TRANSIMS Implementation for a Small Area Network in Maryland and Comparison with Enhanced Four-Step Model

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Word Count: 2,068 + 1 Tables + 2 Figures= 2,818

KEYWORDS: Travel demand forecasting model, four-step model, TRANSIMS, Transportation Planning
INTRODUCTION

Traffic pattern prediction is necessary for infrastructure improvement, one of the highest priorities in the nation. Urban travel demand modeling provides tools to forecast urban travel patterns under various conditions. Modeling involves a series of mathematical equations that represent how people make travel choices. The classical or traditional urban travel demand model is the four-step method, which was introduced in 1950s. The four-step model has been used widely in urban transportation planning. Although it is practical and produces aggregate forecasts, the model has some shortcomings, especially in the short-range planning. It has been observed that, instead of having improved traffic flow, existing and newly constructed roads become congested much faster than forecasted. It seems that current models are not forecasting the travel demand correctly. Thus, the efficiency of the four-step model is questionable. Four-step models are not behavioral in nature. As a result, they are unable to represent the time chosen for travel, travelers’ responses to demand policies (e.g., toll roads, road pricing, and transit vouchers), non-motorized travel, time-specific traffic volumes and speeds, and freight and commercial vehicle movement. Some researchers have modified the four-step model in order to improve its efficiency, while others have proposed new models, such as activity-based models, as alternatives.

This paper proposes an enhancement to the four-step travel demand analysis model called Sub-TAZ. The four-step, proposed (Sub-TAZ), and TRANSIMS Track-1 models are applied to a small network in Fort Meade, Maryland. The models are calibrated and validated for the base year (2005), and the forecast results for the year (2010) were compared to the ground counts. This study compares the forecasting ability of TRANSIMS to the regular and enhanced four-step models and gives some insight about TRANSIMS benefits, challenges, and issues.

The selected case study is Maryland Route 175 (MD-175) and surrounding roads, in total a 60-mile area in central Maryland. The authors developed a four-step model for this small area based on the Baltimore Metropolitan Council (BMC) regional model. The developed model is calibrated and validated for the base year 2005. This model is called the Base model. The BMC model was developed using Citilabs Cube software; however, the authors converted the network to develop the model in TransCAD software.

There are 28 traffic analysis zones (TAZs) and 327 links in the MD-175 study area. Thirteen of the 28 TAZs are external (i.e., outside the study area). All of the trips outside the study area are assumed to traverse one of these TAZs to enter the study area.

Ground counts were obtained for approximately 13 percent of the links in the MD-175 study area (44 counts out of 327 links). Individual link errors were calculated by subtracting the estimated model volume from the link’s ground count. The model was calibrated and validated according to the Federal Highway Administration’s (FHWA) standards in order to reasonably represent reality.

ENHANCEMENTS TO THE FOUR STEP MODEL

The authors developed two models as modifications to the four-step model and applied, calibrated, and validated them on the small study area for the base year 2005. The two models are Sub-TAZ and TRANSIMS Track-1.
Sub-TAZ Model

One of the four-step model’s problems is the lumpiness of loadings around centroid connectors. This is because all trips are generated from centroid in one zone and destined for other zones via the few imaginary centroid connectors of the origin zone. The authors proposed a new approach, Sub-TAZ model to address this problem by including minor roads and driveways in the network and dividing the zones into smaller subzones. The authors allowed each zone to be divided into up to 12 subzones depending on the local roads and driveways locations in each zone. If land use data is available for developments inside each zone, the zones can be divided based on land use rather than based on roads.

If the input data (land use and socio-economic) for all subzones is available, the input data to the four-step model can be extended to reflect the subzone information rather than the zone information and the regular four-step model can be applied in subzone level. However, since all the required input data is usually unavailable in the subzone level, the proposed method applies the Trip Generation step in the zonal level. The productions and attraction of each zone—the Trip Generation output—is then divided between the subzones. This division will be performed equally if there is not much information about land use in each subzone. For example, if a zone is divided into four subzones, each subzone is allocated one-fourth of the total productions and attractions of the original zone. If there is some information about the trip generators located in each zone, the total productions and attractions are distributed proportionally. In this paper, the authors used an equal weight for all subzones. The MD-175 Base model includes 28 zones, while Sub-TAZ model includes 55 zones. The detailed network includes 1,782 links and 1,461 nodes. The Sub-TAZ model was developed, calibrated, and validated for the study area. The results are presented later in Table 1-a.

TRANSIMS Model

TRANSIMS is based on individual behavior and interactions. It traces and simulates the movements of each individual in a fully described network as he or she accomplishes tasks in a 24-hour period. TRANSIMS also collects statistics on traffic, congestion, and pollution. The two major goals of applying the TRANSIMS model for the study area are to implement TRANSIMS in Maryland for the first time and to compare the ability of TRANSIMS to the prior four-step models regarding planning and future demand management issues.

TRANSIMS is part of the Travel Model Improvement Program, which aims to precisely model the interaction between the demand and supply aspects of travel. Microsimulation is typically the supply side of TRANSIMS, while Track-1 and Track-2 are the two approaches for the demand side. In most studies, researchers utilize the standard trip origin-destination matrix for the demand side, which can be simply extracted from the existing four-step model of the desired study area. The Track-1 approach is mainly a trip-based approach to the TRANSIMS model that only uses Route Planner and Microsimulator modules. Track-1’s advantage over the four-step models is the dynamic traffic assignment capability. Track-1 TRANSIMS is developed, calibrated, and validated for the study area.

The Track-2 approach, which is activity-based, utilizes the whole TRANSIMS model package (including the Population Synthesizer, Activity Generator and Router modules) to provide the travel demand. This approach is more complicated and more data intensive, but is microscopic and addresses the existing problems in the four-step model. The authors also
developed Track-2 approach, however, the results were not plausible. The reason is that Track-2 approach has some problems with estimating external trips. Since the study area is small and majority of trips are externals, the model underestimated traffic volumes.

Two major inputs from the four-step model are required to create Track-1 of the TRANSIMS model. The first is the network data, which is necessary for both approaches and needs to be converted into the TRANSIMS format. TRANSIMS requires considerably more detailed network data than the regular four-step model typically requires. Since this research created a network detailed down to the local level of roadway classification for the Sub-TAZ model, the detailed network is completely compatible with the TRANSIMS model requirement. Therefore, network data for the TRANSIMS model comes from the Sub-TAZ network of the four-step model, with the virtual centroid connectors removed.

The second input is the demand files, which are represented by the four-step model origin-destination (OD) trip matrices. These 24-hour period OD matrices which are the input to Track-1, should be converted into TRANSIMS format. The results of the calibrated Track-1 TRANSIMS model were validated in the same manner as the Base and Sub-TAZ models with traffic counts (Table 1-a).

New Approaches versus the Base Model

Table 1-a compares the calibration/validation results of the three developed models for the base year 2005 along with FHWA guideline. All three models follow the FHWA guideline in most cases. As presented in Table 1-a, while the Base model offers a slightly better correlation coefficient (94 percent compared to 92 and 93 percents in Sub-TAZ and TRANSIMS, respectively), it poorly estimates collector roads. The Sub-TAZ model and TRANSIMS estimate collector roads greatly better, with 1.4 and 5.4 percent errors compared to the 41 percent error in the Base model. Except for the minor arterials, the Sub-TAZ estimation outperforms the Base model for all road classes. TRANSIMS outperforms the other two models for minor arterial and collectors, but it overestimates major arterials and freeways. The estimated volumes versus the actual ground counts for all three models (along with their most fitted linear regression lines and R² values) are presented in Figure 1. While the Base model produces the highest R², TRANSIMS yields a coefficient closest to one.

For validation purposes and the testing of the models’ predictably power, the three calibrated and validated models were applied to forecast traffic in the year 2010. The developed models for 2010 were validated with the traffic counts. As presented in Table 1-b, the TRANSIMS and Sub-TAZ model had a higher correlation coefficient (94 percent) than the Base model (86 percent). The Base model best forecasted freeway traffic, with a 6.2 percent error compared to the Sub-TAZ model’s 12.1 percent and TRANSIMS’ 13.2 percent. However, principal arterials and minor arterials were forecasted better in TRANSIMS (5.3 and 6.9 percent error, respectively) than in the Sub-TAZ (8.6 and 39.9 percent error) and Base models (16.6 and 44.3 percent error). The forecasted volumes and 2010 traffic counts are presented in Figure 2 verify that TRANSIMS and Sub-TAZ models outperform the Base model in short-run forecasting.
### TABLE 1 - Results of the Base, Sub-TAZ and TRANSIMS Models

#### a: 2005 Calibration/Validation

<table>
<thead>
<tr>
<th>Calibration/Validation</th>
<th>FHWA Guideline</th>
<th>Base Model</th>
<th>Sub-TAZ Model</th>
<th>TRANSIMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation coefficient</td>
<td>0.88</td>
<td>0.94</td>
<td>0.92</td>
<td>0.93</td>
</tr>
<tr>
<td>Percent error regional-wide</td>
<td>5%</td>
<td>-5.7%</td>
<td>5.8%</td>
<td>10.9%</td>
</tr>
<tr>
<td>Sum of differences by functional class</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeway</td>
<td>7%</td>
<td>-5.6%</td>
<td>-1.7%</td>
<td>11.5%</td>
</tr>
<tr>
<td>Principal Arterial</td>
<td>10%</td>
<td>-11.5%</td>
<td>0.2%</td>
<td>14.9%</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>15%</td>
<td>1.0%</td>
<td>24.4%</td>
<td>4.7%</td>
</tr>
<tr>
<td>Collector</td>
<td>25%</td>
<td>-41.2%</td>
<td>-5.4%</td>
<td>-1.4%</td>
</tr>
</tbody>
</table>

#### b: 2010 Forecast Validation

<table>
<thead>
<tr>
<th>Validation</th>
<th>Base Model</th>
<th>Sub-TAZ Model</th>
<th>TRANSIMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation coefficient</td>
<td>0.86</td>
<td>0.94</td>
<td>0.94</td>
</tr>
<tr>
<td>Percent error regional-wide</td>
<td>8.0%</td>
<td>16.4%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Sum of differences by functional class</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeway</td>
<td>6.2%</td>
<td>12.1%</td>
<td>13.2%</td>
</tr>
<tr>
<td>Principal arterial</td>
<td>-16.6%</td>
<td>-8.6%</td>
<td>-5.3%</td>
</tr>
<tr>
<td>Minor arterial</td>
<td>44.3%</td>
<td>39.9%</td>
<td>6.9%</td>
</tr>
</tbody>
</table>


FIGURE 1 Estimation-observation regression lines for the 2005 Base, Sub-TAZ, and TRANSIMS models.
This study applied TRANSIMS model in a small area in Maryland. The objective was to provide some insight in transitioning from four-step to activity-based modeling. The authors proposed an enhanced four-step model (Sub-TAZ) to have a more detailed network, smoother traffic volumes around centroid connectors, and a better forecasting model for the short-range planning purposes.

Successful implementations of new approaches like TRANSIMS have demonstrated that the activity-based concept is completely workable. Small MPOs can save money by using FHWA-funded TRANSIMS software instead of expensive commercial software. The Track-1 TRANSIMS model in this study showed promising results. It outperformed the two four-step models in forecasting future travel demand. TRANSIMS model estimated and forecasted minor roads better than the two four-step models.

A review of the outputs demonstrates that the more microscopic the model, the more valid the results for minor roads. Sub-TAZ model showed to be more reliable for the analysis of local roads. It also forecasted the future travel demand better than the regular four-step model.

Since moving from current four-step model to TRANSIMS is a big change, it requires significant effort and human resources. The authors propose a three-step procedure in order to make the transition easier and less overwhelming. These three steps are Sub-TAZ, Track-1 TRANSIMS, and Track-2 TRANSIMS.

**FIGURE 2** Forecast-observation regression lines for the 2010 Base, Sub-TAZ, and TRANSIMS model.
Future direction of this study is to modify Track-2 TRANSIMS in order to account for external trips and apply it for the study area.