# Descriptions of Proposed Work Elements for the TPB Models Development Program to

a) **Address Concerns Raised by the TRB Committee's First Letter Report**

b) **Advance the State of Modeling Practice in the Metropolitan Washington Region**

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# Proposed Work Elements for the TPB Models Development Program

## Introduction

The TRB Review Committee indicated during the September 12, 2003 telephone conference with TPB staff that it would be very helpful to them to review proposed work program elements from the TPB staff as the panel prepares its second letter report. Dr. David Forkenbrock's letter of September 18, 2003 to Dr. Ronald Kirby further articulated the requested information as follows:

> *"Detailed descriptions of work-program elements that ... (TPB) staff proposes to undertake to (a) address concerns raised by our first letter report and (b) advance the state of modeling practice in the Metropolitan Washington region. We very much hope that these descriptions will be fairly explicit and detailed and will include your anticipated schedule for undertaking the work. Additionally, we hope that these descriptions will include consideration of MWCOG's strategy for mobilizing resources in the region to accomplish the work-program elements."*

This document describes TPB staff's proposed outline of work elements in the models development program over the next four and a half years. This time frame extends from the second half of the current fiscal year (FY-2004) until the end of FY-2008. The work elements were developed in response to the TRB committee's recommendations in the first letter report, as well as to meet immediate TPB planning study objectives while continuing to implement incremental improvements to TPB modeling practices.

## The TRB Committee's First Letter Report and TPB Staff Comments

On September 8, 2003 the TRB Committee released its first letter report reviewing the state of the practice of travel demand modeling by the TPB, and on the same date TPB staff released a set of comments on the TRB review developed during a brief comment period on an advance copy of the TRB report.

The TRB Committee noted in its first letter report that with regard to travel demand models:

- "…there are few universally accepted guidelines or standards of practice for these models or their application." (TRB first letter report, 2003, p. 2);
- "…any assessment of these models and their performance must rely primarily on professional experience and judgment."(p. 2)

- "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." (p. 2)
- "The committee did not attempt to identify a vigorously defined agency peer group, but the committee's members agreed that TPB's practices may be appropriately compared with those of MPOs in, for example, Boston, Chicago, Dallas/Ft. Worth, Miami, Philadelphia, Phoenix, and other regions." (p. 7) ; and
- "It is not within either the scope of this study or the limitation of the time and resources available to the committee to conduct a thorough review of practices of MPOs around the country. In both this letter and its deliberations generally, the committee is relying primarily on members' experience and judgment." (p. 8)

The TPB staff comments of September 8, 2003 note that the TPB staff, like the TRB Committee, is handicapped by a lack of specific, up-to-date information on the practices currently being employed by a peer group of other MPOs. To address this issue, TPB staff has begun an effort to collect information from the MPOs suggested by the TPB Committee as well as five additional metropolitan areas, bringing the total to eleven: Atlanta, Boston, Chicago, Dallas/Ft. Worth, Detroit, Houston, Miami, Philadelphia, Phoenix, San Francisco, and Seattle. The results of this effort to date are provided as Appendix A to this document.

The information-gathering effort on the eleven peer MPOs has relied upon documentation that is readily available on web-sites, or from off-the-shelf materials available through the mail. While some very useful information has been obtained through this effort, as reported in Appendix A, there are some issues for which specific additional information requests will be needed, including direct conversations with modeling staff in the individual agencies. It is anticipated that such additional information requests will be made as the TPB models improvement work program proceeds over the coming year.

The TRB Committee organized its observations on the TPB travel models under eleven points presented in a section titled "Principle Observations." The TPB staff comments noted that there are five of these observations with which TPB staff is in agreement, and which do not require further attention. There are three 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:

> *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.*

Finally, there are three observations by the TRB Committee which the TPB staff believes require further consideration and discussion between the TRB Committee, TPB staff and other interested parties:

> *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.*

Each of the above six observations by the TRB Committee is addressed in turn in the work elements proposed for the TPB models development program outlined in this document. TPB staff already has developed some additional information and conducted some sensitivity tests to address each of these observations. Additional research on practices of other MPOs is expected to suggest further alternative methods which can be tested and evaluated as the TPB work program proceeds over the coming year.

## The TPB Models Development Program

TPB staff has historically envisioned the models development program as a series of five parallel 'tracks' upon which the travel forecasting methods would advance over time. Operating concurrently, the following tracks provide useful context for staging modeling improvements:

- **Track 1 – Application**: Improvement of the currently adopted model set to produce adequate forecasts while enhanced models are in development.

- **Track 2 – Methods Development**: The incorporation of advanced practice in travel demand modeling that can be made operational in the next few years.

- **Track 3 – Research**: Keeping abreast of research developments in the areas of travel modeling, surveying, data (GIS) maintenance practices and integration, and simulation.

- **Track 4 – Data Collection**: The implementation of data collection designed to meet the needs of tracks 1, 2, and 3.

- **Track 5 – Maintenance**: Documentation of the current modeling applications, including recent improvements to software and data requirements. This track also includes an ongoing effort to train staff in the use of current and updated application procedures.

Activities aimed at improving the current application method now known as the Version 2.1/TP+, Release C model and the emissions post-processor constitute the Application track (Track 1). These would occur most intensively in the near-term and would include sensitivity tests and validation checks of the model. These types of activities could potentially lead to parameter adjustments and/or structural modifications to the application model based on an assessment of the various model checks.

The development of an enhanced model in the longer term, i.e., either a more advanced four-step travel model, or possibly a 'successor' application to the present four-step process is the focus of the Methods Development track (Track 2). The phasing of activities in this track is heavily dependent upon the selected model specification and data collection schedule (Track 4) required to support the enhanced model.

Activities associated with an ongoing review of emerging travel modeling approaches that could inform long-term model improvements constitutes the Research track (Track 3). These activities take several forms, including participation in modeling conferences, reviews of the literature, and information gathering from relevant websites.

The Data Collection track (Track 4) requires resources which are equal to or greater than those expended in models development. Several travel surveys have been conducted during the past ten years which supported the models development work element. These have included a household travel survey (1994), continuing panel surveys during the past five years, an external auto survey (1994), an internal truck survey (1996), external truck surveys (1996 and 2003), Metrorail ridership surveys (1994 and 2002), a regional on-board bus survey (2000), and the 2000 Census Journey to Work. Given the vintages of some of these surveys, it is envisioned that a new round will be needed during the balance of this decade, costing several million dollars in total when all pre-survey and post-processing elements are included. Additional funding will be required to conduct all of the desired survey activities. Increases in federal planning funds under the reauthorization of the federal transportation program and state SPR funding are considered the most likely sources for this funding. Should the TPB conclude that a departure from the traditional four-step travel demand modeling practice should be undertaken in Track 2, there would be substantial implications for the structuring of surveys, including associated costs and staging.

The Maintenance track (Track 5) is another ongoing work activity that formalizes technical documentation and training with respect to incremental updates and modifications to the travel modeling procedures. The objective is to provide up-to-date training and dissemination of materials for the current application of the travel demand models in any given year.

The proposed multi-year program in models development below addresses these five tracks. As part of the application track, TPB staff proposes to investigate issues raised by the TRB Committee in its first letter report. The activities are mapped in a series of timelines shown in Figure 1.

**Figure 1 Multi-year staging of models development activities**


Notes:

* Version 2.1D model includes updates from Intercounty Connector (ICC) study and TRB-recommended improvements that can be done in short term.

** Level of survey data collection is a function of future federal funding levels

## Application (Track 1)

In formulating Application track work elements TPB staff has considered the observations made in the first letter report and has shared the concerns with stakeholders in the region. One key stakeholder, WMATA, has requested that TPB consider additional improvements relating to transit modeling. Consequently, the Application track elements reflect a combination of near term improvements occurring over the next four and a half years, taking into account both TRB and WMATA recommendations regarding model requirements. The planned improvements will lead to incrementally improved model versions (2.1D, 2.1E, etc.) that are expected to be brought into production at the end of each *calendar* year. While TPB staff seeks to consider all recommendations for improving technical methods on a yearly basis, staff maintains that each new version must undergo internal review to assess its performance for forecasting.

The essential elements of the Application track relate to highway and transit modeling validation (with an emphasis on improving transit models), business and commercial trip modeling improvements, minimizing model adjustments, considering structural modifications to modeled feedback linkages, and testing the mobile emissions post-processor. A more specific description of work elements follows below.

### 1.A Highway and Transit Validation

The TRB Committee observed that "modeled link volumes do not match observed traffic counts and transit ridership as closely as committee members would typically expect in model validation." Ongoing TPB staff efforts are aimed at achieving improvements in these matches. A prime example of such improvements are model refinements resulting from local project planning work in the ongoing Inter-County Connector (ICC) study in Maryland, as described in Appendix B. TPB staff has been working with local consultants on a number of topics to improve the model performance in the study subarea. The study team has investigated, for example, the use of refined free-flow speed and capacity values, a refinement of the zonal area type assignments, adjusted volume-delay functions for certain facility types, and improvements relating to network coding. The activities have not only resulted in an improved performance within the subarea, but have also had beneficial effects in the model performance in neighboring counties. TPB staff feels that the regional model can take advantage of the lessons learned from this project planning work, and that similar refinements can be made through collaborative efforts with local consultants working on other project planning studies in the region.

Element 1.A.1 will focus on implementing network coding refinements, such as those considered in the ICC study area, to other areas in the regional network system. Elements 1.A.2 and 1.A.3 indicate that transit modeling improvements will be implemented on both a short-term basis, including improvements the TPB staff feels can be addressed immediately to serve current planning needs, and a longer-term basis, where more advanced techniques will be implemented. The short term improvements will include the development of pre-existing transit sub-models, linking highway network speeds to transit speeds, and reviewing in-vehicle and out-of-vehicle weighting used in the development of transit paths. In the short term, two models, a sub-mode split model which estimates the shares of rail-related and bus-only transit trips, and a mode-of-

arrival model which estimates the shares of access modes at Metrorail stations, will be migrated to the TP+ platform. These models will be estimated using information contained in the 1994 HTS and the 1994 Metrorail Survey. The longer-term improvements will focus on the development of a nested logit model for the region, and supporting sub-tasks, including enhancing the development of transit fares, improving the representation of PNR lot-to-zone connections, and considering the PNR lot supply to moderate auto-access demand.

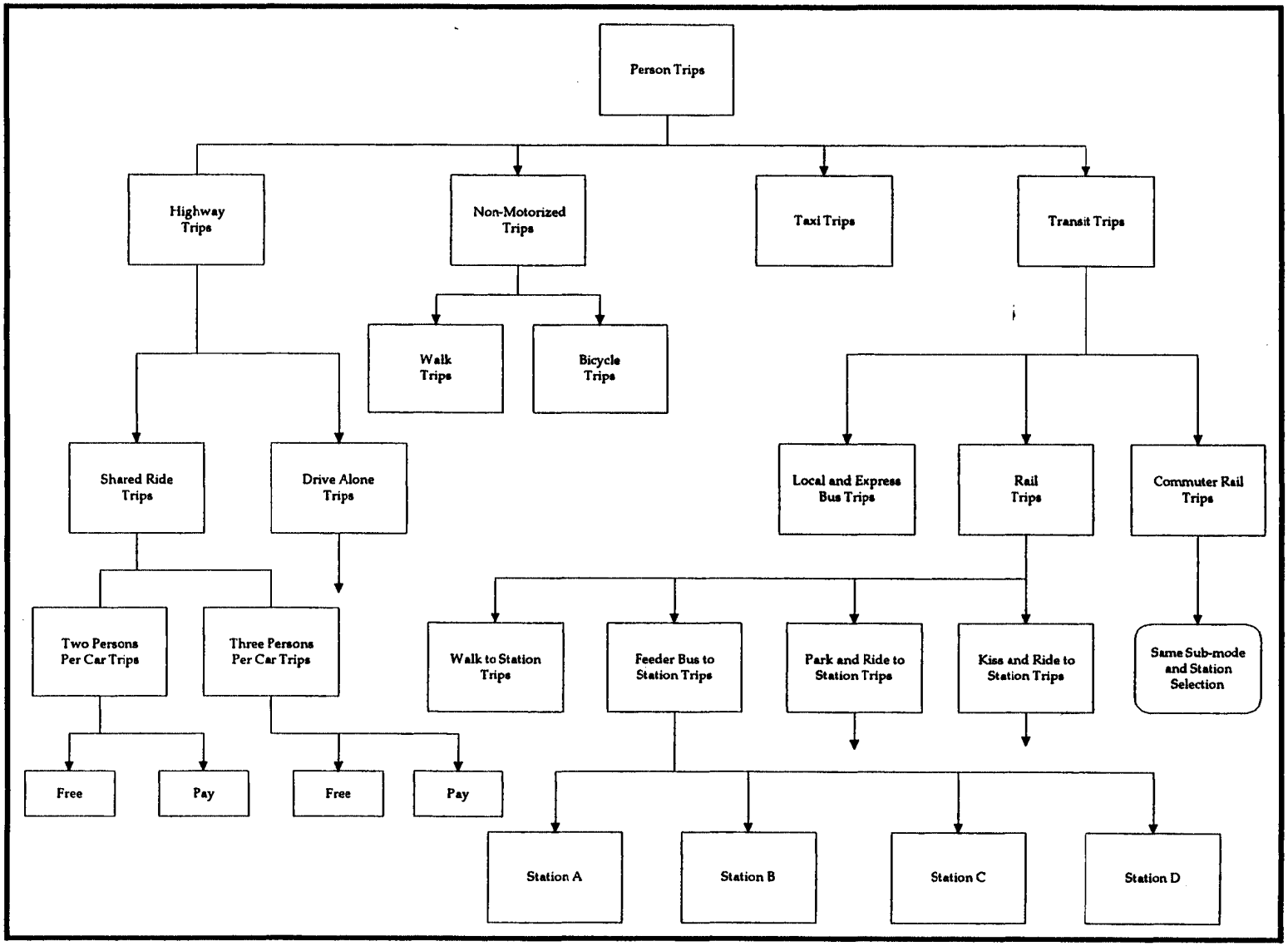
A conceptual diagram of a potential nested logit mode choice model is shown in Figure 2. This structure was the focus of models development for the Dulles Corridor Study several years ago. In that effort, the model coefficients were not developed using statistical packages, but were instead developed using information from other studies. Further, available survey information contained only limited data on the mode choice selection with respect to station and access mode, and the statistical package ALOGIT was found to be inadequate to handle the size nest shown in Figure 2. TPB staff would like the TRB Committee to comment on the level of survey sampling that would be needed to accommodate this model structure during estimation / calibration. Alternatively, the TRB Committee might suggest a different structure that would be less difficult to estimate / calibrate.

TPB staff will also investigate utilizing a newly developed transit analysis package developed by FTA, the SUMMIT program (element 1.A.4). The package is currently in development as a potential tool for assessing transit benefits associated with proposed transit improvements. SUMMIT also holds promise as a quality control device for transit network coding. It may also be used to identify problems associated with other modeling steps beyond mode choice. TPB will work to integrate SUMMIT with the regional mode choice model.

The model validation effort will be undertaken to assess the accuracy of highway and transit simulations using the most recent sources of observed data. It is anticipated that highway ground counts corresponding to calendar year 2002 will be available to check daily screenline crossings and regional VMT. Hourly traffic data from Maryland databases will also be obtained to assess highway performance by time period. Transit validation checks will be accomplished using the 2000 Regional Bus On-Board Survey and the 2002 Metrorail On-Board Survey. (The bus on-board survey incorporates most, but not all, of the major operators in the Washington, D.C. region.)

The TRB Committee has commented in the first letter report that, " The goodness of fit for transit passenger volumes is normally conducted in more detail than systemwide averages and cordon crossings. Additional comparisons by subarea, district interchange, corridor, and rail line and station are typically performed…." TPB staff has historically examined Metrorail assignments in detail after the application of the transit sub models. In contrast, bus trip patterns have not received as much scrutiny beyond a review at jurisdiction levels, due to limitations in local bus data. The 2000 regional on-board bus survey is the first of its kind since 1972. It is hoped that this will allow a more detailed comparison of bus trip patterns produced in the modeling process. A more detailed discussion of the proposed effort in highway and transit validation is provided in Appendix B.

**Figure 2**
**Structure of the Regional Model Mode Choice Model**



## 1.B Business and Commercial Trips

As is the case in many metropolitan areas, the structure of the commercial truck models employed by TPB were developed many years ago, and have been informed by the results of internal and external truck surveys periodically. Most recently, an external truck survey was undertaken for the region in spring and summer 2003, and the information is being tabulated this fall. Post-processing including logic checking, geocoding, and factoring is scheduled to be undertaken during the balance of FY-2004. The last internal truck survey was conducted in 1996 and did not produce a useable dataset for updating the truck models.

The TRB Committee noted that TPB subsumes the estimation of light truck travel in the NHB trip purpose and does not recommend this approach. TPB has responded that until a better means of estimating light truck trips can be developed, there is no choice but to use the NHB trip purpose as a placeholder.

At the urging of the TRB Committee, TPB staff has begun to investigate truck modeling practice in other metropolitan areas. Staff is reviewing the approach adopted in 2002 by the Baltimore Metropolitan Council and has obtained a complete set of model documentation. A description of the Baltimore commercial vehicle model development, together with a summary of truck model development, is presented in Appendix C. This effort to develop a full set of truck models using a synthetic travel pattern derived from classification counts offers promise, given the increased difficulty with internal truck surveys.

For the balance of FY-2004 staff plans to complete its review of modeling practice in this area and develop a design for updating models, including the development of a set of classification counts which could be used to develop a synthetic "survey" trip pattern, in conjunction with the recently completed external truck survey (element 1.B.1). During FY-2006, as part of travel monitoring work program activities, a series of classification counts should be conducted (element 1.B.2). The budget for this effort will need to be funded from sources outside the planning funds in the UPWP, possibly tapping state SPR funding in D.C., Maryland, and Virginia. Assuming completion of the counting program during FY-2006, the development of synthetic trip patterns would commence in FY-2007 with model calibration to follow (element 1.B.3). It is envisioned that the models development work program would provide the resources needed for the design in FY-2004 and the calibration phase in FY-2007/2008 (element 1.B.4). The product would be models providing separate forecasts of light, medium, and heavy trucks.

## 1.C Bus Speeds in TPB Networks

The TRB Committee has observed, "The use of fixed bus speeds in TPB networks may misstate the influence of transit estimates in future trip distribution and mode choice." TPB staff has begun investigating how other MPO's relate bus speeds to congested highway link speeds. TPB staff will work with WMATA and state and local transit agencies to identify a method for representing bus speeds in future years (including expanded services and running way improvements), and integrate the method into the Version 2.1 model. Documentation of the

selected method and related modeling changes will be produced during the second half of FY-2004.

## 1.D Minimize the Use of Adjustment Factors

The TRB Committee has commented that "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 statement that the fundamental behavioral logic is undermined, and has undertaken a review of practice in several major MPOs. TPB staff plans to more fully document the use of these factors (element 1.D.1) in the modeling process, which staff feels reflect, not undermine, the behavioral patterns that cannot be adequately portrayed by a travel demand model structured around time and cost variables. TPB staff maintains that the number of trip interchanges employing adjustment factors is not extensive in the Version 2.1C model, but will undertake a sensitivity analysis to see if reductions could be made (elements 1.D.2 through 1.D.4). Documentation of these activities will be completed during the balance of FY2004. A detailed discussion of adjustment factors currently used in the Version 2.1/C model is provided in Appendix D.

## 1.E Speed Feedback

The TRB Committee has commented that "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." In September 8, 2003 comments on the TRB Committee's first letter report, TPB staff disagreed with the TRB Committee on this point, and referenced the one-year process of review and sensitivity analysis which provided the basis and rationale for the current TPB approach.

TPB staff was mindful in developing its "speed feedback" process of section 93.122(b)(1)(v) in the August 15, 1997 EPA conformity rule amendments which addresses this issue:

> "Zone to zone travel impedances used to distribute trips between origin and destination pairs must be in reasonable agreement (emphasis added) 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 in modeling mode splits"

It is important to note that while this section of the conformity rule requires "reasonable agreement" between travel times used in the various steps of the travel modeling process, it does not prescribe any particular technique for implementing "speed feedback". The appropriate test for whether or not this requirement is being met is to compare the travel times that are estimated from the final assigned traffic volumes with the travel times that are used in the trip distribution

and mode split steps conducted earlier in the sequential trip distribution/mode choice/traffic assignment procedure.

TPB staff has examined the results of some sample applications of the TPB's speedback procedure to assess the level of agreement achieved between the various steps in the modeling process. This examination has focused in particular on running additional iterations of the modeling process to assess whether there are any significant differences between the speeds associated with final assigned traffic volumes for successive iterations of the modeling process. The results of this examination are reported in Appendix E to this document.

The standard application of the Version 2.1C model set involves four sequential iterations referred to as pump-prime, base, first, and second iterations. The pump-prime iteration develops an initial set of highway skims (peak and off-peak). The outputs of this pump-prime iteration are then used as inputs to the base iteration that includes running all of the sequential steps of the modeling process, including mode choice. An appropriate test for "reasonable agreement" of speeds through the process is to compare the outputs of the pump-prime iteration, which are used in the base iteration as inputs to both distribution and mode split, with the outputs of the "second iteration." If reasonable agreement is not achieved, the outputs of the second iteration can be used as inputs to a new base iteration which will rerun both distribution and mode split.

The results of the examination reported in Appendix E suggest that if the inputs to the pump-prime iteration are based on recent modeling results for the year being analyzed, the outputs of the pump-prime (which serve as inputs to the base) compare well with the outputs of the second iteration. If the inputs to the pump-prime iteration are based on modeling results from a much earlier year than the year being analyzed (e.g., using 1994 results as input to pump-prime for a 2025 analysis) the agreement between the inputs to the base and the outputs of the second iteration is not as good. In this latter case, using the output of the second iteration as input to a new base iteration (including distribution, mode split, and assignment) and then conducting "additional" first and second iterations appears to provide much better agreement between the inputs to the base iteration and the outputs of the second iteration.

In summary, it appears that good agreement between the speeds in distribution, mode choice, and final traffic assignment in the current TPB Version 2.1C procedure can be assured either by choosing pump-prime input speeds from earlier modeling results for a year close to the year being analyzed, or by using pump-prime input speeds developed from earlier years and running additional iterations.

TPB staff plans to review the speed feedback practices employed in several other large metropolitan areas, and to conduct other sensitivity analyses with the current Version 2.1 C procedure, including attempting to cycle back through mode split with each iteration and testing alternative forms of the impedance function for trip distribution. This activity will be completed during FY2004, including documentation of the analysis and a recommendation to implement a change to the modeling process if significantly improved procedures are identified.

## 1.F. Emissions Post-processor

The TRB Committee has observed that "the TPB's procedure for estimating hourly traffic volumes and speeds – is questionable ---- Testing will be needed to determine the procedure's effects on emissions estimates." The TRB Committee's first letter report did not provide any specific suggestions for sensitivity tests to be conducted on the TPB's emissions estimation procedures. However, in its detailed comments the TRB Committee seemed particularly concerned about the TPB procedure for establishing volumes, speeds and emissions estimates for links and time periods which are found to be over capacity after the first set of hourly distributions is developed: "the impact of peak-spreading procedures on emissions is very difficult to predict for links that are over-capacity for extended periods."

For links and time periods which are over capacity after the first set of hourly distributions is developed, the link volume/capacity ratio exceeds 1.0 at level of service E, and the link is operating under unstable flow conditions. A procedure is needed to represent these unstable flow conditions for the purposes of emissions calculations. TPB staff has conducted some sensitivity tests employing alternative procedures for addressing over-capacity links and time periods for freeways. The results of these tests are shown in Table 1 for the years 2005 and 2015 for the Washington Metropolitan Statistical Area.

The "base" example in Table 1 represents the TPB's current procedures in which volumes are set at freeway capacity (as determined in look-up tables for different freeway types), and the speed is set using standard speed flow functions corresponding to the maximum of the pre - and post-spread hourly volumes.

The "Test 1" example in Table 1 reduces volumes for all over-capacity links and time periods by 22 percent of the freeway capacity used in the base case to reflect the fact that recurring congestion may reduce flow rates below freeway capacity. The speed in this test is set to correspond to the post-spread volume reflecting congested conditions.

The "Test 2" example in Table 1 reduces volumes for all over-capacity links and time periods to match corresponding flow rates observed in the Skycomp aerial freeway monitoring report for the Washington region. The speed is set to correspond to the post-spread volume under congested conditions.

The "Test 3" example sets the volume to the appropriate freeway capacity as in the base case, but then sets the speed to correspond to the post-spread hourly volume rather than to the maximum of the pre-and post-spread volumes as used in the base case.

In the sensitivity tests reported in Table 1, VOC and NOx emissions generally move in opposite directions as different procedures are employed: VOC emissions decrease from left to right across the table, while NOx emissions increase. This is due to the interplay between the shapes of the VOC and NOx curves, and the differences between the procedures with regard to setting the final volumes and speeds for over-capacity links and time periods. The absolute differences in the emissions estimates in these tests are less than one percent of the base case estimates except for Test 1, where the reductions in NOx estimates were 1.3 and 1.2 percent of the base

**Table 1 Emissions Post-Processor Sensitivity Analysis**

2005 MSA Summary

| | | Test 1 | Base | Test 2 | Test 3 |
|---|---|---|---|---|---|
| | | *Freeway capacity reduced by 22%; Freeway speed based on 'standard' speed-flow function using the post-spread hourly volume.* | *Freeway capacity unadjusted; speed based on 'standard' speed-flow function using the maximum pre-/post- spread hourly volume.* | *For V/C > 1.0 volume adjusted to Skycomp-estimated flow rate. Freeway speed based on 'standard' speed-flow function using the post-spread hourly volume.* | *Freeway capacity unadjusted; Freeway speed based on 'standard' speed-flow function using the post-spread hourly volume.* |
| **Freeways Only** | VMT | 50,022,000 | 50,022,000 | 50,022,000 | 50,022,000 |
| | Speed (mph) | 55.6 | 57.2 | 57.9 | 58.7 |
| | *Diff. WRT Base* | *-1.6* | *N/A* | *0.7* | *1.5* |
| | VOC (tons) | 13.2 | 13.2 | 13.1 | 12.9 |
| | *Diff. WRT Base* | *0.0* | *N/A* | *-0.1* | *-0.3* |
| | NOx (tons) | 87.6 | 90.3 | 90.8 | 91.2 |
| | *Diff. WRT Base* | *-2.7* | *N/A* | *0.5* | *0.9* |
| **All Facilities** | VMT | 126,454,000 | 126,454,000 | 126,454,000 | 126,454,000 |
| | Speed (mph) | 38.7 | 39.3 | 39.6 | 40.0 |
| | *Diff. WRT Base* | *-0.6* | *N/A* | *0.3* | *0.7* |
| | VOC (tons) | 46.8 | 46.8 | 46.7 | 46.5 |
| | *Diff. WRT Base* | *0.0* | *N/A* | *-0.1* | *-0.3* |
| | NOx (tons) | 199.4 | 202.1 | 202.6 | 203.0 |
| | *Diff. WRT Base* | *-2.7* | *N/A* | *0.5* | *0.9* |

2015 MSA Summary

| | | Test 1 | Base | Test 2 | Test 3 |
|---|---|---|---|---|---|
| | | *Freeway capacity reduced by 22%; Freeway speed based on 'standard' speed-flow function using the post-spread hourly volume.* | *Freeway capacity unadjusted; speed based on 'standard' speed-flow function using the maximum pre-/post- spread hourly volume.* | *For V/C > 1.0 volume adjusted to Skycomp-estimated flow rate. Freeway speed based on 'standard' speed-flow function using the post-spread hourly volume.* | *Freeway capacity unadjusted; Freeway speed based on 'standard' speed-flow function using the post-spread hourly volume.* |
| **Freeways Only** | VMT | 59,737,000 | 59,737,000 | 59,737,000 | 59,737,000 |
| | Speed (mph) | 54.9 | 56.5 | 57.2 | 58.1 |
| | *Diff. WRT Base* | *-1.6* | *N/A* | *0.7* | *1.6* |
| | VOC (tons) | 7.0 | 7.0 | 7.0 | 6.8 |
| | *Diff. WRT Base* | *0.0* | *N/A* | *0.0* | *-0.2* |
| | NOx (tons) | 28.1 | 28.9 | 29.1 | 29.2 |
| | *Diff. WRT Base* | *-0.8* | *N/A* | *0.2* | *0.3* |
| **All Facilities** | VMT | 146,521,000 | 146,521,000 | 146,521,000 | 146,521,000 |
| | Speed (mph) | 38.4 | 39.1 | 39.4 | 39.8 |
| | *Diff. WRT Base* | *-0.7* | *N/A* | *0.3* | *0.7* |
| | VOC (tons) | 23.3 | 23.3 | 23.3 | 23.1 |
| | *Diff. WRT Base* | *0.0* | *N/A* | *0.0* | *-0.2* |
| | NOx (tons) | 64.8 | 65.6 | 65.8 | 65.9 |
| | *Diff. WRT Base* | *-0.8* | *N/A* | *0.2* | *0.3* |

case estimates for 2005 and 2015 respectively. Since running emissions represent less than half of total mobile emissions for VOC in both 2005 and 2015, and about 86 and 83 percent for NOx for 2005 and 2015 respectively, these tests generally show relatively small changes in mobile emissions estimates in all of the cases.

In a conformity determination approved by the TPB on December 17, 2003 mobile emissions estimates for milestone years 2005, 2015, 2025, and 2030 were significantly below mobile emissions budgets recently found to be adequate by EPA. The analyses supporting both the mobile emissions estimates for milestone years and the mobile budgets were conducted using the current Version 2.1 C travel model and post-processing procedures referenced in this document, in conjunction with EPA's MOBILE6 emissions model. The emissions budgets and estimates for 2005 and 2015 were as follows (in tons per day):

| | **2005** | | **2015** | |
|---|---|---|---|---|
| | **VOC** | **NOx** | **VOC** | **NOx** |
| Budgets | 98.1 | 237.4 | 98.1 | 237.4 |
| Estimates | 97.4 | 234.7 | 48.3 | 79.3 |
| Budget Adherence Margin | **0.7** | **2.7** | **49.8** | **158.1** |

Additional emissions reductions in 2005 of 4.0 tons per day of VOC and 8.3 tons per day of NOx were documented based on off-line estimates of the benefits associated with transportation emissions reduction measures, bringing the total adherence margins for 2005 to 4.7 tons per day for VOC and 11.0 tons per day for NOx. The changes in mobile emissions estimates for 2005 and 2015 shown in the sensitivity tests in Table 1 that represent increases in emissions are quite small relative to the adherence margins documented in the TPB's December 17, 2003 conformity determination.

Having evaluated the procedures and results shown in Table 1, TPB staff believes that the Test 2 method may be more conceptually appealing than the base case method, and is considering incorporating this method into future production versions of the post-processor. TPB staff is also planning to conduct same comparisons between the time-of-day distributions resulting from the post-processor and distributions observed from permanent count stations located throughout the Washington metropolitan area. TPB staff plans to assess whether the post-processing methodology might be useful in providing improved time-of-day distributions for traffic modeling and analysis, in addition to being used for estimation of mobile emissions as is the case in currently adopted TPB procedures.

TPB staff plans to seek information on emissions estimation procedures employed in other metropolitan areas over the coming year, and to conduct additional sensitivity tests as appropriate. If significantly improved procedures are identified, they will be incorporated into future updates to the TPB's adopted procedures.

### 1.G Incremental Refinements to the Version 2.1C Model

This is a global activity to integrate the latest refinements emerging from the ongoing program, as these can be made ready for production modeling (i.e., air quality conformity of the TIP and Plan, and project planning studies). As indicated in Figure 1, a new label (Version 2.1D, 2.1E, etc.) would be affixed to the production model as these refinements are incorporated into the regional modeling process. While the timeline suggests an annual update, the update might occur at irregular intervals, as warranted by the refinements.

## Methods Development (Track 2)

The activities in the methods development track are associated with the development of a 'next generation' of travel forecasting procedures using the current state of the art in modeling, including improvements to the existing four-step model or the implementation of more advanced approaches such as tour-based models. There are several areas where the current four-step approach possibly could be enhanced. These include the implementation of an airport ground access model, a shift to tour-based or activity-based models, and the development of a more detailed zone structure.

### 2.A Continue Airport Ground Access Model Development

The Washington region has three major airports: Dulles International, Baltimore-Washington International, and Ronald Reagan Washington National. The existence of three airports poses a complex situation in attempting to forecast airport ground access by mode. Fortunately, there is an ongoing program to collect ground access travel data at approximately two-year intervals. Staff activities during FY-2004 include the review of these data and investigation of ground access modeling practices in other metropolitan areas. It is envisioned that development of a model specification and calibration file could be undertaken in FY-2005 with the goal of implementing a production model during FY-2006. A more detailed discussion of the proposed effort in airport ground access model development is provided in Appendix F.

### 2.B Tour-based and Activity-based Models

Two emerging trends in regional travel forecasting models are tour-based models and activity-based models. Nearly all activity-based models include tour modeling, but a tour-based model does not necessarily include activity modeling. A traditional household travel survey, like the 1994 COG/TPB Household Travel Survey, would support development of either traditional trip-based models or the newer tour-based models. By contrast, development of an activity-based model of travel would require that a special activity-based household travel survey be conducted. The main benefit of conducting an activity-based household travel survey is that it could be used to develop all three model types, i.e., trip-based, tour-based, and activity-based models. The principal drawback is that the survey instruments for activity-based surveys tend to be more elaborate, which can lower survey response.

Tour-based models have been used in European countries, such as Sweden and the Netherlands, for a number of years. By contrast, their use in the U.S. is a more recent phenomenon. One of the first operational tour-based models in the U.S. was developed by Cambridge Systematics, Inc. for Boise, Idaho in 1995. It dealt only with auto trips. Boise discontinued using it, because the town did not have the staff to maintain it.

Three tour/activity models are currently in use:

- New Hampshire statewide model (1997), tour-based model
- Portland, Oregon (1998), activity-based model developed by Mark Bradley. Portland's model was enhanced in 2001.
- San Francisco County (2000), tour-based and activity-based

Several urban areas are considering tour- and/or activity-based models: Cincinnati, Dallas, Denver, and Seattle. A recent TMIP-supported peer review panel recommended that the Denver Regional Council of Governments (DRCOG) move away from its traditional four-step model and move toward activity-based modeling, including a tour-based approach to trip making. Similarly, a separate TMIP-supported peer review panel recommended that the Cincinnati MPO (Ohio, Kentucky, Indiana Regional Council of Governments: OKI) move toward tour-based models (Urban Transportation Monitor 2003). In a recent (2001) model review for the Puget Sound Regional Council, a peer review panel led by Cambridge Systematics, Inc. recommended that PSRC move toward both tour-based and activity-based models.

In tour-based models, a tour is generally defined as a series of trips starting and ending at a given place. For example, a home-based work tour starts and ends at home and the "primary activity" of the tour is work. Every tour can have zero, one, or more "intermediate stops." Each tour is eventually decomposed into its component trips, which get assigned to a network, using standard travel modeling software packages, such as TP+ or TransCAD. In activity-based models, instead of beginning with trip generation, the model generally begins with a generation of daily activity patterns. From activity patterns, tours are developed, which later get broken down into trips.

TPB staff would like the TRB Committee to suggest directions that might be taken in the TPB methods development track during the next several years with regard to tour-based and activity-based models.

## 2.C Grain of Analysis Zones

TPB staff would like the TRB Committee to comment on the grain of travel analysis zones. The present 2,191-zone structure covers a 7,000 square mile region. There are 1,972 internal zones, 47 external stations, and 72 spare zone numbers available for corridor detailing. This structure was dictated by limitations in the DOS-based MINUTP software TPB staff had been using. The allocation of zones reflected an allocation by the TPB Travel Forecasting Subcommittee which took into consideration the following:

- the need for more detailed zones around transit stations;
- the need to reflect an expansion of the urbanized area within the region; and

- the need to add jurisdictions to the modeled region reflecting the EPA-designated non-attainment boundary.

Considerable time and energy were expended in getting this 2,191-zone structure in place in 1994. The resulting zone structure was a compromise which addressed each of the three needs. The zone allocation impacted network coding, model estimation, and demographic projections of population, households, and employment in COG's Cooperative Forecast.

With the migration to a Windows-based software, notably TP+, the constraint on number of zones is removed. The three needs identified above remain. TPB staff also recognizes that the present zone structure results in zones that are larger than desirable, in downtown Washington as well as in the outer suburbs, which inhibits transit and highway assignments.

### 2.D Data, Software, Hardware, and Training Requirements

Before embarking on the development of enhanced models, there are several preparation activities that will need to be considered. It will be important to anticipate data requirements necessary to support the enhanced modeling approach. New types of required information may not be readily obtained using conventional data collection techniques. The software and hardware requirements to support the newer models will also need to be funded and put into place. Staff development and training will also need to be addressed. It is envisioned that the use of GIS-aided procedures will play an increasingly important role in the development of model enhancement plans.

## Research (Track 3)

Activities in the research track are important to an ongoing models development program, but are sometimes neglected. Keeping abreast of modeling practice is facilitated by participation in the Transportation Research Board, the AMPO Travel Modeling Subcommittee, the Travel Model Improvement Program, and ITE. Additionally, literature reviews are facilitated by access to MPO and other websites.

## Data Collection (Track 4)

### 4.A Regional Household Travel Survey

Staff has identified three potential options for conducting a new regional household travel in 2004/2005. In Appendix G, a series of important questions that could affect the design and conduct of this new regional household travel survey are posed to the TRB Committee. Staff would like to review and discuss the TRB Committee's responses to these questions with the Travel Forecasting Subcommittee of the TPB Technical Committee before making a final decision on what may be a once in a decade opportunity to collect needed new household travel survey data for future models development activities.

The first option would be to conduct a new regional household travel survey similar to the 1994 COG/TPB Household Travel Survey. This survey would be a trip-based survey designed to support further refinement and validation of the COG/TPB Version 2.1 four-step travel forecasting model. Data collection for this survey would occur in two phases in the fall of 2004 and the spring of 2005. A completed sample size of 2,500 households would be obtained in each survey data collection phase for a total sample size of about 5,000 households. This sample would be stratified by major jurisdiction with the total number of samples allocated to each jurisdiction roughly proportional to each jurisdiction's relative share of regional households. Slight exceptions to this proportional allocation of survey samples would be in the District of Columbia and in lower density outlying semi-rural jurisdictions. District households would be over-sampled by one-third to ensure a sufficient number of sample households residing in higher-density urban areas well served by transit in the overall regional sample. Also, a minimum completed sample size of 150 households would be established for the outlying semi-rural jurisdictions regardless of their proportionate share of regional households to ensure an adequate number of samples for analysis from this jurisdictional area-type. This sample allocation plan would result in approximately 1,000 completed samples in the District of Columbia, 250-300 samples each in the other inner core area jurisdictions of Arlington and Alexandria, 500-700 samples in each of the three major Beltway jurisdictions, 250-300 samples in each of four outer suburban jurisdictions, and about 150 samples in each of two outlying semi-rural jurisdictions in the TPB planning region.

A Computer-Assisted Telephone Interviewing (CATI) survey methodology would be used for this new household travel survey and employ random digit dialing techniques (RDD) to develop the geographically stratified sample of households to be contacted. Households in the RDD sample with published telephone numbers would be identified and sent pre-survey letters explaining the purpose of the travel survey, informing them that someone will be calling them shortly and encouraging their participation. Initial survey recruitment calls would be made in an attempt to contact all potentially eligible households drawn in the RDD sample regardless of whether or not the household has a published telephone number. A minimum of seven call attempts on at least 5 different days would be made to reach and recruit each potentially eligible household to participate in the household travel survey. When a potentially eligible household is reached an initial screener interview would be conducted to obtain some basic information about the household and attempt to elicit the household's participation in the survey. Households agreeing to participate in the travel survey would be sent travel diaries for each member of the household age 5 and older to be completed for a randomly assigned travel day. Travel day trip diary information and personal characteristic data for each household member would then be retrieved via diary retrieval interviews and recorded into the CATI system.

Planned survey quality control and response enhancement procedures for this survey would include: (1) pre-survey letters to households with published phone numbers, (2) use of experienced, well-trained multi-lingual survey interviewers, (3) use of refusal conversion techniques, (4) survey reminder cards and calls, (5) a 1-800-Help Line, (8) use of trip rostering techniques and (7) limited use of proxy interviews.

It is anticipated that this first option for a new regional household travel survey could be designed to fit within expected UPWP budget levels over a two fiscal year period.

The second option for the conduct of a new regional household travel survey would be very similar to the first option, except that it would also include a GPS household vehicle tracking add-on sub-sample. This add-on sub-sample would recruit approximately 200 households who had agreed to participate in CATI to also agree to carry GPS tracking devices in their household vehicles on their travel survey day. Household respondent vehicle trip reports recorded in the CATI would then be compared with the vehicle tracking records recorded using the GPS device. In this manner the GPS add-on sub-sample would provide a direct measure of survey respondent vehicle-trip underreporting and misreporting of vehicle trip details because the GPS tracking would also provide direct measures of trip starting and ending times as well as very accurate measures of trip distances.

It is estimated that such a 200 household GPS tracking add-on sample would increase travel survey costs by about $100,000 and require some increase in UPWP funding for this add-on sub-sample.

The third option would be the conduct of a large-sample methodologically enhanced activity-based regional household travel survey requiring additional funding from sources outside the planning funds in the UPWP. Methodological enhancements would include: (1) development of a GIS-based housing unit sampling frame that would enable selections of travel survey sample households by area type; (2) development of a multi-modal data collection survey methodology that permits household recruitment and diary retrieval by mail, telephone, Internet and in-person contacts; (3) a GPS add-on sub-sample; and (4) a follow-up survey of non-responding households and household members. It is estimated that such an enhanced survey would cost on the order of 3 to 5 million dollars for a 10,000 to 15,000 household sample and would require significant pre-testing of the design enhancements.

Staff believes that there is considerable merit in the third option worth the substantially higher costs, given that this would be a once in a decade opportunity for improving the quantity and quality of data for model development in the metropolitan Washington region. Staff currently plans to begin the design of such a large-sample methodologically enhanced regional household travel survey and to seek additional funding from sources outside the planning funds in the UPWP. Staff is very interested in the TRB Committee's responses to the questions in Appendix G and its comments on the three options for a new regional household travel survey that are currently under consideration.

## 4.B Auto External Survey

This project will obtain information on auto travel to and through the modeled region by persons living in areas beyond the external travel cordon for the modeled area. Information on the origin and destination of the external auto trip, the trip purpose, the number of persons in the vehicle, number of vehicles regularly used by the trip maker's household, and the Potomac River Bridges that may be crossed will be obtained via a very short, mail-out/mail back postcard questionnaire.

### 4.C Analysis of Census Journey to Work Data

This project will obtain, tabulate, and analyze Census Journey to Work data collected in the 2000 Census. This work activity will include tabulation and analysis of Summary File 3 (SF 3), the Public Use Microdata Sample (PUMS) and the Census Transportation Planning Package (CTPP 2000). Place of work geocoding for the CTPP 2000 will be used by comparing it to COG's small area TAZ-level employment data and developing place of work adjustment factors, if necessary. Trip conversion factors will be developed to convert CTPP 2000 worker flow data into Home-Based Work (HBW) commuting trips consistent with the definitions used in COG/TPB travel forecasting model. After applying appropriate HBW conversion factors a TAZ-level data file will be built for use in travel model validation and refinement efforts.

The CTPP 2000 data tabulations and analysis will also be used to review the current 2191-TAZ areas system and to suggest updates and refinements to it, especially in geographic areas that currently have large TAZs.

### 4.D Regional Transportation Data Clearinghouse

Staff will update TPB's Regional Transportation Data Clearinghouse databases with updated traffic volumes and transit ridership data as well as transportation-related data from the 2000 Census. Formal arrangements with local, state, WMATA, and other regional agencies will be continued and expanded to transfer new data to and from the Regional Transportation Data Clearinghouse. The necessary database and communications infrastructure needed to incorporate better access to ITS and other more detailed traffic volume and speed data will also be developed.

## Maintenance (Track 5)

The Maintenance track is envisioned to be an ongoing work element in the models development program focused on documentation and training. Documentation of technical methods is viewed as a critical component of the models program for several reasons. A detailed summary of calibration and validation procedures are important for understanding the model design and the relative importance of specific variables used in each step of the process. Defining input variables and guidelines for applying the travel model in writing minimizes opportunities for misuse and misspecification of the model. The technical users are now only one segment of the community demanding information on the regional modeling process. Elected officials, interest groups, and private citizens are increasingly eager to obtain modeling information. In response, the TPB allows technical information to be accessed directly over the internet. As scrutiny of the TPB travel models has increased in recent years, it has become clear that well prepared documentation fosters public buy-in to the regional planning process and minimizes the opportunities for legal challenges.

Documentation activities will address the application of the current travel model, modeling updates that have been implemented during the year, and progress made in the Methods

Development and Research tracks. TPB staff has prepared a number of special summaries and sensitivity tests of the Version 2.1/C model at the request of the TRB review panel during FY-2003 and FY-2004. These materials will be packaged together as part of FY-2004 documentation.

The 'regionally adopted model' is commonly sought to serve the needs of project planning work conducted by local transportation agencies. Training in the application of the regional model will therefore be an on-going staff activity, particularly as the model incrementally evolves over time.