

Development of a Mode Choice
Component for the Baltimore
Region Travel Demand Model

EXECUTIVE SUMMARY

Prepared for

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Introduction

URS was retained by the Baltimore Metropolitan Council (BMC) to develop a new mode choice model for use in the regional travel simulation process. The BMC regional model encompasses Baltimore and the surrounding counties, which together have a population in excess of 2,450,000. The new mode choice model component was developed to address the emerging planning needs of BMC, which required replacement of the previous mode choice model developed in the 1970s. These planning needs included a more comprehensive treatment of transit mode choice including sub-mode access choice issues. In addition, the new modeling process was structured to include many additional policy-type variables related to the various costs and travel times for each of the primary modes in the region. Key features in the new modeling process included the ability to address tolls and congestion pricing for the auto modes. An overview of this topic is provided in the memorandum entitled “ Task 1 – Model Review”.

The mode choice model development process, along with other necessary modifications, was performed as a multi-year effort during 1999 and 2000. The overall effort was coordinated as part of BMC’s ongoing modifications to the regional simulation model. Prior to this project BMC had extensively revised the trip generation and trip distribution procedures to reflect the latest trip generation rates and trip distribution patterns from the most recent household survey data. In addition, BMC had gathered specific data related to transit service that was necessary to support the development of the new mode choice model. As part of the mode choice model development it was necessary to apply the new procedure to an extensive region that covered both Baltimore and a significant portion of the Washington, D.C. Metropolitan area. As a result, it was necessary to extend representation of the transportation networks, particularly transit service oriented to Washington DC, beyond the area under BMC’s jurisdiction.

Available Data Sets

The development of the model required a significant amount of data related to the existing travel in the region. Some of this data described existing patterns by mode while other data was gathered to obtain travelers’ preferences related to new travel options. The data covering existing travel patterns and mode choice were obtained as part of two recent surveys conducted by BMC. In 1993, BMC conducted an extensive household survey that inventoried travel for households throughout the region. While comprehensive in nature, this particular survey did not generate enough transit observations to support the development of the new mode choice models. In order to increase the number of transit observations, BMC conducted an on-board transit survey in 1996. As part of this effort, ridership data for all lines and modes was gathered. Although the household and transit on-board survey information was processed extensively and geocoded when the data was initially gathered, further effort was required during this project to refine data and remove erroneous observations.

While the household and on-board transit survey data sets contained a wealth of observations pertaining to travel under existing conditions, the data did not provide information related to travelers' response to potential policies such as congestion pricing and tolls. In order to gather this type of data it was necessary to conduct a "Stated Preference" survey. The stated preference survey queried potential travelers with regard to their likely response to new policies that might be implemented. For this project, the consultant team conducted the stated preference survey at multiple locations throughout the study area. The data gathered from this effort was used in several elements of the model development including establishing a reasonable value of time. The design of the survey and results of analysis of the server data are discussed in further detail in the "Task 2 - Stated Preference Survey" Memorandum.

Transportation Modeling Software

Another key element of the project was the migration to "Windows" compatible modeling software that provided a full set of features required for the new model. Previously, BMC had relied upon MINUTP, a DOS-based program to support the regional model simulation process. However due to limitations in memory and the expansion of the region to cover areas around the Washington, D.C. Area, it was not feasible to retain the simulation model on this platform. As a result, a decision was made by BMC to convert to TP+, a successor package to MINUTP. TP+ greatly increased the number of zones and links that could be maintained in the regional model and added many enhancements not previously available. The use of TP+ also increased the speed of the regional models' execution.

Prior to the initiation of the project, BMC had already converted many elements of the simulation process to the new TP+ package. As part of mode choice model development project, URS completed the conversion of the remaining model components. This effort included the new transit networks and path-building procedures. The mode choice models were developed completely within the TP+ package, thus completely avoiding the use of Fortran routines that were initially anticipated for several customized mode choice functions.

The conversion to the new package, however, did require a significant effort in debugging routines as they were released from the vendor. During the course of the project several new versions of the package were released by the vendor. As a result, it was necessary for URS to migrate the simulation model to each new version and benchmark the results. URS also worked closely with the vendor to establish several new features and options for use in BMC's regional simulation process.

The new mode choice model also required the development of GIS-based techniques to inventory areas within walking distance of transit service and to establish drive-access connections from zones to park/ride transit facilities. These new techniques were implemented within MAPINFO, which is the standard GIS package used by BMC.

Network Modifications

As part of the enhanced mode choice modeling process, it was necessary to modify elements of the existing networks used in BMC's regional simulation process. These modifications addressed not only the conversion issues related to TP+, but also the need to provide more realistic estimates of travel times and costs by time-of-day.

The modifications to the highway network were focused primarily on changes required to account properly for toll costs. Tolls were utilized as part the auto cost variable in the new mode choice models. It was also necessary to provide procedures that enabled the highway network to be altered by time-of-day. The use of time-of-day networks enabled the mode choice model to address different travel times associated with special facilities such as HOV lanes, which operate only during limited periods of the day. Time-of-day highway networks were also utilized as the basis for estimating bus travel times. This particular modification enabled the estimation of separate bus travel times for the congested peak and off-peak periods.

There were also significant modifications to the transit network and the associated path-building process. The existing transit network was converted to TP+ format and key parameters such as headways, run times, and routes were reviewed and modified as necessary. URS also developed a fare estimation procedure which estimated transit costs as a function of discounted transit pass usage by the various transit services.

Following the network development, the necessary path-building procedures were created by URS to develop peak and off-peak travel times and costs for each of six separate transit modes. These routines were extensively validated against key statistics derived from the transit on-board survey data. A comprehensive discussion of all these topics is provided in a memorandum entitled "Task 4 – Transit Network and Estimation Data Set".

Regional Model Modifications

The introduction of the new mode choice modeling procedures required significant modifications to several existing components in the regional model. These modifications can be described generally as procedures used to establish key market segments, such as trips by

income group or access condition (walk access and drive access). The mode choice model was structured to provide separate applications to each of these market segments.

The existing trip generation model was modified extensively to provide more comprehensive estimates of total travel in the region. The existing BMC trip generation model estimated only motorized trips. Modifications to this original model were implemented specifically to estimate both motorized and nonmotorized trips. The first element of this modification required new trip generation rates developed from 1993 household survey, which accounted for both motorized and nonmotorized travel. The second element was focused on the development of an initial mode choice model which partitioned these trips into motorized and nonmotorized categories based on the land-use characteristics and auto ownership levels in each zone. The trip generation modifications are described in the “Task 5 – Non-Motorized Mode Choice Model” Memorandum.

The trip distribution model was also modified as part of this effort. During the review of the survey data, it was apparent that the income of the traveler was a key determinant in the selection of travel mode. Those travelers with lower incomes tended to have significantly higher transit mode shares than other travelers. As a result it was necessary to stratify the trips in the region by income level. URS developed submodels that allocated trip ends percentages into three income groups. These submodels were applied to each home-based trip purpose to partition the trip tables. The memorandum entitled “Task 6 – Trip Distribution Modifications” describes these modifications in detail.

Mode Choice Model Development

The development of mode choice models for motorized travel was the principal objective of this project. As part of this effort an extensive review was performed which resulted in the creation of the model specification. The model specification essentially provided a “blueprint” of the overall development process. The specification included a description of the potential variables, proposed model structures, and analytical techniques to be utilized as part of this effort. The specification, together with guidance from the peer review panel and BMC staff, effectively guided the development process. The model specification is fully documented as part of the “Task 3 – Model Specification” Memorandum.

The estimation of initial models was performed with a customized program (ALOGIT) which was created specifically for the development of logit models. Logit models are the dominant form of choice models used in forecasting travel demand. Essentially, logit models estimate the probability of selecting individual travel modes based on the competitive characteristics of each mode, which are reflected primarily as costs and travel times. During the course of the analysis, dozens of potential model structures and variables were considered.

Individual models were developed for each trip purpose initially as simple multinomial models where all modes are considered to be directly competitive. Where feasible, additional model specifications featuring “nested” logit models were developed. The nested logit models are used to combine similar modes in groups based on their competitive characteristics. The grouping of various modes provides a structure where primary decisions, such as “auto” vs. “transit”, are made prior to decisions about individual modes such as “drive-alone” vs. “carpool”. Samples of both of these structures are included in Figure 1. A list of the variables included in the final models is shown in Table 1.

Within each trip purpose the mode choice models are stratified with respect to several conditions. Markets stratifications identifying areas eligible for walk-access transit service and drive-access transit service are provided for each trip purpose. In addition, home-based trip purposes are also stratified by income group. Lastly, each model is further stratified by geographic area in order to address specific conditions associated with these regions. The model estimation and calibration are described in detail in the “Task 7 – Mode Choice Model Estimation and Calibration” Memorandum.

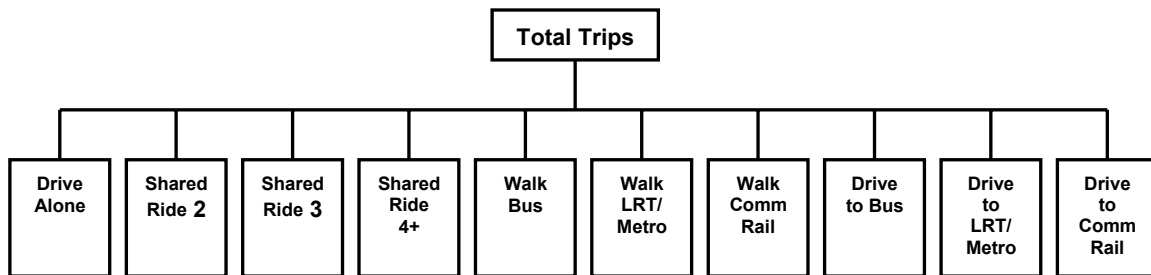
After completion of the model development, a significant effort was undertaken to calibrate and validate these models against a series of observed conditions. This included replication of trips by travel mode along with replication of transit ridership by line. Additional analysis included replication of observed trips by distance. Overall, the model was able to successfully replicate the observed transit and auto trips in the region.

URS also performed a series of sensitivity tests in order to ensure that the model responded acceptably to changes in primary variables such as costs and travel times. These changes included increased transit fares as well as reduced transit wait times and run times. Tests were also conducted with increased auto operating costs and parking costs. The model responded to each of these tests appropriately, with changes in mode share consistent with experience from other regions. The model validation and sensitivity tests are described in detail in the “Task 8 – Mode Choice Model Validation” Memorandum.

Figure 1

Logit Model Structures

Simple Multinomial Model – Example WBO



Nested Logit Model – Example HBW Income Group 3

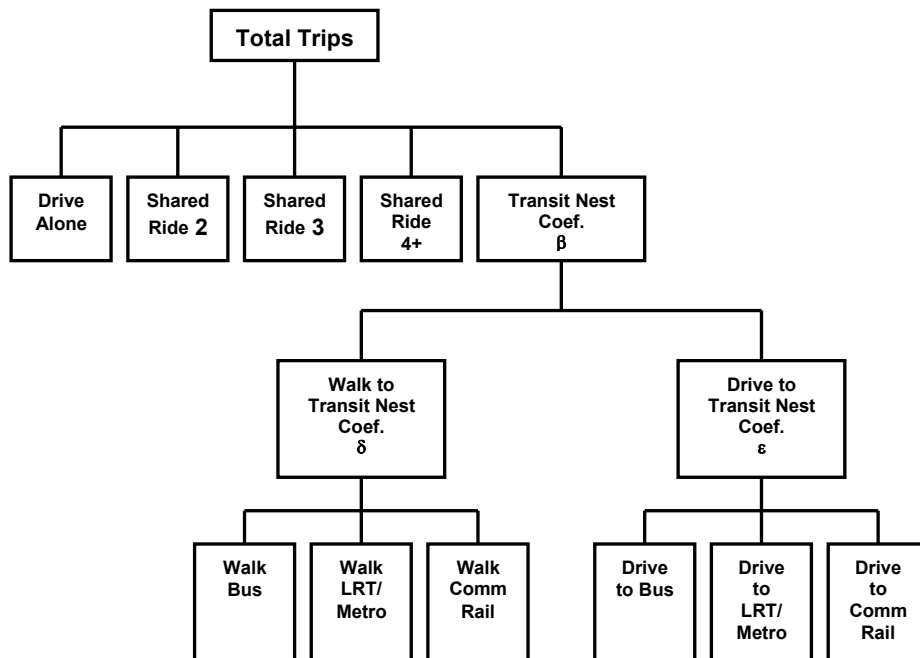


Table 1

Mode Choice Variable Definitions

VARIABLE	DEFINITION
Auto In-Vehicle Time	In-vehicle time for auto modes in minutes
Transit In-Vehicle Time	in-Vehicle time for transit modes in minutes
Out-of-Vehicle Time	Auto mode terminal time, HOV mode wait time and Transit walk time (access, egress, and sidewalk) in minutes
Initial Wait<=7.5	Portion of transit initial wait time that is less than or equal to 7.5 minutes
Initial Wait>7.5	Portion of transit initial wait time that is greater than 7.5 minutes
Transfer Wait	Transit wait time for transfer in minutes
Transfer Dummy	Transfer penalty as a binary variable (if transferring, then 1, else 0)
Auto Cost	Auto mode costs including operating costs, parking and tolls in dollar (1)
Transit Cost	Transit mode costs including fares and operating costs/parking costs for drive-access transit trips in dollar
Short Drive	Binary variable identifying short distance trips (if auto distance less than 5 miles, then 1, else 0)
Ln Auto Dist.	Natural log of the highway distance in miles (2)
Auto/Person HOV	Autos/person HOV modes
Auto/Person Transit	Autos/person Transit modes
Attraction CBD	Binary variable (if area type=CBD, then 1, else 0)
Employment Density	Employees per acre (3)
Population Density	Population per acre (3)

NOTES:

- (1) - auto costs are divided by the respective number of occupants assumed for each HOV mode.
- (2) - highway distance was estimated using minimum paths based on time
- (3) - based on acreage supplied by BMC

Conclusion and Recommendations

The development of the new mode choice models for the regional simulation process will greatly enhance the planning capabilities available to BMC. The new models provide a comprehensive process for estimating mode choice that is applied to individual market segments using a broad set of level-of-service variables. The implementation of the new model within TP+ streamlines the entire simulation process and enables BMC staff to maintain all model components within a common software package. The new model, together with TP+, provides BMC with a full-featured mode choice process that can be supported well into the future.

As part of the implementation of the new model at BMC, several horizon year scenarios have been processed. The scenarios, along with other tests, will be used to further investigate the features of these models. It is anticipated that further modifications to the new models and/or the procedures used to develop the input data sets will be identified as the part of these scenarios. Key modifications would include further enhancements to the trip distribution process. The objective of these modifications would be to provide a new process that distributes trips separately by income group, rather than the post-distribution stratification technique developed in Task 6.

Other recommended modifications would include further abstraction of the transportation networks. It is recommended that the highway and transit networks maintained in TP+ be refined to provide greater consistency with the actual roadways traversed in each route. These refinements should also increase the compatibility of the TP+ transit networks and the general transit network maintained in MAPINFO. The consistency of these networks will increase the accuracy of the access-related market segmentation used in the mode choice model. It is also recommended that separate time-of-day transit networks be developed within MAPINFO to more accurately describe the limitations to walk access transit modes during off-peak conditions. Further refinements to the highway networks, particularly related to the location and treatment of centroid connectors appears warranted.

General refinements to the mode choice model may also be necessary to further improve the estimation of transit usage in key market segments. Of particular concern would be those transit trips destined to Washington, D.C. Transit trips to this particular market segment are predominantly served by the MARC rail service. Within the current model, rail trips related to this area are over-estimated. Further investigation and additional refinements may be necessary to enhance the model's overall performance in this area.