Item #3

Status report on the Version 2.3 Travel Model: Updates to the model and year-2010 validation

Presentation to the Travel Forecasting Subcommittee
March 22, 2013

Mark S. Moran and Ronald Milone, COG/TPB staff
National Capital Region Transportation Planning Board (TPB)
Metropolitan Washington Council of Governments (COG)

Presentation overview

- Model updates prior to year-2010 validation (Moran)
  - Build 50 of the Ver. 2.3 Travel Model
  - Discussion of sensitivity tests on traffic assignment convergence, which resulted in changes incorporated into Build 50
- Year-2010 validation (Milone)
- Model updates done as part of year-2010 validation work (Milone)
  - Build 52
- Conclusions and next steps

At the last TFS meeting (1/25/13)

- Presented updates in Builds 47, 48, and 49 of the Version 2.3 Travel Model
  - Build 47: Additional parallelization: Reduced model run time by 30% (compared to Build 39, the production version of the travel model, used in last year's AQC).
  - Build 48:
    - Uses more consistent names for output files
    - Moves temporary files to a "temp" folder for easy deletion
    - Result: 65% reduction in the size of output files
  - Build 49: Refinement to which files are considered "temp" files: Now all RPT files are kept, even for the earlier speed feedback (SFB) iterations (pump prime through i3).

Overview of model updates discussed at today's meeting

- Sensitivity tests for year-2040 conditions
  - Findings from these tests resulted in model updates that were incorporated into Build 50
- Two most recent "builds" of the developmental travel model, i.e., Builds 50 and 52
  - Production model: Build 39 of the Ver. 2.3 model

Section 1

Model updates prior to year-2010 validation (Moran)

Build 50 of Version 2.3 Travel Model

How has the developmental model changed since January (i.e., Build 49)?

- Progressive relative gap (RG) threshold values
  - Stopping criterion for user equilibrium (UE) traffic assignment now varies by SFB iteration.
  - Previously, the same RG threshold was used during all SFB iterations (10^-3)
- Now, all TXT & TAB files are kept, not simply those associated with the final SFB iteration ("i4")
- Numerous updates associated with model validation
  - These updates result in a better validation for traffic assignment

Sensitivity tests re. relative gap (1 of 5)

- COG/TPB staff regularly performs project planning work for the Maryland State Highway Administration (SHA) involving the study of focused system changes
- As part of that on-going work, Dusan Vuksan & Feng Xie examined the impacts of converting a general purpose lane to an HOV lane on I-270
- Initially, volume difference plots showed "noise" outside the study corridor
- Consequently, TPB staff tested using a higher level of convergence in highway assignment, as a means of achieving more defensible results
  - However, higher level of convergence resulted in longer model run times

Sensitivity tests re. relative gap (2 of 5)

- Upon completion of the SHA "production work," TPB staff executed additional tests to implement the improved model convergence into the regional model while keeping model run times reasonable
- These sensitivity tests included the following:
  - Network change: Converted a southbound general purpose lane on I-270 (between MD 121 & I-370) to an HOV2+ lane in the AM peak period only
  - Model change: Tested various levels for the assumed stopping criterion for traffic assignment, i.e., the relative gap threshold (normally 10^-3 or 0.001)
  - Network represented year-2040 conditions
  - Model used: The production travel model (Ver. 2.3.39)

Sensitivity tests re. relative gap (3 of 5)

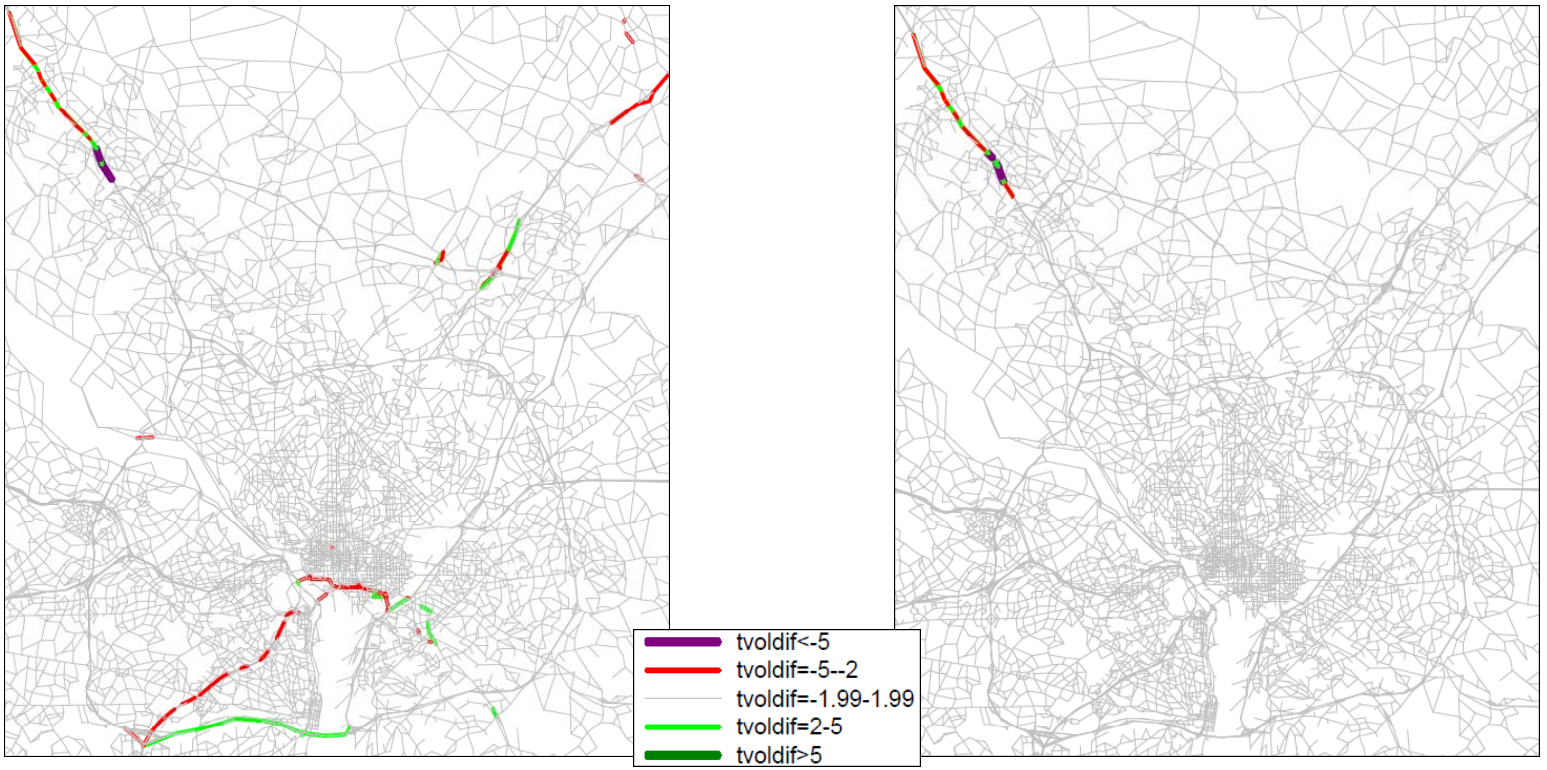
Scenarios tested & resulting difference plots

Model Scenarios	Network Scenarios	
(Changes in the user equilibrium relative gap threshold)	"No Build" (without the lane conversion)	"Build" (with the lane conversion)
Base: RG = 10^-3 for pp-i4	Difference plot #1	
Highly converged: RG = 10^-4 for pp-i4	Difference plot #2	
Progressive1: RG = 10^-3 for pp-i3; RG = 10^-4 for i4	Difference plot #3	
Progressive2: RG = 10^-2 for pp-i2; RG = 10^-3 for i3; RG = 10^-4 for i4	Difference plot #4	

Sensitivity tests re. relative gap (4 of 5)

Base: RG = 10^-3 for pp-i4 (Run time = 18 hrs)

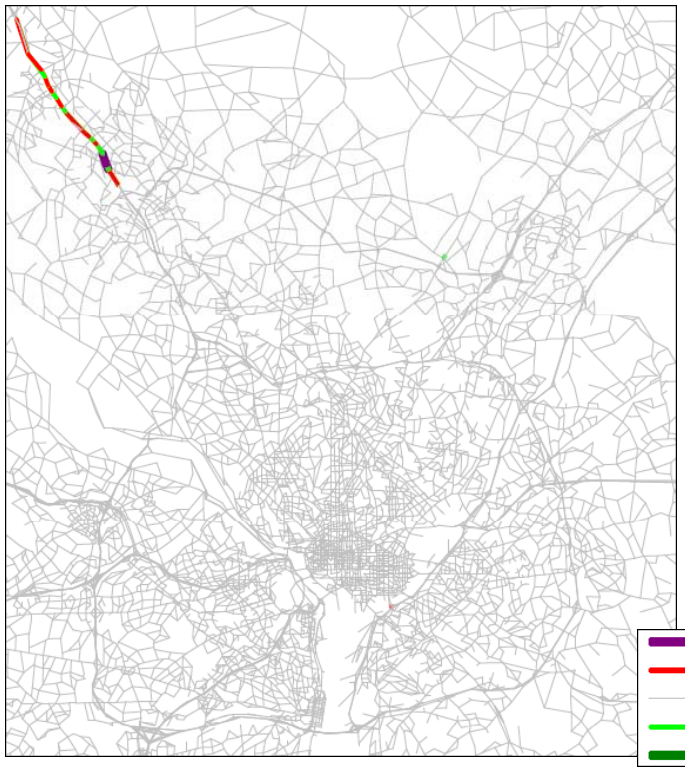
Highly converged: RG = 10^-4 for pp-i4 (Run time = +51%)



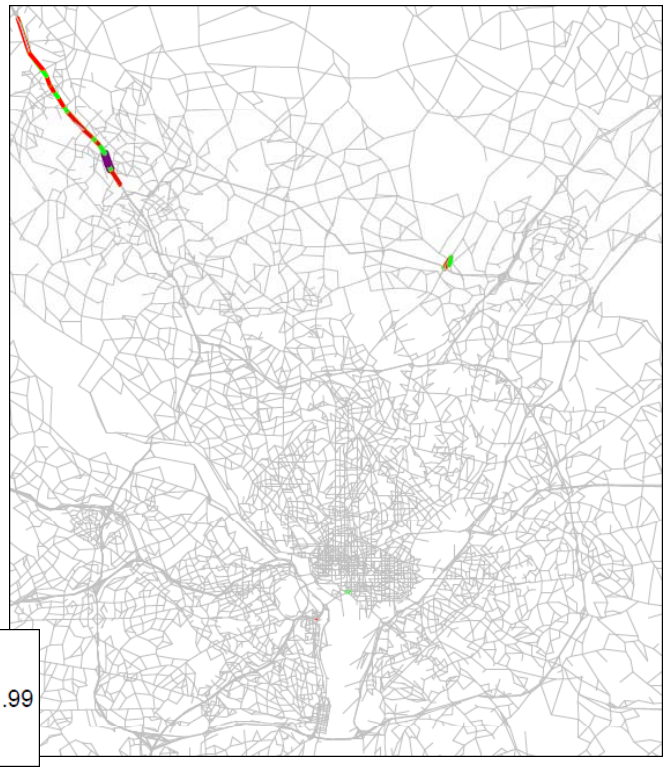
* The year-2040 sensitivity test were conducted on two different computers, with different hardware "specs," meaning that run times could not be compared. Consequently, the run times reported on this slide were from a series of comparable, year-2010 tests performed at a later date on one computer.

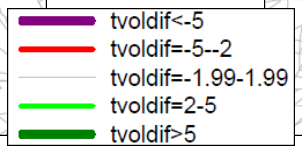
Sensitivity tests re. relative gap (5 of 5)

Progressive1: RG = 10^-3 for pp-i3; 10^-4 for i4 (Run time = +10%)



Progressive2: RG = 10^-2 for pp-i2; 10^-3 for i3; 10^-4 for i4 (Run time = -4%)





* The year-2040 sensitivity test were conducted on two different computers, with different hardware "specs," meaning that run times could not be compared. Consequently, the run times reported on this slide were from a series of comparable, year-2010 tests performed at a later date on one computer.

Build 50, Ver. 2.3 Travel Model (1 of 4)

- Previously, stopping criterion for user equilibrium (UE) traffic assignment was a relative gap (RG) threshold value of 10^-3.
- This threshold value was used for each speed feedback iteration (pump prime, i1, i2, i3, and i4)
- Now, we use a progressively tightening RG threshold, based on the SFB iteration
  - pp - i2: RG threshold of 10^-2
  - i3: RG threshold of 10^3
  - i4: RG threshold of 10^4

Build 50, Ver. 2.3 Travel Model (2 of 4)

- Models development team tested these model scenarios using the Ver. 2.3.50 model for a 2010 year

		Model	Run						Total	Est.		
		Run	Time	Number of UE iterations					# of	Total		
		Time	as a	to reach RelGap thresh.					UE	Regional		Pct.
Scenario	Relative Gap Threshold	(hr:m:s)	Pct	pp	i1	i2	i3	i4	Iters	VMT	Diff.	Diff.
Base	10^-3 for pp-i4	18:09:53	100%	521	333	445	391	390	2,080	160,558,143	0	0.00%
Highly conv.	10^-4 for pp-i4	27:29:07	151%	1,102	716	950	797	846	4,411	160,487,504	-70,639	-0.04%
Progressive1	10^-3 for pp-i3; 10^-4 for i4	19:55:26	110%	521	333	445	391	862	2,552	160,522,144	-35,999	-0.02%
Progressive2	10^-2 for pp-i2; 10^-3 for i3; 10^-4 for i4	17:24:37	96%	177	111	153	391	823	1,655	160,512,549	-45,594	-0.03%

Build 50, Ver. 2.3 Travel Model (3 of 4)

- Implementing the progressive relative gap thresh.
  - Run Model Steps batch file
    - Added two new environment variables
      - relGap: Can be set to any value. Currently, we are using 0.01, 0.001, and 0.0001 (i.e., 10^-2, 10^-3, and 10^-4)
      - maxUeIter: Set to 1000 as a backup stopping criterion
  - Highway_Assignment_Parallel.s
    - Modified to incorporate the two new traffic assignment closure metrics that are set as environment variables
    - However, the type of algorithm (e.g., Frank-Wolfe, bi-conjugate Frank-Wolfe, etc.) is still set in the script itself

Build 50, Ver. 2.3 Travel Model (4 of 4)

- Update to which model output files are considered temporary
  - In the past, TXT & TAB files associated with speed feedback (SFB) iterations pp – i3 were considered “temp” files (only “i4” versions were kept).
  - Now, all TXT & TAB files are retained, even for SFB iterations pp – i3.
  - Even though this results in a larger number of output files that are kept, the revised clean-up process still results in a major space savings
    - The size of output files goes from about 26 GB to about 9 GB (a 65% reduction).

Section 2

Year-2010 validation (Milone)

Focus of 2010 Validation

in progress since September

- Assessment of land activity and demographic model outputs at jurisdiction level, using Census/ACS data
- Comparison of simulated VMT against jurisdictional VMT as reported by state DOTs
- Comparison of estimated link volumes against available ground counts with a focus on screenline crossings
- Comparison of system-wide and station-level Metrorail boardings
- Comparison of estimated non-motorized travel shares with observed shares in geo-focused areas
- **Not** considered: Modal trip flows and trip lengths as no 2010 data were available

Key objectives of validation

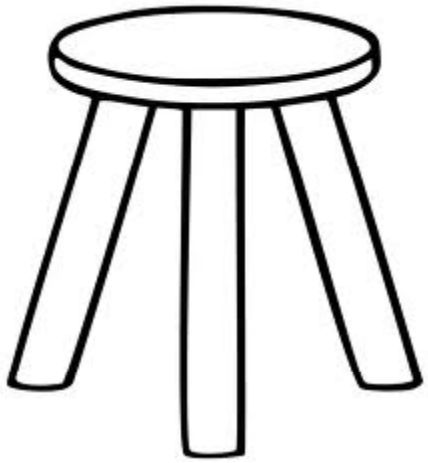
1. To improve the V2.3 model performance using justifiable and reasonable refinements to the model based on known 2010 information
2. To complete model validation in time for the upcoming AQ conformity cycle

Key performance problems identified

- VMT was over-estimated in the District, Alexandria, and Loudoun County
- Traffic crossings over the Potomac River (screenline #20) were over-estimated
- Radial highway crossings within the District were over-estimated (screenline #s 2 and 4)
- Many “outer area” screenline crossings were over-estimated
- Non-motorized travel in densely developed areas was under-represented

The scope of validation involves the "three legs of the stool"

The network
- capacity
- connectivity
- directionality



The traffic counts
- placement of counts in network
-quality of counts

The model
-estimation error
-parameters
-structure

Validation effort focused substantially on observed counts & network checking

- A few counts were **removed** from the database where obvious problems were detected
- Highway capacities in the DC core area were checked against aerial photography and in some cases **refined**
- Freeways in and near DC were **recoded** as *expressways*:
  - Most of these facilities, while freeways in name, function as expressways in terms of speed & throughput

Sensitivity tests explored

- Potomac River bridge time penalty variations
  - 8 to 15 minutes
  - With/without "duplicative" bridge K-factors
  - Expanding the extent of bridge penalties
    - Include bridges at Point of Rocks, Brunswick and Harpers Ferry
- Increased non-work, non-motorized trip shares in dense areas (area types 1 & 2)

Technical tests explored, cont.

- Restructured Trip Gen. and Trip Dist. Process
  - Existing TG, TD structure:
    - Compute total (I-I, I-X) trip Ps & As
    - Subtract I-X trip Ps based on distance to nearest external sta.
    - Scale computed internal As to match internal Ps
    - Run trip distribution
  - Revised TG, TD structure:
    - Compute total (I-I, I-X) trip Ps & As
    - Apply trip distribution for external Ps and As only
    - Summarize zonal I-X trips from extl. distribution process
    - Subtract zonal resulting I-X trips from total trip Ps
    - Scale internal As to match internal Ps
    - Apply trip distribution for internal trip Ps & As only
    - Add external and internal trip tables together

Features of final model (V2.3.52)

- Progressively increasing levels of traffic assignment convergence (Build 50)
- 11-minute bridge penalty; Potomac River-related K-factors removed
- Non-work, non-motorized trip shares in Area Types 1 & 2 increased by 30%
- Restructured TG, TD process adopted
- (Network refinements included)

2010 Daily VMT by Jurisdiction

Observations:

-V2.3.47 was the "Base" model tested in January

-V2.3.52 is the refined/final model

-VMT performance: Well improved in DC and Alexandria

-VMT performance: N**ot** improved in Loudoun

Jurisdiction	Observed VMT	Estimated VMT		Est/Obs Ratio	
		Ver2.3.47	Ver2.3.52	Ver2.3.47	Ver2.3.52
District of Columbia	8,218,979	9,277,286	8,057,876	1.13	0.98
Montgomery Co., Md.	19,693,973	21,105,942	20,822,943	1.07	1.06
Prince George's Co., Md.	23,123,014	23,118,892	22,685,984	1.00	0.98
Arlington Co., Va.	4,256,249	4,529,161	3,876,314	1.06	0.91
City of Alexandria, Va.	2,122,476	2,642,544	2,414,208	1.25	1.14
Fairfax Co.. Va.	26,736,352	26,320,633	25,418,571	0.98	0.95
Loudoun Co., Va.	5,412,448	6,802,826	6,906,894	1.26	1.28
Prince William Co., Va.	8,416,630	8,979,517	8,876,845	1.07	1.05
Frederick Co., Md.	7,738,356	8,630,040	8,460,471	1.12	1.09
Howard Co., Md.	10,491,370	10,400,008	10,575,990	0.99	1.01
Anne Arundel Co., Md.	14,984,795	14,578,753	14,742,784	0.97	0.98
Charles Co., Md.	3,253,562	3,129,606	3,101,335	0.96	0.95
Carroll Co., Md.	3,354,247	3,931,758	3,999,660	1.17	1.19
Calvert Co., Md	2,036,712	1,868,404	1,848,978	0.92	0.91
St. Mary's Co., Md.	2,192,055	2,075,399	2,050,833	0.95	0.94
King George Co., Va.	819,433	722,614	753,741	0.88	0.92
City of Fredericksburg, Va.	919,376	824,063	822,610	0.90	0.89
Stafford Co., Va.	3,920,132	4,139,957	4,141,312	1.06	1.06
Spotsylvania Co., Va.	3,303,754	2,202,562	2,212,010	0.67	0.67
Fauquier Co., Va.	3,133,312	3,162,081	3,187,848	1.01	1.02
Clarke Co., Va.	727,408	870,279	926,425	1.20	1.27
Jefferson Co., WVa.	1,094,762	1,245,818	1,213,570	1.14	1.11
Total	**155,949,393**	**160,558,143**	**157,097,202**	**1.03**	**1.01**

2010 Screenline crossings (000s)– inside of the Capital Beltway

Observations:

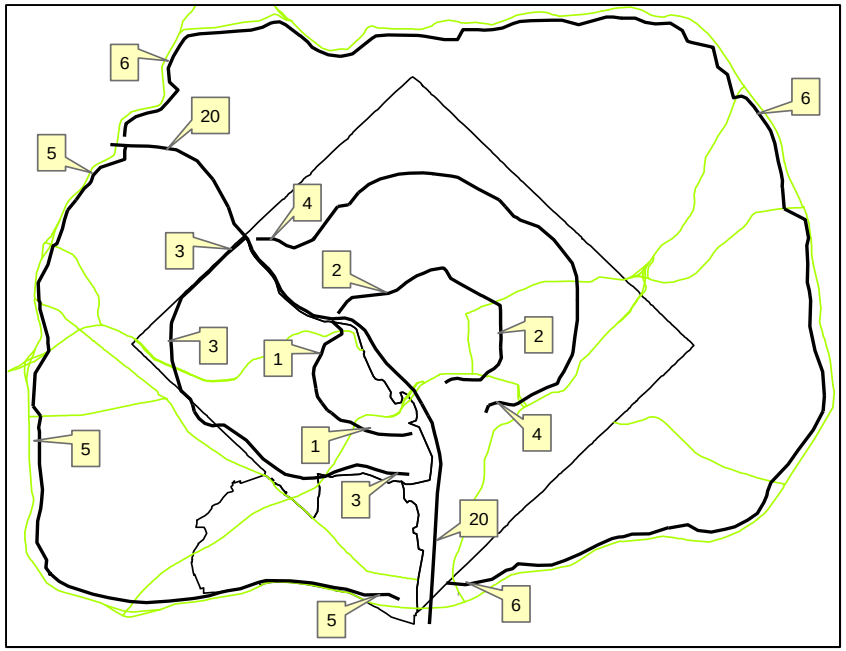
- Potomac River crossings E/O ratio reduced from 1.42 previously to 1.07

-Radial crossings in DC (screenlines 2&4) remain over estimated; Bridge construction that occurred during 2010 may be an explanation

-Estimated crossings at the Capital Beltway appear to match counts well (screenlines 5&6)

-There are count gaps on screenlines; counts do not exist on all facilities crossing screenlines

Screenline	Observed	Estimated Ver2.3.52	E/O Ratio	Percent Screenline Links w/counts
1	544	478	0.88	70%
2	701	920	1.31	86%
3	830	829	1.00	80%
4	686	896	1.31	74%
5	998	1,030	1.03	70%
6	1,464	1,537	1.05	60%
20	846	903	1.07	88%
Subtotal	**6,068**	**6,592**	**1.09**	**73%**



Screenline crossings (000s)– outside of the Capital Beltway

16 of the 28 "outer" screenline crossings are within +/-15% of observed counts

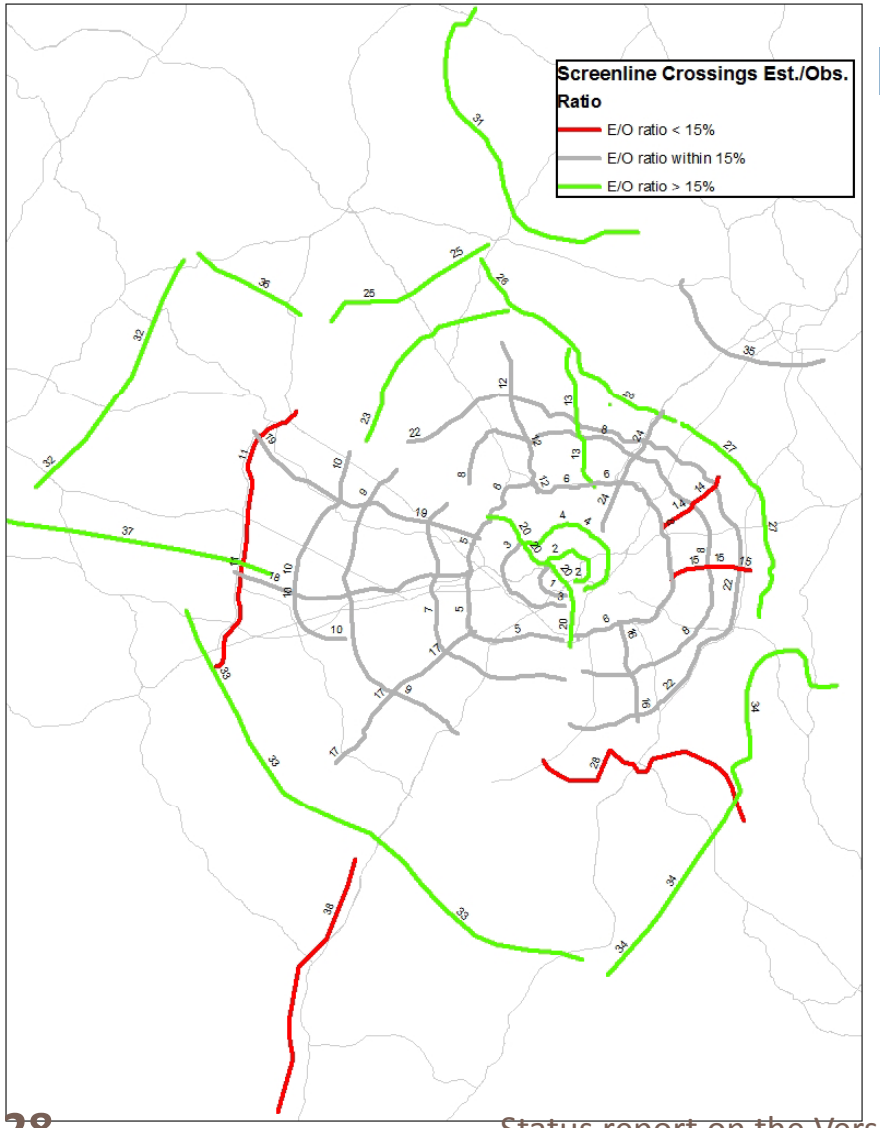
Over-estimation occurs mostly in non-COG-member jurisdictions

(See graphic on following page)

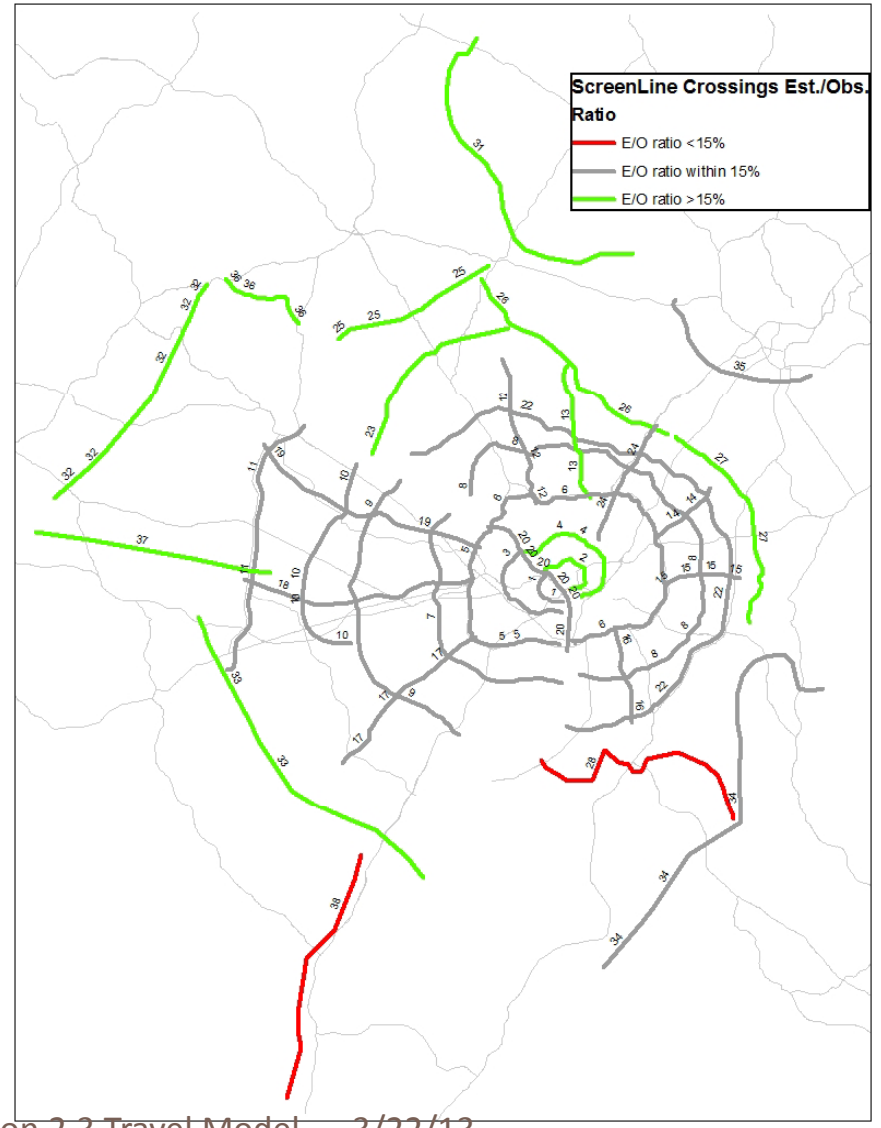
Screenline	Observed	Estimated Ver2.3.52	E/O Ratio	Percent Screenline Links w/counts
7	1,203	1,158	0.96	78%
8	1,415	1,551	1.10	47%
9	856	844	0.99	78%
10	459	499	1.09	83%
11	293	294	1.00	76%
12	456	450	0.99	50%
13	386	501	1.30	70%
14	333	292	0.88	83%
15	331	282	0.85	44%
16	158	147	0.93	25%
17	487	485	1.00	81%
18	719	658	0.92	79%
19	719	640	0.89	77%
22	1,423	1,550	1.09	44%
23	184	231	1.25	58%
24	413	376	0.91	50%
25	99	127	1.28	33%
26	37	75	2.01	30%
27	235	288	1.22	63%
28	177	137	0.78	57%
31	76	174	2.29	60%
32	89	123	1.37	100%
33	261	315	1.21	71%
34	133	153	1.15	100%
35	951	855	0.90	89%
36	47	77	1.64	100%
37	24	35	1.48	50%
38	264	177	0.67	75%
Subtotal	**12,231**	**12,497**	**1.02**	**63%**
All Scrnlins.	**18,298**	**19,090**	**1.04**	**66%**

Screenline performance: V2.3.47 vs. V2.3.52

Ver2.3.47



Ver2.3.52



Percent RMSE

Facility Type:	V2.3.47	V2.3.52
Freeway	27.8%	20.9%
Major Art	40.5%	38.0%
Minor Art	50.9%	50.1%
Collector	73.1%	72.9%
Expressway	31.9%	30.4%
Ramp	27.2%	26.2%
Total	45.8%	39.7%

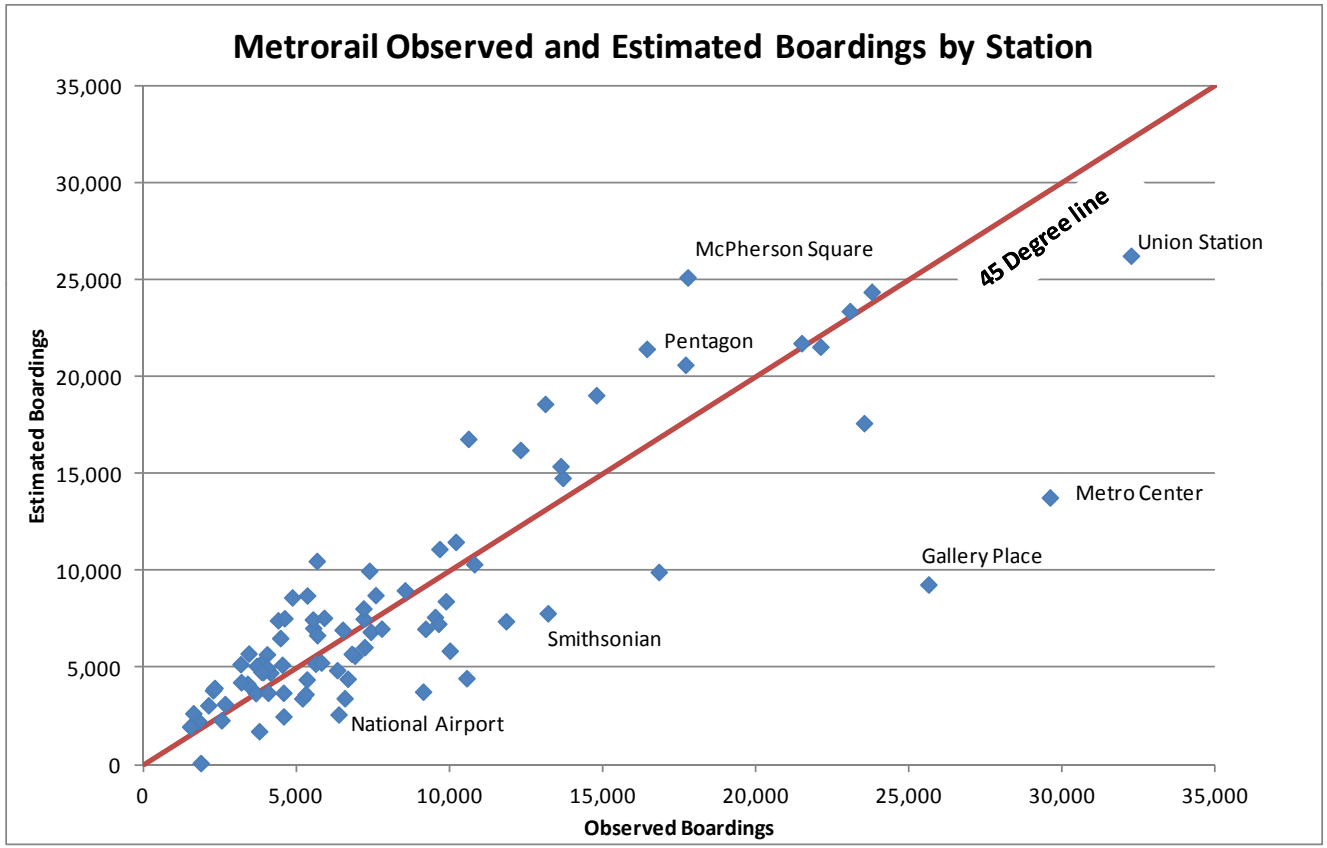
Linked Metrorail Trips May 2010
Faregate counts vs. estimated boardings

	Metrorail Segment	WMATA Counts 2010	Estimated Ver2.3.47	Estimated Ver2.3.52	E/O Ratio Est47	E/O Ratio Est52
1	Red Line - "A" route MD outside Beltway	32,906	34,534	38,530	1.05	1.17
2	Red Line - "A" route MD inside Beltway	25,862	34,851	34,976	1.35	1.35
3	Red Line - "A" route DC non-core	26,141	24,800	23,718	0.95	0.91
4	Red Line - DC core	149,980	114,045	117,335	0.76	0.78
5	Red Line - "B" route DC non-core	26,469	30,768	30,643	1.16	1.16
6	Red Line - "B" route MD	25,508	34,229	36,577	1.34	1.43
7	Green Line - "E" route MD	20,663	17,660	17,656	0.85	0.85
8	Green Line - "E" route DC non-core	24,631	23,309	20,951	0.95	0.85
9	Green Line - DC core	39,586	43,170	38,114	1.09	0.96
10	Green Line - "F" route DC non-core	23,607	24,387	21,935	1.03	0.93
11	Green Line - "F" route MD	22,401	19,032	19,590	0.85	0.87
12	Blue/Yellow Line - VA Fairfax	21,906	23,397	21,358	1.07	0.97
13	Blue/Yellow Line - VA Alexandria	16,098	16,945	15,278	1.05	0.95
14	Blue/Yellow Line - VA Core	56,360	59,937	53,119	1.06	0.94
15	Orange Line - VA Fairfax	29,797	30,964	30,130	1.04	1.01
16	Orange Line - VA Arlington non-core	32,289	49,549	43,439	1.53	1.35
17	Orange/Blue Line - VA/DC core	120,132	135,182	113,400	1.13	0.94
18	Orange/Blue Line - DC non-core	13,656	18,190	15,395	1.33	1.13
19	Orange Line - DC/MD	19,331	16,676	16,552	0.86	0.86
20	Blue Line - DC/MD	16,073	14,710	15,331	0.92	0.95
	Total	**743,396**	**766,330**	**724,021**	**1.03**	**0.97**

-The Ver2.3.52 estimate of Metrorail trips under-estimates total system levels boardings by 3%

-An under-estimation is reasonable since the existing process does not address Metrorail riders that live outside of the region

Estimated (Ver2.3.52) and observed 2010 linked Metrorail trips by station



Section 3

Model updates done as part of year-2010 validation work (Milone)

Build 52, Ver. 2.3 Travel Model

Script/Batch File	Description of Change
Set_Factors.s	Removed Potomac River K factors, since we are now representing bridge penalties using actual bridge penalties, not K factors
V2.3_Highway_Build.s	Bridge penalties have been added: A time penalty of 11 minutes for links crossing the Potomac River (Screenlines 20 and 36)
Trip_Generation.s	1. I-X extraction has been removed 2. No scaling is applied to attractions 3. Non-work, non-motorized trip rates increased by 30% 4. Fixed conditions where the final non-motor P/A share could exceed 1
Trip_Generation_Summary.s	Trip production file name has been updated

Build 52, Ver. 2.3 Travel Model, cont.

Script/Batch File	Description of Change
Trip_Distribution.bat	Trip_Distribution.s has been removed and replaced by 1. Trip_Distribution_External.s 2. Prepare_Internal_Ends.s 3. Trip_Distribution_Internal.s
Trip_Distribution_External.s	External trips are run through the distribution process in isolation
Prepare_Internal_Ends.s	1. New script 2. We subtract external attractions developed above from total (motorized and non-motorized) I-I and I-X trips 3. Also balances trip attractions to trip productions
Trip_Distribution_Internal.s	I-I trip ends developed above are distributed

Build 52, Ver. 2.3 Travel Model, cont.

Script/Batch File	Description of Change
Prepare_Ext_Auto_Ends.s	Updated file names, e.g., "%_iter_%_Trip_Gen_productions.dbf" became "%_iter_%_Trip_Gen_productions_Comp.dbf"
Highway_Skims_mod_md.s, Highway_Skims_mod_am.s, Highway_Skims_md.s, and Highway_Skims_am.s	Implemented time penalties into the skimming process
Mode_Choice_TC_V23_Parallel.bat	Variable containing transit constraint path is set in runModelSteps batch file
Highway_Assignment_Parallel.s	Implemented time penalties into the path cost functions.

Section 4

Conclusions and next steps

Conclusions and next steps

- TPB work for SHA highlights the importance of information sharing among agencies that can lead to improvements in the modeling process
- TPB staff has incorporated a higher degree of traffic assignment convergence into the production model, which will increase the quality of the modeled outputs
- Parallel processing techniques advanced by AECOM have allowed TPB staff to implement higher levels of convergence, along with a reasonable model run time

Conclusions and next steps, cont.

- Year-2010 validation work has proven useful for keeping the regional travel model current
- Documentation will be prepared
  - Version 2.3.52 model User's Guide
  - Validation work and results

Conclusions and next steps, cont.

- Further work on convergence metrics
  - User equilibrium traffic assignment
    - Relative gap (done!)
  - Speed feedback loop
    - %RMSE of travel time skims
- In the view of TPB staff, the inclusion of convergence metrics has potential value and will be pursued