TPB Version 2.3 travel model on the 3,722-TAZ area system: Status report

Travel Forecasting Subcommittee
May 20, 2011

Ron Milone and Mark Moran

National Capital Region Transportation Planning Board (TPB)
Metropolitan Washington Council of Governments (COG)

Activities since April 29 meeting

- TPB Technical Committee debriefed on progress
- 5 requests for draft V2.3 model serviced *thus far*
- Minor changes, refinements made to model
- Sensitivity test suggestions received from WMATA
- Summarized 2040 transit assignment results
- Sensitivity testing on highway assignment

Production schedule for the Version 2.3 Travel Model

1. Air Quality Conformity: June – September
   - Travel model: Version 2.3
   - Land activity: Round 8.0a Cooperative Forecasts
   - Networks: 2011 CLRP & FY 2012-2017 TIP
   - Mobile emissions model: Mobile 6
2. PM Maintenance SIP: December-February
   - Will build off of conformity work
   - Mobile emissions model: MOVES

Analysis years for upcoming studies

Analysis Year	Air Quality Conformity Analysis of the 2011 CLRP & FY 2012-2017 TIP	PM Maintenance State Implementation Plan (SIP)
2002	√	√
2007		√
2016	√	
2017		√
2020	√	
2025		√
2030	√	
2040	√	

Immediate activities/issues

- Excessive model running times
- Tightening convergence metrics in the highway assignment process
- Preparation of ancillary modeling procedures
  - The transit constraint through the regional core
  - Variable highway toll-setting procedures
  - Mobile 6-based mobile emissions post processor
- Preparing V2.3-compliant networks, land activity, and exogenous inputs

Model refinements since April 29

- Script, programming refinements
  - Walkacc.s: Corrected input file specification error
  - Highway_Assignment.s:
    - Refined so that DP is more transparent
    - Decreased nighttime period peaking factor to ensure a more reasonable (less congested) traffic condition
    - Increased max UE iterations to 300
  - Linesum executable: updated
- Other refinements (network corrections, etc.)
- All refinements will be documented

2040 Transit Analysis

2007 and 2040 Transit Assignment Trips by Mode

Mode	HBW		Non-HBW		ALL	
	2007	2040	2007	2040	2007	2040
CR	19,806	46,433	2,913	2,484	22,719	48,918
MR	341,871	520,493	158,113	245,267	499,984	765,760
BUS	196,193	319,409	152,999	217,994	349,192	537,402
BUS/MR	175,078	226,111	52,744	63,397	227,821	289,507
Total Person	3,535,199	5,091,603	13,793,499	19,399,803	17,328,698	24,491,405
Total Transit	732,948	1,112,445	366,768	529,143	1,099,715	1,641,587
Transit Pct	20.70%	21.85%	2.66%	2.73%	6.35%	6.70%

Ver. 2.3.17 model

2007 and 2040 Transit Assignment Trips by Access Mode

Access Mode	HBW		Non-HBW		ALL	
	2007	2040	2007	2040	2007	2040
WALK	475,538	715,703	308,733	453,806	784,271	1,169,509
PNR	197,972	293,634	36,386	46,803	234,359	340,438
KNR	59,438	103,108	21,649	28,532	81,086	131,640
Total Person	3,535,199	5,091,603	13,793,499	19,399,803	17,328,698	24,491,405
Total Transit	732,948	1,112,445	366,768	529,143	1,099,715	1,641,587
Transit Pct	20.70%	21.85%	2.66%	2.73%	6.35%	6.70%

Ver. 2.3.17 model

2007 and 2040 Metrorail Daily Ridership by Metrorail Segment

	Metrorail Segment	Estimated 2007 Prods	Estimated 2007 Attrs	Estimated 2040 Prods	Estimated 2040 Attrs	Ratio of 2040 to 2007 Prods	Ratio of 2040 to 2007 Attrs
1	Red Line - "A" route MD outside Beltway	50,699	15,927	76,772	29,462	1.51	1.85
2	Red Line - "A" route MD inside Beltway	30,503	36,546	42,544	46,495	1.39	1.27
3	Red Line - "A" route DC non-core	32,115	15,343	37,687	17,792	1.17	1.16
4	Red Line - DC core	51,257	174,376	71,914	234,833	1.40	1.35
5	Red Line - "B" route DC non-core	46,512	16,375	58,638	28,399	1.26	1.73
6	Red Line - "B" route MD	49,779	15,618	61,911	23,907	1.24	1.53
7	Green Line - "E" route MD	26,060	8,176	28,026	11,641	1.08	1.42
8	Green Line - "E" route DC non-core	28,193	16,158	35,760	21,228	1.27	1.31
9	Green Line - DC core	20,102	60,441	43,756	80,228	2.18	1.33
10	Green Line - "F" route DC non-core	29,121	21,609	42,897	42,164	1.47	1.95
11	Green Line - "F" route MD	32,550	3,473	48,083	5,434	1.48	1.56
12	Blue/Yellow Line - VA Fairfax	43,172	4,311	58,730	6,832	1.36	1.58
13	Blue/Yellow Line - VA Alexandria	15,946	17,775	21,067	24,971	1.32	1.40
14	Blue/Yellow Line - VA Core	51,280	42,990	61,598	69,559	1.20	1.62
15	Orange Line - VA Fairfax	51,138	9,426	53,431	6,023	1.04	0.64
16	Orange Line - VA Arlington non-core	47,329	38,101	70,945	72,039	1.50	1.89
17	Orange/Blue Line - VA/DC core	50,122	220,911	59,561	247,243	1.19	1.12
18	Orange/Blue Line - DC non-core	25,817	8,808	35,828	12,945	1.39	1.47
19	Orange Line - DC/MD	26,154	5,732	27,336	9,693	1.05	1.69
20	Blue Line - DC/MD	26,918	3,040	46,610	10,699	1.73	3.52
21	Silver Line-Tysons			22,127	39,714	N/A	N/A
22	Silver Line- Dulles			32,598	19,863	N/A	N/A
23	Silver Line-End			23,741	851	N/A	N/A
	Total	734,767	735,136	1,061,560	1,062,015	1.44	1.44
	DC/VA Core Total	172,761	498,718	236,829	631,863	1.37	1.27

Ver. 2.3.17 model

Other Transit Analysis

- Looked at 2040 ridership for the Dulles corridor Metrorail (Silver Line)
  - Version 2.3 estimated daily ridership is around 69,000
- Compared 2040 estimated Silver Line ridership to the 2025 projections from the EIS
  - Daily ridership was projected to be 57,000
- There are caveats to the Version 2.3 ridership figure

Sensitivity tests with respect to traffic assignment, Ver. 2.3.18 model

Traffic assignment: Background

	Period	User classes
Assignment 1	AM	1. SOV 2. HOV 2 3. Trucks 4. Commercial Vehicles 5. Airport PAX
Assignment 2	AM	1. HOV 3+
Assignment 3	PM	1. SOV 2. HOV 2 3. Trucks 4. Commercial Vehicles 5. Airport PAX
Assignment 4	PM	1. HOV 3+
Assignment 5	Midday	1. SOV 2. HOV 2 3. HOV 3+ 4. Trucks 5. Commercial Vehicles 6. Airport PAX
Assignment 6	Night Time	1. SOV 2. HOV 2 3. HOV 3+ 4. Trucks 5. Commercial Vehicles 6. Airport PAX

- Four time-of-day periods (**AM**, **PM**, MD, NT)
- Peak periods segmented by HOV3+ ("two-step assignment")
- Six user classes
- End result: **6 multiclass, user-equilibrium traffic assignments** (for each of the 5 speed feedback iterations)

Traffic assignment: Background

- Convergence criteria (i.e., the goal or target)
  - Relative gap of 0.001 (1×10^{-3}) or
  - Maximum number of user equilibrium iterations (AON assignments) = 300
  - (Whichever is attained first)
- A UE traffic assignment is composed of X all-or-nothing (AON) traffic assignments, where X = number of UE iterations
- Max. no. of AON assignments per speed feedback (SFB) loop = 1,800

  = (300 max. UE iterations) x (6 UE traffic assignments)

Model run times

- Run times are a function of congestion level (modeled year), traffic assignment algorithm, and use of distributed processing (Cube Cluster)
- Run times vary between the following:
  - 109 hours (4.5 days) for **standard Frank-Wolfe** traffic assignment algorithm, **without** Cube Cluster, for a **future-year**
  - 33 hours (1.4 days) for **bi-conjugate Frank-Wolfe** traffic assignment algorithm, **with** Cube Cluster (4 cores), for a **base-year**

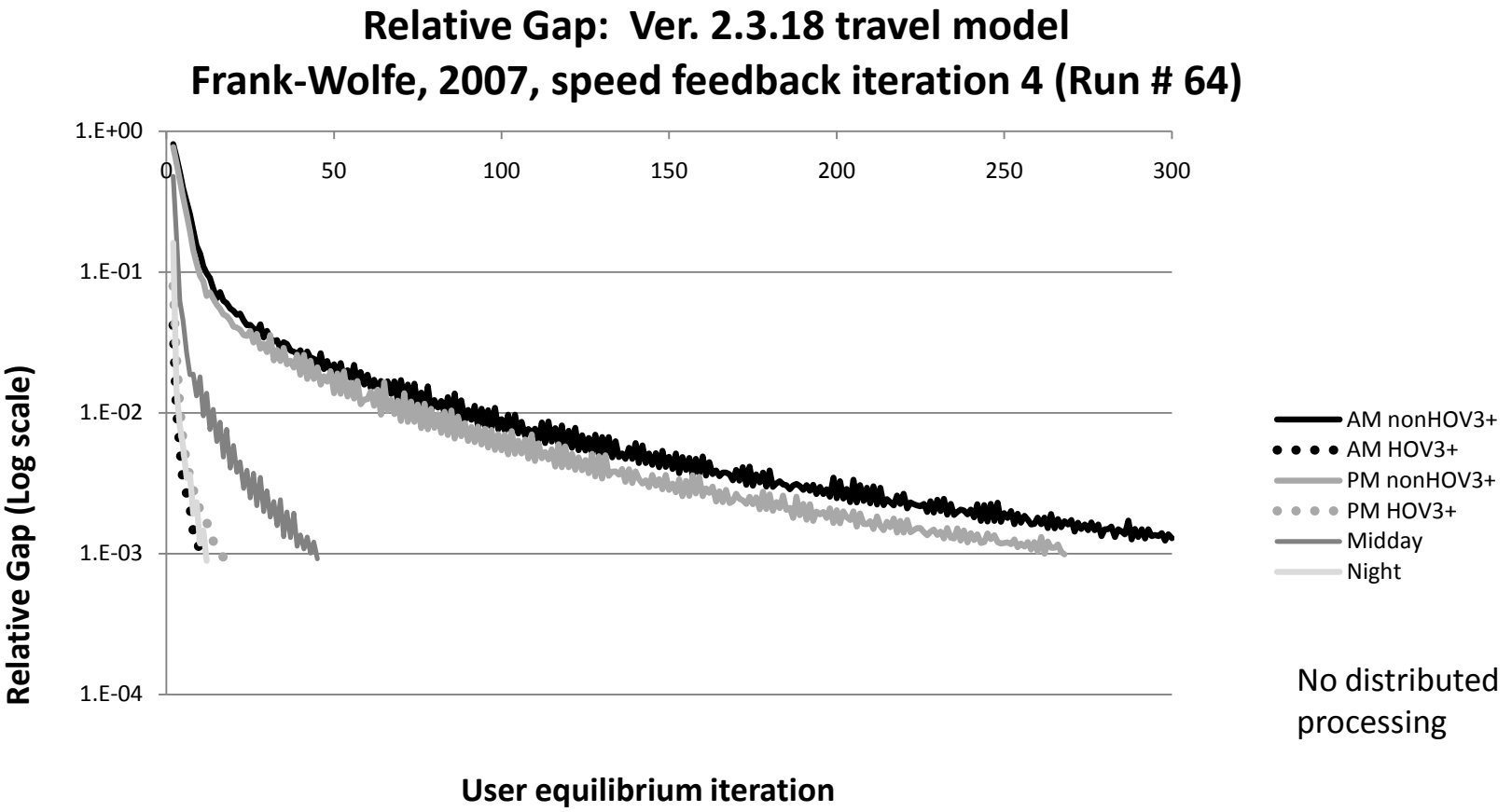
Run No.	Year	Traffic Assignment Algorithm	Cube Cluster (Distr. Proc.)	No. of Cores	Run Time (hrs)	Run Time (days)
64	2007	Frank-Wolfe	No	1	95	4.0
66	2040	Frank-Wolfe	no	1	109	4.5
68	2007	Conjugate FW	no	1	77	3.2
69	2007	Bi-conjugate FW	no	1	75	3.1
70	2007	Conjugate FW	yes	4	37	1.5
71	2007	Bi-conjugate FW	yes	4	33	1.4

Traffic assignment convergence: Targets vs. attainment

- Frank-Wolfe: Slowest to converge
  - 2007: One of the six assignments does not reach rel. gap of 10^{-3}.
  - 2040: Two of the six assignments do not reach rel. gap of 10^{-3}.
- Conjugate FW: Converges faster than FW
- Bi-conjugate FW: Converges the fastest of all

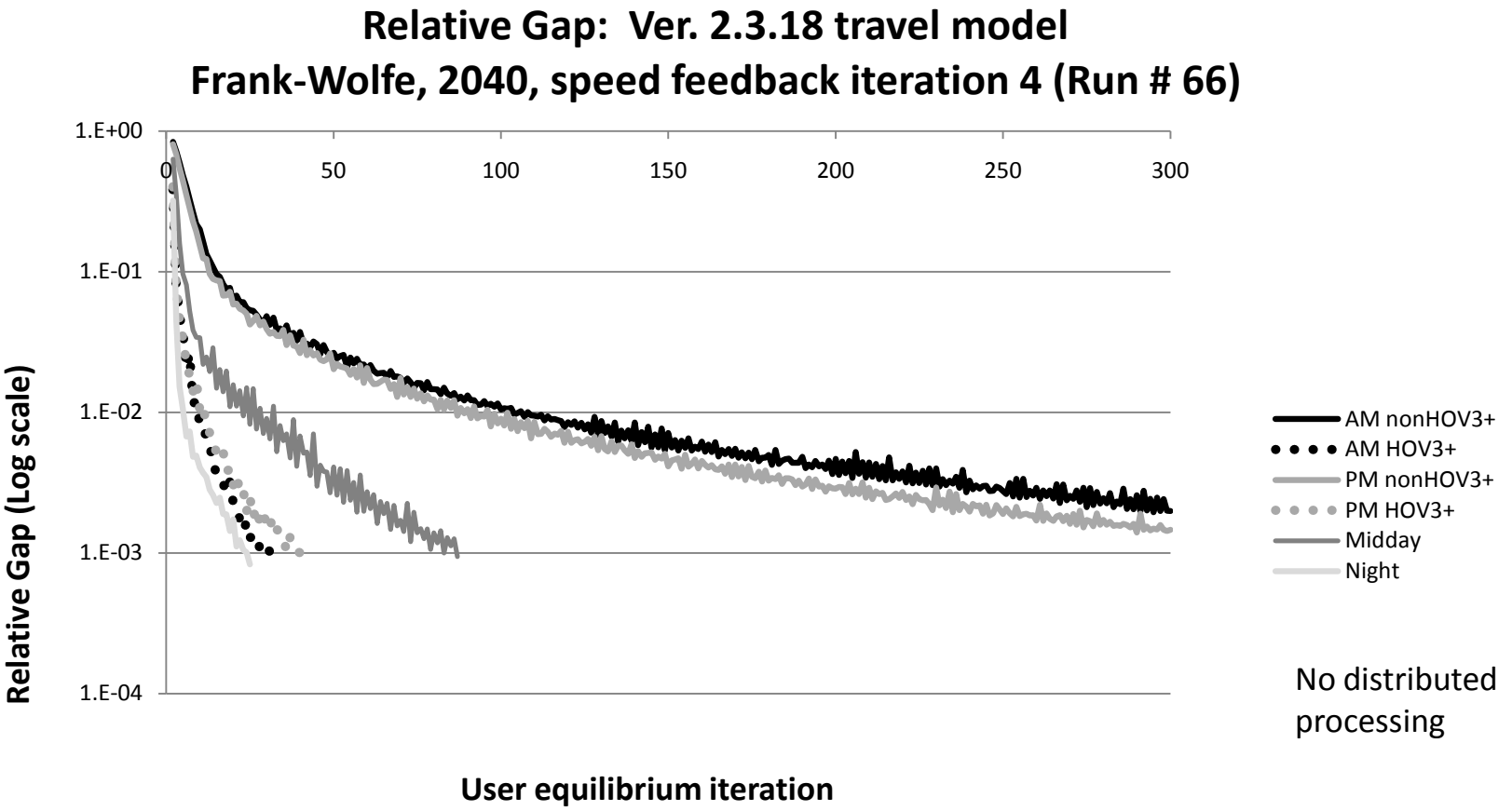
Run No.	Year	Traffic Assignment Algorithm	Cube Cluster (Distr. Proc.)	No. of Cores	Target 1 Relative Gap	Target 2 Max # of user equi iters	Attainment (# of UE iterations by assignm.) AM Non-HOV3+	AM HOV3+	PM Non-HOV3+	PM HOV3+	MD	NT	Total
64	2007	Frank-Wolfe	no	1	1.0E-03	300	300	10	268	17	45	12	652
66	2040	Frank-Wolfe	no	1	1.0E-03	300	300	32	300	40	87	25	784
68	2007	Conjugate FW	no	1	1.0E-03	300	209	11	158	15	31	12	436
69	2007	Bi-conjugate FW	no	1	1.0E-03	300	168	11	144	20	38	20	401
70	2007	Conjugate FW	yes	4	1.0E-03	300	198	11	155	15	33	12	424
71	2007	Bi-conjugate FW	yes	4	1.0E-03	300	176	12	144	18	38	17	405

Relative gap: Frank-Wolfe, 2007



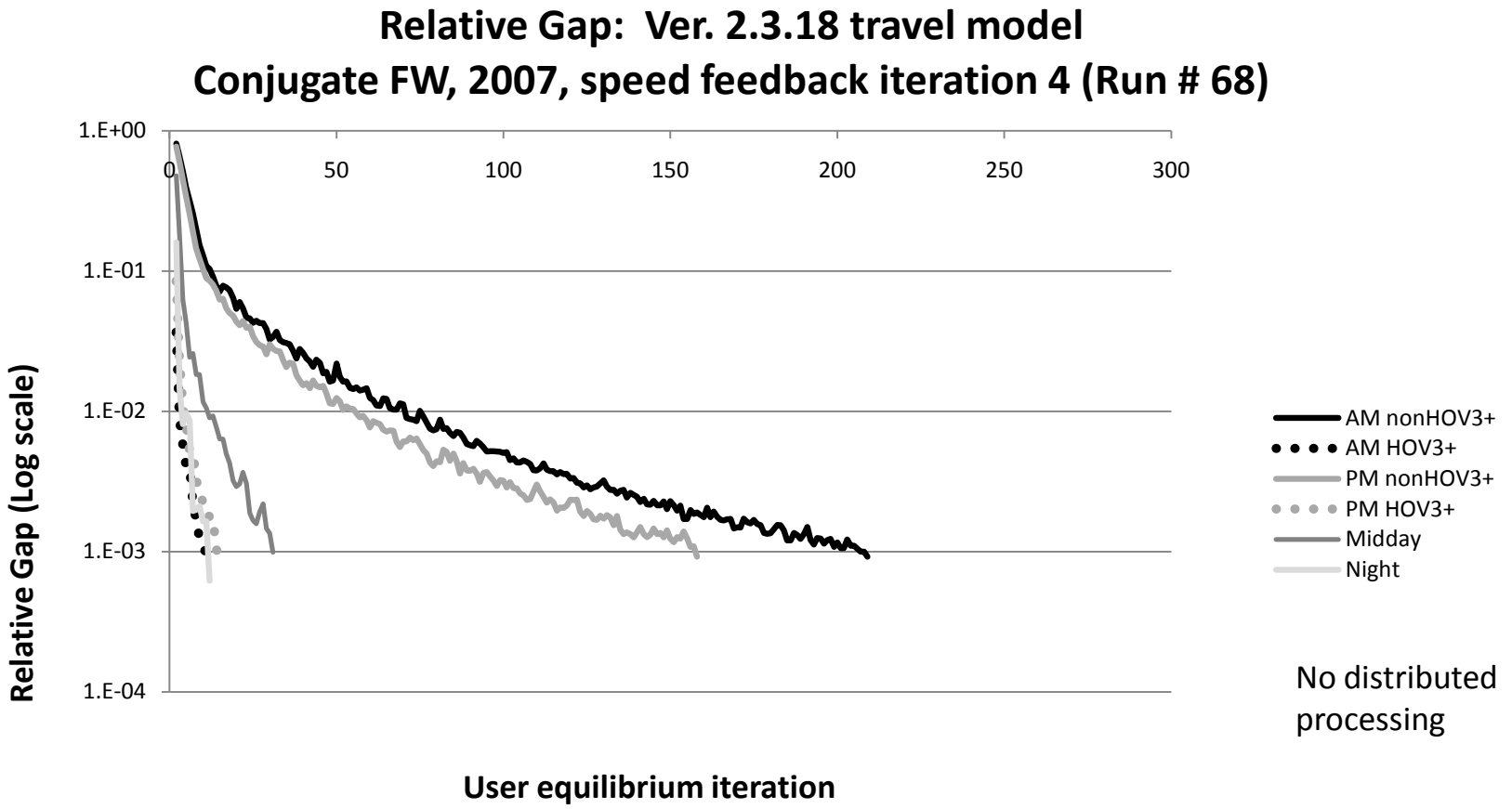
No distributed processing

Relative gap: Frank-Wolfe, 2040



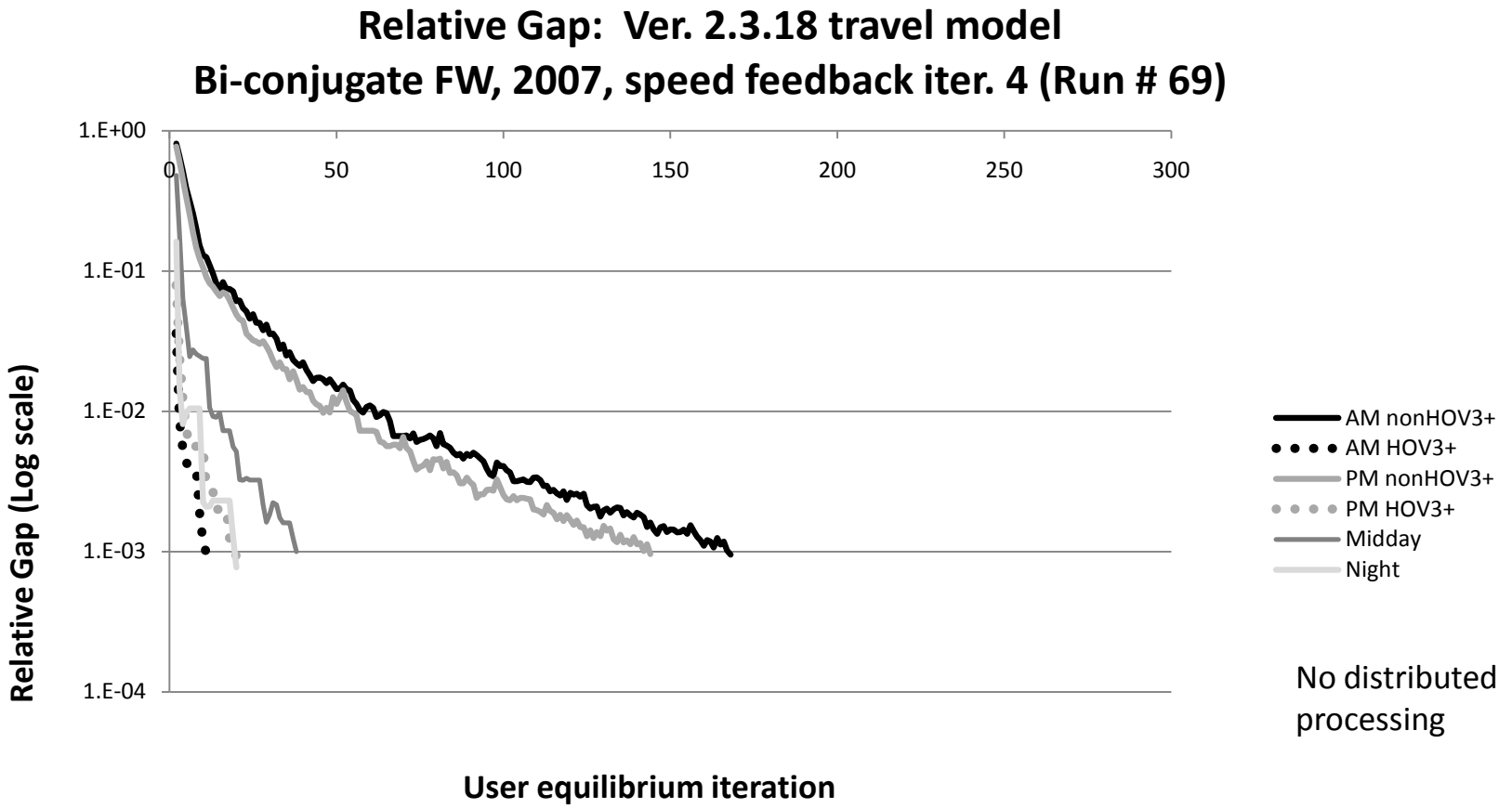
No distributed processing

Relative gap: Conjugate FW, 2007



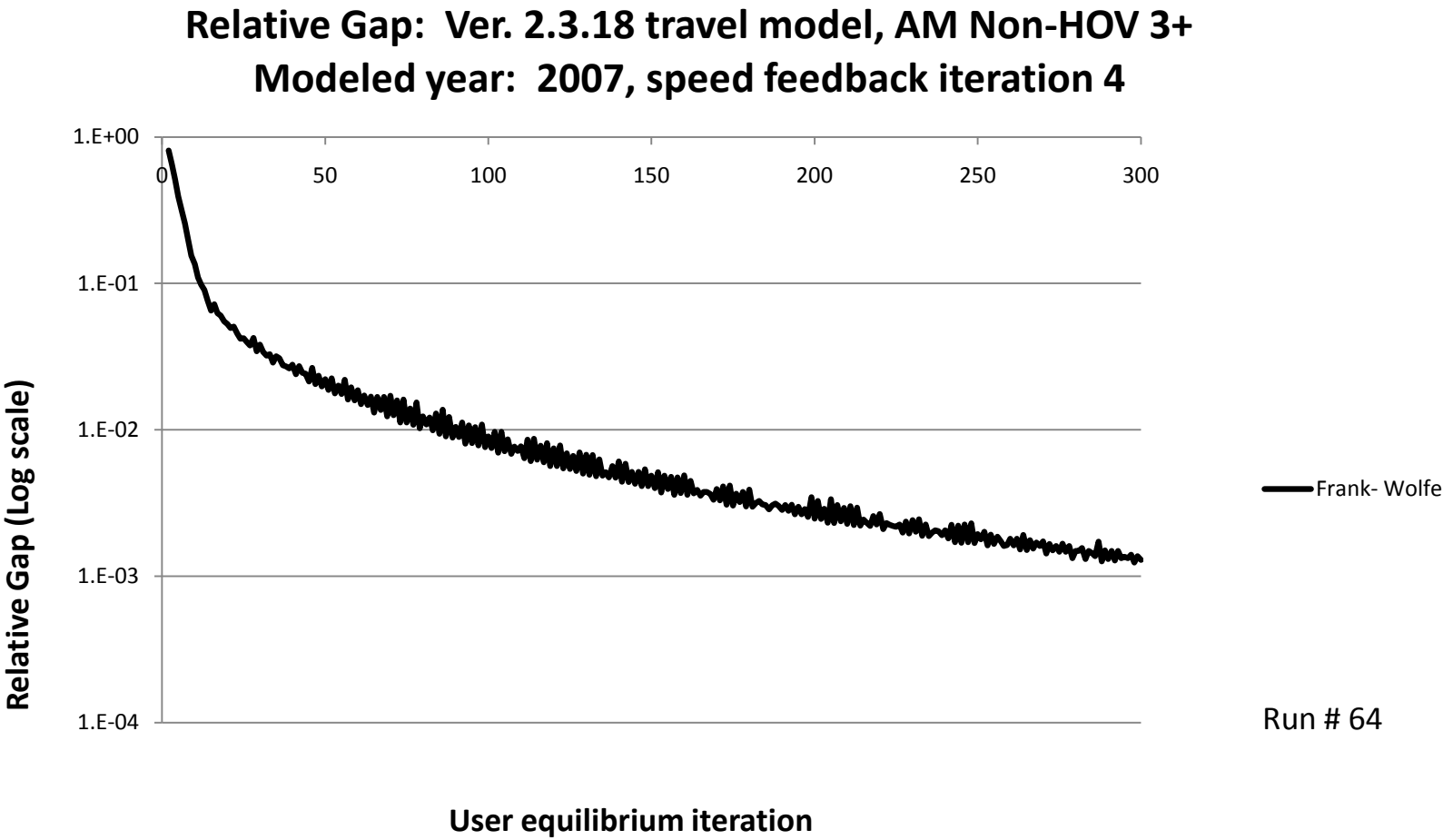
No distributed processing

Relative gap: Bi-conjugate FW, 2007

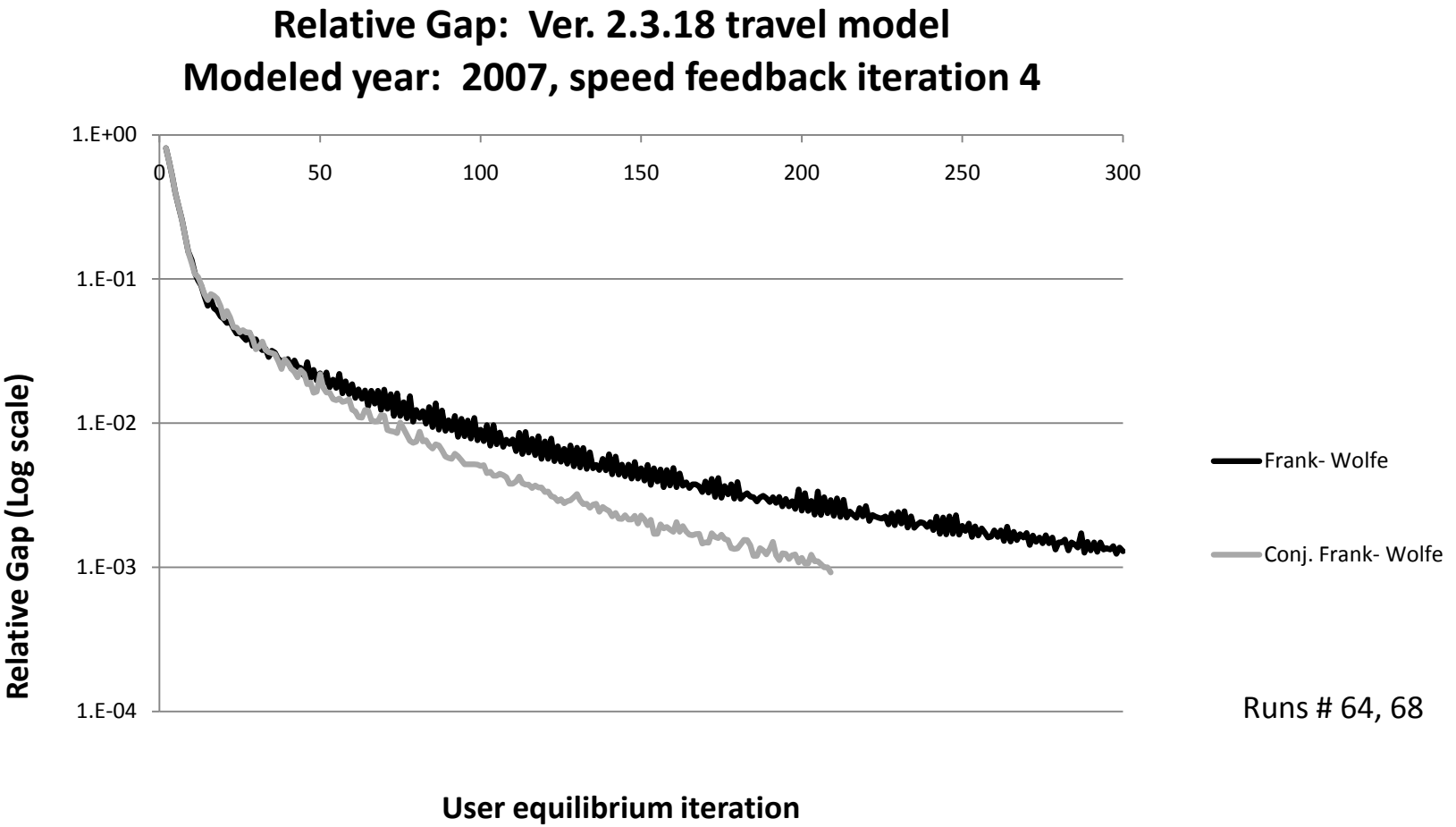


No distributed processing

Relative Gap: Frank-Wolfe

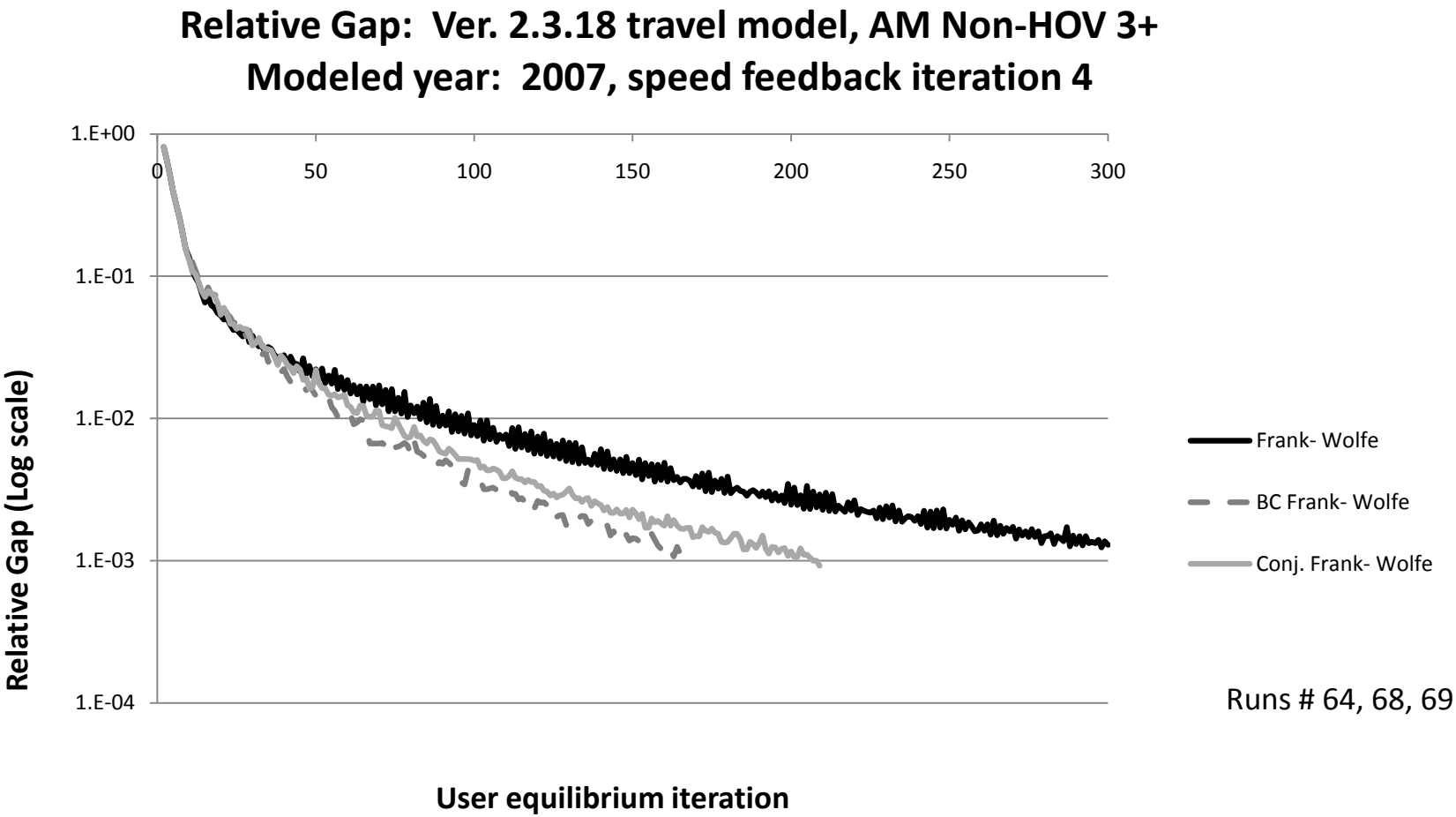


Relative Gap: Conjugate FW



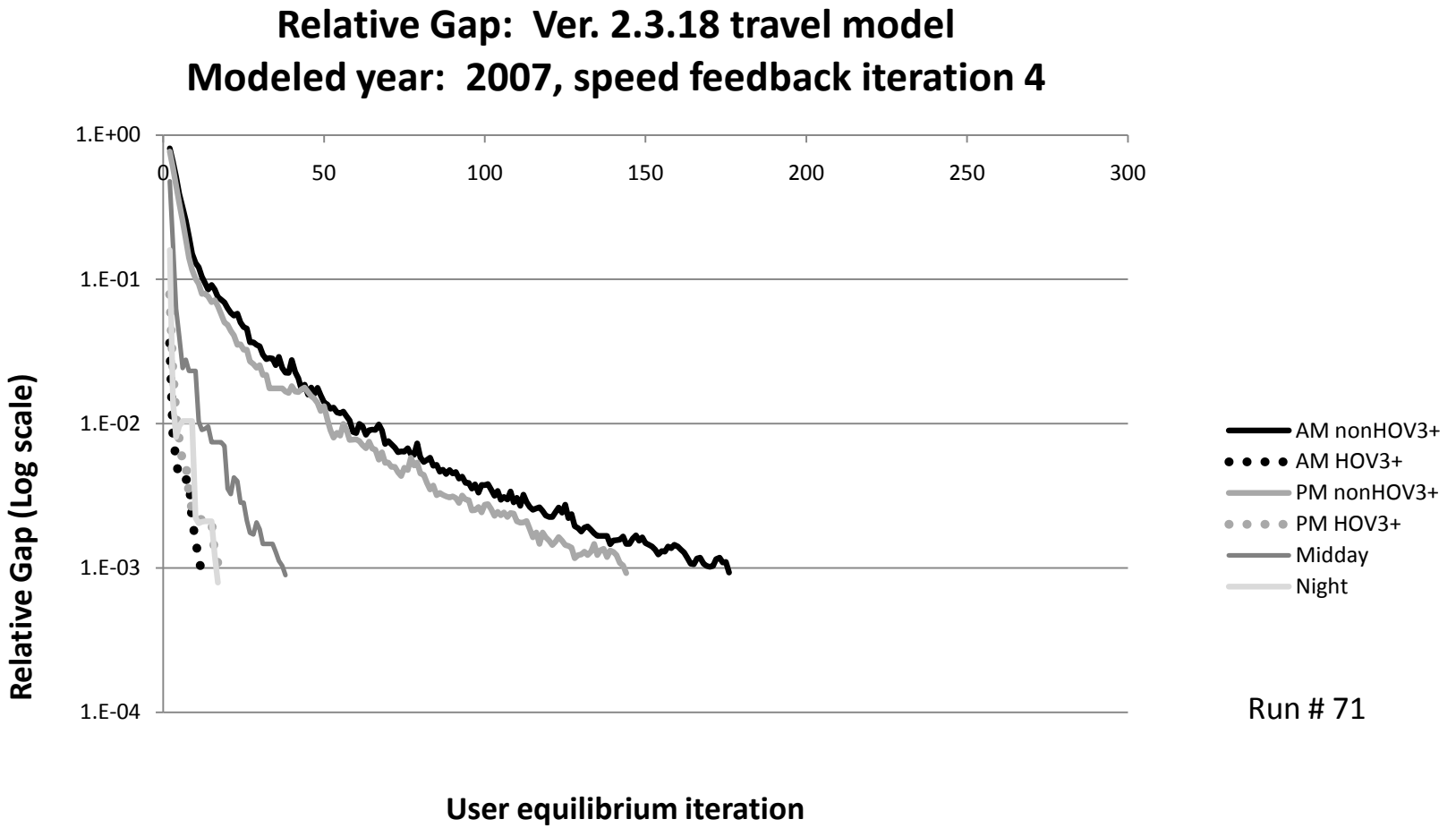
Runs # 64, 68

Relative Gap: Bi-conjugate FW



Runs # 64, 68, 69

Relative Gap: Bi-conjugate FW with DP



Effect of Cube Cluster on est. VMT

- Use of Cube Cluster results in small changes in estimated VMT
  - About 1/100th of a percent to 3/100th of a percent

Run No.	Year	Traffic Assignment Algorithm	Cube Cluster (Distr. Proc.)	No. of Cores	Regional VMT	Diff	Pct Diff
68	2007	Conjugate FW	no	1	156,698,908		
70	2007	Conjugate FW	yes	4	156,653,683	-45,225	-0.03%
69	2007	Bi-conjugate FW	no	1	156,697,741		
71	2007	Bi-conjugate FW	yes	4	156,674,456	-23,285	-0.01%

Final speed feedback iteration (i4)

Effect of Cube Cluster on est. VMT

Difference (CubeCluster - WithoutCubeCluster)								
		Freway	Maj Art	Min Art	Collector	Expressw	Ramp	Total
		1	2	3	4	5	6	6
0	DC	-4,729	-498	-3,764	-91	3,345	-107	-5,846
1	Mont Co	-12,493	-3,327	2,415	1,035	953	17	-11,400
2	PG Co	1,986	-8,778	-1,840	-693	2,676	528	-6,123
3	Arl Co	1,317	-421	-99	-9	-83	41	745
4	Alexandr	1,604	-24	-17	1	0	143	1,707
5	Fairfx Co	-9,668	576	1,177	-894	566	100	-8,144
6	Loud Co	-75	-92	677	-501	379	9	396
7	PW Co	3,086	-181	110	2,887	-18	219	6,101
9	Fred Co	-931	244	-6,479	-104	225	22	-7,025
10	Howard Co	-206	-1,469	1,670	103	-5,386	-1	-5,290
11	AnneAr Co	-4,366	-4,557	1,885	-1,639	782	7	-7,887
12	Charles Co	0	132	-19	378	0	0	492
14	Carroll Co	-119	-6,173	624	1,923	0	0	-3,744
15	Calv Co	0	-1,144	833	-90	0	0	-400
16	StMary Co	0	-327	-22	18	0	0	-331
17	KingG Co	0	117	21	15	0	0	153
18	Fred'burg	129	-120	72	32	0	30	143
19	Staff Co	939	561	-54	-361	0	156	1,240
20	Spots Co	3	71	-12	24	0	13	99
21	Fauq Co	-86	-68	-64	148	0	1	-69
22	Clarke Co	0	-43	32	6	0	0	-6
23	Jeff Co	-26	-56	29	18	0	0	-35
	Total	-23,635	-25,577	-2,825	2,206	3,439	1,178	-45,224

- Year 2007, conjugate FW
- **Difference** in estimated VMT by jurisdiction and facility type
- 45,000 drop at regional level

Final speed feedback iteration (i4)

Effect of Cube Cluster on est. VMT

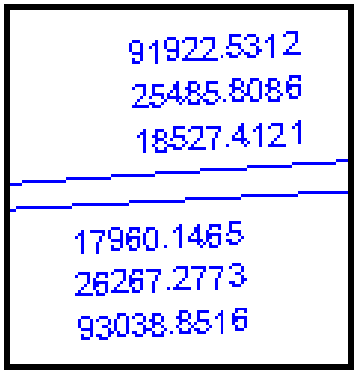
Percent Difference (CubeCluster - WithoutCubeCluster)								
		Freway	Maj Art	Min Art	Collector	Expressw	Ramp	Total
		1	2	3	4	5	6	6
0	DC	-0.169%	-0.013%	-0.306%	-0.012%	3.997%	-0.336%	-0.066%
1	Mont Co	-0.152%	-0.040%	0.092%	0.125%	0.143%	0.007%	-0.055%
2	PG Co	0.020%	-0.115%	-0.136%	-0.040%	0.351%	0.160%	-0.028%
3	Arl Co	0.051%	-0.042%	-0.019%	-0.011%	-0.074%	0.093%	0.017%
4	Alexandr	0.167%	-0.004%	-0.007%	0.001%		0.339%	0.085%
5	Fairfx Co	-0.081%	0.007%	0.041%	-0.057%	0.054%	0.019%	-0.031%
6	Loud Co	-0.005%	-0.005%	0.055%	-0.039%	0.128%	0.009%	0.006%
7	PW Co	0.095%	-0.006%	0.009%	0.324%	-0.008%	0.171%	0.070%
9	Fred Co	-0.020%	0.018%	-0.436%	-0.020%	0.030%	0.040%	-0.081%
10	Howard Co	-0.004%	-0.090%	0.143%	0.046%	-0.355%	-0.016%	-0.052%
11	AnneAr Co	-0.053%	-0.104%	0.200%	-0.467%	0.100%	0.020%	-0.054%
12	Charles Co		0.006%	-0.004%	0.102%			0.016%
14	Carroll Co	-0.110%	-0.189%	0.074%	3.983%			-0.088%
15	Calv Co		-0.078%	0.275%	-0.186%			-0.022%
16	StMary Co		-0.020%	-0.009%	0.011%			-0.016%
17	KingG Co		0.047%	0.006%	0.027%			0.023%
18	Fred'burg	0.031%	-0.043%	0.077%	0.307%		0.127%	0.017%
19	Staff Co	0.037%	0.078%	-0.026%	-0.068%		0.445%	0.031%
20	Spots Co	0.000%	0.014%	-0.005%	0.009%		0.087%	0.005%
21	Fauq Co	-0.009%	-0.005%	-0.014%	0.055%		0.020%	-0.002%
22	Clarke Co		-0.006%	0.021%	0.015%			-0.001%
23	Jeff Co	-0.015%	-0.006%	0.012%	0.027%			-0.003%
0	Total	-0.036%	-0.046%	-0.015%	0.022%	0.055%	0.073%	-0.029%
	Green: Cells that are 1 standard deviation or more above average							
	Red: Cells that are 1 standard deviation or more below average							

- Year 2007, conjugate FW
- **Percent difference** in estimated VMT by jurisdiction and facility type
- About 3/100th of a percent at the regional level
- As large as 9/100th of a percent at juris. level

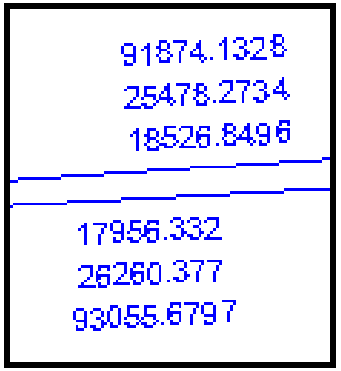
Final speed feedback iteration (i4)

Effect of Cube Cluster on est. VMT

2007, conjugate FW, i4hwy.net,
<u>Without</u> distributed processing



2007, conjugate FW, i4hwy.net,
<u>With</u> distributed processing

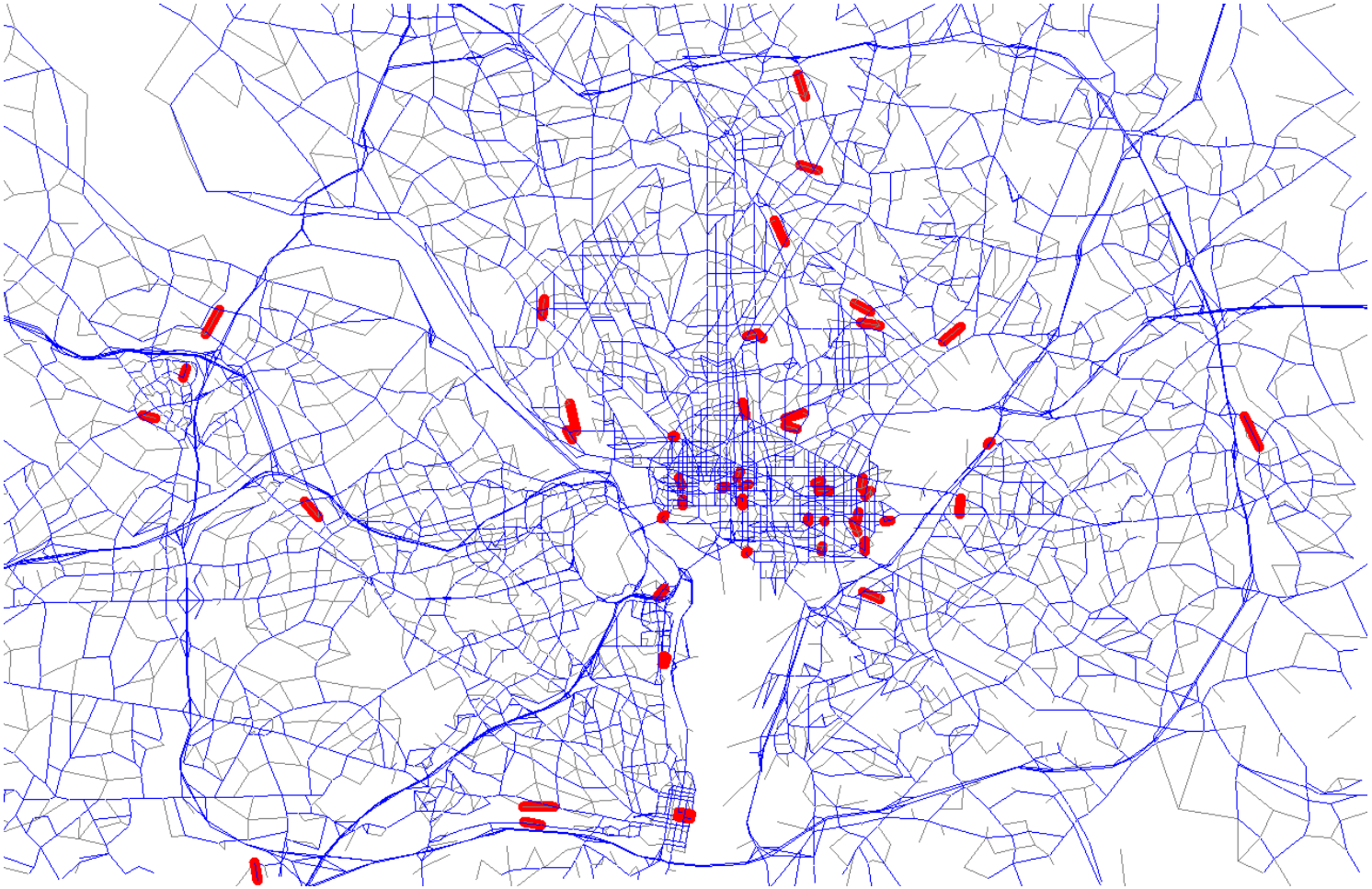


Woodrow Wilson Bridge, westbound, year 2007

i424vol:	**91,874.1328 – 91,922.5312 = -48.3984 (-0.050%)**
i4pmvol:	**25,478.2734 – 25,485.8086 = -7.5352 (-0.030%)**
i4amvol:	**18,526.8496 – 18,527.4121 = -0.5625 (-0.003%)**

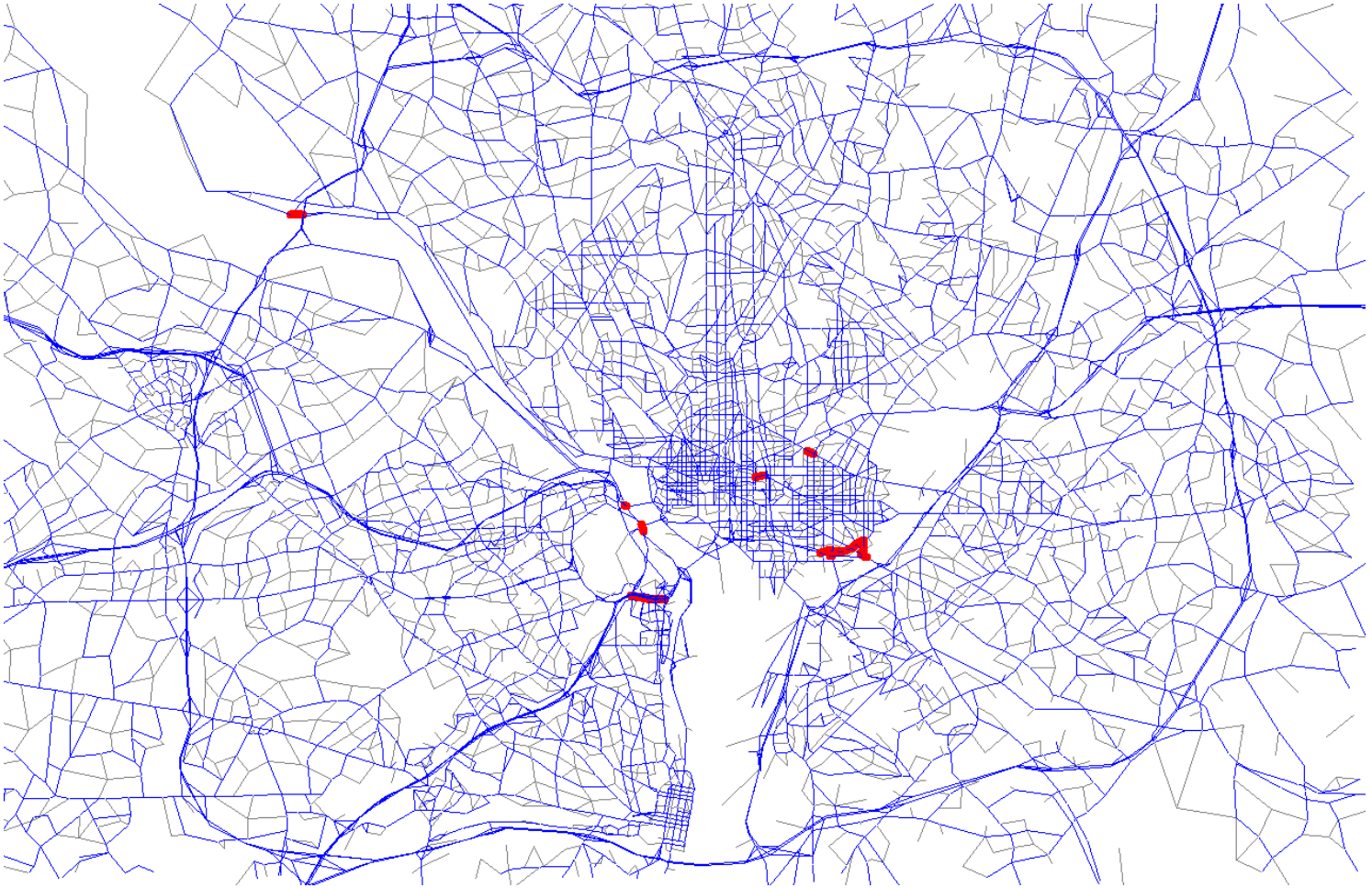
Effect of Cube Cluster on est. VMT

- Links where total volume diff > 20%



Effect of Cube Cluster on est. VMT

- Links where total volume diff > 500 vehs/day (i424vol)



Conclusions and next steps: Transit estimation and assignment

- 2040 transit estimates look reasonable, compared to TPB 2007 estimates and 2025 estimates for the Silver Line from the EIS
- Continue coordination with Cambridge Systematics
- Continue examining transit assignment results, including following up on request by Wendy Jia, WMATA
- Investigate apparent underestimation of walk-access transit
- Consider possible refinements, such as
  - Adding some sidewalk and walk transfer links
  - Development of external and non-resident transit markets

Conclusions and next steps: Traffic assignment

- Continue to work with Citilabs and Cambridge Systematics on differences due to Cube Cluster
  - CS will discuss task order work in the next agenda item
- Investigate rounding of link attributes as possible way of reducing/eliminating differences caused by use of Cube Cluster
- Bi-conjugate Frank-Wolfe with Cube Cluster appears to be the most promising, since it minimizes run times and attains the desired level of convergence
- We recommend using bi-conjugate FW with Cube Cluster, with the following caveat
  - Always use the same number of cores for each alternative tested (e.g. 4 cores for the “build” and 4 cores for the “no-build”)

Conclusions and next steps: Other sensitivity tests

- Continue to investigate tests conducted by models application team
- Finalize list of sensitivity test and determine which tests can be done within our short time horizon

Acknowledgements

- Others who have been instrumental in the development of this model
  - Models development team: Mary Martchouk, Hamid Humeida, Meseret Seifu
  - Network development team: Jim Yin, Wanda Hamlin, Joe Davis
  - Models application staff: Dusan Vuksan, Jinchul Park, and Feng Xie
  - Staff of Cambridge Systematics, Inc.