APPENDIX A
MODIFIED GROWTH AT TRANSIT STATION AREAS

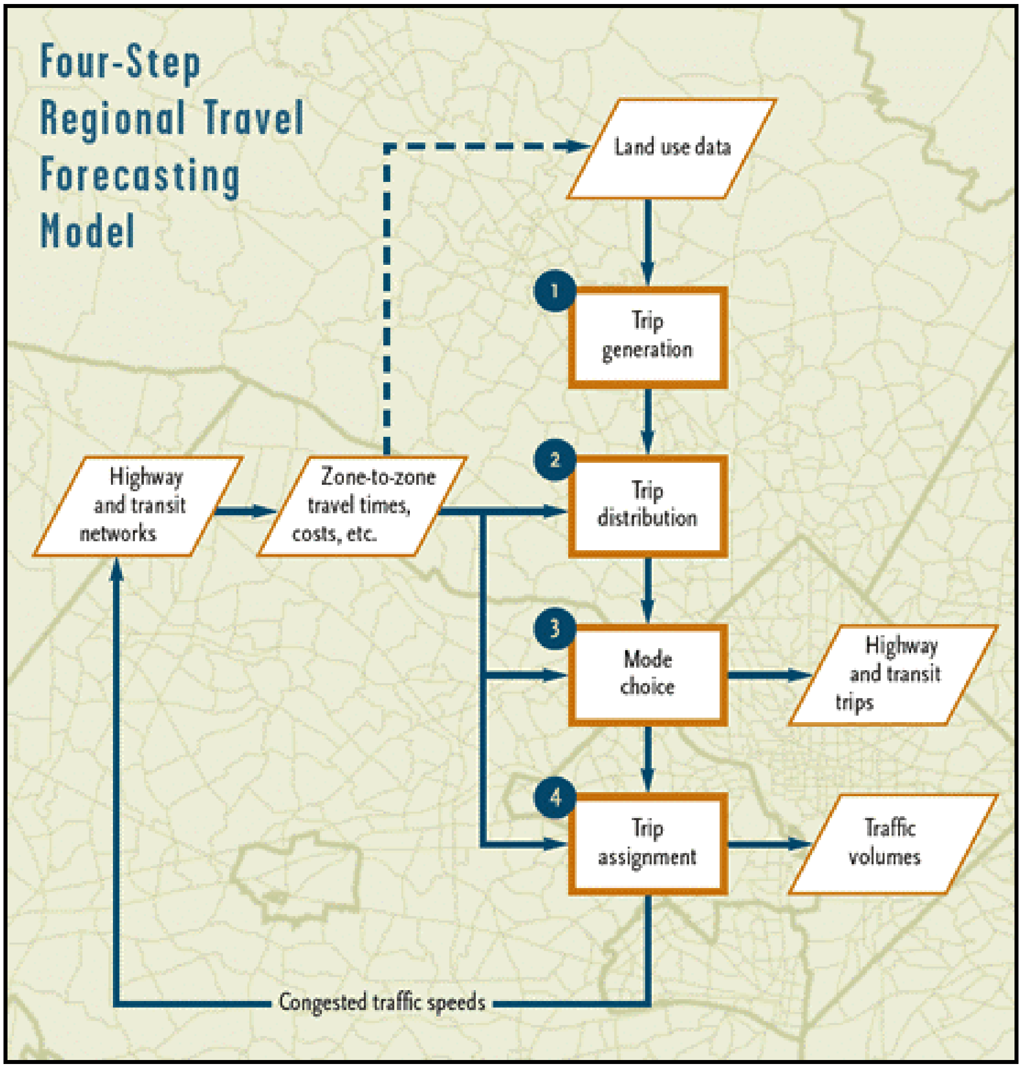
Jobs and Households at Transit Station Areas

Prince George's County						
	Households			**Jobs**		
	# of HH 2000	**Round 6.4 Forecast Growth**	**Round 6.4 Forecast Modified to Balance Transit, Job, & Household Growth**	**# of Jobs 2000**	**Round 6.4 Forecast Growth**	**Round 6.4 Forecast Modified to Balance Transit, Job, & Household Growth**
Langley Park	6,802	390	1,390	2,461	1,215	10,801
West Hyattsville	4,151	534	534	1,419	924	2,924
Prince George's Plaza	1,706	373	1,873	5,661	5,623	14,849
College Park	473	1,136	1,216	2,229	7,896	8,977
Greenbelt	2,476	683	1,313	4,328	6,018	9,118
Cheverly	3,348	638	1,438	9,529	2,099	4,111
Landover	3,536	353	1,053	4,293	1,847	7,603
New Carrollton	1,348	1,348	4,188	7,533	10,029	10,029
Capitol Heights	704	384	884	504	302	952
Addison Road	825	58	558	112	31	1,031
Morgan Boulevard	2,466	1,117	3,117	1,112	3,189	7,189
Largo Town Center	497	10	1,410	3,632	12,981	12,981
Montgomery County						
	Households			**Jobs**		
	# of HH 2000	**Round 6.4 Forecast Growth**	**Round 6.4 Forecast Modified to Balance Transit, Job, & Household Growth**	**# of Jobs 2000**	**Round 6.4 Forecast Growth**	**Round 6.4 Forecast Modified to Balance Transit, Job, & Household Growth**
Friendship Heights	3,325	933	1,050	8,348	3,156	3,961
Bethesda Central Business District (CBD)	5,841	7,345	7,345	33,731	8,445	9,717
Medical Center	267	1	1	16,261	4,734	4,734
Grosvenor	2,682	2,413	3,142	605	25	16
White Flint	956	3,889	6,815	6,752	8,476	4,748
Twinbrook	1,134	1,614	2,497	9,544	1,383	956
downtown Rockville	667	1,287	2,833	9,796	7,191	7,204
Shady Grove	346	4,260	3,954	3,133	2,448	1,726
Downtown Gaithersburg	1,808	2,610	2,610	8,304	771	2,558
Metropolitan Grove	1,178	850	1,755	4,902	2,936	2,098
Germantown Town Center	131	1,620	2,350	2,697	2,167	4,703
Silver Spring CBD	5,187	9,314	5,913	28,865	5,925	16,435
Takoma-East Silver Spring	5,152	72	100	3,777	329	3,623
Forest Glen	902	115	235	29	3	471
Wheaton CBD	2,603	3,579	1,271	3,317	1,721	11,805
Glenmont	1,921	1,310	1,475	970	165	3,498

Note: Due to the large size of traffic zones in Prince George's County and because Metro stations in the County frequently are located between two or more traffic zones, the calculation of transit oriented development should be considered to be approximate.

APPENDIX B
MODELING METHODOLOGY

This study used the Metropolitan Washington Council of Governments/Transportation Planning Board (COG/TPB) Travel Forecast Model Version 2.1D #28.[1] This model is a sequential "four-step" model similar to those in use in other regions in the United States. The four steps are:



Source: http://www.mwcog.org/transportation/activities/models/4_step.asp

1. Trip Generation – Origins and destinations are calculated for each transportation analysis zone ("TAZ"), trip type, and time period. A single origin or destination is called a "trip end."

[1] On October 1, 2004, the TPB staff released version 2.1D #50, which contains relatively minor improvements from version 2.1D #28. This study commenced in September 2004, and was mostly completed by that time. Use of the Version #50 model would not appreciably change the results or findings of this analysis. The ICC DEIS relied on the Version 2.1C transportation model, an earlier version, with many but not all of the modest enhancements that were incorporated into the Version 2.1D model.

2. Trip Distribution – The trip ends calculated in Step 1 are connected to form complete trips. These are "person trips" and include both auto and transit trips.
3. Mode Choice – The person trips are divided among transit trips, auto drive alone trips, and auto shared ride trips.
4. Trip Assignment – The auto trips are assigned to each link of the highway network.

The model is executed using common microcomputers similar to the desktop machines one would encounter in any office environment. The COG/TPB Model Version 2.1D is PC/Windows based but also requires a commercially available transportation-specific software package called TP+ developed by Citilabs, Inc. The model is bundled as a series of batch files, program executable files, program control files, TP+ control files, model parameter/support files, and analysis year input files. This version of the model contains input files for analysis years 1994, 2000, and 2030. The model is run from the command prompt window and takes approximately 15 hours to process a single alternative. The COG/TPB Travel Forecasting Model, Version 2.1D Draft #28 User's Guide contains a more detailed description about the workings of the model.

For this study, the batch, executable, and control files underlying the Version 2.1D #28 model were not modified. Only the 2030 analysis year input files, which are used to define a particular alternative, were manipulated. Three sets of model inputs are used to specify a particular alternative for a given analysis year: 1) the socio-economic land use forecasts, 2) the highway network representing the major roadways in the region, and 3) the transit network representing the major transit services in the region.

Socioeconomic Forecasts. The socioeconomic land use forecasts, which include the allocation of future households and employment by traffic analysis zone, are stored in the file ZONE.ASC. This file contains the forecast households, population, and employment by type for each of the 2,191 traffic analysis zones in the model. To develop the TOD Land Use Pattern, the data in the ZONE.ASC file was modified for the traffic analysis zones making up Montgomery County and northern Prince George's County to include the alternative allocation of households and employment.

Production-Attraction Balancing. The TPB travel model balances regional trip attractions to match regional trip productions. While in the base year, this produces little difference, in MWCOG's future land use forecasts, job growth is forecast to far outpace growth in households and the number of resident workers.[2] It is a common and sound accounting practice in comparing alternative transportation investments to "balance" the number of jobs created with the number of trips generated by the number of resident workers and customers living in or

[2]An expert panel convened by the Federal Highway Administration's Travel Model Improvement Program (TMIP), which helps agencies improve their planning analysis techniques, recently expressed "significant concerns regarding the population and employment forecasting procedures, in particular the fact that there are no employment control totals for the Baltimore-Washington Region. Employment and job projections need to be addressed by both Baltimore and Washington, DC planning agencies because the projected labor pool in the combined regions cannot possibly fill the projected number of new jobs. Both agencies [Baltimore Metropolitan Council and the MWCOG/TPB] project new jobs that far outstrip the number of individuals in the labor pool." FHWA, Travel Model Improvement Program, *Report on the Findings of the First Peer Review Panel of the Baltimore Metropolitan Council*, September 23-24, 2004. At the TPB meeting of December 15, 2004, Ron Spalding, representing the Maryland Department of Transportation, acknowledged that this concern about the regional travel modeling was a valid issue that was being taken seriously by both agencies, with interagency discussions ongoing about how to address it in future planning.

imported to or exported from the modeled region. This is properly done to avoid artificially making some scenarios perform better than others.

The Round 6.4A forecast for the ICC build alternative added 58,300 new jobs, without adding any workers or housing to the region. These jobs are distributed among the various employment types: Industrial (10%), Retail (19%), Office (43%) and Other (28%). TPB staff has stated that the workers at these jobs would commute in from outside the region.[3] However, in the air quality conformity model files obtained from TPB, no adjustments were made in the external trips, artificially deflating the number of trips made to and from these and all other forecast jobs in the region by more than one percent for the ICC Build Alternative only. The additional jobs attributed to the ICC should have been accompanied by an adjustment to the forecast of external traffic coming into and out of the modeled region to properly balance the books. But TPB staff had not adjusted these external traffic forecasts for 2030 since the Round 6.3 forecast or before.

This problem of imbalanced accounting between the alternatives has been corrected in this study's analysis of the ICC Build Alternative by explicitly adjusting the external trip ends to supply sufficient workers and customers for the additional jobs. The required number of additional trip attractions was estimated by multiplying the employees by the model's trip attraction rates. This resulted in 207,509 additional attractions – 72,826 home-based-work, 41,864 home-based-shopping, 32,179 home-based other, and 60,641 non-home-based. The TPB model has 47 external zones. The 207,509 additional external trip ends were allocated in proportion to TPB's 2030 inputs for home-base-work external flows. These are reasonable adjustments based on the testimony of the TPB Planning Director and they hold constant the 2030 production to attraction normalization process for all alternatives.

Highway Networks. The highway network is defined using two ASCII text files, LINK.ASC and NODE.ASC. The highway link file contains the attribute data for each roadway link such as distance, speed, capacity, number of lanes, etc. The node file, which represents the location of intersections, contains coordinate data for every node in the network. Together the files are built into a network that can be visually represented and viewed using the TP+ software. To develop alternative highway networks for the alternative analysis, in some cases, the existing link attribute data in the ASCII text files were modified. In other cases, such as modeling the ICC, new links to represent the new highway were added using the network editor available with the TP+ software. In both cases, highway link attributes for the new and/or modified links were coded according to the model guidelines published in the COG/TPB Travel Forecasting Model Version 2.1/TP+, Release C User's Guide dated December 2002.

Transit Networks. The transit network is defined using the TP+ route line files MODE[##].TB, which contain the transit route data for the bus, express bus, commuter rail, and metro rail service in the region. A number of additional input files define the location of transit stops and dictate the walk and/or drive access available at each transit station. To develop alternative transit networks for the alternative analysis, new transit service was added to the system using these input files. Once again, the new transit coding representing the new express bus and rail

[3] Ron Kirby, Planning Director, TPB, Testimony to the TPB September 2004 work session (available at http://www.mwcog.org/uploads/committee-documents/pF1ZXl020041014152452.pdf) and to the Metropolitan Washington Air Quality Committee October 2004 work session. *See* http://www.mwcog.org/uploads/committee-documents/vV1WW1w20041209152401.doc.

transit service followed the underlying transit modeling framework described in the COG/TPB Travel Forecasting Model Version 2.1/TP+, Release C User's Guide.

Toll Coding. To evaluate toll lane options, a network of tolled lanes was defined and coded. In the COG/TPB model, three user-specified parameter files are used to model highway pricing strategies, TOLL.ESC, TOLL.INC, and TOLL.SKM. The parameter files contain toll deflation rates, per mile toll rates, time-period specific factors, time/toll equivalent rates, and vehicle-type specific time/toll equivalents. By modifying the parameter values stored in these files, the model user can incorporate tolls that vary by time period and vehicle type for any roadway facility in the highway network via the toll and toll group link attributes.

The coding of toll express and HOT lanes sought to follow the conventions used by MDOT planners in the toll express lanes studies the agency is currently carrying out. Non-barrier separated toll lanes were assumed, with continuous entry/exit options for interchange between toll and non-toll lanes, with fully automated toll collection using overhead gantries and in-vehicle EZ-Pass transponders. This represents somewhat of an oversimplification of the traffic operations, as there would be some locations where weaving movements between toll and non-toll lanes would likely be barred for safety or toll administration and enforcement. Traffic operation level analysis, such as considering the effects of queuing in congested lanes on such weaving maneuvers, was beyond the scope of this study. An effort was made to code bus transfer options consistent with assumptions about in-line stations and slip ramps for buses at various locations, prohibiting such interchanges where no investment was assumed in such facilities, and accounting for bus stop delay due to such transfers. Due to limited resources, the study did not seek to optimize the network design and tolling levels to ensure the best system performance or to minimize traffic operations problems. Such preliminary engineering analysis should be undertaken to further refine the alternatives and analysis of their impacts.

Air Quality Analysis. The air quality analysis was performed using the COG/TPB Mobile Emissions Post-Processor. The post-processor is set up as a series of TP+ program scripts, which are called EMIS.BAT by the batch file and are executed in a command prompt window. The post-processor calculates emissions by combining outputs from the travel demand model and emission rates derived from the U.S. Environmental Protection Agency's MOBILE6.2 emission rate model. The post-processor was not modified in any way. Only the directory path names in the batch executable were changed to ensure that the program used the correct network link volumes produced by the travel demand model from the alternatives analysis. Link-based running emissions were then extracted from the post-processor outputs and documented in the report. More details regarding the COG/TPB emissions post-processor can be found in a memorandum that describes the operation of the post-processor used in the 2004 Air Quality Conformity Determination—"Mobile Emissions Post-Processor Description and Results" from Ronald Milone, dated October 1, 2004.

Limitations of the Travel Forecast Model

This study's quantitative analysis of alternatives relied upon the official COG/TPB Version 2.1D #28 transportation model, the latest version available when analysis for this study needed to commence. While the model has considerable value as an analytic tool, it has several considerable limitations with which it is important to be familiar when interpreting the results from the model. For example, knowledge of how well the model has been calibrated and validated to match observed data is helpful to understanding how the model operates.

Since the mid-1980s, the TPB's travel models have faced repeated scrutiny by independent experts and reviewers.[4] Concerns about the need for improvement to these models to properly reflect observed travel patterns, induced travel and land use impacts of various transportation policies, and to allow sensitivity to new policy options, such as pricing and improvements in the pedestrian environment have been raised for the past twenty years.[5]

In 2002, TPB commissioned the National Academy of Sciences' Transportation Research Board (NAS/TRB) to convene an independent expert model review panel to review its models. This panel issued critical letter reports in 2003 and 2004, finding substantial shortcomings in the TPB Version 2.1 C model.[6] For example, it found that,

> TPB's extensive use of adjustment factors in trip generation, trip distribution, and mode choice to enhance the match between simulated and base-year data undermines the fundamental behavioral logic of the four-step process. (pg.3)

It also found that,

> TPB's emphasis on data-fitting to observed base-year through the introduction of mechanical adjustment factors invites the pitfalls of inaccurate and unreliable future-year travel forecasts, especially if over time there are considerable changes in demographics, land use characteristics, and transportation system attributes. (p. 13)

The TRB review panel summarized the TPB time-of-day post-processor model as follows:

> The postprocessing procedure aggregates the period-specific link volumes produced by the travel models to a 24-hour volume for each link. The daily volume is then redistributed to hourly volumes in several steps. First, links are

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[4] For example, Jim Ryan of COMSIS undertook a review of the TPB travel model for the Montgomery County Planning Department of the Maryland National Capital Parks and Planning Commission in 1985 and found the new TPB mode choice model relied far too heavily on adjustment factors at every stage in the model process, and even with those factors, it over-predicted suburban transit ridership and under-predicted metro core transit use. This led the MNCPPC to develop its own models to support growth management, comprehensive planning, and project planning. Replogle, Michael, "Computer Transportation Models for Land Use Regulation and Master Planning in Montgomery County," *Transportation Research Record 1262*, Wash., DC, 1989.

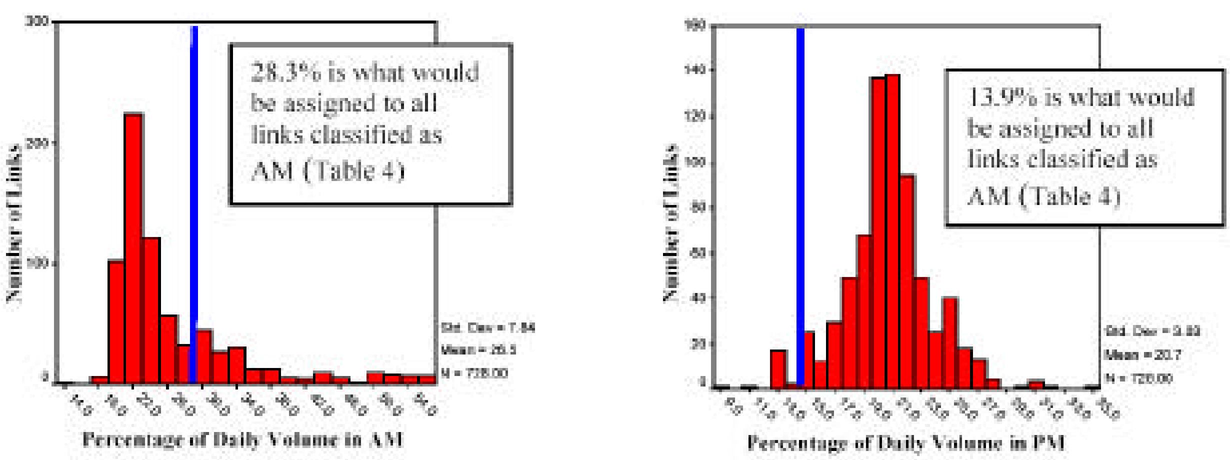
[5] *See*, e.g., Harvey, Greig W., Eric I. Pas, Charles L. Purvis, *Review of Transportation Modeling and Data Collection Activities at the Metropolitan Washington Council of Governments*, Metropolitan Washington Council of Governments, June 30, 1995; Marshall, Norm, and Brian Grady, *A Critique of Transportation Planning Board Travel Demand and Air Emissions Models*, Environmental Defense, Washington, DC, January 14, 2002; Smart Mobility, Inc., *More Sprawl, More Traffic, No Relief: An Analysis of Proposed Potomac River Crossings*. Environmental Defense, October 2002.

[6] The NAS/TRB letter reports are available at the MWCOG website. *See* http://www.mwcog.org/uploads/committee-documents/81pZXg20030908112905.pdf (September 8, 2003) and http://www.mwcog.org/uploads/committee-documents/vl5XXVk20040513164233.pdf (May 10, 2004). The NAS/TRB letter reports have been summarized in less technical terms in a June 2004 report, *A Citizen Guide to Critiques of the Metropolitan Washington Area Travel Model: What Does it All Mean?* Environmental Defense, Washington, DC.

categorized according to one of three default hourly distributions, based on each link's facility class and a peaking-characteristic rating (i.e., am-peak oriented, pm-peak oriented, even peaking). These generic distributions are used with the aggregated total daily link volume to develop an initial distribution of hourly traffic on a link. Next, the hourly volumes and speeds are adjusted for those hours in which the initial volume exceeds link capacity (LOS E). Beginning with peak hours (e.g., 7 to 8 am morning peak then 5 to 6 pm evening peak), projected traffic in excess of capacity is reallocated equally to the "shoulder" hours immediately adjacent to the peak; i.e., volume projected for the 7 to 8 am peak hour is "spread" to the 6 to 7 am and 8 to 9 am hours. Revised projected volumes in excess of capacity (now possibly including traffic reallocated from a peak period) are again reallocated equally to adjacent hours, unless the adjacent hour is a peak hour; in that case all excess traffic is reallocated to the adjacent non-peak hour…Reallocated volumes are then used to compute hourly VMT and hourly average running speeds. The latter parameter is estimated with volume-delay relationships calibrated to the Washington region. The greater of adjusted or unadjusted volume is used to derive a conservative (i.e., lower) estimate of speed. TPB's procedure of aggregating period estimates to 24-hour volumes would seem to be inconsistent with the travel models' assumptions for estimating period-based traffic volumes and travel times that, in turn, influence trip patterns...The committee agrees this use of disaggregated 24-hour volumes, as opposed to period-specific volumes produced in route assignment, is questionable because it produces emission rates that are not strictly based on peak and off-peak assignment results as directed by conformity network modeling requirements.

TPB models traffic for different time periods, including an Average Morning Peak Period and an Average Afternoon Peak Period. But the TRB review committee demonstrated that the "post-processing" results are inconsistent with the transportation model outputs. The graphic below is one of many prepared by the TRB Review Committee to make this point.

Figure 4-1 Freeways—classified as AM link.



FromTRB review committee second letter, p. 20.

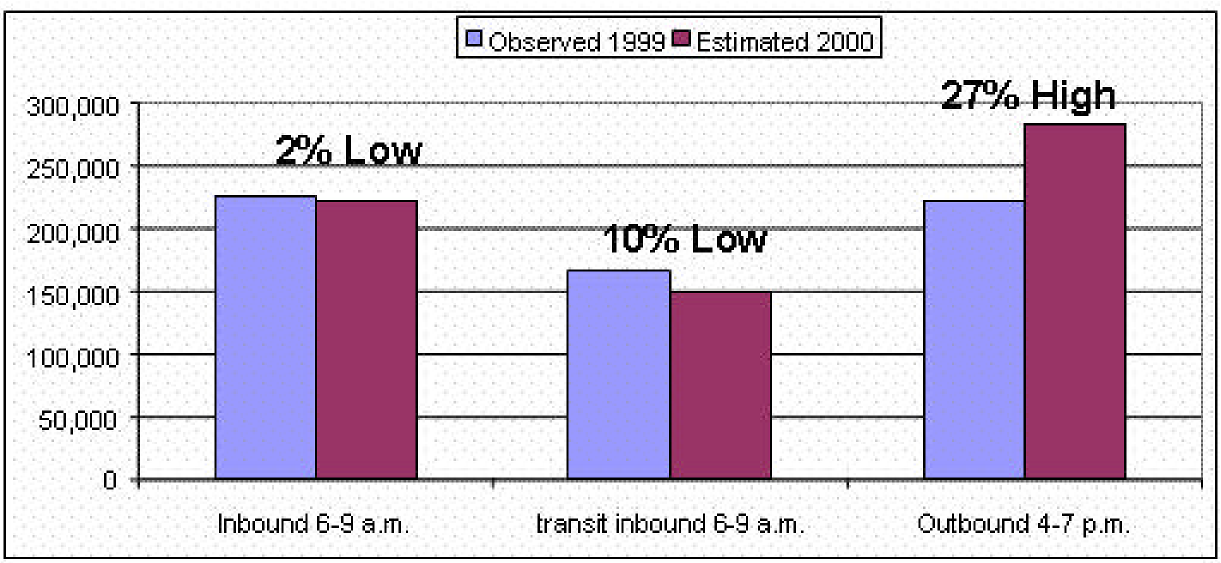
The graphics illustrate the condition for those Freeway links coded as having their peak in the morning hours. The graph on the left shows the morning peak period and the one on the right shows the afternoon peak period. The distributed red bars show the distribution of daily traffic estimated in the AM peak period by the transportation model. The vertical blue line shows the distribution assumed by the postprocessor model. The sharp differences result in significant changes to estimated travel times in the AM peak hour using the raw outputs from the TPB Version 2.1 model compared to the same outputs after they have been run through the post processor model.

The TRB review committee's suggested that,

> Ideally, the ratios of peak-period to daily traffic produced by the four-step model would be tightly clustered in a balanced distribution around the single-number estimate used in the postprocessing procedure. However, we found differences between the two sets that are in many cases strikingly large and skewed. The current postprocessing procedure undermines the relationship that ought to exist between the hourly volumes used for mobile source emissions estimates and the AM, PM, and off-peak volume estimates produced by TPB's four-step model. The estimates of hourly volumes and speeds must be associated directly with the time-of-day (AM, PM, off-peak) travel model output…The committee asserts that such an effort is necessary to produce hourly volumes for the mobile source emissions process that are credibly linked to travel demand estimates. (p. 11-12)

Documentation for the TPB model Version 2.1D demonstrates that the model tends to underassign traffic to the morning peak period and over-assign traffic to the afternoon peak period, at least with respect to the metro core and Beltway cordon.[7]

Version 2.1D Release #18 Peak Period Traffic Outputs vs. AM and PM Peak Period Traffic Counts and AM Peak Transit Ridership – Metro Core Cordon[8]



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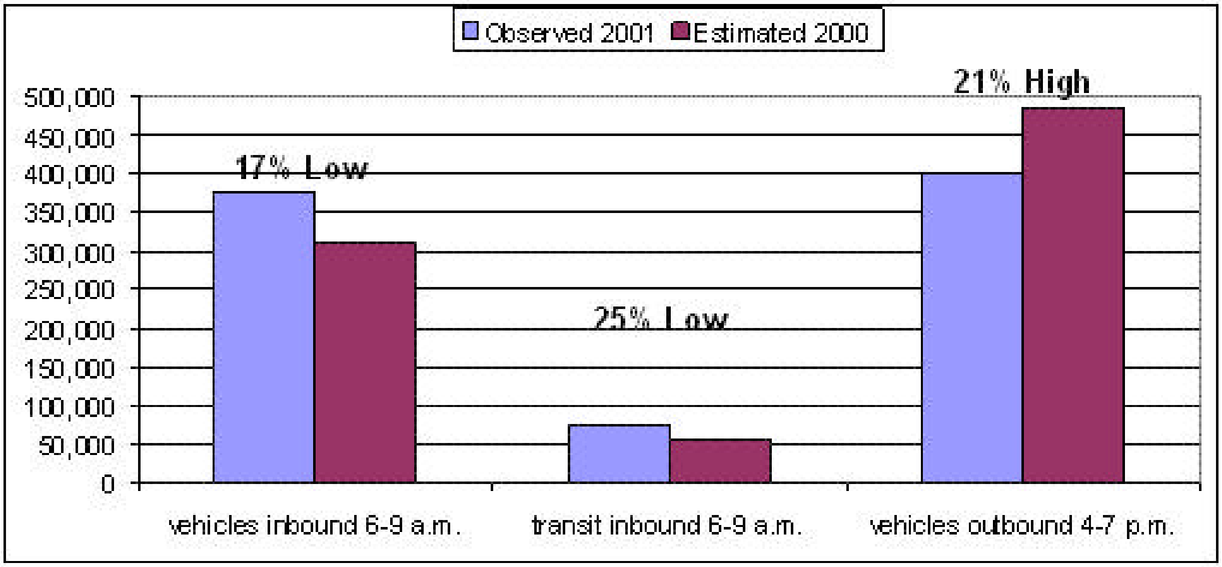
[7] Milone, Ron, Memorandum to Files concerning "Transmittal of Version 2.1D (Draft #16) Model, Tables labeled "Estimated and Observed Metro Core and Beltway Cordon Trip Crossings by Time Period", April 8, 2004.
[8] From handouts distributed by Ron Milone at the May 21, 2004 meeting of the TPB Travel Forecasting Subcommittee.

Version 2.1D Release #18 Peak Period Traffic Outputs vs. AM and PM Peak Period Traffic Counts and AM Peak Period Transit Ridership – Beltway Cordon



No effort was made to adjust the TPB model for this study to account for these issues. Where time-of-day travel times were evaluated, for example in looking at typical origin-destination pairs crossing the ICC study area, this study considered the results using both the raw Average AM peak period travel times and the post-processed model estimates of travel times, clearly identifying the method of analysis used for each estimate.

The TPB staff responded to each TRB peer review panel letter report.[9] In addition, the TPB staff developed a Work Elements Plan for the TPB Models Development Program that identifies individual tasks and an estimated timeline to develop the model in order to address the criticisms raised by the TRB.[10] During Summer 2004 TPB staff addressed some of the concerns raised by the NAS/TRB review, in the Travel Forecast Model Version 2.1D, both versions #28 and #50. However, many of the most serious problems have not been substantively addressed at this time.[11]

These remaining shortcomings that affect Version 2.1D #50 include:

- Systematic underestimation of traffic on the region's roadways that carry the most traffic, and overestimation of traffic on the lowest volume roadways, by large margins. This results in large errors in forecasting traffic on highways such as the Beltway and potentially on new major highways like the Intercounty Connector and reduces

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[9] Responses are available on MWCOG's website. *See* http://www.mwcog.org/uploads/committee-documents/8lpZXQ20030908113042.pdf (Sept. 8, 2003) and http://www.mwcog.org/uploads/committee-documents/vV5XXVg20040513164338.pdf (May 13, 2004).
[10] The MWCOG Work Elements Program is available on the MWCOG website. *See* http://www.mwcog.org/uploads/committee-documents/pF5ZXlw20040409155639.pdf (December 24, 2003).
[11] *See* Testimony of Michael Replogle, Transportation Planning Board, October 15, 2004.

confidence that the model correctly simulates the changes in travel behavior or emissions that will occur when a new highway is added to the region's network.

- Serious time-of-day of travel problems, including sharp differences between the estimated and observed traffic entering and leaving the metro core and crossing the Beltway during the peak periods. For example, the model overestimates traffic crossing the Beltway outbound in the evening peak by 85,200 vehicles—the equivalent of more than 14 lanes of traffic. This makes the model prone to overestimate congestion problems in the central part of the region.

- Renaming and moving a large share of the adjustment factors to a different part of the model rather than fixing the problem of excessive use of adjustment factors, cited by the NAS/TRB as a large problem in the TPB model.

Nonetheless, to facilitate the comparison between the alternatives, this study uses the COG/TPB travel forecast model version 2.1D #28, with all these inherent weaknesses.

APPENDIX C
CAPITAL COSTS OF ALTERNATIVES

Elements of Alternatives	ICC Build	Transit Oriented Land Use and Investment	Add Toll Lane-Express Bus	Convert HOT Lane-Express Bus	Hybrid: Transit Oriented-HOT Lane-Rail and Express Bus
ICC[a]	$1,900,000,000				
Add One Toll/HOT Lane[b]			$849,900,000	$168,600,000	$168,600,000
Convert One Toll/HOT Lane[c]			$84,990,000		
Convert Two Toll/HOT Lanes[d]				$136,260,000	$136,260,000
Convert and Reconfigure Existing Roadways to Upgrade Service[e]		$102,100,000			
New Upgraded Roadway[f]		$63,950,000			
Metro Core[g]		$300,000,000			
Purple Line (Silver Spring to College Park)[h]		$600,000,000			$600,000,000
Metro Rail to Metropolitan Grove[i]		$500,000,000			$500,000,000
Metro Station at Montgomery College[j]		$40,000,000			$40,000,000
Pedestrian Improvements Around Transit Stations[k]		$50,000,000			$50,000,000
Georgia Avenue Busway[l]		$70,000,000			$70,000,000
Other Bus Improvements[m]	$173,676,667	$289,007,917	$321,586,667	$321,586,667	$413,857,083
Road Cost	**$1,900,000,000**	**$166,050,000**	**$934,890,000**	**$304,860,000**	**$304,860,000**
Transit Cost	**$173,676,667**	**$1,839,007,917**	**$321,586,667**	**$321,586,667**	**$1,673,857,083**
Total Cost	**$2,073,676,667**	**$2,005,057,917**	**$1,256,476,667**	**$626,446,667**	**$1,978,717,083**

[a] Average of official estimates of $1.8 billion and $2.1 billion.

[b-f] Costs developed by Smart Mobility, Inc., based on review of typical construction costs in the Washington, DC region and other regions of the United States.

[b] $10 million/lane-mile

[c] $1 million/directional-mile

[d] $1 million/directional-mile

[e] $2 million/lane-mile

[f] $5 million/lane-mile

[g] The Metro Matters cost is equal to the cost of lifting the core constraint. This number is calculated from the data in the report, "Time to Act. The National Capital Region’s Six Year Transportation Capital Funding Needs." The Maryland share of the Washington Metropolitan Area Transit Authority's short-term shortfall amounts to approximately $500 million. About half the funds are designated for buying new rail cars and buses, while approximately one-third is devoted to rehabilitation of existing equipment. The remaining funds are for improved security. The report does not specify how much is allocated for new buses or rail cars. For this study, a total cost of $300 million for lifting the core constraint is assumed: $200 million is allocated for new equipment, and $100 million for rehabilitation. These actions are reasonable to lift the core constraint and allow Metro ridership to increase. Regional officials in fall 2004

(after completion of this study's analysis work) in fact adopted the Metro Matters funding package as part of the regional transportation program.

[h] Based on the cost of the Purple Line reported in Appendix H of the Montgomery County Transportation Policy Report ("TPR") minus the cost of the link from Bethesda to Silver Spring, as reported in the 2003 CLRP.

[i] Based on estimates in the TPR, assuming 1-mile is constructed underground.

[j] Based on estimates in the TPR.

[k] Based on a per station cost of $2.5 million.

[l] Based on estimates in the TPR.

[m] Cost developed by Smart Mobility, Inc., based on review of typical costs for bus improvements in the Washington, DC region and other regions of the United States. Assumes a cost of $2.5 million/peak service hour. This cost is for buses, spares, replacements, and other infrastructure.

APPENDIX D
Sensitivity Analysis of Variations in Scenario Assumptions

In the course of developing the model analysis for this report, several sensitivity tests were conducted to examine how different combinations of transportation building blocks and land use building blocks, as defined in this study, might affect transportation system performance. The goal of this sensitivity testing was to better understand the relative contributions of the separate blocks constituting each alternative to the changes in overall system performance. A secondary purpose was to confirm that the transportation model would predict changes of a reasonable direction and magnitude in relation to the changed combinations.

This study's sensitivity analyses examined the effects of holding the land use forecast building block constant between various transportation building blocks. Additional sensitivity analyses looked at how the traffic model accounts for balancing regional employment growth with housing growth and forecast in-commuting to the region from surrounding areas and the impacts such balancing has on forecasts of transportation system performance.

Analysis 1: Impact of Land Use on the Transit Oriented Alternative

This analysis pairs the Transit Oriented transportation building block with two land use patterns: the TOD Land Use Pattern and the Round 6.4 Land Use forecast associated with the No Build alternative. As described in the study, compared to the Round 6.4 Land Use, the TOD Land Use Pattern shifts a significant share of projected new development in Montgomery and northern Prince George’s Counties to improve the local household-job balance and proximity of jobs and housing to transit. It reflects changes in land use that support the use of and accessibility to transit.

The results of this sensitivity test show that the implementation of transit investments without supportive land use changes is less effective in improving transportation system performance than when the transit investments are accompanied with strategic land use changes. (See Table D-1) However, implementation of the Transit Oriented transportation building block with either Land Use building block performed better in nearly all of the measures of travel effectiveness when compared to the No Build alternative. (See Figures D-1 and D-2)

Table D-1: Results of Sensitivity Analysis of Transit Oriented Alternatives

		No Build	Transit Oriented with Round 6.4 Land Use	Transit Oriented with TOD Land Use
Total Hours Spent in Car	Montgomery & N. Prince George's	2,078,792	2,031,856	1,982,576
	ICC Study Area	1,090,022	1,065,404	1,026,844
Congestion Delay	Montgomery & N. Prince George's	1,028,653	993,609	958,244
	ICC Study Area	549,292	530,145	500,805
Vehicle Miles of Travel	Montgomery & N. Prince George's	40,128,690	40,000,255	39,367,766
	ICC Study Area	21,795,446	21,862,484	21,488,701
Vehicle Miles of Travel on Major Arterials	Montgomery & N. Prince George's	15,731,995	15,079,421	14,774,973
	ICC Study Area	8,118,528	7,545,694	7,368,724
Vehicle Miles of Travel on Local Roads	Montgomery & N. Prince George's	7,549,699	7,400,781	7,141,315
	ICC Study Area	3,359,882	3,303,992	3,115,023
Daily Vehicle Trips	Montgomery & N. Prince George's	5,623,574	5,538,402	5,492,096
	ICC Study Area	2,535,066	2,490,219	2,399,143
Total Transit Share	Montgomery & N. Prince George's	4.07%	4.77%	4.97%
	ICC Study Area	3.27%	4.11%	4.53%
Daily Work Trip Transit Share	Montgomery & N. Prince George's	17.15%	19.13%	19.53%
	ICC Study Area	15.30%	17.60%	18.81%
Travel Speed	Montgomery & N. Prince George's	19.30	19.69	19.86
	ICC Study Area	20.00	20.52	20.93

In the ICC Study Area, for example, congestion delay decreased by 3.5 percent over the No Build alternative using the Round 6.4 Land Use forecast and by 8.8 percent using the TOD Land Use Pattern. In the other study area, congestion delay was reduced by 3.4 percent and 6.8 percent compared to the No Build for the Round 6.4 Forecast and TOD Land Use Pattern, respectively. Similarly, travel speeds increased by nearly 2 percent with the Round 6.4 Land Use and 2.9 percent with the TOD Land Use Pattern for Montgomery and Northern Prince George's County Study Area and by 2.6 percent and 4.7 percent for the ICC Study Area.

The Transit Oriented building block paired with the Round 6.4 Land Use forecast increased the share of people traveling to work on transit by 12 percent in the Montgomery and Northern Prince George's County Study Area and 15 percent in the ICC Study Areas compared to the baseline No Build alternative. When the model was re-run using the TOD Land Use Pattern these positive effects were amplified, and the work trip transit share grew by an additional 2 percent and 8 percent, respectively in the two study areas.

Figure D-1: Percent Change in Travel Effectiveness Measures Relative to the No Build (ICC Study Area)

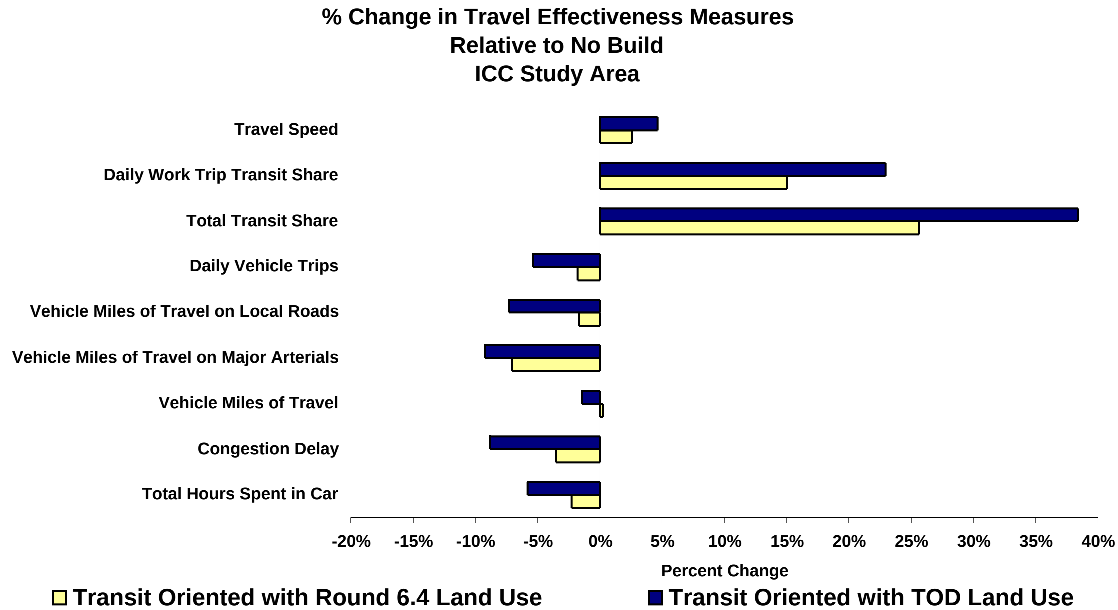
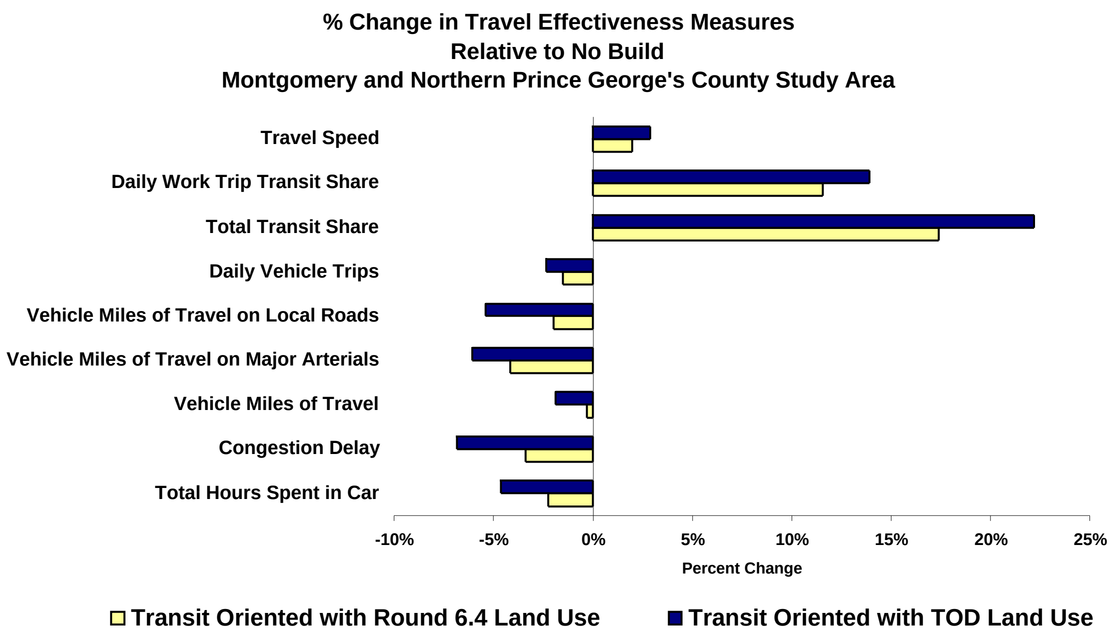


Figure D-2: Percent Change in Travel Effectiveness Measures Relative to the No Build (Montgomery and Northern Prince George's County Study Area)



VMT on major arterials in the ICC study area decreased from 15.7 million miles under the baseline No Build alternative to15.1 million miles when the region invested in transit improvements but did not shift land use patterns. When transit investments were made in conjunction with supportive land use changes, an additional 3 million miles of VMT were dropped. (See Figures D-3 and D-4)

Figure D-3: Selected Travel Effectiveness Measures (ICC Study Area)

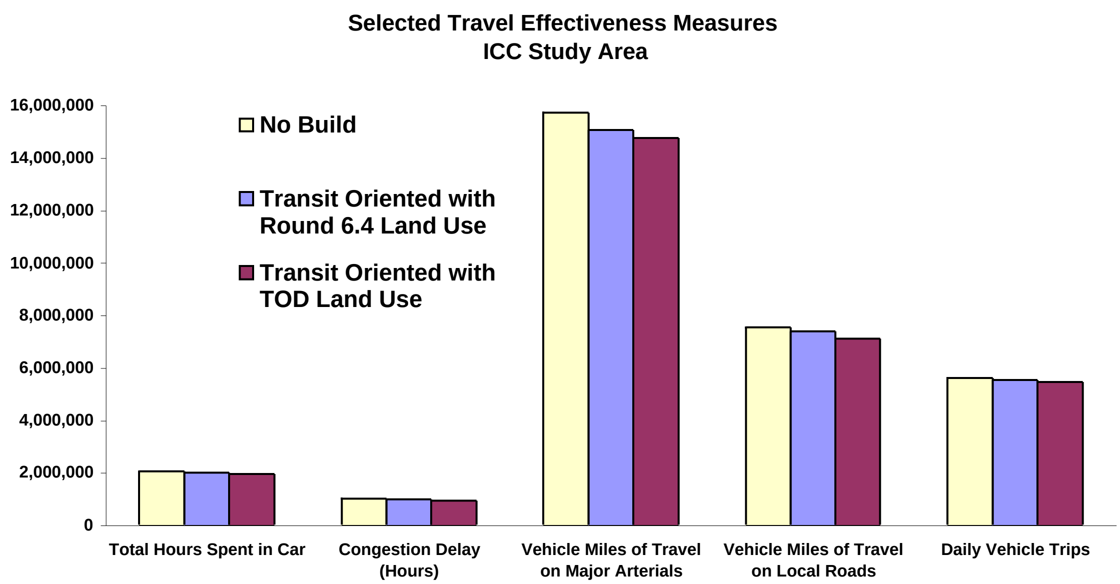
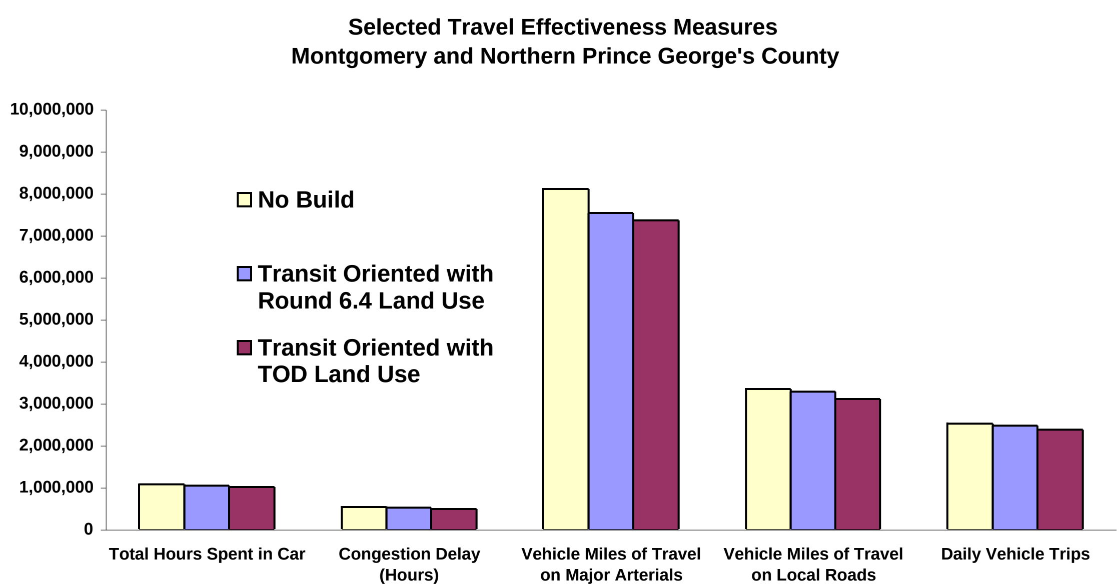


Figure D-4: Selected Travel Effectiveness Measures (Montgomery and Northern Prince George's County Study Area)



Analysis 2: Effect of Land Use Changes and Job-Housing Balancing Account on ICC Build Alternative

The second sensitivity analysis evaluated the changes in the performance of the ICC Build alternative that would result by altering the balance of resident workers and jobs.[12] In this analysis, the following three scenarios were compared:

1. The ICC Build transportation building block with $0.20/mile peak period and $0.15/mile off-peak tolls and Round 6.4 Land Use building block (used in the No Build alternative in this study);

2. The ICC Build transportation building block with $0.20/mile peak period and $0.15/mile off-peak tolls, Round 6.4A Land Use;

3. The ICC Build transportation building with $0.20/mile peak period and $0.15/mile off-peak tolls, Round 6.4A Land Use, and adjusted external attractions to hold constant the balance between projected job growth and the projected growth in resident workers and in-commuters. (The same analysis used in this study.)

Table D-2: Results of Sensitivity Analysis of ICC Build Alternatives

		No Build	ICC with $0.20, $0.15 tolls with Round 6.4	ICC with $0.20, $0.15 tolls and Round 6.4A	ICC with $0.20, $0.15 tolls with Round 6.4A, and Balancing of Jobs & Workers
Total Hours Spent in Car	Montgomery & N. Prince George's	2,078,792	2,024,897	2,077,845	2,115,496
	ICC Study Area	1,090,022	1,054,055	1,099,511	1,125,627
Congestion Delay	Montgomery & N. Prince George's	1,028,653	972,782	1,010,800	1,039,980
	ICC Study Area	549,292	506,550	539,614	560,694
Vehicle Miles of Travel	Montgomery & N. Prince George's	40,128,690	40,758,415	41,135,862	41,451,514
	ICC Study Area	21,795,446	22,574,759	22,878,864	23,082,275
Vehicle Miles of Travel on Major Arterials	Montgomery & N. Prince George's	15,731,995	15,492,065	15,637,885	15,762,081
	ICC Study Area	8,118,528	7,941,260	8,042,845	8,117,497
Vehicle Miles of Travel on Local Roads	Montgomery & N. Prince George's	7,549,699	7,274,275	7,407,276	7,493,744
	ICC Study Area	3,359,882	3,151,804	3,266,234	3,310,299
Daily Vehicle Trips	Montgomery & N. Prince George's	5,623,574	5,586,040	5,688,066	5,690,440
	ICC Study Area	2,535,066	2,515,374	2,612,353	2,613,783
Total Transit Share	Montgomery & N. Prince George's	4.07%	4.04%	3.88%	3.88%
	ICC Study Area	3.27%	3.22%	3.02%	3.02%
Daily Work Trip Transit Share	Montgomery & N. Prince George's	17.15%	16.78%	16.08%	15.98%
	ICC Study Area	15.30%	14.82%	13.94%	13.86%
Travel Speed	Montgomery & N. Prince George's	19.30	20.13	19.80	19.59
	ICC Study Area	20.00	21.42	20.81	20.51

[12] See discussion on “Production-Attraction Balancing” in Appendix B for more information on this topic.

Sensitivity testing shows that the land use assumed in an ICC Build scenario has a significant impact on its estimated system performance and impacts, and that accounting for job-housing balances versus in-commuters has a significant affect on transportation system performance. (See Figures D-5 and D-6)

Figure D-5: Percent Change in Travel Effectiveness Measures for the ICC Relative to the No Build (ICC Study Area)

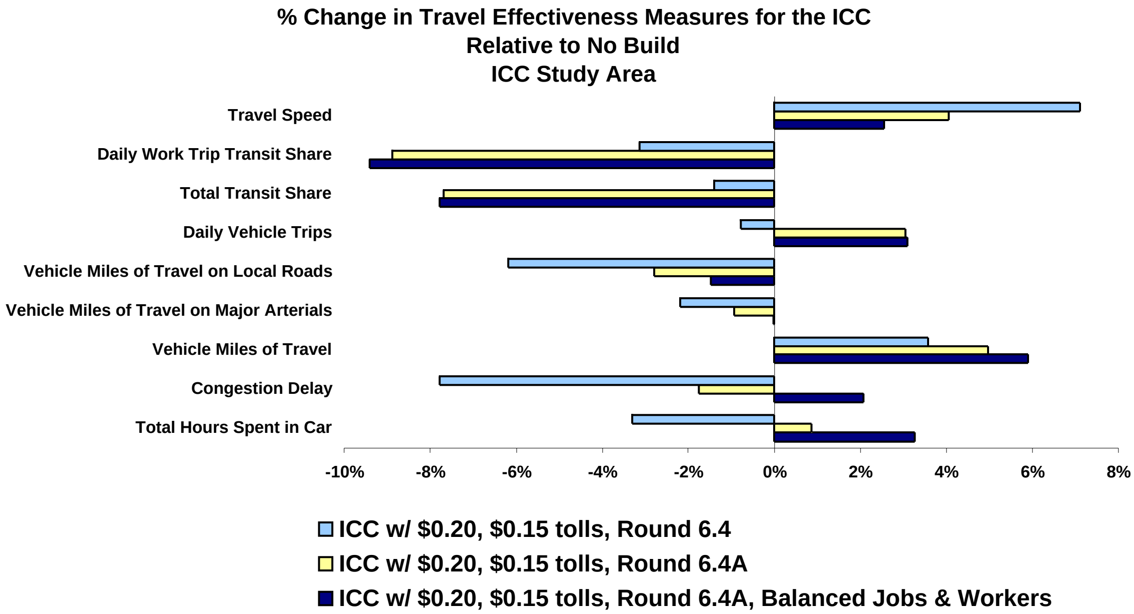


Figure D-6: Percent Change in Travel Effectiveness Measures for the ICC Relative to the No Build (Montgomery and Northern Prince George's County Study Area)

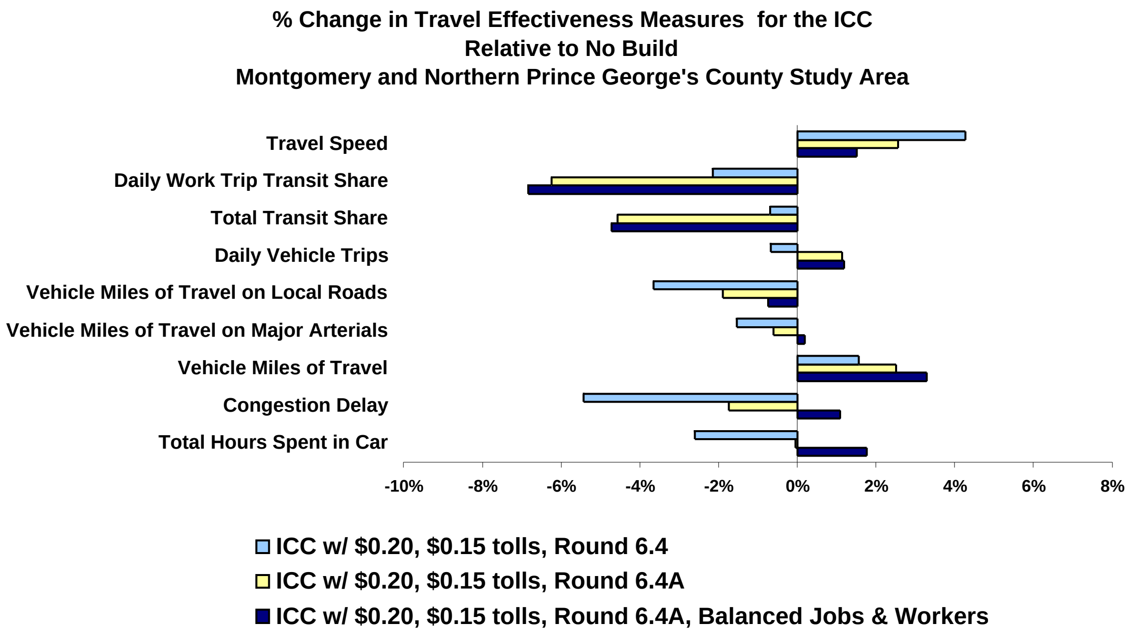


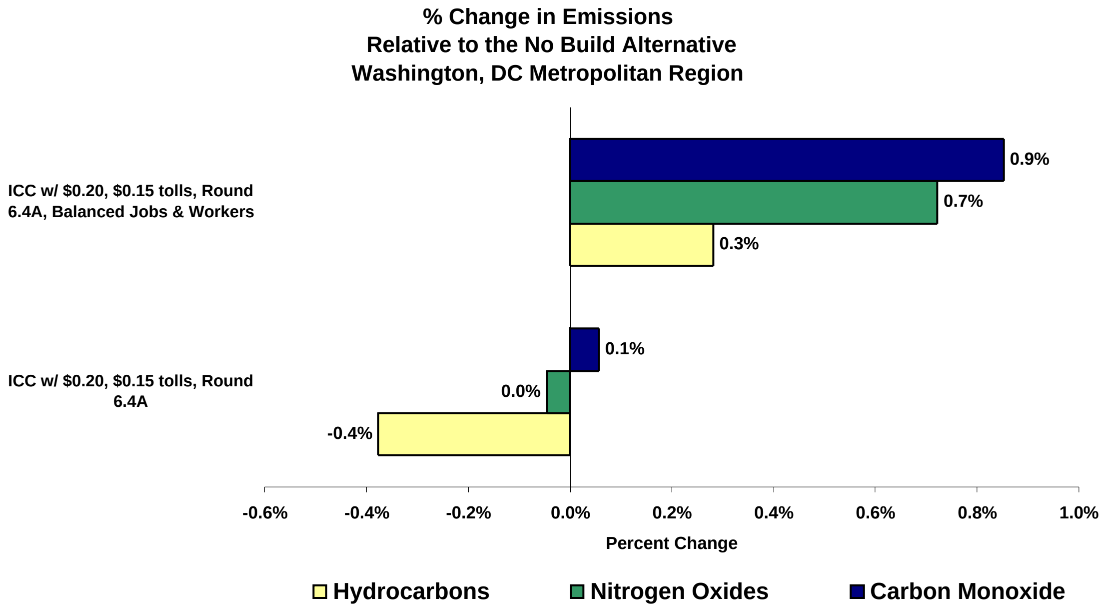
Table D-3 illustrates the effect of these various land use building blocks on VMT when the ICC is modeled using $0.20/mile peak period and $0.15/mile off-peak tolls. With the Round 6.4 Land Use forecast paired with the ICC Build transportation building block, VMT increased by 1.6 percent in the Montgomery County and Northern Prince George's County Study Area and 3.6 percent in the ICC Study Area beyond that predicted in the baseline No Build alternative. When the model was re-run using the Round 6.4A forecast, VMT increased by an additional 0.9 and 1.4 percent in the two study areas. When adjustments were made to balance projected job-growth and the projected growth in resident workers and in-commuters, VMT increased again, resulting in 3.3 percent more VMT in the Montgomery County and Northern Prince George's County Study Area and 5.9 percent in the ICC Study Area, over the baseline No Build.

Table D-3: Percent Change in Vehicle Miles Traveled Compared to the No Build Alternative

	$0.20, $0.15 tolls, Round 6.4	$0.20, $0.15 tolls, Round 6.4A	$0.20, $0.15 tolls, Round 6.4A, Balanced Jobs & Workers
Montgomery and Northern Prince George's County Study Area	1.57%	2.51%	3.30%
ICC Study Area	3.58%	4.97%	5.90%

Figures D-7 and D-8 below indicate the land use assumed in an ICC Build scenario also would have a significant impact on air emissions. In the Washington, DC region, the ICC alternative with only the Round 6.4A land use (that does not properly balance for jobs and workers) would have a small, positive impact on air quality throughout the region. However, when the additional trips made by the in-commuters who fill the new jobs are accounted for in the other scenario, the ICC would have a slight negative impact on the region's air quality. When the extra trips are not considered, for example, the sensitivity tests show that the ICC would reduce hydrocarbon emissions by 0.4 percent over the No Build alternative. When the extra trips are considered, the tests show that the ICC would increase hydrocarbon emissions by 0.3 percent. This is to be expected given that the extra trips in the latter scenario would generate pollution.

Figure D-7: Percent Change in Emissions for the ICC Relative to the No Build (Washington, DC Metropolitan Region)



Both alternatives would have a negative impact on air quality in the Montgomery and Northern Prince George's County Study Area. For all three pollutants, however, an analysis of the ICC that fails to appropriately balance jobs and workers underestimates the likely air pollution increase. Carbon monoxide emissions, for example, would increase by 5.7 percent when the job-worker balancing procedures are properly accounted for. But if ignored, the increase in jobs essentially gets washed out of the model, and carbon monoxide emissions would be forecast to increase by only 4.9 percent.

Figure D-8: Percent Change in Emissions for the ICC Relative to the No Build (Montgomery and Northern Prince George's County Study Area)