Version 2.5 travel demand model development

A Status Report

Ron Milone
Travel Forecasting and Emissions Analysis Program Director, COG/TPB staff

TPB Travel Forecasting Subcommittee
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Models, Models, Models

V2.3.66 – TPB Travel Model supporting the last (2016 CLRP) Air Quality Conformity Cycle

V2.3.70- Currently adopted travel demand model supporting the currently adopted Plan (2016 CLRP "out-of-cycle" Amendments)

- Adopted on October 18
- Includes mostly minor updates to the 66 model
- Will be available by end of the year

V2.5 – Developmental trip-based model developed with assistance from Cambridge Systematics during FY 2017. Currently under evaluation

Version 2.5 Refinements:

1. Updated transit network/path-building software
   - Public Transport (PT)
2. Improved non-motorized model
3. Simplified mode choice model
   - Transit choice set reduced from 11 to 3 modes
4. Highway & transit assignment enhancements
   - Highway assignment: VOT stratification
   - Transit assignment: Transit sub-mode choice

Recent V2.5 staff activities

1. Significant network development work:
   - Working toward "production" network process for PT networks with QC/QA checks
   - Using a single network input file to support highway and transit network processing
     - previous development work used separate network inputs for highway and transit network building
   - Updated network database
2. Executed V2.5 for years 2014 and 2020 using most recent (cleaned) network inputs

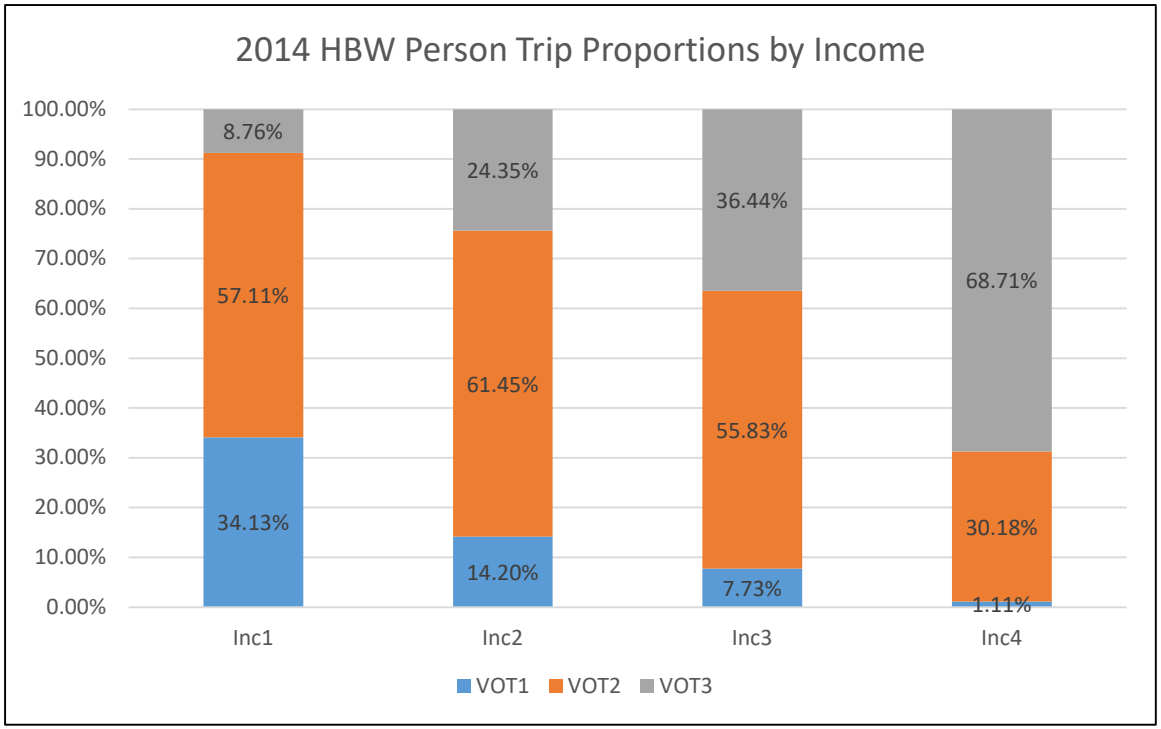
V2.5 staff activities, cont.

3. Developed customized summary scripting for reporting V2.5 for mode choice model outputs
   - V2.5 MC model trips are dimensioned by:
     - Purpose (5);
     - Mode (6);
     - Income level (4); and
     - VOT groups (3) [**…that's 360 segments!**]
   - Regional trip summaries provide segment-level summaries for the region
   - Jurisdictional trips by purpose and mode
4. Explored a possible way to reduce running times
   - Examined speed-feedback convergence behavior of the Version 2.3.66 model for insights

Relationship between income and VOT groups: Example: HBW Trips

There is a direct relationship between income levels and VOT groups:

Higher Incomes are associated with higher time valuations



Regional trips by purpose & mode: 2007/08 HTS vs. 2014 V2.5 model

2007/08 Merged HTS File

Mode	Purpose		
	HBW	Non-HBW	ALL
Auto_Person	2,894,400	13,151,300	16,045,700
Auto_Driver	2,724,800	8,843,100	11,567,900
Transit	773,700	404,600	1,178,300
Total_Person	3,668,100	13,555,900	17,224,000
Transit Pct.	21.1%	3.0%	6.8%
Auto Occ.	1.06	1.49	1.39

Version 2.5: Year 2014

Mode	Purpose		
	HBW	Non-HBW	ALL
Auto_Person	3,283,400	14,991,200	18,274,600
Auto_Driver	3,017,300	10,221,200	13,238,500
Transit	657,300	387,200	1,044,500
Total_Person	3,940,700	15,378,400	19,319,100
Transit Pct.	16.7%	2.5%	5.4%
Auto Occ.	1.09	1.47	1.38

Ratio: V2.5-2014/HTS 2007/08

Mode	Purpose		
	HBW	Non-HBW	ALL
Auto_Person	1.13	1.14	1.14
Auto_Driver	1.11	1.16	1.14
Transit	0.85	0.96	0.89
Total_Person	1.07	1.13	1.12
Transit Pct.	0.79	0.84	0.79
Auto Occ.	1.02	0.99	1.00

- Person trip change appears as expected (12% increase in person travel)
- Modeled 2014 transit trips and transit shares are lower than 2007/08 HTS

Regional trips by purpose & mode: Year 2014 V2.5 model vs. V2.3 model

Version 2.5: Year 2014

Mode	Purpose		
	HBW	Non-HBW	ALL
Auto_Person	3,283,400	14,991,200	18,274,600
Auto_Driver	3,017,300	10,221,200	13,238,500
Transit	657,300	387,200	1,044,500
Total_Person	3,940,700	15,378,400	19,319,100
Transit Pct.	16.7%	2.5%	5.4%
Auto Occ.	1.09	1.47	1.38

Version2.3: Year 2014

Mode	Purpose		
	HBW	Non-HBW	ALL
Auto_Person	3,108,000	14,882,400	17,990,400
Auto_Driver	2,855,300	9,977,000	12,832,300
Transit	819,700	324,900	1,144,600
Total_Person	3,927,700	15,207,300	19,135,000
Transit Pct.	20.9%	2.1%	6.0%
Auto Occ.	1.09	1.49	1.40

Ratio: V2.5/V2.3

Mode	Purpose		
	HBW	Non-HBW	ALL
Auto_Person	1.06	1.01	1.02
Auto_Driver	1.06	1.02	1.03
Transit	0.80	1.19	0.91
Total_Person	1.00	1.01	1.01
Transit Pct.	0.80	1.18	0.90
Auto Occ.	1.00	0.98	0.98

- Similar pattern emerges for 2014 “model vs. model” comparison
- Person trip change is extremely close, as expected
- Modeled 2014 transit trips and transit shares are lower than those of the V2.3 model

Regional trips by purpose & mode: Year 2020 V2.5 model vs. V2.3 model

Version 2.5: Year 2020

Mode	Purpose		
	HBW	Non-HBW	ALL
Auto_Person	3,482,200	15,916,000	19,398,200
Auto_Driver	3,203,900	10,840,900	14,044,800
Transit	748,700	458,300	1,207,000
Total_Person	4,230,900	16,374,300	20,605,200
Transit Pct.	17.7%	2.8%	5.9%
Auto Occ.	1.09	1.47	1.38

Version2.3: Year 2020

Mode	Purpose		
	HBW	Non-HBW	ALL
Auto_Person	3,304,100	15,760,600	19,064,700
Auto_Driver	3,032,800	10,528,900	13,561,700
Transit	905,700	358,600	1,264,300
Total_Person	4,209,800	16,119,200	20,329,000
Transit Pct.	21.5%	2.2%	6.2%
Auto Occ.	1.09	1.50	1.41

Ratio: V2.5/V2.3

Mode	Purpose		
	HBW	Non-HBW	ALL
Auto_Person	1.05	1.01	1.02
Auto_Driver	1.06	1.03	1.04
Transit	0.83	1.28	0.95
Total_Person	1.01	1.02	1.01
Transit Pct.	0.82	1.26	0.94
Auto Occ.	1.00	0.98	0.98

- And… the same pattern emerges for 2020
- Person trip change appears as expected
- Modeled 2020 transit trips and transit shares are lower than those of V2.3 model

VMT Comparison: V2.3.66 vs. V2.5 Years 2014 and 2020

Model	Year		Ratio
	2014	2020	'20/'14
V2.3.66	163,114,000	174,333,000	1.07
V2.5 (current)	175,145,000	187,370,000	1.07

Observed VMT:	159,420,000
Ratio V2.3/Obs.	1.02
Ratio V2.5/Obs.	1.10

Reducing V2.5 Running times

- Issue: V2.5 running time is almost double that of V2.3.66
- Possible ways of addressing running time:
  - Advanced hardware (more cores)
  - Faster assignment algorithms
  - Additional exploitation of distributed processing
  - Reducing speed-feedback iterations

Speed feedback

- What is it?

- Rerunning the 4-Step model iteratively to ensure that input speeds to distribution are consistent with output speeds from the highway assignment

- Why bother?

- I/O speed inconsistencies can impact the travel model results- particularly for out-year forecasts;

- It's also a AQC requirement

How does speed-feedback work in the TPB model?

- 5 four-step iterations are undertaken in a given application:
  - An initial ("PP") iteration
    - Peak, off-peak "lookup" link speeds used in distribution
    - Pre-existing zonal mode choice percentages are used in place of the mode choice model to estimate auto trips
  - 4 "feedback" iterations are undertaken
    - AM, Off-peak speeds from each successive traffic assignment are skimmed and fed back into trip transit network (auto access links) and into trip distribution
    - Link speeds "fed back" are based on MSA averaged volumes:
      - Final i1 link volume= PP volume *0.50 + i1 link volume *0.50
      - Final i2 link volume = Final i1 volume *0.66 + i2 link volume *0.33
      - Final i3 link volume = Final i2 volume *0.75 + i3 link volume *0.25
      - Final i4 link volume = Final i3 volume *0.80 + i4 link volume *0.20

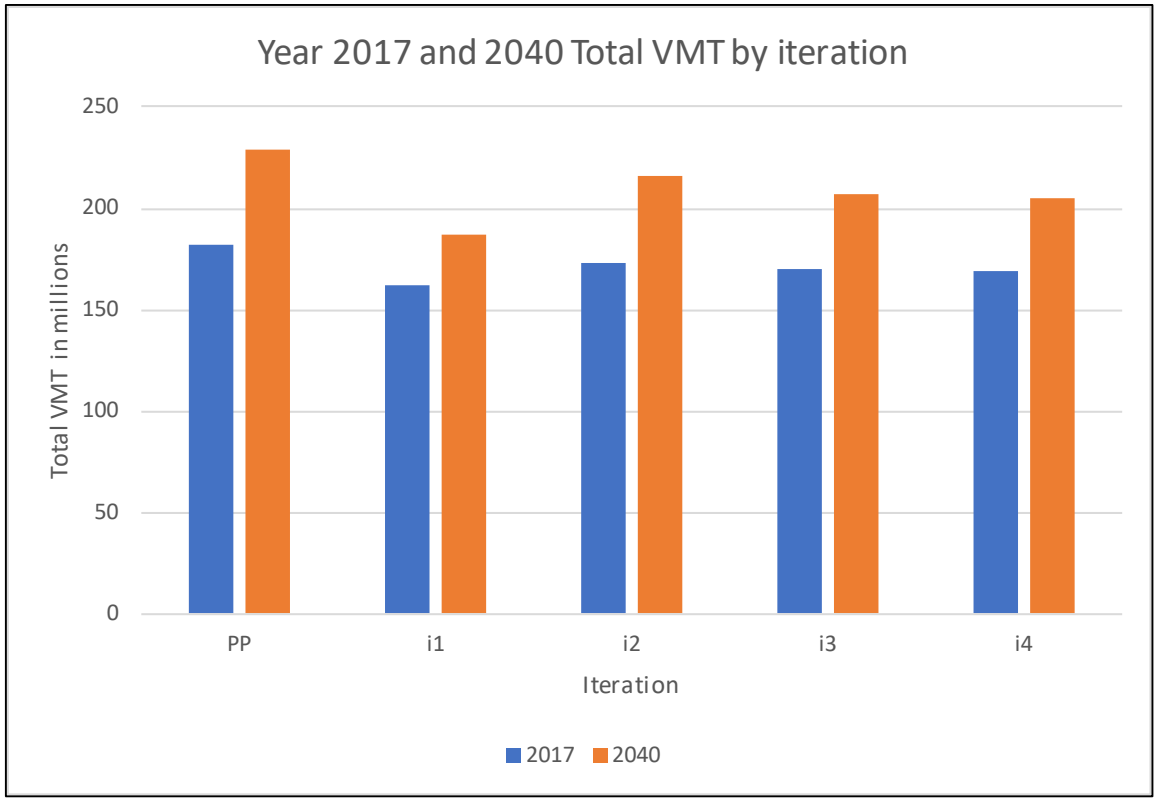
Issues around speed-feedback

- How “should” it be done?
  - Averaging link volumes
  - Averaging highway skims
  - Average both of the above
- What is definition of optimum speed-feedback equilibrium condition?
- Speed-feedback affected by convergence of components within the 4-step step
  - traffic assignment
  - trip distribution

TPB's staff's speed-feedback convergence evaluation

- Version 2.3.66 travel model
- Examined differences (RMSEs) of I/O variables between iterations:
  - Link level volumes
  - Link level speeds
  - Highway O-D skims
  - Highway O-D trips
- By year:
  - 2017
  - 2040

Base and future year VMT by iteration



Base and future year VMT by iteration

Regional VMT convergence does occur between iterations;

Convergence is not as tight in 2040, compared to 2017

2016 CLRP/Version2.3.66 Daily VMT by iteration

Year	PP	i1	i2	i3	i4
2017	181,982,600	161,765,100	173,385,600	169,782,700	169,105,800
2040	228,915,500	187,478,600	215,827,600	206,959,200	205,221,400

Incremental VMT Difference Between Successive Iterations

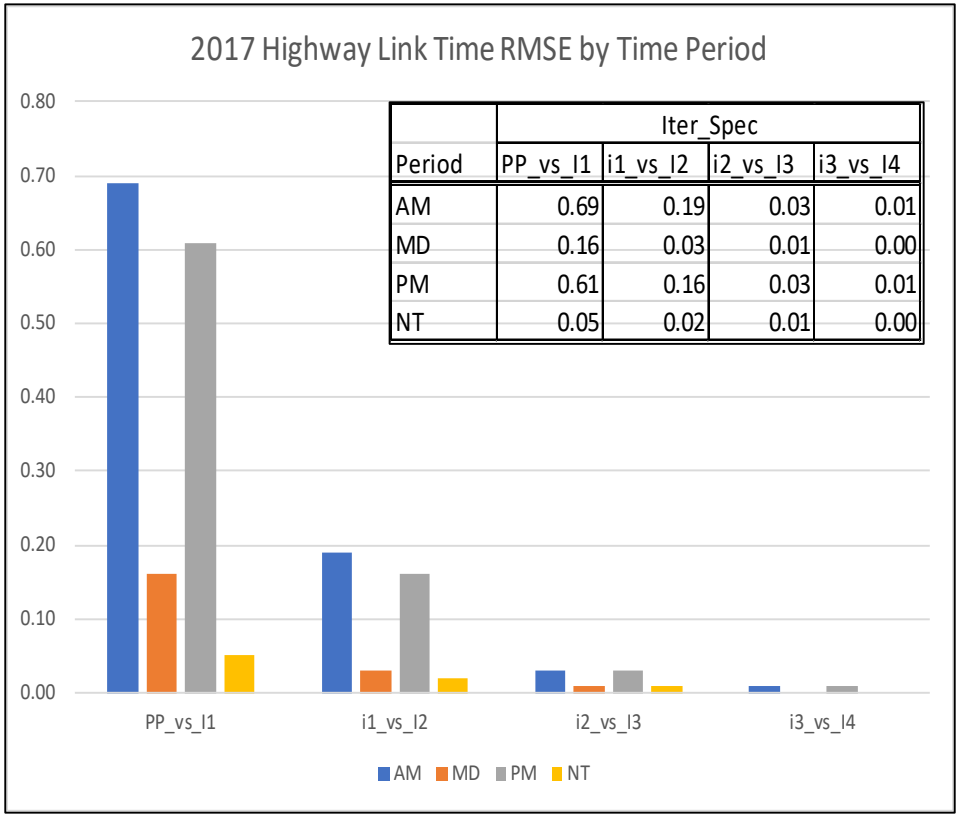
Year	Difference	I1-PP	I2-I1	_I3-I2	I4-I3
2017	Absolute	-20,217,500	11,620,500	-3,602,900	-676,900
	Percentage	-11.1%	7.2%	-2.1%	-0.4%
2040	Absolute	-41,436,900	28,349,000	-8,868,400	-1,737,800
	Percentage	-18.1%	15.1%	-4.1%	-0.8%

% RMSE between network link times from successive feedback loops (year 2017)

RMSE convergence is evident using MSA averaging

Incremental RMSE's diminish at a non-linear rate

Initial RMSEs are very large



	Iter_Spec			
Period	PP_vs_I1	i1_vs_I2	i2_vs_I3	i3_vs_I4
AM	0.69	0.19	0.03	0.01
MD	0.16	0.03	0.01	0.00
PM	0.61	0.16	0.03	0.01
NT	0.05	0.02	0.01	0.00

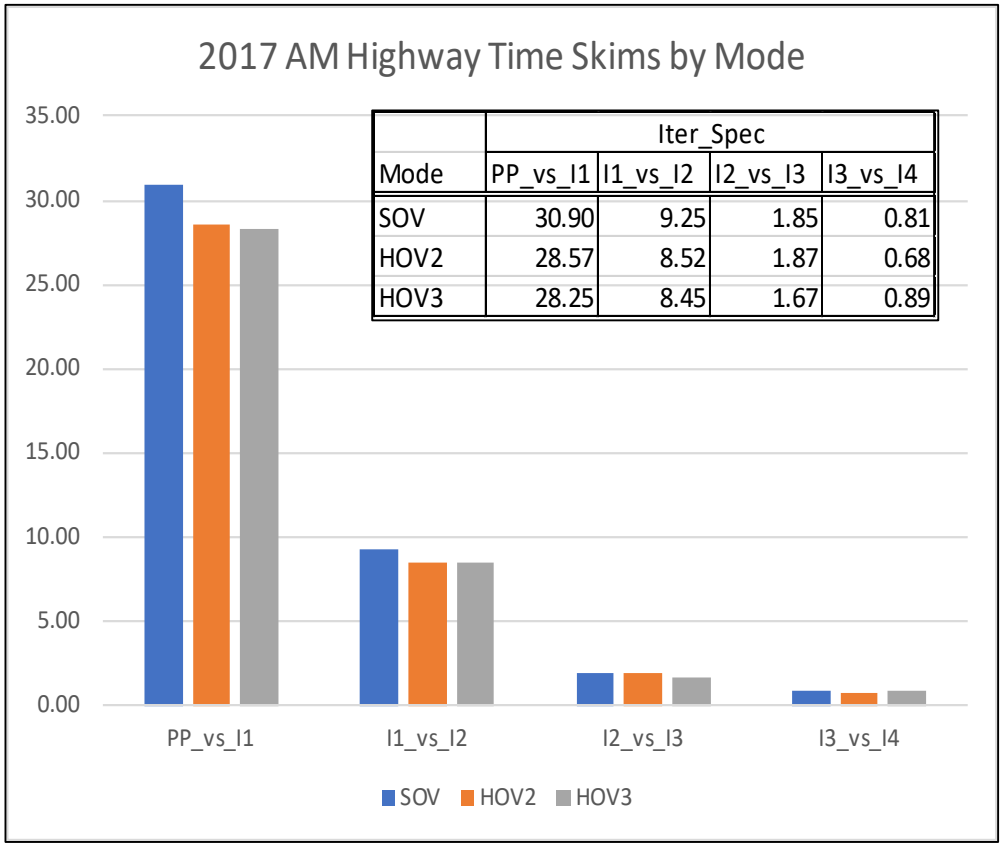
% RMSE between AM time skims from successive feedback loops (years 2017 & 2040)

Similar findings are made, examining highway skims:

RMSE convergence is evident

Incremental RMSE's diminish at a non-linear rate

Initial RMSEs are relatively large



	Iter_Spec			
Mode	PP_vs_I1	I1_vs_I2	I2_vs_I3	I3_vs_I4
SOV	30.90	9.25	1.85	0.81
HOV2	28.57	8.52	1.87	0.68
HOV3	28.25	8.45	1.67	0.89

Speed-feedback findings

- I/O speeds appear to be converging well by the final iteration of the model
- Convergence appears to be looser from in-years (2017) to out-years (2040). This is expected. Nonetheless out-year convergence appears reasonable
- The convergence plots suggest that improving the initial (PP) speeds might result in a faster convergence, which may obviate the need for a fourth (i4) iteration
- We will consider using pre-existing network link speeds for the initial (PP) iteration as an alternative to using table look-up speeds

Final thoughts:

- Version V2.5 model is continuing
- We expect V2.5 will not be used in the next AQC cycle (Visualize 2045) Plan update, but it will be tested
- Special thanks to: Meseret Seifu, Ray Ngo, Jim Yin

Ron Milone

Travel Forecasting and Emissions Analysis Program Director
(202) 962-3283
rmilone@mwcog.org

mwcog.org/TPB

Metropolitan Washington Council of Governments
777 North Capitol Street NE, Suite 300
Washington, DC 20002