Comments on TPB Travel Models and Emissions Post-Processor

Background Information

Under Item #2 of the October 1, 2004 meeting of the TPB Technical Committee, TPB staff briefed the Committee on a mailout item entitled “Status of the TPB Regional Travel Model, Version 2.1D, Draft #50” which had been presented and publicly released at the September 17 meeting of the TPB Travel Forecasting Subcommittee. Between the September 17 Travel Forecasting Subcommittee meeting and the October 1 Technical committee meeting TPB staff received requests for the Version 2.D, Draft #50 model and data sets related to the public release of the model and provided these materials to the following agencies and organizations, all of whom were represented at the September 17 meeting: WMATA, Fairfax County Department of Transportation, Montgomery County Department of Park and Planning, and Environmental Defense/Smart Mobility, Inc. Following the October 1 TPB Technical Committee, TPB staff received an additional request from, and provided these materials to, the Prince George’s County Planning Department.

Following the presentation on the Version 2.1D Draft #50 model at the October 1 meeting, TPB staff distributed a handout entitled “Status of the Emissions Post-Processor for the TPB Travel Model, Version 2.1D, Draft #50”, and gave a presentation based on this handout. At the conclusion of this agenda item, TPB staff announced that copies of a CD-R containing the revised mobile emissions post-processor model were available for any attendees who wished to take them. Copies of the CD-R were provided at the meeting to Michael Replogle of Environmental Defense and to Tim Nutter of the Northern Virginia Transportation Alliance.

Under Item #3 at the October 1, 2004 meeting of the TPB Technical Committee, TPB staff briefed the Committee on the results of the air quality conformity assessment for the 2004 CLRP and the FY2005-2010 TIP, which included two alignments for the Inter-County Connector (ICC) in Maryland. Staff answered questions on the revised land use forecasts used in the conformity analysis to reflect the inclusion of the ICC, and on the peak and off-peak toll values for the ICC that were included in the analysis. TPB staff also responded to questions about a “no-build” scenario excluding the ICC by pointing out that no such analysis was conducted as part of the conformity analysis, but that a comparable analysis without the ICC was included in the Regional Mobility and Accessibility Study to be discussed under Item #7 of the October 1 Technical Committee agenda.

The October 1 TPB Technical Committee meeting and the TPB Steering Committee meeting that followed at noon provided for the release of the information on the conformity analysis for a public comment period that ran through October 31, 2004. During that period almost 1200 comments were received on various aspects of the air quality conformity, 2004 CLRP and FY2005-2010 TIP process. The comments on the travel forecasting and emissions post-processing aspects of the process and recommended responses are summarized below:

26. Comment: The TPB model continues to systematically underestimate traffic on the region's roadways that carry the most traffic, and overestimate traffic on the lowest volume roadways by large margins. This is revealed in the comparison of simulated to observed traffic for over 11,000 links grouped by traffic volume class and facility type.

    Response: This comment is based on an analysis of the data presented in Exhibit 9-4 in the COG/TPB Travel Forecasting Model, Version 2.1D Draft #50, Calibration Report, September 17, 2004. The analysis does not support the conclusion stated in the comment. Careful consideration of the quality and quantity of these data is needed before conclusions are drawn from them, as discussed below.

    The data shown in the average observed volume column in Exhibit 9-4 do not represent actual counts of daily traffic taken on 11,000 link segments of the regional highway network, but rather represent factored estimates of average daily traffic volumes based on continuous traffic counts taken at a very limited number of permanent counting stations located throughout the states of Maryland and Virginia and in the District of Columbia. In 2000, there were only 57 operational permanent counting stations in the TPB modeled area (57 stations with daily counts taken in each direction equals 114 links with continuous daily traffic count data).

    The specific locations of these permanent traffic counting stations have been selected as part of statewide samples designed to produce estimates of various traffic statistics required for the federal Highway Performance Monitoring System (HPMS), as well as to serve the needs of other state DOT traffic monitoring activities. Because the number and locations of these permanent traffic counting stations were designed as part of a statewide sample, as opposed to one designed for a specific metropolitan area, some variation or "noise" is introduced to the estimates of average daily traffic volumes for other links of the regional highway network where daily, seasonal, and annual growth factors computed from the permanent counting station data are applied to one or two-day traffic counts taken on these other links. Additionally, it is not unusual for these factors to be also applied to limited duration traffic counts taken 1, 2, or 3 years previously in estimating a “current” year traffic volumes for many regional highway network links.

Another source of variation or “noise” in the estimation of average daily traffic volumes is the large variability of daily traffic itself. Based on analysis of Maryland permanent traffic count station data, about one-third of the time a weekday traffic count taken on a specific highway network link on a particular day will be 10% to 15% higher or lower than the actual average annual weekday volume for that link. The application of daily, seasonal, and annual growth factors to such single day counts can further amplify the “noise” in the average daily traffic volumes estimated for particular links.

The data in Exhibit 9-4 show a generally good fit between the “observed” estimates of average daily traffic volumes and the “estimated” average daily traffic volumes produced by the Version 2.1D Travel Model for most facility types and volume ranges. The comment, however, focuses on a few values at the high-end of the volumes ranges, and concludes that the model underestimates volumes for the regional highway network links with the highest “observed” volumes.

With regard to the freeway high volume category, the 20 links reported in this range actually represent only five roadway segments in the region: two Capital Beltway locations in Maryland, two Beltway locations in Virginia, and one location on Shirley Highway (I-95). This totals 20 link observations because freeway links are directionally coded, and also because links happen to be ‘split’ between interchanges in the base year 2000 network to simplify database management procedures for forecast year conditions. Further, none of these 20 highest “observed” volumes is an actual count from a permanent traffic counting station. All of these “observed” volumes are either factored estimates of average daily traffic volumes developed from continuous traffic count data at other locations or are “uncounted manual” estimates.

RMSE statistics (root mean square error is a value used to measure a model’s ability to match observed traffic, i.e., a smaller value indicates less error) are published on page 9-6 of the September 17, 2004 calibration Report for the Version 2.1D travel demand model. The table shows an overall score of 47%, which is in keeping with such statistics reported by other, similar scale MPOs across the United States. The trend in RMSE percentages for low volume to high volume facilities is also reasonable, i.e., there is less error associated with higher volume. For example, RMSE declines from a high of 75% for collectors, to 66% for minor arterials, to 47% for major arterials, to 37% for expressways, and to 28% for freeways.

27. Comment: "The transportation model is run in a manner that does not properly balance its books to produce sound, consistent, and repeatable estimates of travel time and traffic flows. In technical terms it fails to reach equilibrium conditions. This likely causes the model to overestimate future traffic volumes on congested roadways."

Response: TPB staff believes that the overall convergence achieved by the model is more than adequate given the level of accuracy of the input data and traffic count data available. The last sentence of this comment ("This likely causes the model to overestimate future traffic volumes on congested roadways") appears to directly contradict the assertion in comment (26) that "the TPB model continues to systematically underestimate traffic on the region's roadways that carry the most traffic, and overestimate traffic on the lowest volume roadways by large margins".

28. Comment: Value of time is treated highly inconsistently in the model.

Response: There is no basis in the extensive empirical literature for expecting that value of time should be treated in the same way in each step of the travel model. Value of time varies widely depending on the choices being made. Recent guidance from the Federal Transit Administration suggests that the value of time used in mode choice models for work trips should be between 25 percent and 33 percent of the average wage rate, for example, while for toll revenue feasibility studies and traffic assignment models a value of time for work trips of 50 percent of the wage rate is commonly used. Somewhat lower values of time are typically used for non-work trips.

29. Comment: A letter dated September 28, 2004 from Sidley Austin Brown & Wood requested that TPB staff provide to Smart Mobility, Inc. "some basic information connected with the public release of travel model Version 2.1D #50" as well as "a full set of any other models used to calculate emissions for the air quality conformity findings to be released on October 1, 2004, including post-processor and Mobile 6 inputs".

A follow-up letter dated October 26, 2004 from Sidley Austin Brown & Wood noted that the TPB staff response to the September 28, 2004 letter "does not include any Inter- County Connector transportation network data" and asked that TPB staff "provide the requested information regarding the ICC." The October 26, 2004 letter requests that in light of the "delay" in the transmittal of these ICC-related materials the comment period be extended until 30 days following the receipt of these additional materials.

Response: All requests for information on TPB travel models and data inputs are handled through two-way written correspondence, and where these requests are related to public access to or comment on new models and information the correspondence is posted on the TPB website. TPB staff responded promptly to each of the requests made by Sidley Austin Brown & Wood, and provided in each transmittal letter a staff contact telephone number for any follow-up questions on the materials transmitted.

Several requests were received for information related to the travel model Version 2.1D #50 following its public release at the TPB Travel Forecasting Subcommittee meeting on September 17, 2004. The information provided to Smart Mobility, Inc. related to Version 2.1D #50 in a transmittal dated September 29, 2004 is identical to that provided to all of the other agencies which made requests, and includes calibration and validation results for 1994, 2000, and 2030 using the 2030 network from the CLRP adopted by the TPB on December 17, 2003. The additional information requested in the September 28, 2004 letter from Sidley, Austin Brown & Wood related to "any other models used to calculate emissions for the air quality findings" was provided to Smart Mobility in a transmittal dated October 1, 2004.

The "Inter-County Connector transportation network data" used in the air quality conformity analysis released on October 1, 2004 and requested in the letter of October 26, 2004 from Sidley, Austin Brown & Wood was transmitted to Smart Mobility, Inc. on October 27, 2004 by Federal Express priority overnight, and was received by Smart Mobility, Inc. on the morning of October 28, 2004.

30. Comment: The TPB model continues to show sharp differences between the estimated and observed traffic entering and leaving the metro core and crossing the Beltway during the peak periods.

Response: The output of the travel model (before the emissions post-processing step) provides travel by three time periods: am peak (6 am to 9 am), pm peak (4 pm to 7 pm), and off-peak. As noted in the TPB staff response to the TRB Committee's second letter report of May 10, 2004, the travel model is calibrated on regional time-of-day distributions based on 1994 survey data by travel purpose and mode, and does not adjust these distributions over time. Actual traffic volumes and transit ridership during the am peal, pm peak, and off-peak hours as measured by counts in specific locations are influenced by localized factors, such as staggered work hours and peak-spreading, which are not well-represented in data used to calibrate and validate the travel model.

With regard to peak-spreading, the TRB Committee noted in its analysis that the volumes assigned to the two three-hour peak periods and to the eighteen hour off-peak period by the travel model do not always match well with the observed time-of-day distributions developed by TPB staff for use in the emissions post-processor. In particular, the travel model tends consistently to assign too high a proportion of daily traffic to the pm peak period. This may be attributed in part to the fact that the travel model does not adjust the time-of-day trip distributions to reflect the fact that congestion at key locations, directions and times on the transportation system causes some travelers to begin their trips earlier or later, and that this "peak-spreading" increases gradually as congestion increases over time.

To address this peak-spreading issue for the purpose of emissions calculations, the TPB modeling procedures employ a "post-processor" which uses the period specific traffic volumes developed by the travel model to group highway links into nine categories (three facility types by three peaking categories). Observed time-of-day distributions developed for each of the nine categories are used together with the period specific traffic volumes to generate an initial hourly distribution. This hourly distribution is then modified by a procedure that spreads traffic from overloaded hours into adjacent hours to reflect operating conditions for different facility types throughout the region. Emissions are calculated based on these "spread" hourly traffic volumes and corresponding speeds.

In developing the post-processing procedure, TPB staff noted in a memorandum of August 27, 2002 that in the first step of the post-processor "the available observed data could be used to stratify the volumes from the three time periods into hourly volume, instead of stratifying daily volume directly into hourly volume." In its second letter report of May 10, 2004 the TRB Committee stated that this alternative approach should be addressed in the TPB's work program. TPB staff have incorporated this refinement into the updated post-processor presented to the TPB Technical Committee at its October 1, 2004 meeting.

A chart on page 4 of the October 1 Technical Committee presentation shows that the peak spreading function in the post-processor has a significant impact in spreading the pm peak volumes produced by the travel model, but only a modest impact on the am peak volumes. The output of this peak-spreading function provides pm peak volumes at the Metro core and the Beltway that are much closer to the observed traffic than the output of the travel model. TPB staff is continuing to work on fully integrating the post-processor into the travel model to improve the match between estimated to observed traffic in peak periods at the Metro core and Beltway cordon lines.

31. <u>Comment:</u> (a) The TPB model includes the additional 56,000 jobs that the regional planning directors have indicated they think will be included in the region by 2030 with the addition of the ICC to the CLRP, but staff have not in any way accounted for such increased in-commuting in doing the conformity analysis for the CLRP.

(b) The TPB model continues to use overly simplistic assumptions that travel into and out of the modeled region grows by 3 percent a year between 1994 and 2030 – producing 190 percent growth over this time period. This assumption of unconstrained growth is not supported by sound scientific evidence or analysis.

<u>Response:</u> These two statements appear to be contradictory, because they refer to the same net-incommuting growth rate of 3% per year between 1994 and 2030.

The TPB travel model controls on trip productions, adjusting trip attractions to ensure a match between productions and attractions. This is standard modeling practice. The model incorporates the additional 56,000 jobs into the trip attractions, and uses this information in the trip distribution step of the model. This has the effect of directing proportionally more work trips to the locations with the additional jobs, and attracting more in-commuters to the TPB planning area from external jurisdictions such as Howard and Anne Arundel County in the TPB modeled area as well as from jurisdictions beyond the modeled area.

32. <u>Comment:</u> The COG/TPB Travel Forecasting Model, Version 2.1D Draft #50, overstates net in-commuting and misplaces the sources of in-commuting.

<u>Response:</u> The data and analysis presented in the Smart Mobility Memorandum on Job Growth Distortion, dated October 27, 2004, does not support this conclusion.

Much of the analysis presented in the Smart Mobility memorandum is based on a comparison of TPB modeled Home-Based Work (HBW) "daily commuting" trips for the 2000 base year with sample data from the 2000 Census that tabulates "workers" by place of residence and place of work. It is extremely important to note that a tabulation of workers by place of residence and place of work is not the same thing as daily HBW commuting trips. Some workers only work part-time, not every "full time" worker commutes directly to and from work every day, and some workers have more than one job that they commute to on different days during the week. HBW trips in the TPB model are based on what workers interviewed in our Household Travel Survey and Auto External Survey told us they actually did on a particular day, whereas the Census asked workers where they “mostly” worked the week before the April 1, 2000 Census and how they “usually” get to work.

Worker-related data collected both in COG/TPB travel surveys and the 2000 Census are based on a relatively small sample of the total population. As such, estimates derived from these sample data are subject to both sampling and non-sampling error, including respondent misinterpretation of the questions being asked. For example, data from 2000 Census tabulations indicate that 760 workers who worked in the TPB modeled region lived in Virginia Beach, VA, another 566 workers working in the region lived in New York City, NY, another 547 workers lived in Cook County, IL and another 379 workers work in the Washington region and live in Los Angeles, CA.

The Smart Mobility analysis attempted through a series of “factors” to convert HBW daily commuting trips in the TPB model into worker data “equivalent to” that collected in the 2000 Census in order to compare it with the Census data. However, many of the numbers presented in the Smart Mobility analysis do not match the data available to TPB staff. For example, Smart Mobility states that *“The number of work trips with destinations in the region and counted in the 2000 Census Transportation Planning Package (CTPP) is 3.06 million.”* The CTPP does not provide a count of “work trips” with destinations in the region. The CTPP tabulation of the number of workers reporting a “place of work” in the modeled region is 3.21 million, if workers who report that they “work at home” are included, and 3.10 million if these “work at home” workers are excluded. Similarly, *“Dividing the number of external productions per job by 1.22 productions per job”* does not equal 150,000 workers as stated by Smart Mobility, nor does *“dividing the 2000 internal attractions in the model”* equal 242,000. There was insufficient documentation in the Smart Mobility analysis to understand the derivation and basis for several other factors and estimates presented in the analysis.

With some care to eliminate “out-of-town” workers, workers who worked at home and workers who got to work by non-motorized means from the Census tabulations, some comparisons of gross “in-commuting” and “out-commuting” can be made between the Census data and the TPB model. For the year 2000, analysis of the TPB model data show that 95.00% of the daily HBW trips are made by workers living in the modeled region and commuting to jobs in the modeled region and 5.00% of the daily HBW trips are made by workers commuting to jobs outside the modeled region. The comparable figures from the 2000 Census data are 95.44% of the workers who live in the modeled region work in the modeled region and 4.56% of the workers who live in the region work outside the modeled region. Also, for the 2000, analysis of the TPB model data show that 92.74% of the daily HBW trips are by workers working in the modeled region and commuting from their homes which are also in the modeled region, 7.26% of the daily HBW trips are made by workers working in the modeled region and commuting from their homes outside the modeled region. The comparable figures from the 2000 Census data are 93.63% and 6.37%. Thus, even with all of the "noise" inherent in making comparisons of modeled HBW trips with Census data, the two independent estimates of "in-commuting" and "out-commuting" match up extremely well.

Finally, analysis of modeled HBW in-commuting and out-commuting trips to and from areas in MD and VA outside the modeled region match up well with comparable data from the 2000 Census. Modeled HBW in-commuting trips show 19.59% of these trips commuting from VA external stations while comparable Census data show 22.63% of the in-commuting workers living in external jurisdictions in Virginia. Modeled HBW out-commuting trips show 13.97% going to VA external stations while comparable Census data show 9.81% of the out-commuting workers traveling to external jurisdictions in Virginia.

33. Comment: The foundation of future transportation modeling is the location of future housing and jobs. From the fudge factor alone, all future modeled work travel is seriously distorted. It is as if each workplace cannot fill 7% of its jobs. The majority of new jobs assumed are in suburbs – distorting employment towards suburbs. This distorts traffic in the model towards suburbs and away from the older centers – both for work and nonwork travel. This will cause future transit ridership to be underestimated, and traffic on suburban roadways to be overestimated.

Response: The forecast year of 2030 represents an interval of time of approximately 25 years from the present. During this period, many current jobholders will have completed careers in their fields of endeavor. Others will have changed locations of employment, while others will have changed the types of work that they perform. The majority of new jobs (i.e., jobs to be filled by new workers) will therefore not be confined to the suburbs, but will be found in all corners of the region, including downtown.

The history of the Cooperative Forecasting process reveals that household projections have been the most accurate at the regional scale. This reflects the ability of local governments to map household projections to local plans. Employment projections have been more difficult to forecast because of changes in the business cycle. It therefore makes sense to control travel demand at the production or residential end of trip making.

34. Comment: The TPB model has no explicit treatment of labor force, and does not base work trips on workers. Instead, it bases work trips on household size, income and autos…. With the aging of the population, there will be increasing numbers of households with multiple autos, fairly high incomes, and no jobs. Rather than basing work trip generation on income and autos, which are difficult to predict anyway, trip generation should be based on the number of workers which is much easier to relate to population growth.

Response: The TPB work trip production model determines person trips based on household size, vehicle availability, and income level. These particular variables have been established as strong determinants of person travel in the Washington, D.C. area based on observed information and are typical of such models in other metropolitan areas. Moreover, they are variables that can be forecasted at fine levels of geography with a reasonable degree of confidence. The assertion that an aging population *will* result in lower jobs per capita in the future is based on speculation. An aging population with a longer life expectancy could in fact result in increased jobs per capita in the future, particularly in an area like the Washington region which has consistently experienced strong employment growth relative to population growth.