The Day Activity Schedule Approach of Bowman, Ben-Akiva and Bradley: 1994-2008

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John L Bowman, Ph.D.
John_L_Bowman@alum.mit.edu
www.JBowman.net

1	Today I will not be discussing a single model system. Rather, I will discuss an approach that I developed with Moshe Ben-Akiva in 1994 as a student at MIT. Since then the approach has been further developed and implemented in a few working model systems. Mark Bradley and I have continued to develop the approach each time a planning organization asks us to implement it with them and is interested in enhanced capabilities. Along the way, we have incorporated features developed with or by others. Today we are continuing this work together with Joe Castiglione, the first person with extensive experience using the approach in a working model system.
2	While other model systems may reflect aspects of the approach we developed, the models in this list could be viewed as direct descendants of my MIT prototype.
3	This and the next few slides come from presentations I gave back in the mid 90s. The day activity schedule can be viewed as an evolutionary step in the use of disaggregate discrete choice methods to model travel demand. --Trip-based models were developed in the early 70s --And these were followed, especially in Europe, by tour based models. The essence of our contribution was to integrate the representation of travel demand across an entire day.
4	This simple graphic, which comes from the first TRB presentation I ever gave, shows how we proposed, and subsequently did this, by modeling a day activity pattern that overarches and ties together the tour models in a nested structure spanning a day. Tours are modeled conditional on the activity pattern, with lower priority tours modeled conditional on higher priority tours And the activity pattern is affected by the ease of carrying out the activities, as measured in the tour models.
5	Although the exact representation of the activity pattern has varied from time to time, this slide from that first presentation still captures the essence. --The activity pattern identifies the number and purposes of the tours --and the number and purposes of additional stops on those tours.
6	For each tour, the timing, destination and travel mode are modeled --for the tour --and for each of its stops

7	The day activity schedule model operates iteratively with equilibrium assignment models to generate its predictions. It essentially substitutes for trip generation, distribution and mode split in a traditional 4-step model system. This helps make it manageable for a planning agency using a traditional 4-step model to advance to the activity schedule approach.
8	By the end of 2004 I had implemented the MIT prototype. This slide from our 1995 TRB presentation gave a report on how well we had achieved our objectives. For the most part we were very pleased with the results --although we hadn't yet actually integrated the model with the traffic assignment models --and we considered our use of five time periods for time-of-day modeling inadequate.
9	But our results were good enough to catch Keith Lawton's attention, and he decided to implement the approach at Metro.
10	I led a design effort to fill in details missing from the prototype, and Mark Bradley subsequently developed an operational model system for Metro while I continued my studies at MIT. This model included.....(run down the list) And the full model system was used for policy analysis.
11	Here are a couple results from the earliest documented application that I could find in my archives, reported before the equilibration with traffic assignment was implemented. At the time we were apologetic about the enormous size of the price increases in the test scenarios (changing auto variable costs from 8 cents per mile to 16) They showed several important aspects of the model sensitivity:
12	The decrease in tours shows that activity generation is sensitive to LOS, but less so than VMT
13	The decrease in tours and miles came primarily from auto travel
14	Elasticity of demand was greater for discretionary and maintenance than for work purposes, when the costs increased for all times of day
15	and when the costs changed only in the peak period, there was a shift from the peak periods to the off-peak periods
16	Unfortunately, the Portland model was mothballed because Metro's money was short and they decided to focus their attention on TranSIMS, where development money was available. But fortunately, by then San Francisco County was interested in developing an activity-based model, and it was decided to implement a version of the activity-schedule approach, with somewhat simplified models and integration. The SFCTA model was developed by PB, Mark Bradley and Cambridge Systematics.
17	It was the first activity-based model to be used extensively and on an ongoing basis for policy analysis and decision-making.

18	And it has been enhanced over time. For example, it has recently been enhanced to --include toll vs free alternatives in mode choice --to use randomly distributed values of time in the models, where values of time are drawn from VOT distributions as part of the simulation. The developers are explaining enhancements to this model right now in the other session.
19	The next major implementation of the approach didn't occur until 2005 in Sacramento. I will spend a bit more time describing the SACOG model, since it is the most recently completed new implementation now in use.
20	As with prior implementations, we re-specified the day activity pattern somewhat. The question in specifying the pattern model is to decide which aspects of the schedule to include in the pattern model itself, and which to model lower in the hierarchy within individual tours.
21	We decided --to identify tour and stop purposes more specifically in the pattern model itself, --and NOT to determine the exact number of stops, --and whether they occur before or after the primary destination of specific tours.
22	Modeling detailed outcomes was important to SACOG, especially in the spatial dimension.
23	All the models distinguish seven distinct purposes
24	We model the choice of a single 30-minute time period --for every time-of-day outcome in the model
25	And we model all location choices as choice of parcel --instead of the customary traffic analysis zone
26	So, looking at the entire model hierarchy --we see that new detail is being added at many levels in the model system
27	In a hierarchical system of models --integration is very important --if the component choices are actually correlated
28	We achieve **“downward integration”** --by conditioning lower level models on upper level outcomes An important aspect of this is the enforcement of time-space constraints.
29	Whenever a tour or intermediate stop is scheduled --its time period is blocked out, --and becomes unavailable for scheduling lower priority tours and stops.
30	Logsum variables are usually considered the best measures for achieving upward integration. They represent, in upper level utility functions, the expected maximum utility among the alternatives available for lower level choices. But in model systems this large, formal nested logit models encompassing the entire model system are not practical. --So compromises are made in representing accessibility in the upper level models. --This has been one of the big challenges in implementing activity-based models. In Sacramento, improving upward integration was an important priority. We used two basic methods to achieve this:

31	Traditionally, logsums that should be calculated across all available times of day ignore that dimension by assuming a most likely time of day. For example, for work destination choice, mode choice logsums are calculated assuming peak period travel.
32	In Sacramento, we instead used a simulated time of day for each person, using Monte Carlo methods to draw a time of day from a distribution observed among similar cases of travel. This makes the models that use the logsum appropriately sensitive to policies that are time-of-day specific.
33	It is desirable to use logsums that use the full information of a very specific choice situation. This requires recalculating the logsums for every distinct case in the population. When the logsums span all available modes and destinations, it becomes too time consuming to do it this way. Therefore, mode-destination logsums are usually not used. In Sacramento we chose to pre-calculate a large number of mode-destination logsums for each zone, each time the model system is run. For a given zone, we have 84 distinct logsums defined in ways that most affect the logsum values: --activity purpose --car availability --proximity of origin parcel to transit. Then, in each case where such a logsum is needed, we use the one we need.
34	We use a similar technique to make it possible to use intermediate stop logsums. These measure the attractiveness of making an intermediate stop when the tour origin and destination are given.
35	These three kinds of logsums are used to more realistically capture sensitivity to LOS in the upper level models.
36	Now lets look at the model system's equilibration method, --which we developed with John Gibb of DKS Associates.
37	Here is a diagram of the model system --The activity-schedule software, called DaySim, generates a simulated trip list. --These trips are aggregated into OD matrices, --combined with commercial traffic and other trips, --and assigned in the static assignment procedures --This process is iterated to an equilibrated solution
38	Here is another picture of the same thing, but redrawn with a different focus. --we've shrunk DaySim and the additional trip models to a simple black box, --and we've expanded network assignment to show that it is an iterative process.
39	We have an iterative assignment loop, with what I call "a" iterations --each iteration's assignment result is blended with prior results --in order to speed convergence by avoiding oscillation around the equilibrium point.
40	This occurs within a larger demand-assignment loop So in the assignment procedure we do a 2-step blending: --in addition to blending with prior a-iterations to prevent assignment oscillation --we also blend with prior da-iterations to prevent da-oscillation

41	Another technique we use to speed convergence is to --run DaySim on only a small fraction of the population in the early iterations --Each of the first 2 da-iterations simulates less than 1% of the population --After that, each iteration simulates twice as many persons as the last --until we finally simulate the entire population on the last iteration So, in 9 da-iterations, DaySim passes through the population only twice.
42	Now lets look at a scenario comparison technique we implemented
43	The use of Monte Carlo microsimulation makes it challenging to compare disaggregate results of two scenarios, because random effects from the Monte Carlo draws can cause bigger differences than the modeled effects This can be dealt with by --running the microsimulation many times and averaging it --OR, running the simulation with a supersample But both of these take a lot of time
44	In order to reduce the effect of differences caused only by Monte Carlo randomness, --we developed a feature that allows two scenarios to share a set of random numbers, --First, generate and save a large set of random numbers associated with every combination of person, tour, trip and model. --Then, use the same set of numbers for corresponding draws in both scenarios. The absolute predictions in both scenarios will have Monte Carlo error --but many of the errors will cancel out --so the DIFFERENCES in two scenarios will come --more from modeled results --and less from simulation error
45	Let's look at the results for a scenario that introduces an AM peak CBD entry fee. The results are only illustrative because...(refer to slide)
46	Here we're looking at changes from base case in the various aspects of the simulated schedules --(walk down 1st column to explain what its showing) What if we hadn't coordinated random numbers?
47	The results are confounded with simulation error and quite different --without coordination.... (again walk down the column) At the individual level, changes attributable to the scenario are dwarfed by changes due to Monte Carlo randomness. In our example, random seed coordination avoided this. In practice, the benefits of random seed coordination may be substantially less than this example, especially in cases where --the scenario change has widespread effects, --and model system is equilibrated

48	This year the SACOG model system has been enhanced in two ways to operate more effectively: --we distributed the day activity schedule model and the traffic assignment to run on multiple processors, to speed up the run time --we enabled the model to distinguish between long-term and short term effects, as well as to run in a way that we think will be acceptable for FTA New Starts analysis
49	For long-term forecasts, DaySim runs all its model components and equilibrates with traffic assignment For short-term effects, the model system is equilibrated in the same way, but comparison scenarios treat the long-term choices modeled in the base scenario as fixed. For FTA New Starts, we think it will be okay to do the same thing but also treat the Day Activity pattern and tour destination choice as fixed.
50	Some additional enhancements are in the works for models based on the activity schedule approach. We are currently working with PSRC in Seattle to design an activity-based model with some additional features. They are using UrbanSim to simulate economic and land development over time and want to integrate this with an activity-based model
51	So the long-term location choices will be moved into the land use simulator, --which will supply the synthetic population to the activity-based model --with residential location, usual work locations and usual school locations attached. And the activity-based model will be able to provide richer accessibility measures back to the land use model than the current trip-based model system
52	PSRC is also considering several possible additional model components to incorporate into the model system. For example, since most workers regularly use the same travel mode to go to work, and PSRC has information about this in their survey, they might include this as one of the long term models that conditions the day activity schedule. This should improve the model's ability to distinguish between long-term and short-term effects.
53	We also believe that the day activity schedule approach could be integrated effectively with a dynamic traffic simulator. In addition to gaining the direct benefits of more realistic traffic assignment results.... if the simulator can supply more accurate distribution of LOS by time of day then the time-of-day models will be able to use that information to improve their predictions of demand by time of day.

54	The activity schedule approach has proven so far to be a framework that can be adapted to incorporate new features and improvements over time. If past experience is a good predictor, then this will continue to happen as more agencies adopt the approach. But it will also be possible for agencies to implement a version that is just like one of those that has already been implemented.