Quality Assurance / Quality Control for the Atlanta Activity-Based Model: A “Look Under the Hood”

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The Atlanta Regional Commission (ARC) maintains a 4-step aggregate trip-based model (TBM) and a disaggregate activity-based model (ABM) for its regional travel demand forecasting process. Both models include the metro Atlanta 20-county nonattainment area, encompassing more than 6,400 square miles and over 9,700 road centerline miles. Quality assurance and quality control of the models have been the ARC’s top priority because the assessment of current and future transportation infrastructure needs heavily rely on the model forecasts. In addition, ARC uses the models to produce the majority of travel inputs used in emissions modeling for federal air quality conformity determinations.

In early 2011, ARC initiated an internal team-based quality assurance project for the models with the main focus on the ABM. The motivation of the project was twofold: first, it aimed to give the ARC staff a thorough understanding of the limits and capabilities of the complex ABM, and second, it intended to ensure model quality through critical review.

OBJECTIVE

The objective of this paper is to present the quality assurance project implemented for the Atlanta activity-based model in 2011. This paper outlines an overview of the ARC ABM model, quality assurance procedures and methodologies, a brief description of the review of primary model components, and lessons learned.

OVERVIEW OF THE ATLANTA ACTIVITY-BASED MODEL

To achieve maximum efficiency in maintaining both the TBM and the ABM, the ABM shares several modeling components with the TBM. These components include socioeconomic data, highway and transit networks, external trip models, commercial vehicle and truck models, air passenger model, and highway and transit assignments. The ABM replaces the trip-based internal demand models with tour-based microsimulation models. The ABM was built based on the CT-RAMP (Coordinated Travel Regional Activity-Based Modeling Platform) family of activity-based models. Figure 1 describes the model structure of the ARC ABM. The CT-RAMP model components are shadowed in the figure.
Figure 1. ARC ABM Model Structure
QUALITY ASSURANCE PROCEDURES

As the first step of quality assurance for the ABM, ARC set the quality assurance/quality control guidelines to aid in reviewing the model. Next, a methodology to effectively help perform an in-depth review of the model results was established. Based on the guidelines and the methodology, ARC initiated critical reviews for every component of the model. The following sections describe these quality assurance procedures in detail.

QUALITY ASSURANCE GUIDELINES

A quality assurance guidelines report was written based on inputs from ARC technical staff, which included not only modelers but also non-modeling planners and engineers with different expertise [1]. The report was also based on guidance set in the recently updated Travel Model Validation and Reasonability Checking Manual [2]. Although the guidelines target both the TBM and the ABM, an emphasis is placed on understanding and enhancing the ABM. The guidelines focus on checking the models from the model user’s perspectives rather than from the model developer’s. The general quality assurance processes outlined in the report are as follows:

- Reasonableness checking of all modeling components
- Comparability between the TBM and the ABM
- Temporal validation between base and forecast years

The report presents specific guidelines for the main building blocks of the model, including the model script, socioeconomic data, transportation network data, tour/trip generation model, tour/trip destination choice model, external trips, mode choice and traffic assignment.

METHODOLOGY

The ABM is a microsimulation model, thus it generates a large amount of output data. For example, the ARC population synthesizer estimates household and person attribute data for approximately 5.2 million persons in year 2010 and about 8.0 million persons in year 2040. The current ARC ABM produces approximately 5.9 million tour records and 15.7 million trip records for 2010 and 9.5 million tour records and 25.2 million trip records in 2040. Because of this vast output database, a simple spreadsheet-based analysis is not feasible. An alternative method could be based on computer programming, but even that method would not allow users to quickly access and view the actual output data.

To overcome these limitations, ARC streamlined the model review process through the use of an SQL server and the ARC ABM model visualization system (ABMVIZ).

After the ABM run, the output data are uploaded to the SQL server database. The ABM data in the server are then directly accessed through a database management tool such as SQL Server Management
Studio. Through the management tool, the user is able to open and review the full raw ABM output data. Queries can be run to obtain various univariate and multivariate tables using Transact-SQL (TSQL) scripting. The overview of the SQL database, a sample TSQL script and a sample result are shown in Figure 2.

Figure 2. SQL Database Management

ABMVIZ is an interactive model analysis and visualization dashboard application implemented in Adobe AIR (Adobe Integrated Runtime) Flash [3]. The dashboard is directly linked to the SQL database and from the database it generates tables, charts, and other innovative visuals such as time-use diagrams, tour tracing, a tree map of mode choice, and radar charts using multiple measures. Figure 3 shows an example of the ABMVIZ dashboard. One of the main advantages of using the dashboard is that it visualizes key ABM outputs in various graphic formats, which cannot be done directly in the SQL database management tool. A significant portion of the model review relied on visual outputs from this tool.
REVIEW OF MODEL COMPONENTS

A prerequisite to quality assurance for the model is to thoroughly understand the building blocks of the model and the interactions among them. Also, quality assurance work must be performed in each and every modeling step, rather than focusing on the end products of the model such as traffic assignment. Any culprits that cause unreasonable results in one step of the model can be propagated to the following steps in the modeling chain, thus any issues in an individual step must be addressed before moving forward. The following sections briefly describe the quality assurance work performed for the major model components of the ABM.

Population Synthesis

The population synthesizer creates synthetic populations based on single and multi-dimensional distributions of households by various attributes from Census data. Based on the distributions established, the population synthesizer samples Public Use Microdata Sample (PUMS) records to estimate the full population.

The population synthesizer results in a record for each household and a record for each person with various household and person characteristics. Because of the large amount of data the synthesizer produces, the data were segmented by various categories such as person type, employment status, student type, age group, income, etc. For the initial check, distributions of households and populations...
in each segmented attribute were reviewed. Next, a number of cross tabulations across the different attributes were made to review the cross-relationships among the attributes. The changes in distributions of the synthesized population by various characteristics between base and forecast years were reviewed for reasonableness.

**Mandatory Activity Location Choice Models**

Mandatory activity location choices include workplace, school and university location choice models. The workplace location choice model assigns a workplace zone for every employee and the school/university location choice models assign a school/university location for every grade and university student in the synthesized population.

The focus of the review on these models was to see whether they indicate a significant correlation between the actual mandatory activity location data and the model estimates. Figure 4 shows an example school location choice model estimate overlaid with the actual grade school locations.

Figure 4. School Location Model Estimates
Auto Ownership Model

The auto ownership model estimates the number of vehicles owned by each household based on household size, household income, parking costs, and accessibility measures.

The focus of the review was to ensure the model’s sensitivity to higher congestion levels in the future year network. The model estimates were also compared with the auto ownership information reported in the Census. The distribution of average auto ownership by traffic analysis zone was compared between the TBM and the ABM, and any discrepancies between the two models were noted.

Daily Activity Pattern Model

The generation of daily activity patterns for the synthesized population is a precursor of individual and joint tour generations. In this model, personal daily activity patterns are classified by mandatory, non-mandatory and at-home patterns.

A reasonableness check was made on the relationship between the three activity patterns and different person types.

Individual Tour Models

Based on the daily activity pattern chosen for each person, individual tours are generated to estimate tour frequencies, the destination of tours, and the time-of-day choices of tours. Individual tours are further categorized by mandatory tours, non-mandatory tours, and at-work subtours.

An aggregation check was performed first for the frequency models for the measures such as average tour generations per person. Temporal variations of the aggregate measures between base and forecast years were investigated. Because of the complexity of tour models, the review necessarily involved a number of cross tabulations of key variables such as person types, tour categories, and detailed tour purposes.

Tour destination models were reviewed for zonal tour distributions by activity pattern. In particular, a level of correlation was examined between the estimates of work tour destinations from the tour destination choice models and the work place locations chosen from the permanent activity location models. Tour time-of-day choice models were reviewed for reasonableness in departure hours, arrival hours, and tour durations by tour purpose.

Joint Tour Models

The joint tour models generate the non-mandatory tours shared by intra-household members in terms of tour frequency, participation level, tour destination, and tour departure/arrival times. As for the individual tour models, similar cross tabulations were made by tour purpose and reviewed for their reasonableness. The variations of joint tour departure and arrival hours were reviewed for every tour purpose.
LESSONS LEARNED

The ARC ABM has a myriad of potential planning applications. Not only can the ABM address the dynamic nature of traffic movement in a realistic manner, but it can also provide valuable information for other planning analyses such as telecommuting, aging, non-motorized travel and environmental justice analysis. The importance of maintaining a good quality model cannot be overstated.

The ARC’s quality assurance project has been rewarding in many aspects. First, it gave ARC staff an opportunity to understand how the ABM works “inside the box,” and to evaluate its capabilities and limits. This understanding was especially helpful for the non-modelers who are not involved in model development but use the model outputs for other planning analyses. Second, making a team of both modelers and non-modelers allowed staff to review the model in both technical and pragmatic perspectives. Third, the SQL database management and the visualization system were the tools suitable for this project because they can produce a number of customized model results from the vast ABM database in an interactive manner. Finally, although this quality assurance project aimed to enhance the ABM, it also gave staff an opportunity to improve ARC’s trip-based model as a result of simultaneously cross-referencing and cross-checking numerous components of the two models.

REFERENCES

1. Atlanta Regional Commission, *Quality Assurance and Quality Control of Travel Demand Models*, Internal Discussion Copy, April 2011.