DYNAMIC TRAFFIC ASSIGNMENT IN REGIONAL TRAVEL DEMAND MODELS: THE FUTURE IS NOW

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ABSTRACT
Most regional travel demand models assign traffic to roadway networks using static traffic assignment (STA) models. However, it is well known that STA does not model congested networks well because each roadway segment in the model is treated independently. Dynamic traffic assignment (DTA) models represent congestion much better. Using the Austin, Texas regional travel demand model, it is demonstrated that substituting DTA for STA gives much more accurate estimates of peak period freeway traffic volumes and travel speeds. No additional data are needed, and the increased computation requirements are reasonable.

Keywords: Regional Planning, Travel Demand Modeling, Dynamic Traffic Assignment, Congestion, Delay

OBJECTIVES AND MOTIVATIONS

The regional travel demand models developed and maintained by Metropolitan Planning Organizations (MPOs) are used to evaluate transportation alternatives in regional transportation plans (RTP) and for major transportation projects in Environmental Impact Statements (EIS). Congestion and delay measures derived from these models are critical in evaluating system performance.

Most of the MPO travel demand models assign traffic to roadway networks using static traffic assignment (STA) models. This is true even for the new generation of Activity-Based Models (ABMs). While the long-term goal is to combine the ABM demand model with microsimulation, this has not yet been accomplished due to the much greater computer resources required (1). STA models treat each roadway segment as independent. STA models have no queues and no spillback affecting upstream roadway segments.

> *In a static model, inflow to a link is always equal to the outflow: the travel time simply increases as the inflow and outflow (volume) increases. The volume on a link may increase indefinitely and exceed the physical capacity … as represented by a volume-to-capacity (V/C) ratio > 1… The drawback of using V/C is that it does not directly correlate with any physical measure describing congestion (e.g., speed, density, or queue (2)***.**

Dynamic traffic assignment (DTA) models have been developed that have intermediate computer processing requirements between STA and microsimulation. A 2012 reference on modeling practice states: "The DTA methodology offers a number of advantages relative to the STA methodology, including the ability to address traffic congestion, buildup, spillback, and oversaturated conditions through the explicit consideration of time-dependent flows and the representation of the traffic network at a high spatial resolution" (1).

Studies that have compared STA and DTA for the same case study have found large differences in model performance measures. Boyles et. al. concluded: "The results indicate that traditional static models have the potential to significantly underestimate network congestion levels in traffic networks, and the ability of DTA models to account for variable demand and traffic dynamics under a policy of congestion pricing can be critical" (3). In a study of choice between managed lanes (ML) and general purpose lanes (GPL) by the Florida Department of Transportation, it was concluded that: "the difference in the travel time of using the GPL or the alternative ML, and the resulting number of travelers that decide to choose the ML, is considerably underestimated by static assignment" (4). In previous research, I compared STA and DTA estimates of vehicle delay and other congestion metrics in simple test networks and concluded that STA: "cannot accurately estimate vehicle delay or other congestion metrics in congested urban networks", and "should be replaced with DTA in regional travel demand models as soon as possible" (5).

The primary obstacles to making this change are concerns about resources, including data requirements and computing time. In this research, DTA is substituted for STA in a typical regional travel demand model for the Austin, Texas region with an emphasis on practicality.

METHODOLOGY

The Austin regional model is maintained by the Capital Area Metropolitan Planning Organization (CAMPO). The model has a 2010 base year and was completed in 2014 (6). The model is implemented in TransCAD. It covers 6 counties with 1.7 million population in 2010. The model has 2102 internal and 58 external Transportation Analysis Zones (TAZ). The CAMPO model is a 4 step model with 4 time periods. The model structure is shown in Figure 1.

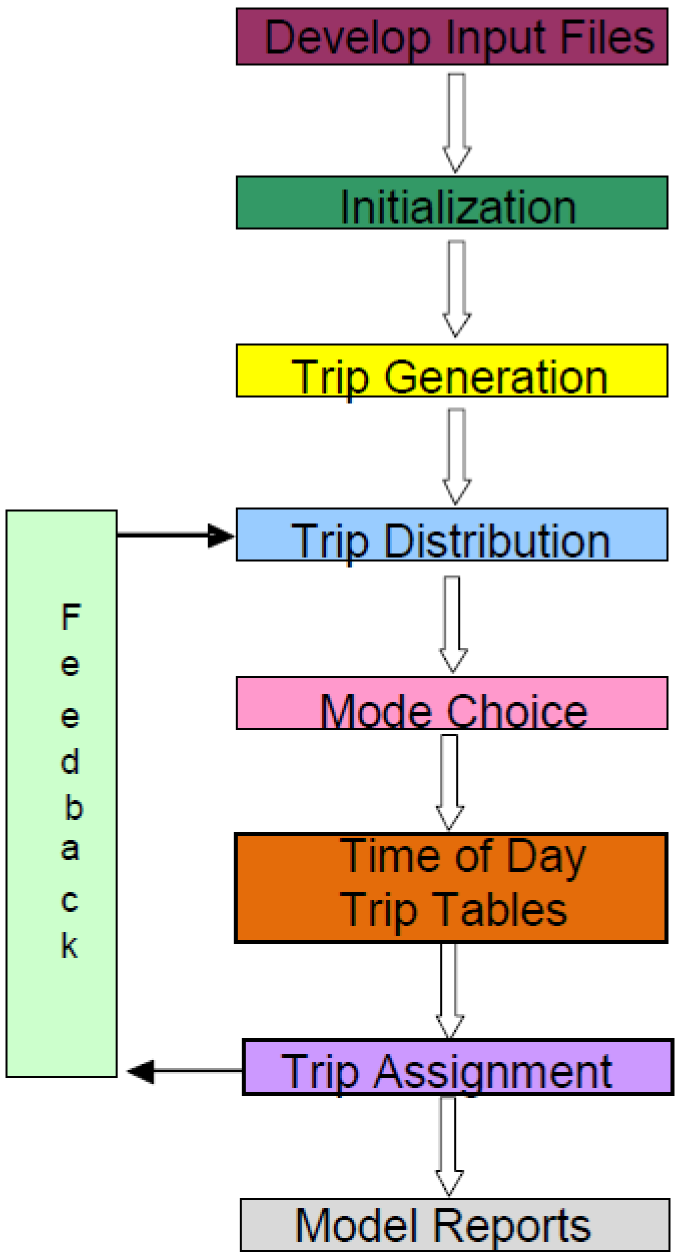

FIGURE 1: CAMPO Travel Demand Model Structure Reproduced from (6)

In this research, the model structure is kept the same as shown in Figure 1 except for substituting DTA for STA in the “Trip Assignment” step. Java software was developed to automate the exchange of data between the TransCAD model components and the DTA component.

DTALite software (7) is used for DTA. The DTALite developers state: “DTALite, an open-source mesoscopic DTA simulation package, in conjunction with the Network eXplorer for Traffic Analysis (NeXTA) graphic user interface, has been developed to provide transportation planners, engineers, and researchers with a theoretically rigorous and computationally efficient traffic network modeling tool” (8). STA models are “macroscopic” with no representation of individual vehicles. Microsimulation models are “microscopic” with full representation of individual vehicles. DTA models including DTALite are “mesoscopic” and represent vehicle behavior using aggregates. DTALite uses a queue-based approach (8). The tests described below were done using the DTALite default Newell’s kinematic wave model.

DTA can be implemented at a very fine level of detail. However, in this work the emphasis is on practicality. Simplifications include:

1) Only network data already in the CAMPO model is used.
2) Intersections are not modeled explicitly.
3) Each of the four CAMPO time periods is modeled in abbreviated form as a 90-minute simlulation with 30 minutes of initial seed time followed by a 60-minute analysis period

MAJOR RESULTS

This paper reports on the first stage of this work – using DTA to assign the vehicle trip tables from the final CAMPO model feedback iteration. Work is currently underway to fully integrate DTA into all of the feedback stages, and this work will be reported on at the conference.

In previous work, I documented that STA systematically overassigns traffic to urban freeways during congested periods (5). As expected, this issue is present in the Austin STA model. I-35 is the major roadway in the Austin region. In downtown Austin, I-35 has three or more freeway lanes in each direction plus three or more frontage lane roads in each direction. Widening and reconfiguration is being planned. Figure 2 shows the existing cross section at the Ladybird Lake bridge just south of downtown Austin. This bridge is one of the most critical links in the regional road network.

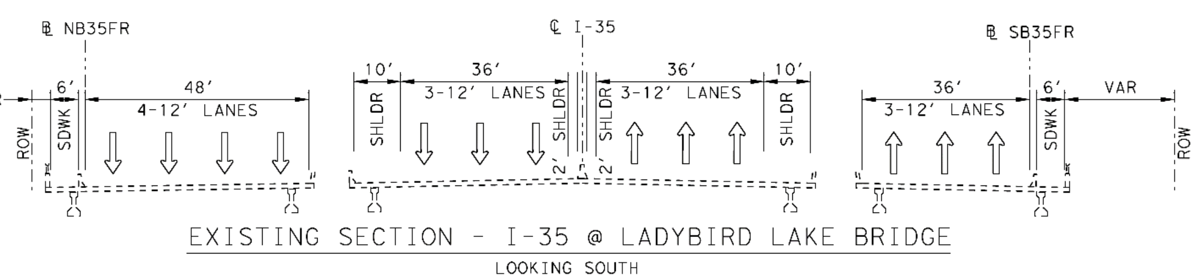

FIGURE 2: I-35 Cross Section at Ladybird Lake Bridge Reproduced from (9)

The information company INRIX uses data collected from vehicles to calculate congestion throughout the world on both a regional basis and a corridor basis. The INRIX list of the most congested corridors in the world includes 7 sections of I-35 in the Austin region. The most congested of these (24th most congested in the U.S.) is a 5-mile segment that includes the Ladybird Lake bridge (10).

Figure 3 compares peak period STA and DTA assignment for the Ladybird Lake bridge using the same vehicle trip tables. STA assignment greatly overassigns traffic (relative to traffic counts) in both directions during both the morning peak period (6-9 a.m.) and the afternoon peak period (3:30 – 6:30 p.m.).

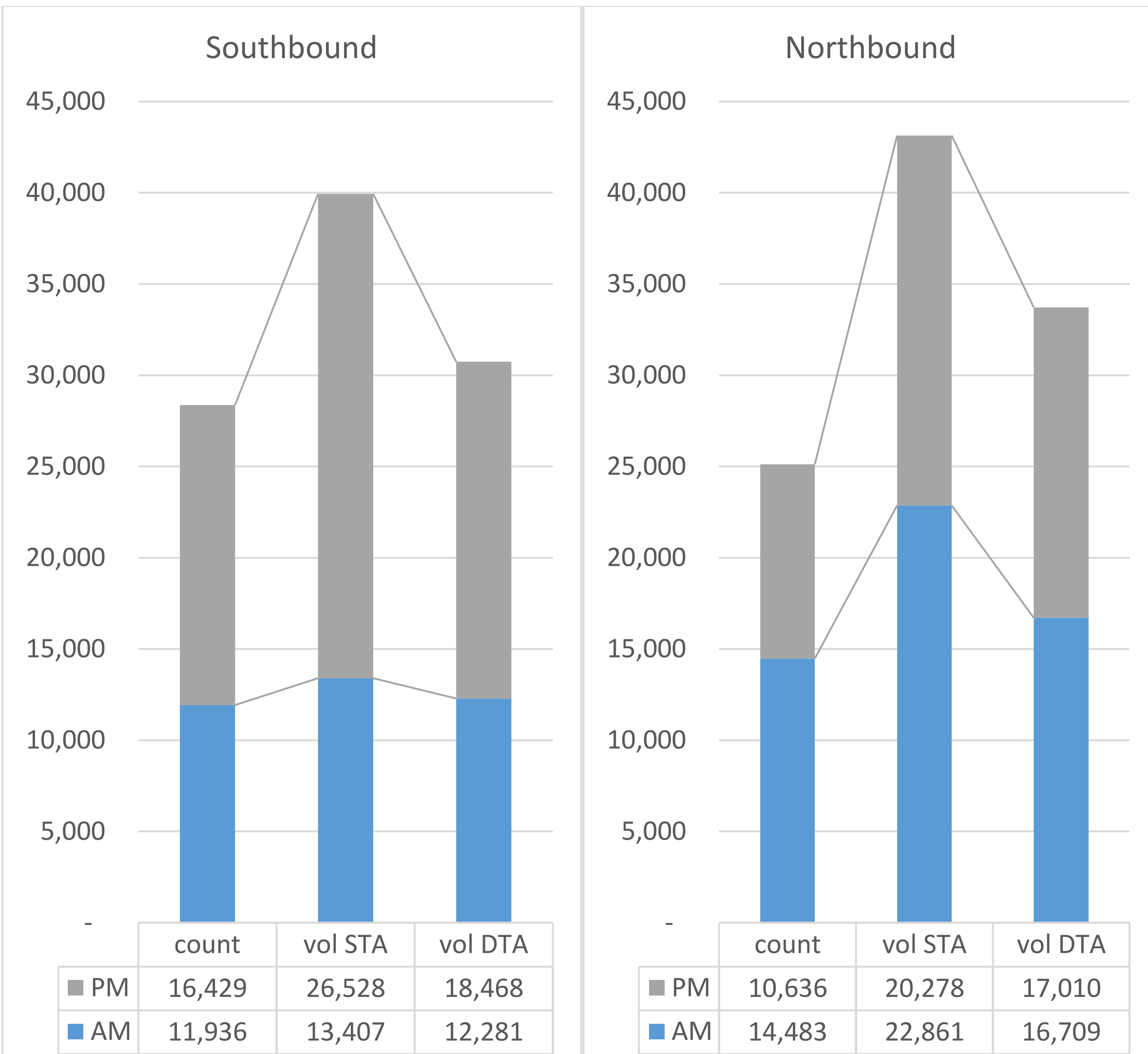

FIGURE 3: 2010 STA and DTA Assignment for I-35 on Ladybird Lake Bridge (summing freeway and frontage lanes for 3-hour morning and 3-hour afternoon peak periods)

To a lesser extent, the DTA assignment also overassigns traffic. However, the DTA assignment used the same vehicle trip tables as in the STA assignment. With appropriate feedback including DTA travel times, the DTA assignments would be considerably lower. This can be illustrated by comparing modeled travel speeds. For the 5-mile section northbound from Texas 71 to Martin

Luther King Boulevard (the 24th most congested corridor in the U.S.), INRIX gives an average afternoon peak travel speed of 20 mph The STA model gives an average travel speed of 39 mph for the afternoon peak period, even though the model is overestimating traffic on the Ladybird Lake bridge by 91% compared to the traffic count. This combination of greatly overestimated travel volume and greatly underestimated speed demonstrates that the STA model is incapable of giving a proper feedback signal In contrast, the DTA model estimates a speed of only 12 mph This is lower than the INRIX value of 20 mph but this is reasonable because the traffic volume assigned is too high. With feedback from the DTA travel times, both the peak traffic volume and travel time would be reduced in the model.

IMPLICATIONS FOR THE PRACTICE OF TRAVEL MODELING

Regional Transportation Plans (RTP) and roadway Environmental Impact Statements (EIS) rely on static assignment models for future years that are typically 20 to 25 years in the future. In larger U.S. regions, these horizon year models typically show many important roadway links over capacity. Here is an extreme example from a 2015 Draft EIS for a proposed tunnel in southern California, the SR 710 North Extension Project (11). For I-710 northbound at I-10 (the primary upstream source of northbound tunnel traffic), model files for 2035 for the full tunnel alternative show an average traffic volume of 2214 vehicles per lane per hour for the 13-hour period from 6 AM to 7 PM which exceeds the capacity of the roadway. If there was such a traffic volume and there were no alternative routes, queues and delays would get increasingly longer throughout the day. Instead, the static model assumes that all the traffic will pass through the section with a delay of about a minute and a half. The EIS uses these incorrect traffic volumes and speeds to evaluate the alternatives.

In cases like this tunnel study, future traffic demand would be much lower than modeled with STA. When future static models show volumes exceeding capacity on important links, the first conclusion that should be drawn is that the model is wrong. The traffic volumes shown are impossible, and also outside the range of traffic volumes that were observed in model validation. The second conclusion to draw is that if traffic volumes are anywhere near as great as shown, then delays are greatly underestimated because of the model's failure to account for queues. Furthermore, these delays will be concentrated in bottlenecks that STA is not well equipped even to identify.

The growing practice of linking STA outputs to microsimulation tools does not address these deficiencies. The underlying traffic volumes used in the microsimulation model are taken from the STA. When these STA results include over-capacity links (which cannot be modeled in microsimulation without queues of ever-increasing length), the problem generally has been addressed inadequately in one of two ways. Most commonly, the scope of the microsimulation is constrained to the project area where sufficient capacity is assumed. In these cases, issues about unrealistic upstream and/or downstream traffic volumes are not addressed. The other approach is to arbitrarily scale down the STA traffic volumes so that the traffic can be simulated. Neither approach results in realistic network traffic volumes.

Instead, it is strongly recommended that DTA be substituted for STA and integrated into regional travel demand models. As demonstrated above, this substitution does not require additional network detail (although that could be added at a later date if desired). The computer computation requirements are manageable. The CAMPO model with STA and feedback takes about 12 hours to complete the 2010 simulation with a quad-core computer (5). Substituting DTA for all feedback steps likely will increase this time by a factor of about 3 to 4 (depending on the protocol uses). However, this time difference could be made up simply by substituting a workstation with 16 cores at a cost of under $5,000. Workstations with up to 64 cores running Windows are now available.

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