August 20, 2003

Mr. Michael A. Replogle
Transportation Director
Environmental Defense
1875 Connecticut Avenue, N.W.
Washington, DC 20009-5728

Dear Mr. Replogle:

In my letters to you of November 20, 2002 and February 19, 2003 I provided responses and comments by COG/TPB staff on a Technical Report accompanying a study entitled *More Sprawl, More Traffic, No Relief: An Analysis of Proposed Potomac River Crossings, October 2002,* prepared by Smart Mobility, Inc. (SMI).

In my February 19, 2003 letter I noted that in response to a request by COG/TPB staff for the inputs, outputs and model code for the SMI "enhanced model" discussed in the Technical Report, COG/TPB had received a set of CD-ROMs which we were unable to read. After additional correspondence between Mark Moran of the COG/TPB staff and SMI (attached), a new set of CD-ROMs was provided which COG/TPB staff has been able to read and analyze.

With this letter I am transmitting the results of the COG/TPB staff analysis, which compares the COG/TPB Version 2.1C travel forecasting model and the SMI enhanced model with respect to screenline volumes as reported by SMI, as well as other key performance metrics including vehicle trips, vehicle miles of travel (VMT), travel patterns by jurisdiction, and vehicle emissions. The analysis concludes that while the SMI enhanced model does indeed provide better matches to overall screenline totals and to 24 of 38 individual screenlines as claimed by SMI, the SMI model significantly underestimates vehicle trips, VMT and vehicle emissions for the region. Further, daily person trips to and from DC are underestimated by 28 to 40 percent (depending on directionality), while trips to and from Virginia are overestimated by 15 to 16 percent. As noted in earlier responses by COG/TPB staff (included as Appendix A in the enclosed report), the COG/TPB model calibration effort has focused on optimizing model performance across all of these (and other) metrics. Making modifications as SMI has done which improve one metric (matches to screenline volumes) has significantly worsened performance with respect to other key metrics.

SMI reports that its enhanced model used a more limited set of K-factors than the COG/TPB model. The COG/TPB analysis found that while the number of different K-factors used by SMI is indeed more limited than in the COG/TPB model, the SMI K-factors are applied to 38 percent of the zonal interchanges, compared to only 9 to 20

percent of interchanges (depending on trip purpose) in the COG/TPB model. Further, while the COG/TPB K-factors are developed by trip purpose on a jurisdiction basis, the SMI model applies the same K-factors for all trip purposes on a state basis. Given the variation in trip length and trip patterns between different trip purposes, the assumption that K-factors are constant across travel markets is difficult to justify.

While SMI made several modifications to the COG/TPB model, the modification which appears to be most responsible for the significant worsening of the performance of the model is the downward factoring of vehicle trips by approximately 25 percent, designed to match lower trip generation rates developed from a small local sample of households drawn from the National Personal Transportation Study (NPTS). COG/TPB staff commented earlier that the sample of households located in the Washington region from the NPTS is too small to be used in developing or enhancing a travel forecasting model for the region. The NPTS is designed to produce a national estimate of annual daily travel. The resultant trip generation rates for the SMI model are 27 percent lower than those for the COG/TPB model and 30 percent lower than the NPTS national estimates. These low rates appear to account for much of the SMI underestimation of VMT for the Washington region.

On page 3 of your November 4, 2002 letter transmitting the SMI report, you stated that the COG/TPB Version 2 model "will overestimate motor vehicle travel demand in the future" and "lead to serious underestimation of mobile source emissions." In my letter of November 20, 2002 providing COG/TPB responses and comments in the SMI report, I questioned the logic relating these two apparently inconsistent statements. Based on the recent analysis of the SMI model, COG/TPB staff understands (but does not agree with) the modifications made to the COG/TPB model to produce significantly lower motor vehicle trips and VMT for the Washington region. COG/TPB staff concludes, however, that these lower motor vehicle trips and VMT will produce significantly lower estimates of motor vehicle emissions than the COG/TPB model, and can still find no explanation for your assertion that the COG/TPB model will "lead to serious underestimation of mobile source emissions."

COG/TPB staff is continuing to develop refinements to the Version 2.1C travel forecasting model as it is applied to travel forecasting and emissions estimation at the regional level, and to analysis of alternative transportation improvements at the corridor level. Staff expects that the forthcoming report from the Transportation Research Board (TRB) peer review panel will provide some helpful recommendations in this regard.

We appreciate your continuing comments and interest in the ongoing effort to improve the COG/TPB travel forecasting and emissions estimation procedures.

Sincerely,

Ronald F. Kirby
Director, Department of
Transportation Planning

Attachments

cc: Dolores Milmoe, Solutions Not Sprawl
Neal Fitzpatrick, Audubon Naturalist Society of the Central Atlantic States
Lee Epstein, Chesapeake Bay Foundation
Chris Miller, Piedmont Environmental Council
Stewart Schwartz, Coalition for Smarter Growth
Lora Byala, Chair, TPB Technical Committee
Bill Mann, Chair, TPB Travel Forecasting Subcommittee
Tom Dernoga, Chair, MWAQC Technical Advisory Committee
Julie Wagner, Chair, COG Planning Directors Technical Advisory Committee
Jane M. Kenny, Regional Administrator, EPA Region 2
Nelson Castellanos, Division Administrator, FHWA Maryland Office
Roberto Fonseca-Martinez, Division Administrator, FHWA Virginia Office
Gary Henderson, Division Administrator, FHWA DC Office
Susan E. Schruth, Regional Administrator, FTA
Rep. Frank Wolf
Rep. Chris Van Hollen
Senator Mikulski
Senator Sarbanes
Senator Warner
Senator Allen

Attached Correspondence

smart mobility

Brian Grady / Treasurer

Aldrich House, Suite #3
16 Beaver Meadow Road
PO Box 750
Norwich, VT 05055-0750
802.649.5422
fax 802.649.3956
bgrady@smartmobility.biz

MEMORANDUM

To: Ron Kirby
From: Brian Grady and Norm Marshall
Subject: Data Request
Date: January 31, 2003

Mr. Kirby,

For the report *"More Sprawl, More Traffic, No Relief: An Analysis of Proposed Potomac River Crossings"* dated October 2002, four different scenarios were analyzed using the Transportation Planning Board Version 1 Travel Demand Model referred heretofore as the "DCV1" model. The model was run for a 1994 base year, a 2025 No Build, and two 2025 Build alternatives, WTC and Techway. For information regarding the travel demand modeling effort as well as a more detailed description of the scenarios, please reference the report above.

Enclosed please find per your request four CDs labeled 1994, 2025NB, WTC, and Techway. Each CD contains a ZIP file of the same name. The ZIP file contains all the inputs necessary to run the DCV1 model. Model outputs for each scenario have also been included.

smart mobility

MEMORANDUM

To: Mark Moran
From: Brian Grady
Subject: Re-transmittal of CDs
Date: June 26, 2003

Mr. Moran,

Per your request during our June 23rd phone conversation and your subsequent follow-up email, I have burned four additional CDs containing the models used to analyze the scenarios we studied for the Potomac River Crossings study. I checked that the CDs are in fact readable on other machines within the office. As such, you should have no problem accessing the data. If you have any difficulties, please don't hesitate to contact me directly.

For the report *"More Sprawl, More Traffic, No Relief: An Analysis of Proposed Potomac River Crossings"* dated October 2002, four different scenarios were analyzed using the Transportation Planning Board Version 1 Travel Demand Model referred heretofore as the "DCV1" model. The model was run for a 1994 base year, a 2025 No Build, and two 2025 Build alternatives, WTC and Techway. For information regarding the travel demand modeling effort as well as a more detailed description of the scenarios, please reference the report above.

Enclosed please find per your request four CDs labeled 1994, 2025NB, WTC, and Techway. Each CD contains a ZIP file of the same name. The ZIP file contains all the inputs necessary to run the DCV1 model. Model outputs for each scenario have also been included.

Mark Moran

From: Mark Moran
Sent: Monday, June 30, 2003 10:18 AM
To: 'Brian Grady'
Subject: RE: Request for re-transmittal of CDs with enhanced travel demand model

Brian,

We did receive the 4 CDs on Friday and we are able to read all four.

Thank you for your quick response.

Mark Moran

Mark Moran
Principal Transportation Engineer
Metropolitan Washington Council of Governments
Washington, DC

-----Original Message-----
From: Brian Grady [mailto:bgrady@smartmobility.biz]
Sent: Monday, June 30, 2003 10:04 AM
To: 'Mark Moran'
Cc: 'Norm Marshall'
Subject: RE: Request for re-transmittal of CDs with enhanced travel demand model

Mark,

I sent out the CDs Thursday 06/26. If you didn't receive them Friday, you should be getting them today.

FYI – I never received your fax, so thank you for sending a follow-up email.

Brian Grady

-----Original Message-----
From: Mark Moran [mailto:mmoran@mwcog.org]
Sent: Wednesday, June 25, 2003 2:49 PM
To: 'Brian Grady'
Cc: Ron Kirby
Subject: Request for re-transmittal of CDs with enhanced travel demand model

Brian Grady, Treasurer, Smart Mobility, Inc.:

The purpose of this e-mail is to summarize our phone conversation Monday, June 23 regarding the re-transmittal of 4 CDs containing data from an enhanced travel forecasting model developed by Smart Mobility, Inc. The e-mail begins with some background.

Background:

In October 2002, your firm issued the report "More Sprawl, More Traffic, No Relief: An Analysis of Proposed Potomac River Crossings." That report describes an "enhanced model," developed by your

firm, which was similar to the COG Version 2.0 travel forecasting model, but had a more limited set of K factors. In January 2003, in response to our request, you sent us 4 CDs with information relating to the enhanced model (memo of transmittal dated January 31, 2003). According to the transmittal memo, the CDs contained modeling inputs and outputs. It is our hope that the CDs also contain the model code, so that we may better understand the enhanced model. On February 19, Ron Kirby sent a letter to Michael Replogle, which, among other things, stated that we were unable to read any of the data on any of the 4 CDs (When each of the CDs was inserted into a PC, the computer indicated that the CD was unformatted and asked us if we wanted to format it. The CDs were tried in several different computers.). In this last letter, Mr. Kirby requested that the staff of Smart Mobility, Inc. contact Mark Moran to facilitate transmittal of a new set of CDs. As of June 23, we have not received a new set of CDs. We understand that, since Ron Kirby's letter was sent directly to Mr. Replogle, and not Smart Mobility, it is possible that your firm did not learn of our request. Hence the reason for my phone call to you on Monday, June 23.

Summary of phone conversation:

After describing some background, I explained our inability to read the data on the 4 CDs sent to us by Smart Mobility in January 2003, and asked if you could re-send a new set of CDs that our computers could read. You said that that would be no problem. I agreed to fax you a copy of your January 31 transmittal memo and a copy of Ron Kirby's February 19 letter requesting that a 2nd set of CDs be sent (I sent the fax on June 23, 2003). You agreed that you would try to send us the new CDs by the end of the week (Friday, June 27, 2003).

Thank you, in advance, for your attention to this matter. If you have any questions, please do not hesitate to contact me via phone or e-mail.

Sincerely,

Mark S. Moran

Mark Moran

Principal Transportation Engineer

Metropolitan Washington Council of Governments

777 N. Capitol Street, N.E., Suite 300

Washington, DC 20002-4239

Tel: 202-962-3392

Fax: 202-962-3202

mmoran@mwcog.org

www.mwcog.org

Metropolitan Washington Council of Governments
National Capital Region Transportation Planning Board

A Comparison of the COG/TPB Travel Forecasting Model with the Smart Mobility, Inc. Enhanced Travel Model

August 20, 2003

Executive Summary

In the fall of 2002, Smart Mobility, Inc. (SMI), a transportation and land use planning consulting firm, modified the COG/TPB Version 2 model to create an "enhanced" travel forecasting model for the Washington metropolitan area. The impetus for creating the model was to present an alternative to the COG/TPB Version 2 travel model, which SMI alleged had a number of deficiencies. The enhanced SMI model, which was built off of the COG/TPB Version 2.0 model, was presented in an October 2002 report entitled "More Sprawl, More Traffic, No Relief: An Analysis of Proposed Potomac River Crossings". The SMI report compares the enhanced model to the COG/TPB Version 2 model, and concludes that in some key respects, the SMI enhanced model is superior to the COG/TPB Version 2 model.

Like the SMI report, this report also compares the SMI enhanced model with the COG/TPB Version 2 model. However, this report goes into more detail than the SMI report, which focused on how the SMI model was able to replicate traffic volumes on screenlines better than the COG/TPB model. This report goes on to make comparisons of other metrics that are vital to validating a regional travel model, including vehicle trips, vehicle miles of travel (VMT), travel patterns by jurisdiction, and vehicle emissions.

SMI made five major changes to the COG/TPB Version 2 model: 1) Applying fewer distinct K-factors to a far greater number of trip interchanges (38 percent of total interchanges vs. 9 to 20 percent of total interchanges in the COG/TPB Version 2.1C model); 2) Elimination of income-level time penalties in the trip distribution step, 3) Factoring downward by approximately 25 percent the vehicle trips assigned to the transportation network, as a surrogate for reducing trip rates to reflect a local sample of NPTS [Nationwide Personal Transportation Survey] data; 4) Implementation of a new set of friction factors for each trip purpose based upon use of NPTS data rather the 1994 COG Household Travel Survey; and 5) Applying only AM congested speeds to assign trips to the transportation network regardless of trip purpose.

The COG/TPB analysis finds that, while the screenline matches are closer to observed patterns with the SMI model than the Version 2 model, the results from the SMI 1994 model application are not impressive with respect to trip patterns: total daily person trips to and from DC are underestimated by 28 to 40 percent (depending on directionality), while trips to and from Virginia are overestimated by 15 to 16 percent. By contrast, the COG/TPB Version 2.1C model achieves a much better fit with the observed travel pattern, producing estimated travel within 2 percent of the observed pattern to and from DC, Maryland, and Virginia.

Additionally, the SMI model underestimates VMT for the region, which leads to a corresponding underestimation in vehicle emissions. A test for 1994 between the SMI model and the COG/TPB Version 2.1C model, each operating in tandem with the EPA-mandated Mobile 6 emissions model, results in from 20 to 24 percent fewer vehicle emissions, depending on pollutant, estimated using the SMI model than obtained with the COG/TPB Version 2.1C model.

Given these findings, COG/TPB staff has serious reservations about the merit of SMI's model enhancements and the overall quality of the SMI's model performance. An in-depth analysis of SMI's model work has concluded that the case that SMI's model is superior to the COG/TPB Version 2.1C model has not been demonstrated.

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Introduction

In the fall of 2002, Smart Mobility, Inc. (SMI), a transportation and land use planning consulting firm, modified the COG/TPB Version 2 model to create an "enhanced" travel forecasting model for the Washington metropolitan area. The impetus for creating the model was to present an alternative to the COG/TPB Version 2 travel model, which SMI alleged had a number of deficiencies. The enhanced SMI model, which was built off of the COG/TPB Version 2.0 model, was presented in an October 2002 report entitled "More Sprawl, More Traffic, No Relief: An Analysis of Proposed Potomac River Crossings." SMI validated its model on a 1994 base year and then applied it to three additional scenarios: (1) a 2025 no build; (2) a 2025 Western Transportation Corridor, i.e., a new bridge crossing the Potomac River east of Leesburg, Virginia; and (3) a 2025 Techway, i.e., a new bridge crossing the Potomac near the Fairfax/Loudoun County line. The SMI report compares the enhanced model to the COG/TPB Version 2 model, and details a number of alleged deficiencies in the COG/TPB model, all of which have been subsequently addressed by COG staff.

Like the SMI report, this report also compares the SMI enhanced model with the COG/TPB Version 2 model. However, this report goes into more detail than the SMI report, which focused on how the SMI model was able to replicate estimated volumes on screenlines better than the COG/TPB model. This COG/TPB report goes on to make comparisons of other metrics that are vital to validating a regional travel model, including vehicle trips, vehicle miles of travel (VMT), travel patterns by jurisdiction, and vehicle emissions.[1] The report also compares model inputs and the models themselves, which are implemented through a variety of scripts, batch files, and supporting files, to verify exactly which model components were changed by SMI and which were left unchanged. Although SMI ran their model for four scenarios, this report focuses on only the 1994 base-year run, since this is the only modeled year with observed data. COG/TPB staff obtained the SMI model on a series of four CD-ROMs in late June 2003. The report makes reference to two COG/TPB travel models: Version 2.0, which was released in March 2002 and formed the base of the SMI model, and Version 2.1, Release C, which was released in December 2002. The Version 2.0 represents an earlier stage in the development of the Version 2.1C model, which is the model set currently in use by COG/TPB.

The SMI enhanced model used the COG/TPB Version 2.0 model as its starting point. SMI made five major changes to the Version 2.0 model:

- SMI simplified the system of K-factors used in trip distribution (from 68 distinct K-factor values used in Version 2.1C to only 2 in the SMI model), but applied K-factors to a much larger number of zone-to-zone trip interchanges (from 9 to 20 percent of trip interchanges in the Version 2.1C model, depending on trip purpose, to 38 percent in the SMI model for all six trip purposes).

- SMI eliminated the use of income-level time penalties from trip distribution.

[1] COG/TPB staff ran the model outputs from both the SMI model and the COG/TPB Version 2.1 through the Mobile 6 emissions model, using 1990 M6 rates for each, since 1994 emission rates were not available off the self.

- SMI factored down vehicle trips, by approximately 25 percent, to match NPTS trip generation rates. This factoring was done in the time-of-day step, not in the trip generation step, since, according to SMI, modifying COG's Fortran trip generation program was beyond their scope of work. The actual factors used by SMI are applied by trip purpose: HBW (0.737), HBS (0.679), HBO (0.718), and NHB (0.789). The COG/TPB model does not involve any such factors in the time-of-day step.

- SMI derived and implemented a new set of friction factors for each trip purpose that they assert, "replicate the observed trip length distances extracted from the NPTS database."

- SMI used AM congested travel times to distribute all trip purposes. This practice contrasts with both the Version 2.0 and 2.1C models, which use the AM congested travel times to distribute HBW trips and use off-peak travel times to distribute HBS, HBO, and NHB trips.

Comparison of Model Structures and Inputs: SMI vs. COG/TPB Travel Models

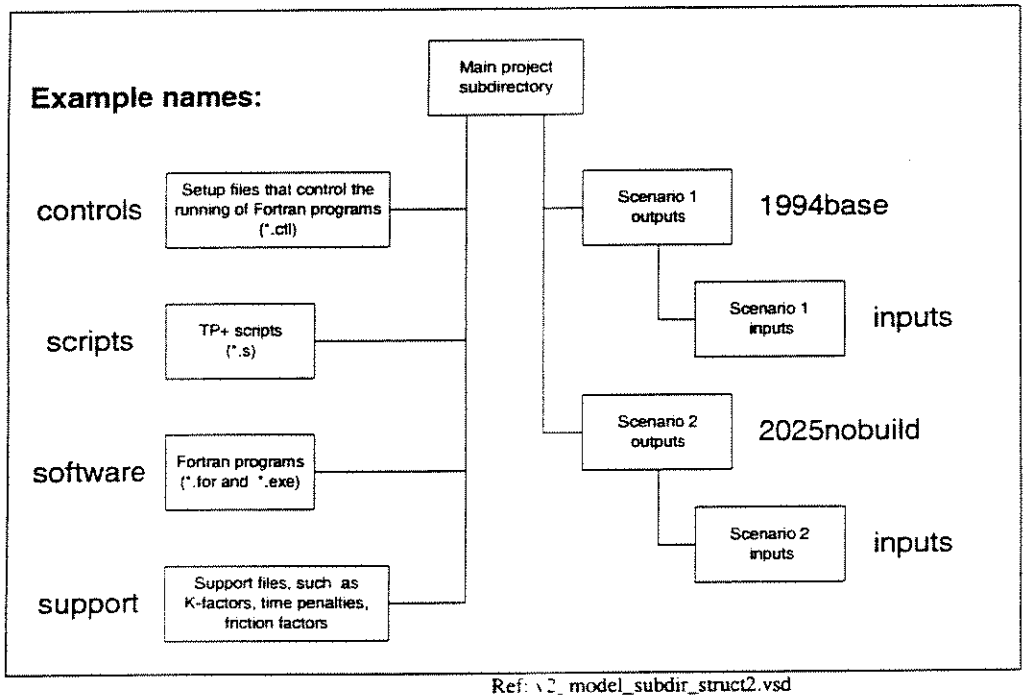
Before comparing the performance or output between any two models, one should be clear about differences in model inputs and differences in the models themselves. This section discusses differences in the models and their inputs.

Directory Structure

The COG/TPB Version 2.1C travel model uses a specific directory structure to organize input files, output files, model program code, and other related files. First, there is a main project subdirectory which contains all of the batch files that are used to run the model and a series of subdirectories for model components (See Figure 1). One of the subdirectories directly below the project subdirectory is the "control" subdirectory, which contains all the setup or control files needed to run various Fortran programs. Also below the main project subdirectory, is the "scripts" subdirectory, which contains all of the TP+ scripts that run various model components. The "software" subdirectory contains Fortran programs that are used to implement various models. The "support" subdirectory contains a series of support files, such as K-factors, friction factors, time penalties, and bridge penalties.

When SMI developed its enhanced model from the COG/TPB Version 2.0 model, it dispensed with the multi-directory concept, and simply put all files relating to one scenario in one subdirectory.

Figure 1 Subdirectory Structure Used for the COG/TPB Version 2.1C Travel Model



Ref: v2_model_subdir_struct2.vsd

Input Files, Batch Files, and Fortran Programs

SMI made no changes to the input files. However, there were changes that occurred between COG/TPB Version 2.0 and Version 2.1C. These involved some cleanup of various support files to conduct better housekeeping of input data. More accurate information regarding GIS coordinates and transit speeds resulted. Due to the network changes, the mode choice model was re-estimated and re-calibrated in Version 2.1C.

SMI made no substantive changes to the Version 2.0 batch files that run the modeling process. However, three points should be made regarding these files. First, since SMI moved all files to one scenario-specific subdirectory, path names have been updated. Second, SMI used its own process to create the binary K-factor and time penalty files. This means that when one compares the COG/TPB model with the SMI model, one must compare the binary versions of these files, not the text (ASCII) versions. Third, there were significant changes between batch files in COG/TPB Version 2.0 and COG/TPB Version 2.1C. In Version 2.0, there were 29 batch files; in Version 2.1C, there were 34 because extra steps were included to reflect roadway congestion on drive-to-transit links. Drive-to-transit links are imaginary links that represent the over-the-highway-network travel needed to drive-access transit service. In Version 2.0, drive-to-transit links did not congest, whereas these links do congest in Version 2.1C.

SMI made no changes to the Fortran programs. In moving from the Version 2.0 model to the Version 2.1 model, COG staff modified programs so that they give an error message when input files are not found. SMI made no changes to the Fortran setup/control files, other than the aforementioned path name changes.

Major Changes to COG/TPB Models Implemented by SMI

SMI made five major changes to the COG/TPB Version 2.0 model, all of which occurred in the TP+ scripts and the "support" files:

- SMI simplified the system of K-factors used in trip distribution, but expanded the set of zonal interchanges to which such K-factors are applied.
- SMI eliminated the use of income-level time penalties from trip distribution.
- SMI factored down vehicle trips by approximately 25%.
- SMI derived and implemented a new set of friction factors for each trip purpose.
- SMI used AM congested travel times to distribute all trip purposes. This contrasts with the Version 2.0 and 2.1C models, which use the AM congested travel times to distribute HBW trips and use off-peak travel times to distribute HBS, HBO, and NHB trips.

In addition to these changes, COG staff made the following changes when moving from Version 2.0 to Version 2.1C:

- Mode choice: Due to the network changes, the mode choice model was re-estimated and re-calibrated.

- Trip distribution script: Corrected spelling of MAXITERS (changed "MAXITRS=7" to "MAXITERS=7"). With the misspelled keyword, the gravity model iterated only the default number of times (three). SMI found this error.
- Traffic assignment script, volume-delay function for freeways: Changed what happens in a lookup function when the lookup value is above the top value in the range. The overall effect of this change, combined with fixing the misspelling of MAXITERS was a slight increase in regional VMT (about 1%) using Version 2.1C compared with Version 2.0.
- Highway assignment script: Updated to provide a total VMT summary and to explicitly deal with freeway ramps.
- Script files were updated to provide total purpose trip summaries.

K-Factors

The COG/TPB Version 2.0 and 2.1C models use K-factors on a jurisdiction-to-jurisdiction level.[2] The Version 2.1C model has 68 K-factors for the four "resident" trip purposes - home-based work (HBW), home-based shop (HBS), home-based other (HBO), and non-home based (NHB) - and 114 K-factors for the two truck trip purposes - medium-weight and heavy-weight trucks. SMI replaced the COG/TPB K-factors with a more limited set. Specifically, for each of the six trip purposes, two state-specific K-factors were developed and applied. A K-factor of 1.8 was applied for all trips from DC to DC (Transportation Analysis Zones 1-319); a K-factor of 1.4 was applied for all trips internal to the state of Maryland (TAZs 320-1229) and all trips internal to the state of Virginia (TAZs 1230-2144).

K-factors and income-level time penalties are normally stored in ASCII text files and/or ASCII scripts, which are then converted to TP+ binary files before use by the model. SMI did not use the normal method to convert these parameters to binary format. It created its own procedure. Consequently, one cannot simply compare the ASCII files; one must compare the binary files, either by opening them up in Viper, the graphical user interface to TP+, or by running TP+ scripts that read the binary files. COG/TPB staff compared the binary K-factor files and produced the following summary in Table 1.

As expected, the K-factor system used by SMI is much simpler than that used in the COG/TPB Version 2.1C model. However, the percent of zonal interchanges that have a non-unitary K-factor value is significantly higher with the SMI model (38% vs. 9% to 20% with the COG/TPB models). Further, the K-factors used by SMI are identical across all modeled purposes, including the modeled truck purposes. Given the variation in trip length and trip patterns between the modeled purposes, the assumption that K-factors are constant across travel markets is difficult to justify.

[2] There are 23 "jurisdictions" in the COG/TPB modeled area covering roughly 6,800 square miles. Washington, D.C. and Arlington County are each counted as two jurisdictions, because they are broken into "core" and "non-core" sections.

Table 1 Comparison of K-Factor Values Used in the SMI and COG/TPB Version 2.1C Models

		COG/TPB Vers. 2.1, C	SMI Enhanced Model
HBW	Min	0.100	1.000
	Max	3.000	1.800
	Ave.	1.190	1.156
	N where K <> 1	903,008	1,767,086
	% where K <> 1	19.6%	38.4%
HBS	Min	0.500	1.000
	Max	2.800	1.800
	Ave.	1.085	1.156
	N where K <> 1	522,079	1,767,086
	% where K <> 1	11.4%	38.4%
HBO	Min	0.200	1.000
	Max	2.500	1.800
	Ave.	1.119	1.156
	N where K <> 1	650,709	1,767,086
	% where K <> 1	14.2%	38.4%
NHB	Min	0.200	1.000
	Max	2.500	1.800
	Ave.	1.076	1.156
	N where K <> 1	395,575	1,767,086
	% where K <> 1	8.6%	38.4%
Med Trk	Min	0.001	1.000
	Max	6.600	1.800
	Ave.	1.074	1.156
	N where K <> 1	835,987	1,767,086
	% where K <> 1	18.2%	38.4%
Hvy Trk	Min	0.001	1.000
	Max	7.000	1.800
	Ave.	1.064	1.156
	N where K <> 1	809,539	1,767,086
	% where K <> 1	17.6%	38.4%

Note: "N where K <> 1": The number of zonal interchanges where the K-factor is not equal to one.

Ref: k_fac_compar.xls

Time Penalties

Income-level time penalties are optional adjustment factors that are sometimes used in income-stratified trip distribution models to allow the model to better replicate observed trip patterns. They represent perceived time penalties across physical barriers, such as bridges, or between jurisdictions, such as counties or states. In the trip distribution application of both the COG/TPB Version 2.0 and Version 2.1C models, the following market segmentations are used: The region is divided into 12 super-districts; trips are divided into 4 non-truck ("resident") purposes; the

trip-making population is segmented into 4 income levels. This means there are 2,304 possible trip interchanges with respect to income-level time penalties (= 12 x 12 super-districts times 4 trip purposes times 4 income levels). The Version 2.1C model uses 193 income-level time penalties, which is about 8% of the 2,304 interchanges. SMI has removed all the income-level time penalties from its enhanced models.

Global Adjustment Factors

In the SMI report, SMI claims that the COG/TPB Version 2.0 model overestimates daily vehicle trips by 36% for HBW, 49% for HBS, 48% for HBO, and 27% for NHB, when compared to NPTS trip generation rates. To correct for this "deficiency," the SMI model applies a series of global trip generation adjustment factors to vehicle trips. However, instead of applying these factors in the trip generation step, SMI applies them in the time-of-day step, saying that it was beyond the scope of their work to modify the COG Fortran program used for trip generation.[3] Since SMI applies these trip generation rate factors in the time-of-day step, there effect does not show up in the trip distribution or mode choice steps, just the traffic assignment step. The factors used by SMI vary by purpose: HBW (0.737), HBS (0.679), HBO (0.718), and NHB (0.789). COG/TPB models do not use such factors.

Friction Factors

SMI developed its own set of friction factors using the 1995 Nationwide Personal Transportation Survey (NPTS), now called the National Household Travel Survey (NHTS). The Version 2.1C friction factors are based on COG's 1994 Household Travel Survey. Plots of the friction factors for both the SMI model and the COG/TPB Version 2.1C model can be found in Appendix B. In general, the SMI friction factor functions decay faster than their corresponding TPB friction factor functions. To develop the friction factor plots, one needs both a trip table and a set of travel time skims. It should be noted that we have used the COG/TPB travel time skims for both sets of friction factors in order to provide a consistent basis of length between the two sets of trips, since networks have changed between the COG/TPB and SMI models. Otherwise, differences in the friction factor plots, might be due to network differences, which influence the building of travel time skims.

Travel Times Employed in Trip Distribution

The COG/TPB Version 2.1 model uses AM congested travel times for distributing HBW trips and off-peak travel times for the other three trip purposes (HBS, HBO, and NHB). By contrast, the SMI model uses the AM congested highway times for all four trip purposes.

Summary of Differences

Table 2 summarizes the major differences between the COG/TPB Version 2.1C travel model and the SMI enhanced travel model.

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[3] Although COG/TPB does not agree with the premise that these global factors should be used, if one wanted to use such factors, it is easy to do by changing one value in each of the trip generation control files. There is no need to modify the Fortran program itself.

Table 2 Major Differences Between the COG/TPB Version 21.2C Model and the SMI Enhanced Travel Model: Scripts and Support Files

Item	Model step	Notes
K-factors simplified • TPB V2.1C: 68 K-factors for HBW, HBS, HBO, NHB. 114 K-factors for medium & heavy truck. (9% to 20% of zone-to-zone interchanges). • SMI: 2 K-factors for all six purposes (38% of zonal interchanges)	Trip distribution	K-factors are normally stored as text values embedded in the script set_factors.s. The factors are then converted into binary files, *k.dat, stored in the "support" subdirectory. SMI does not use the ASCII-format files, only the binary files, which it has developed using its own process.
Income-level time penalties • TPB V2.1C: 193 non-zero values for HBW, HBS, HBO, NHB • SMI: None used	Trip distribution	These are normally stored as text files, *pen.03, in the "support" subdirectory. The factors are then converted into binary files: *pen.dat. SMI does not use the ASCII-format files, only the binary files, which it has developed using its own process.
Global factors to reduce vehicle trips • TPB V2.1C: Does not use these • SMI: o HBW 0.737 o HBS 0.679 o HBO 0.718 o NHB 0.789	Time-of-day model	These factors have been placed in the time_of_day.s script, but they really affect trip generation rates. Consequently, summaries produced by SMI for trip generation or mode choice would not show the effect of these factors.
Friction factors • TPB V2.1C: Based on 1994 Household Travel Survey (4,800 households) • SMI: Based on 1995 Nationwide Personal Transportation Survey (NPTS) (313 households in Washington region)	Trip distribution	The SMI friction factor functions generally decay faster than their corresponding TPB friction factor functions.
Travel times used to distribute trips • TPB V2.1C: Uses AM congested highway times for HBW, uses off-peak times for the other three trip purposes (HBS, HBO, and NHB). • SMI: Uses the AM congested highway times for all four trip purposes	Trip distribution	These are specified in the Trip_Distribution.s script.
Bridge penalties • TPB V2.1C: Bridge penalties no longer used. • SMI: 5 Potomac River bridges, each with a 5-minute time penalty	Traffic assignment	The 5-minute time penalties on the five Potomac River bridges were employed in the TPB Version 2.0 model.

Model Performance: SMI vs. COG/TPB Version 2.1C

Volumes on Screenlines

After COG/TPB staff obtained the SMI model on a series of CDs, we loaded the SMI model files onto a PC and re-ran the 1994 base-year scenario. We confirmed that we could replicate the model results shown in the SMI report. For example, Table 3 shows estimated and observed volumes by screen line for the 1994 base-year scenario, for both the SMI model and the COG/TPB Version 2.1C model.

Table 3 Estimated and Observed 1994 Volumes by Screenline: SMI vs. COG/TPB Version 2.1C

Screen line		Est Vol COG v2.1c	Est Vol SMI	Obs Vol	Est/Obs COG	Est/Obs SMI	Closest to obs
1	Ring 1, Virginia	811,000	643,616	802,000	1.01	0.80	COG
2	Ring 1, DC	1,115,000	809,961	915,000	1.22	0.89	SMI
3	Ring 3, Virginia	971,000	856,553	866,000	1.12	0.99	SMI
4	Ring 3, DC	1,139,000	841,810	966,000	1.18	0.87	SMI
5	Beltway, Virginia	1,203,000	1,069,896	1,078,000	1.12	0.99	SMI
6	Beltway, Maryland	1,753,000	1,496,134	1,591,000	1.10	0.94	SMI
7	Ring 5, Virginia	1,252,000	1,021,291	1,154,000	1.08	0.89	COG
8	Ring 5, Maryland	1,606,000	1,359,784	1,368,000	1.17	0.99	SMI
9	Ring 7, Virginia	687,000	645,603	598,000	1.15	1.08	SMI
10	Eastern Loudoun Co.	254,000	267,859	230,000	1.10	1.16	COG
11	US 15, Loudoun / Pr. William Co.	164,000	153,055	156,000	1.05	0.98	SMI
12	Central Montgomery Co. Radial	548,000	435,602	472,000	1.16	0.92	SMI
13	Eastern Montgomery Co. Radial	418,000	362,995	370,000	1.13	0.98	SMI
14	NE. Pr.Geo. Co. Radial	324,000	256,109	318,000	1.02	0.81	COG
15	Central Pr.George's Co. Radial	285,000	203,979	238,000	1.20	0.86	SMI
16	Southern Pr.George's Co. Radial	254,000	168,874	214,000	1.19	0.79	COG
17	Southern Fairfax / Pr. Wm. Radial	438,000	368,698	390,000	1.12	0.95	SMI
18	Central Fairfax Co. Radial	627,000	568,110	544,000	1.15	1.04	SMI
19	VA Route 7 Radial	486,000	459,918	466,000	1.04	0.99	SMI
20	Beltway & 'Inner' Potomac River X-ings	1,096,000	936,561	892,000	1.23	1.05	SMI
22	Central Mtg./P.G. Radial	1,473,000	1,252,880	1,196,000	1.23	1.05	SMI
23	NE Montgomery Co. Radial	179,000	166,788	136,000	1.32	1.23	SMI
24	Montgomery / Pr.Geo. Co. border	445,000	427,707	444,000	1.00	0.96	COG
25	Montgomery/ Frederick Co. border	105,000	122,187	78,000	1.35	1.57	COG
26	Montgomery / Howard Co. border	375,000	383,145	256,000	1.46	1.50	COG
27	Pr.Geo. / Anne Arundel Co. Border	302,000	319,408	290,000	1.04	1.10	COG
28	Charles / Pr.Geo. Co. Border	116,000	144,983	108,000	1.07	1.34	COG
	Inner screenline subtotal	18,426,000	15,743,506	16,136,000	1.14	0.98	SMI
31	Frederick / Carroll Co. Border	131,000	149,559	58,000	2.26	2.58	COG
32	Western Loudoun Co. Border	96,000	84,335	54,000	1.78	1.56	SMI
33	'Outer' Southwestern Circumferential	301,000	250,549	226,000	1.33	1.11	SMI
34	'Outer' Southeastern Circumferential	100,000	108,616	94,000	1.06	1.16	COG
35	South of Baltimore City	843,000	703,532	782,000	1.08	0.90	COG
36	'Outer' Northwestern Radial	78,000	58,437	28,000	2.79	2.09	SMI
37	'Outer' Western Circumferential	28,000	26,524	24,000	1.17	1.11	SMI
38	'Outer' I-95 (South) Radial	124,000	123,077	174,000	0.71	0.71	COG
	Outer screenline subtotal	1,701,000	1,504,629	1,440,000	1.18	1.04	SMI
	Grand total	20,127,000	17,248,135	17,576,000	1.15	0.98	SMI
				Minimum	0.71	0.71	
				Maximum	2.79	2.58	
				Average	1.23	1.11	

Ref: smi_cog_compar.xls, vol_scrn

This table is very similar to Table 9 in the SMI report (p. 12). This table shows that the SMI model performs better on this metric - estimated screen line volumes - than does the COG/TPB model, even though the SMI model has a simplified K-factor structure and no income-level time penalties. Nonetheless, the COG/TPB model does perform better than the SMI model on 14 of the 38 screen lines. The next section will discuss other model performance metrics.

Global Adjustment of SMI Results During Application of Time-of-Day Model

Since the SMI model includes trip generation factors on vehicle trips that are not applied until the time-of-day model, the comparisons with observed data in the trip generation, trip distribution, and mode choice steps, in many cases, will not take this into account. One should be aware that the results shown for the SMI model should be reduced from between 21 percent to 32 percent, depending upon trip purpose. The screen line summaries shown above in Table 3 reflect this adjustment, whereas other tabulations do not.

The order of magnitude of these differences can be seen from the output of the time-of-day model, shown for both models in Table 4. In a time-of-day model, one normally converts daily trips in production-attraction (P/A) format to time-of-day trips in origin-destination (O/D) format. The time-of-day script carries out this conversion using a series of equations. Due to some rounding issues, the number of input and output vehicle trips in the time-of-day process may be slightly different, as is the case with the COG/TPB Version 2.1C model, shown in the left-hand portion of Table 4. The SMI model results, shown in the right-hand portion of Table 4, looks quite different. Approximately one quarter of the input trips disappear in the output time-of-day tables that are used in traffic assignment. This is because SMI explicitly applies global trip generation rate factors in the time-of-day model. These reduced output trips were used to construct SMI's screenline summary comparison with observed data in Table 3.

Table 4 Estimated 1994 Daily Vehicle Trips from Time-of-Day Model: COG/TPB vs. SMI

	COG/TPB Version 2.1C Model				SMI Enhanced Model			
	Input Trips	Output Trips	Difference (Out - In)	Ratio (Out/In)	Input Trips	Output Trips	Difference (Out - In)	Ratio (Out/In)
HBW	2,919,117	2,918,938	-179	0.9999	2,948,747	2,173,041	-775,706	0.7369
HBS	2,261,561	2,261,341	-220	0.9999	2,252,942	1,529,584	-723,358	0.6789
HBO	6,027,518	6,027,529	11	1.0000	5,642,959	4,051,617	-1,591,342	0.7180
NHB	5,111,502	5,111,455	-47	1.0000	5,068,465	3,998,996	-1,069,469	0.7890
	16,319,698	16,319,263	-435	1.0000	15,913,113	11,753,238	-4,159,875	0.7386

Ref: I2_Time-of-Day.tab, time_of_day.xls

Person Trip Pattern Comparisons

Estimated motorized person trips for the 1994 base year are shown in Table 5. The first column shows the estimated results from the COG/TPB Version 2.1 model. The second column shows the comparable results from the SMI model. The two models appear to give very similar results,

but this is misleading because the SMI model applies global factors to vehicle trips after the time-of-day model step. If we were to apply the SMI global factors to the SMI trip generation numbers, the number of estimate total motorized person trips would be approximately 25% below the COG/TPB Version 2.1C model estimate. This means that the SMI model is actually estimating about 3 trips per capita, versus 4.1 trips per capita for the Version 2.1C model. According to the 1995 NPTS data for all trips made in the U.S., the local person trips per capita in 1995 was 4.3. This means that the SMI model estimates trips per capita at 30% below the national NPTS trip rates, which is ironic, since the SMI model was built on the premise of matching data from the 1995 NPTS.

Table 5 Estimated 1994 Motorized Person Trips

	COG V2.1	SMI
HBW	3,689,217	3,735,864
HBS	2,763,041	2,840,811
HBO	8,457,670	8,681,479
NHB	6,155,459	6,477,248
Total motorized person trips	21,065,387	21,735,402
Motorized psn trips per HH	11.0	11.4
Motorized psn trips per capita	4.1	4.2

Socio-economic data

Households	1,912,782
Employment	3,049,559
Population	5,168,380

(Round 6.0 Updated to the Cooperative Land Use Forecasts)

Ref: trp_distrib.xls

Since the SMI model makes use of three intra-state K-factors having two distinct values (1.8 for all trips within DC; 1.4 for all trips within Maryland; and 1.4 for all trips within Virginia), trip distribution results for 1994 are presented at the state-to-state level in Table 6 and Table 7. While the overall performance of the SMI model is within five percent of observed travel (not taking the additional 25 percent reduction that should be applied based on the factoring occurring in the time-of-day model step), trips to and from DC are far too low, and trips to and from Virginia are far too high. The fit is much better for these patterns using the Version 2.1C model.

Table 6 SMI Model Trip Distribution Performance

1994 Estimated SMI Model Total Motorized Person Trips

	DC	MD	VA	Total
DC	744,762	247,488	141,058	1,133,308
MD	669,462	8,516,807	410,593	9,596,862
VA	411,074	281,661	7,275,178	7,967,913
Total	1,825,298	9,045,956	7,826,829	18,698,083

1994 Observed Total Motorized Person Trips

COG HTS, COG AES, Baltimore HTS1994 Motorized Person Trips

	DC	MD	VA	Total
DC	1,284,842	389,460	222,092	1,896,394
MD	755,163	8,317,556	275,881	9,348,600
VA	488,602	170,199	6,276,118	6,934,919
Total	2,528,607	8,877,215	6,774,091	18,179,913

Difference (Est. - Obs.) Total Motorized Person Trips

	DC	MD	VA	Total
DC	-540,080	-141,972	-81,034	-763,086
MD	-85,701	199,251	134,712	248,262
VA	-77,528	111,462	999,060	1,032,994
Total	-703,309	168,741	1,052,738	518,170

Ratio (Est./Obs.) Total Motorized Person Trips

	DC	MD	VA	Total
DC	0.58	0.64	0.64	0.60
MD	0.89	1.02	1.49	1.03
VA	0.84	1.65	1.16	1.15
Total	0.72	1.02	1.16	1.03

Note: Total refers to HBW, HBS, HBO, and NHB summed together, excluding trips to and from external stations.

Ref: smi_3x3.xls

Table 7 Version 2.1C Model Trip Distribution Performance

1994 Estimated Version 2.1C Model Total Motorized Person Trips

	DC	MD	VA	Total
DC	1,296,542	357,100	257,200	1,910,842
MD	751,022	8,289,687	366,992	9,407,701
VA	535,391	253,351	6,133,558	6,922,300
Total	2,582,955	8,900,138	6,757,750	18,240,843

1994 Observed Total Motorized Person Trips

COG HTS, COG AES, Baltimore HTS1994 Motorized Person Trips

	DC	MD	VA	Total
DC	1,284,842	389,460	222,092	1,896,394
MD	755,163	8,317,556	275,881	9,348,600
VA	488,602	170,199	6,276,118	6,934,919
Total	2,528,607	8,877,215	6,774,091	18,179,913

Difference (Est. - Obs.) Total Motorized Person Trips

	DC	MD	VA	Total
DC	11,700	-32,360	35,108	14,448
MD	-4,141	-27,869	91,111	59,101
VA	46,789	83,152	-142,560	-12,619
Total	54,348	22,923	-16,341	60,930

Ratio (Est./Obs.) Total Motorized Person Trips

	DC	MD	VA	Total
DC	1.01	0.92	1.16	1.01
MD	0.99	1.00	1.33	1.01
VA	1.10	1.49	0.98	1.00
Total	1.02	1.00	1.00	1.00

Note: Total refers to HBW, HBS, HBO, and NHB summed together, excluding trips to and from external stations.

Ref: cog_3x3.xls

Traffic Assignment Comparisons

Estimated and observed 1994 VMT by jurisdiction is shown in Table 8 for the two models. The COG/TPB Version 2.1C model overestimates VMT by 6% at the regional level, and the SMI model underestimates VMT by 7%. The fact that the SMI model underestimates VMT would make it unacceptable for use in regional air quality conformity analyses.

Table 8 Estimated and Observed VMT by Jurisdiction in 1994: SMI vs. Version 2.1C

Jurisdiction	Est VMT COG v2.1c	Est VMT SMI	Obs VMT	Est/Obs COG	Est/Obs SMI
0 DC	9,426,000	6,991,629	7,875,000	1.20	0.89
1 Montgomery	19,506,000	16,036,055	17,129,000	1.14	0.94
2 Prince George's	20,784,000	17,836,321	20,333,000	1.02	0.88
3 Arlington	4,304,000	3,657,907	4,124,000	1.04	0.89
4 Alexandria	2,103,000	1,929,196	2,072,000	1.01	0.93
5 Fairfax	24,158,000	21,191,553	22,979,000	1.05	0.92
6 Loudoun	2,581,000	2,887,084	2,902,000	0.89	0.99
7 Prince William	5,974,000	5,271,016	6,221,000	0.96	0.85
9 Frederick	6,072,000	5,092,305	4,879,000	1.24	1.04
COG subtotal	94,908,000	80,893,066	88,514,000	1.07	0.91
10 Howard	8,536,000	7,584,481	6,990,000	1.22	1.09
11 Anne Arundel	8,556,000	8,826,155	8,580,000	1.00	1.03
12 Charles	1,832,000	2,111,819	2,007,000	0.91	1.05
1478-TAZ subtotal	18,924,000	18,522,455	17,577,000	1.08	1.05
14 Carroll	2,456,000	2,512,886	2,167,000	1.13	1.16
15 Calvert	1,245,000	1,094,524	1,280,000	0.97	0.86
16 St. Mary's	1,083,000	1,266,582	1,166,000	0.93	1.09
17 King George	630,000	478,007	559,000	1.13	0.86
18 Fredericksburg	496,000	378,431	663,000	0.75	0.57
19 Stafford	3,080,000	2,472,273	2,935,000	1.05	0.84
20 Spotsylvania	1,334,000	1,095,746	1,940,000	0.69	0.56
21 Fauquier	1,987,000	1,697,094	2,104,000	0.94	0.81
22 Clarke	575,000	500,870	492,000	1.17	1.02
23 Jefferson	961,000	778,004	601,000	1.60	1.29
Outer counties subtotal	13,847,000	12,274,417	13,907,000	1.00	0.88
Grand total, exp. cordon	127,679,000	111,689,938	119,998,000	1.06	0.93

Ref: smi_cog_compar.xls, vmt_jur

Mobile Emissions and Speeds Comparisons

COG/TPB staff ran the mobile emissions post processor with the travel model output from both the Version 2.1C model and the SMI model. Because 1994 emissions rates were not available from a previous run of Mobile 6, we used the 1990 rates for both models. According to this analysis, the SMI model operating in tandem with the Mobile 6 model estimates less mobile emissions than the Version 2.1C model operating with the Mobile 6 model, by 20 to 24 percent, as can be seen in Table 9. The SMI model estimates19 percent less VMT than the Version 2.1C model. In the SMI model, the estimate of average highway speed is 4% higher than for the COG/TPB model.

Table 9 Estimates of VMT, Speed, and Mobile Emissions for the SMI and COG/TPB Version 2.1C Models

		1990	1994		
		COG V2.1C 1990 Mobile6 rates	COG V2.1C 1990 Mobile6 rates	SMI - V2.0 1990 Mobile6 rates	Pct Diff
Modeled/Trend-Line Based	Veh.Trip Starts	11,974,447	12,787,886	9,579,423	-25.1%
	Veh.Trip Stops	11,976,527	12,787,049	9,578,452	-25.1%
Trip-End Emissions (tons)	Start-Up / HC	60	64	47	-25.4%
	Start-Up / CO	757	809	605	-25.1%
	Start-Up / Nx	23	25	18	-25.2%
	Hot Soaks / HC	21	22	17	-25.5%
Running Emissions (tons)	HC	162	175	135	-23.0%
	CO	2,577	2,730	2,190	-19.8%
	Nx	324	344	279	-19.1%
Total Emissions (tons)	HC	243	261	199	-23.8%
	CO	3,334	3,539	2,795	-21.0%
	Nx	347	369	297	-19.5%
VMT		100,208,899	106,433,142	86,571,679	-18.7%
Average Highway Speed (mph)		40.5	40.0	41.4	3.5%

MSA Mobile Emission Results (as of 5/01/03) -- Note: MOBILE6 Rates Include the 'Technical Corrections'

ppchk_flow2.xls

Findings

Smart Mobility Inc. compared the performance of their enhanced travel model, which employs a greatly reduced set of K-factors, with the COG/TPB Version 2 model by evaluating one metric – traffic volumes crossing screenlines. Other metrics were not evaluated by SMI in their report, but have been evaluated in this report. These include the performance of the trip distribution step of the SMI model, VMT by jurisdiction, and mobile emissions when coupled with the Mobile 6 emissions model. The following findings are made in comparing the performance of the SMI model with that of the COG/TPB Version 2.1C model:

- The SMI model does achieve a closer match than the Version 2.1C model with observed counts on 24 of 38 screenlines employed by COG/TPB to check model performance. However, it accomplishes this performance by loading vehicle trip tables from the time-of-day model which have been globally adjusted downward by a combined 25 percent prior to the traffic assignment step.

- The SMI model makes use of only three intra-state K-factors, with two distinct values - 1.8 for trips within DC; 1.4 for trips within Maryland; 1.4 for trips within Virginia. These K-factors are applied to 38 percent of all zone-to-zone trip interchanges in the SMI model. The specific three values of the K-factors are applied to all trip purposes, including the two categories of trucks. By contrast, the COG/TPB Version 2.1C model employs 68 K-factors in the residential trip purposes, which are applied to a range of 9 percent to 20 percent of zone-to-zone trip interchanges, depending on trip purpose - far fewer interchanges than in the SMI model.

- Comparison of model performance with respect to trip patterns reveals that the SMI model is not well fitted to observed patterns. Total 1994 motorized person trips to and from DC are underestimated by 28 to 40 percent (depending on directionality), while trips to and from Virginia are overestimated by 15 to 16 percent. By contrast, the COG/TPB Version 2.1C model, operating with 68 K-factors applied to far fewer trip interchanges than the SMI model, achieves a much better fit with the observed travel pattern, producing estimated travel within 2 percent of the observed pattern to and from DC, Maryland, and Virginia.

- Comparison of VMT by jurisdiction reveals that the SMI model underestimates regional vehicle miles of travel in 1994 by 7 percent, while the COG/TPB Version 2.1C model overestimates VMT by 6 percent. Given the need to avoid underestimating emissions in air quality analyses, it is preferable that a travel demand model not underestimate VMT.

- Finally, the SMI model when coupled with the EPA-mandated Mobile 6 emissions model estimates 20 to 24 percent fewer total vehicle emissions in a 1994 test, depending on pollutant category, than the COG/TPB Version 2.1 model coupled with Mobile 6.

Given these findings, COG/TPB staff has serious reservations about the merit of SMI's model enhancements and the overall quality of the SMI's model performance. An in-depth analysis of SMI's model work has concluded that the case that SMI's model is superior to the COG/TPB Version 2.1C model has not been demonstrated.

References

Reports and Working Papers

Metropolitan Washington Council of Governments (MWCOG) (2002) Version 2.0/TP+ Application and Flowchart. A memo to the Travel Forecasting Subcommittee (TFS) from Ronald Milone. July 15, 2002.

Metropolitan Washington Council of Governments (MWCOG) (2002) COG/TPB Travel Forecasting Model, Version 2.1/TP+, Release C, Calibration Report. Draft. December 23, 2002.

Metropolitan Washington Council of Governments (MWCOG) (2002) COG/TPB Travel Forecasting Model, Version 2.1/TP+, Release C, User's Guide. Draft. December 23, 2002.

National Capital Region Transportation Planning Board (TPB) (Feb. 2003) Responses to A Critique of the TPB Version 2 Travel Model and Mobile Source Emissions Procedures: A Compendium of Comments, Responses, and Related Documents. February 24, 2003.

Smart Mobility, Inc. (SMI) (2002) More Sprawl, More Traffic, No Relief: An Analysis of Proposed Potomac River Crossings. Technical Report of Research. Prepared for the Audubon Naturalist Society of the Central Atlantic, States, Chesapeake Bay Foundation, Coalition for Smarter Growth, Environmental Defense, Piedmont Environmental Council, Solutions Not Sprawl. October 2002.

Worldwide Web Links

Smart Mobility, Inc. (http://www.smartmobility.com/)

Appendix A
An excerpt from "Responses to a Critique of the TPB Version 2 Travel Model and Mobile Source Emissions Estimation Procedures: A Compendium of Comments, Responses, and Related Documents," February 24, 2003

Responses to

A Critique of the TPB Version 2 Travel Model and Mobile Source Emissions Estimation Procedures

A Compendium of Comments, Responses, and Related Documents

February 24, 2003

National Capital Region
Transportation Planning Board
Metropolitan Washington Council of Governments
777 North Capitol Street, NE – Suite 300
Washington, D.C. 20002-4239

Contact: Deborah Leigh
202/962-3315
e-mail – cogdtp@mwcog.org

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Responses to Critique of TPB
Version 2 Travel Model and
Mobile Source Emissions Estimation
Procedures

February 24, 2003

In a letter of November 4, 2002 to the Chair of the National Capital Region Transportation Planning Board (TPB) and the Chair of the Metropolitan Washington Air Quality Committee (MWAQC), Mr. Michael Replogle of Environmental Defense and representatives of five other organizations made reference to "critical deficiencies in the TPB Version 2 model that must be remedied." The reference was based on detailed comments provided in a Technical Report accompanying a study entitled, ***More Sprawl, More Traffic, No Relief: An Analysis of Proposed Potomac River Crossings, October 2002.***

Mr. Norm Marshall of Smart Mobility, Inc. joined Mr. Replogle in presenting these initial comments at the TPB Travel Forecasting Subcommittee meeting on November 15, 2002. COG/TPB staff provided responses to these comments at the November 15, 2002 meeting, and these responses were summarized in a letter from COG/TPB staff to Mr. Replogle dated November 20, 2002.

At the TPB Travel Forecasting Subcommittee meeting of January 24, 2003, Mr. Replogle distributed and discussed at length a letter dated January 22, 2003 (with an attached memorandum from Norm Marshall and Brian Grady of Smart Mobility, Inc.) which responded to the COG/TPB staff letter of November 20, 2002. Since COG/TPB staff had not seen Mr. Replogle's January 22, 2003 letter prior to its distribution at the January 24, 2003 Travel Forecasting Subcommittee meeting, only general responses and comments were provided at the meeting by staff and subcommittee members. A follow-up letter of February 19, 2003 from COG/TPB staff to Mr. Replogle provided more specific responses based on a review of the various points raised in Mr. Replogle's January 22, 2003 letter.

The following sections provide a summary of the assertions and comments made by Mr. Replogle and others, along with the responses by COG/TPB staff, in chronological order. Complete copies of all correspondence by COG/TPB staff and the TPB related to these matters are provided as Attachment A to this chronological summary. Complete copies of all correspondence by Mr. Replogle and others are provided as Attachment B.

COG/TPB staff is currently encouraging all interested parties to review the results obtained with the Version 2.1 travel forecasting model. Comments received may result

in additional refinements to the Version 2.1 model as it is applied to travel forecasting over the coming months.

In addition, the COG/TPB emissions post-processor, which computes mobile emissions by combining travel demand data with emissions rates, has recently been refined for use with the Version 2.1 travel model and EPA's Mobile 6 emissions model. The initial results of applying this refined post-processor are currently being reviewed by TPB and MWAQC, and by their associated technical committees and subcommittees. COG/TPB staff is encouraging all interested parties to review the mobile emissions results obtained with this post-processor. Comments received may result in additional refinements to the post-processor as it is applied in the development of mobile emissions estimates over the coming months.

COG/TPB has contracted with the Transportation Research Board (TRB) of the National Academy of Sciences to provide an independent assessment of the TPB's Version 2.1 travel demand model and the emissions post-processor through an ad hoc peer review committee formed by the TRB. The peer review committee will include individuals familiar with MPO travel demand modeling, consultants with expertise in developing and applying travel demand models, and scholars in the field. (Experts and stakeholders involved in transportation issues in the Washington region will be excluded from the peer review committee.) Deliverables of this effort include a brief letter report assessing whether the TPB's modeling is "state of the practice" by June 30, 2003, and a second letter report providing guidance on future topics by December 31, 2003. The first meeting of the peer review committee is scheduled for February 27-28, 2003. A copy of the scope of work for this peer review is provided as Attachment C.

A. Traffic Assignment Feedback Into Trip Distribution

Critique (11/4/02):

The authors of the Smart Mobility, Inc. report state that "the TPB DCV2 model does include distribution feedback. However, the feedback mechanism is only applied to home-based work trips."

Staff Response (11/20/02):

This statement is incorrect. COG/TPB staff has implemented feedback for all trip purposes in both the Version 2.0 and 2.1 models. The feedback has been implemented using a time of day model prior to traffic assignment, which takes into account the distribution of trips by purpose by time of day. Both the a.m. peak and off-peak travel times flowing from the traffic assignment step are fed back into trip distribution.

Critique (1/22/03):

Mr. Replogle states that the 11/4/02 assertion by Smart Mobility, Inc. (SMI) was a "misstatement": "rather than stating that the TPB DCV2 model includes ***no*** feedback for non-work trips, SMI's report should have stated that the TPB DCV2 model includes only ***weak*** distribution feedback for such trips" because such feedback is based on off-peak travel times. SMI staff reports that in their modeling effort "the AM travel times were fed back for all trip types", and that "this approach is more accurate than using off-peak travel times with feedback that is too weak during both peak periods."

Staff Response (2/19/03):

Since almost two-thirds of non-work vehicle trips occur in the off-peak hours, COG/TPB staff believes that off-peak travel times are more appropriate for this feedback than, for example, the a.m. peak travel times recommended by Smart Mobility, Inc. COG/TPB staff will continue to compare the feedback aspect of the Version 2 model structure with proposals from research efforts and with procedures in production models currently in use by other metropolitan areas.

B. Use of Data from the Nationwide Personal Transportation Study (NPTS)

Critique (11/4/02):

Smart Mobility, Inc. claims that "the DCV2 model is estimating too many trips and that on average the trips are too short," and supports this claim by appealing to data extracted from the NPTS.

Staff Response (11/20/02):

COG/TPB staff does not recommend using the Nationwide Personal Transportation Survey (NPTS) as a means to develop or enhance a travel demand model, as appears to have been done by Smart Mobility, Inc. in producing an "enhanced" model. The 798 households from the NPTS mentioned in the SMI report in fact represent more than just the Washington region. They include the combined Washington-Baltimore-Hagerstown DC-MD-VA-WV consolidated metropolitan statistical area. Only 496 of these households are located in the Washington region, and of these, only 313 households provided information about their weekday travel. Such a sample is too small to develop or enhance a travel demand forecasting model for the metropolitan Washington region. By comparison, the 1994 COG/TPB Household Travel Survey, upon which the Version 2.1 model and previous models were developed, collected weekday travel data from more than 4,700 households living in the Washington region.

The NPTS was designed to produce a national estimate of annual daily travel, and national control totals, not control totals for individual metropolitan regions, were used to develop the sample expansion factors for the NPTS survey data. There can be no reasonable expectation that NPTS data will reliably estimate the number of daily weekday person or vehicle trips in the metropolitan Washington region, or even correctly estimate regional population, household and worker totals. Further, the NPTS data is based on very approximate "self-reported" travel distances, which research has shown are not very accurate. The actual starting point and ending point of each trip is not reported. In the 1994 COG/TPB Household Travel Survey such information is reported.

Critique (1/22/03):

Mr. Replogle states that "it is my judgement that SMI's use of NPTS data is appropriate and reasonable in the current application."

Staff Response (2/19/03):

Staff continues to disagree with Mr. Replogle's judgement on this issue, for the reasons provided in the 11/20/02 staff response.

C. Misspelled Parameter in Gravity Model Execution

Critique (11/4/02):

Smart Mobility, Inc. points out a misspelled TP+ parameter "MAXITERS" in the original execution of the Version 2.0 gravity model (or trip distribution model).

Staff Response (11/20/02):

This parameter spelling has been corrected along with other corrections in the latest runs of the Version 2.1 model.

D. Model Validation

Critique (11/4/02):

(1) Smart Mobility, Inc. comments that the "Enhanced Model performs better than both the Version 2.0 and 2.1 models in estimating Potomac River crossings." They also comment that their "modifications have also improved the overall performance of the model on the other screenlines analyzed by TPB. In the Enhanced Model, 20 of the 35 screenlines show improvement over the DCV2 model (i.e., the ratio of estimated to observed volume is closer to 1)."

(2) Smart Mobility, Inc. argues that K-factors and time penalties should be used sparingly in travel demand modeling, and they indicate that they have taken the Version 2.0 model, removed all the income-level time penalties, and replaced the TPB K-factors with a more limited set to form what they describe as an Enhanced Model .

(3) The authors of the Smart Mobility, Inc., report state that "the DCV2 model assigns too many vehicles to the low class facilities which have count volumes under 20,000 vehicles per day. The estimated volume on these roadways is 13 percent too high. In addition, the model is under-assigning vehicles to the high class facilities which have count volumes greater than 100,000 vehicles per day. The estimated volumes on the two high class facility types are 11 percent and 28 percent low respectively when compared against the count VMT. The evidence in Table 1 suggested that the DCV2 model is estimating too many trips and that on average the trips are too short."

(4) At the TPB Travel Forecasting Subcommittee meeting on November 15th, the authors of the Smart Mobility, Inc. report comment that the model validation needs to focus on comparisons with time-of-day traffic counts obtained from permanent count stations in the region.

Staff Response (11/20/02):

(1) COG/TPB staff has had to address model performance in several areas:

- Vehicle Miles of Travel (VMT)
- Trip Length Frequency
- Travel Patterns by Mode, by Jurisdiction
- Speed Estimation

As such, the model calibration effort has focused on optimizing the performance across these areas. The authors of the Smart Mobility, Inc. report have not reported how the Enhanced Model performs in areas beyond screenline traffic volume summaries and vehicle miles of travel. Staff has found that, given the limitations in various data (traffic counts, survey samples), it is necessary to look across this spectrum of indicators when judging the performance of any travel demand model. It should be noted that the observed data are subject to a range of variation. Smart Mobility, Inc. should investigate the performance of the Enhanced Model for all of these measures before reaching conclusions about its performance relative to Version 2.0 or Version 2.1.

(2) COG/TPB staff concurs that K-factors and time penalties should be used sparingly. Indeed, the referenced K-factors in both the Version 2.0 and 2.1 models are the fewest ever employed in TPB travel forecasting models in estimating vehicle miles of travel and trips by mode (transit, HOV, LOV). As part of the review of the Version 2.0 model performance, COG/TPB staff have removed the bridge time penalties in traffic assignment.

(3) COG/TPB staff notes that the comparison in Table 1 is for count ranges, not facility classes, as implied in the use of terms such as "low class facilities" and "high class facility types." The performance of the Version 2.0 model with respect to facility type is given in Exhibit 8.5 of the report, Version 2.0/TP+ Travel Model Calibration Report. Overall, the Version 2.0 model estimates volumes on links for which observed counts are available to within 4 percent. A similar finding is made for the Version 2.1 model in Version 2.1/TP+Travel Model Calibration Report, October 4, 2002.

(4) There are very few permanent count stations in operation in the Washington region at present (3 to 4 in Maryland, 12 to 13 in Virginia, of which as many as one half may be inoperable). This number is insufficient to check traffic simulations by the models. Vehicles miles of travel need to be checked against reporting from the Highway Performance Monitoring System (HPMS) in order to test whether or not a travel demand model simulates regional VMT.

Critique (1/22/03):

Mr. Replogle states that "permanent count station data--- as well as the many other sources of hourly traffic count data available across the region provide a statistically robust sample of major facilities across the region", and implies that the TPB Version 2 model should be evaluated using those data.

Staff Response (1/19/03):

COG/TPB staff continues to disagree with Mr. Replogle's assertion that the available hourly count data provide a "statistically robust sample" for evaluating the Version 2 model, for the reasons provided in the 11/20/02 response.

E. Relationship Between Vehicle Travel Demand and Mobile Source Emissions

Critique (11/4/02):

On page 3, paragraph 2 of the November 4th letter, Mr. Replogle states

> "Thus, like the TPB Version 1 travel demand model, Version 2 will overestimate motor vehicle travel demand in the future and overestimate the benefits of proposed highway improvements." (emphasis added)

On page 3, paragraph 3 of the same letter, Mr. Replogle states:

> "Use of the Version 2 model to support SIP air quality planning or transportation conformity analysis without remedying these problems threatens to lead to serious underestimation of mobile source emissions, ..." (emphasis added)

Staff Response (11/20/02):

The logic relating these two apparently inconsistent statements is unclear. Staff requests that Mr. Replogle provide further explanation of his reasoning so that staff may provide appropriate comment.

Critique (1/22/02):

Mr. Replogle states that "I stand by these statements,--- and will explain the logic behind them." He asserts specifically that the Version 2 model "is likely to overestimate the motor vehicle travel demand especially in the peak hour direction on congested highways", and that this "overestimation" by Version 2 "leads to large errors in the speeds of traffic on area highways, which in turn leads to significant errors in estimation of emissions, which are dependent in part on vehicle speeds."

Staff Response (2/19/03):

Emissions associated with the travel demand estimated by Version 2 are based not on speeds developed within Version 2 but on speeds developed by a mobile emissions post-processor, which distributes daily vehicular volumes on highway links by hour of day and takes into account the effects of travel speeds on VOC and NOx emissions. Mr. Replogle makes no mention of this post-processor, and consequently provides no explanation of how an overestimation of motor vehicle travel demand could be accompanied by a "serious underestimation of mobile source emissions."

F. Provision of Smart Mobility "Enhanced Model" on CD-ROM

Critique (11/15/02):

At the November 15, 2002 Travel Forecasting Subcommittee meeting Mr. Replogle indicates that he is willing to make available in CD-ROM the "enhanced" model that Smart Mobility has developed.

Staff Response (11/15/02):

COG/TPB staff expresses interest in receiving this model for the purpose of reviewing its performance against a range of observed data that had been used to assess the performance of the Version 2.1 travel demand model.

Critique (1/22/03):

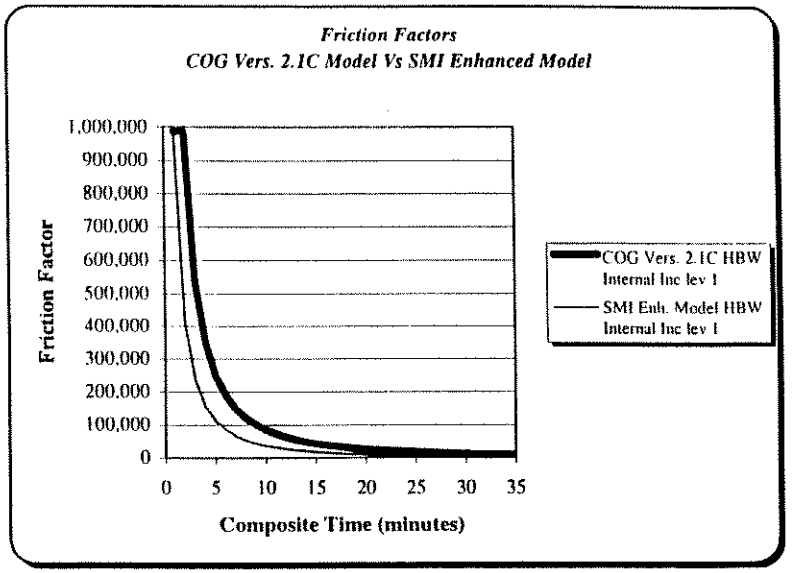
Mr. Replogle states that Smart Mobility, Inc. has been asked to provide a CD-ROM to COG/TPB staff "containing further details of the Enhanced Model, which will be forthcoming shortly."

Staff Response (2/19/03):

Staff reports receiving a set of CD-ROMs from Smart Mobility, Inc., with a transmittal memorandum dated January 31, 2003. However, COG/TPB staff have been unable to read any of the information on the CD-ROMs. Further, the transmittal memorandum indicates that the

inputs and outputs of different model runs are provided on the CD-ROMs, but not the model code which COG/TPB staff would need to assess the performance of the model. COG/TPB staff requests that Smart Mobility, Inc. contact Mark Moran of the COG/TPB staff to facilitate the transmittal of the appropriate information on the Smart Mobility "enhanced model."

Appendix B
Friction factors: COG/TPB Version 2.1C vs. SMI Enhanced Model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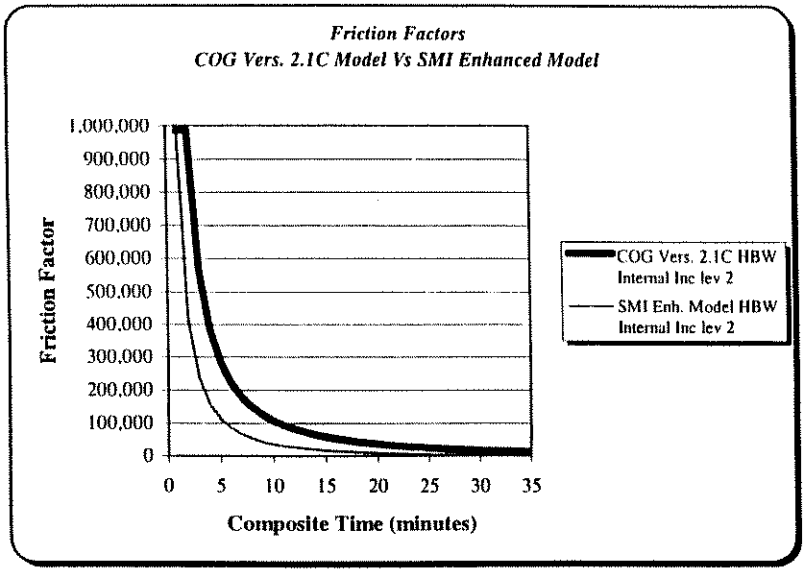
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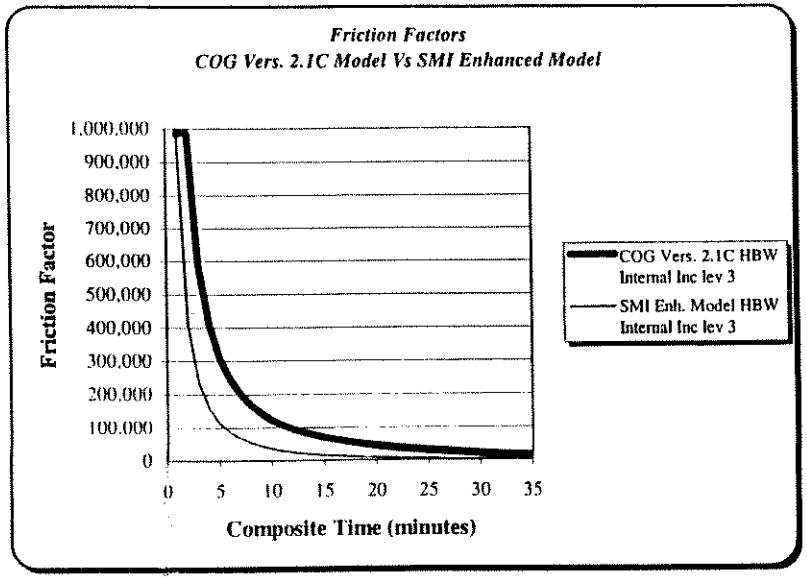
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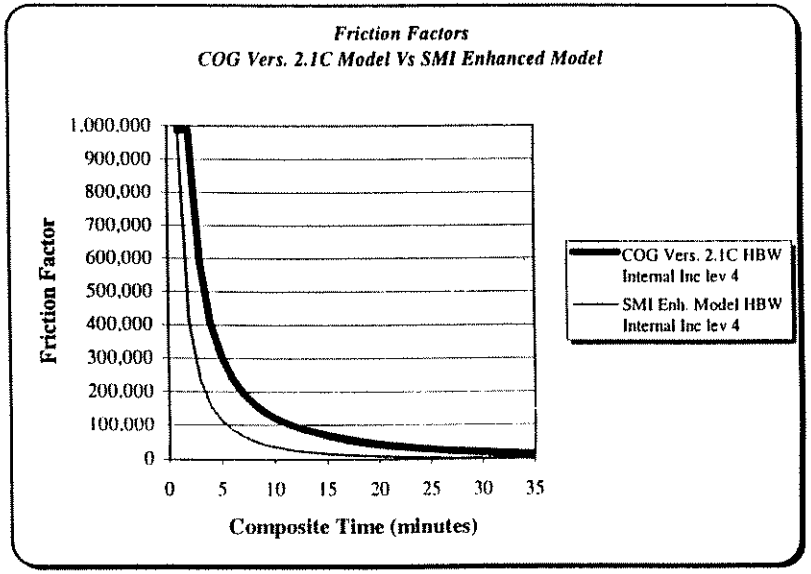
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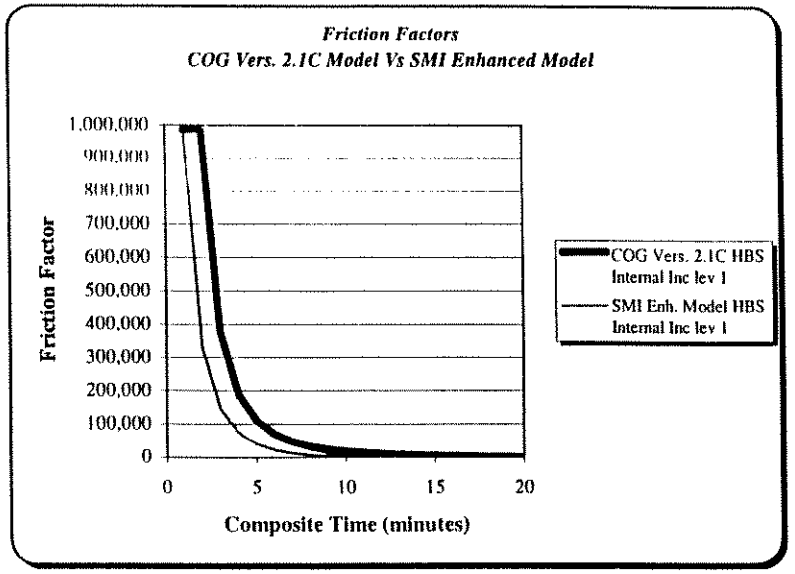
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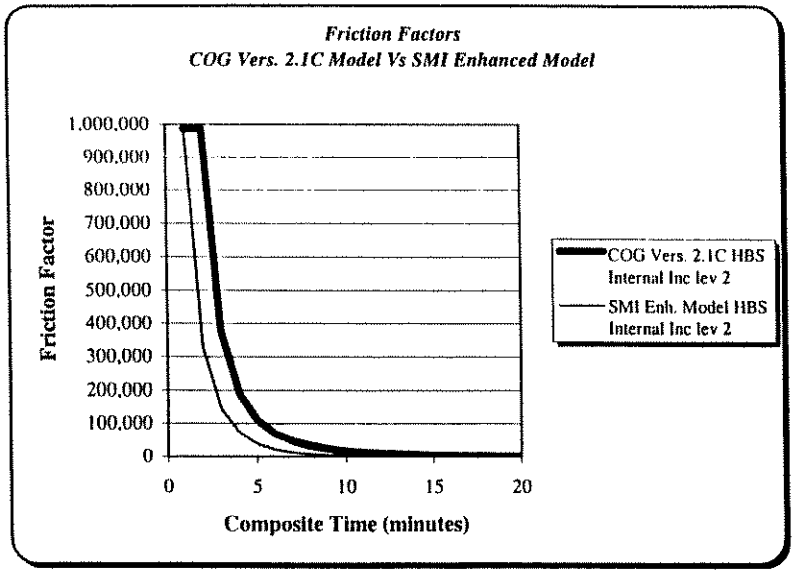
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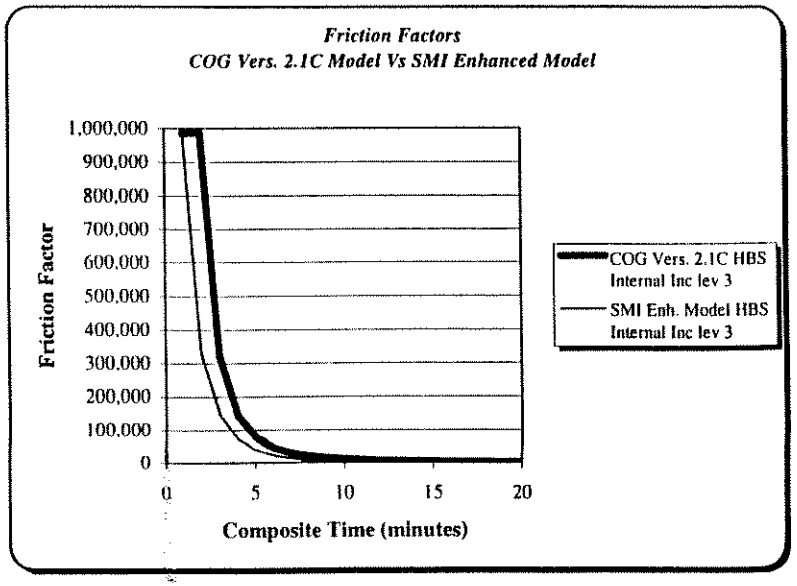
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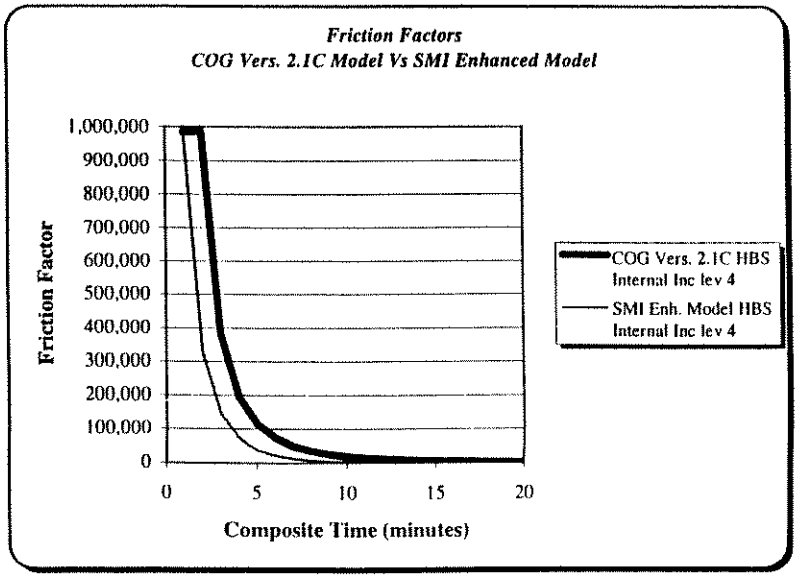
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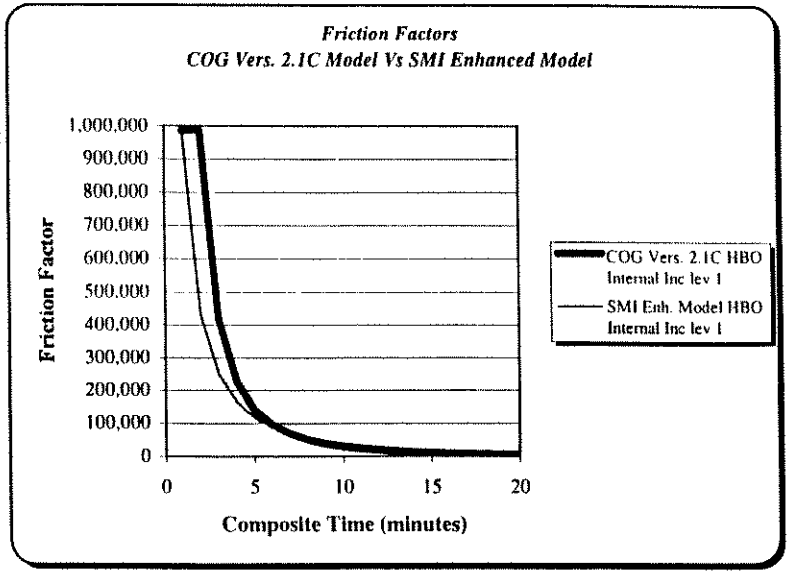
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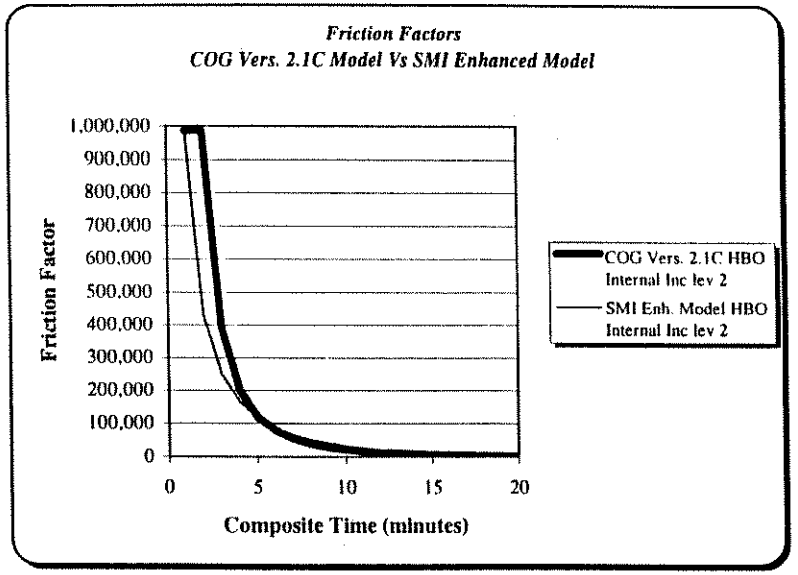
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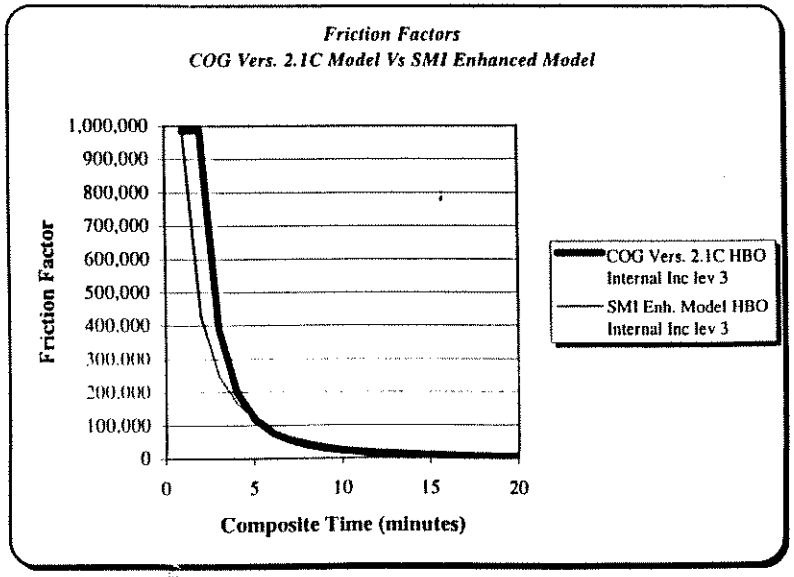
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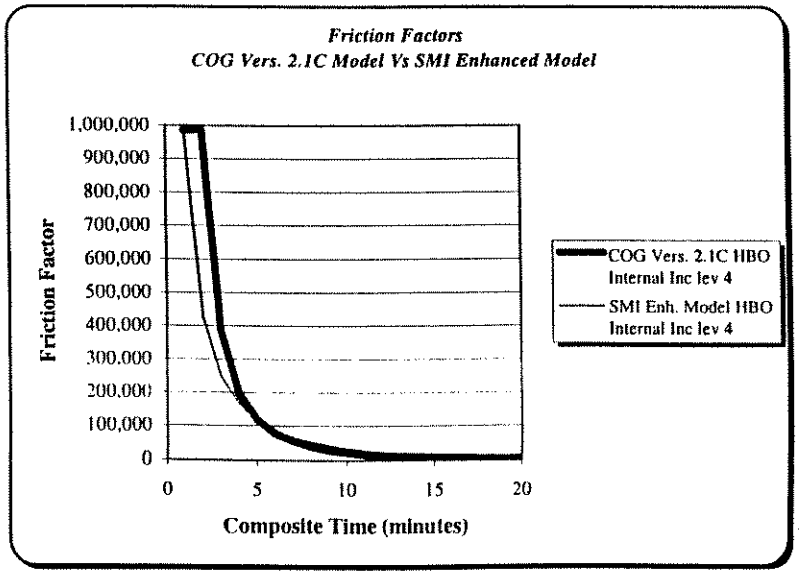
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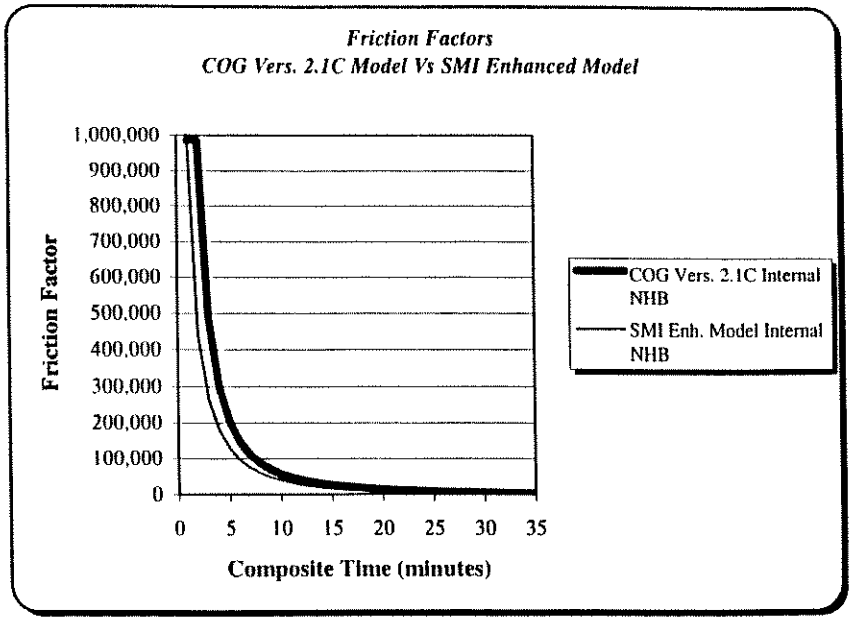
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