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Dr. David Forkenbrock
Chairman
TRB Committee for Review of Travel
Demand Modeling by the
Metropolitan Washington Council of Governments
Transportation Research Board
500 Fifth Street, N.W.
Washington, D.C. 20001

Dear Dr. Forkenbrock:

Staff of the National Capital Region Transportation Planning Board (TPB) has been provided an advance copy of the first letter report by the TRB review committee on travel demand modeling in the Washington region, which is to be released on September 8, 2003. This letter provides comments by the TPB staff on this first letter report for consideration by the TRB Committee. The comments provide the views of the TPB staff on certain key aspects of the first letter report, as well as additional information and context for the second phase of the model review to be conducted over the remainder of this calendar year. As stated in your first letter report, a second letter report will be prepared by the TRB Committee later in the year to address other issues in the Statement of Task for this peer review, as well as certain issues raised in your first letter.

The TPB staff comments on your first letter report are organized under the following topic headings:

(1) The overall structure and conduct of the TRB review.

(2) Observations by the TRB Committee with which the TPB staff is in agreement, and which do not require further attention.

(3) Observations by the TRB Committee which the TPB staff agrees offer potential for improvement in the modeling process that can be addressed by TPB staff.

(4) Observations by the TRB Committee which TPB staff believes require further consideration and discussion between the Committee, TPB staff and other interested parties during the second phase of the review.

(5) Conclusion

It should be emphasized that the comments provided in this letter reflect only the views of the TPB staff as developed during a brief comment period. Once your report is released on September 8, 2003 you may expect to receive additional comments from other public and

private sector stakeholders in the TPB process, as well as from TPB staff as more calendar time allows for a more in-depth review and analysis of particular technical issues.

(1) The Overall Structure and Conduct of the TRB Review

Having participated extensively in technical and procedural discussions with the TRB Committee and TRB staff during the first phase of the review process, the TPB staff has been impressed by the degree of commitment to the process by all of the participants. The administration of the process by TRB staff has been excellent, and the objective procedures for selection of the review committee and for independent review of the committee's observations under the procedures of the National Research Council are particularly valuable for a subject like this in which some aspects are highly technical, and some (like the use of K-factors) are in the words of the Committee the *"subject of active, continuing debate among modeling professionals."*

Some of the overall observations made by the TRB Committee on the task of assessing the performance of travel models in a particular metropolitan area are especially valuable for interested parties in the Washington area, and indeed for the transportation planning profession as a whole. The introductory sections to the *"Principal Observations"* portion of the report provide a context within which all such assessments of travel models must be viewed:

> *"Although travel demand models have been used in transportation planning for some four decades, there are few universally accepted guidelines or standards of practice for these models or their application. Similarly, the methods metropolitan planning organizations (MPOs) employ in reformatting and otherwise modifying data produced by their travel models for use in mobile-source emissions estimation—postprocessing—are varied and typically change as each new generation of the emissions model enters current practice (MOBILE6 is the most recent). The committee observes that any assessment of these models and their performance must rely primarily on professional experience and judgment.*
>
> *The committee's findings are based upon its experience in regions with populations, institutional complexity, travel patterns, and air quality planning requirements comparable to those of the metropolitan Washington area. No two metropolitan areas are the same however, and the committee has had neither time nor resources to conduct comprehensive statistical comparisons among regions."*

TPB staff noted that in the course of conducting the peer review the Committee did not provide in its first letter report any specific measures of performance for travel models in other metropolitan regions. The Committee relied instead on the experience and judgment of the Committee members in developing its observations on the performance of the TPB travel models relative to other metropolitan areas. In commenting on these observations, TPB staff, like the TRB Committee, was handicapped by a lack of specific, up-to-date information on the practices currently being employed by a peer group of other MPOs. TPB staff believes that further productive discussion of these observations requires

specific information about practices in such a peer group of comparable metropolitan areas. The TRB Committee has suggested areas which could serve as members of such a peer group. TPB staff suggests that five additional metropolitan areas be added to the TRB Committee's list, bringing the total to eleven: Atlanta, Boston, Chicago, Dallas/Ft. Worth, Detroit, Houston, Miami, Philadelphia, Phoenix, San Francisco, and Seattle. TPB staff is currently collecting information from these areas related to the TRB Committee's observations.

TPB staff appreciates the willingness of the Committee to delve into the details of the logic and results of the travel models, and was pleased to provide the supplemental information requested by the Committee to enhance its understanding of these details. However, TPB staff believes that for certain aspects of the models and results, provision of further information by TPB staff and further consideration and discussion by the Committee are needed during the second phase of the review. Such further consideration will provide for a more in-depth and comprehensive assessment by the Committee on these aspects, and a stronger foundation for the development of recommendations on the direction of future model upgrades.

(2) Observations by the TRB Committee with which TPB staff is in agreement, and which do not require further attention

The TRB Committee and TPB staff are in agreement on a number of key issues which have been raised by stakeholder groups from time to time about the TPB travel models. The TRB Committee has organized its observations on the TPB travel models under eleven points which are presented in the section titled *"Principle Observations"*. TPB staff is in agreement with five of these eleven points, as follows:

1. *TPB's travel model set is based on the four-step representation of travel demand that is widely adopted in current U.S. practice. The most recent TPB version of these models—the "COG/TPB Travel Forecasting Model, Version 2.1/TP+, Release C"—is generally typical of how these models are implemented by MPOs.*

2. *As has become common practice among MPOs, TPB's use of locally gathered household survey data to develop estimates of trip rates and trip lengths for travel model development and calibration is preferable to the use of national census data or travel surveys for these purposes.*

4. *MWCOG's consensus-based method for projecting regional distributions of population and employment is similar to practices used by many other MPOs.*

9. *TPB's disaggregation of VMT into detailed vehicle classes is similar to the procedures used by some MPOs, as is the estimation of off-network VMT. The agency's frequent updating of vehicle registration data is commendable.*

11. TPB's procedures for estimating emission rates are for the most part comparable with those of other major MPOs. The development of weighted emission rates reflecting county-level travel patterns is commendable.

(3) Observations by the TRB Committee which the TPB staff agrees offer potential for improvement in the modeling process that can be addressed by TPB staff

This section of the TPB staff comments deals with the following three of the Committee's eleven points:

3. Statistical measures indicate that base-year modeled link volumes do not match observed traffic counts and transit ridership as closely as committee members would typically expect in model validation.

5. TPB's inclusion of the home-based shopping trip (HBS) category in trip generation is commendable. Combining business and commercial trips in the non-home-based trip (NHB) category is not advisable.

6. The use of fixed bus speeds in TPB networks may misstate the influence of transit in estimates of future trip distribution and mode choice.

TRB Committee Point No. 3: "S*tatistical measures indicate that base-year modeled link volumes do not match observed traffic counts and transit ridership as closely as committee members would typically expect in model validation."*

TPB staff recognizes that there is always potential for improvement in matching modeled link volumes with observed traffic counts and transit ridership data (as well as for improving the quality of the observed count and ridership data forming the bases for the comparisons.) Refinements to the Version 2.1C model are currently in progress, as part of ongoing project planning work, to better delineate area type codes using aerial photography, to refine capacity and free flow speed values in area type and facility type cross-classes, to implement refinements in volume-delay functions for certain critical network links, and to review and refine zone centroid connections.

Regarding RMSE values, the peer review panel in its report on page 10 states *"...for 8 of 33 traffic volume classes, RMSE values were only marginally acceptable, on the basis of literature and the committee's experience."* However, no specific RMSE acceptance criteria are defined. Reference is made to the Model Validation and Reasonableness Checking Manual (footnote 22 on page 10). Detailed RMSE information in that document is provided for Reno, Phoenix, and Concord, metropolitan areas that are not comparable in complexity to the Washington region. (It should be noted that the RMSE values reported for the Washington region cover a very large "modeled" area that includes ten external jurisdictions beyond the non-attainment area. For many of these

outer jurisdictions the model contains large traffic zones and coarse network representation.)

TPB staff believes that the acceptability of RMSE values is a topic for which more information for areas of a size and complexity of the Washington region would be very helpful. TPB staff also believes more detailed information and discussion are needed on the limitations of available traffic count data. While RMSE statistics for the Version 2.1C model are generally consistent with historical modeling results in the Washington region, ongoing work by TPB staff to refine inputs to the Version 2.1C model and to review available traffic count data will seek to achieve improvements in these RMSE statistics. TPB staff will make the results of this work available to the TRB Committee as the work progresses.

Regarding the underestimates of transit trips for the year 2000 in the range of 5 to 8 percent, TPB staff noted in the model calibration report that two non-model factors were at work. First, the population and household forecasts provided for 2000 in the District of Columbia had declined substantially from 1994 totals, the validity of which was questioned by staff. (More recent updates to these data based on the 2000 Census provide higher totals for 2000). Second, the recent growth in popularity of the Metrochek transit fare subsidy program is not explicitly modeled in Version 2.1C at present, but the effects are captured in mode choice post-processing as part of a tracking sheet for regional Transportation Emissions Reduction Measures (TERMs). The mode choice models employed in Version 2.1C were calibrated with the 1994 Household Travel Survey and simulated 1994 conditions for most major transit markets to within 1 to 5 percent of observed data. It should be noted that considerable effort was needed by staff to derive an "observed" transit trip pattern in outlying areas of the expanded Washington region, for which there were no travel surveys, only ridership counts.

TRB Committee Point No. 5: "*TPB's inclusion of the home-based shopping trip (HBS) category in trip generation is commendable. Combining business and commercial trips in the non-home based trip (NHB) category is not advisable.*".

TPB staff agrees that ideally, developing a separate model for light commercial travel in the Washington region would be preferable to the present approach, under which this category of travel is included in the NHB (non-home based) trip category. (TPB did use a separate model for light commercial trucks until the late 1980s, when the separate model was dropped due to lack of data.) However, present data constraints make it extremely difficult to develop such a model in the Washington region, and in many other regions as well.

That the problem exists for other metropolitan areas as well was demonstrated by the consensus of the MPO representatives who attended the July 2002 AMPO (Association of Metropolitan Planning Organizations) Travel Modeling Subcommittee held in Chicago. These representatives concluded that data collection and commercial light truck modeling were exceedingly difficult to perform, and that the best approach available to them was

either to use count data to develop synthetic light truck models or to use parameters from data sources outside their individual metropolitan areas.

TPB staff agrees with TRB Committee's statement that *"…lack of data and issues of confidentiality in commercial data have constrained the ability of models to produce reliable results."* The panel mentions Baltimore, New York, and Columbus, Ohio as regions employing distinct commercial-trip models. TPB staff will explore the experience of these models in those regions in an effort to gain insight into whether and how commercial light truck modeling might better be performed in the Washington region. In the meantime a workable procedure is needed, and TPB staff believes that, for the immediate future, including light commercial truck travel in the NHB trip category is the best available alternative.

TRB Committee Point No. 6: "*The use of fixed bus speeds in TRB networks may misstate the influence of transit in estimates of future trip distribution and mode choice."*

The TRB Committee states on page 13:

"…Scheduled transit times are used throughout the modeling process, rather than estimated travel times calculated from loaded highway networks. Committee members noted that many MPOs in larger metropolitan areas derive bus transit speeds from algorithms that estimate transit link speed as a function of the corresponding highway link speed, usually by facility type and area type to reflect the prevailing stop density and traffic conditions. TPB's use of fixed schedule speed in estimating zone-to-zone impedances is likely to misrepresent mode choice forecasts due to the effect of highway congestion on bus transit speeds, overstating transit performance where congestion increases and understating it where congestion decreases. This could lead to improper performance evaluations of highway and transit improvements in the TPB model, especially in areas with existing or potentially large market shares."

The Committee further states:

"The committee agreed that such practices as using schedule times for transit…are widely adopted by MPOs, often expedient, and may introduce errors that are relatively small. These practices nevertheless contradict the fundamental premise underlying these forecasts: that the models simulate how the system operates. Establishing an appropriate balance between theoretical correctness and practical limitations of data, time, resources, and the concerns of stakeholders is a problem common to all modeling efforts."

TPB staff employs the latest schedules available from transit providers in the Washington region for each annual update of the transit networks. For the recent SIP network development, completed during the Spring of 2003, information from Fall 2002 transit schedules was used to update all transit networks, including the year 2005 network which was input to the modeling that was performed to help establish mobile emissions

budgets. WMATA bus operations staff report that every Metrobus bus route schedule is updated every two to three years. TPB staff believes that the use of these most recently available schedules in network development gives an accurate description of conditions through 2005 (the air quality attainment year for the Washington region).

With regard to long-range projections, these most recent bus schedules are maintained in the transit networks for out-years such as 2015, 2025 and 2030. Greater specificity is provided, however, for additions to the rail network, including Metrorail, commuter rail, light rail services, and bus services designed to feed the rail network. WMATA and the other transit providers have been engaged in a Regional Bus Study during recent years to anticipate what the market for bus service might be in the future and to what extent existing services might be modified. As part of this study, measures to improve bus running ways are being addressed, including removal of on-street parking during peak service hours, provision of transit vehicle signal priority systems, providing left turn lanes to better improve traffic flow, and providing bus-only lanes and queue jumpers. In addition to improvements to running speeds, this study calls for a substantial expansion in bus service over current schedules assumed in the out-years of the Plan. (The study calls for an increase in the regional bus fleet from 2000 today to 3500 vehicles by 2025, for example.) TPB staff is currently working with WMATA and local transit agencies to develop future transit networks based on the Regional Bus Study. These networks will be used with the Version 2.1C travel model to analyze alternative future land use and transportation scenarios.

TPB staff agrees that directly relating the bus speeds to congested highway speeds would offer some theoretical improvement in the modeling process for years beyond 2005. However, the full benefit would not be achieved without more specificity with regard to bus route changes, including service expansions in growing areas in the region and programs to effect future running way improvements. TPB staff believes that the net effect of the lack of long-range bus service specificity in the out-years of the Plan is likely to be underestimation of bus service levels and transit usage, particularly in growing areas of the region. TPB staff agrees that further work is warranted in this area, but believes that the scope should involve a comprehensive approach to defining future bus services, of which the effects of growing congestion on bus speeds should be just one component.

<u>(4) Observations by the TRB Committee which TPB staff believes require further consideration and discussion between the TRB Committee, TPB staff and other interested parties during the second phase of the review.</u>

This section of the TPB staff comments deals with the following three of the TRB Committee's eleven points:

7. *TPB's extensive use of adjustment factors in trip generation, trip distribution, and mode choice to enhance the match between simulated and observed base-year data undermines the fundamental behavioral logic of the four-step modeling process.*

8. *TPB's feedback of highway and transit times to trip distribution bypasses mode choice and is not typical of good modeling practice in regions with significant transit services and ridership.*

10. *The TPB's procedure for estimating hourly traffic volumes and speeds—aggregation of peak-and off-peak period traffic assignments to a 24-hour total that is then redistributed to hourly period—is questionable, because the final emission estimates are not strictly based upon assigned peak and off-peak link volumes and speeds. Testing will be needed to determine the procedure's effects on emissions estimates.*

TRB Committee Point No. 7: "*TPB's extensive use of adjustment factors in trip generation, trip distribution, and mode choice to enhance the match between simulated and observed base-year data undermines the fundamental behavioral logic of the four-step modeling process."*

TPB staff disagrees with the TRB Committee on this point. TPB staff believes that there are inter-jurisdictional influences on travel patterns in the Washington region (and in other complex regions) which cannot be fully described by the time and cost variables in the four-step travel demand modeling process without the use of adjustment factors. Such factors reflect real influences on travel behavior which have been present historically and are likely to continue over time. In the Washington region, the limited number of river crossings tends to deter some travel in ways not captured by travel time and cost alone. Several military installations are present, as well as numerous institutions of higher learning for which differences in tuition (resident vs. non-resident) apply. School districts serve just their own local jurisdictions, and many trades contractors are licensed to work in only one state. The Maryland suburbs have a stronger orientation to other neighboring jurisdictions in the Washington region than to those in the Baltimore region. Further, in order to enhance their tax bases and achieve better jobs-housing balance, individual states and jurisdictions have explicit policy goals and programs aimed at attracting and retaining a mix of land activities that will encourage their residents to work, shop and conduct other activities within their jurisdiction of residence. The four step modeling process has no explicit parameters designed to represent these significant intra-and inter-jurisdictional influences on travel behavior.

The TRB Committee notes that *"the use of K-factors is a subject of active, continuing debate among modeling professionals."* A recent report prepared by Smart Mobility, Inc. for Environmental Defense and other environmental organizations and aimed at improving the TPB's models illustrates this point well. In the report, More Sprawl, More Traffic, No Relief: An Analysis of Proposed Potomac River Crossings, Smart Mobility, Inc., October 2002, the authors indicate on page 4 that they applied K-Factors to the TPB's travel model for each of the six trip purposes (HBW, HBO, HBS, NHB, two truck purposes) for intra-state movements (within D.C., within Maryland, within Virginia). They justify this by stating, "We believe the best case for K-Factors in the Washington region can be made for state-to-state movements (considering D.C. as another "state"). In these cases, taxation can be different, affecting both work and

shopping trips. Other trips can be linked to those trips." Adjustments were made with a set of 12 K-Factors (3 intra-state factors for each of the four purposes, HBW, HBO, HBS, NHB), that were applied to 38 percent of the zone-to-zone trip interchanges for each of these trip purposes. By comparison the TPB's Version 2.1C model makes use of a larger set of K-Factors (68 total factors across these four trip purposes) but applies them to far fewer zone-to-zone trip interchanges (9 to 20 percent depending upon trip purpose) than the Smart Mobility, Inc. model. The TRB Committee has expressed concern that this lower fraction of zone-to-zone pairs affected by K-factors in the TPB's Version 2.1C model *"is inordinately large."* TPB staff believes that this is an area where more specific information on the practices of a peer group of MPOs is needed in order to provide a basis for comparison and assessment of alternative K-factor procedures.

A second important point involves the development of trip generation models. The estimation of these models occurs at a disaggregate level, based on trip rates of sampled households in each cross-classification. As such, when the sampled rates are applied to aggregate zonal household data, they are subject to aggregation error. An adjustment has to be made to achieve a match between estimated productions and observed productions. An appropriate technique to address this problem is to apply adjustment factors to both productions and attractions on a jurisdictional basis. The Version 2.1C model was adjusted in this manner, employing factors developed on the basis of super-districts and income levels.

TPB staff is developing additional information describing the rationale for and use of adjustment factors in the Washington area and other metropolitan areas for presentation to and discussion with the TRB Committee. While the use of these factors is subject to professional judgment and might be carried out differently by different practitioners, TPB staff believes that the rationale for their use is sound and that their use in the TPB models in no way *"undermines the fundamental behavioral logic of the four-step modeling process."* TPB staff looks forward to further discussion with the TRB Committee on this topic.

TRB Committee Point No. 8: "*TPB's feedback of highway and transit times to trip distribution by-passes mode choice and is not typical of good modeling practice in regions with significant transit services and ridership."*

TPB staff disagrees with the TRB Committee on this point, which TPB staff has found to be a much more complex issue than it appears. In structuring the speed feedback component of the TPB modeling process to meet the requirements of EPA's conformity rule, TPB staff executed and analyzed a number of alternative approaches. While initially appealing in theory, TPB staff found that there were a number of conceptual and practical problems (as described below) with feeding highway speeds back through a sequential trip distribution/mode choice/traffic assignment procedure. The approach chosen for the TPB modeling process was felt to be the best option available for both addressing these problems and meeting EPA's requirements.

EPA provided information on this topic in the August 15, 1997 Federal Register conformity rule amendments (40/CFR section 93.122, "Procedures for determining transportation-related emissions"). This section identifies requirements which network-based travel models must satisfy, i.e., included in subsection (v): "Zone-to-zone travel impedances used to distribute trips between origin and destination pairs must be in reasonable agreement with the travel times that are estimated from final assigned traffic volumes. Where use of transit currently is anticipated to be a significant factor in satisfying transportation demand, these times should also be used for modeling mode splits."

This language from the 1997 conformity regulations amendments closely matches the 1993 conformity regulations which were required to be used by severe and above ozone nonattainment areas after January 1, 1995. Staff conducted the original implementation of speed feedback procedures in FY93 and FY94 to meet that date; the work activities were reviewed and discussed extensively by the TPB's Travel Forecasting Subcommittee, including state and local technical staffs and representatives of consulting firms working in the Washington region.

The objective of the speed feedback process is to create a more realistic modeling representation by recycling capacity-restrained speeds from traffic assignment back to trip distribution and iterating until equilibrium is achieved, to reflect the impact that congestion has upon travel choice / behavior. Since trip distribution depends primarily on highway travel conditions to establish trip length and orientation (even with the composite time function in the Version 2.1C model which includes weighted highway and transit travel times), under certain conditions the feedback can significantly reduce person trip interchanges in these heavily traveled and congested corridors. If these revised distributions are fed directly through mode choice, TPB staff has found that unrealistic reductions occur in estimated levels for transit and HOV on priority lanes because overall person trip levels decrease significantly due to the speed feedback operation. Even with somewhat higher transit and HOV percentages for these interchanges in the subsequent modal choice execution, transit and HOV levels drop significantly.

The conceptual issue here is that transit service speeds provided as inputs to the model in the calibration and validation years are not affected by changes in highway speeds that occur during the speed feedback process. Rail and HOV services have their own rights-of-way, and bus services are specified in terms of published schedules, which are based on actual traffic conditions at the time of the schedules. (As discussed earlier under point No. 6, bus speeds and overall service levels <u>will</u> be affected in various ways in the out-years of 2015 and beyond). For these instances, allowing variations in highway speeds during the speed feedback process to modify distribution of transit trips through a weighted average of highway and transit times seems conceptually inappropriate, and in practice can produce poor results. The behavioral characteristic in effect here is that many travelers choose their mode of travel in conjunction with their choice of trip origin and/or destination, and not after their origin/destination choice. (A traveler employed in downtown Washington, D.C. may choose to live in a remote suburb because of the availability of commuter rail services, for example. Variations in highway speeds were not a part of and should not affect that origin/destination choice).

The current TPB process evolved and was finalized over more than twelve calendar months of review and extensive use of sensitivity analysis to test alternative approaches to resolving this issue. The adopted approach preserves in subsequent speed feedback iterations the transit and HOV estimates obtained from execution of the primary modal choice analysis, i.e., speed feedback person trip reductions for affected interchanges do not lower usage of transit and HOV modes. This occurs in the speed feedback iterations through a 'mode split' operation in which the reduced volume person trip table serves as input to a matrix operation from which the base transit and HOV trips are subtracted, leaving (reduced) drive alone and low occupancy vehicle trips as the residual. This method allows the speed feedback mechanism to execute and realize the desired balance between trip distribution and traffic assignment travel times, while preserving realistic transit and HOV volumes throughout the region. TPB staff believes that this approach meets the requirements of the EPA conformity regulation cited above, and has found that it produces satisfactory modeling results.

In June 1995 these technical methods were incorporated into TPB's travel demand modeling methods. This technique has been used in subsequent long range planning, project planning, state air quality implementation (SIP) and conformity planning activities. Such SIP plans and conformity assessments provided to EPA, FHWA and FTA were explicitly reviewed for adequacy with respect to planning requirements and were found to be appropriate.

While results of this component of the modeling process have been shown to be satisfactory, this area has been (and continues to be) identified as one deserving further research. TPB staff would be most interested in the experience of other metropolitan areas with extensive rail and priority HOV systems, and in any suggestions the TRB Committee may have for improving this component of the process.

TRB Committee Point No. 10: "*The TPB's procedure for estimating hourly traffic volumes and speeds -- aggregation of peak and off-peak period traffic assignments to a 24-hour total that is then redistributed to hourly period -- is questionable, because final emissions estimates are not strictly based upon assigned peak and off-peak link volumes and speeds. Testing will be needed to determine the procedure's effects on emissions estimates.*"

TPB staff disagrees with the TRB Committee on this point, because TPB staff does not agree with the way the TRB Committee has characterized certain key aspects of the TPB's procedure for estimating hourly traffic volumes and speeds. TPB staff is concerned in particular with the Committee's introductory paragraph describing the TPB's procedure:

> *"Materials provided to the committee and discussions with TPB staff indicate that the post-processing procedure aggregates the period-specific link volumes produced by the travel models to a 24-hour volume for each link. The daily volume is then redistributed to hourly volumes in several steps. First, links are categorized according to one of three default hourly distributions, based on each link's facility*

> *class and a peaking-characteristic rating (i.e., am-peak oriented, pm-peak oriented, even peaking). These generic distributions are used with the aggregated total daily link volume to develop an initial distribution of hourly traffic on a link."*

TPB staff does not believe it is accurate to say that *"the post-processing procedure aggregates the period-specific link volumes produced by the travel models to a 24-hour volume for each link. The daily volume is then (*emphasis added*) redistributed to hourly volumes in several steps. First, links are categorized according to one of three default hourly distributions, - - -"* The categorization of links according to default hourly distributions is based on the period-specific link volumes produced by the travel models which are provided as input to the post-processor. If the volumes were aggregated to a 24-hour volume before this categorization, there would be no time-of-day information available to categorize the links. The peak and off-peak traffic assignments are in fact the starting point for the post-processing procedure, resulting in an integrated travel demand/post-processor relationship. The default hourly distributions used in the post-processor are developed for three peaking classes and three functional classes (nine distributions in all) using empirically observed distributions for the Washington region.

In the final portion of point No. 10 the Committee states that *"the final emissions estimates are not strictly based on assigned peak and off-peak link volumes and speeds."* TPB staff does not consider this statement a criticism of the post-processor, but rather a recognition that the post-processor is fulfilling its explicit purpose, as required by the following EPA and DOT guidance:

> "Since emissions are extremely sensitive to vehicle speed, EPA and DOT recommend that speeds be estimated in a separate step after traffic assignment (emphasis added) (also known as post-processing), using refined speed-volume relationships and final assigned traffic volumes. Post-processed speeds estimated in the validation year should be compared with speeds empirically observed during peak-and off-peak periods-- Based on these comparisons, speed-volume relationships used for speed post-processing should be adjusted to obtain reasonable agreement with observed speeds. Regardless of the specific analytical technique, every effort must be made to ensure that speed estimates are credible and based on a reproducible and logical analytical procedure." (Transportation Conformity Reference Guide, FHWA, Revised 7/30/2001. Page D-6-9).

TPB staff believes that use of an emissions post-processor of the type employed by the TPB is essential for meeting this requirement, because the three link speeds (am peak, pm peak, and off-peak) which are developed as a result of traffic assignment do not provide information on speed variations between different hours within the two peak periods or during the off-peak period. Such variations in speed can have a significant impact on emissions, and need to be incorporated into the estimation procedure. TPB staff would appreciate the opportunity to have more detailed discussion with the TRB Committee on this point.

With respect to the peak-spreading procedure, the TRB Committee states that *"whether period-specific or 24-hour volumes are spread, the impact of the peak-spreading procedures on emissions is very difficult to predict for links that are over capacity for extended periods. Committee members acknowledge TPB staff's assertions that the procedure was designed to yield conservative (i.e. higher) estimates by projecting lower running speeds [49] (Footnote: As noted the procedure outputs the lower of the speeds before or after traffic volume has been redistributed to other hours.)"* TPB staff has reviewed the TRB Committee's analysis, and does not agree with the Committee on this point. TPB staff does not assert that with regard to emissions *"the procedure was designed to yield conservative (i.e. higher) estimates by projecting lower running speeds."* The procedure is designed to select an appropriate running speed for emissions calculations for each hour of the day. In some cases, both the speed and NOx emission rate after traffic volume has been redistributed will be lower than before, appropriately reflecting the fact that at higher speeds NOx emissions rates decline as speed declines.

For links and time periods that are initially over capacity, the link volume/capacity ratio exceeds 1.0 at level of service E, and the link is operating under unstable flow conditions. In these cases the initial (lower) speed before spreading of volume will be chosen for emissions calculations to represent this operating condition.

There will be a significant number of initially uncongested links and time periods for which the peak-spreading procedure will reduce speeds and NOx emissions estimates due to traffic from hours that are initially over capacity being shifted to adjacent periods that are initially under capacity. This phenomenon properly reflects the fact that if heavy duty diesel trucks, for example, are forced to slow down on a freeway from 65 mph to 50 mph due to traffic congestion, the corresponding NOx emission rate will be reduced. Speed limit adherence on freeways has been proposed (and in some locations implemented) as a NOx emissions reduction measure to take advantage of this reduction in NOx emissions rates which occurs when speeds are reduced at the high end of the speed range. (It should be noted that for VOC emissions, for which rates increase steadily with reduced speed, in shifting traffic from hours that are initially overloaded to hours that are initially under capacity the peak-spreading procedure will consistently reduce speeds and increase emissions rates for the affected links and periods.)

In interpreting Figure 2b displaying NOx emissions rates in its report, the TRB Committee states that *"The initial emissions rates that would have been assigned had there been no smoothing after assigning 24-hour volumes to an hourly profile are generally lower than final rates based on post-processed speeds, because the reduced speeds after post-processing fall into the speed range where the emissions rate is increasing with speed (Figure 2a)."* As discussed in the previous paragraph, TPB staff believes that the opposite is the case; that is, under the conditions described here initial NOx emissions rates are generally higher than final rates because the post-processing procedure is properly reflecting the fact that at the high end of the speed range, ("*where the emissions rate is increasing with speed,"*) increasing volumes in an hourly time period will result in reduced speeds and reduced NOx emissions rates.

TPB staff appreciates the TRB Committee's discussion of severely overloaded links, since this is an issue that has been raised by some of the TPB's stakeholder groups. The TRB Committee recognizes that, as TPB staff has pointed out previously, all network traffic is included in the emissions calculations conducted as part of the post-processing procedure. Further, the TRB Committee notes that this severe overload phenomenon occurs on only about 6 percent of all network links, which together account for only about 0.40 percent of total regional daily VMT. As these statistics suggest, the vast majority of these severely overloaded links are low-capacity collector roads. Much of the traffic assigned to these links is actually traveling on lower-capacity road links which are not included in the coded networks because they are below the grain of the analysis.

After reviewing the TRB Committee's analysis and observations on the TPB's procedure for estimating hourly traffic volumes and speeds and associated emissions, TPB staff continues to believe that the logic of the procedure is sound, that the procedure properly uses the period-specific link volumes produced by the travel models as a starting point for link categorization and for peak spreading, that the structure of the procedure will ensure that emissions are not understated, and that the procedure is in full compliance with EPA and DOT requirements. However, TPB staff would be pleased to discuss with the TRB Committee additional sensitivity analyses that might help to address any reservations the Committee may continue to have with regard to this procedure.

(5) Conclusion

The TPB staff appreciates the level of effort and commitment demonstrated by the TRB Committee and TRB staff in carrying out the first phase of this peer review. The Committee has conducted a searching analysis and focused sharply in its comments on a small number of key issues. This will allow for a more in-depth review and discussion on these key issues in the second phase of the review. The TPB staff looks forward to these discussions over the remainder of this calendar year, and to the completion of the peer review project.

Sincerely,

Ronald F. Kirby
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Transportation Planning