Session #4

SIMPLIFIED 4 - STEP TRANSPORTATION PLANNING PROCESS FOR ANY SIZED AREA

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ABSTRACT

This paper presents a streamlined version of the Washington D.C. region's 4-step travel demand forecasting model. The purpose for streamlining the model was to have a model that could:

- Replicate the regional model, and
- Be run in a new software, TP/4in1, that executes the entire 4-step process in one execution on a PC.

The streamlined model is similar to, but more simplified than, the regional MPO model, with one major difference. The trip generation and mode split steps result in a trip generation rate of 10.0 vehicle trips per detached household for the suburban/rural trip rate. This is more in line with that of smaller communities and yet much higher than the traditional MPO trip rate for larger areas.

The model is now being used for travel forecasting for rural and small communities, such as Fauquier County, Virginia, (55,000 population in 1995) on the urban fringe. This model can be adjusted to local area surveys or used "as is" for any sized area, large or small. Using this model makes executing the traditional 4-step modeling process quite easy, even for the novice model practitioner. This article also describes, very briefly, the new software developed to execute this model and is available for free to any public agency.

INTRODUCTION

Since the passage of the Clean Air Act Amendments (CAAA) of 1990 and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, the travel forecasting process has evolved into a very comprehensive and complex process. Prior to 1990, many travel forecasting models were run on IBM mainframe platforms that required about 20% of one's study budget just for the data processing charges. Because they were so expensive to run and because of the lack of funds to improve them, these models were simple and straight- forward. As a result, they could be executed by just about any transportation modeler having access to a mainframe computer. One serious flaw with these models was their inability to address peak hour conditions and speed feed back; e.g., having congested speeds used in trip distribution and mode split.

With the passage of ISTEA, the pendulum has swung in the other direction. Money flowed to Metropolitan Planning Organizations (MPOs) to increase staff and hire consultants to improve these models to address many policy sensitive variables, air quality issues, for use in major investment studies (MIS) and other regional studies. As a result, these new models can now address almost any transportation forecasting issue including forecasting usage for heavy rail, light rail, rail access, express bus, priority bus, fare changes, parking cost changes, HOV-2 facilities, HOV-3 facilities, and HOT (high-occupancy lanes plus toll) lanes. While these models can now perform all these great and wonderful functions, they are so complex that very few regional modelers in any one region can run them. They are also very time consuming making them infeasible to use for smaller subarea studies requiring turn-around times of only a few weeks. What has been ignored over the past few years during the development of these comprehensive MIS-type models, is the need for quick turn-around models that can replicate the MIS models without all the "bells and whistles". A model that can be executed by local jurisdictions for numerous subarea studies in a quick turn-around time frame is needed now, or will be soon, by just about every MPO in the country.

A few years ago, the Northern Virginia District office of the Virginia Department of Transportation (VDOT) saw the need for this type of subarea model for the Northern Virginia subregion of the Metropolitan Washington Council of Governments (MWCOG) region and began model formulation and calibration. Since its development about one year ago, it has been used extensively. The new subarea model is called the VDOT model and is a streamlined version of the MPO/MIS model. New software was developed to run the VDOT model. It is called TP/4in1. This is a DOS based (soon to be Windows 95-based) stand alone software. The software executes the 4-step process in one execution on the computer and does it using network and zonal data from the Washington DC regional model, with 2211 zones and 17,000 nodes. For the Washington region the model executes the entire 4-step process in about two hours on a Pentium 133 Mhz PC.

It is these authors' opinion that every MPO in the country, large and small, currently needs two types of models:

⇒ a regional/MIS type model, to address numerous policy sensitive variables.
⇒ a subarea/suburban type model, calibrated to the same highway network as the regional model, that produces results similar to the regional model and can be run in one execution on a PC computer with minimal set-up time.

This article describes the VDOT model (a streamlined 4-step process) which can be used as a default model for any sized metropolitan area anywhere in the US. It is currently being used for several counties in Northern Virginia studies and other jurisdictions in Virginia. In addition, it is being used as the modeling tool for the development of the 2020 Northern Virginia Transportation Plan (a long- range plan for the region to guide VDOT and local comprehensive planning). This model could be used, as is, in other areas around the country or modified to replicate any region's MPO/MIS model.

TP/4in1 Software

Traditional 4-step travel demand models execute each of the steps sequentially but independently using specific driver files or control files. In most calibrations, validations and area studies, all of the steps must be run with many auxiliary computer runs in each step. TP/4in1 is software designed to execute a streamlined four-step model chain in one execution on an IBM compatible PC computer. It can also be stopped and restarted after each of the steps if desired. Full documentation of the software is provided in the report *TP/4in1, Volume II, Users Manual, March 1997*. TP/4in1 is software that was developed by William W. Mann, P.E., for use by VDOT and any local jurisdiction in the Washington, DC region. The software will be made available to public agencies at no cost once the software has been completely de-bugged. Hardware requirements are Pentium with 16 MB RAM minimum.

TRAVEL DEMAND MODELING PROCESS FOR VDOT MODEL

The Subregional VDOT model executes essentially the same 4-step process as the MPO model and is calibrated to the same area (Maryland, D.C. and Virginia) as the MPO model. The modeled area is shown in Figure 1. The complete modeling process is shown in Figure 2. This figure also shows the INPUTS and OUTPUTS. The four basic model steps in this process are as follows:

- Trip Generation Model
- Trip Distribution Model
- Mode Split Model
- Trip Assignment Model

Each of these submodels is described below:

Trip Generation Model

The development of the trip generation model began with modifying the MWCOG trip generation model. Over the years, numerous traffic counts have been taken in the suburbs, which showed average trip rates for these areas to be 10 vehicle trips per household per day for single family detached homes. These trip rates were measured by counting traffic on roadways with only one access/egress point from the arterial roadway to/from the residential area. In some cases; e.g., in Loudoun County, these rates were as much as 14 vehicle trips per household per day. Thus, one of the stipulations of this new model for subarea applications was to calibrate the model to 10 vehicle trips per detached household in the suburbs, with a descending trip rate for areas with higher densities. This rate is considerably more than the regional MWCOG models.

The VDOT Model applies the trip rates at the 2211- zone-level based on an Area type (density) system, rather than at the 293 District level, currently employed by MWCOG. However, the same four trip purposes presently used by MWCOG are employed, namely:

1) *Home Based Work (HBW)* production and attraction *person* trips based on households, group quarters and total employment by zone by Area Type (density).
2) *Home Based Shopping (HBS)* production and attraction *auto* trips based on households, group quarters and retail employment by zone by Area Type (density).
3) *Home Based Other (HBO)* production and attraction *auto* trips based on households, group quarters and office, retail, and other employment types by zone by Area Type (density).
4) *Non-Home Based (NHB)* production and attraction *auto* trips based on office, retail, and other employment types by zone by Area Type (density).

Note that only the HBW trip rates are defined for person trips requiring application of a Mode Choice Model. The other trip purposes are defined as auto driver trips. This is the same process used by MWCOG. The final trip generation rates are shown in Table 1.

Table 1

Weekday Trip Generation Rates

	Productions					Attractions				
HBW-Person										
	Reg. Core	Urban	Fringe	Suburb	Exurb		Reg. Core	Urban	Fringe	Suburb
HH	1.70	1.75	1.93	2.45	2.15	Total E	1.70	1.40	1.40	1.40
GQ	0.26	0.15	0.15	0.15	0.15					
HBS-Auto										
	Reg. Core	Urban	Fringe	Suburb			Reg. Core	Urban	Fringe	Suburb
HH	0.09	0.43	1.33	1.67		Retail E	0.30	2.12	5.41	6.88
GQ	0.04	0.26	0.29	0.34						
HBO-Auto										
	Reg. Core	Urban	Fringe	Suburb			Reg. Core	Urban	Fringe	Suburb
HH	0.35	0.87	3.41	3.80		Office E	0.14	0.28	0.27	0.57
GQ	0.26	0.70	1.27	1.22		Retail E	1.49	1.90	3.71	3.30
						Other E	0.74	1.18	2.90	3.20
						HH	0.36	0.46	0.69	0.63
NHB-Auto + Light Trucks								.		
	Reg. Core	Urban	Fringe	Suburb						
Office	0.12	0.16	0.31	0.52						
Retail	1.03	2.36	5.13	4.76			Same as productions			
Other	0.23	0.29	0.64	0.63						
HH	0.19	0.14	0.21	0.23						

Notes:
HH : Households
E : Employment
GQ : Persons in group quarters
Exurb : Any rural portion of the suburb for HBW only

Trip Distribution Model

The spatial trip distribution gravity model was calibrated using separate procedures for work and non-work trips. Work person trips were calibrated to match Census jurisdiction-to-jurisdiction trip tables. Non-work trips were calibrated to match ground counts iterating the process shown in Figure 2. Trip generation rates were fixed while the F-curves were adjusted to alter trip lengths to ultimately match ground counts. This approach was used because of more confidence in the measured household trip generation rates than in either the home-interview trip generation rates or the home-interview trip length frequency distributions. And, more specifically, the authors believe that interviewees in travel surveys under-report short trips to a greater extent than long trips and may even inflate the long trips reported for a typical "yesterday".

Total travel times used in the gravity model trip distribution model are the sum of highway terminal times, vehicle access times, highway network travel times and intrazonal travel times. Vehicle terminal times were derived from MWCOG's destination times. Network travel times, as processed by TP/4in1, are based on link distances and a look-up table for speeds by facility type and area type. Link speeds are then modified based on each link's capacity and user specified

Speed Delay Functions calibrated to the region. Intrazonal speeds are determined using a nearest neighbor technique available in TP/4in1.

For the nearest neighbor technique an 80 percent factor was used for both intrazonal distances and times. The derived intrazonal distances in TP/4in1 are used in estimating average trip lengths by trip purpose but are not accumulated in estimating network VMT.

The gravity model estimates travel between internal-to-internal zones, internal-to-external zones, and external-to-internal zones in one gravity model execution by trip purpose. In calibrating this model for the Washington, D.C. region, very steep friction factors were needed for the external stations along the Baltimore fringe. Figure 1 shows the cordon line adjacent to the City of Baltimore. In typical regions where the cordon line is located in the rural areas, the model can be calibrated with one regional F-curve. With the Washington D.C. region's cordon line following the City of Baltimore's fringe, trips crossing the Baltimore external station required special (short trip length) F-curves to calibrate.

Mode Split Model

The third step in the travel forecasting process is the mode split model and is presently applied to work trips only in the Washington region. The mode split factors for all forecast years were taken from MWCOG and are not explicitly modeled by TP/4in1. For this reason, they are referred to as "Freeze Dried Mode Split Factors". A regional factor is used to calculate the auto driver trips from the HBW person trips derived in Trip Generation. These factors can be modified to reflect the impact of express bus, light rail, heavy rail or HOV lanes. Techniques to model these freeze-dried modal split factors are currently being developed and refined as part of a study to develop a multi-modal transportation plan for all of Northern Virginia.

Trips Not Modeled

Trips not modeled were taken from MWCOG for all forecast years and added to the VDOT model results to obtain total vehicle trips. The categories of trips not modeled are:

1) Total truck trips in the Region
2) Miscellaneous trips in the Region including taxi, visitor and school type trips
3) Through trips that travel from external station to external station; that is, trips with neither an origin nor a destination within the cordon line.

Vehicle Trip Assignment Model

Following the trip distribution and mode split steps; the resultant production and attraction format trip tables for each trip purpose are added together by TP/4in1 and balanced using the MWCOG procedure. A single factor is applied to internal attractions to make total productions (internal plus external) equal total attractions. Next, this table is converted to true origin and destination of individual trips based on a 50 percent split in both directions. This approach is suitable for two-way trips in a 24-hour model.

For the trip assignment process, TP/4in1 uses four iterations of the incremental capacity restraint loading of the trips onto the highway network. Each incremental loading adds 25 percent of the total trips to the network. The 24-hour capacity constraint on individual links is based on the 2KD factors and peak hour LOS-C speeds and capacities.

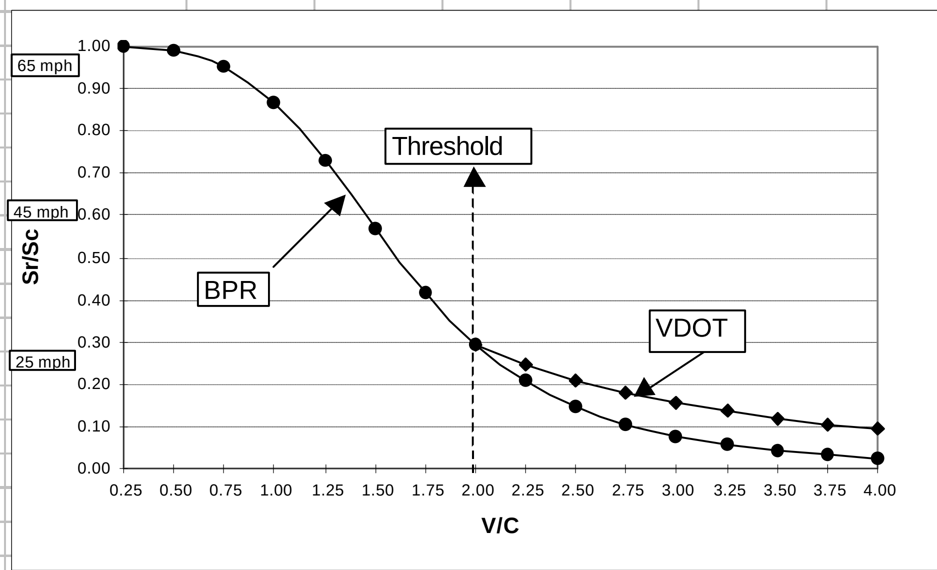
Speed Flow Relationships

Reductions or increases in link speeds, calculated for each successive iteration, are estimated for each path by relating congestion, defined by the volume-to-capacity ratio (V/C), to changes in speeds.

The VDOT Model applies a modified Bureau of Public Roads (BPR) equation to relate speeds at LOS-C to restrained speeds based on changes in V/C ratios. Figure 3 shows the standard form of the BPR equation and the calibrated curve used in the VDOT Model. The modified BPR curve uses a typical fourth power function up to V/C of 2.0 and a second power function for V/C ratios above 2.0. Calibration revealed that this flatter curve is more appropriate when V/C's exceed 2.0. The flatter curve for V/C ratios exceeding 2.0 not only produced better traffic assignments, but the final speeds matched the input gravity model speeds, which was one of the objectives for the model calibration. Federal rules require that gravity model input and traffic assignment output speeds in non-attainment areas be similar or a speed feedback procedure must be used. Thus, the typical speed feedback for the Washington region was not necessary.

Simulated VMT versus ground count VMT were compared across several screenlines and by jurisdiction, facility type and area type. The results showed no model biases in these comparisons after many iterations of model adjustments. At this point, the model was considered calibrated.

Figure 3
Speed Flow Relationship



BPR CURVE V/C < 2.0 : Sr = Sc*1.15 / [1.0 + 0.15(V/C)4]**
VDOT CURVE V/C > 2.0 : Sr = Sc*1.15 / [1.0 + 0.60(V/C)2]**

Where:

Sr = Restrained Speed (Congested Speed)
S_C = Speed at Practical Capacity (Level of Service "C")
V = Volume
C = Practical Capacity (Level of Service "C")

SUMMARY

In brief, some of the features and advantages of the VDOT Model are as follows:

1. Designed as a detailed regional model with up to 2250 zones, 17,000 nodes and multiple trip purposes.
2. Based on the new MIS model network link attributes.
3. Develops trip generation, mode choice and trip distribution on a zonal basis.
4. Capacity to run speed feedback loops, select link analysis, screen line summaries and VMT summaries.
5. Ability to implement link and node delay capacity restraints as well as turn volumes for traffic assignment.
6. Numerous formatted outputs; e.g., trip ends by purpose; trip length frequency distributions by purpose; formatted squeezed trip tables by purpose; and VMT by area, jurisdiction, V/C ratio, and speed ranges.

More importantly, TP/4in1, can run the entire standard 4-step transportation planning process (such as the VDOT model) in one execution on a PC computer, or it can be used to run each step separately.

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