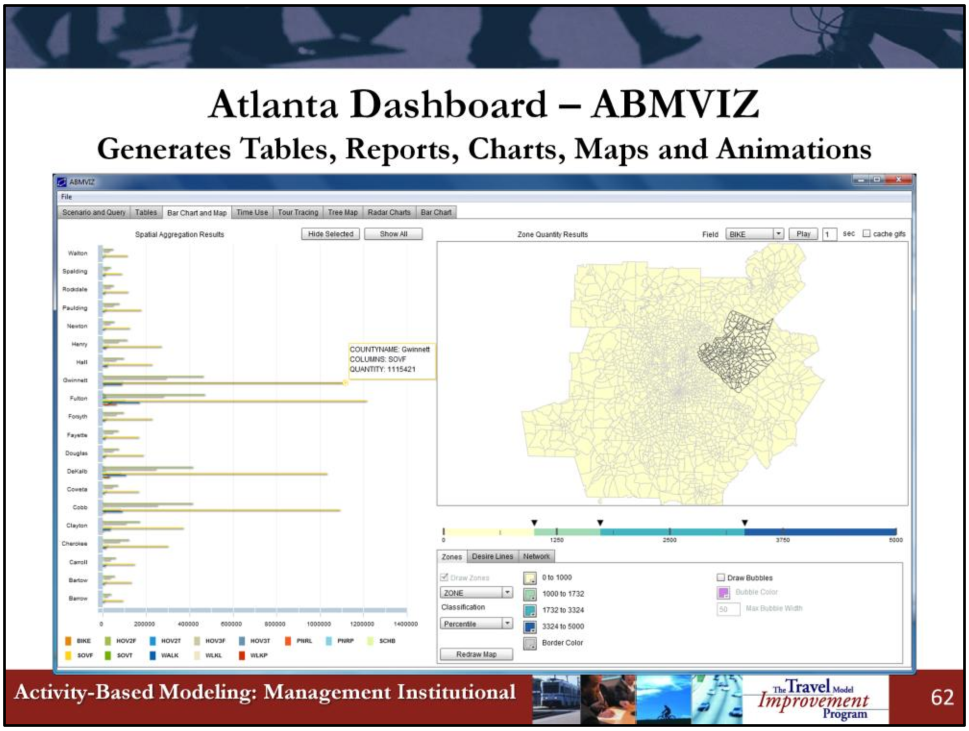
There are success stories that suggest that none of the concerns that we just discussed are insurmountable barriers. The long list of applications that I just showed you is proof that these models can be used by agency staff and others in the course of their everyday work. In the 10 years that it has been in practice, the New York Best Practice Model counts more than 30 different users, including consultants and local agencies other than NYMTC.

One of the obstacles cited towards acceptance of some activity-based models is the need to own a cluster of computers in order to run the model in a reasonable amount of time, which can be a substantial cost for infrequent users of the model. Agencies such as ARC in Atlanta and SANDAG are exploring ways to provide easy access to their model, whether via remote access to their own servers, or by making the models available in the cloud.

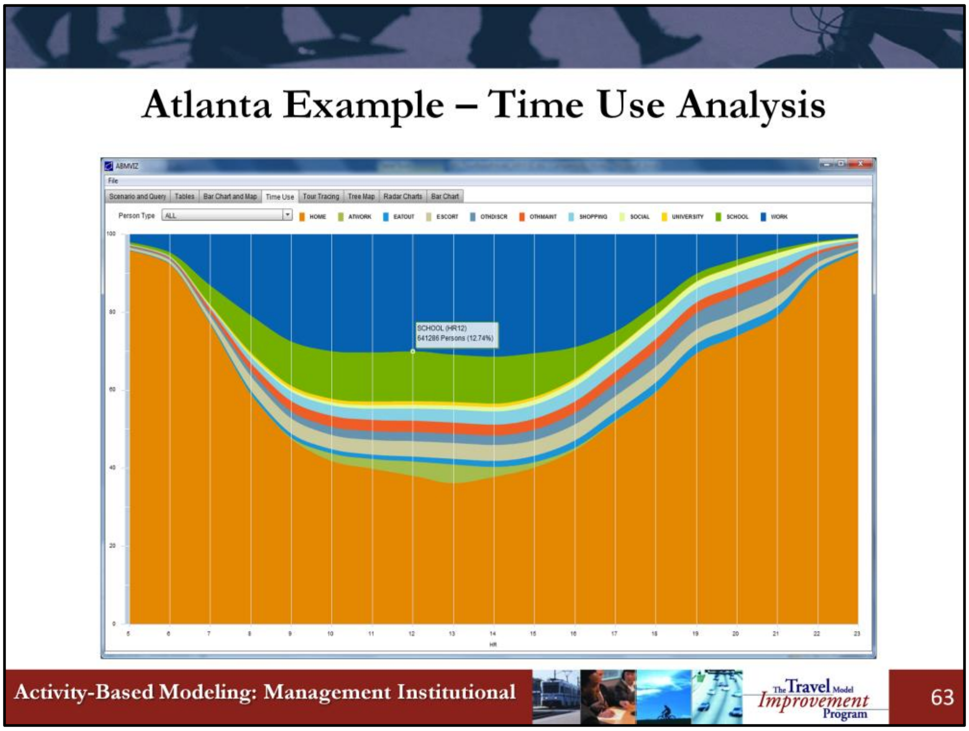


Let's turn now to the last topic of today's presentation, stakeholder acceptance and use. The key to acceptance of the model by stakeholders, both inside and outside the agency, is to focus on answering the questions that are relevant to the agency. Because the models produce output that is akin to data from a travel survey – a list of people with information about all their trips – they provide unprecedented opportunities for data exploration and derivation of performance measures. The main concepts behind the models are easier to grasp by lay people because they relate closer to their own behavior than trip-based constructs do. But to the unprepared staff person, the models can appear as double-edged swords, in that the vast amount of model output can be challenging to sort through and summarize in clear, concise ways that tell a story. So again, one key to model acceptance is to make sure that your staff understands it well, so they can explain it to others and use it effectively. A second lesson learned is that it pays to develop tools and procedures to prepare standardize reports and present your results in visually appealing ways.

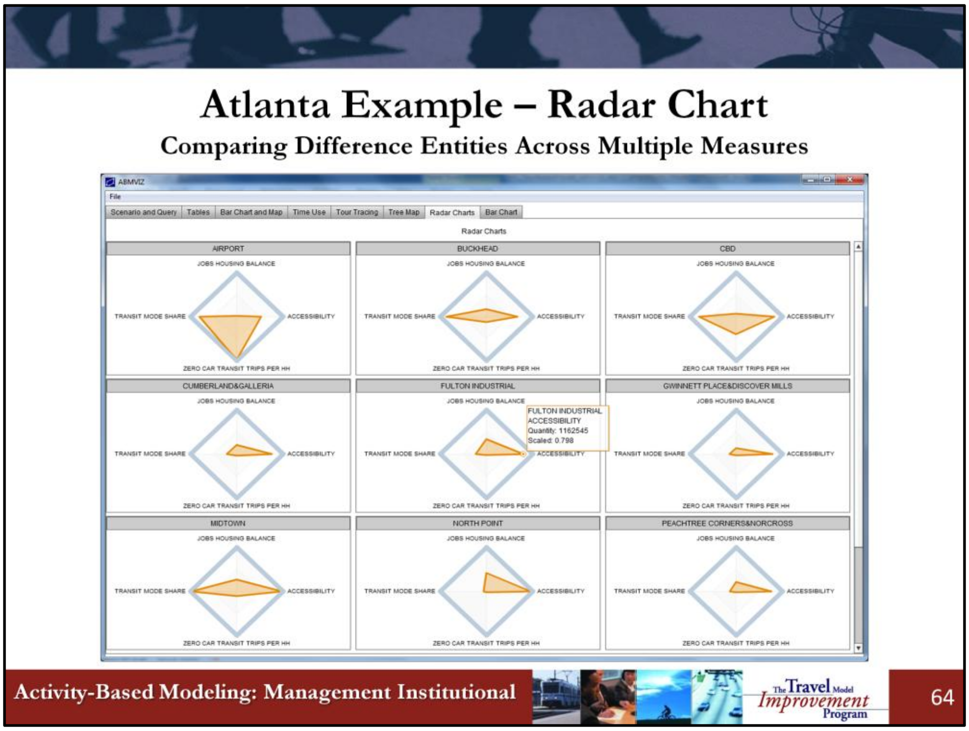
The following slides show various examples of reports and charts produced with the Atlanta visualization tool. This tool was originally developed for the Oregon Statewide Model, and since then has been enhanced and applied as part of other model systems.



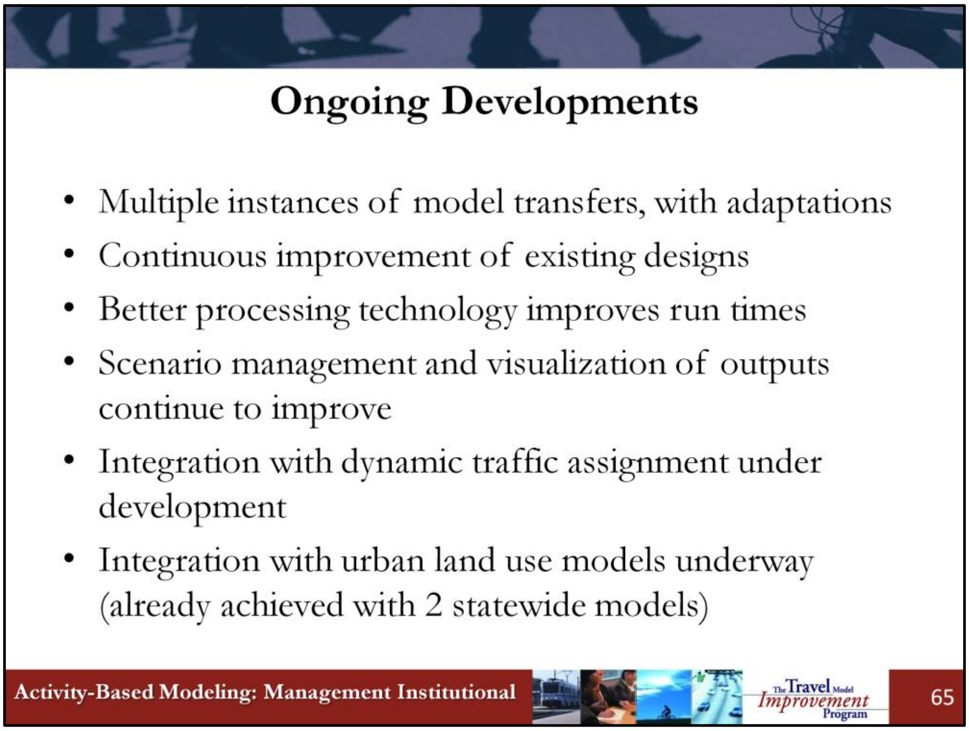
The Atlanta ABMViz is a visualization dashboard. It's a stand-alone tool that includes multiple built-in standard reports, as well as the ability to build queries of the datasets produced by an activity-based model. It can be used to compare performance measures across scenarios or across regional subareas. It generates a variety of built-in reports, from simple one-way and two-way tables to charts, maps and animations.



This slide shows how time is used over the course of a day. The drop down bar at the top lets you select different person types – full time workers, or university students, of pre-school children, for example. The colors identify different types of activities – at home, at work, at school, etc. The chart shows that at noon, for example, about 40% of the population is at home, 13% of the people are at school, and over 25% are at work. This type of chart can be useful, for example, to show the effect of telecommuting policies on work at home and on the time use of other family members. Some effects of telecommuting incentives on workers are obvious – they'll be more likely to stay at home and work from there. But others are less so – will the "gain" of time that was formerly used for traveling now result in more time spent working, or more time spent in non-work out of home activities? What will be the impact of people working from home on the time use of other family members, for example?

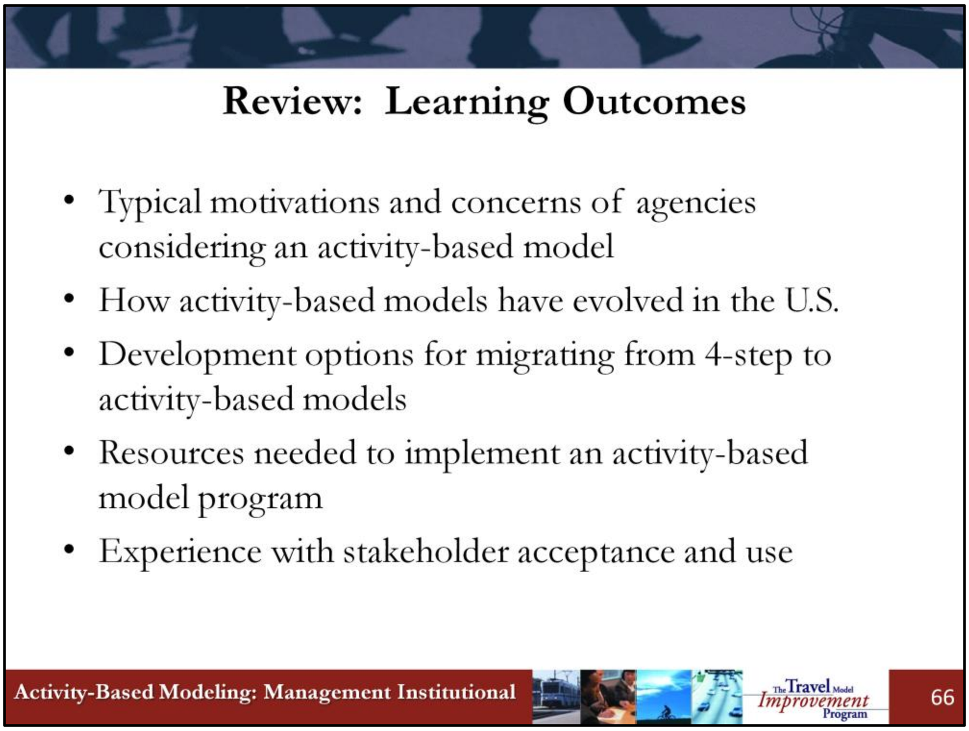


This type of chart is called a radar chart. It is used to compare multiple performance measures across different population groups, which can be identified by geographic location (as shown in this example), or by a population attribute (such as household income, or auto ownership, or ethnic group). The four corners of each blue diamond correspond to four different performance measures. In this example the performance measures are jobs-housing balance, transit mode share, accessibility, and zero car transit trips per household. The orange area shows how well each population group does with respect to each of the four measures. Where the group does well, the orange area touches the corresponding corner. The size of the orange area is relative to how well the group scores relative to all other groups being compared. ARC has found that these types of charts are useful in planning studies to show and explain the impact of various scenarios on different population groups.



We'll end our discussion today with a brief overview of what's going on with the implementation of activity based models.

First of all, now that there are two relatively mature and well-tested model systems, DaySim and CT-RAMP, we are seeing multiple instances of model transfers, typically coupled with some adaptations. There is continuous improvement of existing designs, whether to incorporate research findings or to address populations and travel markets that were somewhat ignored or not well-understood previously. There are new paradigms being put into practice, as is the case in Portland and Los Angeles. Hardware and software continue to improve, resulting in better model performance. There is a lot of interest and on-going activity towards integrating activity-based models with dynamic traffic assignment, as well as towards integrating urban land use models with activity-based models.



By now we hope that you will be able to

a. Discuss the typical motivations and concerns of agencies considering an activity-based model
b. Describe how activity based models have evolved in the United States
c. Describe development options for migrating from trip-based to activity based models
d. Understand the different resources needed to implement an activity-based model program
e. And understand the experience to date with stakeholder acceptance and use of activity-based models.

Questions and Answers

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Executive and Management Sessions	
Executive Perspective	February 2
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Technical Issues for Managers	March 15
Technical Sessions	
Activity-Based Model Framework	April 5
Population Synthesis and Household Evolution	April 26
Accessibility and Treatment of Space	May 17
Long-Term and Medium Term Mobility Models	June 7
Activity Pattern Generation	June 28
Scheduling and Time of Day Choice	July 19
Tour and Trip Mode, Intermediate Stop Location	August 9
Network Integration	August 30
Forecasting, Performance Measures and Software	September 20

This is a reminder that our next webinar will cover technical issues for managers. It will be held on March 15 at this same time.

Continue the discussion online…

The new TMIP Online Community of Practice includes a Discussion Forum where members can post messages, create forums and communicate directly with other members. Simply sign-up as a new member, navigate to http://tmiponline.org/Community/Discussion-Forums.aspx?g=posts&t=523 and begin interacting with other participants from today's webinar session on Activity-Based Modeling.