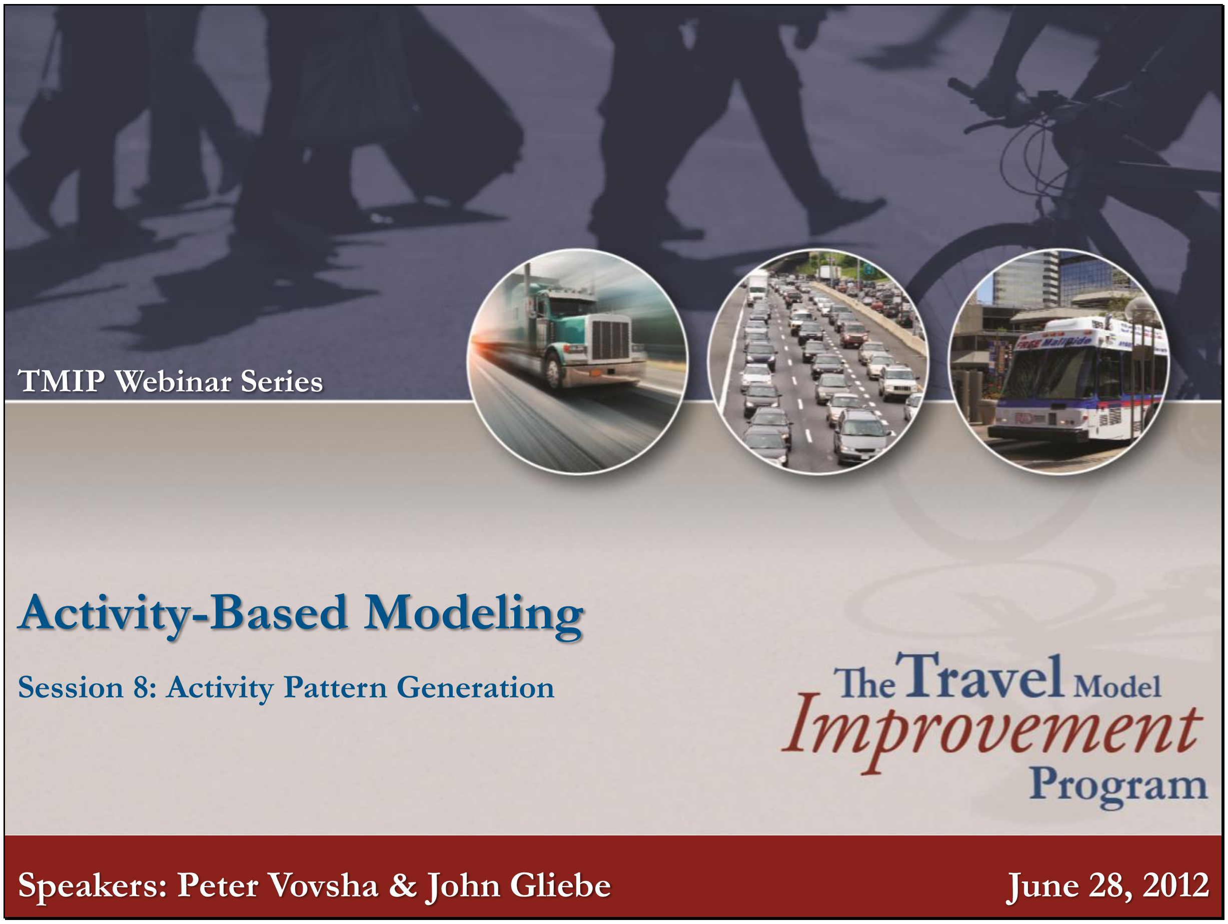
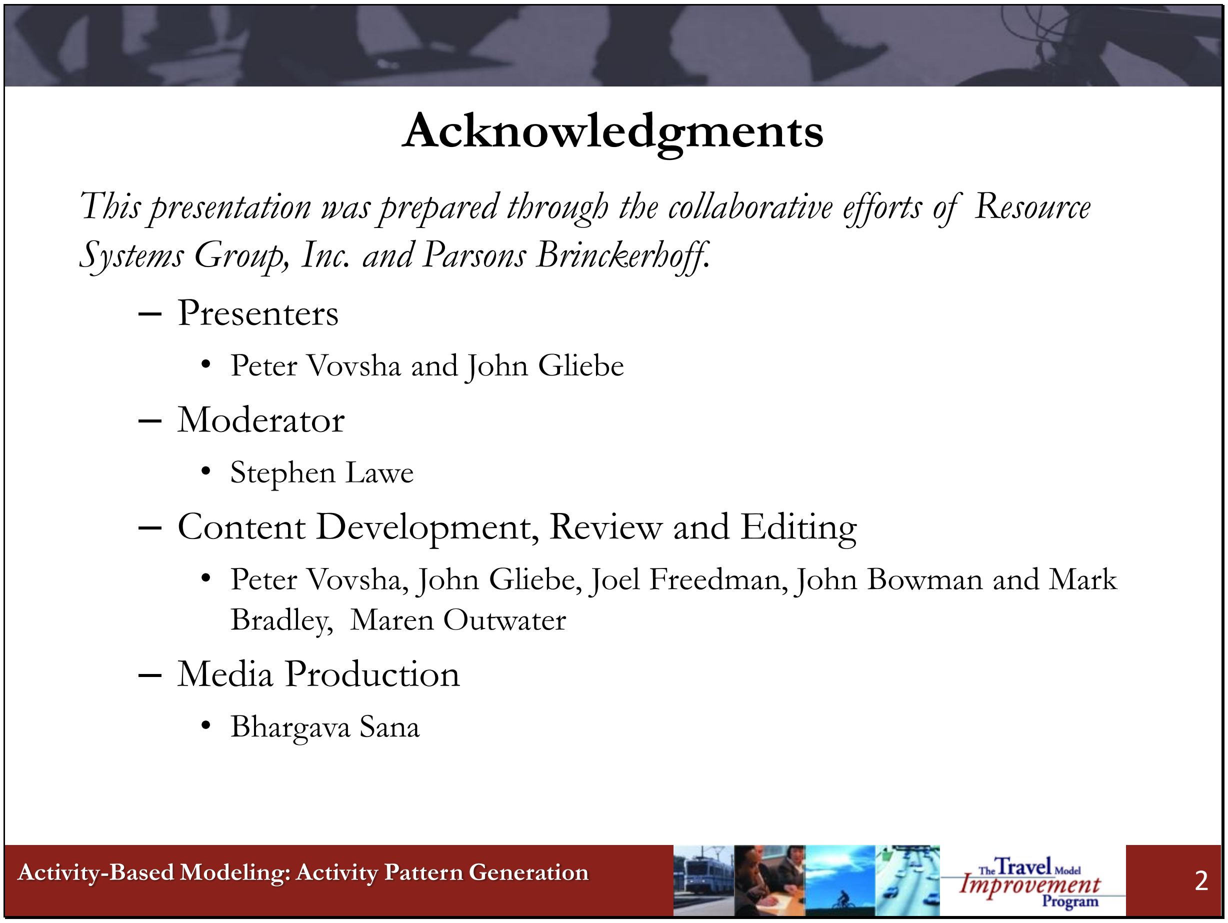

TMIP Webinar Series
Activity-Based Modeling
Session 8: Activity Pattern Generation
The Travel Model Improvement Program
Speakers: Peter Vovsha & John Gliebe
June 28, 2012



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

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

2012 Activity-Based Modeling Webinar Series

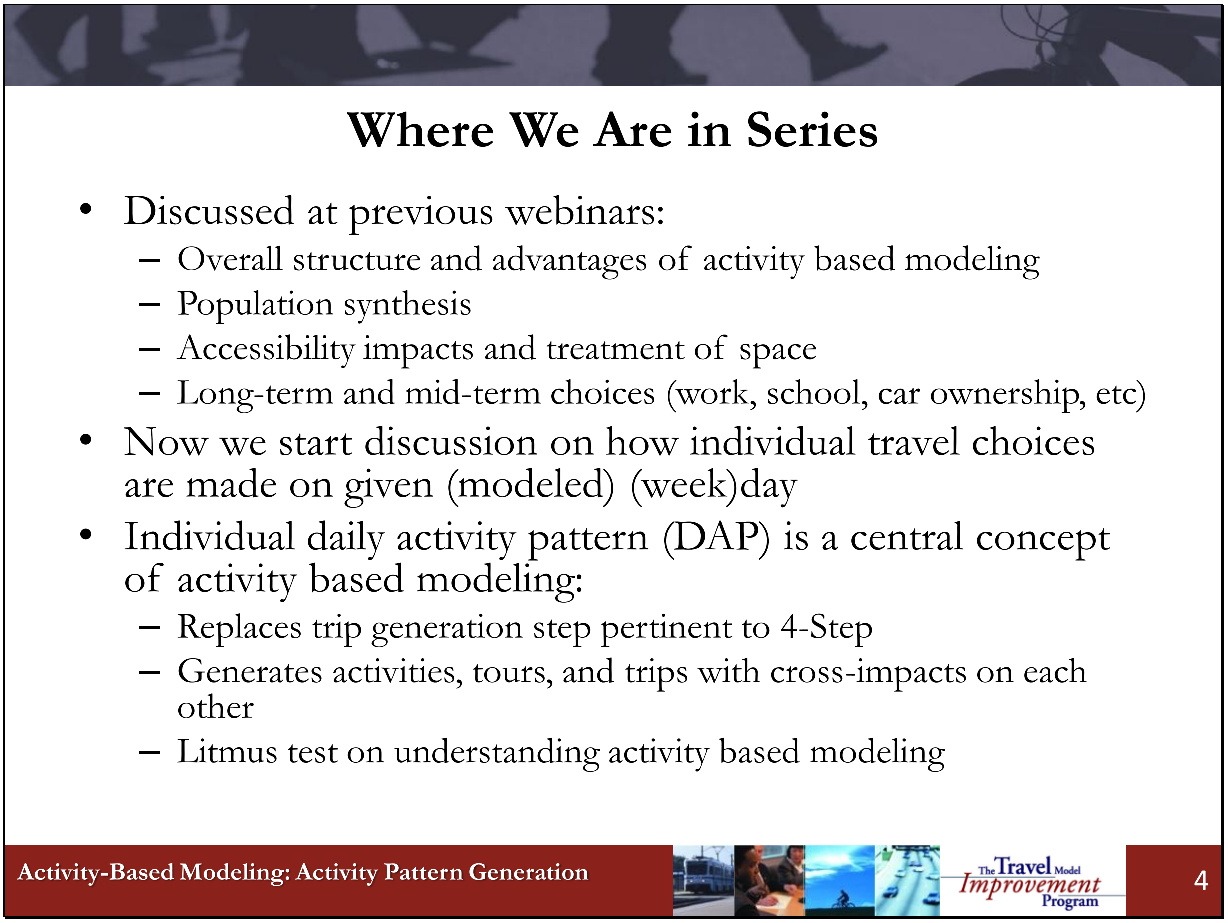
Executive and Management Sessions	
Executive Perspective	February 2
Institutional Topics for Managers	February 23
Technical Issues for Managers	March 15
Technical Sessions	
Activity-Based Model Framework	April 5
Population Synthesis and Household Evolution	April 26
Accessibility and Treatment of Space	May 16
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

Activity-Based Modeling: Activity Pattern Generation

The Travel Model Improvement Program

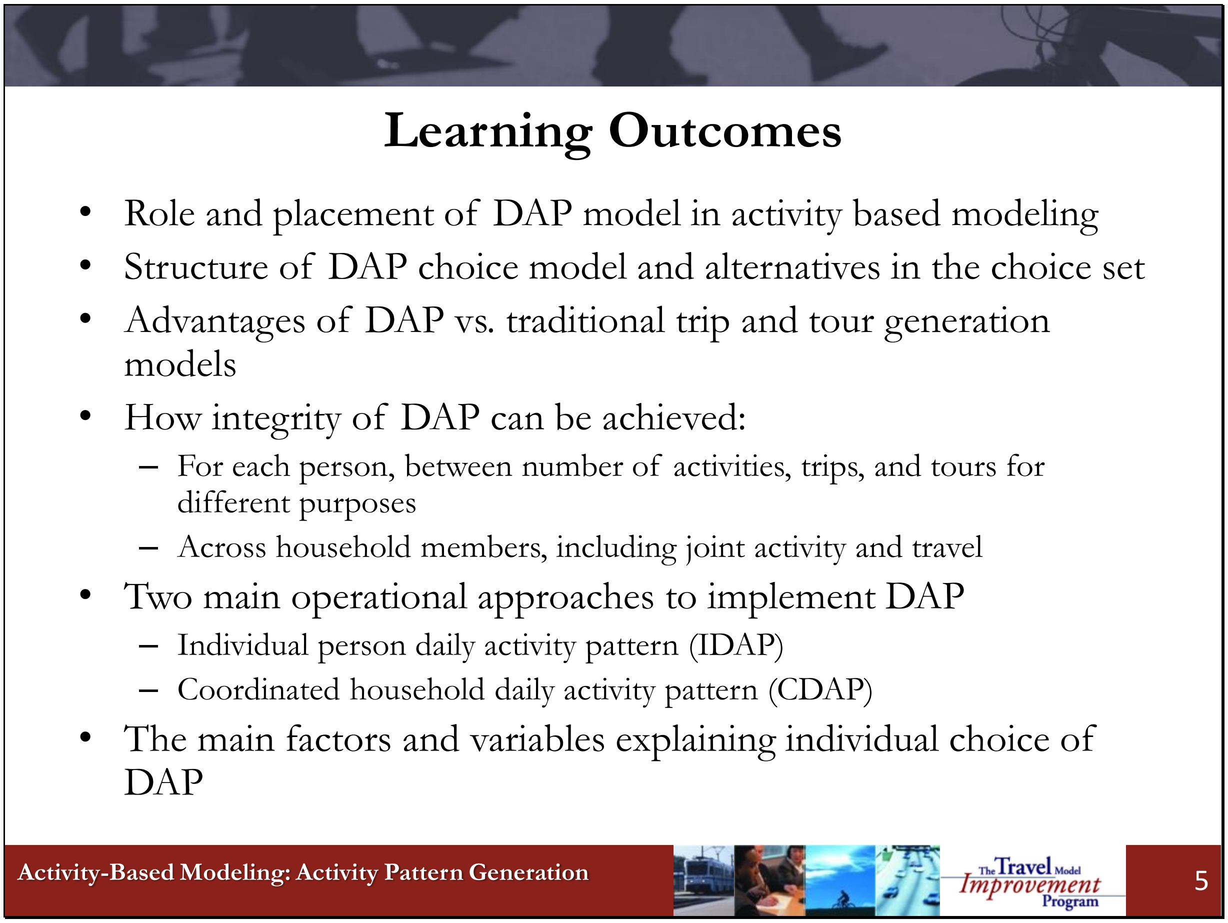
3

This is the 9th session overall and the 5th technical session. Understanding of the previous topics is essential since we will be using the terminology introduced in the previous sessions. In particular, we assume a basic knowledge of micro-simulation principles as well as familiarity with tour structures.



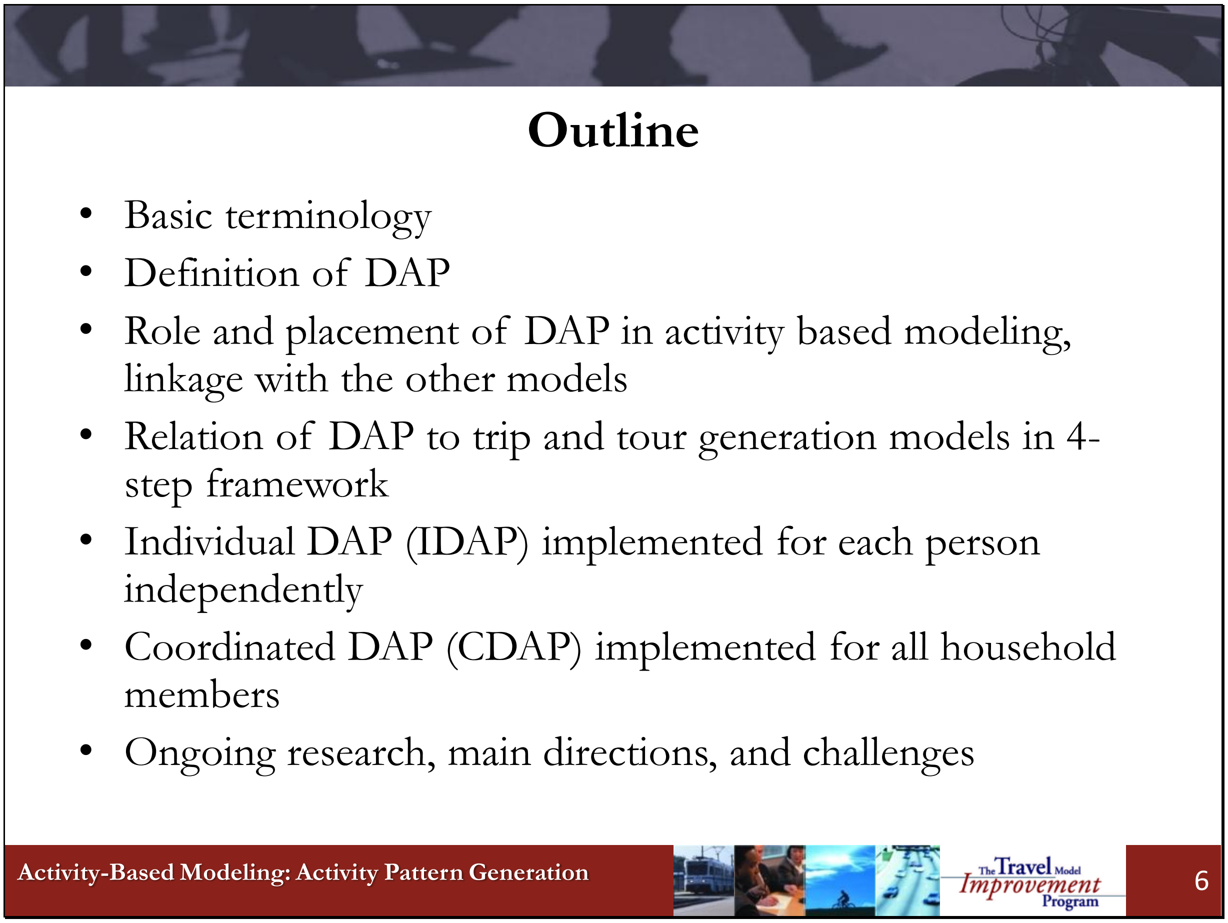
At the previous webinars we discussed overall structure of activity based modeling and corresponding advantages over 4-step models. We discussed population synthesis and now the daily activity pattern (DAP) model can be applied to each individual person and households in the synthetic population. The DAP model uses accessibilities, long-term and mid-term choices as important explanatory variables. These variables are assumed known when we discuss DAP.

Today we start discussion on how individual travel choices are made on given (modeled). Our material is limited to a regular weekday. Weekends can be modeled with a similar approach but many details would be different. The Individual DAP is a central concept of activity based modeling. It roughly replaces trip generation step pertinent to 4-step models. The DAP model generates activities, tours, and trips with cross-impacts on each other. DAP is the cornerstone of activity based modeling and key differentiating feature from 4-step. It is also a good litmus test on understanding the entire activity based modeling concept.



We would like you to learn today the following particular aspects:

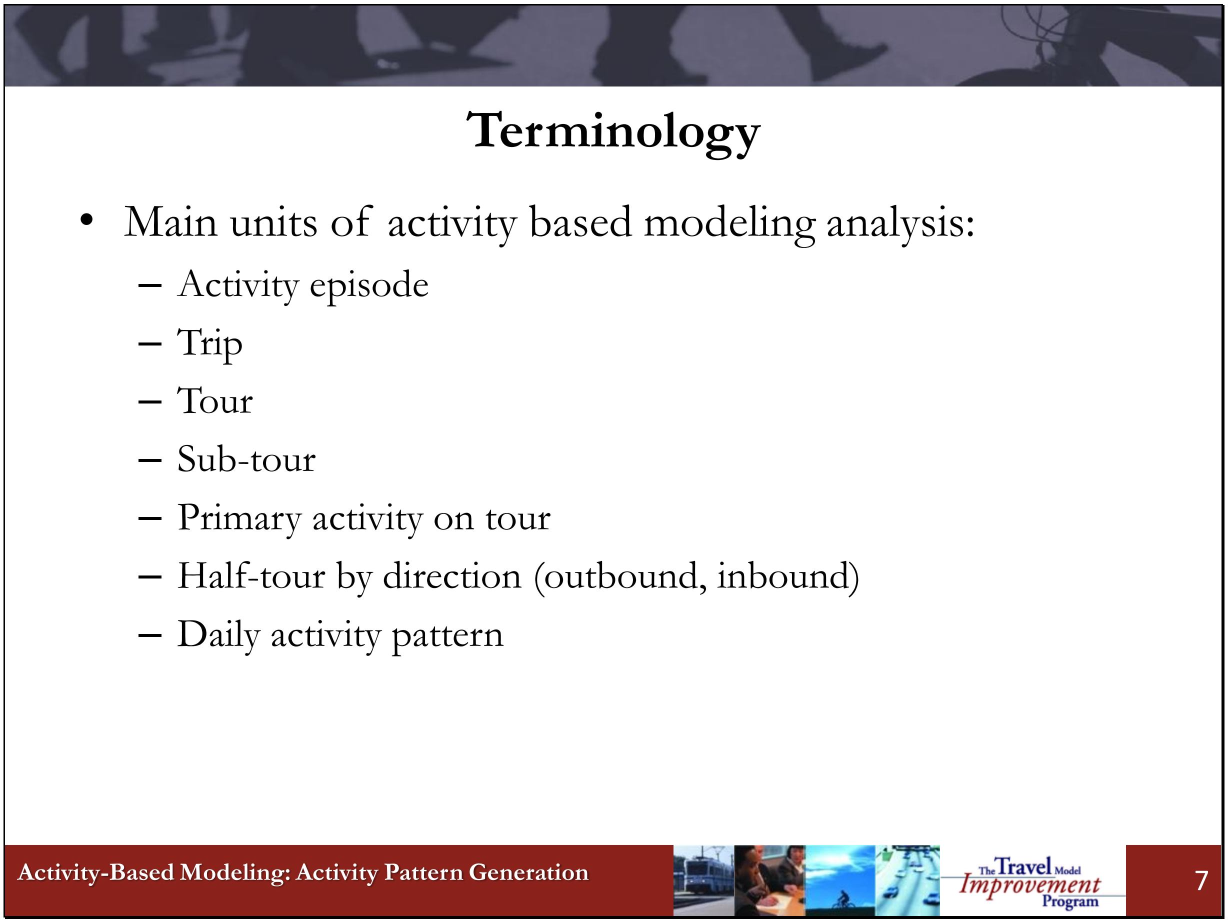
- Role and placement of DAP model in activity based modeling
- Structure of DAP choice model and alternatives in the choice set
- Advantages of DAP vs. traditional trip and tour generation models
- How integrity of DAP can be achieved:
- For each person, between number of activities, trips, and tours for different purposes
- Across household members, including joint activity and travel
- What are two main operational approaches to implement DAP
- Individual person DAP (IDAP)
- Coordinated household DAP (CDAP)
- What are the main factors and variables explaining individual choice of DAP



This is the outline of our session. We will cover:

- Basic terminology
- Definition of DAP
- Role and placement of DAP in activity based modeling, linkage with the other models
- Relation of DAP to trip and tour generation models in 4-step framework
- Individual DAP (IDAP) implemented for each person independently
- Coordinated DAP (CDAP) implemented for all household members
- Ongoing research, main directions, and challenges.

The discussion of these practical examples is the most essential part of this session. The rest is the necessary build-up.



We will be using activity based modeling terminology intensively. We assume you are familiar with the main units of activity based modeling analysis from the previous webinars. Today we will be frequently using classification of activities that has also been discussed before. We will also introduce and discuss in detail definitions of terms specific to daily activity patterns, with an emphasis on operational models of individual and coordinated daily activity pattern types.

Activity episode is an event in which an individual is engaged in an activity at a specific place and time. In modeling out-of-home activities, we usually assume that the activity purpose does not change while the person remains at the same location and only model changes in activity when there is a change in location. We typically group all in-home activities together, except perhaps for modeling in-home paid work.

Trip refers to travel between the locations of activity episodes, including between home and out-of-home activity locations.

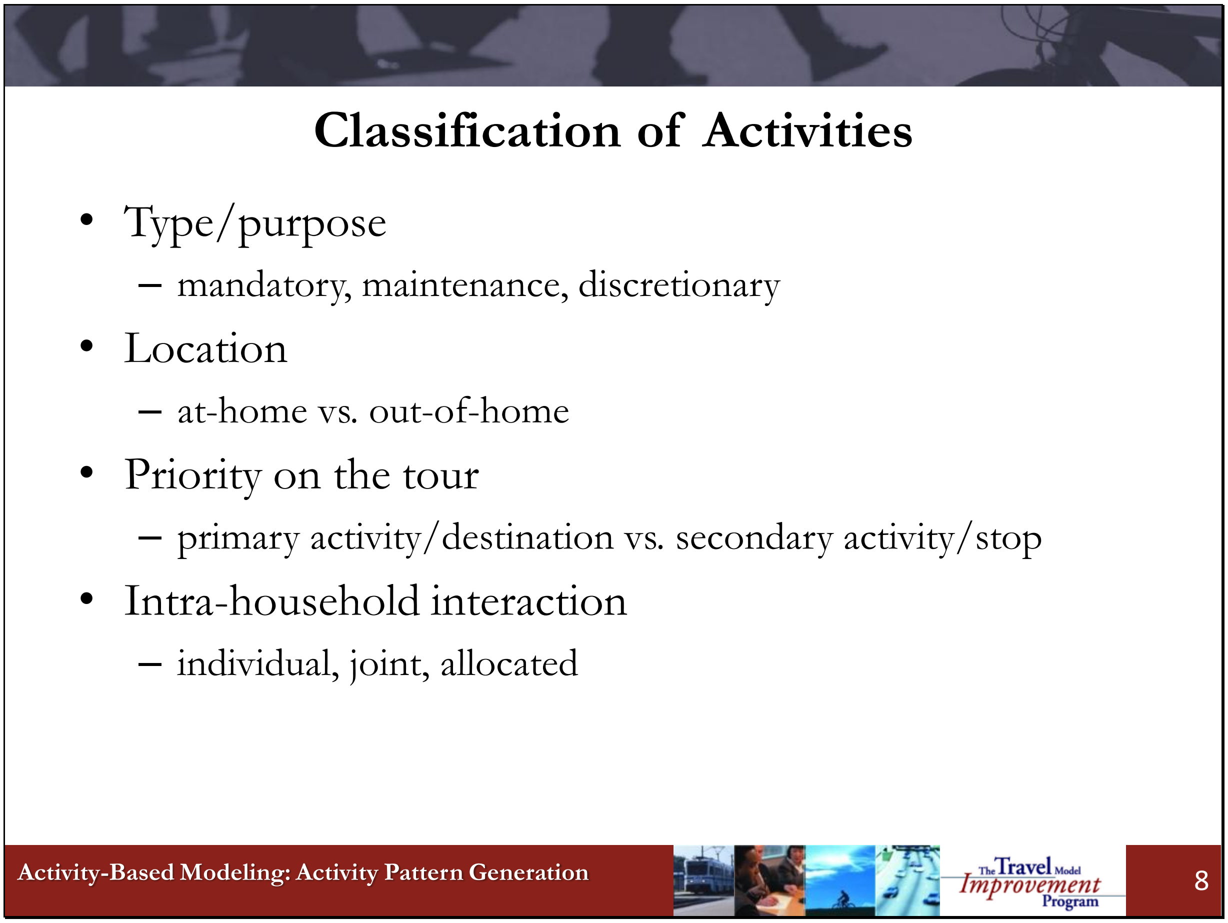
Tour is a sequence of two or more trips, traveling from an anchor location (usually home) to one or more activity locations (out of home) and with a return trip back to the anchor location, thereby completing the “tour.”

Sub-tour – In addition to modeling home-based tours, we typically model work-based sub-tours. Sub-tours for other activity purposes are theoretically possible, but not typically done in practice. A sub-tour would be travel from a non-home, usually work anchor point, to one or more other activity locations, then returning to the same work anchor point. A sub-tour is a tour within a larger home-based tour, so returning home for lunch and then going back to work would actually constitute two home-based tours, not a sub-tour.

Primary activity on tour – the activity episode designated as the main reason for the tour. This may be defined and specified in different ways. For example, in our survey diary data we may designate the activity episode with the longest duration as the primary stop on the tour. This may be combined with rules related to activity purposes, giving primacy to work and school activities, regardless of duration. Other strategies are to choose the activity episode furthest from the tour's anchor location, or to choose the first stop on the tour, though these rules are not used as often. An even better approach would be to ask survey respondents to identify a primary purpose for the tour.

Half-tour – an "outbound" half tour would include travel and any intermediate stops on the way to the primary activity location of the tour. The "inbound" or return half of the tour would include the travel and any intermediate stops between the primary activity location on the tour and the anchor location (usually home, or work if a work-based sub-tour).

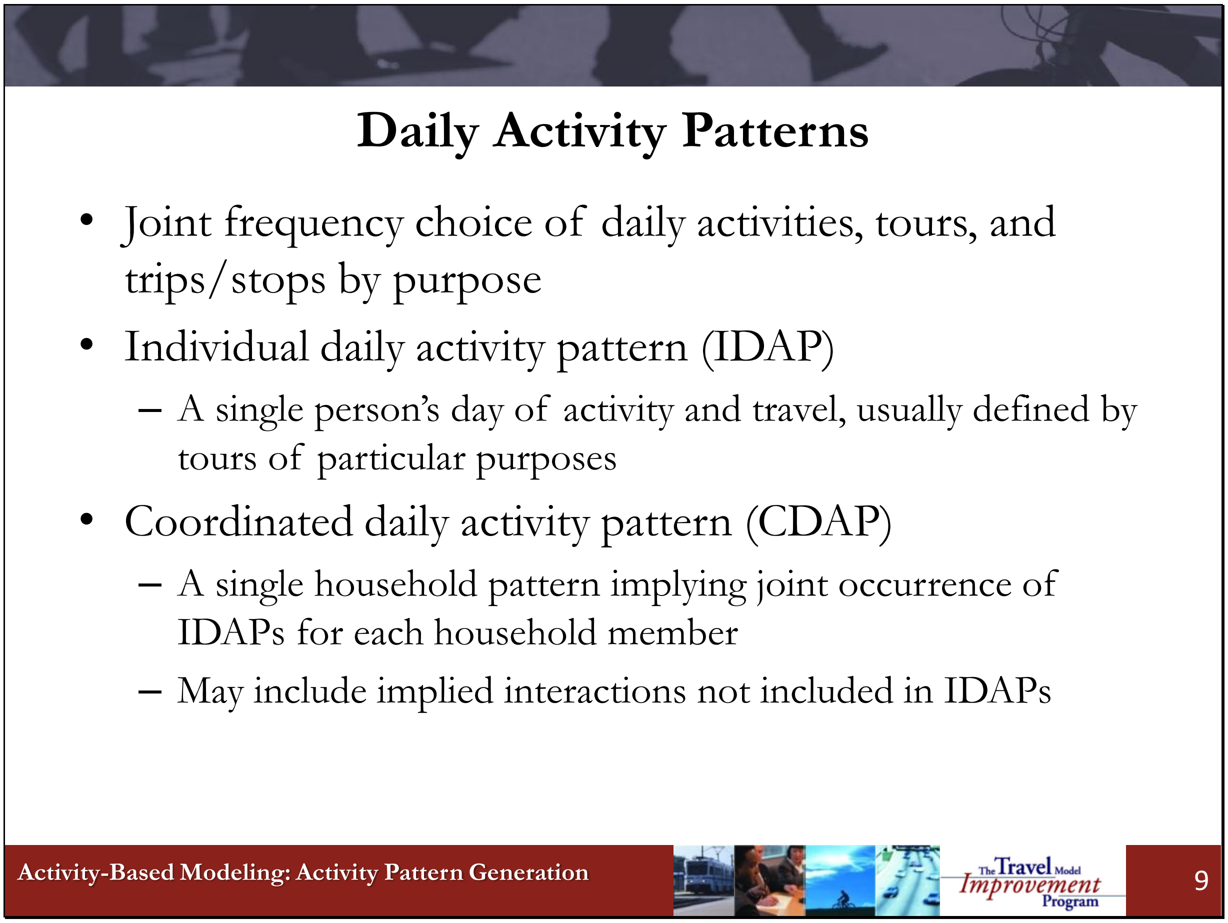
Daily Activity Pattern is a typology describing a combination of tours made by persons over the course of a day. In a simple form, we can define these by the number of tours of a particular purpose, such as "1 home-based work tour + 1 home-based social/recreational tour". Or, we can use an over-arching description such as "mandatory" or "discretionary" or "stay home all day." There have been a lot of ways in which activity-based modelers and researchers have sought to describe daily activity patterns, and we will look at several examples in the rest of this webinar.



It is useful at this point to review how we classify activities. Much of this has been covered to some extent in previous webinars in the series, particularly Webinar 4, which was the introduction to activity-based modeling frameworks. One way to classify activities is by type and purpose. We will talk about grouping activity purposes by whether they are mandatory, maintenance, or discretionary—labels intended to convey prioritization.

We will also classify activities by whether they take place at home or out-of-home. Typically, we model only out-of-home activities for the purposes of travel, but it is now becoming an accepted best practice to at the very least model in-home work activities for the purposes of modeling telecommuting policies. As I just mentioned above, we will also be establishing primary activity types, destinations and modes on a tour, and of course identifying secondary activity stops.

Finally, we will be discussing in great detail concepts related to intra-household interactions. This includes joint activities and travel between individuals, often eating out, social/recreational and shopping; providing rides to other household members—pick-ups and drop offs, especially children; and allocation of activities. Allocated activities may include activities such as shopping, household business, or escorting children that are more of a household-level decision—a responsibility allocated to a member of the household.



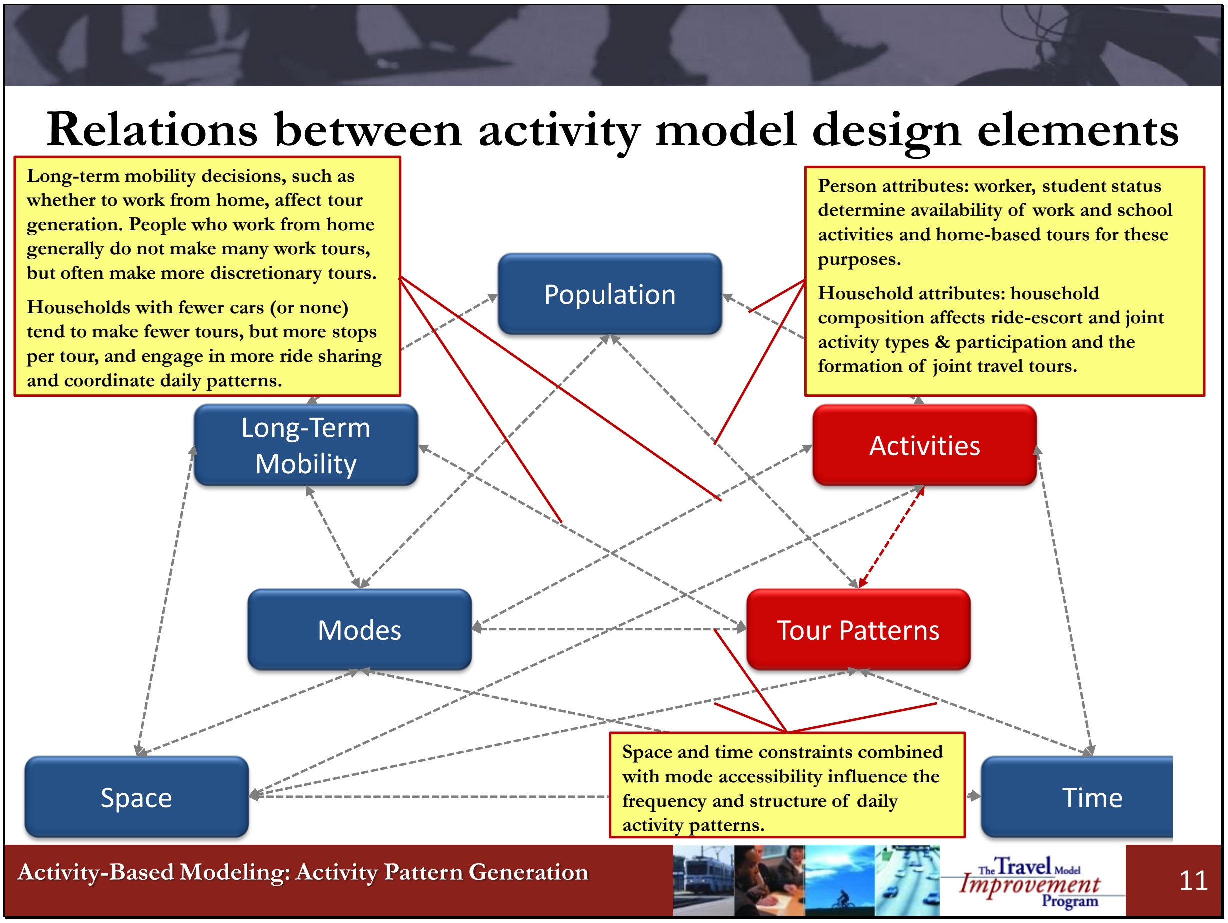
We can also talk about daily activity patterns in different ways. Identification of daily activity patterns begins by classifying activities, tours, trips and stops by purpose and tabulating their joint frequencies. For example, in a sample population, what is the joint distribution, for a given day, of the numbers of home-based tours, as classified by mandatory, maintenance and discretionary purposes? We will show you examples, but typically the simplest daily patterns are the most common—a single tour for the day, with more complex combinations of multiple tours and sub-tours being much less common. Also, know that persons who stay home all day are fairly common, particularly among pre-school-age children and adults past the retirement age.

In this webinar we will focus primarily on two ways of defining daily activity patterns—individual and coordinated. An individual daily activity pattern describes a single person's day of activity and travel, usually defined by tours of particular purposes. A coordinated daily activity pattern refers to a single household pattern, which implies the joint occurrence of individual patterns for each household member. The coordinated pattern may also include interactions that are not included in an individual daily pattern approach, such decision models related to allocation of activities to individual household members, auto allocation, explicit escorting of household members (drop off and pick up), and joint activities between household members which require jointly decided upon locations, timing and modes.

Out-of-Home Activities / Travel Purposes

- Mandatory:
  - Work/Business
  - School/College/University
- Maintenance:
  - Escort Passenger(s)
  - Shopping
  - Personal Business (e.g., Medical)
- Discretionary:
  - Eating out
  - Visiting relatives and friends
  - Social/Recreational

Classification of out-of-home activities and travel purposes by major types is essential. We have tended to group these into mandatory and non-mandatory activities. Mandatory activities include work, business-related and school activities. Maintenance activities include escorting passengers (primarily children), shopping, medical, etc. Discretionary activities include eating out, visiting relatives and friends, and social/recreational activities. There are some grey areas between maintenance and discretionary activities (for example, visiting a shopping mall can combine shopping and eating out). In addition, the more we learn about these activities the less clear it is whether people really prioritize maintenance activities over discretionary activities. For example, a recreational activity might be the big event of the day—and people may make a quick stop at a store to pick up some food or drinks on the way.



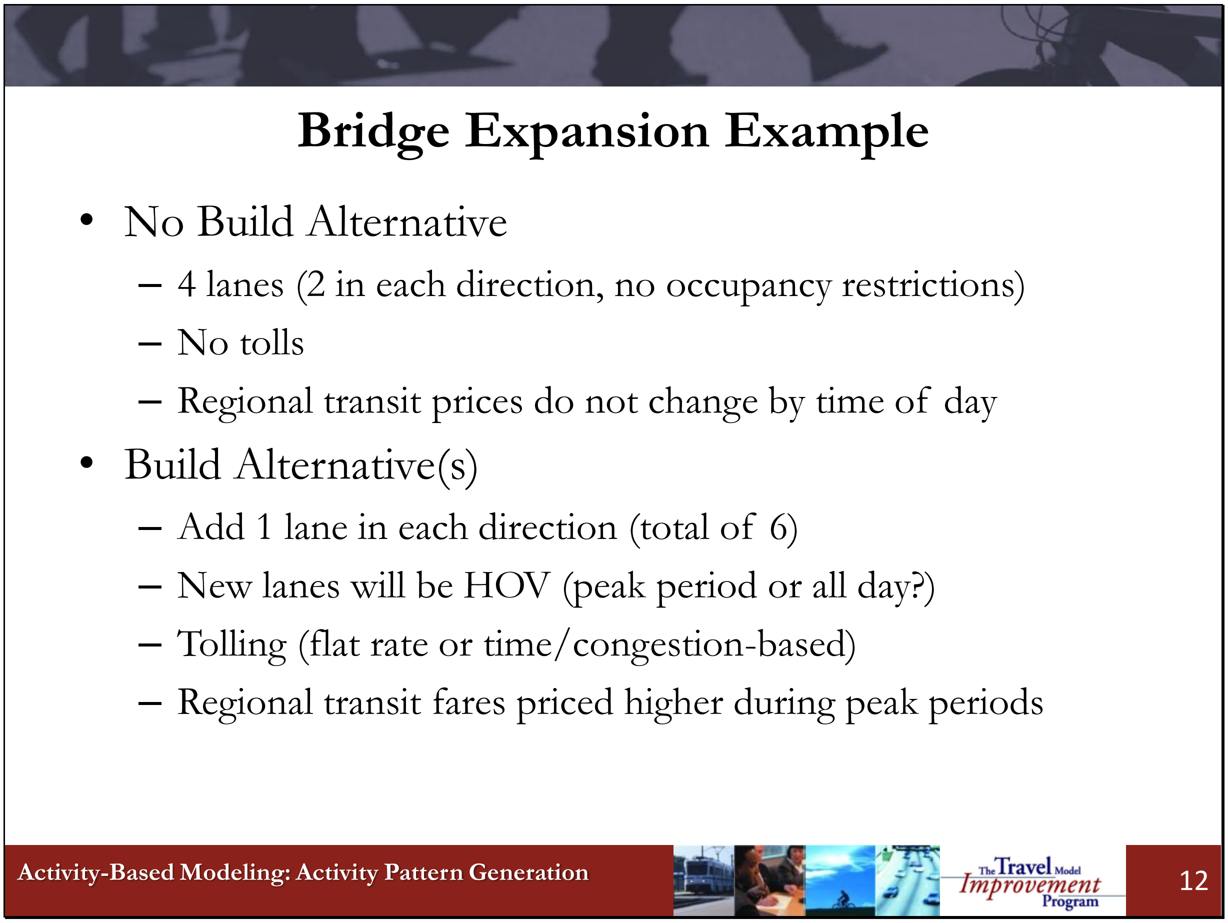
Let's consider how decisions regarding definition and modeling of Daily Activity Patterns (DAP) affect other aspects of model system design.

This diagram serves as a backdrop for describing the relationships between key design elements in activity-based modeling. These elements include: defining the population, modeling long-term and mobility-related choices, defining activity types, defining modes, defining tour patterns and an entire day-pattern elements, as well as the treatment of space and accessibility and treatment of time. We discussed each of these design elements in the previous webinar on activity-based modeling frameworks and techniques, and have already devoted entire sessions to population synthesis, the treatment of space, and to long-term choices and mobility models.

DAPs are defined by activity purposes and by tour patterns. As you shall see in the rest of this session, DAPs represent how individual persons and groups of persons in households arrange their days into tours for various activity purposes. We model these patterns directly in part to recognize that tours made by the same person on the same day are in fact interdependent and that certain combinations of tours and activities are more likely to be observed than other combinations. In addition, modeling daily activity patterns, as opposed to independent tours, allows us to better control their timing.

As this yellow box show, characteristics of persons and their households have a huge impact on what activities people choose and what are available to them. Household structures also play the major role in determining ride sharing and joint activity participation.

Long-term mobility choices, such as where one works, or if one can work from home, have an obvious effect on the generation of work tours. Persons who work from home often take advantage of this and make more discretionary tours. In addition, space-time constraints and the level of service provided by available mode options affect the ability of persons to fit activities and tours into their day.



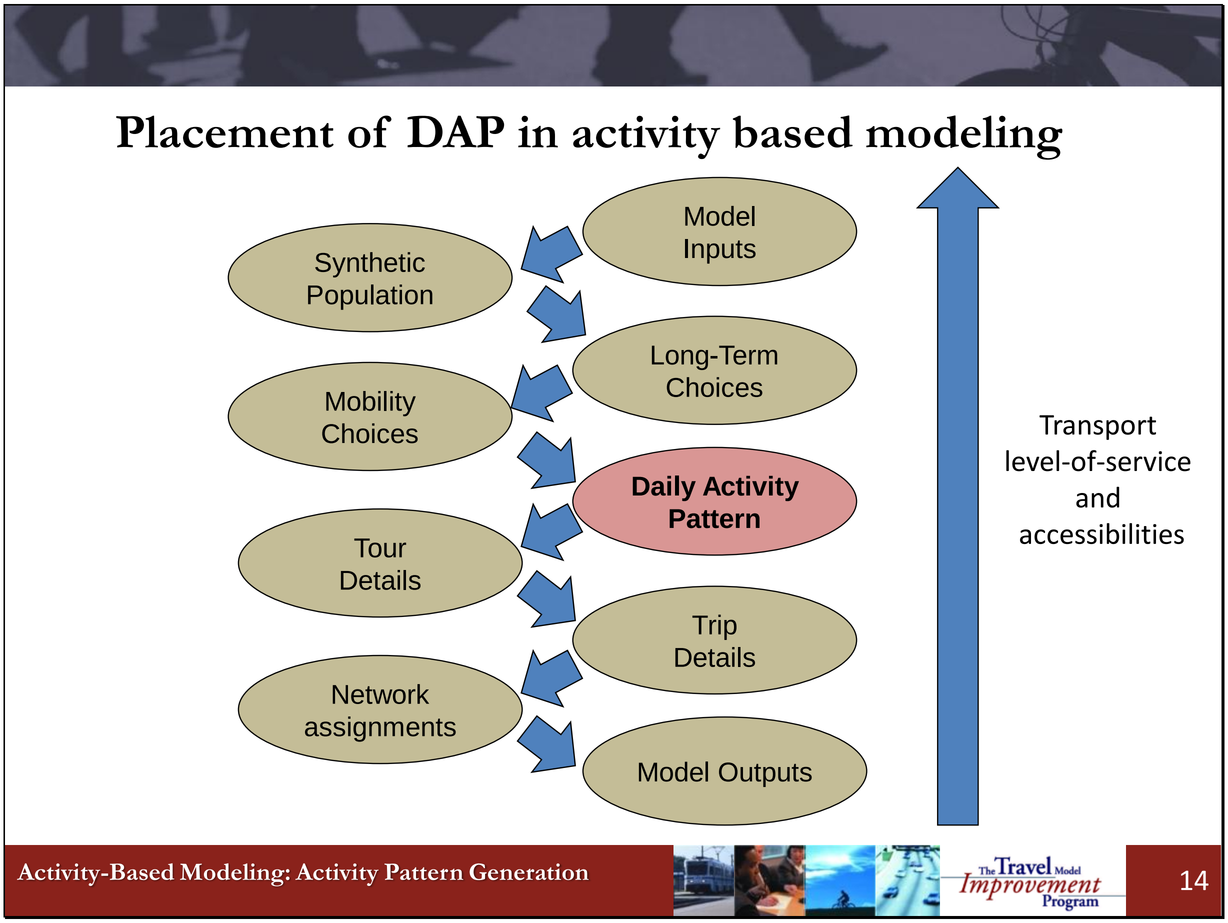
Let's consider a transportation planning and policy project that might be faced by an MPO or DOT and how daily activity pattern modeling fits into the picture. We have used this example in several previous sessions to talk about how activity-based modeling components might affect the analysis. Here, we have a planning or policy case in which an agency is looking a bridge crossing study. Some of the design options that they will need to consider in their alternatives analysis include:

- The bridge will be expanded from 4 to 6 lanes. The two new lanes are expected to be HOV lanes, one in each direction, and the bridge will be tolled.
- Various tolling schemes will be considered, including flat rates and time-variable pricing. The times of enforcement for the HOV lanes are likely to be peak periods, but another option is that they be enforced at other hours.
- In addition, the regional transit system is simultaneously considering a fare policy that will charge more during peak periods.

Bridge Expansion Example—Relevance to Daily Activity Pattern Generation

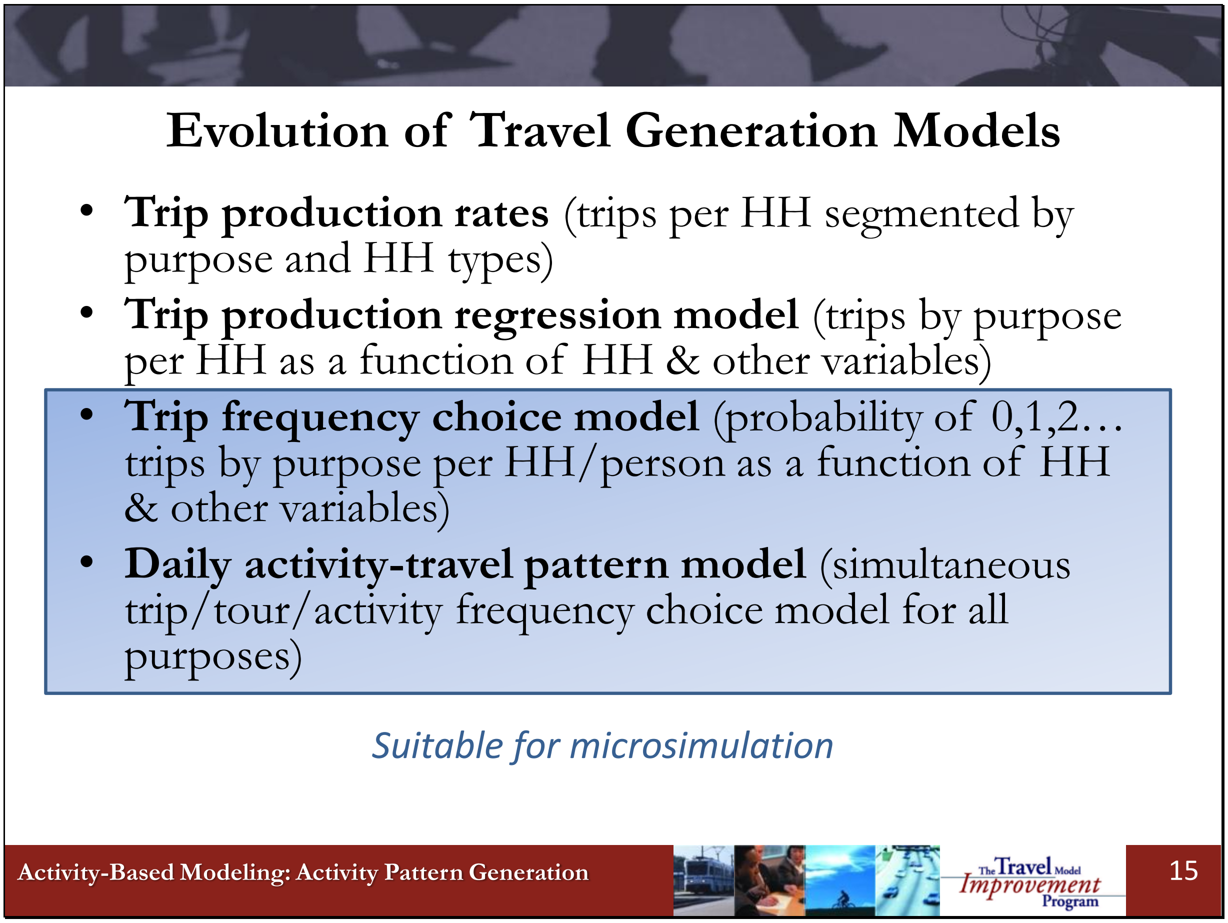
- Accessibility increases may lead to a greater frequency of activities
  - More discretionary activities, possibly more tours
- Potential increase in intra-household ridesharing to take advantage of HOV
  - Affects tour type choice—coordination between household members for commutes
    - More joint tours/fewer independent tours
    - May result in more joint activities—joint discretionary stops before/after work

For this bridge example, daily activity pattern generation may be affected in the following ways. Persons whose accessibility is improved by the bridge may increase their discretionary activity episodes. In order to take advantage of HOV lanes, household members may decide to share rides to work. This not only affects mode choice, but also affects daily activity patterns, because of the coordination of patterns between household members. It may even lead to increased non-work joint activities.

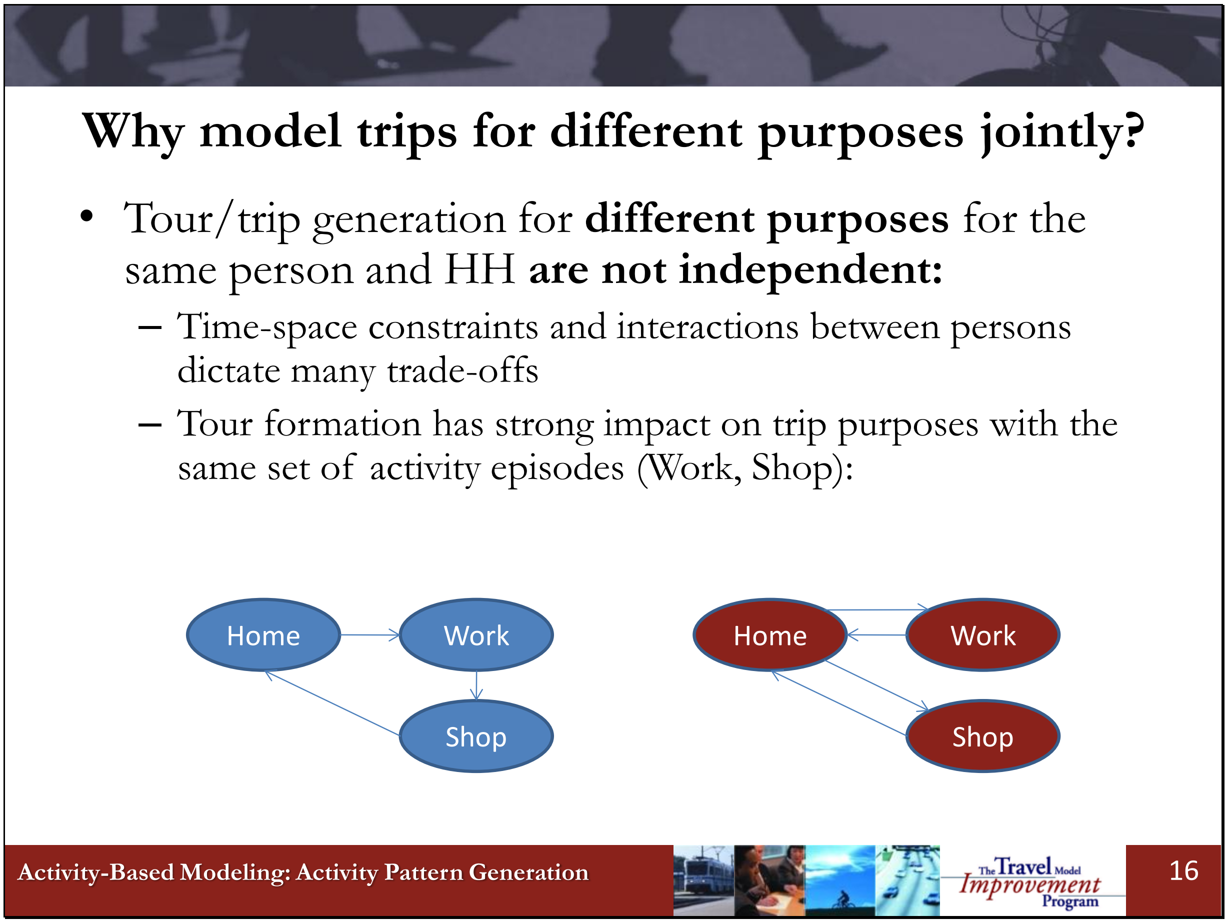


Activity based models vary in terms of their exact structure. However, there are some common elements. All models start with some inputs (transport networks, land-use forecasts, etc). A synthetic population is created. Then long-term choices (work location, school location) are typically modeled. Mobility choices (such as auto ownership) are modeled next. Daily activity patterns and tours are created for each person in the synthetic population, and details about each trip are “filled in”. Trips are assigned to networks, and transport levels-of-service are fed up through the system.

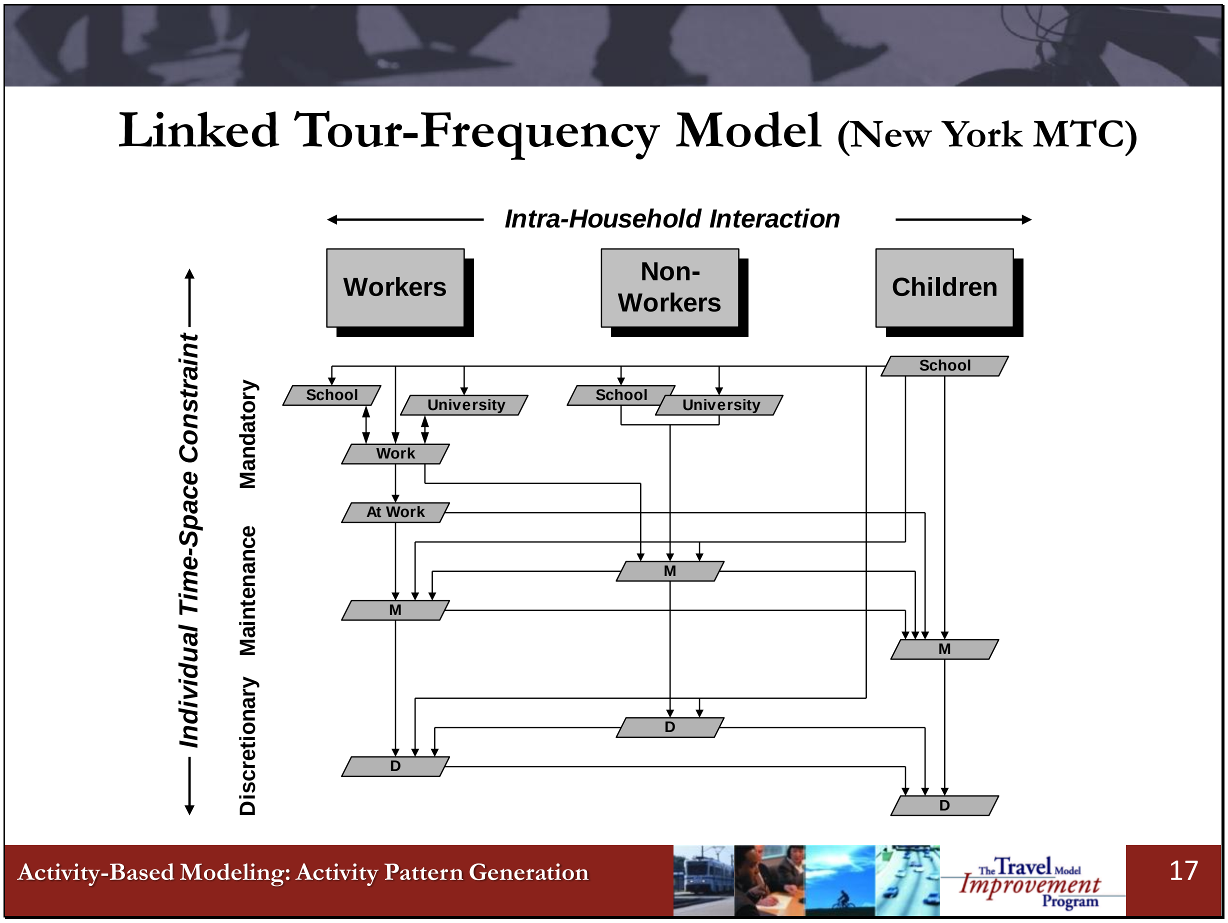
DAP is a first major travel-related model in the activity based modeling chain that generates activities, tours, and trips (analogous to trip generation in 4-Step). There are some variations in advanced activity based models w.r.t. the DAP model structure that we will be discussing today. They primarily relate to the incorporation of intra-household interactions.



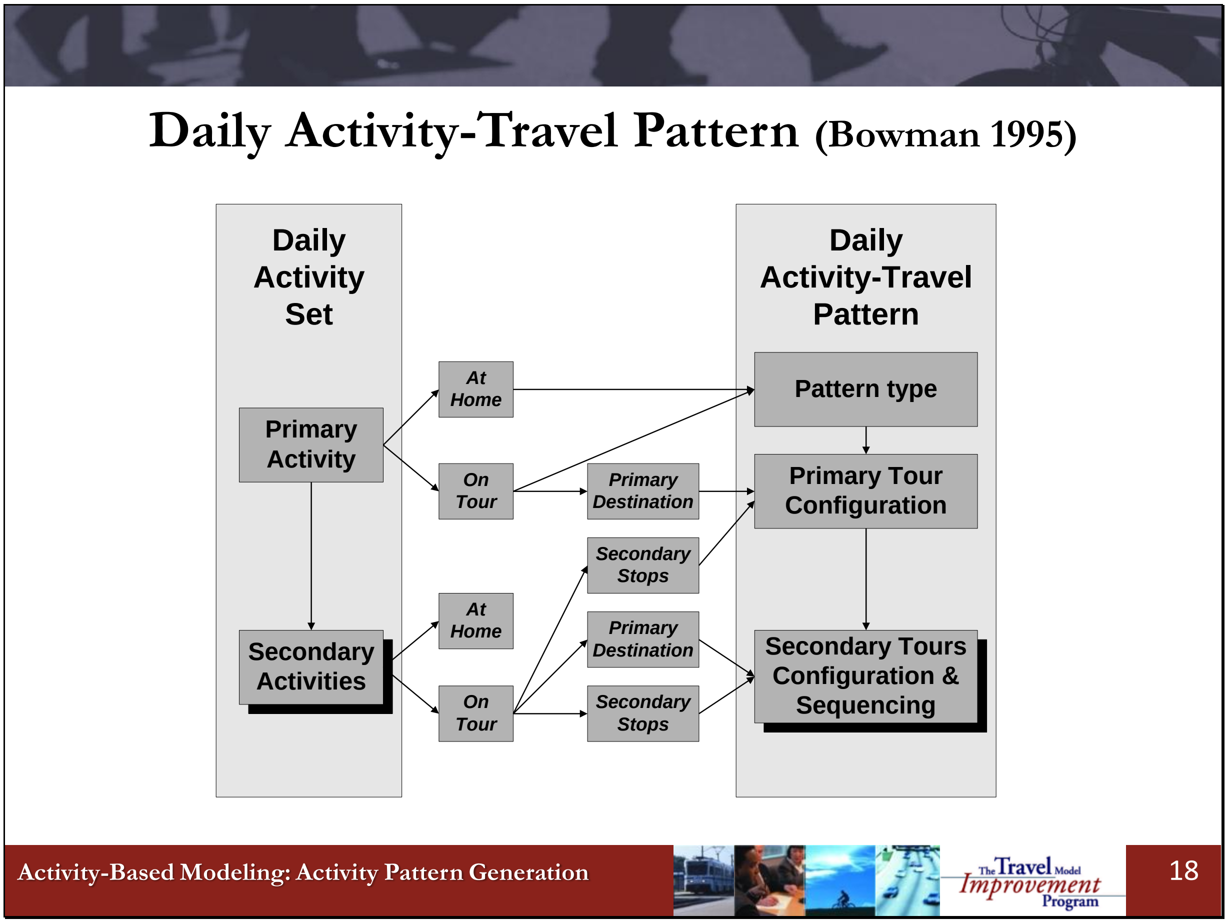
Despite the common view on activity based models in general and DAP in particular as a revolutionary concept it was actually largely a long evolution process that went through four major steps. First two steps relate to conventional 4-step models. The 3rd step relates to advanced 4-step models and simplified activity based models. The 4th step corresponds to advanced activity based models that we discuss today. The 3rd and 4th types of models specifically tailored to by applied in a micro-simulation activity based model. Conceptually DAP is just a simultaneous or joint trip/tor/activity frequency choice model for all purposes.



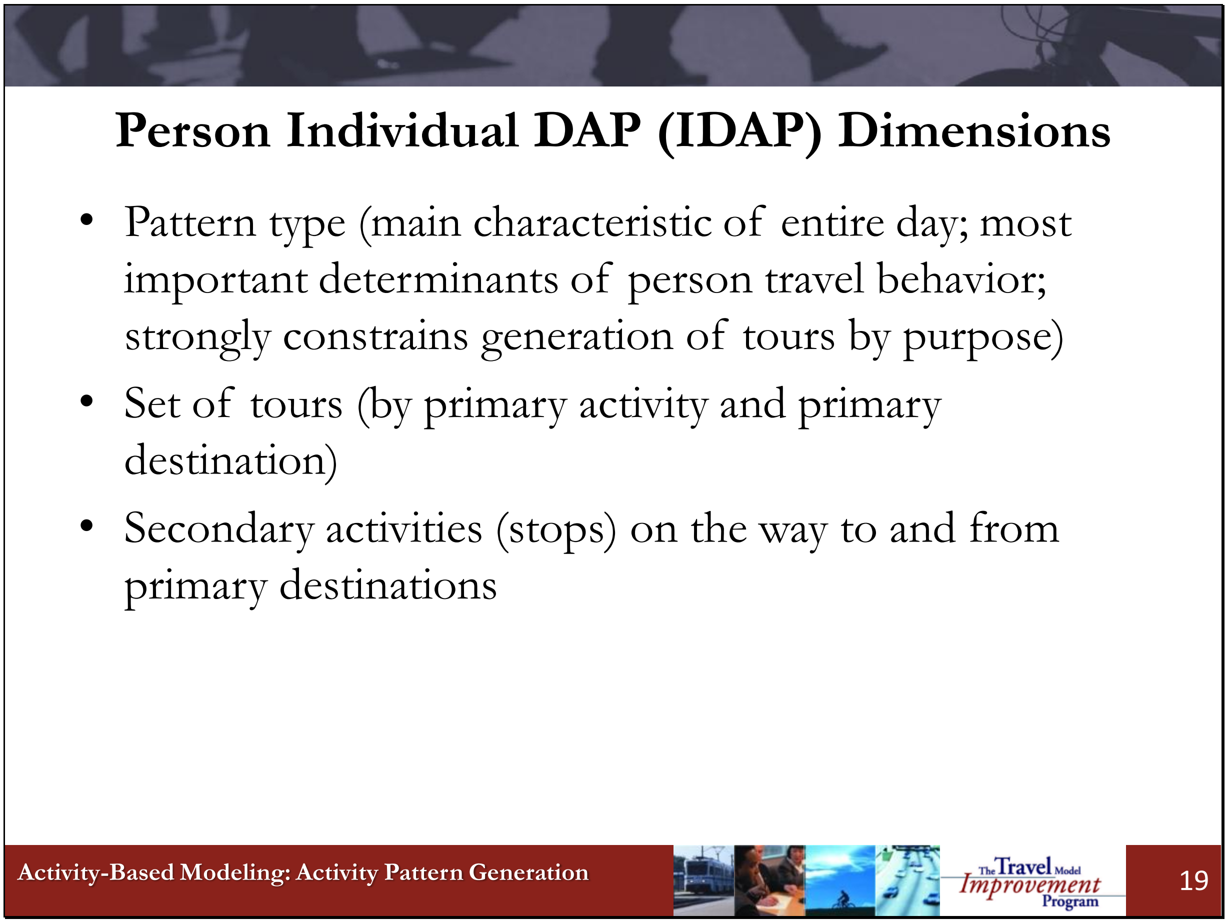
The first important technical point to discuss today is why we want to model trips for different purposes jointly in the DAP framework? What's wrong in applying several separate models for different trip rates? After all it is simpler. The reason for this is that trip rates for different purposes are not independent for the same individual. For example, a person who did not have either mandatory or maintenance trips on a day would have a higher probability of not having discretionary trips either (being sick, absent from the town, working from home, etc). However, the same logic is reversed when it comes to comparison between one and multiple activities. For example, those who have multiple maintenance activities on the day will have a lower probability of multiple discretionary activities on the same day. Thus modeling different trip purposes for the same person independently loses information and may result in an illogical, inconsistent DAP.



This represents an historical attempt of transitioning from trip generation (3^{rd} type) to DAP models. It was applied in the NY activity based modeling designed in 2001. In this model DAP is broken into a subset of 13 interlinked tour-frequency models for different purposes and person types with some simplified accounting for intra-household interactions.

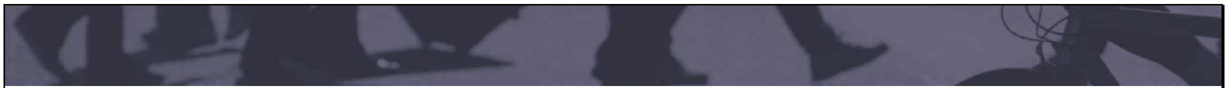


Definition of J. Bowman and M. Ben-Akiva per Bowman's master's thesis, where the first attempt was made to formulate an integrated individual DAP for a person instead of a set of frequency models. This formulation distinguished between primary and secondary activities and subsequently between travel tours. We will discuss some more recent modifications of this model in detail today.



We start with a concept of Individual DAP applied for each person. At this point we do not consider intra-household interactions explicitly and focus on one person. There are three major components of IDAP that we want to model:

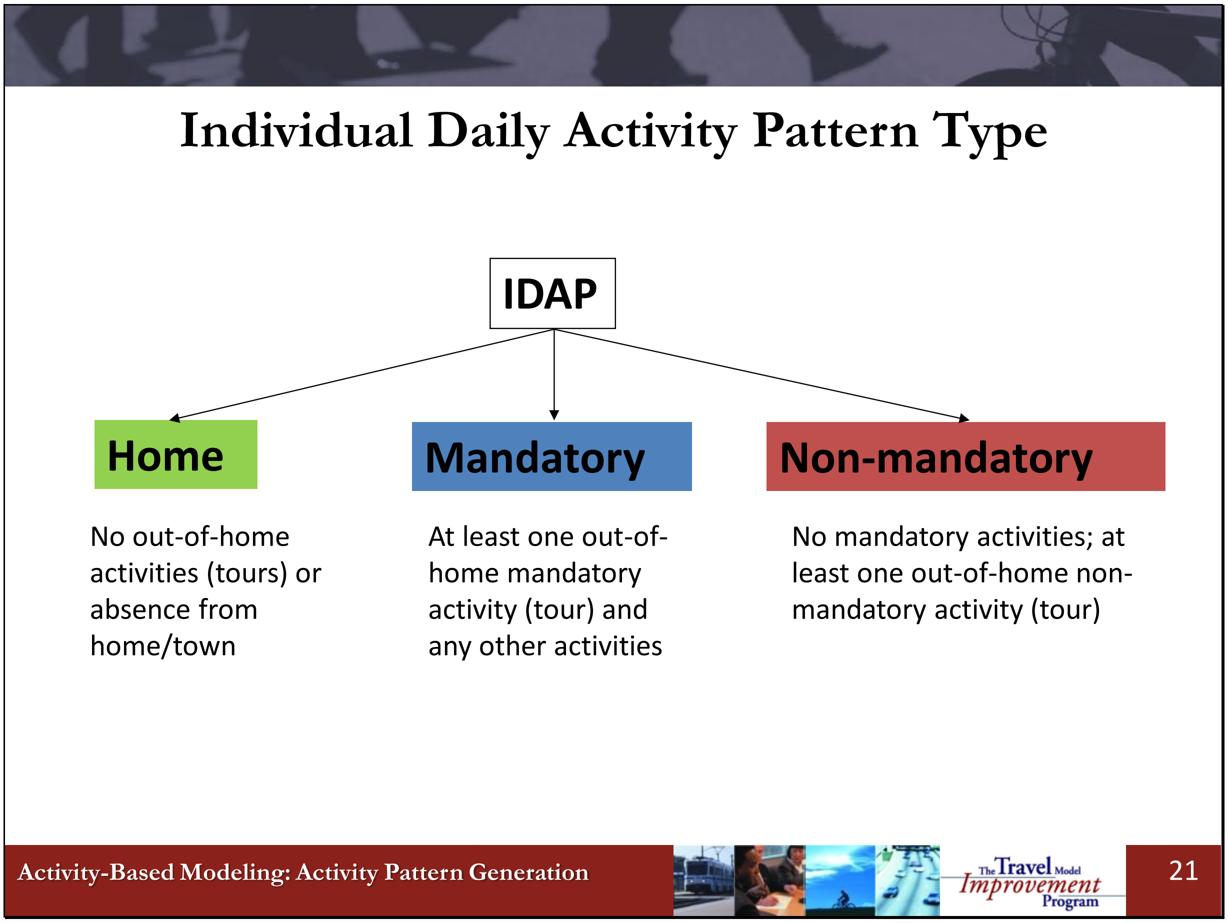
- Pattern type (main characteristic of entire day; most important determinants of person travel behavior; strongly constrains generation of tours by purpose);
- Set of tours (by primary activity and primary destination); and
- Secondary activities (stops) on the way to and from primary destinations.



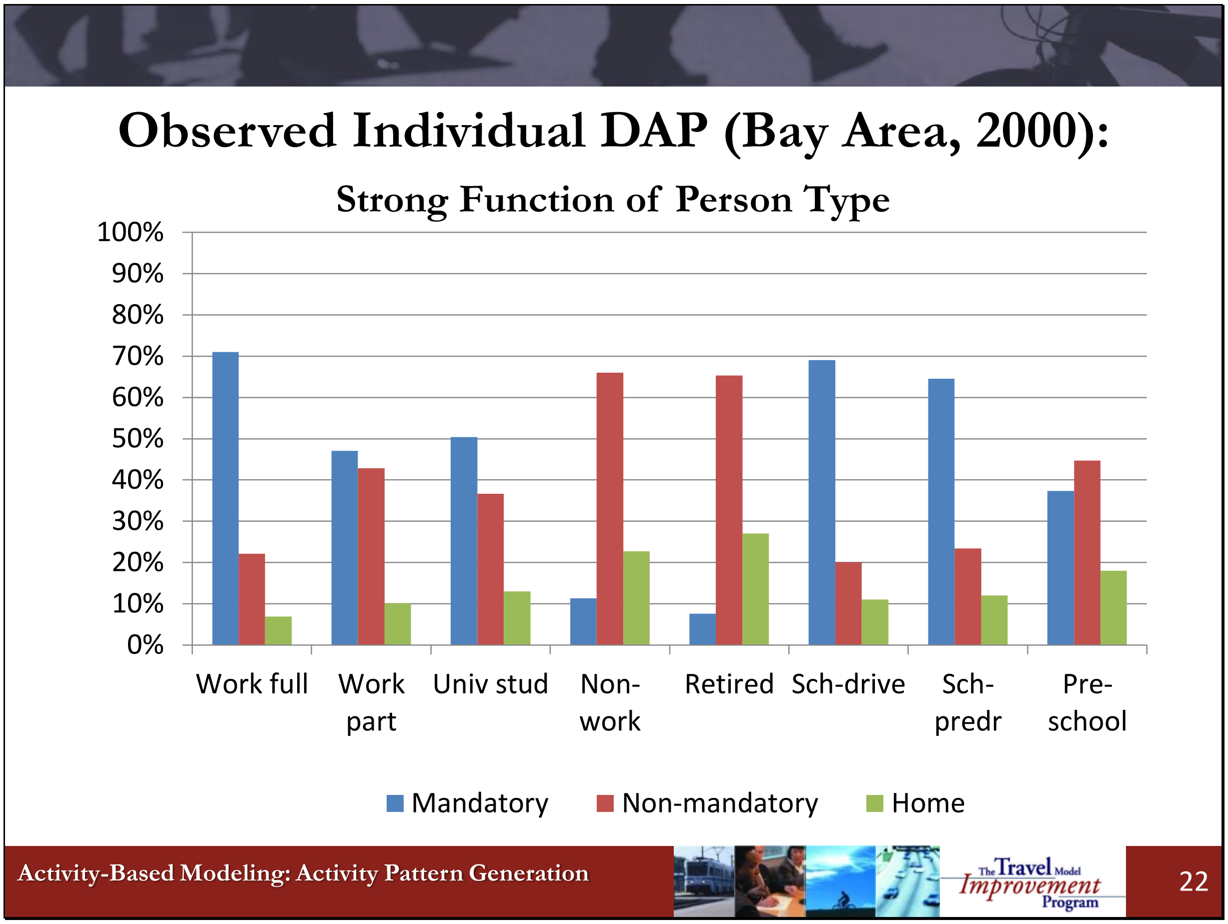
Main Person Types

Type	*Age*	*Work stat*	*Stud stat*
Full-time worker	18+	Full	Part
Part-time worker	18+	Part	Part
University student	18+	Part	Full U
Non-worker	18-64		Part
Retired	65+		
Driving school child	16+	Part	Full S
Pre-driving school child	6-15		Full S
Pre-school child	U6		Full S

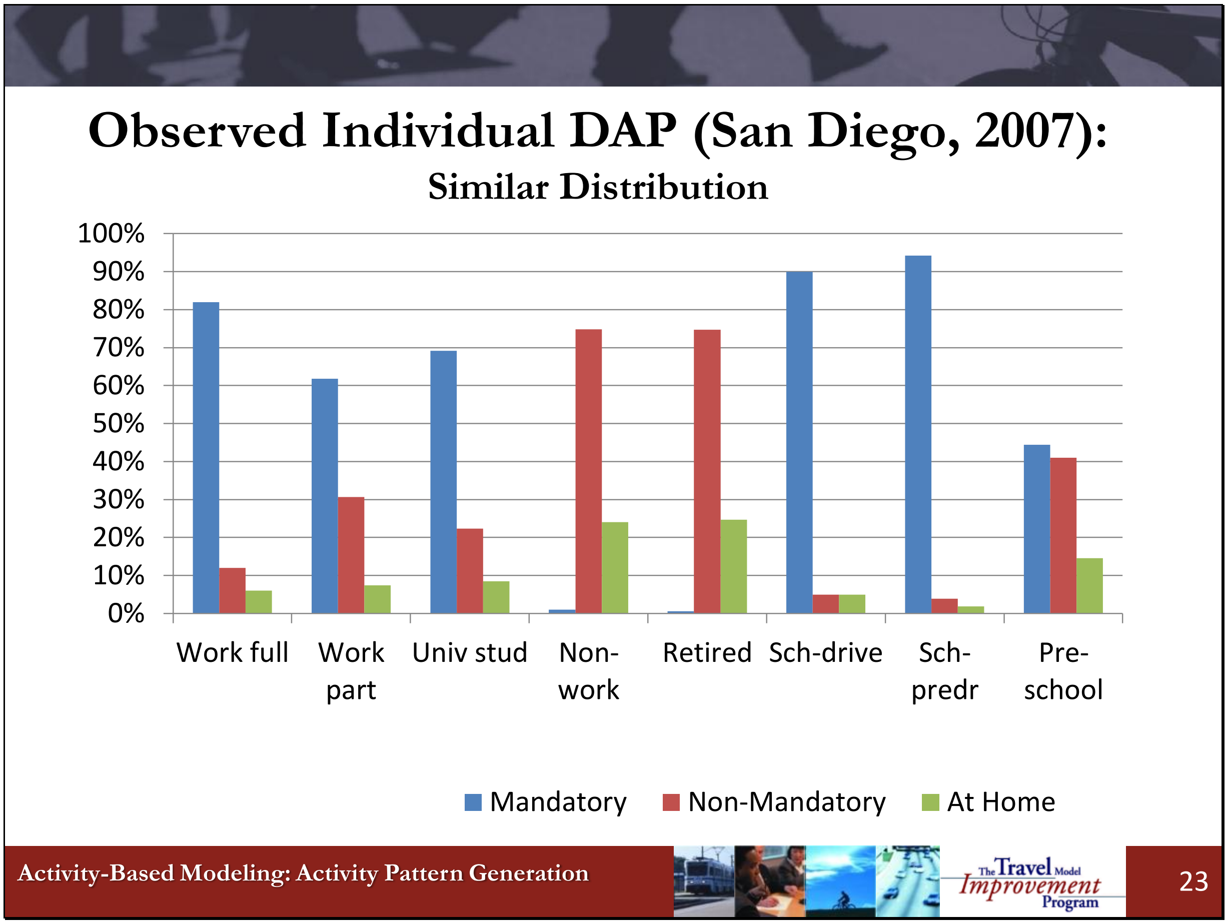
Typical DAPs are very different for different person types. When we analyze DAP stats we will consider 8 main person types as defined in the table (read the definitions). Black attributes are necessary. Grey attributes are optional.



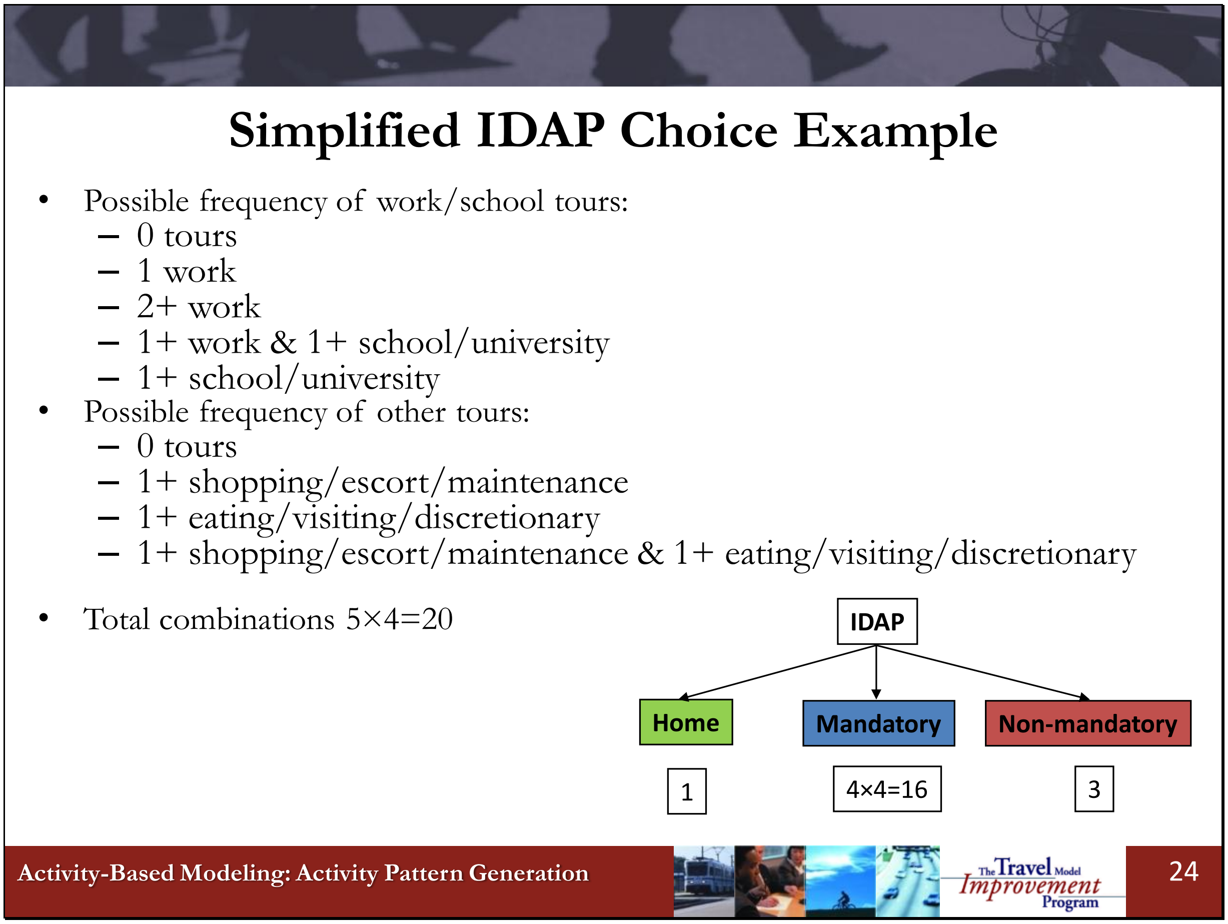
Every DAP falls into one and only one category. This is obviously is the most important day-level decision made by each person that has a crucial conditional impact on the number and schedule of all activity episodes. We start our analysis at this aggregate level by classifying DAPs by whether they are at-home (no travel), mandatory, or non-mandatory. As defined above, a mandatory pattern would include at least one out-of-home mandatory activity (tour)—work, college, and school—and may include any other non-mandatory activities. The non-mandatory DAP group excludes mandatory activities and must include at least one non-mandatory activity (tour)—shopping, eating out, social/recreational, personal business/medical, and providing rides to other household members (escort).



Observed frequency of DAP types is obviously a strong function of the person type. Full-time workers, university students, and school children are naturally characterized by a dominance of the Mandatory DAP type. Contrary to that, non-workers and retired people are characterized by a dominance of the Non-mandatory DAP type as well as frequent staying at home.



This distribution is stable across regions and years since it reflects on the most fundamental features of travel behavior. However, there are some significant differences and sensitivities to the local conditions. For example, the work attendance factor may vary between 70% (Bay Area) and 80% (San-Diego) that has significant implications on regional VMT, etc.



Now let’s consider a realistic but simplified example of an IDAP structure where we limit the possible frequency of mandatory and non-mandatory tours as shown on the slide. We also will focus on number of tours and assume that there are no intermediate stops on these tours. Thus all tours have a form of a round trip with a single destination. We will also distinguish between 2 aggregate non-mandatory purposes only (maintenance and discretionary) without details of each particular purpose. With these simplifications we arrive at 20 possible IDAPs of which one pattern is to stay at home all day; 16 patterns include at least one work or school activity; and 3 patterns have only non-mandatory tours.

Daily Activity Patterns

DAP Type	Mandatory Tours	Non-Mandatory Tours	DAP alternative
Home	0	0	1
Mandatory	1 Work	0	2
		1+ Escort/Shop/Maintenance	3
		1+ Eating/Visit/Discretion	4
		1+ Maintenance & 1+ Discretion	5
	2+ Work	0	6
		1+ Escort/Shop/Maintenance	7
		1+ Eating/Visit/Discretion	8
		1+ Maintenance & 1+ Discretion	9
	1+ Work & 1+School/University	0	10
		1+ Escort/Shop/Maintenance	11
		1+ Eating/Visit/Discretion	12
		1+ Maintenance & 1+ Discretion	13
	1+ School/University	0	14
		1+ Escort/Shop/Maintenance	15
		1+ Eating/Visit/Discretion	16
		1+ Maintenance & 1+ Discretion	17
Non-Mandatory	0	1+ Escort/Shop/Maintenance	18
		1+ Eating/Visit/Discretion	19
		1+ Maintenance & 1+ Discretion	20

Activity-Based Modeling: Activity Pattern Generation

The Travel Model Improvement Program

25

Exploring the combinatorics of DAP are essential for understanding this webinar. Thus, we list all these patterns explicitly for this example. You can see that the home pattern does not have any travel. All mandatory patterns are different but each of them has at least one mandatory activity. Please note that Mandatory pattern can also have non-mandatory tours although not necessarily. All non-mandatory patterns are different but each of them has at least one non-mandatory activity and does not have any mandatory activity. The list of patterns is mutually exclusive and collectively exhaustive under the adopted simplification scheme. It includes all possible combinations.

Observed Frequency for Workers: Your Guess?

Bay Area Transportation Survey (2000)

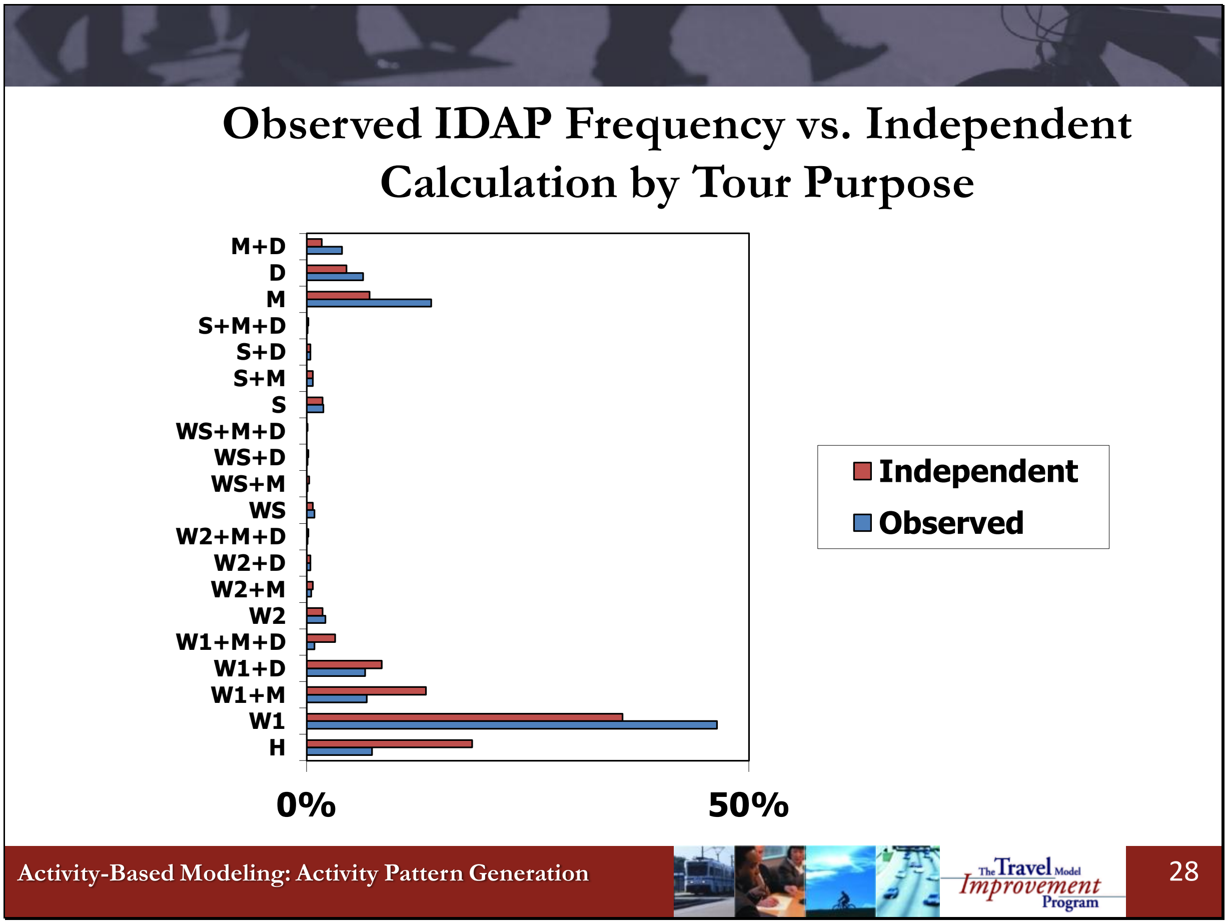
IDAP Type	Mandatory Tours	
Home	0	7.4%
Mandatory	1 Work	60.8%
	2+ Work	3.1%
	1+ Work & 1+School/University	1.2%
	1+ School/University	3.1%
Non-Mandatory	0	24.5%

All listed patterns are observed in reality for workers chosen as an example of person type (BATS, 2000 in this example). You can see that while the distribution is logically dominated by a Mandatory pattern with a conventional single work tour there are enough nonconventional cases. The relatively high share of workers having a Non-mandatory pattern on a regular weekday is a signature feature of the Bay Area with a large share of telecommuters and workers with flexible workdays.

Observed Frequency for Workers: Your Guess?

Non-Mandatory Tours	
0	58.7%
1+ Escort/Shopping/Maintenance	22.2%
1+ Eating/Visiting/Discretionary	14.0%
1+ Escort/Shopping/Maintenance & 1+ Eating/Visiting/Discretionary	5.2%

If we focus for a moment at the relative frequency of non-mandatory tours only we obtain the following logical distribution for workers. Majority of cases logically corresponds to a single non-mandatory tour. Overall maintenance activities are more frequent for workers on the regular workday compared to discretionary activities.



Now we present the relative observed frequency of each of the 20 IDAPs. We also present a frequency calculated as a Cartesian product of the observed frequency of mandatory activities by observed frequency of non-mandatory activities. This calculation assumes independent tour rates for mandatory and non-mandatory tours. You can see that the independent calculation is quite far from the observed frequency. This means that IDAP cannot be predicted as a combination of frequencies by purpose. In other words, tour rates for different purposes are not nearly independent. This is another important illustration why the concept of integrated IDAP is essential for understanding travel behavior.

Utility Formation Examples

DAP=3 (1 Work + Maintenance)	W1 (pattern) + W (tour) + M (tour)
DAP=13 (Work + School + Maintenance + Discret)	WS (pattern) + W (tour) + S (tour) M (tour) + D (tour)
DAP=19 (Discretionary)	N (pattern) + D (tour)

To model choice of IDAP we have to form a meaningful utility function that portrays the worth of each pattern. This utility is formed in a component-wise fashion reflecting that each activity has a certain value for each person plus there is an additional effect of the intensity of the entire pattern. Several examples of utilities are shown on the slide. This technique where a utility for each IDAP is combined of these components is absolutely essential when a real IDAP choice model is formed with thousands of possible patterns. This is a way to handle a large combinatorial choice with a parsimonious structure in terms of coefficients. This technique is also frequently applied for other sub-models of an activity based modeling like TOD choice that will be discussed at the next webinar.

IDAP Example from Sacramento activity based modeling

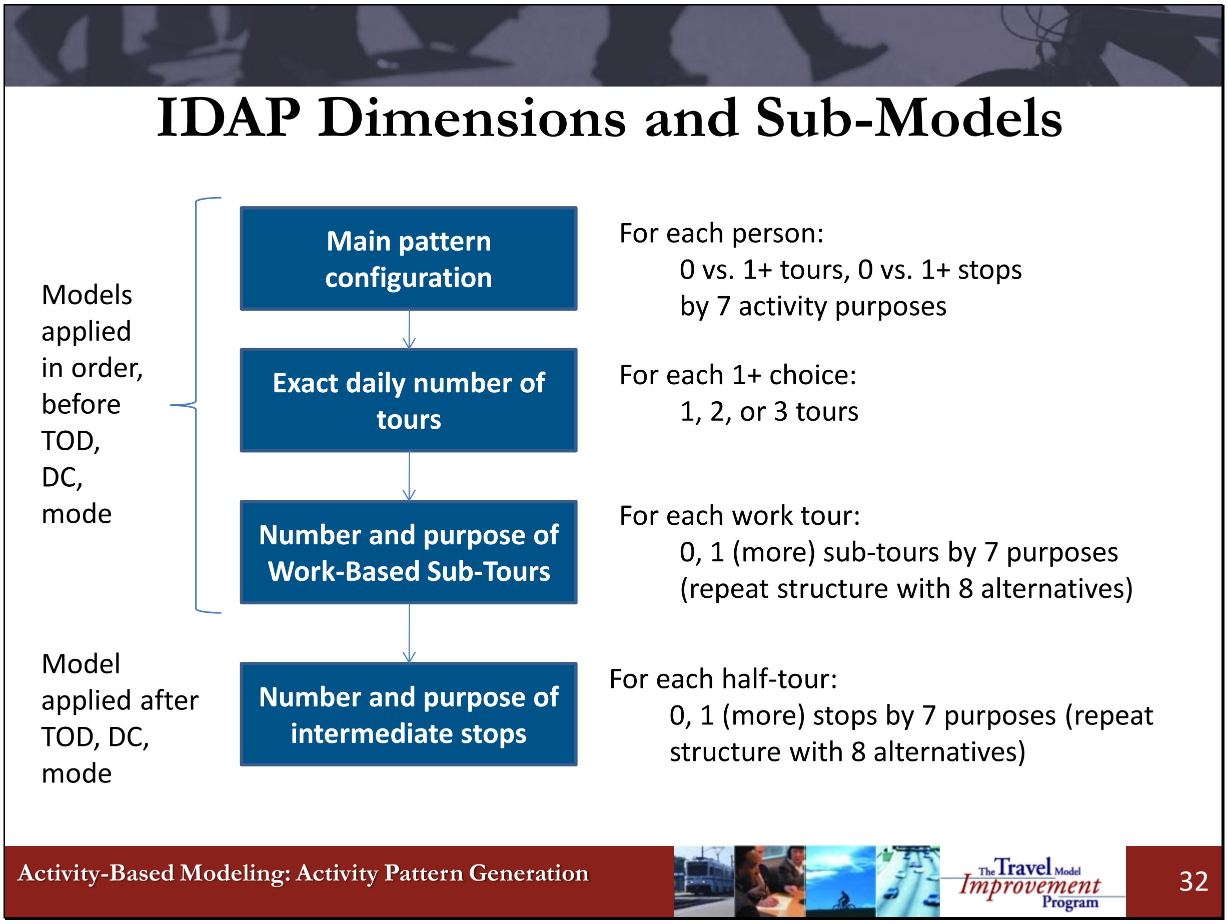
- Further on, we will consider example of IDAP applied in Sacramento, CA (SACOG) activity based modeling (DaySim) in detail
- Similar structures successfully applied in many activity based models in practice:
  - San Francisco, CA (SFCTA)
  - Denver, CO (DRCOG)
  - Seattle, WA (PSRC)
  - Jacksonville, FL (NFTPO)
  - Fresno County and San Joaquin Valley, CA

Now we are ready to consider an example of real IDAP applied in an advanced operational activity based modeling in practice with all details. We have chosen the Sacramento activity based modeling that is called DaySim as an example. Similar structures were successfully applied in several other activity based models in practice. Overall, it is a well-tested and well-explored structure.

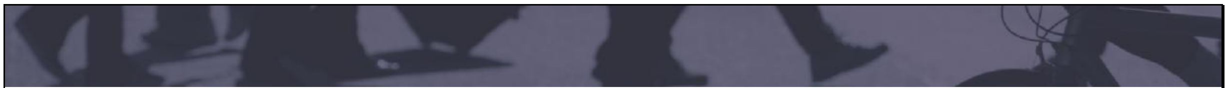
IDAP Main Features

- Predicts for each person:
  - Tours by purpose
  - Purposes for which intermediate stops occur during the day
- High level of intra-person consistency of the day's tours and stops for seven different purposes
- Relatively simple and possible to enumerate all main IDAPs although results in thousands of alternatives
- Intra-household interactions not modeled explicitly but somewhat accounted implicitly through household variables

The Sacramento IDAP model predicts for each person, tours by purpose, and purposes for which intermediate stops occur during the day. IDAP also offers a high level of intra-person consistency of the day's tours and stops for 7 different purposes. It is relatively simple and possible to enumerate all main IDAPs, although results in thousands of alternatives. Intra-household interactions not modeled explicitly but somewhat accounted implicitly through household variables.



The DaySim IDAP goes through the following foru steps. First three steps are applied sequentially before the time-of-day, destination and mode choices are modeled for each tour. The last, 4th step is modeled after the times-of-day, destinations and modes have been predicted for each tour. Thus, there are some additional sub-models between the 3rd and 4th step that we skip over today. Those will be covered in subsequent webinars on those topics.



IDAP Main Pattern Configuration

Purpose	Possible # tours		Possible # additional stops	
1=Work	0	1+	0	1+
2=School	0	1+	0	1+
3=Escort	0	1+	0	1+
4=Personal business	0	1+	0	1+
5=Shopping	0	1+	0	1+
6=Eating out	0	1+	0	1+
7=Social & recreational	0	1+	0	1+

- 2^{14}=16,384 possible combinations
- Truncation by max of 3 tour purposes, 4 stop purposes, 5 total purposes
- Exclusion of unobserved and infrequent combinations
- 2,080 realistic choice alternatives

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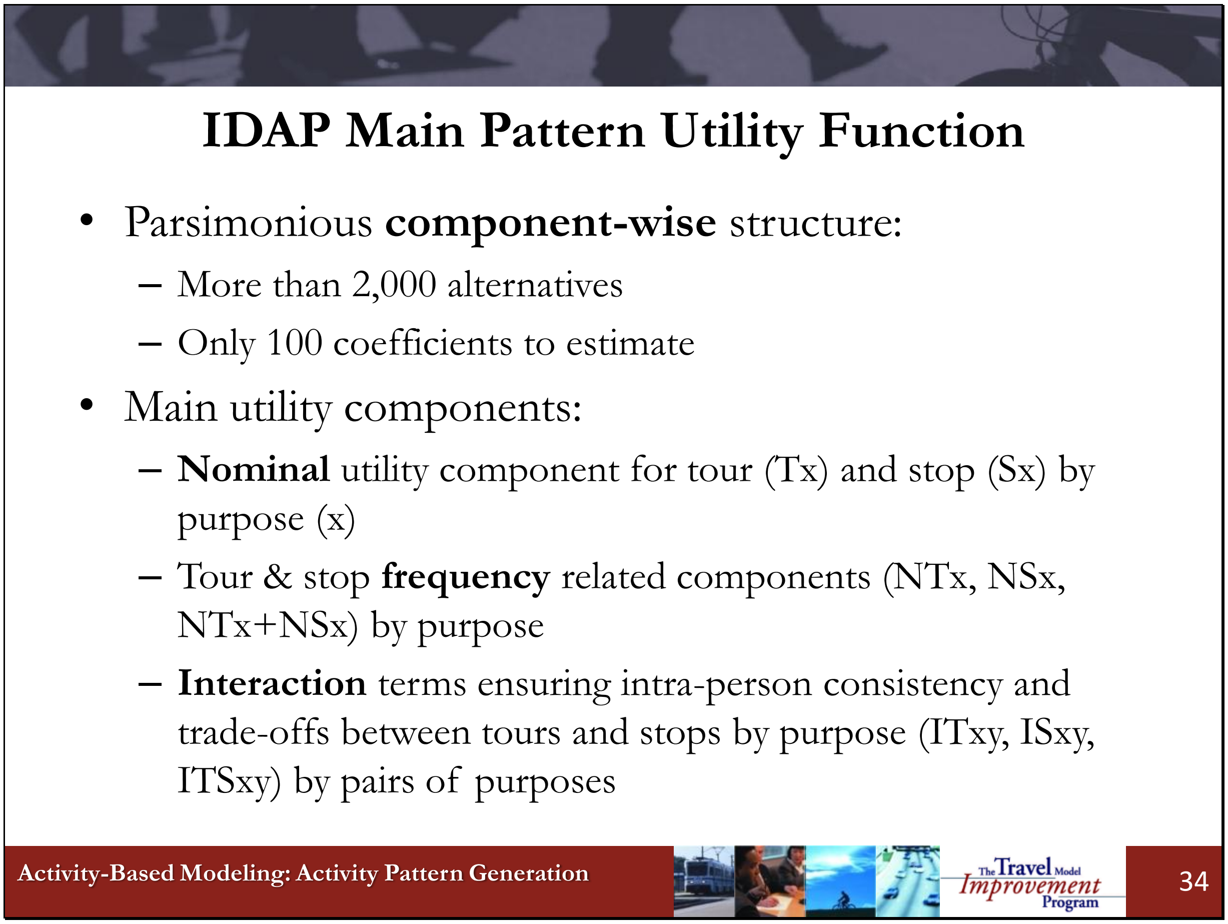
The first component of the IDAP relates to the main pattern configuration in terms of tours and additional stops on these tours. At this step we do not yet model details like an exact number of tours or stops if more than 1. However, for each of the 7 purposes we want to know if there is at least one tour made and at least one additional stop made. Even with these simplifications, the combinatorics of the IDAP model are impressive. If we consider all possible combinations mechanically we arrive at over 16,000 possible different patterns; however, the number of possible combinations can be effectively truncated since many of them are never observed (for example a pattern with all seven tour purposes present for the same person on the same day is unrealistic). This reasonable truncation leads to about 2,000 of choice alternatives that can be handled efficiently as a simultaneous choice.



Even after truncation we have way too many alternatives to construct a different utility for each…what to do? The solution that is a very important technique applied in activity based models that we already have touched upon is a parsimonious component-wise structure of the utilities. We have many utilities but they are combined of a limited number of components and require only a limited number of coefficients to estimate. The main utility components of IDAP are:

- Nominal utility component for tour (Tx) and stop (Sx) by purpose (x);
- Tour & stop frequency related components (NTx, NSx, NTx+NSx) by purpose; and
- Interaction terms ensuring intra-person consistency and trade-offs between tours and stops by purpose (ITxy, ISxy, ITSxy) by pairs of purposes.

IDAP Main Pattern Utility Examples

IDAP	Tour component	Stop Component	Interaction term
Work tour + shopping tour	(work) + (shop)		(work, shop)
Work tour w/shopping stop	(work)	(shop)	(work, shop)
Work tour + school tour + recreational stop	(work) + (school)	(recreational)	(work, school) + (work, recreational) + (school, recreational)
Recreational tour	(recreational)		
2 shopping tours	(shop) + (shop)		

In this table we provide several examples how utility can be constructed for different patterns and what are the main components. You can see that many components are used in several IDAPs. For example, the work tour utility component is included in first three patterns.

Formulation of Component-Wise Utilities

- Form a utility by components for IDAP that includes work tour and shopping tour:
  - Component that measures the utility for total number of 1+ tours
  - Component that measures utility for 1+ tours for a particular purpose
  - Component that measures the joint utility of 2 tours of different purpose

$$\text{Utility}_{1+\text{work},\ 1+\text{shop}} = \text{Utility}_{1+\text{work}} + \text{Utility}_{1+\text{shop}} + \text{Utility}_{2+\text{ tours}} + \text{Utility}_{1+\text{work}\ \&\ 1+\text{ shop}}$$

- Where:
  - $\text{Utility}_{1+\text{work}} = 2.5 + -0.2*(0,1)_{\text{part-time worker}} + 0.5*\text{work\_MC\_logsum}_{\text{home-work}}$
  - $\text{Utility}_{1+\text{ shop}} = -0.3 + 2*(0,1)_{\text{high-income hh}} + 1.5*\text{hh\_size} + 0.5*\text{shop\_DC\_logsum}_{\text{home}}$
  - $\text{Utility}_{2+\text{ tours}} = -1.0$
  - $\text{Utility}_{1+\text{work}\ \&\ 1+\text{shop}} = -0.18$

Constants

Household and person variables

Accessibility information

Activity-Based Modeling: Activity Pattern Generation

The Travel Model Improvement Program

36

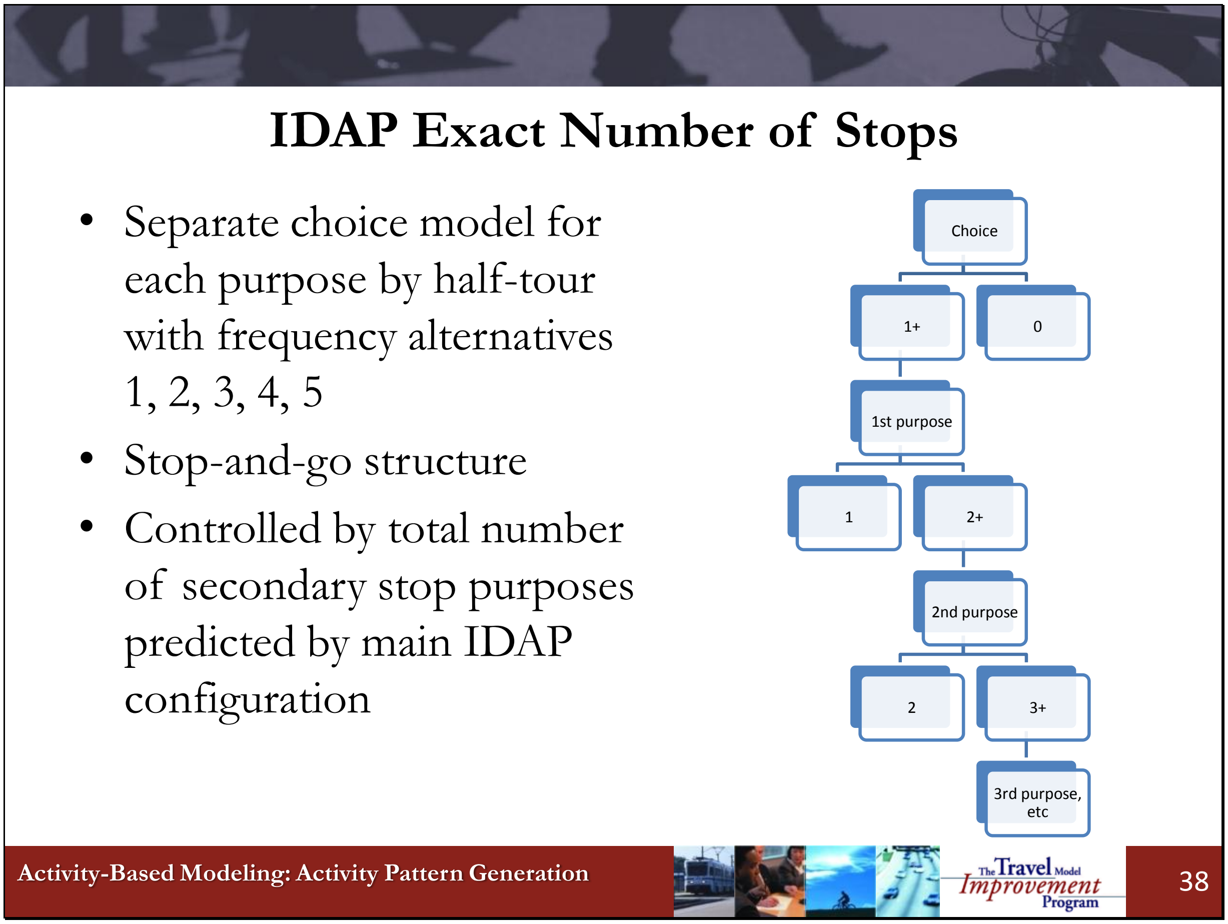
Now let's consider a more specific example. How we can form a utility function for a pattern that includes one or more work tours and one or more shopping tours? We need to include a component for each tour type and also account for interactions. Thus our utility would include the following 4 components as shown in the formula. Each of these components is in itself a function that can include a constant, some household and person variables, as well as some accessibility variables.

IDAP Exact Number Tours: e.g., Shopping

Main variables	1 tour	2 tours	3 tours
Constant	0	-7.469	-14.18
Accessibility to shops		0.5011	0.9517
Full-time worker		0.5642	0.5642
School child age 5-15		-0.6396	-0.6396
Adult age group 26-35		-1.661	-1.661
Male w/children of age 5-15		1.105	1.105
Female w/children of age 5-15		0.5436	0.5436
Only adult in HH		0.5404	0.5404
HH Income 75K+		0.3538	0.3538
Work at home		0.4937	0.4937
# work tours		-2.443	-2.443
# personal business tours		-0.2152	-0.2152

After the main pattern configurations have been predicted for each person, we have to add details for each tour. It might be a single tour that is the most frequent case, but some people implement 2 or even 3 tours per day of the same purpose. A reminder is that tours might be non-motorized and short. The exact number of tours is defined by a choice model that considers numbers of tours as alternatives as shown in the example for shopping tours. A single tour per purpose is the base alternative with 0 utility. Alternatives that represent multiple tours have many explanatory variables. Large negative constants reflect on the fact that having more than 1 tour for the same purpose is an infrequent case.

In this model formulation, many coefficients (in black) proved to be generic across alternatives since they relate to the person's propensity to be engaged in multiple shopping activities, while the constants and impact of accessibilities (in red) proved to be the differentiating part.



Finally, we have to define number of stops on each tour. We have a separate choice model for stop purpose that is applied by half-tours. It is a so-called sequential stop-and-go structure. It is controlled by the total number of secondary stop purposes predicted by the main IDAP configuration that we discussed before.

Questions and Answers

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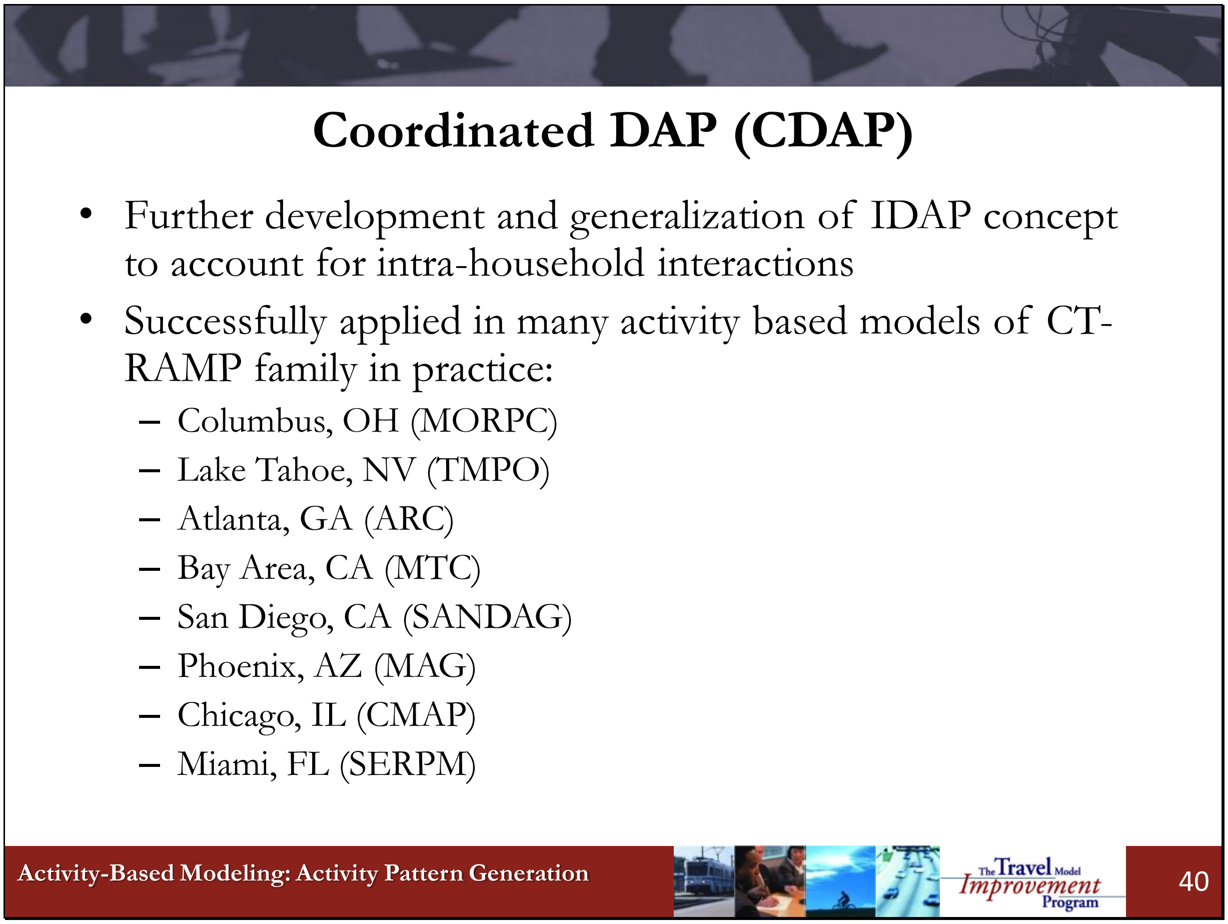


As we discussed before one of the fundamental limitations of the IDAP model is that it predicts activities, tours, and trips for each person independently of the activities, tours, and trips made by the other household members. To overcome this limitation a concept of CDAP has been developed. It is a further development and generalization of the IDAP concept that accounts for intra-household interactions explicitly. It has been successfully applied in many activity based models in practice, specifically in activity based models of the CT-RAMP family:

- Columbus, OH (MORPC)
- Lake Tahoe, NV (TMPO)
- Atlanta, GA (ARC)
- Bay Area, CA (MTC)
- San Diego, CA (SANDAG)
- Phoenix, AZ (MAG)
- Chicago, IL (CMAP)
- Miami, FL (SERPM)

Importance of Intra-Household Interactions

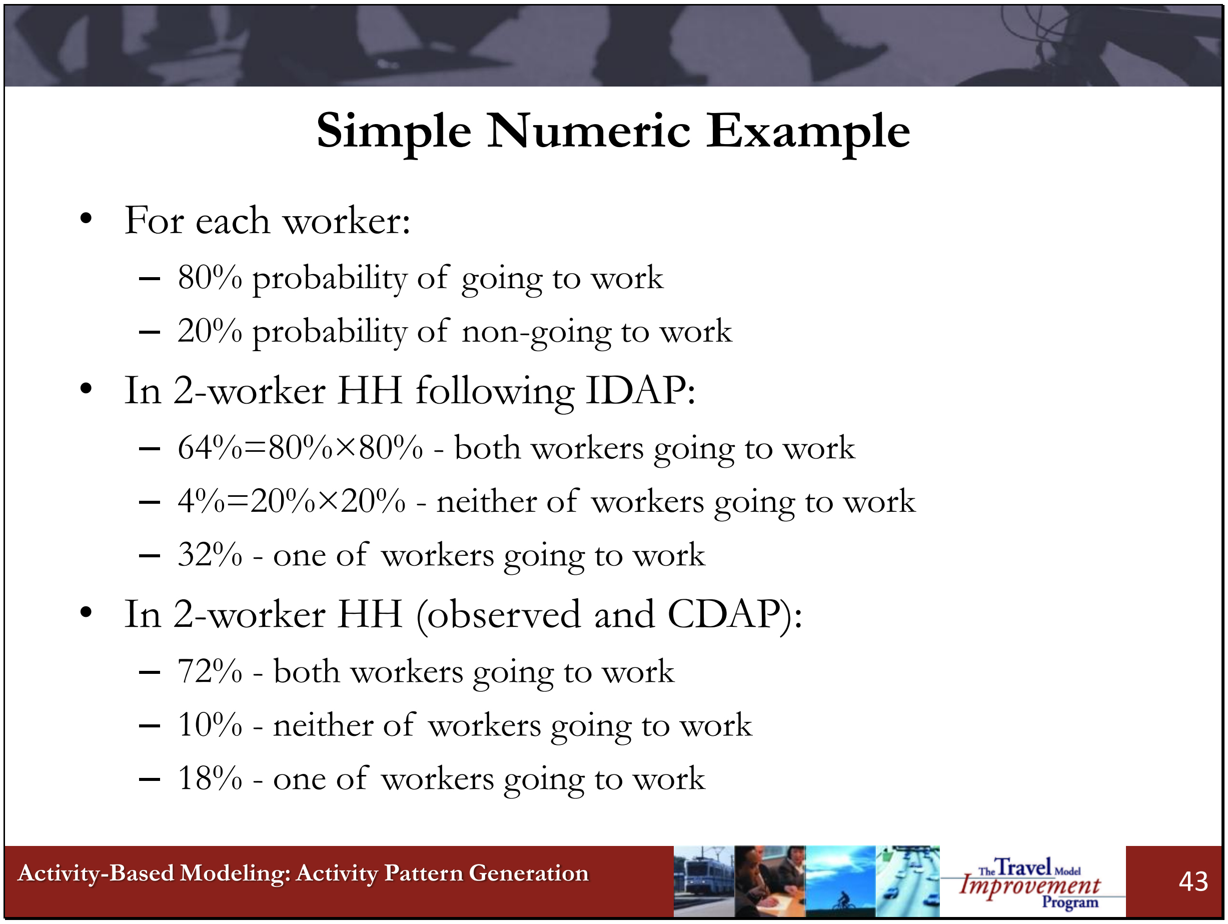
- For understanding and modeling travel behavior:
  - More than 30% of activities and trip implemented jointly
  - More than 50% of activity schedules affected by schedules of other persons
- For modeling practical policies:
  - HOV and joint travel (not mode choice!)
  - Impact of changing demographics
  - Reluctance to switch to transit and give up car

Incorporation of intra-household interactions is important, not only for theoretical or research reasons but also for better forecasts in practice. If we want to understand and model travel behavior we have to take into account that more than 30% of activities and travel episodes are implemented jointly and more than 50% of activity scheduling decisions affected by schedules of other persons at least to a some extent. Carpooling and use of HOV lanes is not a simple mode choice made by each person individually. Carpooling is a joint travel decisions that requires schedule coordination between the participants. Changing demographics, in particular, bigger or smaller households affect travel decisions strongly and these effects cannot be fully captured by individual person-based models. Workers in households with more children are reluctant to use transit, usually because they are engaged in drop-offs /pick-ups of children on the way to and from work.

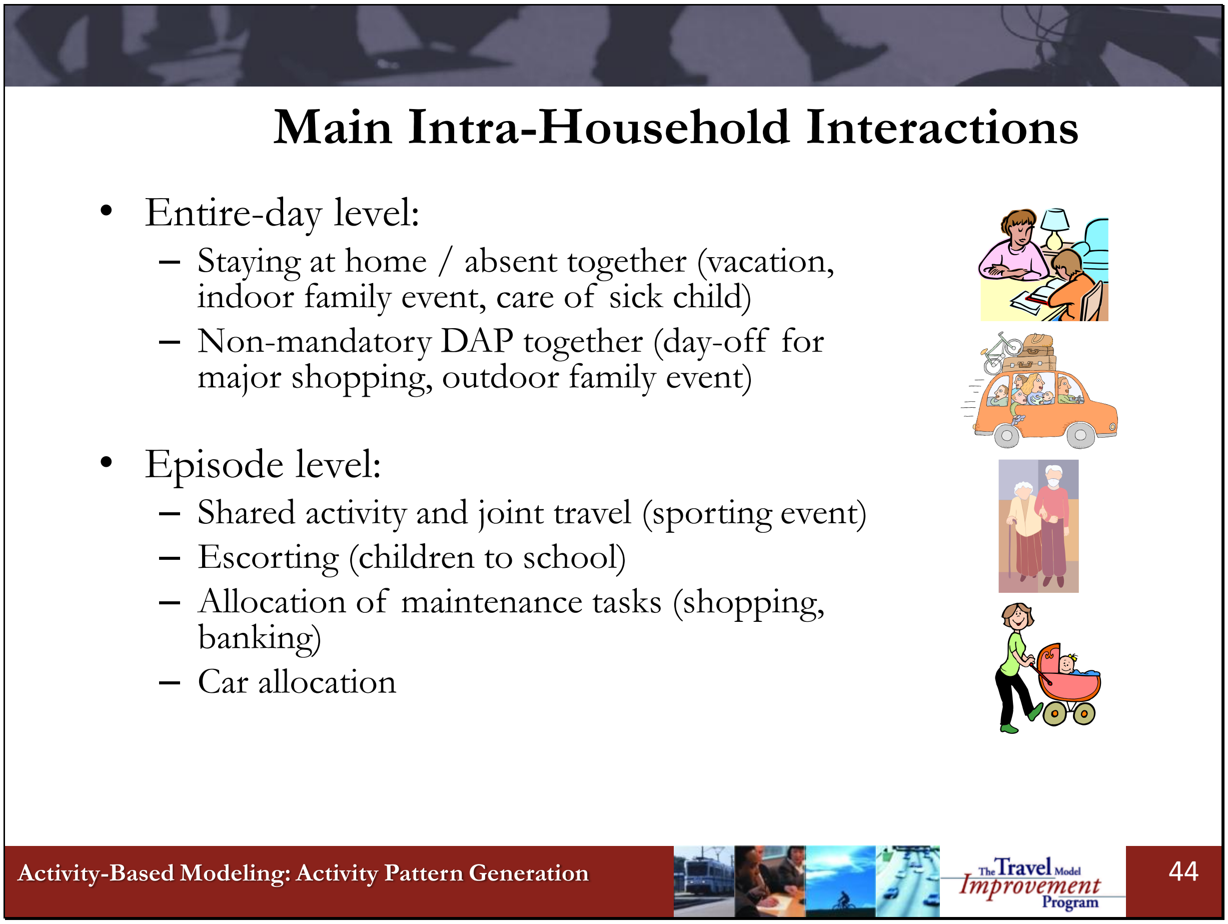
Micro-simulation aggravates intra-household inconsistency

HH members	Daily pattern		
	Work, School	Non-mandatory	Stay at home / vacation
Fractional probability:			
1st Worker	0.70	0.15	0.15
2nd Worker	0.60	0.25	0.15
Child	0.65	0.05	0.30
"Crisp" choices:			
1st Worker	Go to work		
2nd Worker		Major shopping	
Child			Sick at home

Independent micro-simulation of person tends to produce inconsistencies at the HH level even if the core probabilities are realistic and properly conditioned. In this example, we have reasonable estimates of probabilities for each person that correspond to the reality (read the slide). However, if we roll the dices for each person separately there is a significant probability (0.70*0.25*0.30=0.04) to have a combination of choices that has a very low observed frequency (when both household heads leave a sick child at home alone). Thus, an explicit linkage across choices is necessary.



Let’s consider another simple numeric example with the observed numbers that are very stable and practically identical across all regions. For each full-time worker there is an 80% probability of going to work and a 20% probability of not going to work. An IDAP model will replicate this successfully. However, if we consider a households with 2 workers and apply IDAP to each of them independently we obtain the joint result in which there is a 64% chance of both persons going to work, a 32% chance of one person going to work, and only a 4% chance of neither person going to work. This is not what we observe in reality. In reality, in a 2-worker household in 72% of cases both workers go to work, in 10% of cases neither of them go to work, and in 18% of cases one of the workers go to work, i.e. we observe a coordination between DAPs of different household members. CDAP will replicate this joint effect while IDAP would fail.

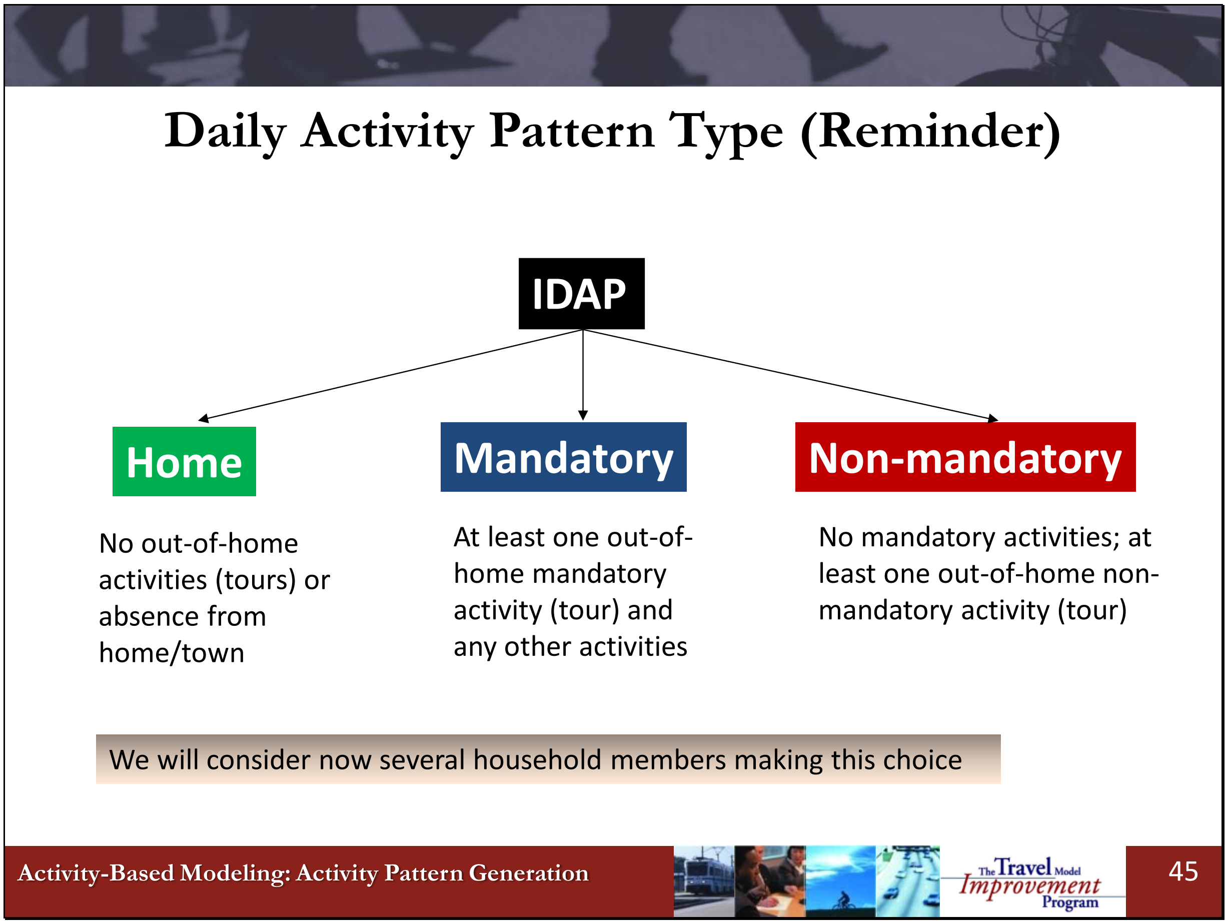


In general there are many layers of intra-household interactions that are important to consider when modeling DAP. Some of them manifest itself at the entire-day level:

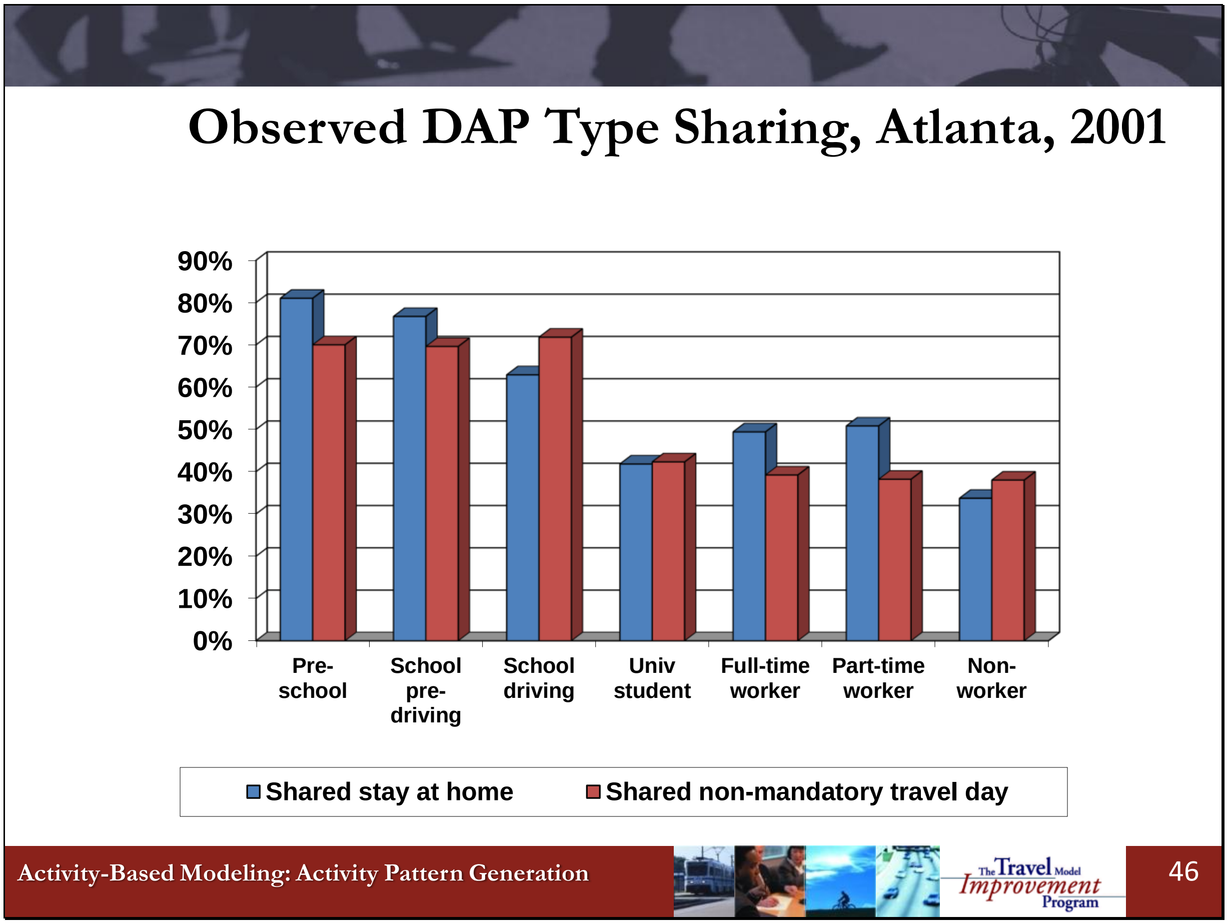
- Staying at home / absent together (vacation, indoor family event, care of sick child)
- Non-mandatory DAP together (day-off for major shopping, outdoor family event)

Some other ones relates to particular activity or travel episodes:

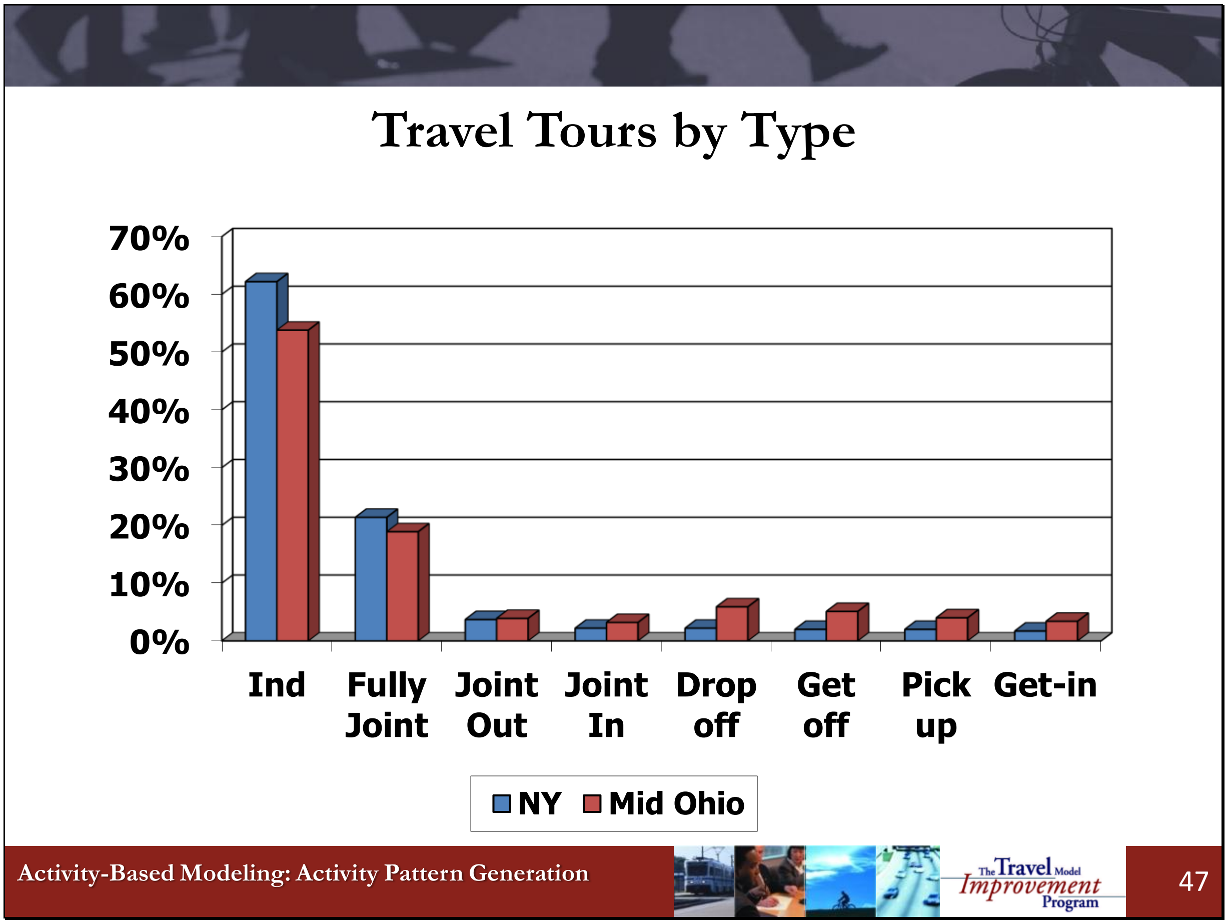
- Shared activity and joint travel (sporting event)
- Escorting (children to school)
- Allocation of maintenance tasks (shopping, banking)
- Car allocation



This is a reminder that every person has a DAP type that falls into one and only one category. This is obviously is the most important day-level decision made by each person that has a crucial conditional impact on the number and schedule of all activity episodes. We will be using this classification but consider several household members together rather than one at a time. We will see that strong intra-household interactions already show up at this aggregate level.



On this slide, we present relevant stats on sharing the same Home or Non-Mandatory pattern by several household members. You can see that school children, especially younger ones, are characterized by a very high degree of sharing. For example, if a preschool child stay at home or have a non-mandatory travel day (in both cases not going to day care or school) there is a very high probability for somebody else to share this pattern, i.e. not go to work or school. For adult household members the probability to share a home or non-mandatory pattern is lower compared to children but it is still very substantial (40%+).

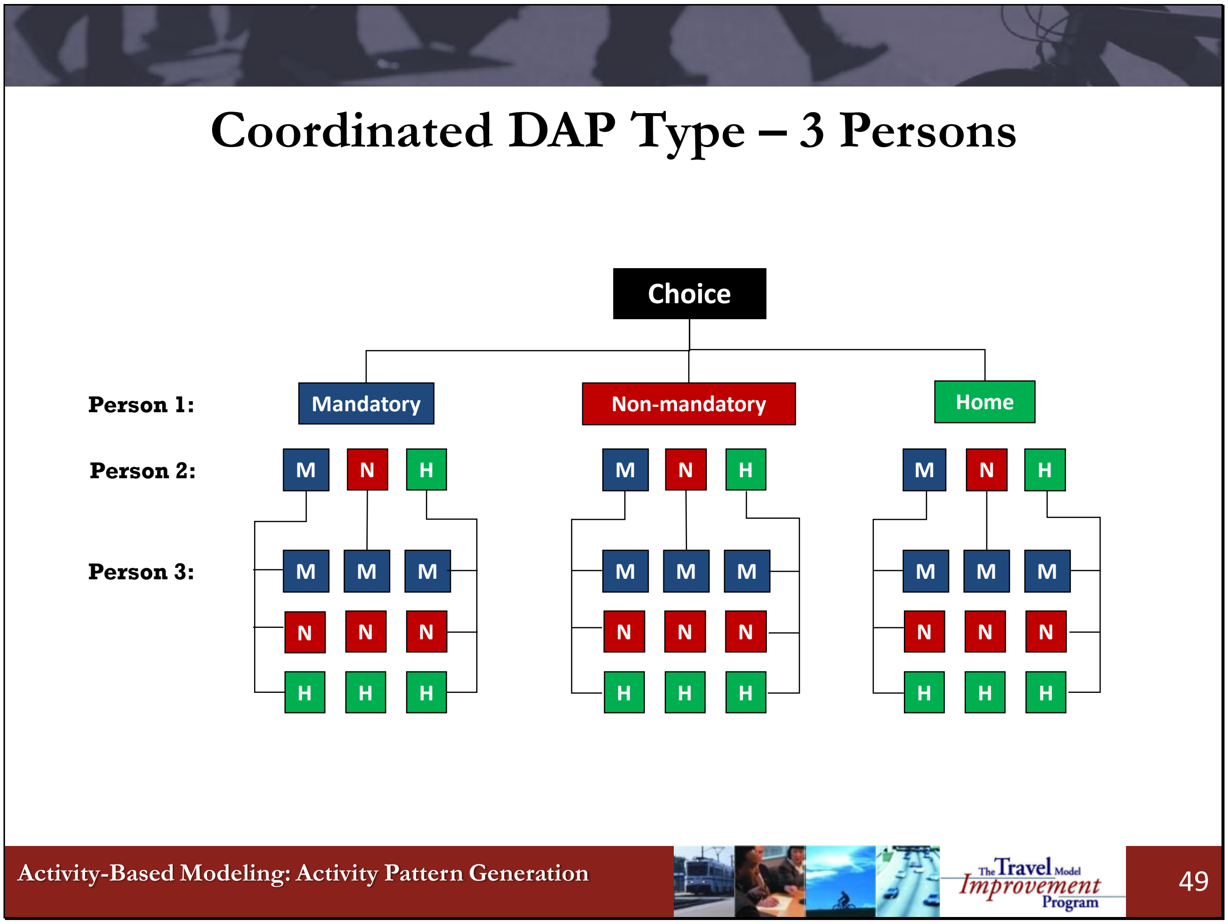


Another related stats show a share of joint travel by household members. It is very high in different metropolitan regions. Individual travel constitutes only 50-60%. Almost half of travel tours are somewhat joint between the household members. Fully-joint tours are the biggest chunk (~20%),, but all partially joint tours together total to the same 20%. There is of course a significant variation across different travel purposes with respect to the share of joint travel and also across household and person types. Thus, it is important to model intra-household interactions. How can we do that?

Basic Choice Structure for CDAP

- Simultaneous rather than sequential modeling of all HH members
- 363 alternative combinations of individual trinary choices for HH≤5 (98%):
  - 1 person: 3 alternatives
  - 2 persons: 3×3=9 alternatives
  - 3 persons: 3×3×3=27 alternatives
  - 4 persons: 3×3×3×3=81 alternatives
  - 5 persons: 3×3×3×3×3=243 alternatives

The main approach is to model DAP choice for all household members together, i.e. simultaneously rather than sequentially. Each person has 3 alternatives but when we consider several household members, the number of alternatives becomes quite large but still manageable. The key factor that we will discuss later is a parsimonious component-wise specification of utilities. It is important to understand why we have 9 alternatives for 2 persons, 27 alternatives for 3 persons and so forth. In general, this type of combinatorics is essential for understanding activity based models.



In the CDAP structure each possible choice of each person is combined with each possible choice for the other household members. Consider an example of a 3-person household. Person 1 has 3 choices. Each of them can be combined with 3 possible choice alternatives for Person 2. This yields 9 possible combinations between Persons 1 and 2. Now each of these 9 combinations is combined with 3 possible choices for Peron 3 that results in 9*3=27 alternatives. This structure is not simple and results in a large number of alternatives for bigger households. Is it really essential to go into these complexities?

Is Coordination of DAPs Significant?

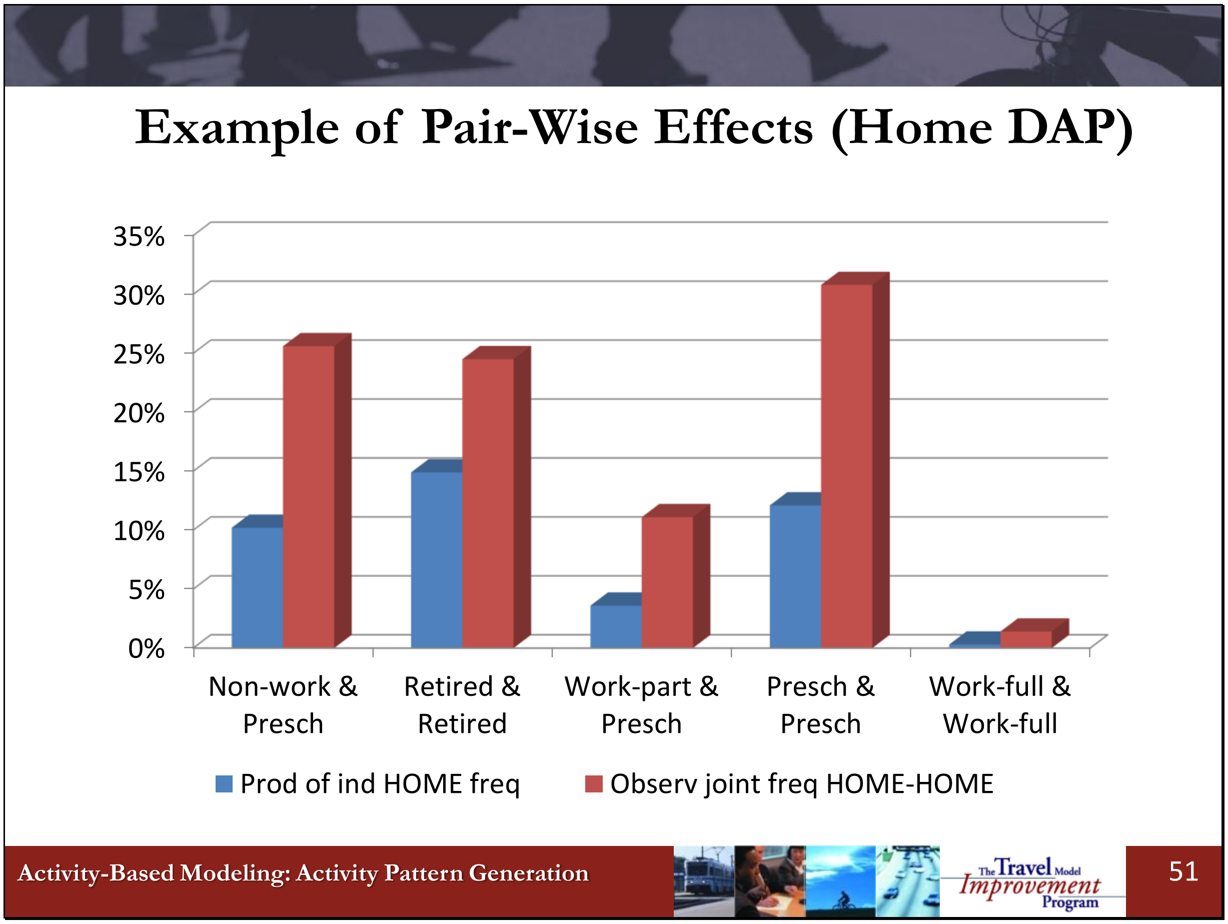
- If intra-household interactions are not significant and DAPs independent across persons, frequency of any DAP type combination would be close to product of individual frequencies
- Significant biases in group-wise choice frequency versus products of individual frequencies express intra-household interactions
- All possible 36 pair-wise combinations and 120 three-way combinations of 8 person types were explored with respect to joint NON-MANDATORY and HOME patterns (Atlanta HTS, 2001, 8060 HHs, 2 days)

In other words, is coordination of DAPs that significant? Here is another statistical analysis that is important to understand and recognize.

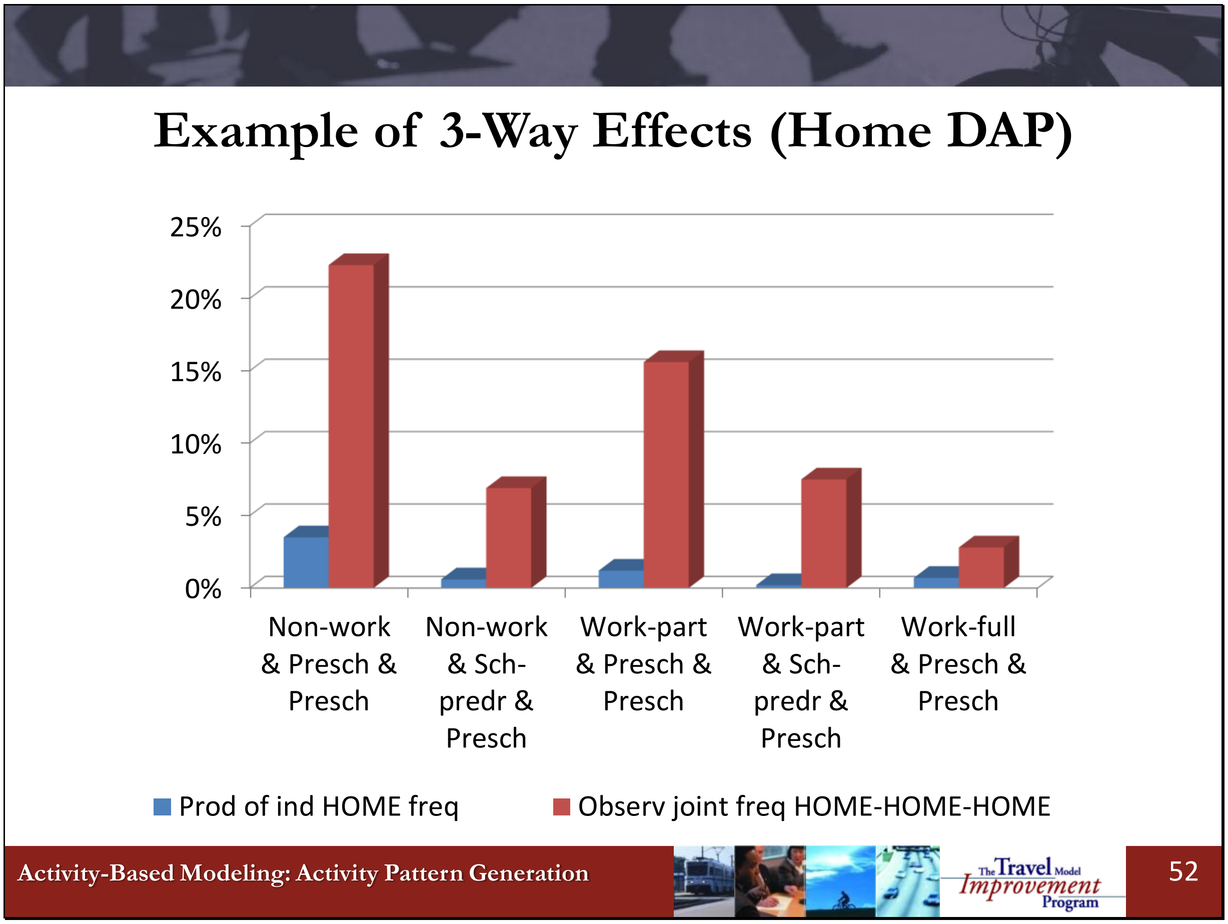
If intra-household interactions are not significant and DAPs independent across persons, frequency of any DAP type combination would be close to product of individual frequencies. Significant biases in group-wise choice frequency versus products of individual frequencies express intra-household interactions

All possible 36 pair-wise combinations and 120 three-way combinations of 8 person types were explored with respect to joint NON-MANDATORY and HOME patterns (Atlanta HTS, 2001, 8060 HHs, 2 days).

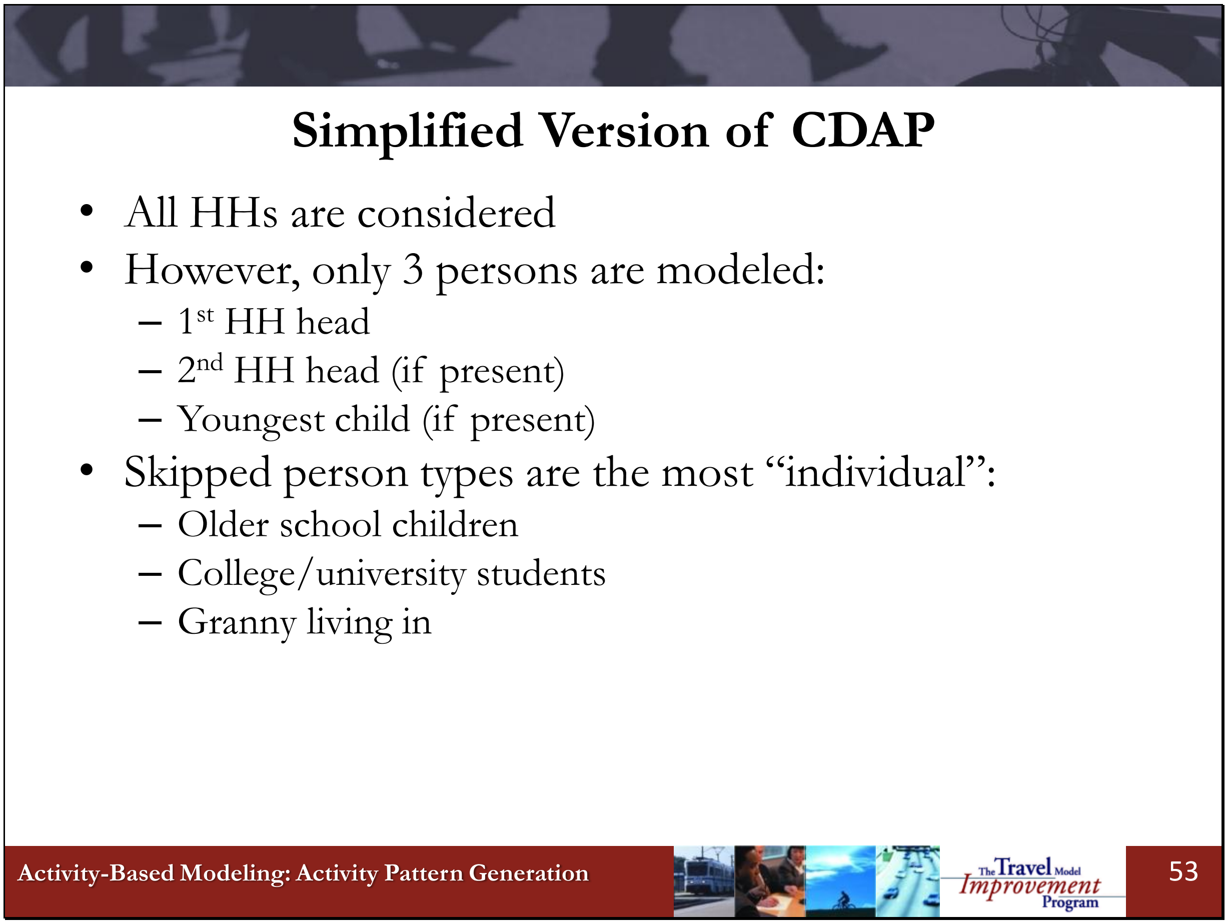
Here are some of the results.



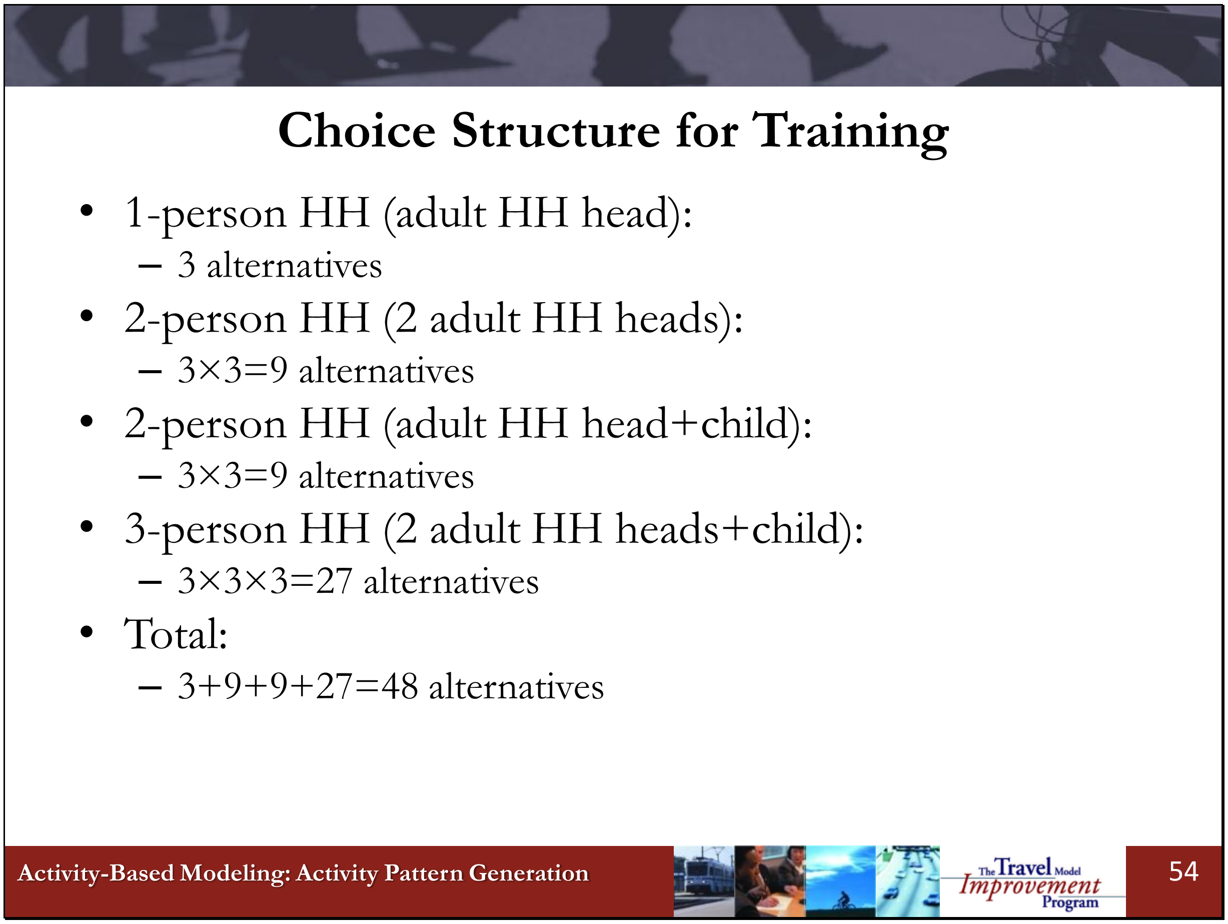
Blue bars correspond to a calculation of a product if individual frequencies. That's what you obtain if you apply IDAP. Red bars correspond to actual, observed joint patterns. For example, logically preschool children and caretaking non-workers stay at home the whole day together. This is true for almost every other pair of household members.



The differences are even more prominent when we consider triples of household members. Independent DAP calculation fails to recognize that household members coordinate their DAPs.



Now consider a fully realistic by slightly simplified version of CDAP where we choose 3 representative persons to model, the 1st household head, second household head (if present), and youngest child (if there is a child in the household). The other household members left aside are frequently the most individual including older school children, colleague students, or granny living in. This trio that includes the household heads and youngest child is good example to illustrate how CDAP works. The other household members can then be added sequentially one-by-one to the modeled three.



If we limit number of modeled persons in the household to 3 we obtain the following choice structure for our training purpose. In a 1-person household we model the household head who has three choice alternatives. In a 2-person household we may have two adults, or an adult plus a child. In both cases we have to model nine choice alternatives. In a 3-person household we have 2 adult household heads plus child (by virtue of the rule how we choose up to 3 representative members in each household). A 3-person household requires 27 choice alternatives to consider. The total is 48 alternatives that we have to consider and develop a utility function.

Utility Components of CDAP Logit Model

- Individual choice (H, M, N):
  - Adult HH head (gender, age, income, worker status etc)
  - Child (age, school grade, etc)
- 2-way interaction terms (HH, NN, MM):
  - Between HH heads
  - Between HH head and child
- 3-way interaction terms (HHH, NNN, MMM):
  - HH heads + child

The utility function for each CDAP alternative has 3 types of components. First type reflects individual choice preferences (Home, Mandatory, Non-mandatory). We have to form a utility function for each adult household member that should address such person characteristics as gender, age, income, worker status, etc. We also have to form a utility for the child that should address such person characteristics as age, school grade, etc. The second type of utility component includes 2-way pair-wise interaction terms between each pair of household members if they choose the same DAP (added utility of joint participation in activities). The third type of utility term includes 3-way interactions when all three persons choose the same DAP.

CDAP Utility (1-Person HH)

1st head	2nd head	Child	Alternative	Utility
H	Missing	Missing	1	H1
M	Missing	Missing	2	M1
N	Missing	Missing	3	N1

For a 1-person household, we have only one household head. The 2nd household head and child are missing. Thus, for each of the 3 alternatives we have a single utility component. H1 corresponds to choice of the Home DAP by the 1st person. M1 corresponds to choice of the Mandatory DAP by the 1st person. N1 corresponds to choice of the Non-mandatory DAP by the 1st person. Each component, H1, M1, and N2 can include many explanatory variables or utility terms.

CDAP Utility (2 Adults)

1st head	2nd head	Child	Alternative	Utility
H	H	Missing	1	H1+H2+HH12
	M	Missing	2	H1+M2
	N	Missing	3	H1+N2
M	H	Missing	4	M1+H2
	M	Missing	5	M1+M2
	N	Missing	6	M1+N2
N	H	Missing	7	N1+H2
	M	Missing	8	N1+M2
	N	Missing	9	N1+N2+NN12

For a 2-person household with 2 adults, a child is missing. We have 9 choice alternatives for which utilities are constructed in the following way. First, 2 individual components are including reflecting the DAP chosen by each person. Secondly we add interaction terms to the 1st and 9th alternatives where both person choose the same DAP. For the 1st alternative, they both stay at home. For the 9th alternative, they both have a non-mandatory travel day and do not go to work. These additional terms make the difference between IDAP and CDAP and express and added utility of joint participation in implied activities. There is no specific term of joint mandatory DAP (in the 5th alternative) since mandatory activities like work or school are primarily individual.

CDAP Utility (Adult + Child)

1st head	2nd head	Child	Alternative	Utility
H	Missing	H	1	H1+H3+HH13
	Missing	M	2	H1+M3
	Missing	N	3	H1+N3
M	Missing	H	4	M1+H3
	Missing	M	5	M1+M3
	Missing	N	6	M1+N3
N	Missing	H	7	N1+H3
	Missing	M	8	N1+M3
	Missing	N	9	N1+N3+NN13

Following the same logic we can construct utility functions for a 2-person household that includes an adult and child. However, the variables entering each utility component will be different from the previous case.

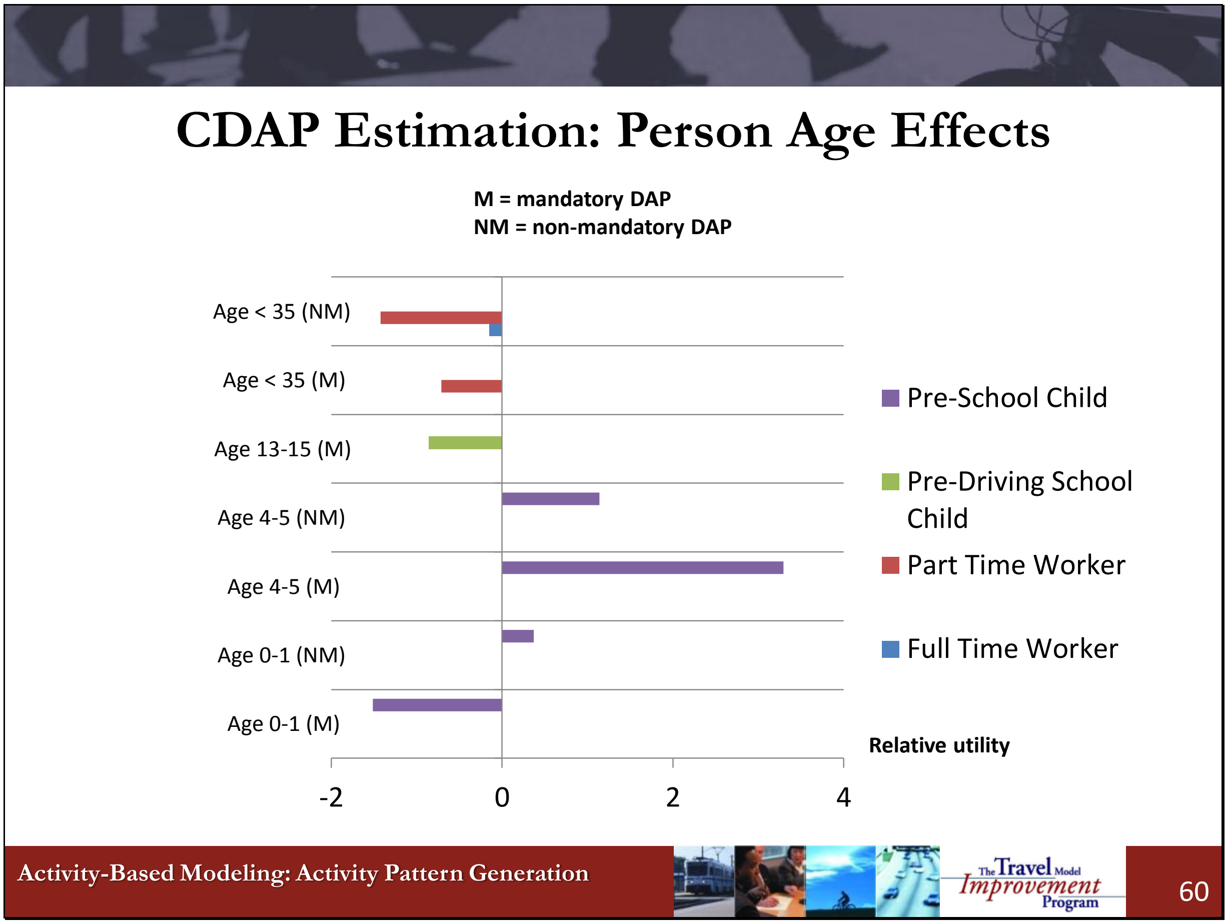
CDAP Utility (2 Adults + Child)

1st head	2nd head	Child	Alternative	Utility
H	H	H	1	H1+H2+H3+HHH
		M	2	H1+H2+M3+HH12
		N	3	H1+H2+N3+HH12
	M	H	4	H1+M2+H3+HH13
		M	5	H1+M2+M3
		N	6	H1+M2+N3
	N	H	7	H1+N2+H3+HH13
		M	8	H1+N2+M3
		N	9	H1+N2+N3+N23
M	H	H	10	M+H2+H3+HH23
		M	11	M+H2+M3
		N	12	M1+H2+N3
	M	H	13	M1+M2+H3
		M	14	M1+M2+M3
		N	15	M1+M2+N2
	N	H	16	M1+N2+H3
		M	17	M1+N2+M3
		N	18	M1+N2+N3+NN23
N	H	H	19	N1+H2+H3
		M	20	N1+H2+M3
		N	21	N1+H2+N3+N13
	M	H	22	N1+M2+H3
		M	23	N1+M2+M3
		N	24	N1+M2+N3+NN13
	N	H	25	N1+N2+H3
		M	26	N1+N2+M2+NN12
		N	27	N1+N2+N3+NNN

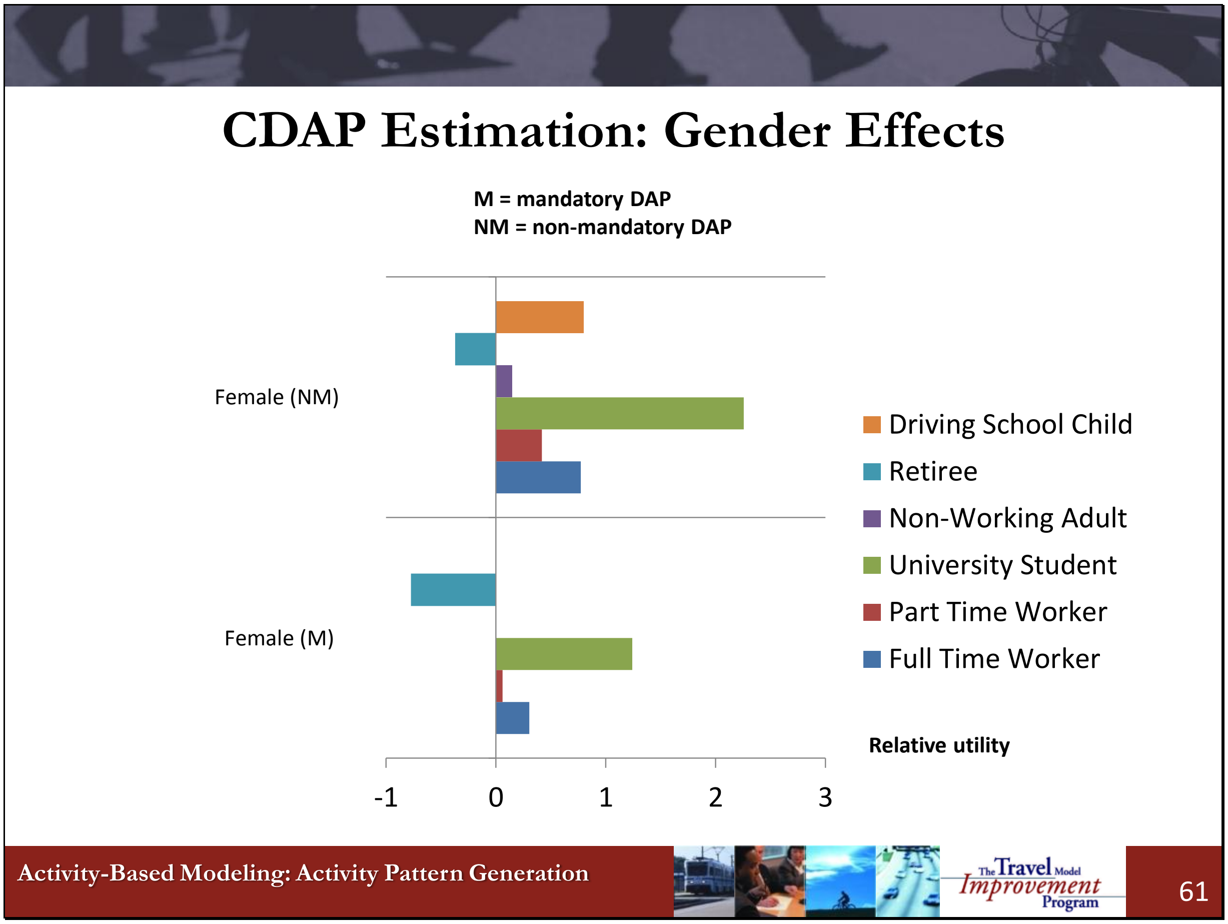
Activity-Based M

59

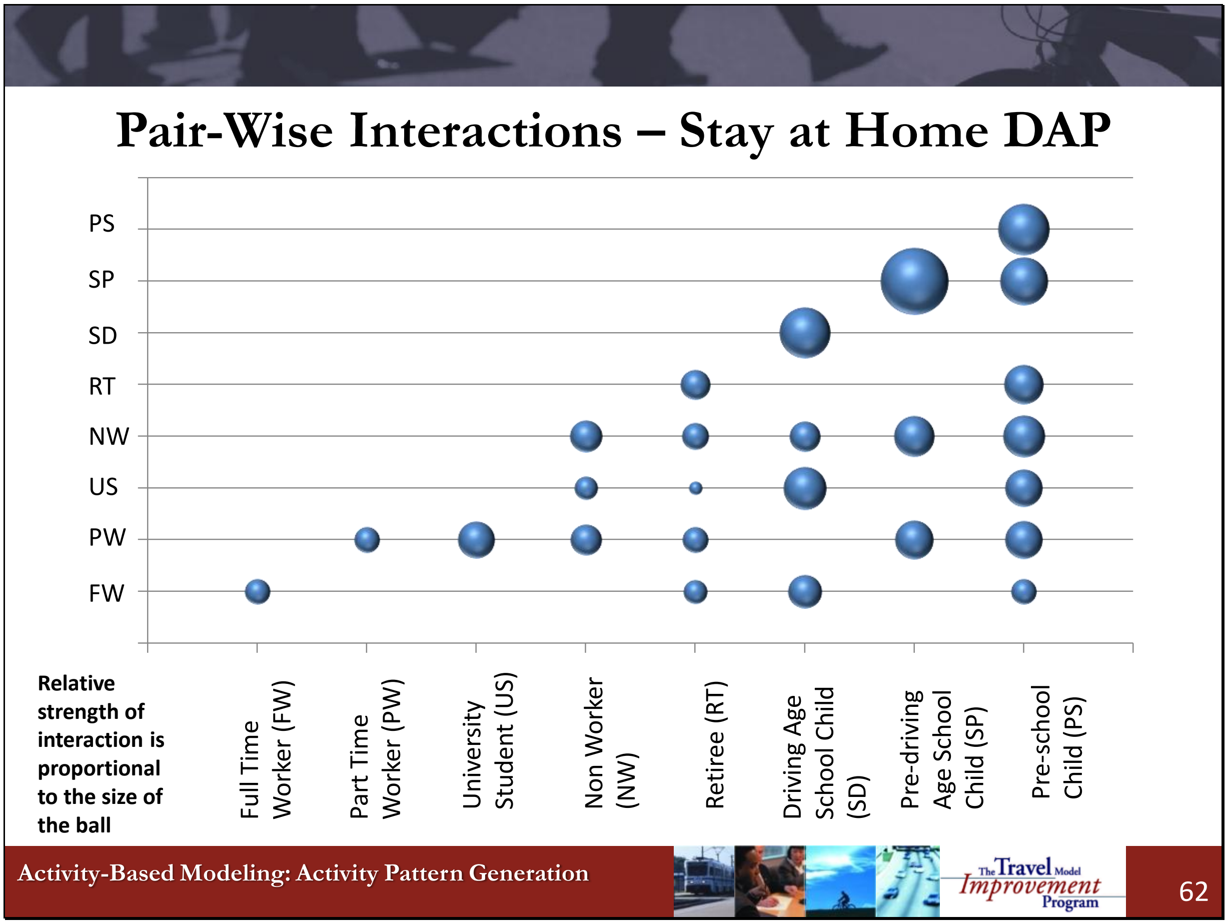
Finally, we can construct all utilities for a 3-person household for all 27 alternatives. The principle is the same. For each alternative, we sum 3 individual person components, then add pair-wise interactions where appropriate, and, lastly add 3-way interactions where appropriate. For example, alternative 10 assumes that 1st household head goes to work while the 2nd adult and child stay at home. Since this is a frequent child caretaking case, there is an added interaction term for the 2nds adult and child to stay at home together on the same day rather than on different days. This is a parsimonious structure where instead of 27 unique utilities we have to estimate only 9 individual components, 6 pair-wise components, and 2 try-way components. These components are reused multiple times in different utilities.



Each component can include many variables. Here is an example of impacts of person age on certain individual DAPs for different person types. For example, logically, preschool children of age 4-5 more frequently go to school, kindergarten or day care compared to younger children. Part-time workers of younger age (U35) less frequently have non-mandatory and mandatory patterns, etc.

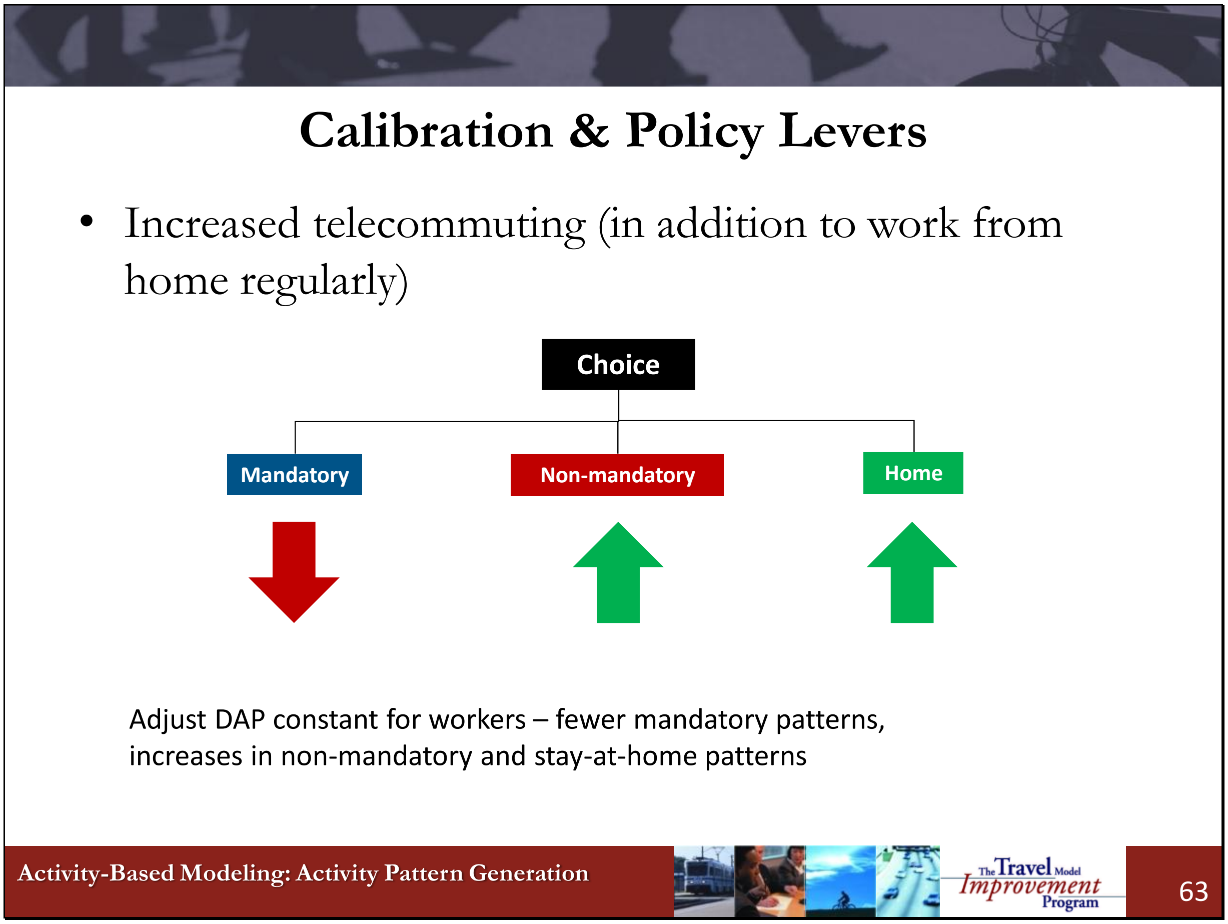


In a similar way, we can capture many effects associated with gender. For example, female university students and workers have non-mandatory DAP more frequently compared to males. In a similar way we can analyze impacts of many other variables, like income, car ownership, density, accessibility, etc. CDAP models applied in practice include hundreds of explanatory variables encapsulated in the utility components described above.

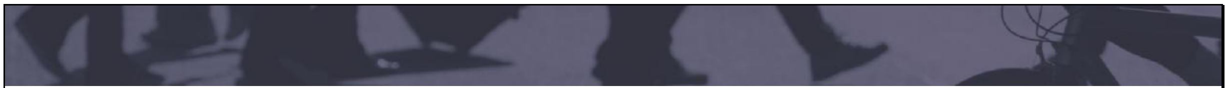


We also include all possible types of interactions between different person types. Relative strength of interaction is proportional to the size of the ball (in utility units).

For example, for staying together at home for the entire day, the strongest linkages in relative terms are between school and preschool children (between them) and with the non-workers and part-time workers (who are the primary child caretakers). However, some statistically significant interactions manifest itself almost everywhere (for each pair of person types).



CDAP is an essential model in the activity based modeling system. It is responsible for such crucial choice dimension as going to work or school. This model must be well calibrated and sensitive to policies that we need to model (or at least take into account). In this regard, the proposed structure is instrumental in practice since it allows for calibration of individual choices for each person type based on the observed data or policy scenarios. For example, we observe a growing share of telecommuting and work from home on a regular basis. The share of regular telecommuters and workers from home has been more than doubled over the last 10 years (from 5% to 10% of workers). To address this tendency we can adjust the corresponding constant for workers to meet the target share as shown on the slide. In this regard, CDAP calibration is as easy as calibration of a conventional trip mode choice model.

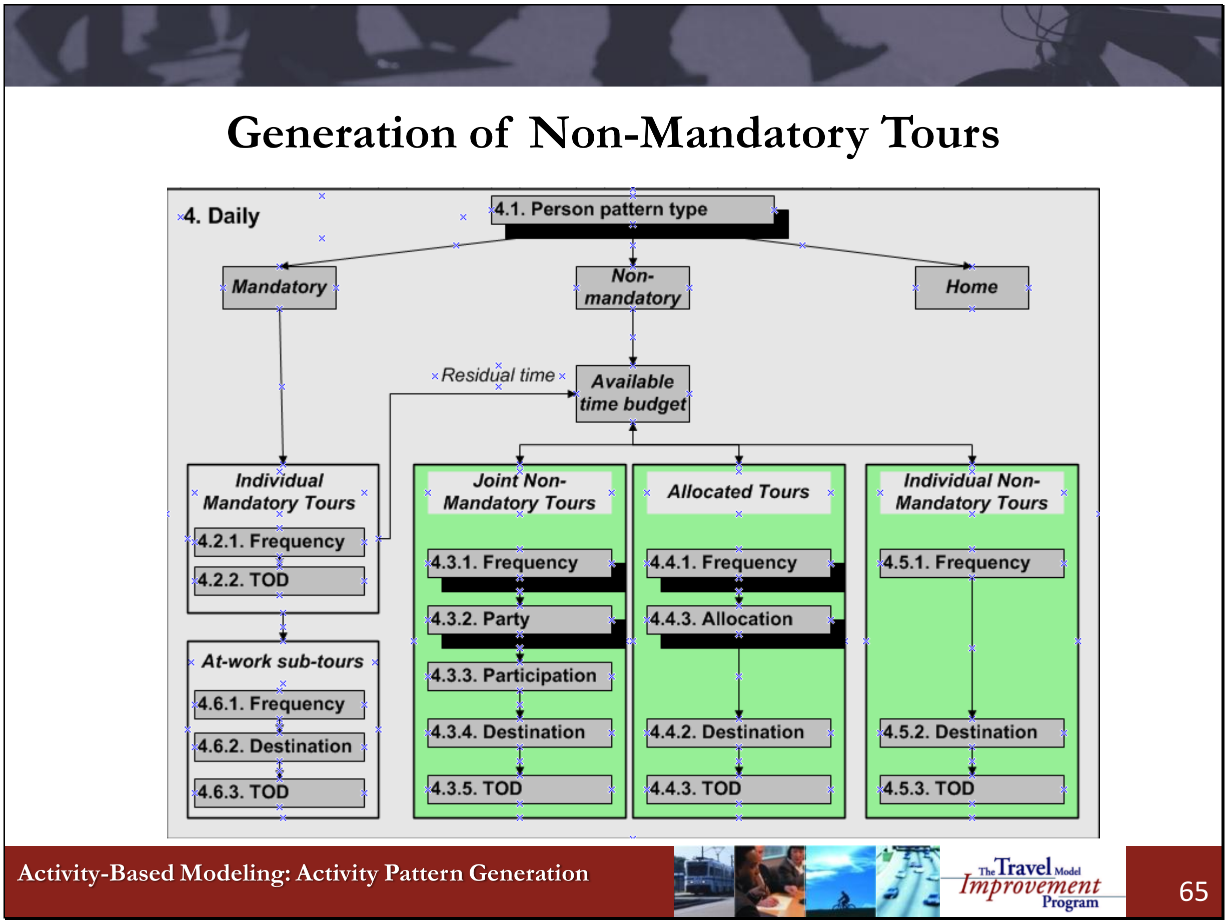


Calibration Results (DAP Type, San Diego activity based modeling)

- IDAP and CDAP models are of crucial importance and have to be well-calibrated

Scaled Survey CDAP by Person type	Pattern (observed)				Pattern (modeled)			
Person type	**Mandatory**	**Non Mandatory**	**Home**	**Total**	**Mandatory**	**Non Mandatory**	**Home**	**Total**
Full-time worker	87%	8%	5%	100%	87%	8%	5%	100%
Part-time worker	73%	20%	7%	100%	72%	21%	7%	100%
University student	66%	25%	9%	100%	66%	25%	9%	100%
Non-working adult	0%	75%	25%	100%	0%	75%	25%	100%
Non-working senior	0%	73%	27%	100%	0%	73%	27%	100%
Driving age student	91%	4%	5%	100%	91%	4%	5%	100%
Pre-driving student	94%	4%	2%	100%	94%	4%	2%	100%
Pre-school	44%	41%	16%	100%	44%	40%	16%	100%
Total	**61%**	**28%**	**11%**	**100%**	**61%**	**28%**	**11%**	**100%**

We normally calibrate CDAP to replicate the observed shares of DAP type for each person type exactly. DAP models (whether it is IDAP or CDAP) are of crucial importance and discrepancies at this stage are not allowed. It must be well-calibrated.



This is the corresponding part of the CT-RAMP model system where CDAP is applied. You saw it at the previous webinars. After the CDAP has been applied for each person, further details are predicted conditional upon the chosen DAP type. These details include number of mandatory non-mandatory tours by purpose and type. In particular, we distinguish between three types of non-mandatory tours:

- **Fully Joint**: All participants engage in same activity/trip sequence (full participation by members of same household)
- **Allocated**: Maintenance activities that are conducted individually, on behalf of the household (escort, shop, other maintenance)
- **Individual**: Discretionary activities implemented individually (includes inter-household ridesharing for non-mandatory activities)

We will discuss some of the key sub-models applied after CDAP type.

Types of Joint Travel

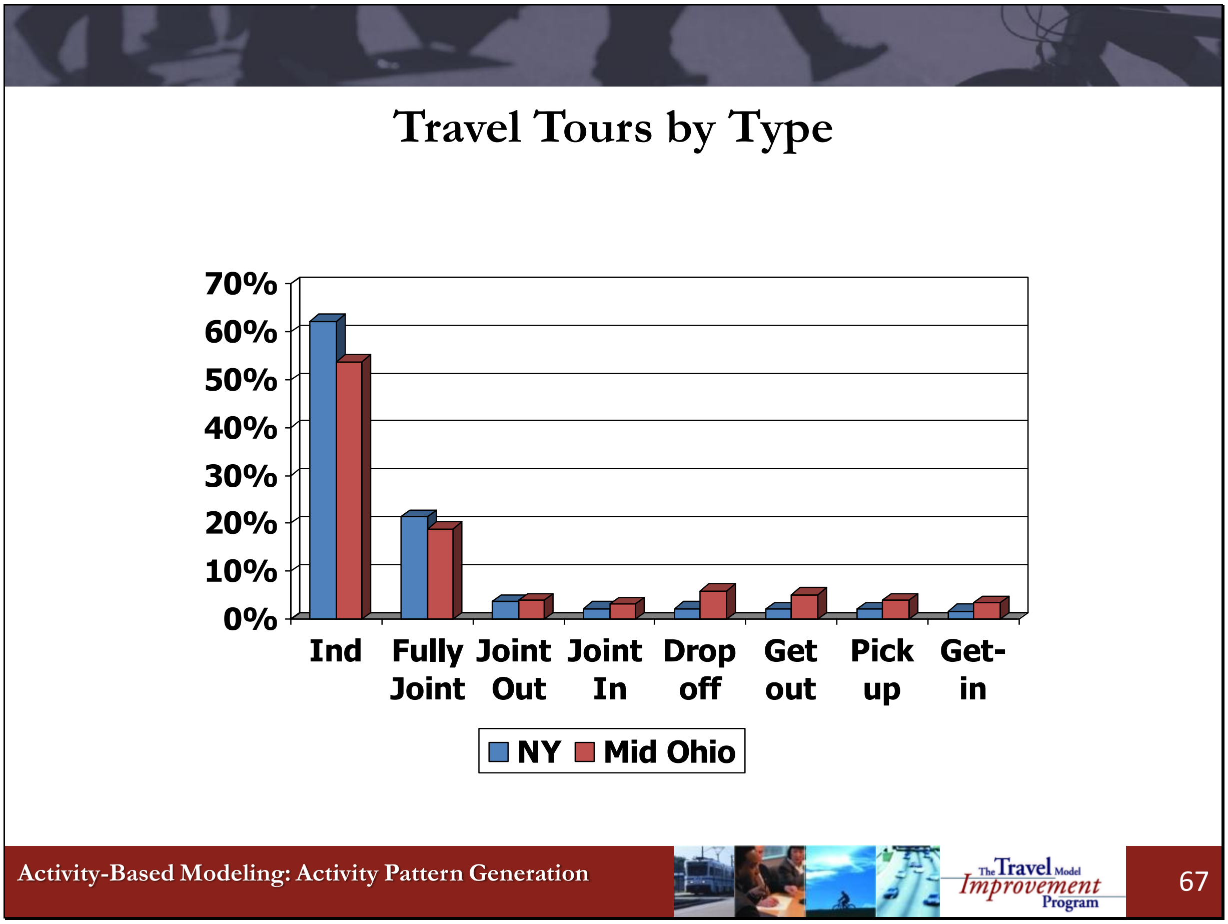
By travel party	By individual
	Individual
Fully-joint tour	
Joint outbound	
Joint inbound	
Drop-off (outbound)	Drop-off
	Get off
Pick-up (inbound)	Pick-up
	Get-in

Activity-Based Modeling: Activity Pattern Generation

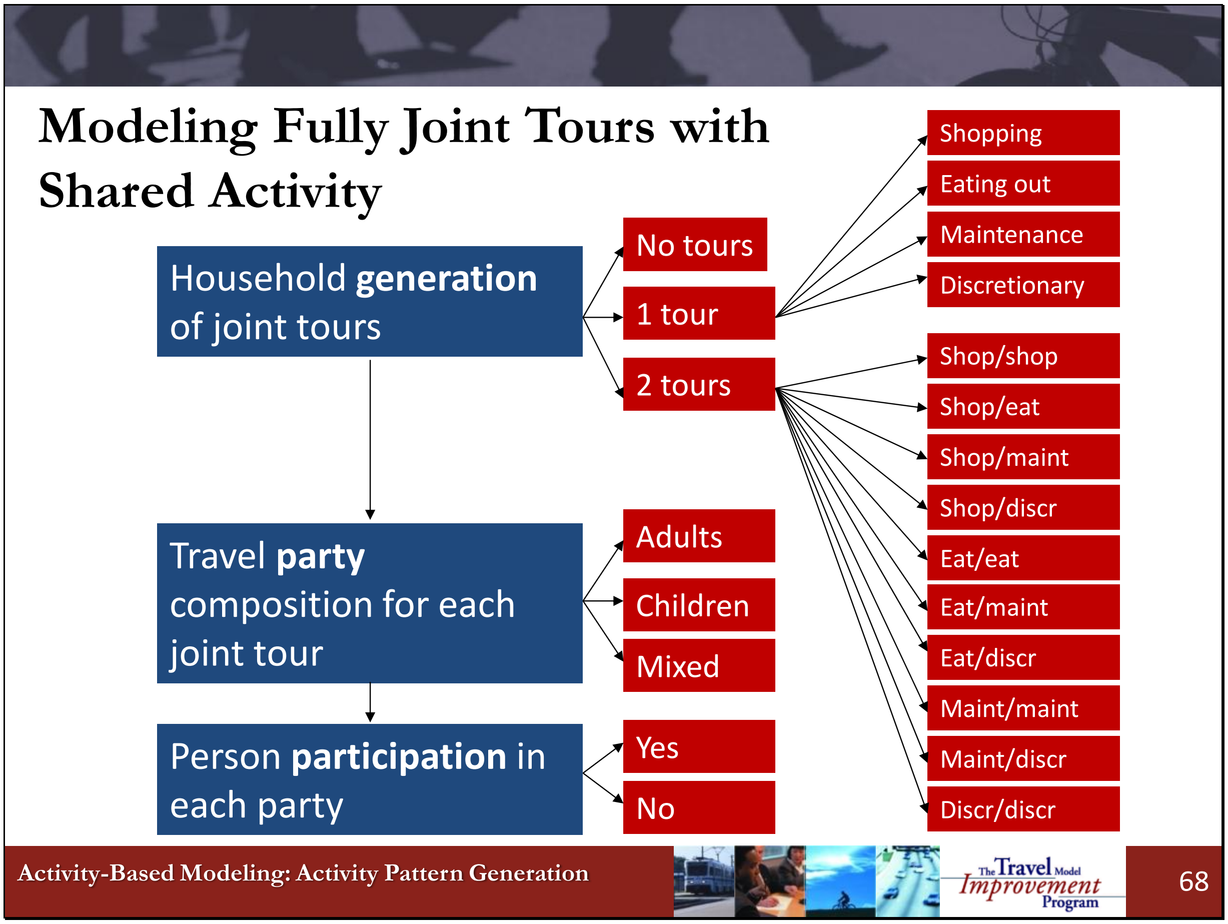
The Travel Model Improvement Program

66

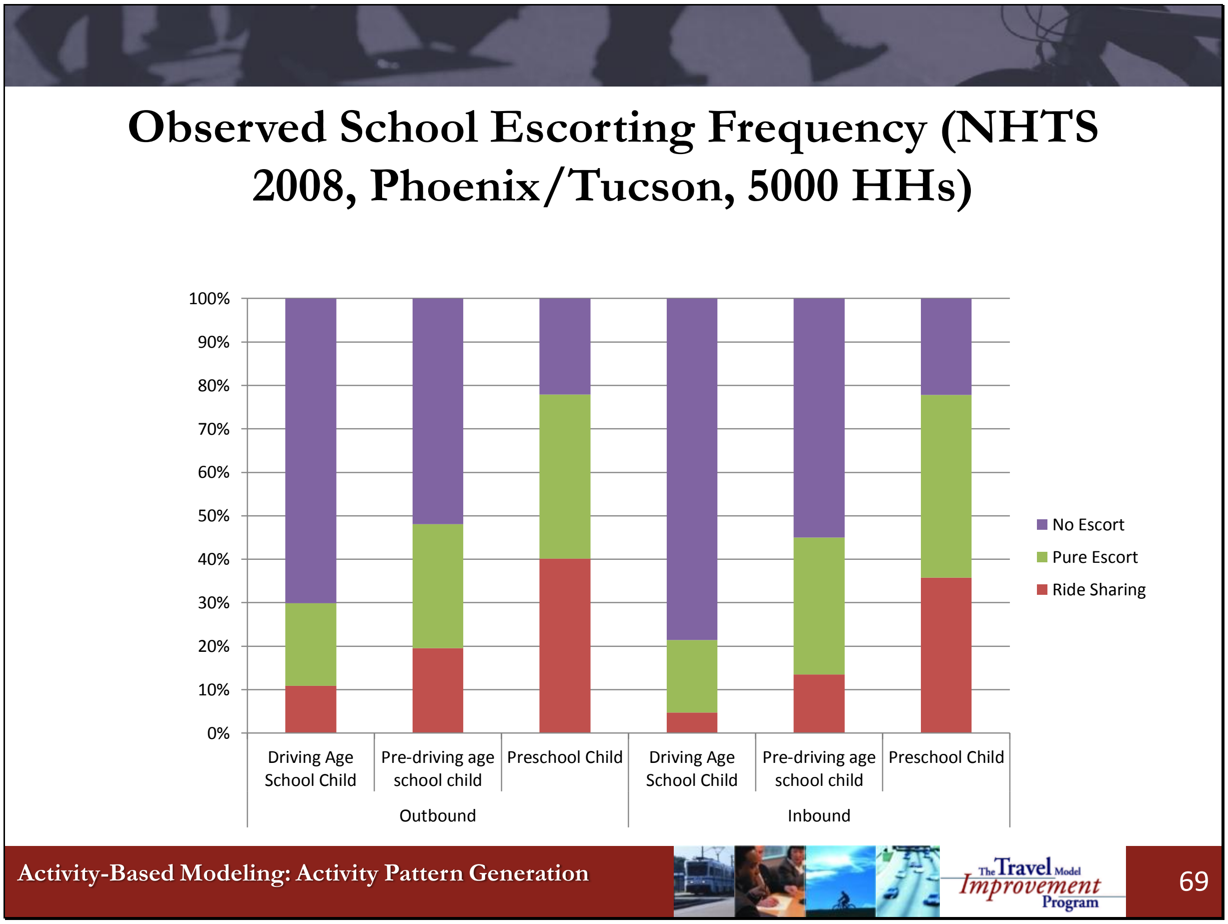
We distinguish several types of joint travel stemming from the tour-based modeling technique. In particular, we will focus first on fully joint tours where all members of the travel party travel together and participate in all activities. Further on, we will consider an example of escorting children to school that is a partially joint tour.



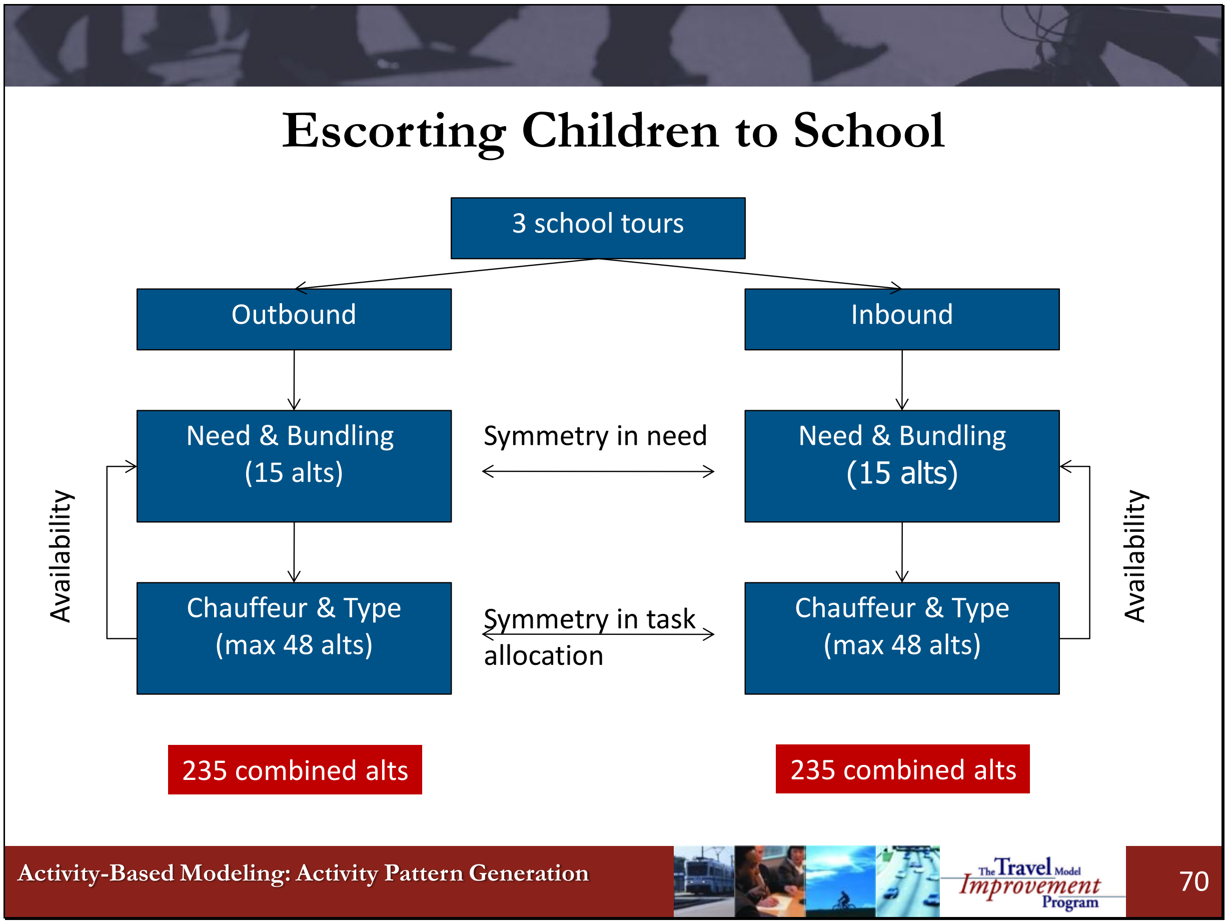
This tabulation from two very different regions shows a high share of joint travel (40-50%) where fully joint tours and partially joint tours of different types have approximately equal shares (20% each).



We model fully joint HH tours by a sequence of three choice models each of a them is a discrete choice model (either multinomial or nested). The first model is a choice of frequency and purpose of the joint tours. The second model is a choice of the travel party composition for the tour. It is a trinary choice model that distinguishes between three travel party compositions. Then, conditional upon the travel party composition we model person participation in each appropriate party by means of the binary choice model. In many cases, especially for adult and children parties person participation is predetermined by the HH composition. But there are cases especially for big households and mixed parties where participation is really non-trivial.

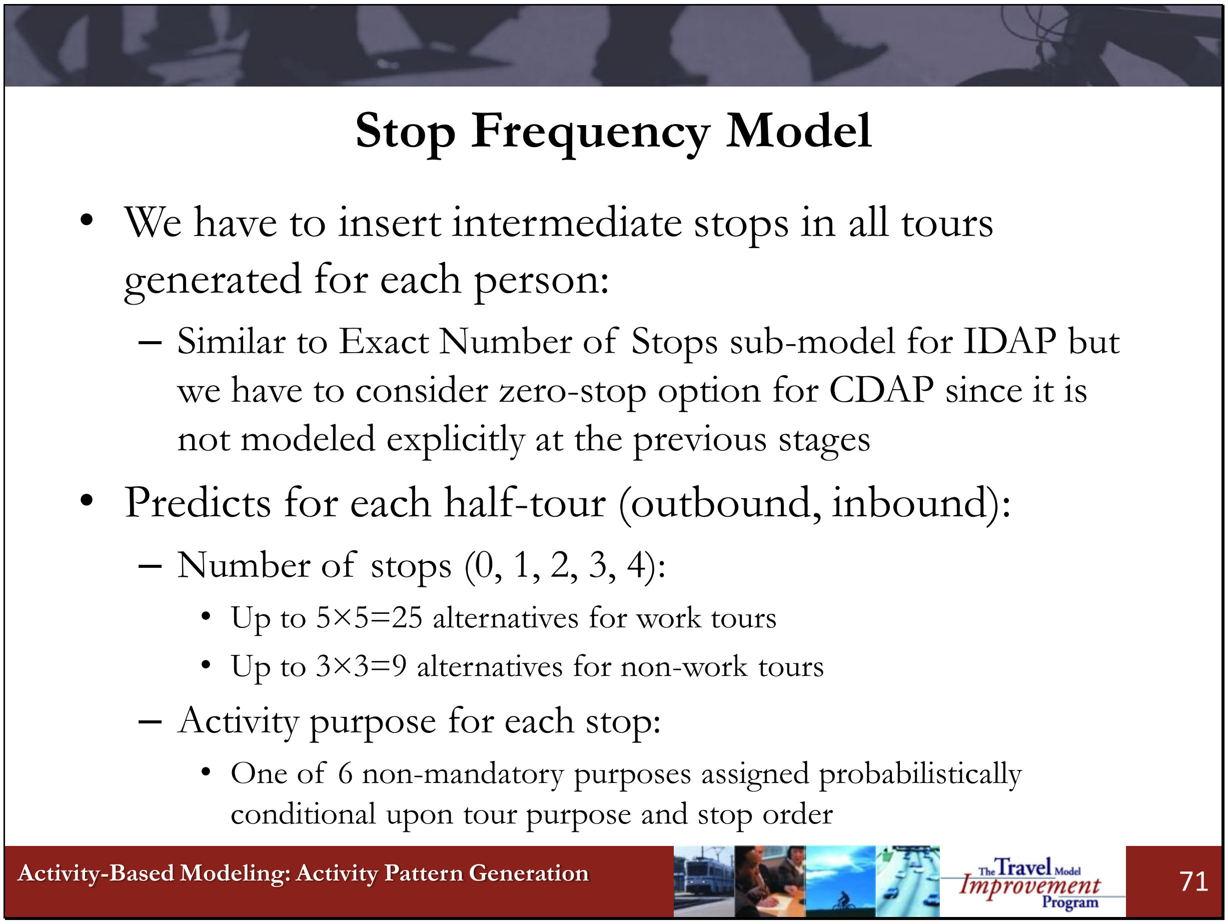


Another very frequent phenomenon observed in many metropolitan areas is escorting children to school. For example, based on the data from Phoenix and Tucson we have approximately 50% of children escorted to school by a parent. There is also a logical pattern in terms of impact of the child age, and by direction (outbound is somewhat more frequent than inbound). We also distinguish between two types of escorting: 1=pure escort and 2=ride-sharing. These two types are modeled differently.



As an example of a recent development, we added a model for escorting children to school. School escorting is a frequent phenomenon in the US. In many metropolitan regions, up to 50% of school children are escorted by the parents to school. In this choice model, we consider up to 3 school children. The model predicts if they are to be escorted to and/or from school, if it makes sense to bundle some of them together and escort to or from school on the same tour, and finally who is the chauffeur for each bundle. The model has a large number of alternatives, but they can be handled efficiently using the same component-wise structure of the utilities as was discussed for the CDAP model.

The outbound and inbound choices cannot be modeled independently, since we observe a certain level of symmetry (in statistical terms) between these choices. In particular, children who are escorted in one direction are more frequently escorted in the opposite direction as well (although not always). In the same vain, frequently the same chauffeur is involved in escorting both directions (although some cases of rotating chauffeurs are also observed).

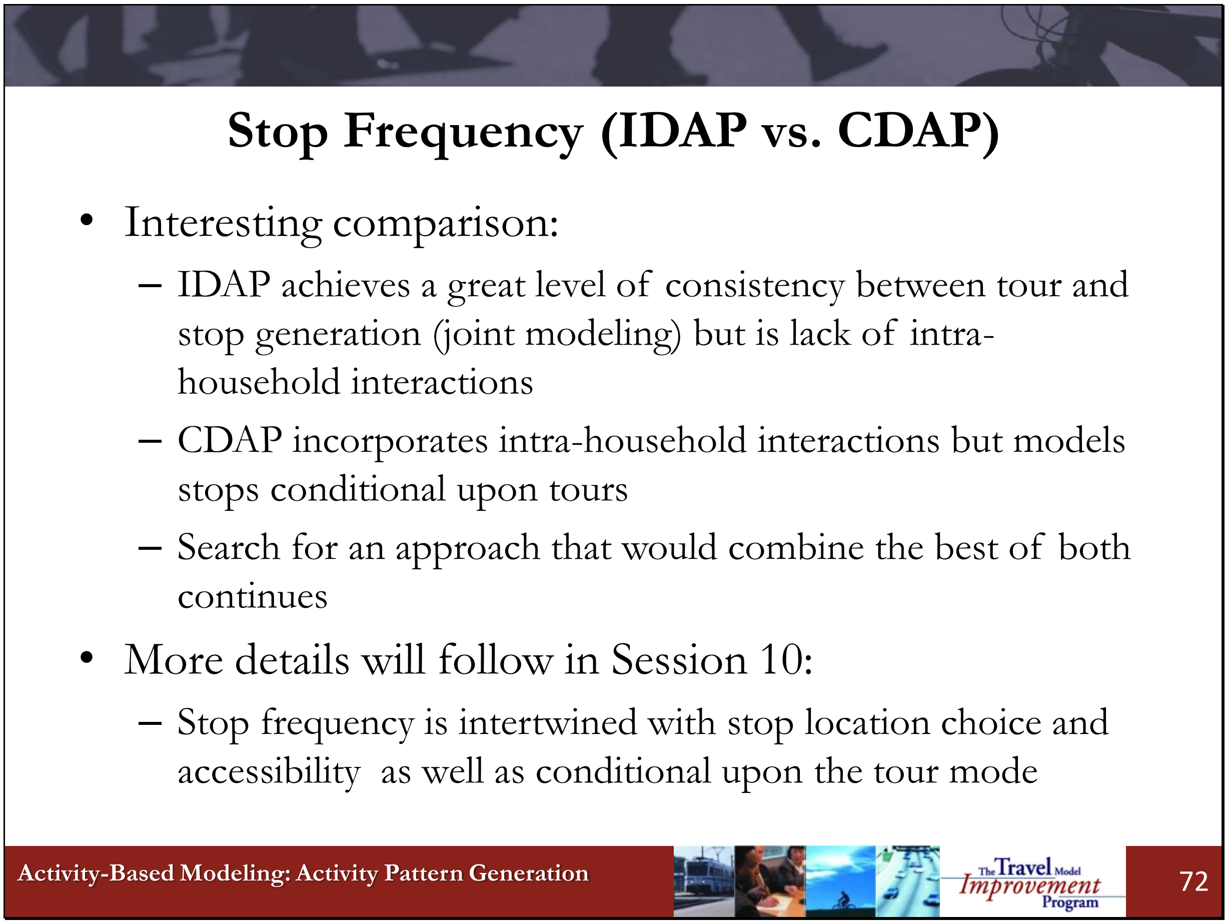


After all tours have been generated for each individual we have to insert intermediate stops in these tours. This model is called Stop Frequency model and it is similar to the Exact Number of Stops sub-model for IDAP but we have to consider zero-stop option for CDAP, that was handled differently in IDAP. The stop-frequency choice model predicts number of stops and their activity purpose for each half-tour (outbound, inbound).

We consider up to 4 stops on each half-tour for work tours and up to 2 stops on each half-tour for non-work tours. This is based on the observed stats in many metropolitan regions in the US. This results in:

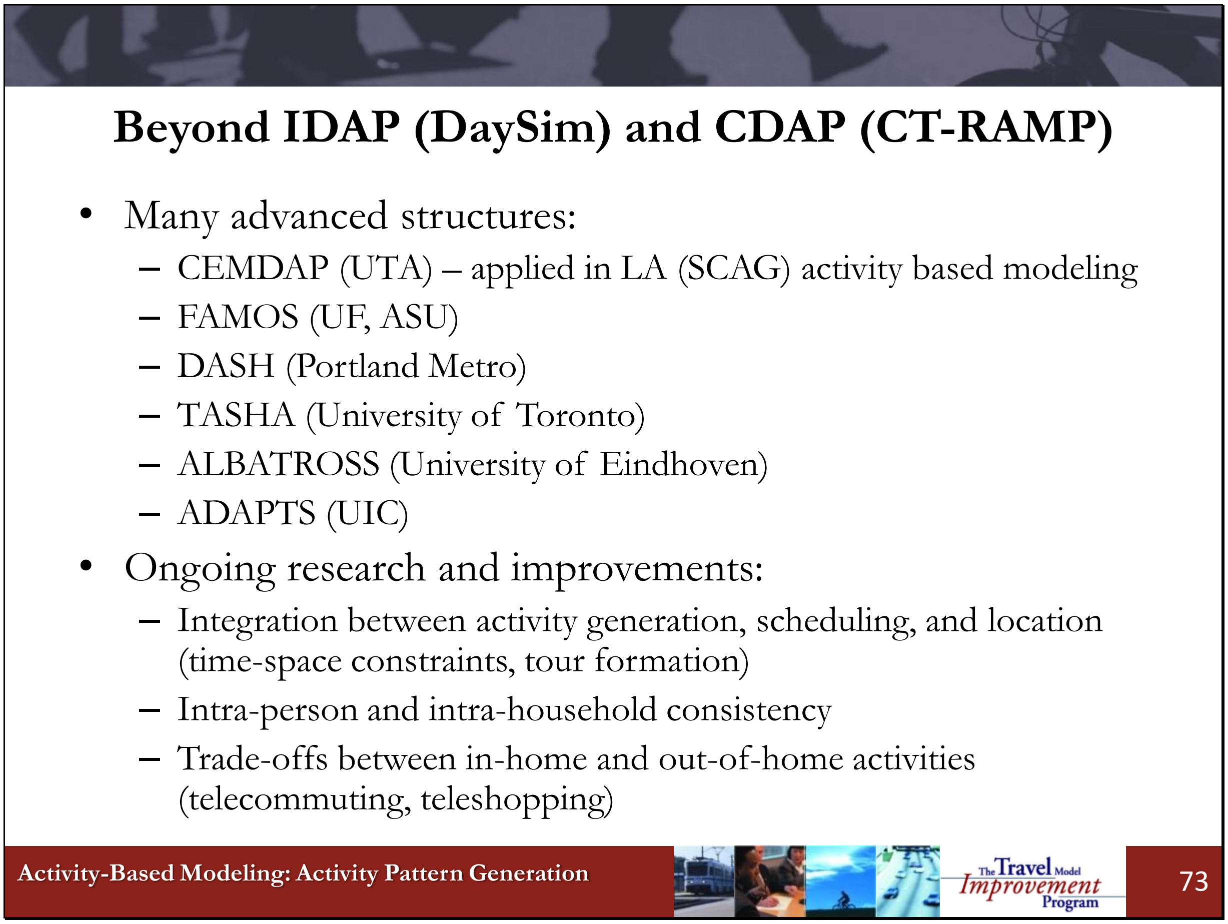
- Up to 5×5=25 alternatives for work tours; and
- Up to 3×3=9 alternatives for non-work tours.

Then we assign an activity purpose for each stop. This can be one of 6 non-mandatory purposes assigned probabilistically and conditional upon the tour purpose and stop order.

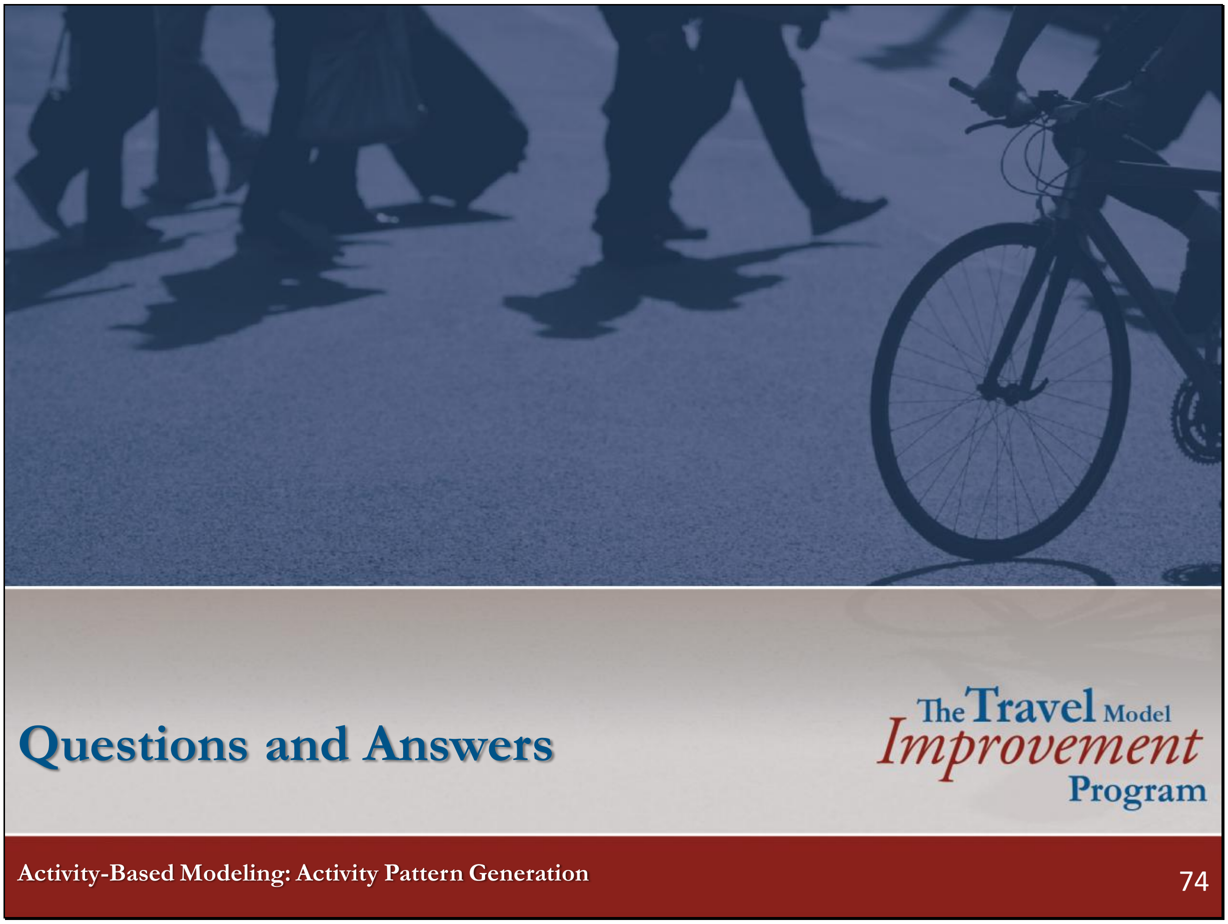


It is interesting to compare IDAP and CDAP structures in this particular respect. IDAP achieves a great level of consistency between (joint modeling of) tour and stop generation but is lack of intra-household interactions. CDAP incorporates intra-household interactions but models stops conditional upon tours. Search for an approach that would combine the best of both continues.

More details will follow in Session 10 in which we will see how stop frequency is intertwined with stop location choice and accessibility, and is conditional upon the tour mode.

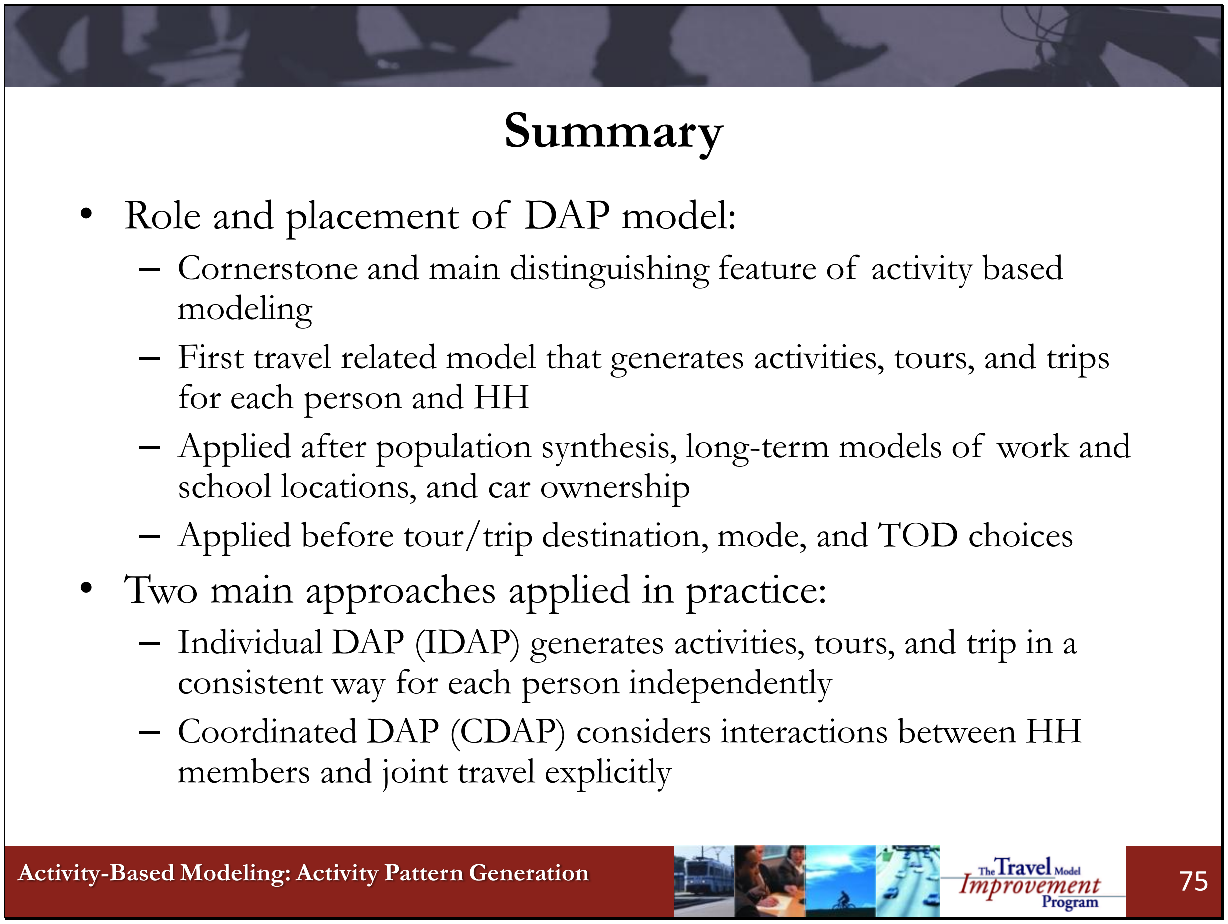


The described structures like IDAP and CDAP, specifically, DaySim and CT-RAMP are the most frequently applied in practice. That's why we used them as prototype in our webinar. However, there are many other advanced structures proposed in academia and some already being applied in practice. To name just a few, they include CEMDAP, FAMOS, DASH, TASHA, ALBATROSS, and ADAPTS. These approaches reflect the ongoing research and improvements in our profession. In particular, we are looking for a better and more realistic integration between activity generation, scheduling, and location. We want to better understand and model how people obey time-space constraints and form travel tours. All modelers are also looking for more consistency of the generated choice for the same person and between person within the households. Additionally, with the advent of telecommuting and teleshopping technologies we need a better understanding and modeling of trade-offs between in-home and out-of-home activities.



We are done with the main part of our webinar and would like to answer your questions. After that we will provide a short overview of the recent advances beyond the basic structures discussed so far and summarize the session.

Page 75



To summarize today's webinar we hope you have a better understanding of the role and placement of the DAP model in the activity based modeling system:

- DAPs are the cornerstone and main distinguishing feature of activity based modeling;
- First travel related model that generates activities, tours, and trips for each person and HH;
- Applied after population synthesis, long-term models of work and school locations, and car ownership; and
- Applied before tour/trip destination, mode, and TOD choices.

We have also given two practical examples of approaches widely used in practice IDAP and CDAP:

- Individual DAP (IDAP) generates activities, tours, and trip in a consistent way for each person independently; and
- Coordinated DAP (CDAP) considers interactions between HH members and joint travel explicitly.

Page 76

Next Webinar

Executive and Management Sessions	
Executive Perspective	February 2
Institutional Topics for Managers	February 23
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 16
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

Session 8 Questions and Answers

What criteria are used to determine the primary activity of a tour?

Peter: A tour includes several activities, one of which is designated as the primary activity. To do so, a weight is assigned to each activity based on three attributes. The activity with the highest weight is chosen as the primary activity of each tour. The three criteria are:

- Activity type, where mandatory activities have higher weight than non-mandatory activities;
- Activity duration, where longer activities are given higher weight; and
- Activity location, where all else equal, the longest trip is considered the primary activity.

The means by which travel behavior data is collected plays a role, because certain ways of collecting data are better at eliciting activity duration, for example. Thus, the quality of the data may influence the exact criteria used to determine the primary activity.

What are the units of measurement?

Peter: Since activity pattern is a choice model, it deals with utilities, which is measured in utiles. Differences in utility are proportional to changes in the probability of selecting a given pattern; +1 utile means that the choice probability is approximately doubled, while -1 utiles means that choice probability is approximately halved.

How and when does mode choice figure in an activity based model?

John: This webinar focused on activity pattern generation; that is, the type, sequence and number of activities performed during the day. Mode choice enters at a later step in the model sequence. It is a separate module and will be discussed in Webinar #10. In general terms, once the activity pattern is known, then a mode choice is made for each tour in the day-pattern. But it may be more involved, because in some models the activity pattern changes after the choice of mode. For example, after the tour mode (and location and time-of-day) are chosen, there may be a residual time window in the day-pattern that allows for an intermediate stop in one of the tours.

How do activity-based models account for summer school when predicting school trips?

Peter: Like trip-based models, activity based models model a regular weekday. In this sense, most ABMs do not model seasonal differences, which may include summer school, vacation, and season-specific resident populations, among others. These models also do not represent weekend travel, which can be very different from weekday travel. The first attempt to have a seasonal component in an activity based model is the Maricopa Association of Governments model. It is currently under development, so we cannot share any findings yet. The short answer is that the model needs to be segmented by season. In the case of Phoenix, there are important seasonal differences in the resident population and in travel patterns related to weather differences. Some regions attempt to incorporate seasonal effects by averaging across seasons. This is incorrect, as it doesn’t represent any real condition. If only one model can be maintained, it is best to choose a season to model and develop complementary methods to account for seasonal differences.