STATEWIDE DYNAMIC TRAFFIC ROUTING FOR TRANSPORTATION PLANNING: MARYLAND CASE

By

Sevgi Erdoğan\(^{(1,*)}\)
Faculty Research Associate
National Center for Smart Growth (NCSG)
1112J Preinkert Field House
University of Maryland, College Park, MD 20742
P (301) 405 9877, F (301) 314 5639
serdogan@umd.edu

Krishna Patnam\(^{(2)}\)
Consulting Manager, Transportation, AECOM
2101 Wilson Blvd., Suite 800, Arlington, VA 22201
krishna.patnam@aecom.com

Frederick W. Ducca\(^{(3)}\)
Director, TPRG Group
National Center for Smart Growth,
1112M Preinkert Field House
University of Maryland, College Park, MD 20742
fducca@umd.edu

Zuxuan Deng\(^{(4)}\)
Graduate Research Assistants
National Center for Smart Growth,
Preinkert Field House
University of Maryland, College Park, MD 20742
zdeng@umd.edu

Di Yang\(^{(5)}\)
Graduate Research Assistant
National Center for Smart Growth,
Preinkert Field House
University of Maryland, College Park, MD 20742
dyang114@umd.edu

Xiang Wang
Ph.D. Candidate, Visiting Scholar at the NCSG
Key Laboratory of Road and Traffic Eng. of the
Ministry of Education,
Tongji University 4800 Cao’an Road,
Shanghai, 201804, P. R. of China
wx20060726@163.com

and

Subrat Mahapatra\(^{(7)}\)
Transportation Engineering Manager, Office of Planning and Preliminary Engineering
Maryland State Highway Administration
707 N. Calvert Street I Mail Stop C-503 I Baltimore, MD 21202
smahapatra@sha.state.md.us

(* Corresponding Author)

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ABSTRACT

This paper presents development steps, results and the lessons learned from an application of volume-delay functions-based dynamic network model on the Maryland Statewide Transportation Model (MSTM) project. The MSTM was developed to analyze traffic issues throughout the state including traffic in rural areas, freight movements and travel between the Baltimore and Washington Metropolitan areas. An issue facing the MSTM and other statewide models is how to account for the dynamic conditions of a large-scale network and to understand the impact of these conditions on trips which span multiple time periods. As a way of improving the understanding of daily network conditions but avoiding the problems of detailed data collection and validation, a proof of concept dynamic network model of MSTM is developed. The model is able to track individual travelers but does not simulate vehicle movements. Instead an analytical approach is used where volume-delay functions are used to update link delays. The model is implemented using TRANSIMS Version 6 Router application. The model is validated against traffic counts and static assignment model (MSTM) results. The results show that the method used in this paper provides better estimates of dynamic traffic conditions, enables tracking the location of individual travelers, and allows for the rerouting of vehicles in anticipation of congested conditions, while avoiding the need for detailed intersection information. The method also allows for computation within a reasonable amount of time. The validation results, despite the proof-of-concept nature, are comparable with the static assignment results and consistent with observed data.

Key Words: Dynamic statewide models, analytical DTA, router-based assignment, TRANSIMS
1. INTRODUCTION
The Maryland State Highway Administration (SHA) uses the Maryland Statewide Transportation Model (MSTM) to analyze traffic issues throughout the state including traffic in rural areas, freight movements and travel between the Baltimore and Washington Metropolitan areas. The model has been well calibrated and validated and is currently being used for analysis.

While the MSTM framework assists in planning and decision-making; as with many statewide travel demand models (1), it is macroscopic and static in nature without the capability to analyze the spatial and temporal aspects of congestion at a higher resolution. It relies on static assignment procedures for four time periods and does not account for dynamic network conditions. In addition, like with other static models, trips are assigned to a single time period and assumed to complete within that time period. However, effective planning requires consideration of representing user response to issues such as peak spreading, freight analysis and congestion at finer resolutions. The applications for which a time-dependent modeling approach can assist the statewide models include: (i) tracking statewide time-dependent flows, (ii) more accurate representation of congestion, (iii) analyzing impact of temporal travel restrictions, (iv) analyzing impact of peak hour tolling, and (v) tracking time-dependent freight flows.

The Baltimore-Washington region is one of the most congested urban areas in the nation with over-saturated conditions, extended peaks, visitor travel, through trips, commercial and truck activity. An issue facing the statewide models in general and the MSTM in particular is how to account for changing temporal conditions and understand the impact of these conditions on travel.

Mesoscopic and microscopic methods provide alternatives to static assignment procedures. Microscopic techniques have a fine grained level of detail and represent detailed lane change and car following behaviors, and intersection movements. Mesoscopic models operate between the macroscopic and microscopic, applying macroscopic traffic flow models to individual vehicles, producing more realistic traffic flow measures such as speed and flow, while tracking individual vehicles. Mesoscopic models allow for temporal changes in traffic for a discrete (with small intervals, e.g. 15 minutes) time-of-day representation of traffic conditions without having to deal with the complexities of microscopic models. Since microscopic models are too detailed to represent a network of statewide size and macroscopic models do not provide time-dependent traffic patterns, mesoscopic models are most appropriate for analyzing temporal conditions at the statewide level.

A number of different approaches have been developed to analyze the dynamic movement of vehicles through the network at the mesoscopic level. A typical method for dealing with temporal network conditions is the Dynamic Traffic Assignment (DTA) ((2), (3)). DTA models are advantageous in evaluating scenarios because of their enhanced ability to reproduce traffic congestion and to reflect changes in vehicle routes depending on changing temporal and network conditions ((4)). They emphasize the dynamic nature of the network under time-varying demand and capture traffic conditions such as congestion build-up and dissipation. DTA models can yield useful estimates of state variables such as speed and delay to better understand the functional and environmental impacts of various projects in transportation planning and operations management (e.g. (5)(6),(4)).
As a method to improve the understanding of daily network conditions while avoiding the cost and effort related to collection and use of detailed data, the Federal Highway Administration and the SHA have provided support to the University of Maryland to develop a proof of concept to test whether a variant of the DTA method can improve the understanding of dynamic conditions without the detailed data collection and calibration. In this study, we track individual travelers and move them at fifteen minute time intervals based on link delays computed from volume-delay functions rather than propagating vehicles and simulating their interactions. The model is implemented using TRANSIMS Version 6 Router application. The results suggest that this method provides better estimates of dynamic traffic conditions, enables tracking the location of individual vehicles, and allows for the rerouting of vehicles in anticipation of congested conditions, while avoiding the need for detailed intersection information. The method also allows for computation within a reasonable amount of time, since with today’s software and computing capability the application of a DTA to a network of approximately 167,000 links (the size of the MSTM) would require massive computational capability. The method can not only be used as a planning tool but can also be used to provide improved input into small area simulations or detailed DTA applications. Thus, it enables transition from large scale statewide models to meso- or micro- level subarea or corridor level models. The method provides greater detail than traditional planning models by utilizing finer resolution origin-destination (OD) demand data and time-dependent routing information obtained from the TRANSIMS Router. The level of detail obtained from such a multi-resolution approach provides improved input to more detailed micro- or meso- level analysis compared to outputs directly from the traditional static models.

2. MODELING APPROACH
A review of available dynamic network modeling tools was made focusing on functional specifications such as the ability to track individuals and vehicles, the ability to develop an analytical DTA model which did not require detailed network and signal information and the ability to include both highways and transit networks. Five software packages were reviewed: two were proprietary (TransModeler and Cube Avenue) ((7),(8)) and three were open sourced (DynusT, DTALite and TRANSIMS) ((9),(10),(11)). The Router component of TRANSIMS were selected, primarily due to the maturity of its transit module (for details, please see (12)).

A typical DTA process would involve mesoscopic or microscopic simulation of vehicle movements and time-dependent network attributes such as signal control. However, given the large size of the MSTM, an incremental approach is adopted in developing a DTA model using the static MSTM with TRANSIMS (MSTM-TRANSIMS). In MSTM-TRANSIMS, the Router is applied as a standalone dynamic traffic assignment tool without using the simulation and associated complexities of detailed network data requirements. The latest version of TRANSIMS, Version 6 (V6 hereafter), provides three different router applications: (1) All-or-Nothing routing, (2) Dynamic Traffic Routing, and (3) Dynamic User Equilibrium (DUE). These applications can be used individually or, in combination depending on the needs. The DUE option was under development at the time of this project, so only Dynamic Routing and AON routing options were utilized for this study.

Network assignment in MSTM-TRANSIMS model is done using the V6 Router as a single application wherein successive all-or-nothing least generalized-cost paths are built within
each iteration and the resulting link flows (at 15-min increments) are combined between iterations so as to minimize the total vehicle hours of travel. The convergence is defined by a user-specified maximum number of iterations and/or link-gap threshold and/or trip-gap threshold. V6 Router retains the paths and link-delay information in memory during iterations towards reduced processing time. During each iteration, the link travel-times (at 15-min intervals) are updated using the latest combination of link-flows (at 15-min intervals) with the help of volume-delay functions (VDFs). The VDFs used in this application were based on the Bureau of Public Roads (BPR) formulas as applied in the original MSTM. It may be noted that the link travel times are computed for every 15-minute increment as opposed to a much larger peak-period; this differs from a traditional static traffic assignment model, the link travel times are time-dependent as described above. A DUE condition is established by this Router application because the link travel times converge (link gap reaching a set threshold) providing converged link flows, at 15-minute increments. However, since this approach involves combining link-flows between iterations, the path-flows, similar to static assignments, are not unique. Hence the final output paths do not correspond to the converged link flows. However, for scenario comparisons, all-or-nothing paths are rebuilt using the converged link-flows (converged link delay file) on both the baseline and scenario networks for consistent path-based comparisons.

It is worth noting that the V/C ratios can exceed 1.0 as in traditional BPR functions. According to AECOM (13), the V/C ratios in fine grained TRANSIMS models are more likely to exceed 1.0 than V/C ratios calculated using peak period or daily volumes. Care needs to be taken in choosing parameters for volume-delay functions.

2.1 Convergence

DUE in TRANSIMS is determined by trip-based relative gap and link-based relative gap. In TRANSIMS (14), trip-based relative gap is defined as the difference between the trip cost using the most recent trip path and the trip cost using the shortest path:

\[
\text{Trip Gap} = \frac{\sum (CR_x\{C_{mt}\} - CA_x\{C_{mt}\})}{\sum CR_x\{C_{mt}\}}
\]

Where \( \{C_{mt}\} \) is the current time varying link costs;

\( CA_x \) is the AON cost of trip \( x \) based on link cost \( \{C_{mt}\} \); and

\( CR_x \) is the reskilled costs of trip \( x \) along the path used to generate \( \{C_{mt}\} \).

In TRANSIMS, link-based relative gap is defined as the difference of vehicle hours between the actual and minimum impedance paths:

\[
\text{Link Gap} = \frac{\sum VE_t \times CE_t - \sum VA_t \times CE_t}{\sum CR_x\{C_{mt}\} \sum VA_t \times CE_t}
\]

Where \( VE_t \) is the current volume on a given link and time increment;

\( CE_t \) is the travel cost associated with volume \( VE_t \); and

\( VA_t \) is the link volume from an AON assignment based on \( CE_t \).
Once the relative gaps are less than a pre-set threshold, the DUE solution is assumed to have converged. The stopping thresholds for both link gaps and trip gaps in the statewide model are set at 0.05. Usually they are achievable within twenty-five iterations of model runs. Note however that satisfying the relative gap criteria does not guarantee a converged DUE solution.

3. **BUILDING NATIONWIDE and STATWIDE MODELS FOR MARYLAND APPLICATION**

3.1. **Input Data**
The MSTM is a multi-layer travel demand model representing national and statewide travel. The MSTM forecasts key measures of transportation system performance and provides a very powerful tool for analyzing transportation movements within Maryland and the immediate surrounding areas. The model accounts for nationwide truck movements, interregional external-external, external-internal movements and travel within the MSTM study area. The study area includes all of Maryland, Delaware and the District of Columbia, along with adjacent portions of Virginia, Pennsylvania, and West Virginia (Figure 1 (a)). The MSTM operates at a large scale, with more than 167,000 links, 67,000 nodes and over 30,000,000 inter-zonal vehicle trips. The model uses the traditional four step approach to modeling: trip generation, trip distribution, mode choice and static highway assignment. Travel is represented in four time periods with multi-class assignment capabilities of person and freight travel in and around the state. The MSTM was developed with technical support from the National Center for Smart Growth Research and Education (NCSG) at the University of Maryland in collaboration with Parsons Brinckerhoff. The MSTM has been developed using the commercial software package Cube Voyager from Citilabs (15).

3.2. **Network (Supply) and Demand Conversion**
The MSTM operates at two levels, a statewide level with greater detail including Maryland and immediate surrounding areas and a nationwide level representing the entire United States but with lower levels of network and demand detail (see Figure 1 (a) and (b)). Two DTA models in TRANSIMS, the nationwide model and the statewide model were generated. The nationwide model is generated mainly to obtain necessary demand input for statewide model. The nationwide model is converted directly from the MSTM Cube model and the statewide model is extracted from the nationwide model as a subarea model.

The nationwide model generation process involves network and demand conversions. The network conversion is a relatively straightforward process. The TRANSIMS network preparation utility, NetPrep, basically takes the link and node ArcGIS shape files, which are exported from the original MSTM Cube model, and converts them into corresponding link, node and zone files using ArcGIS and TRANSIMS utilities.
An origin-destination (OD) trip-table based approach is used for demand conversion. However, as an Agent-Based-Model (ABM), TRANSIMS requires that all trips start and end at activity locations. Each link normally has multiple associated activity locations, representing household or employment locations. Since this is a Router-based DTA application with less detail than a simulation-based DTA, all activity locations were placed at centroids due to (1) the size of the model, (2) need to avoid arbitrary disaggregation of original zone level trip data, (3) need for direct comparison with MSTM Cube model.

Since an OD trip-based demand input is used, trip tables needed to be converted to “Origin-Destination-Number of Trips” format through Cube Voyager scripts (note that the MSTM included 216 statewide OD tables by purpose, mode, time-of-day and income categories and 20 nationwide OD trip tables, totaling to 50,818,693 trips, both inter- and intra-zonal). The final trip activity records were obtained by further disaggregating the converted trip files based on corresponding diurnal distributions and merging them into a single file using another TRANSIMS utility, ConvertTrip. The diurnal distributions were derived from the 2007 Level 2
Statewide Model
15,049 Nodes
21,748 Links
1,706 Zones
~24.9 million veh.

Level 1
Regional Model
68,243 Nodes
87,785 Links
1,739 Zones
~27.5 million veh.

Level 2
Statewide Model
15,049 Nodes
21,748 Links
1,706 Zones
~24.9 million veh.

(b)

FIGURE 1 The MSTM-TRANSIMS Models, (a) Nationwide Model, (b) Statewide Model.
Baltimore-Washington Region Household Travel Survey data after applying a moving average smoothing technique.

The converted nationwide model is simulated for three iterations to determine the entry points for trips originated from zones outside of the statewide model boundary. We do not seek to achieve convergence in the nationwide model assignment because (1) the entire nationwide model is too big and therefore is much more computationally intensive than the statewide model, and (2) the traffic conditions on the external links are not our primary focus, (3) external links have much lower level of detail.

Similar to the network conversion process of the nationwide model, the creation of the statewide model network was relatively straightforward. The network was created using a TRANSIMS utility called SubareaNet. This utility takes the nationwide model and windows it along a predetermined boundary polygon that surrounds the statewide modeling area (Figure 1 (a)). The SubareaNet utility generated the necessary network files i.e. node, link, and zone. New boundary zones are created at the intersections of truncated links and boundary edges.

The statewide model demand input was generated using a TRANSIMS utility called SubareaPlans. This utility takes the assignment result of the nationwide model, trip plan file, and the created statewide network files; processes original trip activity records and creates a new trip activity file specifically for the statewide model by selecting trips that use links within the range of the statewide network. A total of 24,992,518 inter-zonal trips remain in the statewide model, compared to a total of 27,466,321 trips in the nationwide model (considering only inter-zonal trips since demand loading is done from activity locations placed at zone centroids).

3.3. Model Runs and Computational Performance
Initial runs were made of the nationwide model to determine the entry and exit points for external trips into the statewide model. Since our focus was on the statewide area, no additional runs of the nationwide model were required. Once external entry and exit points were determined and the trips that use the statewide network were identified, multiple iterations were made of the statewide model. The model used link-based (≤0.05) and trip-based relative gap (≤0.05) as convergence criteria, comparing link volumes and path costs (typically travel time) on successive iterations. The runs were mostly made on a server with 16 core CPU @2.39GHz and 12GB of RAM. One iteration took approximately 8.5 hours for the nationwide model and 2 hours for the statewide model. It typically took less than two calendar days for the statewide DTA model to converge to DUE conditions. Faster results undoubtedly could have been obtained with improved computational capability. In fact, a 27% improvement was obtained by using a virtual Windows machine with 20 core CPU and 32 GB RAM provided by the National Socio-Environmental Synthesis Center (SESYNC).

4. MODEL VALIDATION
The validation was done focusing on the MSTM-TRANSIMS statewide model. Three datasets were used for validation: daily and hourly traffic volume counts and Maryland SHA’s Highway Performance Management System 2007 (HPMS) estimates of vehicle miles traveled (VMT). The model validation was conducted at both the macro (network wide) and micro (link) levels. At the
network level, Vehicle Miles of Traveled (VMT) and Vehicle Hours of Traveled (VHT) are compared with MSTM results. VMT results are further compared with HPMS data for the State of Maryland. Following network wide level validation, screenline and corridor level results were validated against daily traffic counts at a more disaggregate level. Finally, link level results were compared to 24-hour field count data.

4.1. Network wide Validation
The comparison of VMT and VHT between MSTM-TRANSIMS, MSTM and HPMS results is presented in Table 1. Compared to HPMS VMT value of 173.51 million, TRANSIMS results give a better approximation with 0.33% difference from HPMS and a 13.98% difference from the MSTM. It is interesting that there is relatively a big difference in VMT obtained from TRANSIMS and MSTM, while VHT values are fairly close. The reason for this could be that the TRANSIMS finds routes that are longer but take less time to travel. In each time interval, link travel times are updated based on congestion levels and the shortest paths are updated accordingly. So with travel times updated at every 15 minute interval, the routes may be more realistic.

<table>
<thead>
<tr>
<th></th>
<th>VMT (vehicle miles traveled)</th>
<th>VHT (vehicle hours traveled)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MSTM-TRANSIMS</td>
<td>MSTM</td>
</tr>
<tr>
<td>Total</td>
<td>172,944,424</td>
<td>149,251,620</td>
</tr>
<tr>
<td>%Diff. from HPMS</td>
<td>-0.33%</td>
<td>13.98%</td>
</tr>
</tbody>
</table>

Another potential explanation of the discrepancy might be that “spill-over” trips between time periods are captured in the DTA model and therefore caused higher VMT and VHT. FIGURE 2 shows the number of trips starting at each time period and ending at each time period in a day in a continuous scale. The difference between trip starts and trip over a certain time period is the uncompleted trips remain on the network. In a static model, trips are constrained within their own time period. However, in a continuous DTA, trips in an earlier time period can “spill-over” to the next time period. For example, in the TRANSIMS model, the “spill-over” trips from the a.m. time period to the midday time period are 676,889 (~17.0%) and from the midday time period to the p.m. time period are 859,670 (~15.6%) (See Figure 2).
<table>
<thead>
<tr>
<th>Time Period</th>
<th>Trips Started</th>
<th>Trips Completed</th>
<th>Spillover</th>
<th>% Spillover</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>3,985,413</td>
<td>3,601,209</td>
<td>676,889</td>
<td>17.0</td>
</tr>
<tr>
<td>PM</td>
<td>5,498,286</td>
<td>5,459,362</td>
<td>859,670</td>
<td>15.6</td>
</tr>
</tbody>
</table>

**FIGURE 2 Trip Start and End Time Distribution.**

### 4.2. Screenline Validation

A screenline is an imaginary line across a section of freeway or arterials, used to determine how much volume is entering or exiting a particular area. Three sources of screenline data are used for this study: Baltimore MPO and Washington D.C. MPO screenlines and screenlines of WMDESH (Western Maryland and Eastern Shore).

The comparison of daily screenline volume between TRANSIMS and count data was done at three levels of coverage. The coverage level indicates how many links on a given screenline actually have count data. Level 1 (High) includes screenlines for which at least 75% of links have count data, Level 2 (Medium) includes screenlines on which 50% to 75% of links have count data, and Level 3 (Low) includes screenlines with less than 50% of links with counts. The Level 1 screenlines are considered to be most reliable, while Levels 2 and 3 screenlines are less informative given the higher uncertainty due to missing counts.

The R-square for different coverage level are 0.891 (high, 75%), 0.9042 (medium, 50%-75%), and 0.9687 (low, <50%) respectively. This indicates that TRANSIMS’s results fit count data on screenline level quite well.
4.3. Corridor-based validation

Several corridors in Maryland were chosen for validation against count data, including I-95, Capital Beltway (I-495 Inner/Outer Loops) and US50. TABLE 2 presents the statistical results, namely R-square ($R^2$) and Root-mean-square-error (RMSE) values, obtained for each corridor. The results in TABLE 2 suggest that the TRANSIMS provides consistent results with count data and with the MSTM Cube model at corridor level. Performance on some corridors is better than others. For example, in I-95 and I-495 Outer Loop, the $R^2$ of TRANSIMS are 0.71 and 0.64 and RMSEs are 16,861 and 29,243 respectively. While R-squares indicate that TRANSIMS has a good performance in these corridors, the high RMSE indicates high residuals. One should note that the TRANSIMS model was a proof of concept and needs further calibration. Despite the proof of concept nature, the results are comparable.

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Model</th>
<th>$R^2$</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-95</td>
<td>TRANSIMS</td>
<td>0.71</td>
<td>16,861</td>
</tr>
<tr>
<td></td>
<td>MSTM</td>
<td>0.78</td>
<td>8,729</td>
</tr>
<tr>
<td>I-495 Inner Loop</td>
<td>TRANSIMS</td>
<td>0.51</td>
<td>28,369</td>
</tr>
<tr>
<td></td>
<td>MSTM</td>
<td>0.5</td>
<td>27,311</td>
</tr>
<tr>
<td>I-495 Outer Loop</td>
<td>TRANSIMS</td>
<td>0.64</td>
<td>29,243</td>
</tr>
<tr>
<td></td>
<td>MSTM</td>
<td>0.71</td>
<td>28,340</td>
</tr>
<tr>
<td>US-50</td>
<td>TRANSIMS</td>
<td>0.5</td>
<td>16,908</td>
</tr>
<tr>
<td></td>
<td>MSTM</td>
<td>0.56</td>
<td>15,294</td>
</tr>
</tbody>
</table>

4.4. Link-based Validation

The most significant improvement of the DTA model is the time-variant representation of the travel patterns from network wide to link level. As an example of link level validation, FIGURE 3 (a) illustrates the aggregated 24-hour volumes against traffic counts across all available count locations on freeways. For a network of statewide scale and for a proof-of-concept work, the DTA output volumes represent the temporal traffic volume distributions fairly well on freeway facilities. It shows the fidelity of the DTA model is an improvement over a static model.

Figure 3 (b) further looks into hourly link volume of a single link located on the Baltimore Beltway (I-695). The link volume temporal distribution shows a consistent pattern with count data, with start time and duration of peak hour similar with count data. However, the TRANSIMS results seem to shift later in time compared to the counts during the AM peak on many links with the exception of an I-95 link (please refer to (12) for details). This may be because TRANSIMS adjusts the arrival time of trips based on travel times. Adjusting the departure times with a fixed arrival time may improve the results. In general, TRANSIMS results match with 24-hour traffic counts given the proof-of-concept nature of the project.
5. OUTPUT VISUALIZATION

This section summarizes the tools and methods used in visualizing the outputs of TRANSIMS model. Several visualization examples are presented to demonstrate the visualization methods developed which are a combination of TRANSIMS utility programs and spatial analysis software ArcGIS.

5.1. Network-wide Performance Measures

In order to illustrate how measures like volume and speed change by time-of-day, these performance measures are animated on major facilities using both 2D and 3D effects. Figure 4(a) illustrates a snapshot of a 3D animation where the volume changes by 15 minute intervals. Only major facilities, interstates and expressways were represented in the animation for effective visualization.
Another performance measure animated for 24 hours is Travel Time Index (TTI). TTI is a concept that has been used by the SHA (16). It represents the ratio of congested travel time to free flow travel time and is a common measure to quantify congestion. As shown in Figure 4(b), the traffic congestion in northern I-495 and MD 295 is clearly more severe than the rest of the network in the evening rush hours (17:00 – 17:30).

5.2. Time-dependent Vehicle Paths
At the individual vehicle level, time-dependent path examples are given to demonstrate the capability of the DTA model in tracking vehicles and representing the time varying performance measures such as speed on different segments, which cannot be obtained from conventional trip-based static traffic assignment models. Figure 5 (a) is an example of a time-dependent path in the morning peak. Segments with different colors indicate the vehicle trajectory within 30 minutes. For one specific traveler, we are now capable of analyzing where the traveler was within a specific time interval, how long he/she traveled and how fast this traveler was driving during this time interval.
5.3. Congested Segment Analysis
Figure 6 illustrates an example of congested segment analysis (I-495 Outer Loop). With the help of network wide analysis, congested segments can be identified for further analysis with more detailed measures. The volume and average speed change by time-of-day on this segment (freeway portion highlighted in green) are displayed in figure 6. Morning and afternoon peaks are clearly observed in these figures. The volume increases sharply after 6:00 am, indicating the beginning of the morning rush hours. Corresponding to that, the average speed on this segment begins to fall after around 6:00 am. The dissipation of the evening peak can also be observed.
6. SCENARIO TESTING
In order to test the model capability in evaluating scenarios, two scenarios are identified, an incident and a work zone scenario. However, due to space limitations only the work zone scenario is reported. These scenarios are intended to test short-term and long-term impact analysis capability of the model.

6.1. Work zone Scenario
This scenario tests a work zone on I-95 Southbound causing a one lane closure for long term (e.g. closed all day for several days) on three consecutive links past exit 39 near Scaggsville Road/MD 216. For details users are referred to NCSG, 2014 (12).

We examined how the speed changes at the restricted link and how the travel time varies on the whole I-95 segment compared to the base case. In Figure 7, the graph on the left hand side shows the I-95 segment and the selected link for the travel time comparison. The comparison result is listed in the upper-right graph. The travel time goes up in this corridor because of the one-lane-closure in the work zone. In the lower-right graph, the speed on the restricted link is dramatically reduced compared to the normal condition.
These preliminary test results suggest that MSTM-TRANSIMS is capable of analyzing operational scenarios. However, further scenario testing and results analysis is needed to better understand the behavior of the models. Generally, we observe that the models provide results which would be expected. Thus, it can be concluded that the method presented is suitable for policy analysis compared to detailed operational micro- or mesoscopic models providing a cost-effective large-scale policy impact analysis.

7. CONCLUSIONS

This paper demonstrates two major accomplishments; using existing statewide models and data sets to develop a DTA and showing that the DTA can provide greatly improved information on temporal characteristics of travel within the state. The statewide travel patterns can be represented in a continuous day with higher time resolution i.e. 15 min intervals (can be finer as well). In addition, by tracking individual vehicles and travelers, a much better picture of travel characteristics and temporal characteristics are obtained. It also demonstrated the scenario analysis capability with higher temporal resolution.

Many other issues can be better addressed by the DTA. While not specifically tested in this study, policies which deliberately affect/ target the time-of-day of travel can easily be tested. These include reversible lanes, HOV lanes and lane restrictions by time-of-day. When compared to static assignment, the DTA provides a better picture of the location and duration of congestion. Using the DTA the build-up of congestion in anticipation of the peak hour, and the spillover of traffic from the peak hour to off peak hours can be estimated. The DTA provides a more accurate picture of how long it takes to complete a trip, during which time of the day the trip occurs and the speeds for different components of the trip. In addition to providing better
information on the temporal aspects of travel, the DTA tracks the travel of individual vehicles and trip makers, estimating the routes and speeds. This provides a more accurate estimate of the impacts of different actions and conditions.

However, many challenges were faced. The large size of the MSTM Cube model made network and demand conversion somewhat cumbersome. The large data files required high storage and hard drive processing capacity. The model size also made model debugging challenging due to difficulties in processing the large files, visualizing the results and long run times. The visualization needed to be done using ArcGIS, outside of TRANSIMS platform, typically after processing output files in TRANSIMS environment.

While this study provided a major improvement in the ability to analyze travel, it also required greater computing power to run the DTA. However, computers continue to evolve and with computing speeds continually increasing, we can expect continual improvements in computing hardware and software in the future, making for faster and faster DTA run times.

The results demonstrate that DTA can be an effective tool in statewide transportation planning. However, we recommend that the potential users be aware of the challenges of such an effort. Attention must be paid to identify the type of questions an agency needs to be answered, what type of scenarios they need to conduct and whether a statewide DTA model is a suitable tool to address those questions or not. The size of the planning model determines the computational requirements, thus the agency needs to consider computational resources and technical staff expertise beforehand. It has been our experience that, assistance is needed from the software developer to address unknown challenges that the large model size introduces both related to software and hardware sides. As logical next steps of this research, the process could potentially be incorporated in the standard MSTM run. There needs to be more focus on understanding the trips that ‘spill’ into the next time-of-day period.

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