Version 2.3 travel model on the 3,722-TAZ area system: Traffic assignment of observed trips

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of the TPB Technical Committee
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Acknowledgements

- Mary Martchouk for her help with model runs and analysis work

Motivation

- Provides a first look at TG adjustments that may be needed to match VMT (e.g., to address underreporting in the HTS)
- Estimation and calibration of both the trip distribution model and the mode choice model requires a set of zone-to-zone travel time/cost matrices ("skims")
  - These time/cost matrices are an output of the traffic assignment process
- Need to select convergence criteria and functional form

Comparison of 2007 Auto Driver Trips: Ver. 2.2 model vs. 2007 HTS

	A	B	
Purpose	**Version 2.2**	**2007/08 HTS**	**B / A**
HBW	3,519,500	2,786,400	0.79
HBS	2,777,000	1,934,300	0.70
HBO	7,900,500	3,808,900	0.48
NHB	4,527,700	3,230,400	0.71
Total	18,724,700	11,760,000	0.63

Notes:

Ver. 2.2 figures include internal & external trips; 2007/08 figures include only internal trips
Ver. 2.2 figures include production rate adjustments of 1.17 to 1.50 for NHB and HB non-work purposes

Total Vehicle Trips and Assigned VMT Comparison: Ver. 2.2 model vs. 2007 HTS trips combined with residual trips

	A	B	
	Version 2.2	HTS Auto Trips + Residual Trips	B / A
Trips	21,243,000	14,205,500	0.67
VMT	155,407,000	116,295,500	0.75
Trip Length	7.32	8.19	1.12

Residual trips: Commercial vehicles, trucks, through trips, visitor/tourist, school, taxi, airport passenger

Specifications for this analysis

- Input network: 2007
- Observed trip tables assigned:
  - 2007/2008 Household Travel Survey (factored)
    - Additional adjustment: Non-work auto driver trips factored by 1.77 to address underreporting and to better match observed VMT
  - Residual trips (e.g., commercial vehicles, trucks, through trips, visitor/tourist, school, taxi, airport passenger)
- Software: Cube Voyager 5.1.2
- Hardware: Travel model server
  - TMS3: Intel Xeon W5580 @ 3.2 GHz, 4 GB RAM, 2 CPUs x 4 cores = 8 cores
- We are seeking TFS input on VMT-related adjustments to the model

Parameters tested

- Volume-delay function (VDF)
  - Functional form: Conical vs. Akçelik
  - Implementation: Function vs. look-up table
  - Parameters: Akçelik: 2000 HCM vs. VDOT/Corradino Group
- Queuing delay function (QDF)
  - Conical VDF + explicit QDF
  - Akçelik (implicit QDF)
  - Applied to
    - Freeways and Ramps
    - All facilities
    - Surface streets (all facilities except freeways and ramps)
- Closure metrics
  - Maxiters (60, 200), relative gap (0.01, 0.001)

Conical VDF

- Heinz Spiess, "Conical Volume-Delay Functions," Transportation Science 24, no. 2 (May 1, 1990): 153-158

$$\frac{t}{t_0} = f(x) = 2 + \sqrt{\alpha^2(1-x)^2 + \beta^2} - \alpha(1-x) - \beta$$

where

t = Congested link travel time

t_0 = Link free-flow travel time

$x = \frac{V}{C}$ = link volume to capacity ratio

α = slope of the function at $\frac{\mathrm{V}}{\mathrm{C}}$=1 (slope must be>1.0)

$\beta = \frac{2\alpha - 1}{2\alpha - 2}$

Akçelik VDF

- Transportation Research Board, Highway Capacity Manual: 2000 (Transportation Research Board, 2000).
- Rahmi Akçelik, “Travel time functions for transport planning purposes: Davidson's function, its time-dependent form and an alternative travel time function,” Australian Road Research 21, no. 3 (December 1991): 49-59.

$$t = f(x, L) = t_0 + 0.25\left[(x-1) + \sqrt{(x-1)^2 + 16J * x * L^2}\right]$$

where

t = link traversal time (hours)

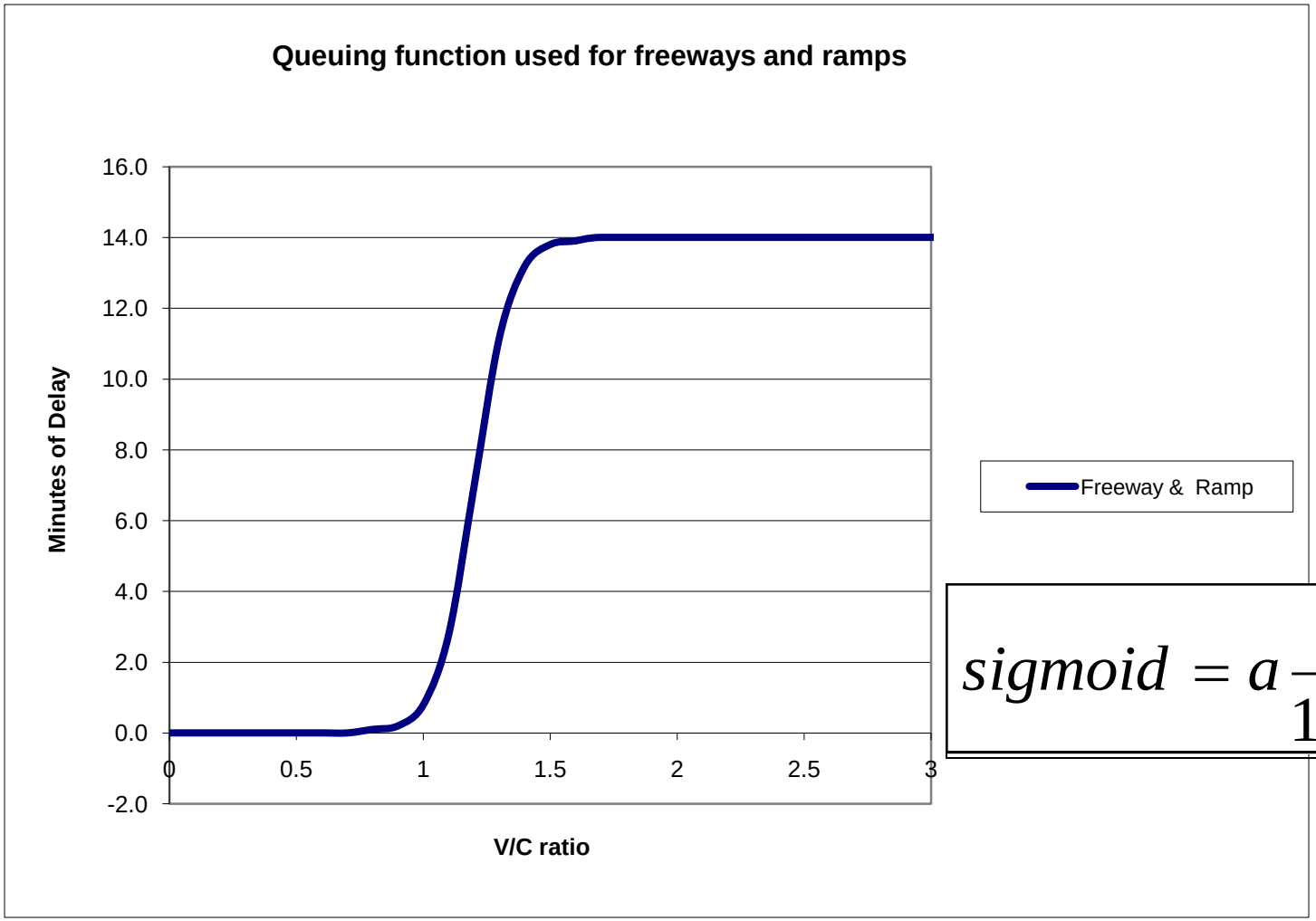
t_0 = link traversal time under free flow conditions (hours)

x = link demand to capacity ratio $\left(\frac{\mathrm{V}}{\mathrm{C}}\right)$

J = calibration parameter

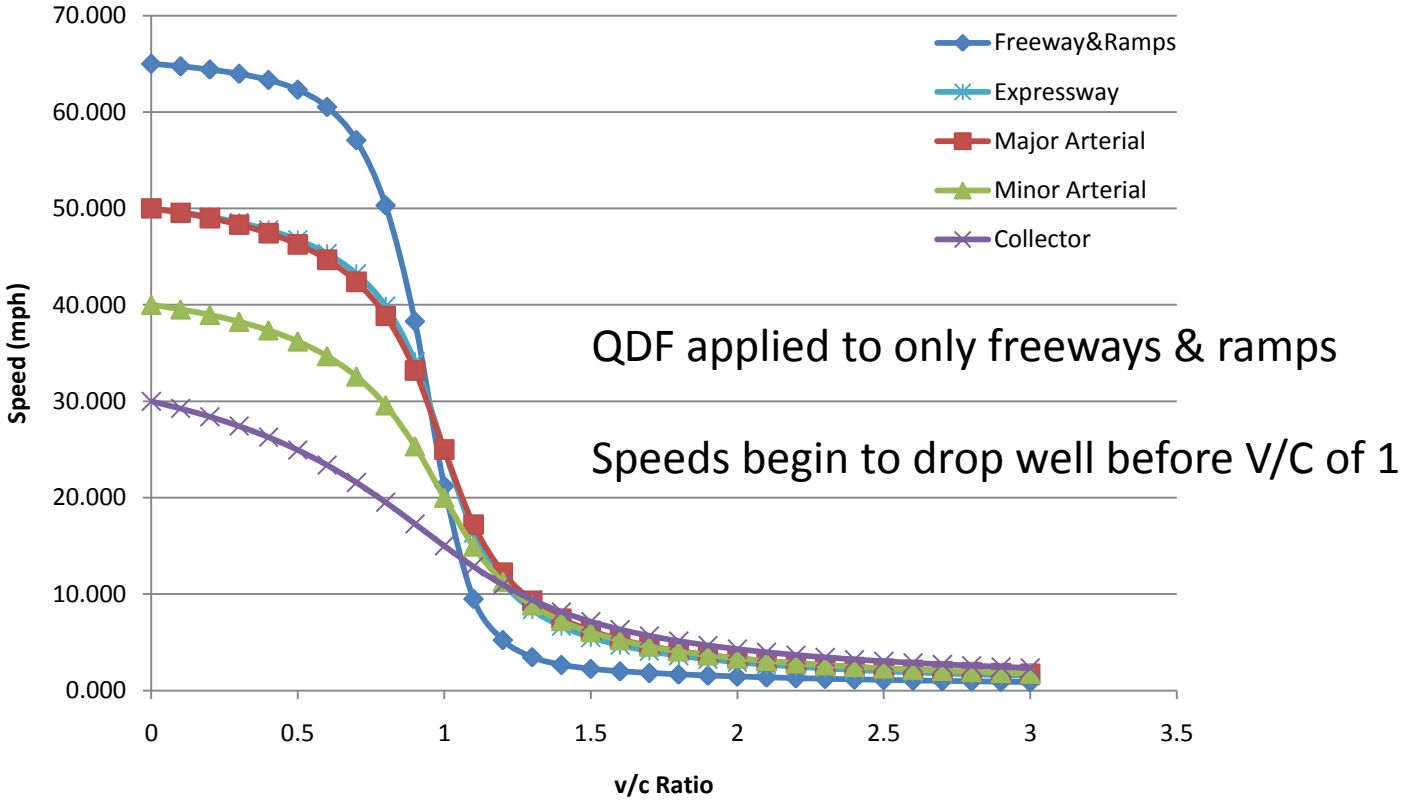
L = link length (miles)

Queuing delay function (QDF)

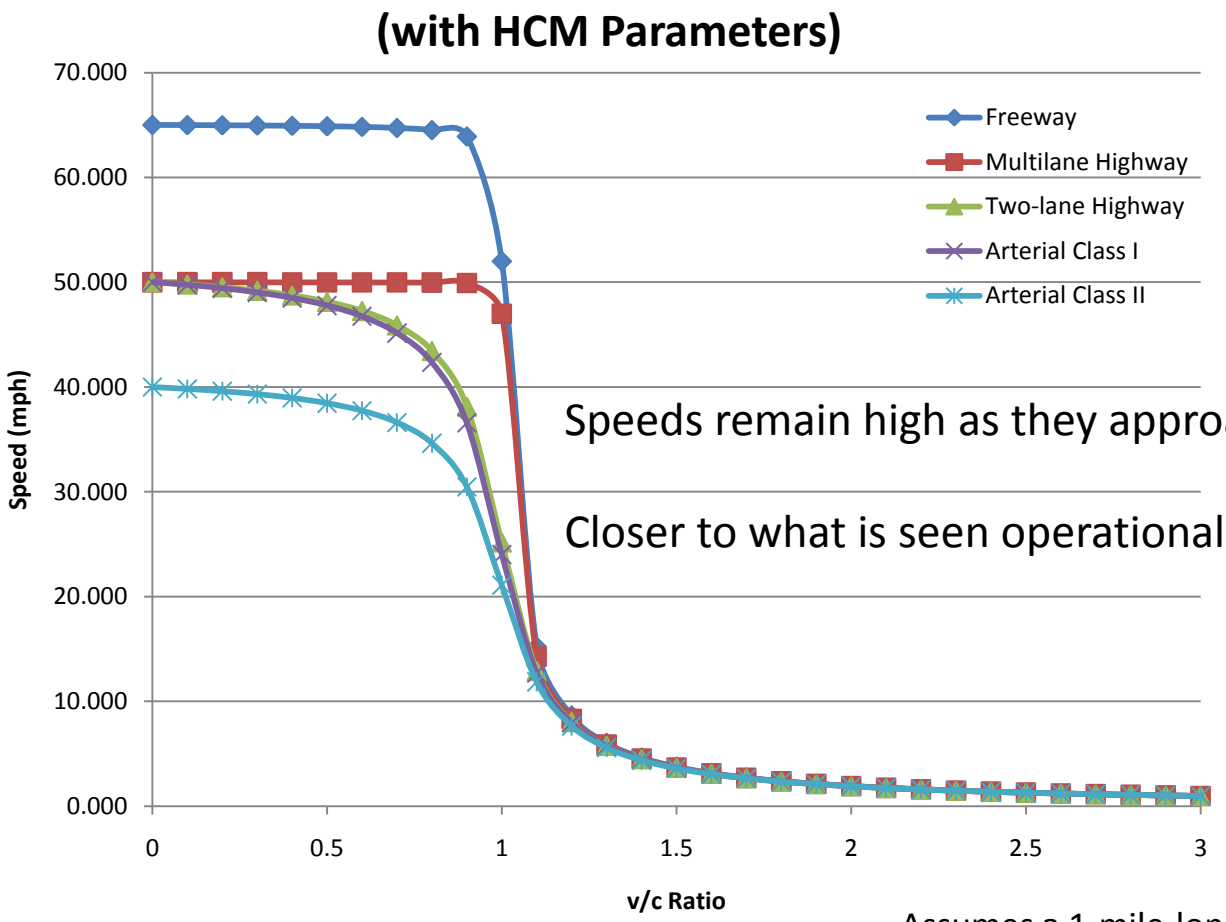


$$sigmoid = a\frac{1}{1+e^{-b(x-c)}}$$

Conical VDF + QDF



Akçelik VDF

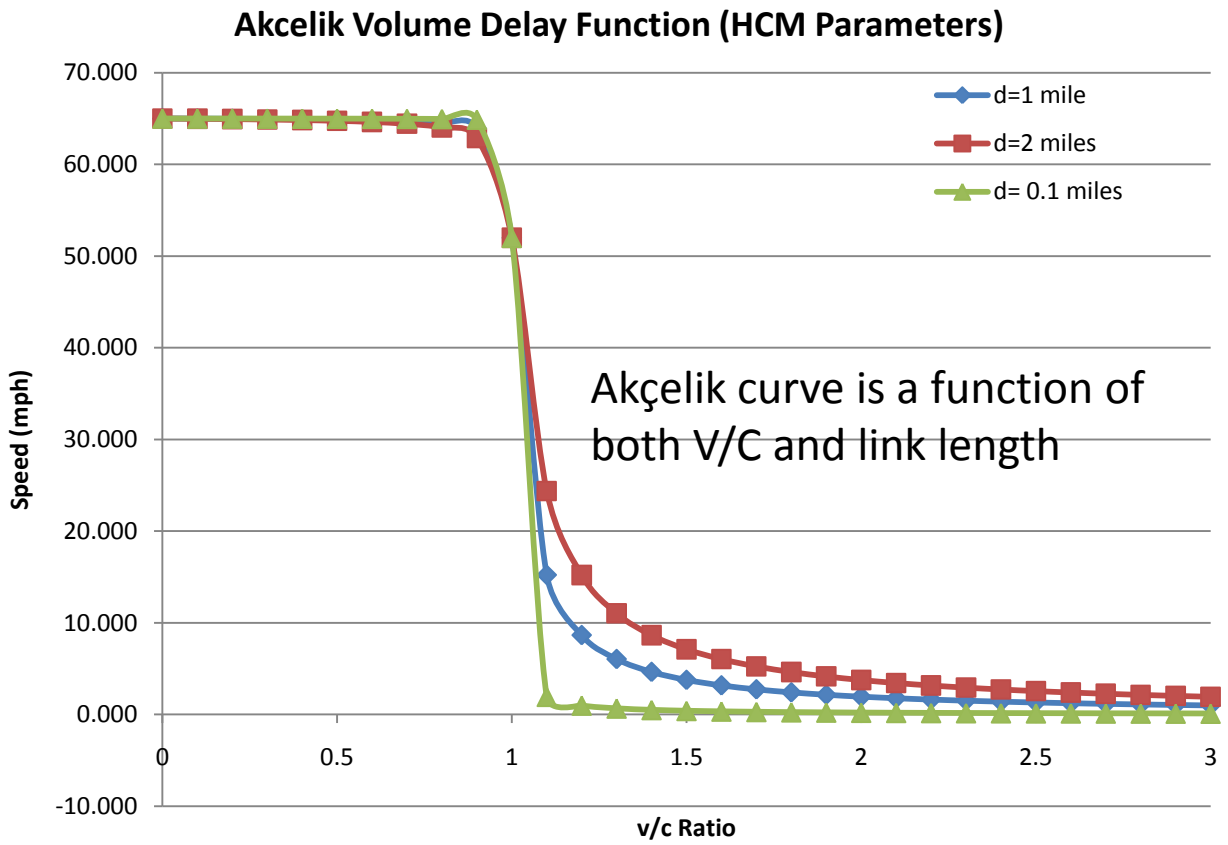


Speeds remain high as they approach a V/C of 1

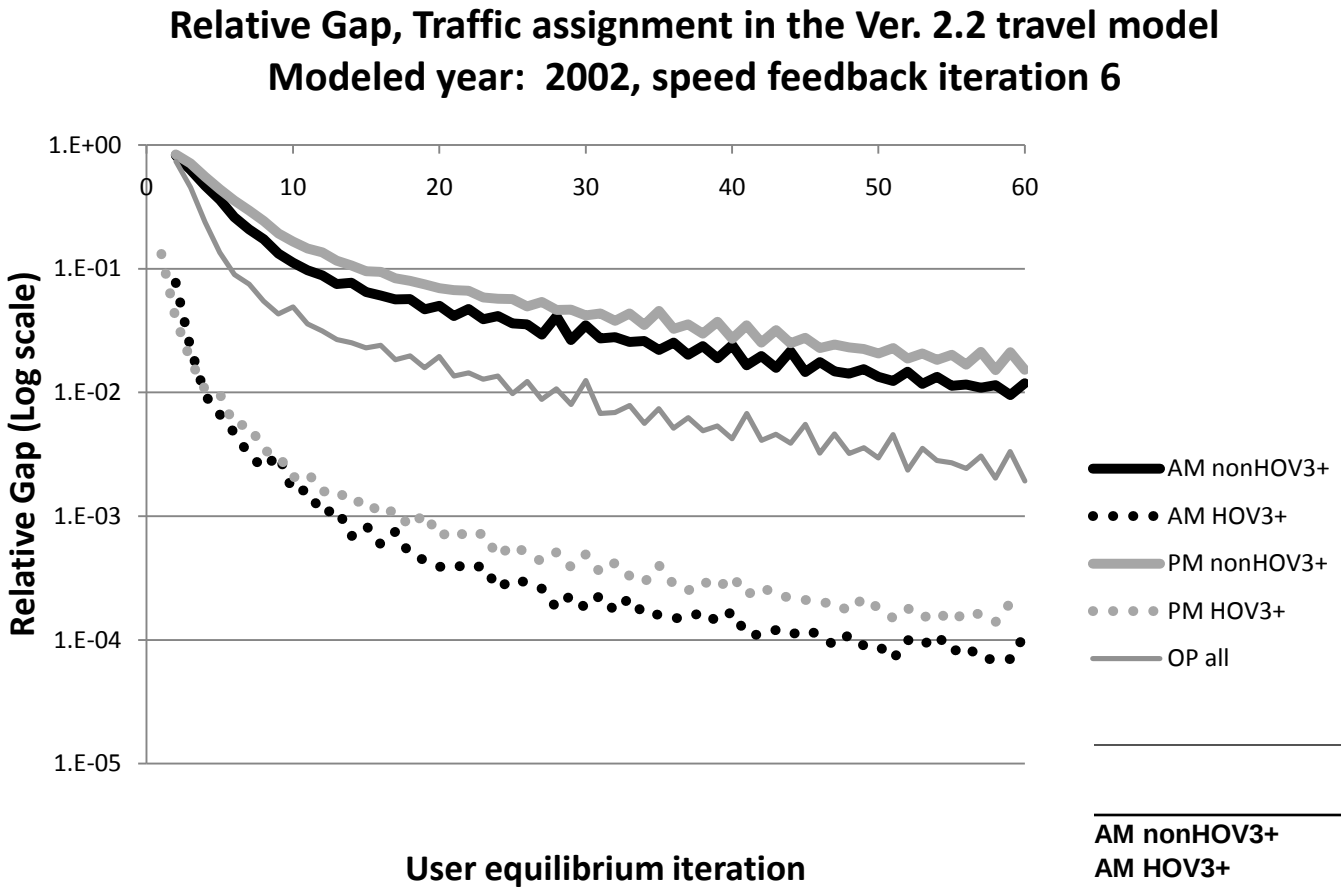
Closer to what is seen operationally

Assumes a 1-mile-long link

Effect of link length: Akçelik

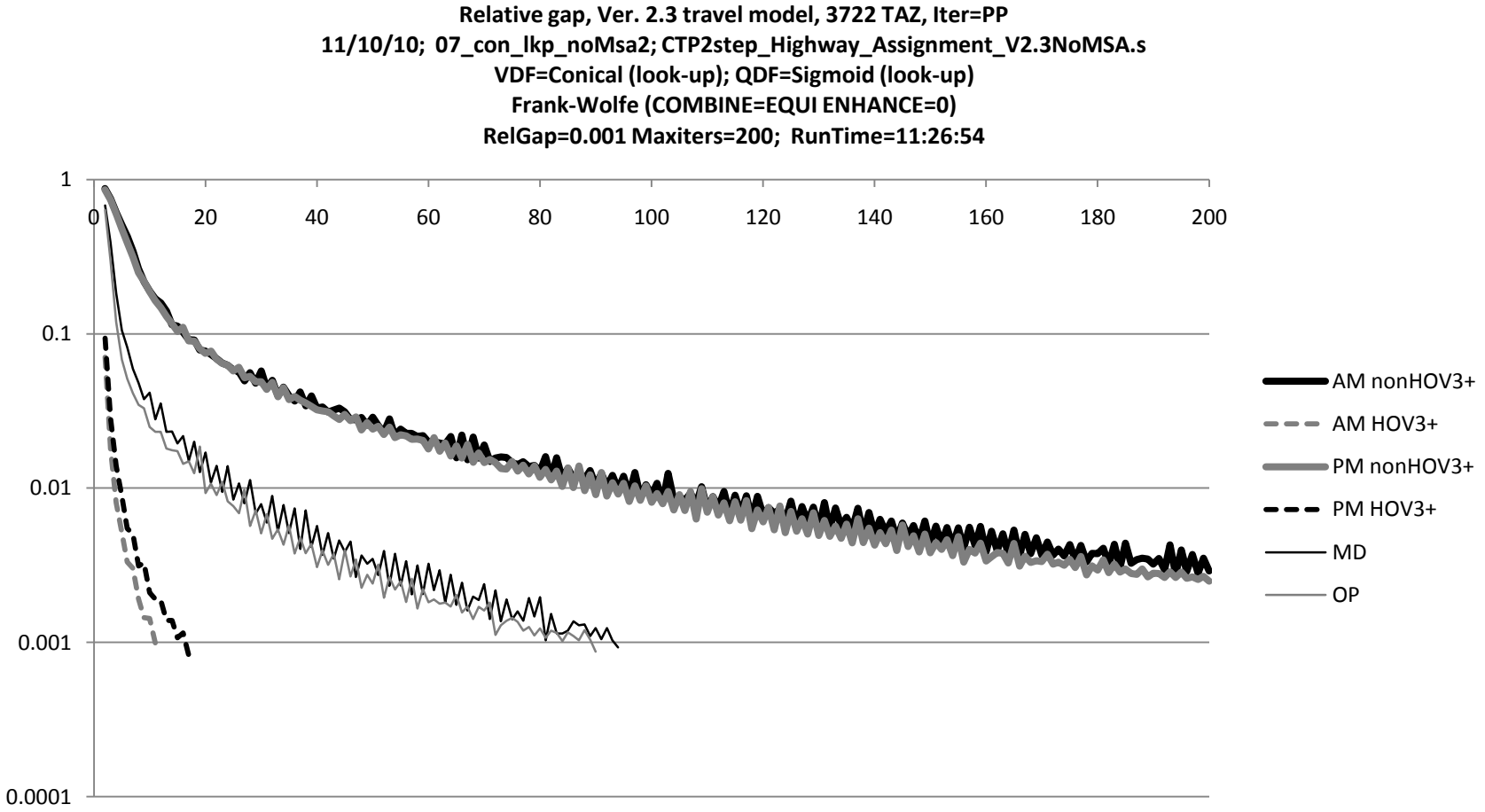


Ver. 2.2: What level of convergence?

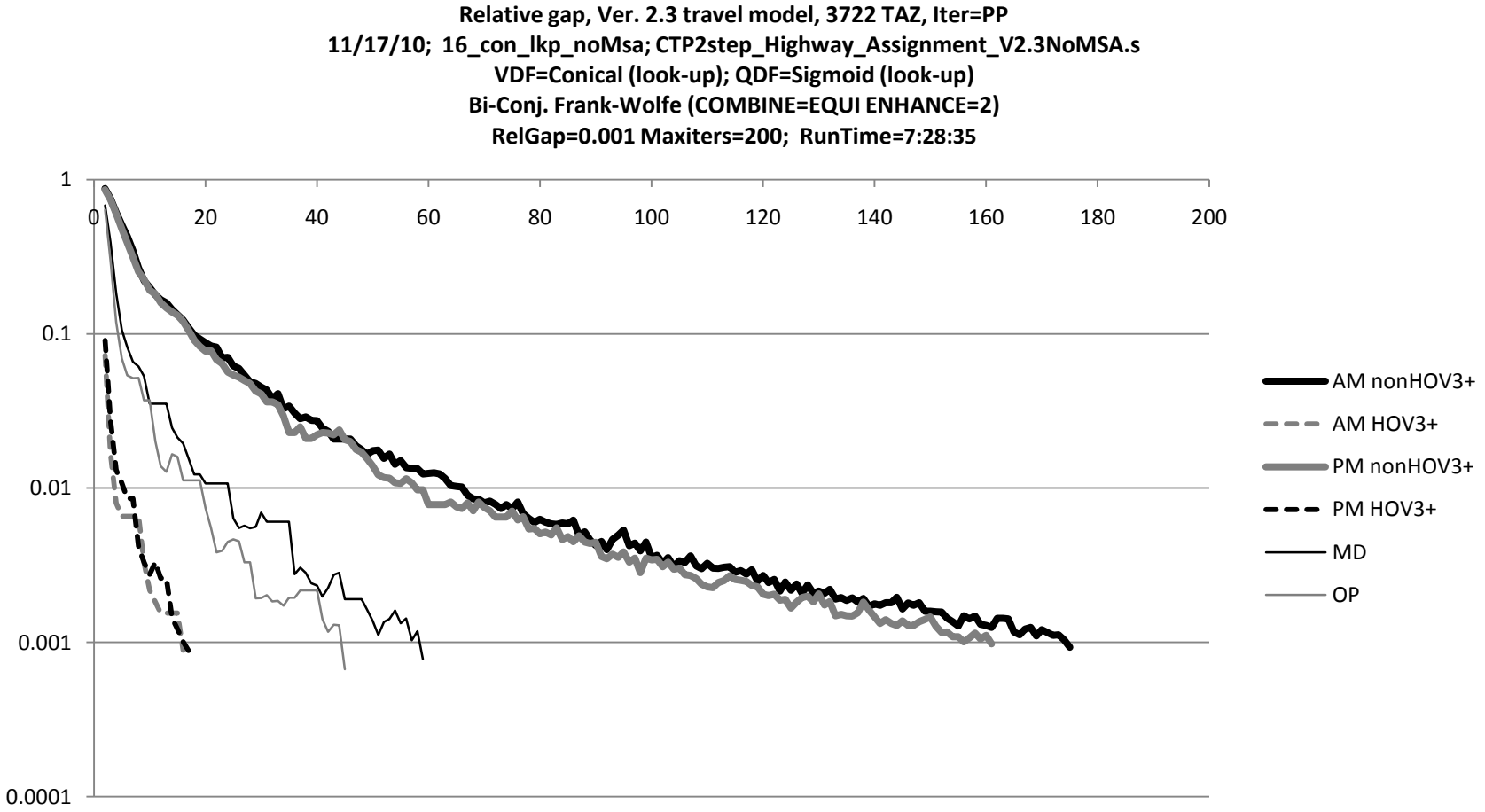


	Scientific Notation	Decimal
AM nonHOV3+	1.19E-02	0.0119
AM HOV3+	1.10E-04	0.0001
PM nonHOV3+	1.52E-02	0.0152
PM HOV3+	2.00E-04	0.0002
OP all	1.93E-03	0.0019

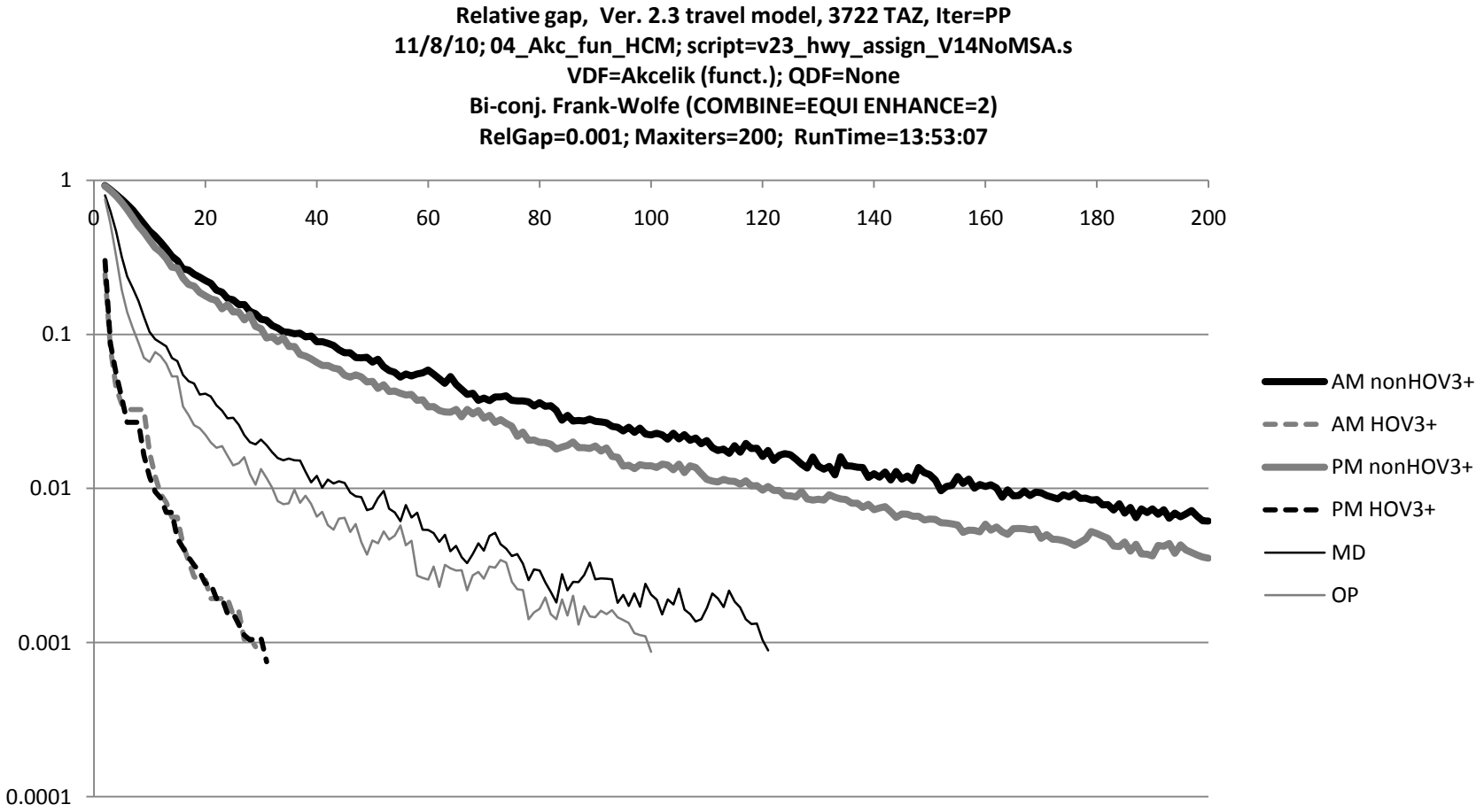
Ver. 2.3: What level of convergence? Base case with Frank-Wolfe



Ver. 2.3: What level of convergence? Base case with bi-conjugate F-W

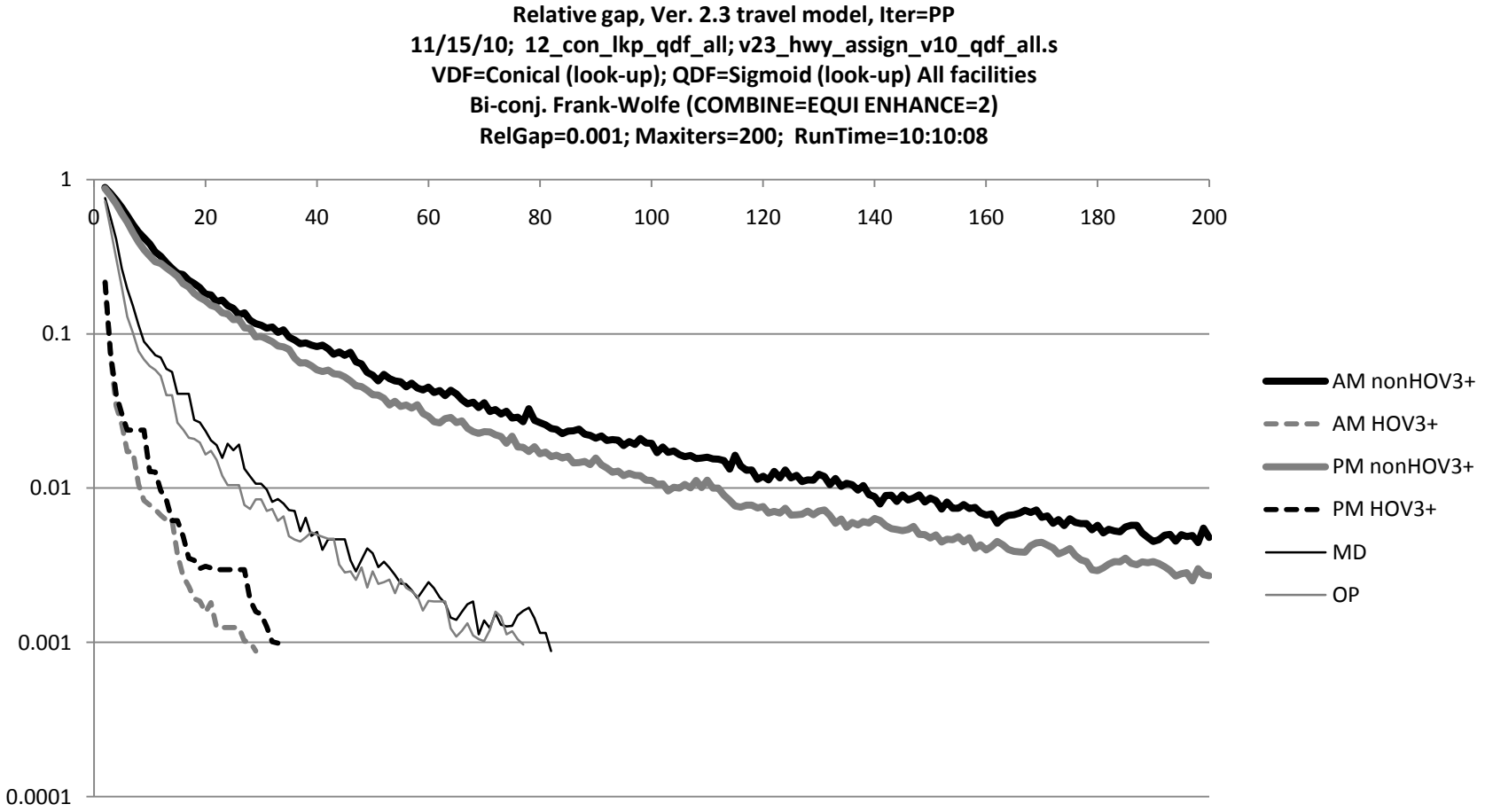


Ver. 2.3: What level of convergence? Akçelik VDF, RG=0.001



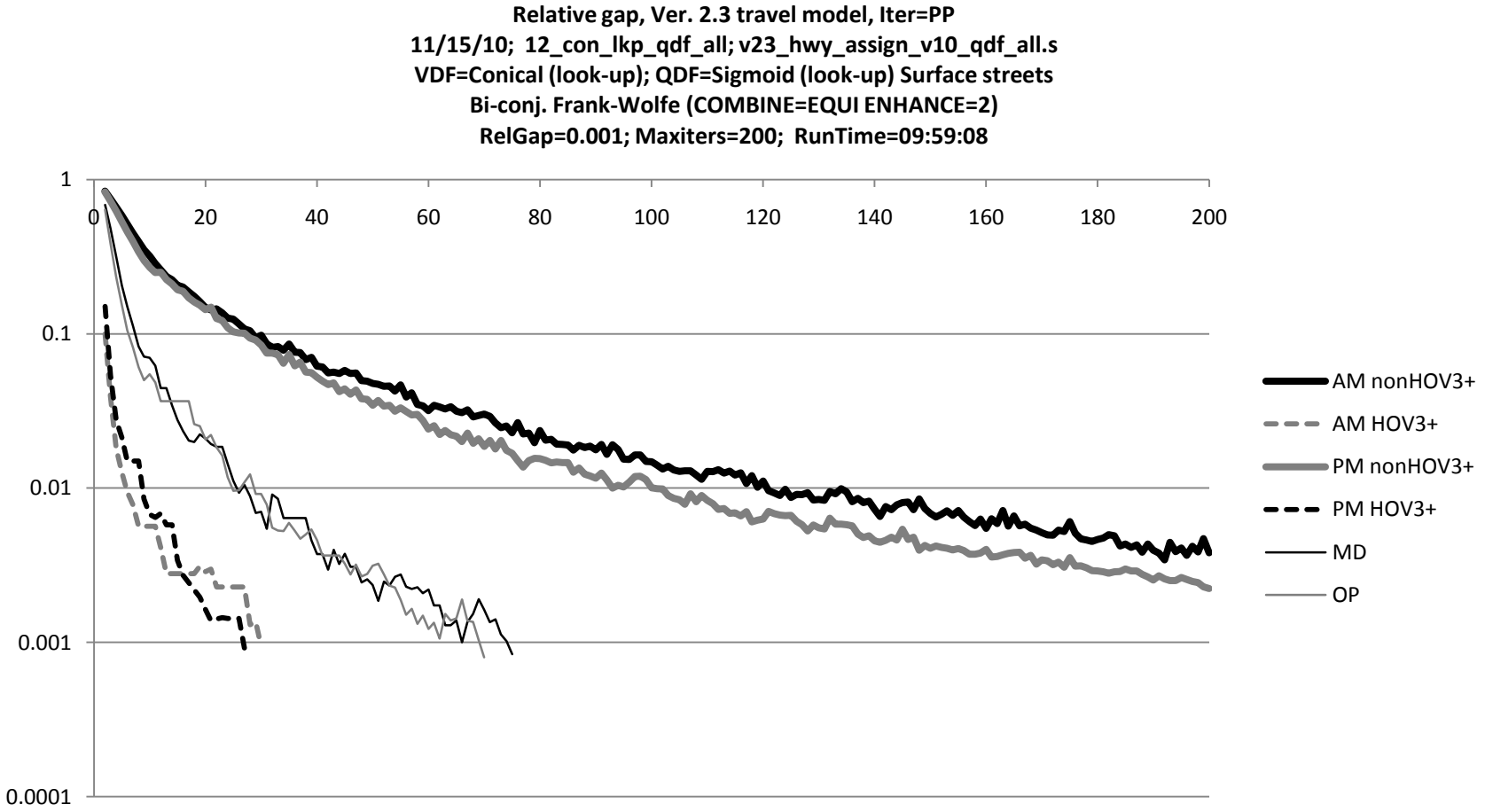
Ver. 2.3: What level of convergence?

Conical VDF, QDF: all facilities; RG=0.001



Ver. 2.3: What level of convergence?

Conical VDF, QDF: surface streets; RG=0.001

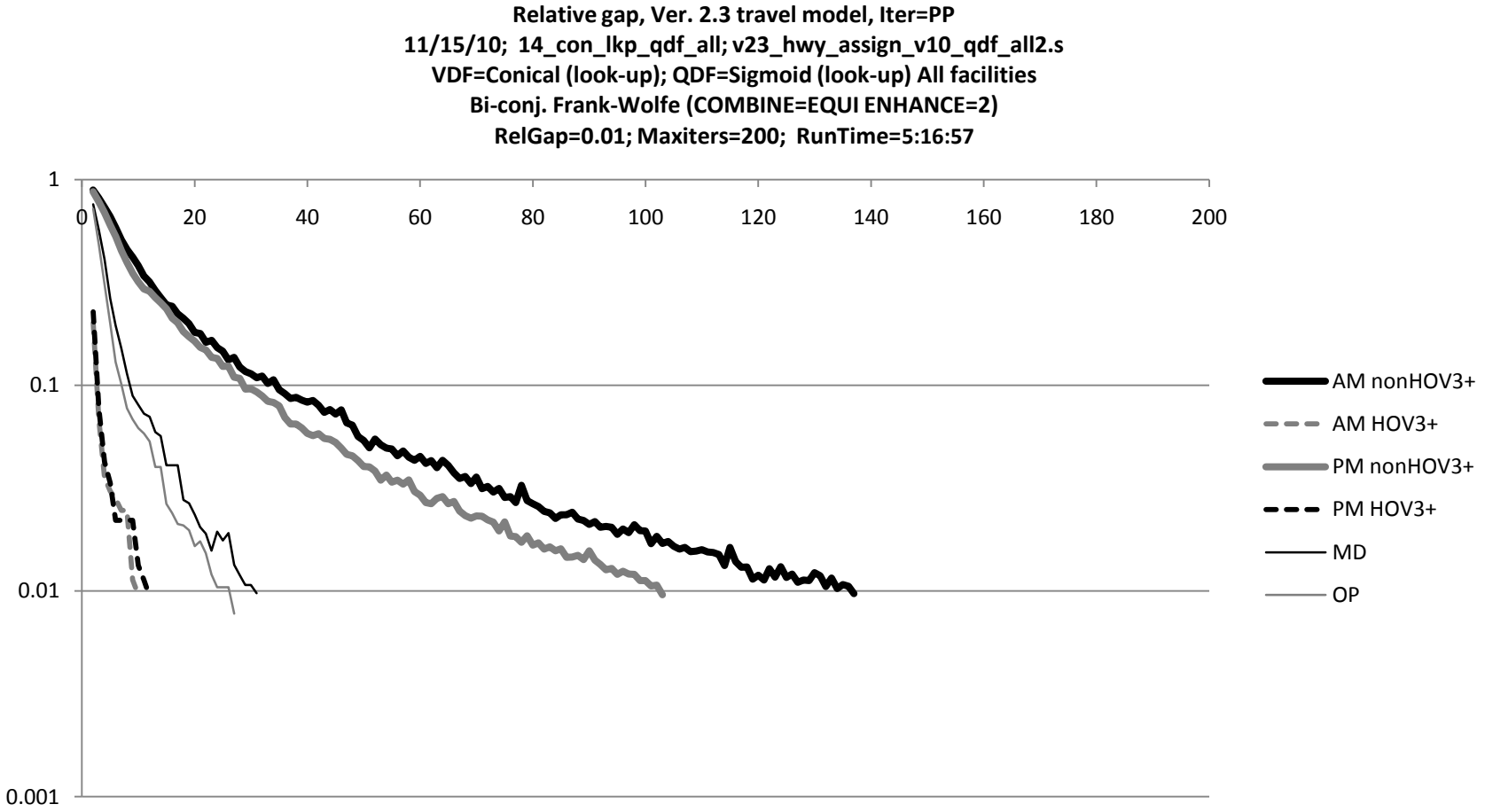


Goal for run time?

- 4-5 hours or less
- (4 hours)*(4 speed feedback iterations) = 16 hours
- 16 hours for traffic assignment + 10 hours for other parts of the model = 26 hours total run time (3722 TAZ)
- With distributed processing, we may be able to shrink 26 hours to the 15-19 hours required by the current Ver. 2.2 travel model (2191 TAZ)

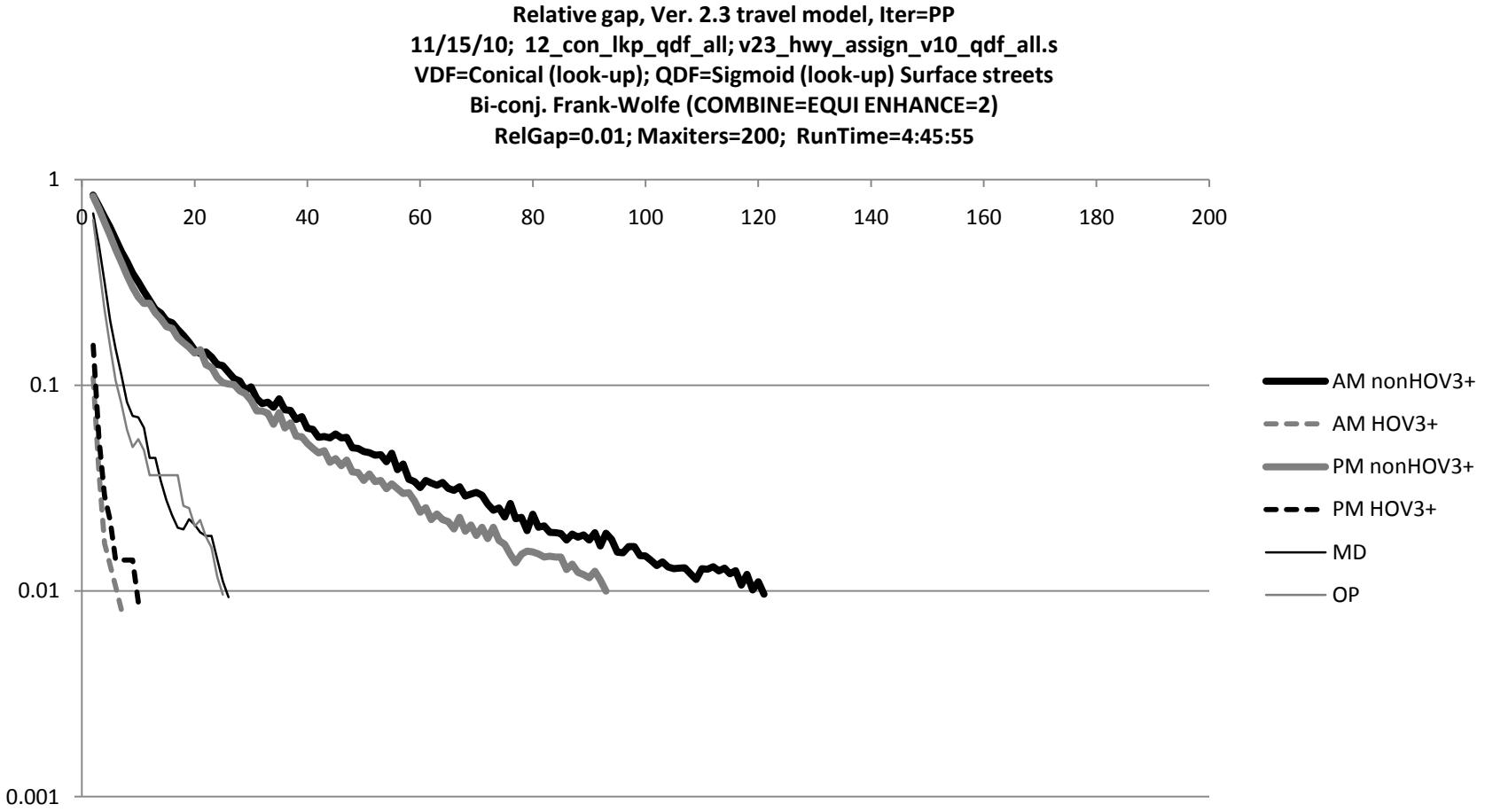
Ver. 2.3: What level of convergence?

Conical VDF, QDF: all facilities; RG=0.01



Ver. 2.3: What level of convergence?

Conical VDF, QDF: surface streets; RG=0.01



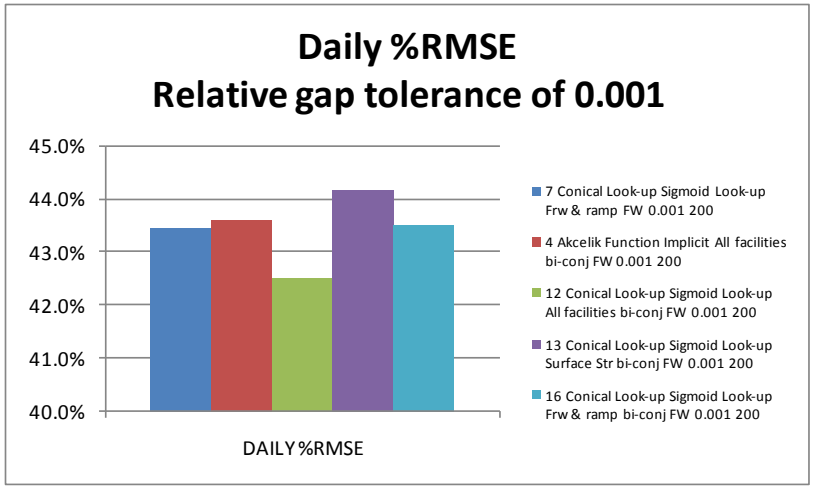
Summary of convergence & other statistics

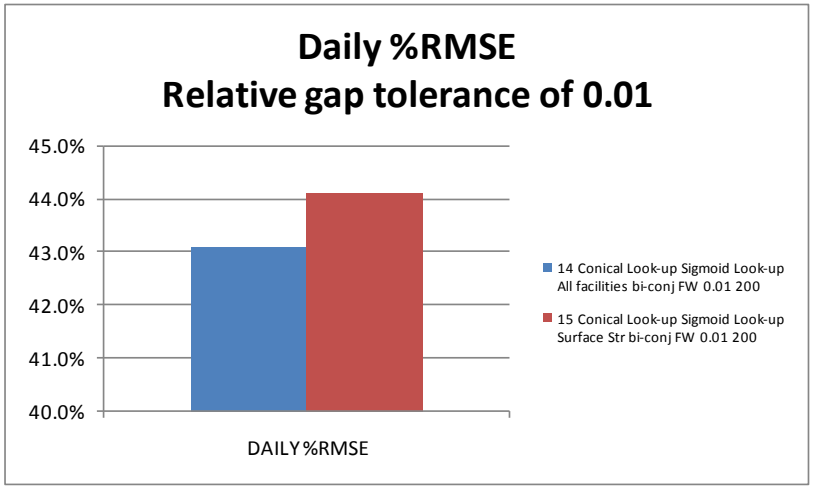
Run ID	VDF Funct. Form	VDF Implen-tation	QDF Funct. Form	QDF Implen-tation	QDF Extent	Algo-rithm	Stopping Crit. Rel. Gap	Stopping Crit. Max. No. of Iters	Run Time (h:m:s)	Total VMT
7	Conical	Look-up	Sigmoid	Look-up	Frw & ramp	FW	0.001	200	11:26:54	154,906,218
4	Akcelik	Function		Implicit	All facilities	bi-conj FW	0.001	200	13:53:07	159,313,692
12	Conical	Look-up	Sigmoid	Look-up	All facilities	bi-conj FW	0.001	200	10:10:08	159,535,714
13	Conical	Look-up	Sigmoid	Look-up	Surface Str	bi-conj FW	0.001	200	9:59:08	158,910,747
16	Conical	Look-up	Sigmoid	Look-up	Frw & ramp	bi-conj FW	0.001	200	7:28:35	154,762,237
14	Conical	Look-up	Sigmoid	Look-up	All facilities	bi-conj FW	0.01	200	5:16:57	160,051,141
15	Conical	Look-up	Sigmoid	Look-up	Surface Str	bi-conj FW	0.01	200	4:45:55	159,516,461

Run ID	No. of Iterations Needed to Converge: AM Non-HOV3+	AM HOV3+	PM Non-HOV3+	PM HOV3+	MD	OP	Relative Gap Values: AM Non-HOV3+	AM HOV3+	PM Non-HOV3+	PM HOV3+	MD	OP	Total Iter	Time per Iter (h:m:s)
7	200	11	200	17	94	90	0.00291	0.00099	0.00249	0.00082	0.00093	0.00087	612	0:01:07
4	200	29	200	31	121	100	0.00614	0.00094	0.00353	0.00075	0.00089	0.00087	681	0:01:13
12	200	29	200	33	82	77	0.00479	0.00088	0.00270	0.00099	0.00088	0.00097	621	0:00:59
13	200	30	200	27	75	70	0.00381	0.00094	0.00223	0.00092	0.00084	0.00080	602	0:01:00
16	175	16	161	17	59	45	0.00093	0.00089	0.00098	0.00088	0.00078	0.00067	473	0:00:57
14	137	10	103	12	31	27	0.00972	0.00956	0.00958	0.00938	0.00975	0.00776	320	0:00:59
15	121	7	93	10	26	25	0.00963	0.00814	0.00998	0.00884	0.00932	0.00959	282	0:01:01

Goodness of fit

	7	4	12	13	16	14	15
VDF function	**Conical**	**Akcelik**	**Conical**	**Conical**	**Conical**	**Conical**	**Conical**
VDF implem.	**Look-up**	**Function**	**Look-up**	**Look-up**	**Look-up**	**Look-up**	**Look-up**
QDF function	**Sigmoid**		**Sigmoid**	**Sigmoid**	**Sigmoid**	**Sigmoid**	**Sigmoid**
QDF implem.	**Look-up**	**Implicit**	**Look-up**	**Look-up**	**Look-up**	**Look-up**	**Look-up**
QDF extent	**Frw & ramp**	**All facilities**	**All facilities**	**Surface Str**	**Frw & ramp**	**All facilities**	**Surface Str**
Algorithm	**FW**	**bi-conj FW**	**bi-conj FW**	**bi-conj FW**	**bi-conj FW**	**bi-conj FW**	**bi-conj FW**
RelGap toler.	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.01**	**0.01**
Max Iters	**200**	**200**	**200**	**200**	**200**	**200**	**200**
AM %RMSE	57.5%	57.6%	56.0%	57.7%	57.6%	56.8%	57.6%
Midday %RMSE	45.8%	51.4%	45.9%	48.1%	45.8%	46.7%	48.2%
PM %RMSE	50.4%	50.5%	48.3%	51.7%	50.4%	49.5%	51.6%
Night %RMSE	96.3%	93.0%	96.3%	95.1%	96.3%	96.1%	94.7%
DAILY %RMSE	43.4%	43.6%	42.5%	44.2%	43.5%	43.1%	44.1%





Summary and conclusions

- Need consensus on VMT-related adjustments to model
- Use bi-conjugate F-W
  - Cut run time in half for relative gap of 0.001 (10^{-3})
- Do not use path-based assignment
  - Still running after seven days
- Use a relative gap (RG) stopping criterion, instead of the current criterion of MAXITERS=60
- Convergence goal of 0.001 (10^{-3}) RG would be nice, but 0.01 (10^{-2}) is more realistic and slightly exceeds Ver. 2.2 model

Summary and conclusions, 2

- Akçelik curve better fit with observed speed data
  - But, based on our tests, it converges slower than conical VDF
- Functional form of VDF (conical vs. Akçelik) does not have a large effect on goodness of fit metrics (%RMSE)
- Recommend:
  - Conical VDF with sigmoid QDF applied to all facilities
  - Right now: VDF & QDF applied as look-up tables; could also try applying as functions in the assignment script

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