

## **New York Metropolitan Transportation Council (NYMTC) Tour-based Model Development, New York, New York**

NYMTC is responsible for transportation improvement programming activities in the greater New York Metropolitan Region, including the preparation of plans that comply with the requirements of both the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Clean Air Act Amendments of 1990 (CAAA). The NY model developed for NYMTC in the period 2000-2002 (actual modeling work period, though the data collection and network preparation stages started in 1994) is the first comprehensive multi-modal model developed for the NY Metropolitan Region that encompasses the entire 28-county 3-state region including portions of Connecticut and New Jersey with the total population of 20 million residents. The NYMTC model success has proven that the concept of micro-simulation activity-based tour-based model can be applied for a large metropolitan area with a unique level of complexity of the transportation system.

The NYMTC model structure is presented in the **Figure 1** below. It has 4 major consecutive modules:

- Tour generation that includes household synthesis, auto ownership, and journey frequency choice models,
- Tour mode & destination choice that includes pre-mode choice, primary destination choice, entire-tour mode combination choice, stop-frequency choice, and stop-location choice,
- Time-of-day choice and pre-assignment processor that include tour time-of-day choice for outbound and inbound directions, trip mode choice, and construction of mode-specific and time-of-day period-specific trip tables,
- Traffic and transit simulation that is implemented by time-of-day periods.

First three modules are implemented as fully-disaggregate micro-simulation procedures working with individual records for the synthesized population (households, persons, tours). The last module has been currently based on standard aggregate (zone-to-zone) assignment algorithms built in TransCAD. The developed software allows for numerous feedbacks to be implemented until equilibrium is reached. Level of service skims after the last stage can be fed back to the mode and destination module as well as to the tour-generation components through accessibility indices.



less than a number of workers, cars equal to workers, cars more than workers), and 3 personal categories (worker, non-working adult, child)

- 6 travel purposes (work, school, university, household maintenance, discretionary activity and non-home-based at-work sub-tours),
- 4 time-of-day periods (AM peak 6:00-10:00, midday 10:00-16:00, PM peak 16:00-20:00, and night 20:00-24:00, 0:00-6:00).

The tour-generation module of NYBPM consists of three successive models that include household population synthesizer, auto-ownership model, and tour-frequency choice model. The household synthesis is based on the predetermined socio-economic controls (number of households, population, and labor force) for each zone. The auto ownership choice model is applied for each household and is sensitive to the household characteristics and residential zone accessibility by auto and transit respectively. The tour-frequency model is implemented at the person level. There are three person types and six travel purposes that finally yield 13 tour-frequency models taking into account that children cannot implement journeys to work, at work and to university and non-working adults cannot implement journeys to work and at work. Each model is essentially a multinomial logit construct having three choice alternatives (no tours, 1 tour, 2 or more tours). A set of the tour-frequency models is ordered and linked in such a way that choices made for some purposes and household members have an impact on the other choices of the same person as well as the other household members.

The mode & destination module starts with pre-mode choice where each tour is assigned to either motorized or non-motorized mode of travel. Density of non-motorized attractions is essentially a log-sum from the subsequent destination-choice model for non-motorized travel with individual attractions available in a 3-mile radius around the tour origin. If the motorized option is chosen then the motorized branch of the algorithm is activated. First the mode and primary destination choice for the entire journey is modeled (without intermediate stops). It can be thought of as a nested structure where destination choice comes at the upper level of hierarchy while mode choice is placed at the lower level conditional upon the destination choice.

The motorized destination choice model has been calibrated by 8 purposes (6 original purposes with additional subdivision of work tours by 3 income categories). In a micro-simulation framework the destination choice model is applied as a doubly-constrained construct (either fully-constrained or relaxed-constrained). Constraining the destination ends is achieved by removing the chosen (taken) attraction from the zonal size variable after each individual journey simulation. For fully-constrained mandatory purposes (work, school, university), an entire attraction unit is removed. For relaxed-constrained non-mandatory purposes (maintenance, discretionary, at work), only a part (0.5) of the attraction unit is removed.

The mode-choice model has been calibrated by 6 purposes as a nested logit construct with differential nesting depending on the purpose. In most cases drive-alone and taxi modes proved to be in separate nests while transit and shared-ride mode were nested in different combinations.

At the second stage of the motorized branch of the algorithm, intermediate stops are modeled conditional upon the chosen mode and primary destination for the tour. Stops are modeled by means of two linked choice models: stop frequency and stop-location. Stop-location model includes a zonal stop-density size variable that is similar to the attraction size variable. The

composite log-sum from the stop-location model is used in the upper-level stop-frequency model.

Stop-frequency model has been calibrated for 6 purposes as a multinomial logit construct. After having considered observed stop frequencies from the survey (it was found that an absolute majority of journeys have not more than 1 stop on each leg – 90-95% depending on the journey purpose) we decided to limit a number of choice alternatives to the following four: 1=no stops on either outbound or inbound direction; 2=one outbound stop leg, no inbound stops; 3=no outbound stops, one inbound stop, 4=one stop on each direction.

The proposed stop-location choice model is also a multinomial logit construct. Similar to the destination-choice model, the stop-location model requires a procedure for selecting a limited subset of relevant zones (for both model calibration and application) in order to reduce computational burden. In a case of stop-location model, however, both origin and destination of the journey are known, thus, effective rules were applied to build a “spatial envelope” that reflect the observed travelers behavior.

The current version of the NYMTC model has a time-of-day choice model based on a set of predetermined time-of-day distributions segmented by travel purpose, mode, and destination area. One of the ongoing works of PB Consult for further enhancement of the NYMTC model includes replacement of the time-of-day distribution with a time-of-day choice model sensitive to person, household, and level-of-service variables. Time-of-day choice is followed by trip mode choice (in most cases predetermined by the entire-tour mode) and pre-assignment processing procedure that constructs mode-specific and period-specific trip tables.

In the period 2002-2006, the NY model has been used by NYMTC more than 30 local planning agencies for various projects including environment conformity analysis, Tappan-Zee bridge study, Goethals bridge study, Manhattan area pricing study, and many others. Since 2002, PB Consult has been constantly supporting NYMTC and the other users through the ongoing model support contract with NYMTC.

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## Mid-Ohio Regional Planning Commission (MORPC) Tour-based Model Development, Columbus, Ohio

In 2002, MORPC contracted with PB Consult to develop a new regional travel forecasting model. The new model is an activity-based tour-based model applied with micro-simulation. The development was based on the 1999 Household Interview Survey, which was supplemented by the 1993 COTA On-Board Survey and an External Cordon Survey that had been conducted in 1995. The new model system was completed in 2004.

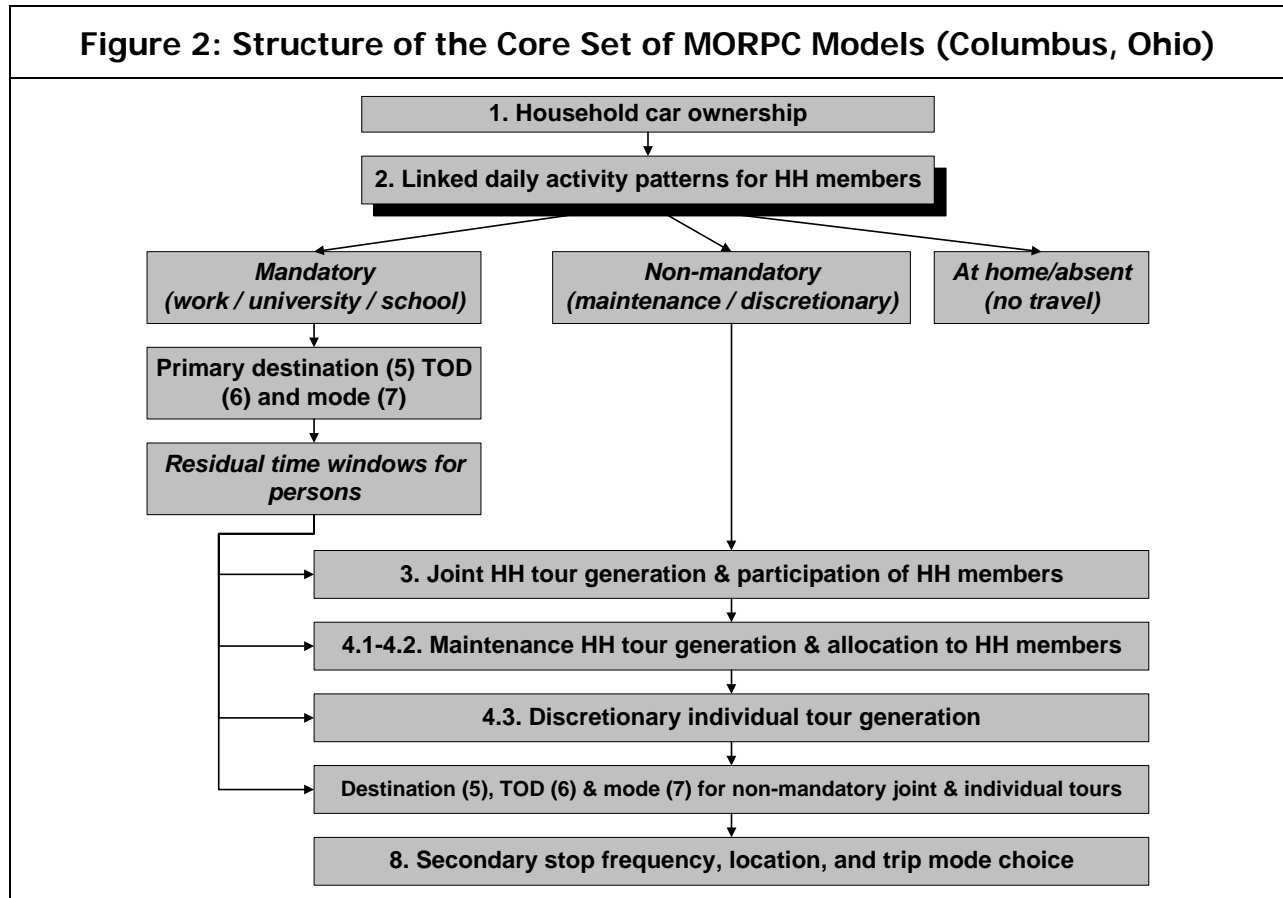
The MORPC model incorporates most of the positive features of the other activity-based and tour-based models as well as the growing body of research on activity-based modeling and micro-simulation. In particular, the structure and application experience of the SFCTA model and NYMTC model had been carefully studied before the decisions regarding the MORPC structure was made. Comparing to the predecessors, the MORPC structure represents two significant steps further in a better and more realistic description of travel behavior:

- Explicit modeling of intra-household interactions and joint travel that is of crucial importance for realistic modeling of the individual decisions made in the household framework and in particular for choice of the high occupancy vehicle (HOV) as travel mode. The original concept of a “full individual daily pattern” that constituted a core of the previously proposed activity-based model systems has been extended in the MORPC system to incorporate various intra-household impacts of different household members on each other, joint participation in activities and travel, and intra-household allocation mechanisms for maintenance activities.
- Enhanced temporal resolution of 1 hour with explicit tracking of available time windows for generation and scheduling of tours instead of the 4-5 broad time-of-day periods applied in most of the conventional and also activity-based models previously developed. The time-of-day choice model adopted for MORPC is essentially a continuous duration model transformed into a discrete choice form. The enhanced temporal resolution opens a way to explicitly control the person time windows left after scheduling of each tour and use the residual time window as an important explanatory variable for generation and scheduling of the subsequent tours.

At the first step, the model system generates a synthesized list of all households and population for the entire area, consistent with the household and workforce variables in the zonal data. The output from this Population Synthesis model is a file with a record for every person in the area (currently about 1.5 million), containing various attributes for each synthesized person. Attributes include what household the person belongs to, whether it's a high, medium or low income household, and the type of worker/person (e.g. part-time worker, school child, university student, etc). To gain more information about a household and household composition, a record is sampled from Public Use Micro Sample (PUMS).

Then the core set of choice models is applied for each household and person. It is presented in the **Figure 2** below. It includes 8 main linked choice models. The numbering of the models 1-8 is not strictly sequential but corresponds to the meaningful “blocks” of which the model stream is built. Some of the models (like for example the TOD choice model 6) are called twice in the procedure – first time for mandatory tours (after the model 2) and second time for non-mandatory tours (after the model 4). Models 5, 6, and 7 are also closely connected by sharing

mode choice log-sums, thus they are implemented together for technical convenience and computer time savings.



The first model is the Auto Ownership model, which determines the exact number of vehicles available for each household based on household attributes and the transit accessibility level of the residence. The second model determines what the “Daily Activity Pattern” (DAP) is for each person. A person can either have a mandatory activity pattern, such as work or school, only non-mandatory activities such as shopping, or no travel activity for the day. This model also determines how many mandatory tours each person with a mandatory activity pattern makes during the day. After a mandatory tour is scheduled, the available time left for other travel opportunities is updated.

The third model is unique to the MORPC set of models and determines joint travel among household members. This model allows two or more members of a household to travel jointly for a shared activity, for example eating out. Given the high propensity of household members to travel together, this model is important in that it more accurately accounts for the characteristics of this travel, particularly in terms of mode choice. In virtually all other models in US, this phenomenon is not accounted for directly. Again, after joint tours are determined,

the available time left for additional travel is updated for each synthesized person. The fourth model generates all individual non-mandatory tours, such as shopping, eating out, and recreational. Each tour can be scheduled only within the residual time window left after the scheduling of all previous tours. If no time exists for additional tours, then additional tours cannot be scheduled.

The next three models are applied together and include Tour Destination Choice, Time of Day Choice (TOD), and Tour Mode Choice models. The Destination and Mode Choice models are both logit based, and the Destination Choice step uses the “LogSum” composite impedance measure from the Mode Choice model. The Time of Day model is based on the “time windows” concept, accounting for the use of a person’s time budget over the day. It includes the mode choice LogSum for various TOD periods, making it sensitive to congestion. These models are applied at the tour level, yielding the primary destination, time of day, and mode choice for the entire tour, and consider both out-bound and in-bound portions of the tour.

The eighth model is the Stops and Trip Mode Choice model. This model determines if any stops are made on either the outbound (from home), or inbound leg of the tour and the location of those stops. Additionally, given the overall tour mode previously determined, the exact mode the traveler uses for each segment or “trip” on the tour is set based on a set of rules. Each of these trips is connected and all stops are based upon the previous choices. Therefore if the main tour mode is transit, then a person will not be able to choose drive alone for a lunch trip made at work. Furthermore, if the primary mode of a tour was auto, then a person would be allowed to drop off a child at school, and then drive to work. The final trips are then aggregated by zones and assigned as conventional trip tables to the highway and transit networks.

The core choice models (1 through 8 as described above) are applied in a disaggregate manner. Instead of using aggregate fractional probabilities to estimate the number of trips, the new model is applied with micro-simulation of each individual household, person, or tour, mostly using Monte Carlo realization of each possibility estimated by the models, with use of a random number series to determine which possibility is chosen for that record. Both the Population Synthesizer and the Auto Ownership models, however, perform the micro-simulation using a deterministic “discretizing” procedures that avoid Monte Carlo variability. The new model is applied with an implementation of three global feed back loops for consistency between highway travel times that are both used as inputs to, and as forecast outputs of the model.

The new model is being used by MORPC for Conformity Analysis, transit alternative analysis, and for highway related MIS projects in the Columbus region. It is currently being used to generate forecasts for the North Corridor Transit Project (NCTP), currently in the Draft Environmental Impact Statement (DEIS) stage, with a potential New Starts submittal within the next few years. The NCTP is analyzing various travel modes along a 13-mile corridor. The corridor includes three major employment centers – the Central Business District (CBD), the Ohio State University (OSU), and the Crosswoods/Polaris area – interspersed with large residential areas.

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