# ITEM 9 - Information

July 21, 2004

Review of Proposed Work Program to Address the Travel Demand Modeling Topics Identified in the Transportation Research Board (TRB) Review

**Staff Recommendation:** Receive briefing on the proposed travel models development work program to address the comments and recommendations provided in the TRB final letter report.

**Issues:** None

**Background:** At the June 16 meeting, the Board was briefed on the final letter report of the TRB review of the region's travel modeling procedures and on the staff comments for addressing the six topics identified in the report.

In April 2002, the TPB approved a process for conducting a review of the region's travel modeling procedures. The process called for the TPB to engage the TRB in appointing a review panel and overseeing the review process. The TRB began its analysis of the TPB modeling procedures in January 2003 and submitted its first letter report on September 8, 2003. The analysis has been completed with the submission to TPB of the second letter report on May 10, 2004.

METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS

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**M E M O R A N D U M**

Date: July 15, 2004

To: Transportation Planning Board

From: Ronald F. Kirby
Director, Department of
Transportation Planning

Re: Attached Materials on Addressing the Travel Demand Modeling Topics Identified in the Transportation Research Board (TRB) Review

Attached are three items that will be referenced in the special TPB work session scheduled from 10:30 to 11:45 am on Wednesday July 21, and under item #9 of the TPB meeting agenda:

- A short article reproduced from the TPB's 2002 Annual Report describing the travel forecasting process

- A briefing paper outlining the six key topics identified in the TRB Modeling review, and proposed TPB staff responses in the short-term, medium term, and longer-term

- The detailed TPB Work Program Document prepared by TPB staff on December 24, 2003 in response to the TRB Committee's request, with updates as of July 15, 2004 (shown in bold italics) to reflect comments received in the TRB Committee's second letter report dated May 10, 2004.

Attachments

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# Forecasting Future Travel

When the front page of the *Washington Post* Metro section featured a story on regional travel forecasting, it seemed a clear sign of the increased—and somewhat unusual—attention that has focused in recent years on the TPB's analytical work.

"Usually, the calculations end up in technical reports seen by only a handful of politicians, air quality experts and transportation planners," wrote *Post* reporter Katherine Shaver on January 8, 2002. "Now those estimates could jeopardize billions of dollars in new road and transit projects across the region—and, suddenly a lot more people are noticing."

The *Post* was referring to a potential cutoff in federal funding that could happen if the region failed to meet air quality improvement goals for 2005. Emissions estimates caught a lot of attention in 2002, but these forecasts are really just the tip of an iceberg of data produced through the regional transportation modeling process.

The TPB's travel forecasting process combines scientific theories, an enormous amount of data and a painstaking level of professional effort. Ultimately, this process yields a wealth of information reflecting the transportation choices we make every day, and predicting how our travel behaviors might change down the road.

## Finding Patterns in Human Behavior

Across the region, similar scenes are taking place every morning in thousands of places:

*Jane leaves her Silver Spring home at 7:15 a.m. She drops off her kids at school and weaves her way through traffic to her job in Rockville. Over the years, she generally has figured out which route is fastest, although she's always looking for better options.*

*Near Bailey's Crossroads, Jim dashes out the door to catch the 7:48 bus. If he gets on the express bus, he knows he will be at the Pentagon early enough to find a seat on the Yellow Line train, and get downtown 20 minutes earlier.*

In their daily commutes, Jane and Jim follow regular patterns, although they frequently make adjustments based on emerging conditions. A lot of "Janes" are going to Rockville every day; as certain roads become progressively worse or better, a certain number of these commuters can be expected to change their routes. And a lot of "Jims" are taking buses to the Pentagon every morning. Crowds on trains, bus availability, and the prices of different trips are among the many factors that will persuade a certain number of these workers to travel earlier or later, or find some other way to get downtown.

These small changes in travel behavior, which often seem random, actually follow fairly predictable patterns. Collectively, they can add up to big changes in traffic flow and congestion.

Planners and engineers working for the Transportation Planning Board have developed computer models that reflect the millions of decisions that, in combination, cause traffic at different points in the region to move at various speeds—and sometimes not to move at all. These travel forecasting models enable planners to look at the effects of what has been planned and to test potential changes. What if a road is widened? How about a new rail line? How will new jobs affect traffic?

The models are essential tools for the development of the TPB's Constrained Long-Range Transportation Plan (CLRP) and the six-year Transportation Improvement Program (TIP). Any time these documents are amended, the region's road and transit networks, including all new projects, are "modeled." This process produces travel forecasts, including information on the number of miles people will be traveling (vehicle miles of travel), the way they will travel (mode choice), how fast they will be going, and many other pieces of information.

Modeling is required by federal law. Travel forecast data are fed into a separate model that forecasts vehicle emissions levels. This "mobile emissions" model is mandated by the U.S. Environmental Protection Agency. Under the Clean Air Act, the TPB must show the CLRP and TIP are "in conformity" with regional air quality improvement goals. A new conformity finding is required any time the CLRP and TIP are amended to include projects that affect air quality.

The TPB's travel forecasting models are also used in various studies throughout the region. State departments of transportation, the Metro system and local transportation departments all use the models to produce corridor studies and other analyses.

Travel forecasting is not a crystal ball that can precisely predict traffic patterns in small areas, especially over a longer time frame. Instead, its greatest value is comparative. The travel forecasting models offer a means by which decision makers can look at different transportation options and see the potential effects they might have at the regional or corridor level.

## What Goes Into the Models?

The Transportation Planning Board maintains a staff of specially trained transportation engineers with expertise in developing, running and validating models. Staff also performs various types of surveys to obtain data for the models and to check the accuracy of their predictions.

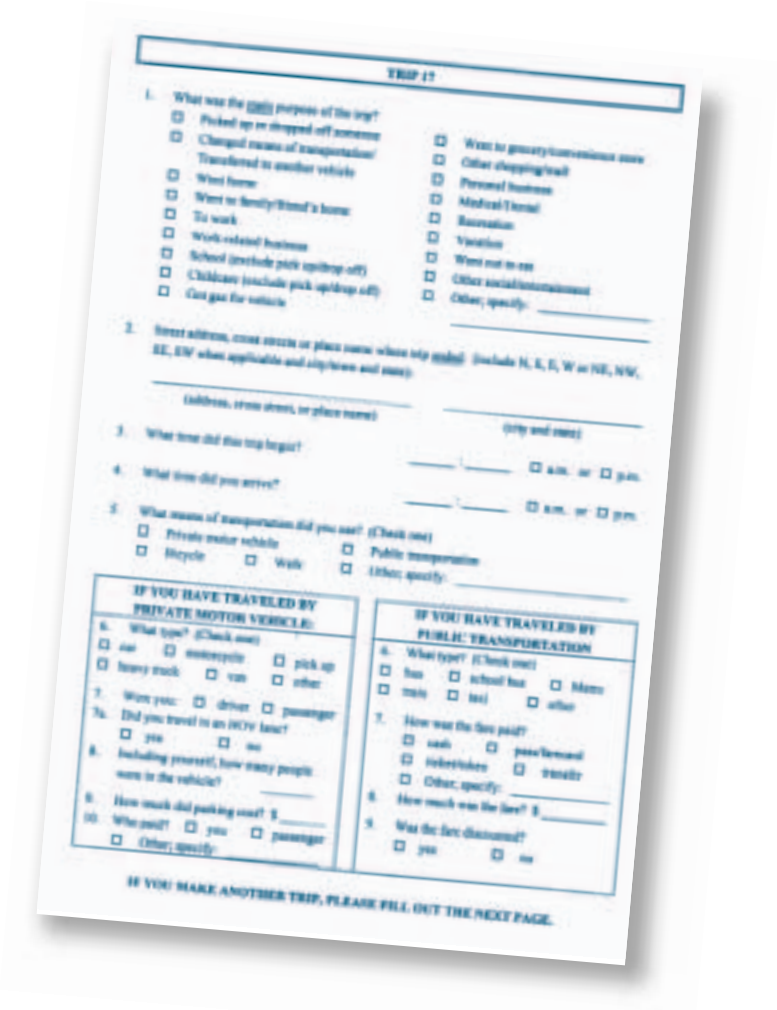
Modeling is not cheap. In a four-month period in 2002, modeling to test the air quality conformity of the proposed CLRP and TIP cost more than $400,000 for staff and other resources. Overall, maintaining and applying the models requires approximately 36 percent of the TPB's transportation planning budget, or about $2.9 million per year.

The two basic inputs for applying the travel demand models are:

- Land use inputs, including forecasts of future population, household growth, and employment; and
- Transportation inputs, including the current transportation network, and planned or potential changes.

COG's Cooperative Forecasting Program develops the land use inputs. The data developed through this program, which reflect the best judgment of local planning officials, enable local and regional planning to be coordinated by using common assumptions about future growth. The Cooperative Forecasts combine regional data, which are based upon national economic trends and regional demographics, with local projections of population, households and employment. These local projections are based upon data about real estate development, market conditions, adopted land use plans and the effects of planned transportation improvements.

Transportation inputs are a little more straight-forward. What facilities and policies, such as Metro fares, are now in place? What projects and other changes are planned? These are the kinds of inputs that are coded into the model. For example, modeling for the CLRP includes the existing transportation system along with changes planned across the region over the next 25 years. The model also can be coded for "what-if" scenarios, asking questions like: What would happen if we upgrade a local bus route to express service?


TRIP 1?

IF YOU HAVE TRAVELED BY PRIVATE MOTOR VEHICLE:

IF YOU HAVE TRAVELED BY PUBLIC TRANSPORTATION

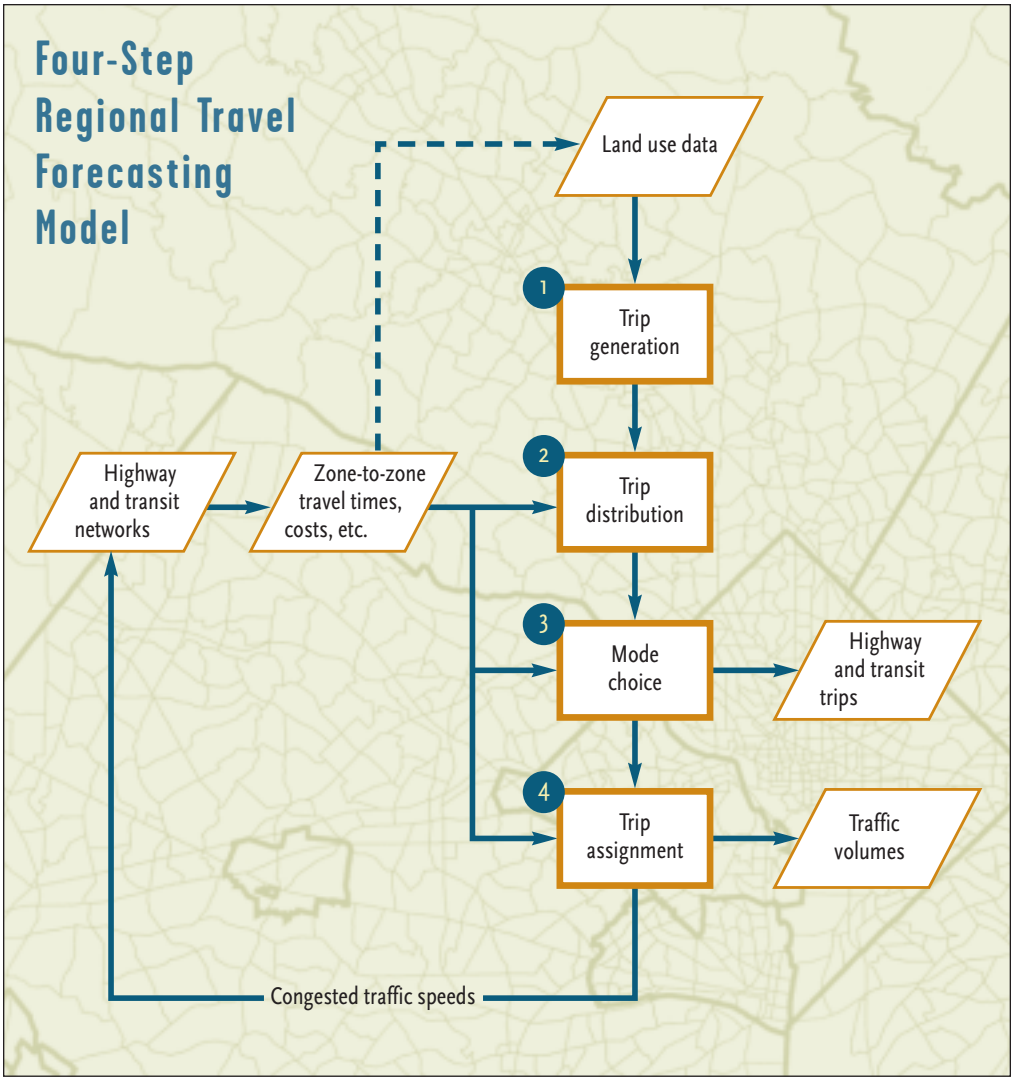
IF YOU MAKE ANOTHER TRIP, PLEASE FILL OUT THE NEXT PAGE.

The TPB's Household Travel Survey is a primary source of data for travel demand modeling. Survey respondents fill out trip diaries, pictured above.

TPB staff performs a variety of surveys that provide data used to develop and validate the travel models.

A household travel survey is based on "trip diaries" filled out by randomly selected individuals. For every trip they take, respondents fill out a page-long questionnaire recording where they went, how long it took, how they traveled, and other information. The respondent is also frequently telephoned for followup information.

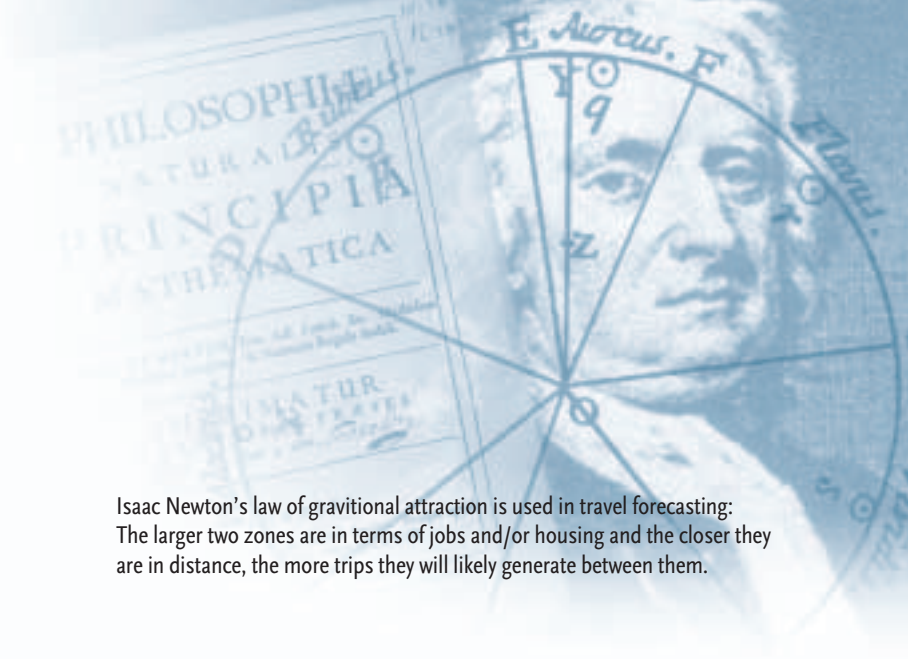
U.S. Census data is another important source of information for developing and validating the models. Transportation "journey to work" information is derived from the Census long form, distributed to one out of six Census respondents. It is limited, however, to information about work trips only.




In addition, the TPB staff performs various traffic counts. Temporary workers do much of the basic work for these surveys, which requires them to sit by the sides of roads and actually count the number of cars that pass and how many people are in each car.

Other studies focus on transportation demands for certain types of facilities. A freeway monitoring study, performed every three years, uses aerial photography to record traffic along every stretch of freeway in the region. A survey of travel times on arterial roads is performed using global positioning systems hooked up to conventional automobiles. An airline passenger survey provides information about traffic coming in and out of the region's three major airports. These surveys are valuable tools for developing the TPB's travel forecasting model and validating its outputs. (See the previous chapter for recent results from the freeway, arterial and airport surveys.)

Traffic counts and truck surveys are two more sources of data for the TPB's travel forecasting process.




Isaac Newton's law of gravitional attraction is used in travel forecasting: The larger two zones are in terms of jobs and/or housing and the closer they are in distance, the more trips they will likely generate between them.

## How Do the Models Work?

Virtually all U.S. metropolitan areas use a similar "four-step process" to replicate regional travel behavior:

### 1. Trip Generation: How much travel?

First, the TPB's modelers divide the region into 2,200 traffic analysis zones. A zone can be as small as a few city blocks in downtown Washington or bigger than 100 square miles in rural areas.

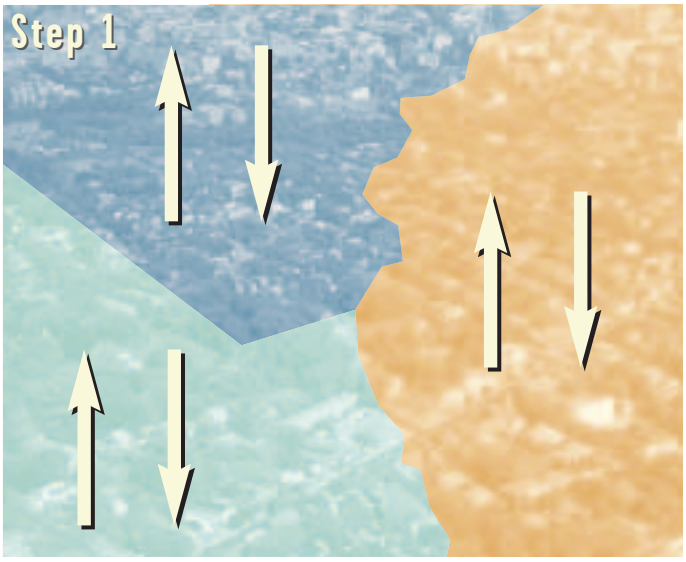
Then the modelers estimate the number of trips to and from each zone. The model separates trips according to purpose—people going to work, shopping, and so forth. Each zone "produces" and "attracts" a certain number of trips. The model estimates the number of trips produced by and attracted to each zone, based on the residential and employment characteristics of the zone. For example, a zone in downtown Washington would attract far more morning trips than it produces.

### 2. Trip Distribution: Who goes where?

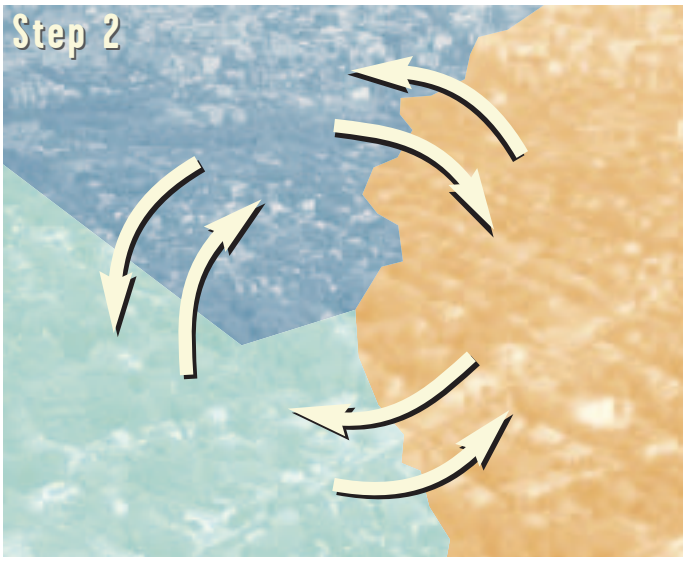
This second step matches the trips produced in each zone with the zones to which they are attracted. For example, after step one estimates the number of work trips produced by a zone in Gaithersburg, step two matches all those trips to other zones around the region — to downtown DC, to nearby suburbs, to Northern Virginia, and elsewhere. These linkages are counted as origin/destination pairs.

Modelers invoke Newton's law of gravitational attraction at this point. In planetary science, this theory says that the greater two planets are in size, the greater the gravitational pull between them. Similarly, in transportation modeling, the larger two zones are (in terms of jobs, households or both), the more trips they will generate between them.

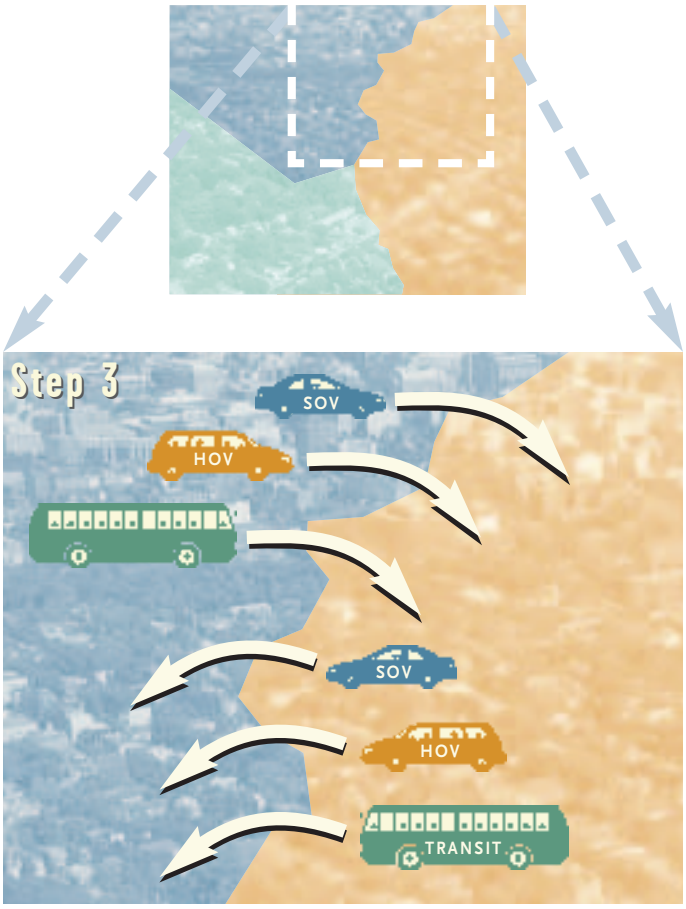
Distance is also key. A Fall Church resident feels more "gravitational pull" to Tysons Corner than to a shopping center in Montgomery County.



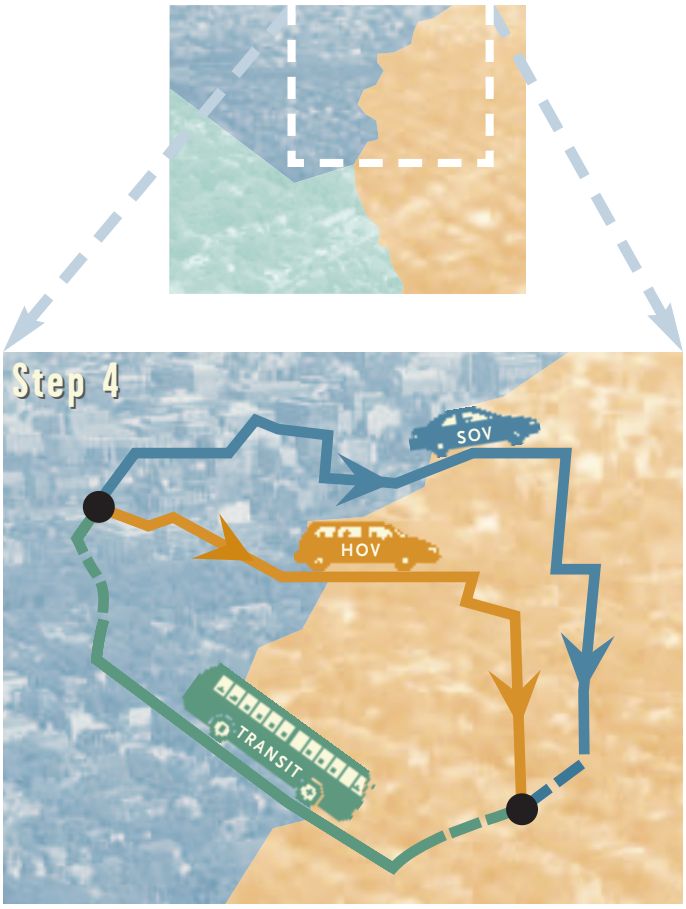

Trip generation in three fictitious traffic analysis zones: This step estimates the number of trips produced by and attracted to each zone.




Trip distribution among three fictitious zones: This step estimates how many trips are going from zone to zone.




Mode choice between two fictitious traffic analysis zones: Estimating the way people get from zone to zone.




Trip assignment between two fictitious traffic analysis zones: Selecting the fastest route between zones.

### 3. Mode Choice: How do people travel?

Drive or walk? Bus or train? In step 3, the model determines how people are likely to get around based on the relative attractiveness and availability of each transportation option.

The model considers factors like the accessibility of mass transit, automobile ownership and proximity to carpool lanes. It also factors in costs and time required to use the mode of travel. Cost variables include the price of gas and parking, transit fares, and other expenses. Time considerations include time waiting for trains and buses, time for transfers, time to drive and park, and time to walk to a final destination. These and numerous other factors are plugged into a series of equations estimating the probability of each traveler selecting each mode.

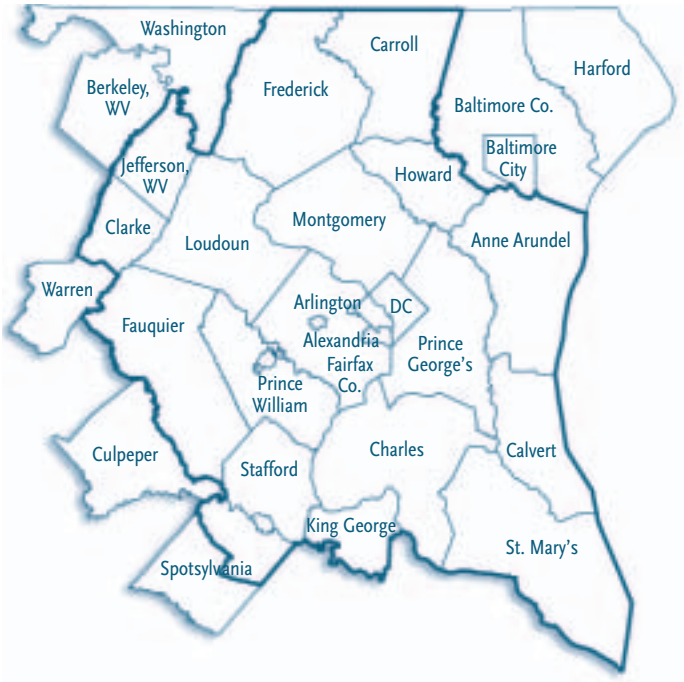
### 4. Trip Assignment: What routes do travelers take?

Finally, the model selects the best "paths" for travelers to take. It assumes people will take the quickest route, avoiding traffic jams and bottlenecks where they may occur. The model looks at each type of trip, determining the best path—both in terms of time and distance—to get from zone to zone.

The model also predicts factors that might trigger changes in travel behavior. If Jim is frustrated by the growing congestion on his drive to work, he may find an alternative place to live or work. If Jane gets a Metrochek transit subsidy from her employer, she might take Metrorail instead of driving.

The whole modeling process takes a lot of time. The models currently include computerized representations of more than 28,000 road segments, hundreds of transit lines, and travel data for 2,200 geographic zones. Depending on the application, each model "run" can take as much as eight hours of processing time on a personal computer (11 hours with the new Version 2 model).

The area used for travel forecasting, shown by the heavy blue line, extends beyond the boundaries of the TPB's member jusridictions.




## New Tools, More and Better Outputs

An updated travel demand model, known as Version 2, has been developed by TPB staff. This new model is more sensitive to things like household size and income, bicycle and walking trips, non-work transit use, and the time of day when trips are made. The TPB staff is planning a number of other enhancements, both in terms of inputs and applications of the model.

Emissions forecasting is also undergoing major changes with the introduction of another new model, which was mandated by U.S. EPA. This mobile emissions model, known as Mobile 6, requires substantial new data and relies on a new understanding of vehicle emissions.

## Models Under Scrutiny

The TPB's computer models took on a heightened relevance in 2001 when the region's regular transportation planning process was put on hold after forecasts predicted that transportation-related emissions would exceed the region's air quality improvement goals in 2005.

TPB staff spent months reexamining and documenting the analysis predicting the region would exceed its 2005 limits on nitrogen oxides (NOx), a component of ground-level ozone. Facing an indefinite delay of new transportation projects, state and local officials, and their staffs, closely examined the findings that created the deadlock and worked with TPB staff to develop solutions.

The TPB's technical work came under added scrutiny in December 2001 when a coalition of environmental groups issued a critique of the TPB's modeling. Although staff found no basis for the coalition's assertions, the TPB agreed this was a good time to conduct an independent peer review of the region's transportation modeling process. In April 2002, the board authorized staff to proceed with organizing this review.

The Transportation Research Board of the National Academies will conduct the peer review in 2003. In this process, national experts on travel forecasting will provide comments on the model's effectiveness, and advice on how to refine it further.

TPB members and staff welcomed the opportunity to find new ways to enhance the modeling process. "I think COG has been known in the past for having a state of the art model," said Marsha Kaiser who represents the Maryland Department of Transportation on the TPB. "I'd hope that Version 2 continues to keep us on the leading edge."

As a basis for travel forecasting, TPB staff develop detailed computerized networks that include current and future transportation facilities.

# Listening to Citizens, Promoting Transportation Options

The TPB continued to develop and implement programs in 2002 that broadened outreach and expanded travel choices.


The pedestrian safety campaign urged drivers to "imagine the impact."

## "Street Smart" Campaign Aims to Improve Pedestrian/Bike Safety

Regional leaders launched a public education and outreach campaign in October 2002 to reduce pedestrian deaths and injuries throughout the Washington region. With pedestrian fatalities outnumbering homicides in many jurisdictions, leaders vowed to work together on a multi-year effort to heighten awareness about pedestrian safety and change the behavior of drivers.

The campaign, titled "Street Smart," is aimed at young drivers who are involved in the majority of pedestrian collisions. The campaign features Metrorail and Metrobus ads, radio ads, television public service announcements and posters. The campaign materials urge drivers to "Imagine the Impact" of traffic accidents on the lives and families of both pedestrians and drivers.

A special task force of the TPB's Bicycle and Pedestrian Subcommittee developed the regional concept for the campaign and launched it at a news conference on October 1.

Phil Mendelson, D.C. Councilmember

## Citizens Committee Reaches Out

The TPB's Citizens Advisory Committee continued to host public meetings across the region in 2002. The sessions focused on projects reflecting strong local interest, but with important regional implications. Topics included the Dulles rapid transit extension in Fairfax and Loudoun counties, the Corridor Cities Transitway in Montgomery County, updates to the Prince George's County Master Plan and D.C. Strategic Transportation Plan, and pedestrian safety concerns along Route 1 in Fairfax County.

Montgomery County provided the seed money for the Street Smart campaign, along with the state of Maryland. Montgomery County Executive Douglas Duncan established a blue ribbon panel in 2000 to improve pedestrian safety. That year pedestrian fatalities exceeded the number of homicides in the county.

The District of Columbia, Virginia and Maryland each contributed federal funds to the project. Fairfax and Montgomery counties, and the City of Alexandria, provided local funding.

In December an evaluation of the campaign's effectiveness reported an increased awareness of messages featured in the campaign. One message reported to be particularly memorable was "Every seven minutes a pedestrian is injured or killed."

A regional forum on pedestrian safety issues was held on November 12 on Richmond Highway (Route 1) in Fairfax County. Dana Kauffman, Fairfax county supervisor, moderated the meeting. It was co-hosted by the TPB's Citizens Advisory Committee and the Safe Crossings Coalition, a group promoting pedestrian safety improvements along Route 1 in Virginia.

Katherine Hanley, Chair, Fairfax County Board of Supervisors

Peter Shapiro, Chair, Prince George's County Council

# Proposed Work Program to Address Six Topics Identified in TRB Modeling Review

**Transportation Planning Board**

**July 21, 2004**

# OVERVIEW OF TRB REVIEW

1) Letter of May 8, 2002 from TPB Chairman Phil Mendelson to TRB requesting an “arms-length” review of TPB procedures

2) COG/TPB contract with TRB effective January 1, 2003:

- Review the performance of TPB’s Version 2.1C travel model and mobile emissions post-processor
- Provide guidance on future model upgrades, survey and other data needs, and detail (grain) of travel analysis
- Contract for $130K over calendar year 2003, extended through May 2004
- First TRB letter report dated September 8, 2003; TPB staff comments dated September 8, 2003
- In response to TRB Committee’s request, detailed TPB Work Program Document prepared and submitted by TPB staff on December 24, 2003
- Second and final TRB letter report dated May 10, 2004; TPB staff comments dated May 13, 2004

# FIRST TRB LETTER REPORT

1) Letter dated September 8, 2003 provides eleven “Observations” by TRB Committee with accompanying discussion

2) TPB staff comments dated September 8, 2003 based on brief review of advance copy of TRB Committee letter:

- ❖ Agree with five observations – no further attention required
- ❖ Agree that three observations offer improvement potential that TPB staff can address
- ❖ Believe that remaining three observations require further information and discussion

# SECOND TRB LETTER REPORT

1) Provides overall observations on the state of travel demand modeling practice and the availability of documentation on current practices throughout the U.S.

2) Includes TPB Work Program Document of December 24, 2003 as Attachment 4, and discusses responses provided in the Document to the six topics identified in the TRB Committee's first letter report:

- Improving model validation
- Truck and commercial vehicle travel
- Bus network characterization
- Use of adjustment factors
- Speed feedback incorporating mode choice
- Traffic speed and volume estimation for air pollution emissions estimation

3) Responds to questions posed by TPB staff in December 24, 2003 Work Program on options for future data collection programs and model improvements

# OVERALL OBSERVATIONS BY TRB COMMITTEE ON STATE OF TRAVEL DEMAND MODELING IN THE U.S.

- "-- There are few universally accepted guidelines or standards of practice for these models or their application"

- "In both this letter and its deliberations generally, the committee is relying primarily on members' experience and judgment"

- "TPB has undertaken to collect information from other MPOs---for comparative analysis of modeling practices---the committee anticipates that this effort will continue to be challenging"

- "TRB, with sponsorship from the U.S. Department of Transportation, is undertaking a study to gather information and prepare a synthesis of practice on metropolitan area travel demand modeling. This study should be useful to TPB."

# OVERALL TPB STAFF OBSERVATIONS ON TRB REVIEW

1) TRB review has been a very productive and valuable undertaking

2) Use of the Version 2.1C model was approved by federal agencies in February 2004 for the 2003 CLRP update and FY2004-2009 TIP

3) Some refinements to the Version 2.1C model recommended by the TRB Committee are being incorporated into the Version 2.1D model to be used for conformity analysis for the 2004 CLRP and FY2005-2010 TIP

4) Other refinements will be incorporated into future versions of the TPB model as time and resources permit

5) December 24, 2003 Work Program will be reviewed and revised to address fully the comments by the TRB Committee in its second letter report of May 10, 2004

# TOPIC 1: IMPROVING MODEL VALIDATION

TRB comment: Base year modeled link volumes do not match observed traffic counts and transit ridership as closely as committee members would expect.

TPB staff response:

(1) Short-term: Improvements achieved through refined volume/delay functions, zonal area types, and network coding.

(2) Longer-term: Continued refinement of network representation, use of the FTA Summit model to compare transit alternatives

# TOPIC 2: LIGHT DUTY COMMERCIAL VEHICLES

(Package delivery, postal, courier, service technicians using light duty vehicles)

TRB Comment: Combining business and commercial trips in the non-home-based trip category is not advisable.

TPB Staff Response:

(1) Short-term: Consultant engaged to develop additional light duty commercial vehicle classification counts to adjust base year vehicle trip tables.

(2) Long-term: Monitor ongoing research activities on accounting for light duty commercial vehicles.

## TOPIC 3: BUS NETWORK CHARACTERIZATION

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

TPB Staff Response:

(1) Short-term: Bus speeds adjusted for congestion delays in the out-years.

(2) Longer-term: More comprehensive analysis and coding of future bus services and priority treatments.

# TOPIC 4: USE OF ADJUSTMENT FACTORS

TRB Comment: TPB makes extensive use of adjustment factors to enhance the match between simulated and observed base-year data.

TPB Staff Response:

(1) Short-term: All adjustment factors reviewed, and some removed or dampened as employment and other data inputs are refined.

(2) Longer term: Continuing review, refinement, and documentation of adjustment factors.

# TOPIC 5: SPEED FEEDBACK AND MODE CHOICE

TRB Comment: TPB's feedback of highway and transit times to trip distribution "bypasses mode choice."

TPB Staff Response:

(1) Short-term: Good agreement between speeds in distribution, mode choice, and assignment assured by using input speeds from earlier modeling results for years analyzed, and running additional iterations of the entire process.

(2) Medium-term: Integrate post-processor with travel demand model to reflect impacts of peak-spreading on peak speeds.

(3) Longer-term: Review weighting of highway and transit times in impedance function for trip distribution; assess alternative functional forms for impedance functions; monitor ongoing research and development activities on "speed feedback"

# TOPIC 6: HOURLY TRAFFIC VOLUMES, SPEEDS, AND EMISSIONS ESTIMATION

TRB Comment: TPB's estimates of hourly traffic volumes, speeds, and emissions are not strictly based upon assigned peak and off-peak link volumes and speeds produced by the travel models

TPB Staff Response:

(1) Short-term: Review alternative approaches for improving time-of-day forecasts by travel models

(2) Medium-term: Integrate post-processor into travel model so that the effects of peak-spreading are reflected in assigned peak and off-peak link volumes and speeds.

(3) Longer-term: Monitor ongoing research and development activities on time-of-day modeling and peak-spreading

# ONGOING ASSISTANCE FOR ENHANCING TPB TRAVEL MODELS

1) Comprehensive external review can be conducted only infrequently

2) Federal Travel Model Improvement Program (TMIP) can provide ongoing assistance

- Cooperatively funded and supported by FHWA, FTA, DOT/OST, and EPA
- Managing ongoing applied research
- Funding TRB Synthesis project
- Familiar with travel demanding forecasting and air quality analysis needs and practices nationwide
- Can quickly identify sources of specialized knowledge and expertise

# 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**

**December 24, 2003**
**(Updated July 15, 2004: Changes in bold italics)**

**National Capital Region**
**Transportation Planning Board**
**Metropolitan Washington Council of Governments**
**777 North Capitol Street, N.E. – Suite 300**
**Washington, D.C. 20002-4290**

**Contact: Meseret Seifu**
**202-962-3372**
**E-mail- mseifu@mwcog.org**

# 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.

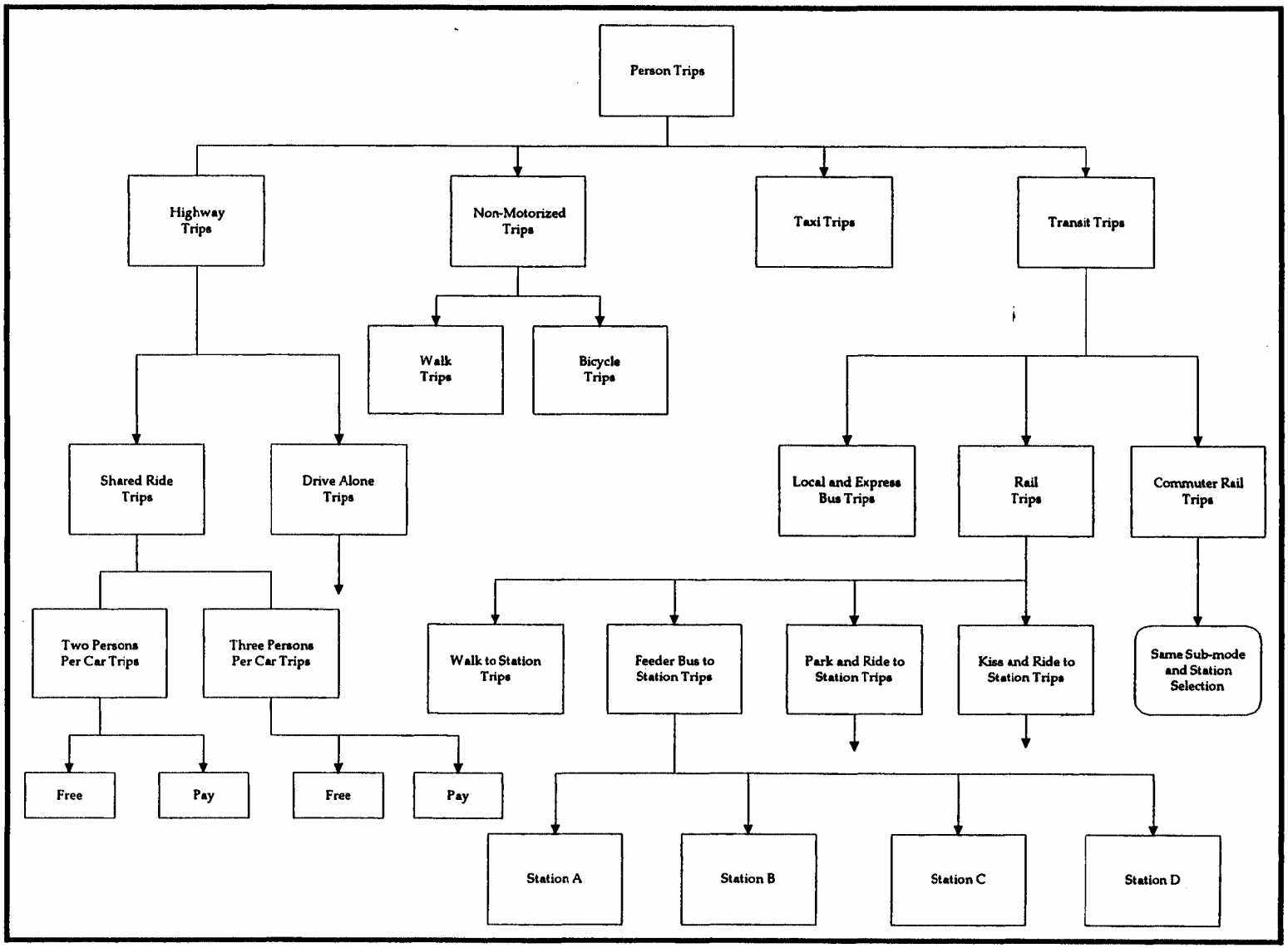
TPB staff will also investigate utilizing a newly developed transit analysis package developed by FTA, the SUMMIT program (element 1.A.4). The package is currently in development as a potential tool for assessing transit benefits associated with proposed transit improvements. SUMMIT also holds promise 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.

***Effort to date in the development of the Version 2.1D travel demand model has produced model estimation and validation results comparable to or better than those obtained with the Version 2.1C model, but with far fewer adjustment factors, due to the revised model structure and a more consistent definition of employment by TAZ which is one of the inputs to the model.***

**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-2004/2005 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-2004/2005 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.

***The TRB Committee has urged TPB staff to expedite this effort. At the close of FY-2004, a consultant with specialization in this area has been retained to recommend methods for data collection. Technical memoranda have been prepared documenting count procedures, and TPB staff is planning to expedite data collection during FY-2005.***

## 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.

***As part of the development of the Version 2.1D travel demand model, TPB staff is now implementing an adjustment to bus speeds in the forecast years to reflect the decline of speeds on major and minor arterials in the forecast year highway networks. A simple ratio of arterial travel times between base year and forecast year, stratified by jurisdiction and facility type (major and minor arterials) is being applied to bus route running times on these facilities to slow them down as well. Work is also underway to have a committee of transit professionals (similar to the group assembled for the Regional Bus Study) examine the potential for bus service expansion and bus priority treatments in the forecast years as the region grows.***

## 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.

***At the close of FY-2004, substantial reduction in the use of adjustment factors had been accomplished, due to the introduction of a new freeway volume / delay function in the trip distribution model, a revised set of speed / volume lookup tables, and the adjustment of employment data by TAZ input to the modeling process to reflect a consistent definition for each jurisdiction. The Version 2.1C model contained 68 "K" factors. In the new Version 2.1D model there are only 52 "K" factors, and of these, 31 have been reduced in magnitude (i.e., the adjustment more closely approaches 1.0) from their values in Version 2.1C. As future***

***improvements to the travel demand model are implemented, reviews will be performed to see if additional adjustment factors can be either eliminated or reduced in magnitude.***

## 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 FY2005, including documentation of the analysis and a recommendation to implement a change to the modeling process if significantly improved procedures are identified.

***One topic for special focus is the estimation of peak-period speeds for highly congested segments of the highway system. As noted in the following section on the emissions post-processor, the period specific traffic volumes provided by the travel model do not always match well with observed time-of-day distributions. Integration of the post-processor with the travel model may improve the representation of peak-spreading in the assignment process, which in turn may improve the representation of peak speeds. Using these new peak speeds in the speed feedback process may help ameliorate the problems encountered to date in cycling back through mode split in each iteration.***

## 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 some 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.

***In its second letter report, the TRB Committee elaborated on its view that "the estimates of hourly volumes and speeds must be associated directly with the time-of-day (am,***

***pm, off-peak) travel model output." TPB staff responded that, as the TRB Committee noted in its analysis, the volumes assigned to the two peak three-hour periods and to the eighteen hour off-peak period by the travel model do not always match well with observed distributions. TPB staff decided in the first step of the post-processor to use the period-specific outputs of the travel model to group links into nine facility and peaking categories, and then to apply observed time-of-day distributions for the nine categories to 24-hour link volumes rather than to the period-specific link volumes. In this work plan, TPB staff will review approaches to time-of-day modeling and peak spreading in other areas, and investigate how the post-processor methodology can be integrated into the travel demand model so that the effects of peak-spreading are reflected in assigned peak and off-peak link volumes and speeds.***

### 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.