TPB nested logit mode choice model: 2002, 2005, and 2030 results

Presentation to the
Travel Forecasting Subcommittee

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

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Presentations to the TFS

- March 23, 2007
  - Model structure
  - Status of NL MC model development & use at other MPOs
  - Status of NL MC model development at TPB
  - Preliminary 2002 region-level results
    - Generally good, but auto occupancies were overestimated
    - Need for re-calibration of NL MC
- July 20, 2007
  - Two slides in a presentation about FY-2007 models development
  - Status report on 2002 re-calibration of NL MC model
- Today (March 21, 2008)

Overview

- Background: Development of the NL MC model
- Calibration issues
- Model versions: 2.2 vs. 2.3
  - Description of 2.2 model
- Region-level model results
  - Assumptions & network coding
  - 2002 (calibration year; transit validation year)
  - 2005 (highway validation year)
  - 2030 (reasonableness validation)
- Other developments
- Conclusions
- Next steps

Background

Development of the NL MC model

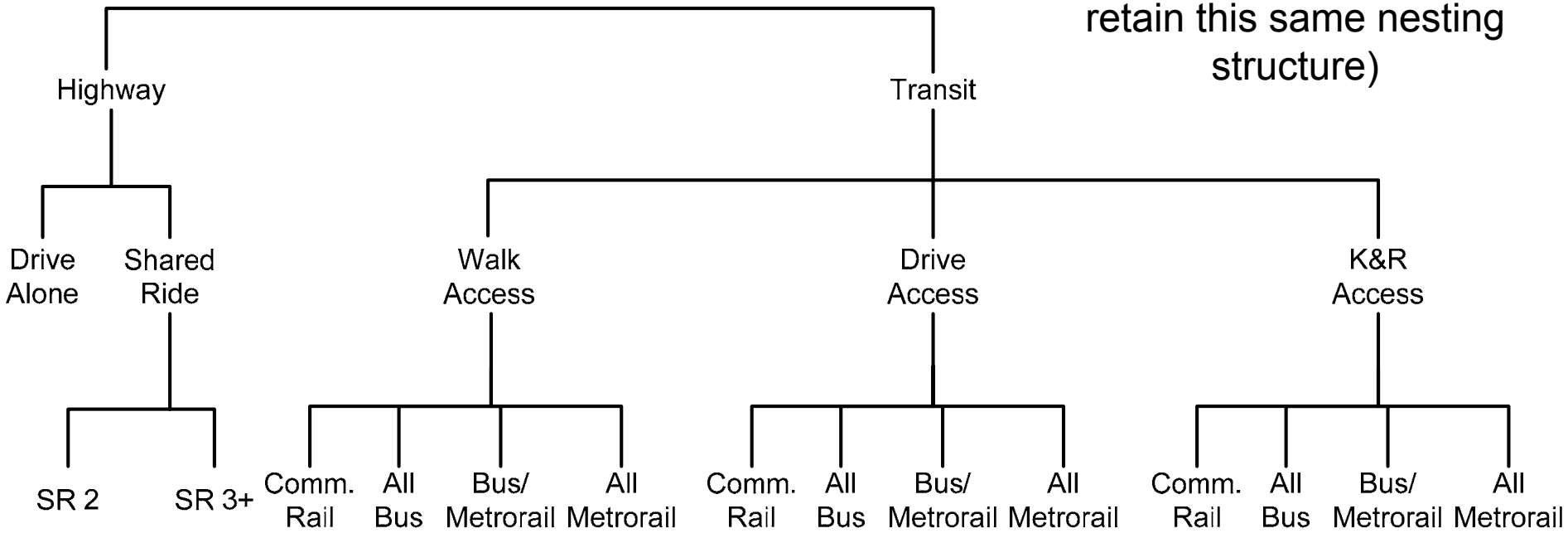
Development of the NL MC model: AECOM

- In 2004 and 2005, AECOM Consult, Inc. developed a new NL MC model for WMATA for the purpose of studying LRT alternatives in DC and Arlington
- Model was calibrated using
  - 2002 Metrorail survey
  - 2000 regional bus survey
  - Boarding counts for express bus & commuter rail
- Model was applied for the years 2002 and 2030 (also 2010, 2020, & 2030 in a later study: WMATA station access study)
- The AECOM/WMATA NL MC model is applied as a post-process to the COG/TPB four-step travel model
- Model has 15 choices
  - Three auto modes (DA, GR2, GR3+)
  - Four transit modes (Commuter rail, all bus, bus/Metrorail, all Metrorail) by three modes of arrival (Walk, PNR, KNR)

Development of the NL MC model: AECOM

Choices and nesting structure

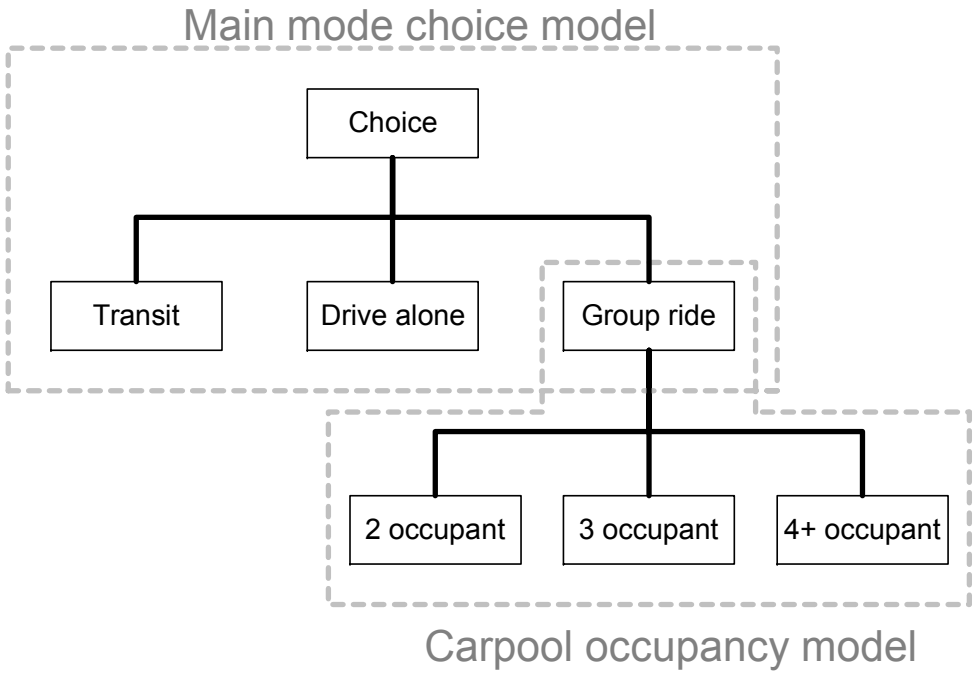
(TPB has chosen to retain this same nesting structure)



For comparison

Existing TPB mode choice model

- 5 modes
- Sequential multinomial logit (MNL)



Development of the NL MC model: AECOM

- The AECOM NL MC model is applied using a Fortran program named AEMS (AECOM mode split modeling package)
  - AEMS is completely parametric: All characteristics of the chosen MC model are specified in a control file. Characteristics include nesting structure, market segmentation, disutility functions, and values of coefficients/constants.
  - AEMS can handle models with any nesting structure and up to 15 choices (18 choices for a newer version)
- NL MC model has three trip purposes (HBW, HBS/O, NHB) and two transit levels of service (AM and off peak), combined such that there are six MC models
  - HBWAM, HBWOP, HBOAM, HBOOP, NHBAM, NHBOP

Development of the TPB NL MC model

- The TPB NL MC model has the same structure as that used by AECOM and is applied using the same software (AEMS)
- The TPB NL MC model is not applied as a post process. It replaces the existing, 5-mode multinomial logit (MNL) model within the speed feedback loop.
- The TPB NL MC model has four trip purposes (HBW, HBS, HBO, NHB) and two transit levels of service (AM and off peak), combined such that there are four MC models
  - HBWAM, HBSOP, HBOOP, NHBOP
- Due to the above changes, we have re-calibrated the NL MC model (2002 calibration year)

Calibration issues

Calibration of the NL MC model

- The NL MC model (both AECOM & TPB) consists of
  - A set of available modes/choices (15) and a nesting structure
  - Utility equations, which include time & cost coefficients, and income constants
  - Nesting coefficients (a.k.a. logsum parameters, or Φ) and nesting constants (NC)

Calibration of the NL MC model

- Utility equations, which include time & cost coefficients, and income constants
  - Disaggregate statistical estimation used for some parameters (Alogit)
  - Rules of thumb and professional judgment used for others (See next slide)
- Nesting coefficients (a.k.a. logsum parameters, or Φ)
  - Set using professional judgment
- Nesting constants (NC)
  - Estimated in calibration process

Time & cost coefficients and income constants

		Trip Purpose (4)				
Variable		**HBW**	**HBS**	**HBO**	**NHB**	**Rule**
In-vehicle time	ivt	-0.02128	-0.02168	-0.02322	-0.02860	Stat Est
Auto access time	ovtaa	-0.03192	-0.03252	-0.03483	-0.04290	1.5*ivt
Walk access time	ovtwa	-0.04256	-0.04336	-0.04644	-0.05720	2.0*ivt
Other out-of-vehicle time	ovtot	-0.05320	-0.05420	-0.05805	-0.07150	2.5*ivt
Cost - Income group 1	costinc1	-0.00185	-0.00202	-0.00202	-0.00994	Stat Est
Cost - Income group 2	costinc2	-0.00093	-0.00101	-0.00101	-0.00994	(base)/2
Cost - Income group 3	costinc3	-0.00062	-0.00067	-0.00067	-0.00994	(base)/3
Cost - Income group 4	costinc4	-0.00046	-0.00051	-0.00051	-0.00994	(base)/4
Boarding penalty	boardpen	-0.05320	-0.05805	-0.05805	-0.07150	2.5*ivt
Walk time	walktime	-0.04256	-0.04644	-0.04644	-0.05720	2.0*ivt
Constant		**HBW**	**HBS**	**HBO**	**NHB**	
INC1		2.00000	2.00000	2.00000	none	
INC2		0.00000	0.00000	0.00000	none	
INC3		0.00000	0.00000	0.00000	none	
INC4		-2.00000	-2.00000	-2.00000	none	

Nesting coefficients (Φ)

- Φ is a function of the underlying correlation between the unobserved components for pairs of alternatives in a nest, and it characterizes the degree of substitutability between those alternatives

$0 < \Phi < 1$	Valid range for NL (decreasing values of Φ indicate increased substitution among alts in the nest)
$\Phi > 1$	Reject NL model
$\Phi = 1$	Zero correlation among mode pairs in the nest, so NL => MNL
$\Phi = 0$	Implies perfect correlation between pairs of alternatives in the nest

Calibration approach, 1 of 2

- Initial approach taken by AECOM (2004)
  - Use trip-end production and attraction variables (the preferred approach by FTA).
  - However, calibration was problematic
    - Large/unstable constant values
    - Poor calibration results in some markets
- Revised calibration approach used by AECOM & TPB
  - Seven superdistricts were defined:

1 DC core	5 VA urban
2 VA core	6 MD suburban
3 DC urban	7 VA suburban
4 MD urban	

Calibration approach, 2 of 2

- Seven superdistricts were combined to make 20 production/attraction "market segments"
- There is one nesting constant (NC) for each market segment and each travel mode
- Calibration consists of estimating these nesting constants
- Automated calibration routine: CALIBMS

	Production Area	Attraction Area
1	DC	DC core
2	DC	VA core
3	DC	Urban DC, MD, VA
4	DC	Suburban MD, VA
5	MD urban	DC core
6	MD urban	VA core
7	MD urban	Urban DC, MD, VA
8	MD urban	Suburban MD, VA
9	VA core/urban	DC core
10	VA core/urban	VA core
11	VA core/urban	Urban DC, MD, VA
12	VA core/urban	Suburban MD, VA
13	MD suburban	DC core
14	MD suburban	VA core
15	MD suburban	Urban DC, MD, VA
16	MD suburban	Suburban MD, VA
17	VA suburban	DC core
18	VA suburban	VA core
19	VA suburban	Urban DC, MD, VA
20	VA suburban	Suburban MD, VA

2002 calibration: Targets vs. observed data

- To calibrate the NL MC model, you need a series of calibration "targets," which are simply daily person trips stratified by
  - Trip purpose (HBW, HBS, HBO, NHB),
  - Market segment (1-20), and
  - Travel mode (1-15)

2002 calibration: Targets vs. observed data

- 15 modes: 3 auto person and 12 transit
- Sources for transit targets (observed data)
  - Metrorail: 2002 WMATA rail survey
  - Bus: 2000 bus survey
  - Commuter rail and express bus: boarding counts
- Source for auto person targets
  - Simulated 2002 auto person trips, squeezed to 20 market segments, from a recent run of the Ver. 2.2 travel model.

Example: HBW targets for market segment 1 (DC to DC core)

Market Seg.	Mode	HBW Targets
(1) DC to DC CORE	DR ALONE	23,083
	SR2	5,483
	SR3+	2,192
	WK-CR	0
	WK-BUS	57,803
	WK-BU/MR	13,458
	WK-MR	39,020
	PNR-CR	0
	KNR-CR	0
	PNR-BUS	750
	KNR-BUS	263
	PNR-BU/MR	280
	KNR-BU/MR	107
	PNR-MR	7,476
	KNR-MR	2,769

Calibration: Lessons learned

- Calibration of nesting constants is done at an aggregate, market segment level (not the disaggregate level used for statistical estimation)
- Values of calibrated nesting constants should be checked. Large NCs
  - Could be the result of cases with a small number of observations
  - Could lead to unreasonable forecasts
  - Could be symptomatic of upstream problems

Model versions

2.2 versus 2.3

Model versions: 2.2 vs. 2.3

- **Version 2.2**
  - Production travel model
  - Final documentation, dated March 1, 2008, is available on the COG/TPB Website (www.mwcog.org, click Transportation => Committees => TPB Travel Forecasting Subcommittee => Documents)
  - All nested-logit mode choice (NLMC) work is built on top of the Ver. 2.2 model
  - Version 2.2 model has gone through a number of refinements over the last year
  - As the Ver. 2.2 model has been refined, those refinements have been reflected in the NL MC model work
  - All NL MC model work is DRAFT
- **Version 2.3** (forthcoming)
  - NL MC + new truck models
  - Planned release: May 2008

New features of Ver. 2.2 model

- 60 iterations of user equilibrium traffic assignment
  - 7 speed feedback iterations (pump prime, i1, …, i6)
- Commercial vehicle (CV) model
  - Previously CV trips were subsumed in NHB
- Assumptions about external and through travel were moderated
- Freeway queuing delay function
  - Previously there was none
- Reduced number of adjustment factors
- New approach for modeling HOT lanes

Toll and HOT lane modeling in the Ver. 2.2 model: Assumptions

- Speeds on HOT lanes should not degrade below prevailing speed
- HOV 3+ level of service should remain unaffected by HOT lane traffic

Toll and HOT lane modeling in the Ver. 2.2 model: Procedures

- Travel forecasts involving HOT-lane facilities are developed using two separate model runs:
  - The “base” run
    - All HOT lanes are coded as HOV 3+ lanes
    - Resulting HOV 3+ skims are preserved for later use
  - The “final” run, which uses specially developed HOT lane toll rates and the HOV 3+ skims from the base run.

Toll and HOT lane modeling in the Ver. 2.2 model: Procedures

- Mode choice: Travel model distinguishes between tolls on variably priced facilities, e.g., HOT lanes & electronic toll lanes (ETLs) and tolls on fixed-price facilities, e.g., Gov. Nice Bridge, Dulles Toll Road
  - Variably priced toll facilities: Tolls are converted to equivalent minutes, which are then added to the highway time
  - Fixed-price toll facilities: Tolls are maintained as monetary values

Region-level model results

2002, 2005, 2030

Modeling assumptions

- 2030 is run without the transit capacity constraint through the regional core
- Network coding
  - The 2002 network has enhanced network coding, added by AECOM for NL MC model
  - Due to resource limitations, 2005 and 2030 networks have only a subset of the enhanced network coding for the NL MC model (see next slide)

Network enhancements: Optimal vs. necessary - Manual vs. automatic

Network enhancement for using with NL MC model	Manual or automatic	Optimal or necessary	Used in "shortcut coding"
Revisions to the highway and transit networks			
1. Detailed coding around Metrorail stations that have park-and-ride lots (37 stations in 2002)	Manual	Optimal	No
2. Re-routing of transit routes around these Metrorail stations to take advantage of the detailed coding	Manual	Optimal	No
3. Highway network clean-ups	Manual	Optimal	No
4. Application of board-only, alight-only stops for express bus service in CBD	Manual	Optimal	No
Transit access coding			
5. Enhancements to the consolidated station database	Manual	Necessary	Yes
6. New method for coding auto-access links	Automatic	Necessary	Yes
7. Station transfer links	Automatic	Necessary	Yes
8. Sidewalk links and zonal walk links	Automatic	Necessary	Yes

Due to time constraints, the 2005 and 2030 networks make use of only the "necessary" network enhancements (#'s 5-8). The 2002 network had all eight enhancements.

2002 results

Calibration year, Transit validation

2002 mode choice output vs. targets: Trips by purpose and mode

Seg	Mode	HBW		HBS		HBO		NHB		ALL	
		Target	Model	Target	Model	Target	Model	Target	Model	Target	Model
All 20 Segments	DR ALONE	2,474,073	2,486,910	2,104,624	2,107,543	5,676,374	5,679,626	3,409,463	3,319,153	13,664,534	13,593,232
	SR2	421,199	422,084	617,343	618,278	2,143,646	2,144,801	1,119,518	1,152,837	4,301,706	4,338,000
	SR3+	137,425	139,085	328,506	328,728	1,499,201	1,499,683	646,987	707,836	2,612,119	2,675,332
	WK-CR	1,685	1,806	9	54	177	265	84	222	1,955	2,347
	WK-BUS	229,215	227,541	23,392	23,570	88,985	87,792	49,100	51,058	390,692	389,962
	WK-BU/MR	102,250	106,087	3,713	4,063	20,596	20,493	15,880	18,010	142,439	148,653
	WK-MR	127,994	117,727	5,069	5,620	36,247	35,853	75,458	76,548	244,768	235,748
	PNR-CR	20,901	20,634	92	88	1,627	2,493	1,725	2,088	24,345	25,304
	KNR-CR	1,492	1,481	7	10	117	378	121	211	1,737	2,081
	PNR-BUS	17,176	18,319	271	286	1,249	1,081	3,727	4,252	22,423	23,938
	KNR-BUS	5,393	5,426	422	434	1,112	1,057	2,456	2,197	9,383	9,114
	PNR-BU/MR	9,765	9,806	121	128	1,046	1,573	603	1,016	11,535	12,523
	KNR-BU/MR	5,012	5,104	258	251	1,382	1,929	1,465	1,941	8,117	9,225
	PNR-MR	141,501	141,185	1,080	1,269	17,302	16,561	9,134	8,090	169,017	167,104
	KNR-MR	39,193	39,626	551	599	5,625	5,250	4,955	3,966	50,324	49,441
	Total Person	3,734,274	3,742,822	3,085,458	3,090,922	9,494,686	9,498,835	5,340,676	5,349,424	21,655,094	21,682,004
	Total Transit	701,577	694,744	34,985	36,372	175,465	174,726	164,708	169,598	1,076,735	1,075,440
	Transit Pct	18.8%	18.6%	1.1%	1.2%	1.8%	1.8%	3.1%	3.2%	5.0%	5.0%

Sources of data for target trips:

1) Transit: 2002 WMATA rail survey; 2000 bus survey, adjusted; boarding counts for express bus & commuter rail.

2) Auto: Most recent run of the NL MC model within the speed feedback loop of the Vers. 2.2 travel model

2002 mode choice output vs. targets: Trips by purpose and market segment

Market Seg.			HBW		HBS		HBO		NHB		ALL	
			Target	Model	Target	Model	Target	Model	Target	Model	Target	Model
1	DC	DC core	152,684	151,495	17,559	17,702	139,698	143,588	137,162	132,062	447,103	444,848
2	DC	VA core	14,850	15,464	6,418	9,267	9,759	9,400	13,501	14,814	44,528	48,945
3	DC	Urban DC, MD, VA	98,003	97,973	137,912	138,753	482,102	480,094	226,100	223,333	944,117	940,153
4	DC	Suburban MD, VA	49,995	51,766	51,650	48,622	136,144	130,805	163,374	174,148	401,163	405,341
5	MD urban	DC core	30,207	29,505	683	748	12,359	12,518	10,206	11,030	53,455	53,801
6	MD urban	VA core	2,941	2,985	151	254	847	830	1,075	1,147	5,014	5,216
7	MD urban	Urban DC, MD, VA	37,294	36,849	58,552	57,148	159,233	157,016	84,830	76,447	339,909	327,460
8	MD urban	Suburban MD, VA	25,435	26,046	40,951	41,605	69,692	68,765	76,581	81,031	212,659	217,447
9	VA core/urban	DC core	49,399	49,323	647	410	30,505	29,165	31,246	33,682	111,797	112,580
10	VA core/urban	VA core	21,678	21,236	11,375	13,356	26,450	28,127	23,841	23,464	83,344	86,183
11	VA core/urban	Urban DC, MD, VA	45,641	45,662	91,803	92,953	223,420	225,656	132,268	128,998	493,132	493,269
12	VA core/urban	Suburban MD, VA	45,138	46,029	24,899	22,307	117,726	116,715	116,627	128,649	304,390	313,700
13	MD suburban	DC core	227,200	232,161	1,480	1,517	60,636	60,992	37,452	40,779	326,768	335,448
14	MD suburban	VA core	28,210	29,987	1,007	1,683	5,804	6,211	4,555	5,377	39,576	43,259
15	MD suburban	Urban DC, MD, VA	254,948	256,796	42,907	44,089	307,909	309,559	166,145	178,007	771,909	788,452
16	MD suburban	Suburban MD, VA	1,309,720	1,302,899	1,432,115	1,430,876	4,389,428	4,385,181	2,321,219	2,301,970	9,452,482	9,420,924
17	VA suburban	DC core	137,560	137,101	502	374	35,438	31,908	27,663	27,889	201,163	197,272
18	VA suburban	VA core	50,042	48,981	5,132	6,567	17,595	17,928	13,905	15,597	86,674	89,074
19	VA suburban	Urban DC, MD, VA	122,093	123,335	57,762	66,015	158,230	160,659	110,635	120,768	448,720	470,777
20	VA suburban	Suburban MD, VA	1,031,236	1,037,229	1,101,953	1,096,674	3,111,711	3,123,718	1,642,291	1,630,234	6,887,191	6,887,855
			3,734,274	3,742,822	3,085,458	3,090,922	9,494,686	9,498,835	5,340,676	5,349,424	21,655,094	21,682,004
			701,577	694,744	34,985	36,372	175,465	174,726	164,708	169,598	1,076,735	1,075,440
			18.8%	18.6%	1.1%	1.2%	1.8%	1.8%	3.1%	3.2%	5.0%	5.0%

Sources of data for target trips:

1) Transit: 2002 WMATA rail survey; 2000 bus survey, adjusted; boarding counts for express bus & commuter rail.

2) Auto: Most recent run of the NL MC model within the speed feedback loop of the Vers. 2.2 travel model

2005 results

Highway validation

2005 model results

- Regional traffic assignment
  - VMT by state:
    - Comparison with HPMS data: VMT by state
  - Traffic assignment by facility type:
    - Root mean square error (RMSE)
  - Traffic assignment by screenline

Comparison with HPMS data: Ver. 2.2 w/ MNL MC vs. Ver. 2.2 w/ NL MC

Estimated and Obseved VMT by state (HPMS), 2005
Ver. 2.2 travel model with 5-mode MNL MC model

MSA	Est.	Est(000s)	Obs(000s)	E-O Ratio
DC	8,999,024	8,999	8,619	1.04
MD	56,001,823	56,002	56,806	0.99
VA	51,031,195	51,031	50,733	1.01
MSA Total	116,032,042	116,032	116,158	1.00

Run date: 2/6/2008

Estimated and Obseved VMT by state (HPMS), 2005
Ver. 2.2 travel model with 15-mode NL MC model

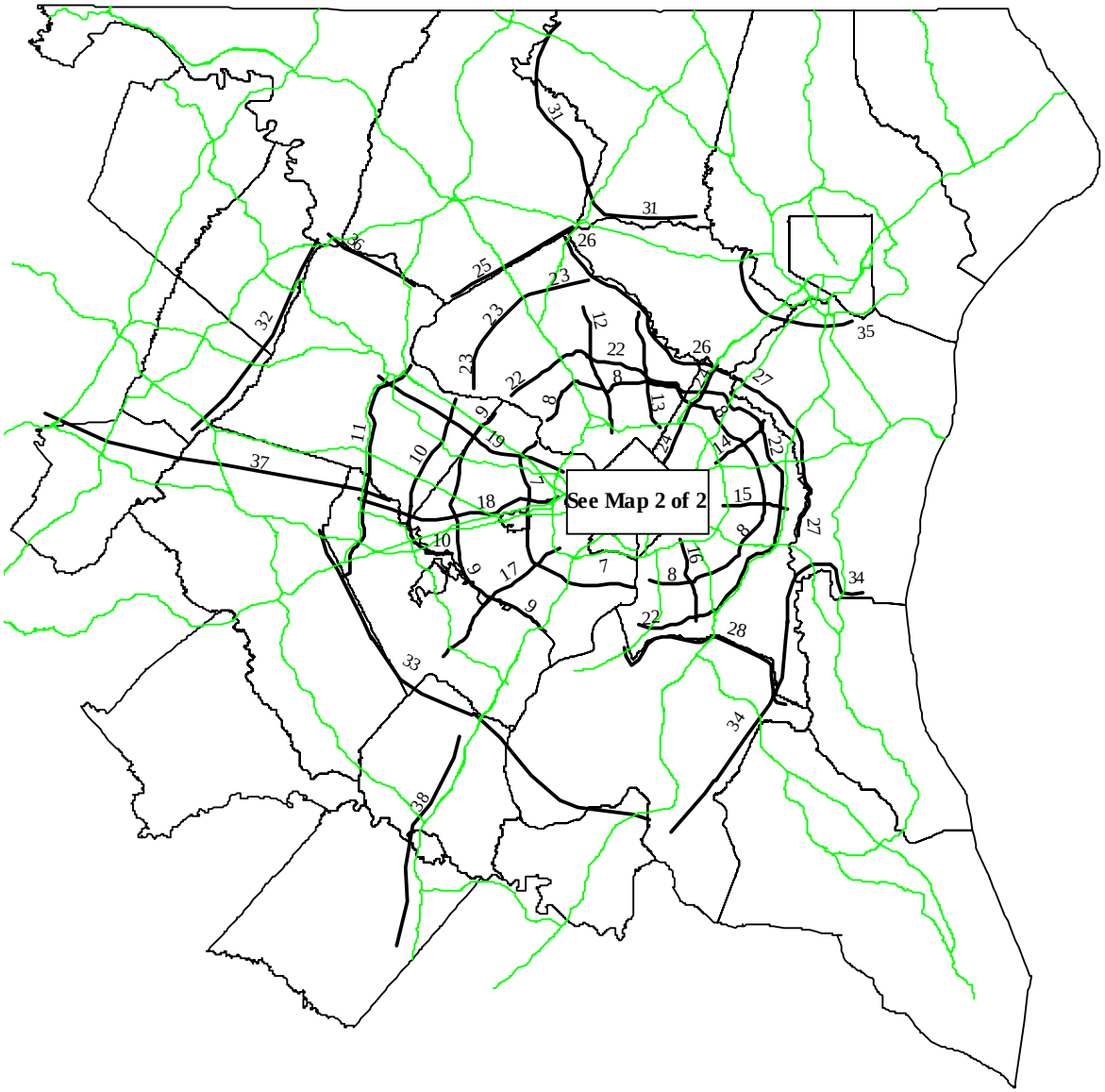
MSA	Est.	Est(000s)	Obs(000s)	E-O Ratio
DC	8,905,733	8,906	8,619	1.03
MD	57,086,008	57,086	56,806	1.00
VA	52,241,946	52,242	50,733	1.03
MSA Total	118,233,687	118,234	116,158	1.02

Run date: 2/26/2008

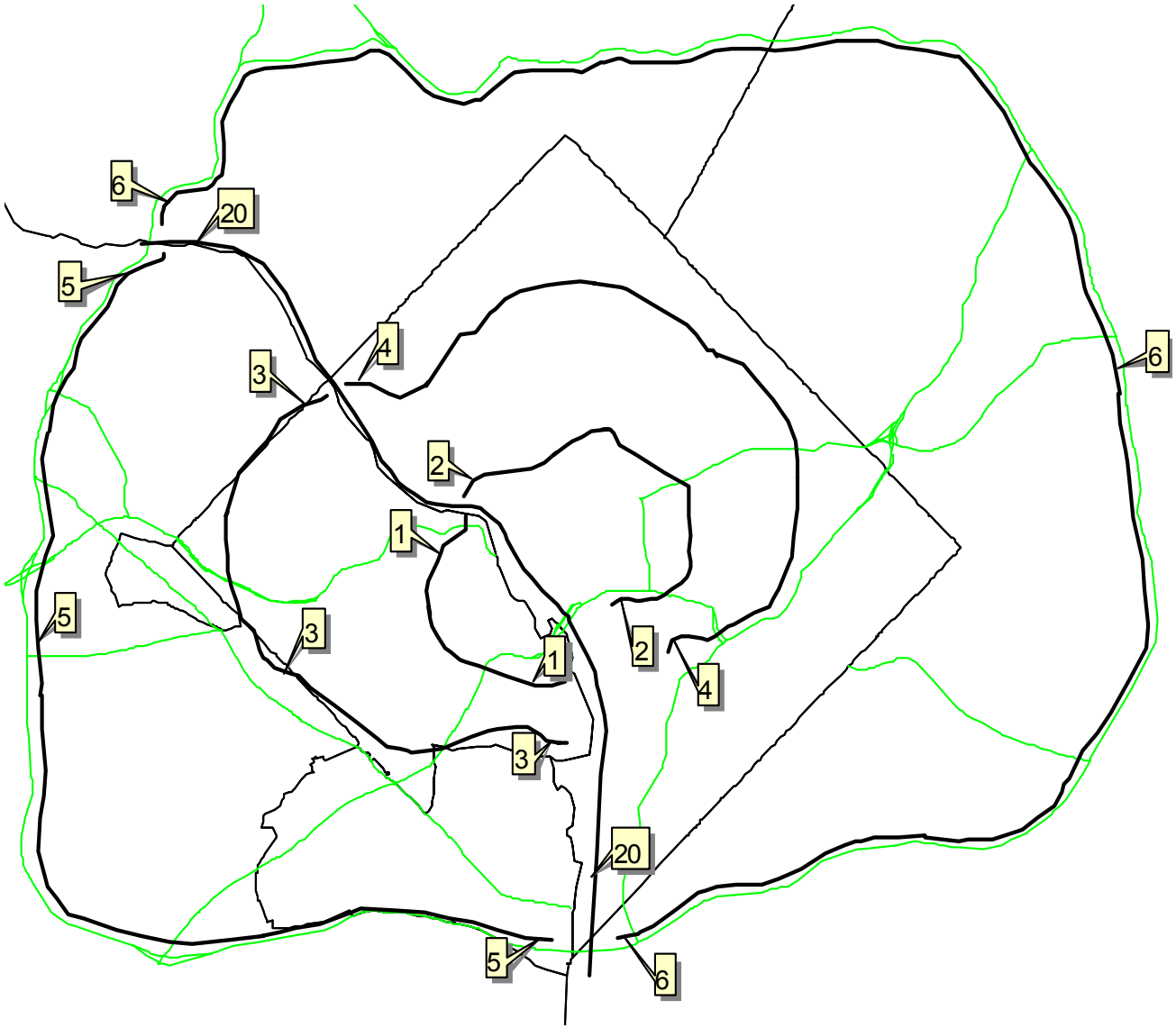
Regional traffic assignment performance: %RMSE by facility type

Facility Type	Ver. 2.2 MNL MC Percent RMSE	Ver. 2.2 MNL MC Link Count	Ver. 2.2 NL MC Percent RMSE	Ver. 2.2 NL MC Link Count
Freeway	21.05	539	21.01	539
Major Arterial	42.21	2,376	42.86	2,376
Minor Arterial	60.56	1,338	61.76	1,338
Collector	77.56	973	77.62	972
Expressway	34.48	136	34.60	136
Total	41.12	5,362	41.44	5,361

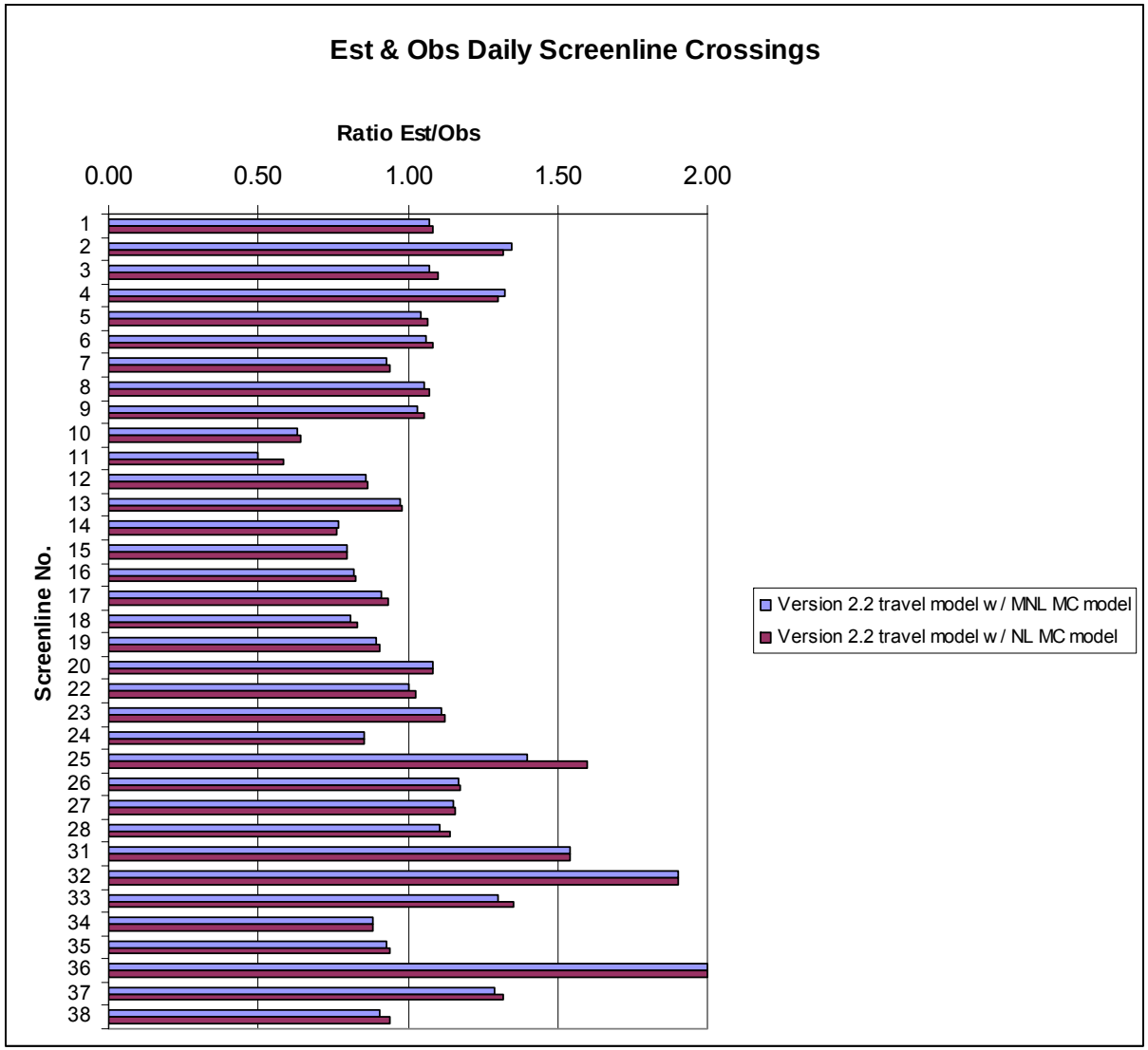
Screenline map (1 of 2)



Screenline map (2 of 2)



Year-2005 validation: Screenlines

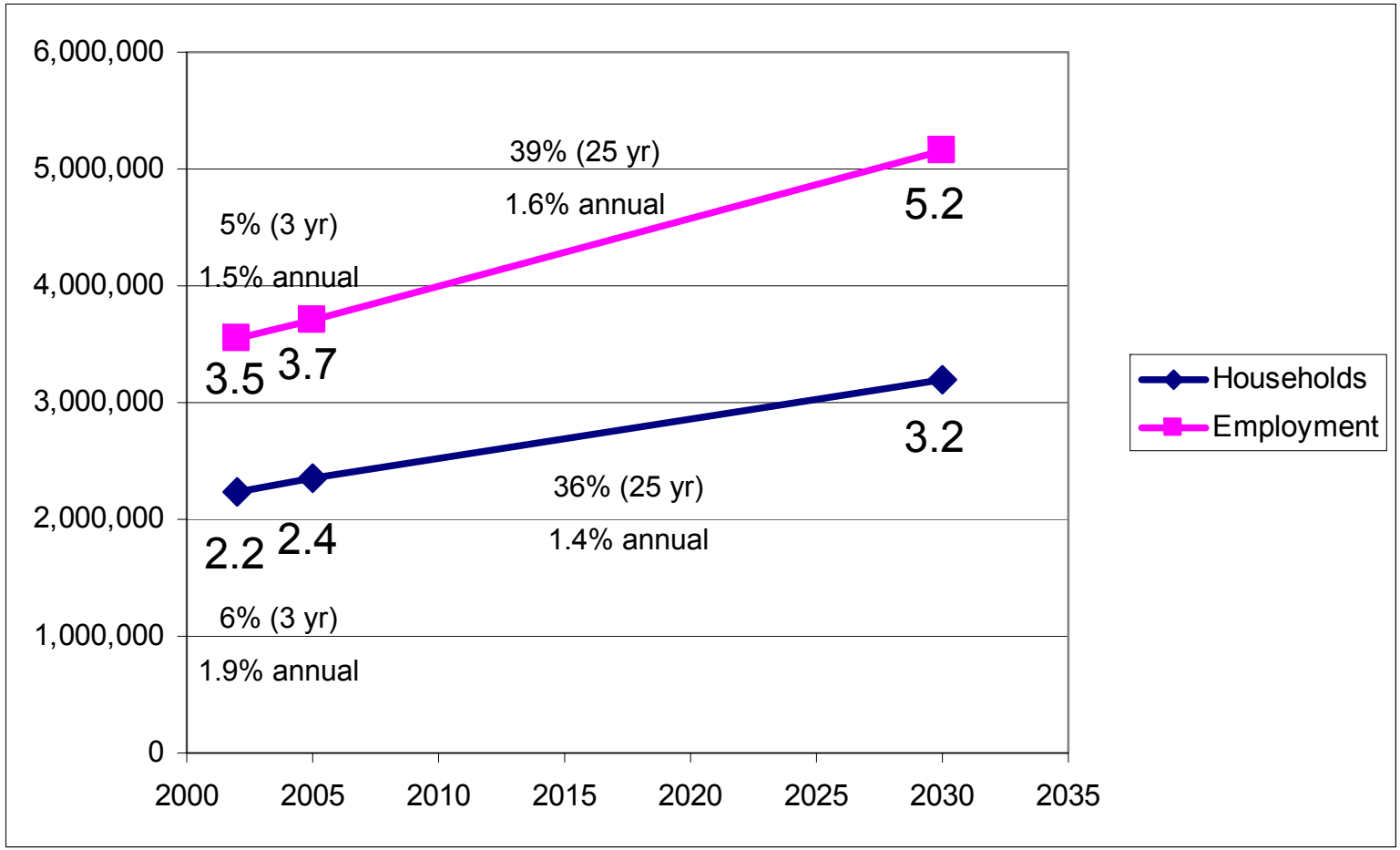


Year-2005 validation: Screenlines

Screen-line No.	Version 2.2 travel model w/ MNL MC model						Version 2.2 travel model w/ NL MC model					
	Est	Obs	Ratio Est/Obs	Number of links with screenline code	Number of links with observ counts	Pct of links with counts	Est	Obs	Ratio Est/Obs	Number of links with screenline code	Number of links with observ counts	Pct of links with counts
1	325	304	**1.07**	40	18	45.0%	329	304	**1.08**	40	18	45.0%
2	396	294	**1.35**	74	14	18.9%	388	294	**1.32**	74	14	18.9%
3	381	356	**1.07**	56	22	39.3%	392	356	**1.10**	56	22	39.3%
4	485	366	**1.33**	66	22	33.3%	477	366	**1.30**	66	22	33.3%
5	394	378	**1.04**	52	14	26.9%	402	378	**1.06**	52	14	26.9%
6	1,050	992	**1.06**	100	40	40.0%	1,072	992	**1.08**	100	40	40.0%
7	667	720	**0.93**	66	30	45.5%	675	720	**0.94**	66	30	45.5%
8	521	494	**1.05**	102	22	21.6%	529	494	**1.07**	102	22	21.6%
9	685	664	**1.03**	46	26	56.5%	699	664	**1.05**	46	26	56.5%
10	77	122	**0.63**	20	8	40.0%	78	122	**0.64**	20	8	40.0%
11	6	12	**0.50**	18	4	22.2%	7	12	**0.58**	18	4	22.2%
12	234	272	**0.86**	32	6	18.8%	236	272	**0.87**	32	6	18.8%
13	234	240	**0.98**	18	4	22.2%	235	240	**0.98**	18	4	22.2%
14	187	244	**0.77**	16	2	12.5%	186	244	**0.76**	16	2	12.5%
15	172	216	**0.80**	12	2	16.7%	172	216	**0.80**	12	2	16.7%
16	133	162	**0.82**	16	2	12.5%	134	162	**0.83**	16	2	12.5%
17	84	92	**0.91**	30	10	33.3%	86	92	**0.93**	30	10	33.3%
18	248	306	**0.81**	35	18	51.4%	254	306	**0.83**	35	18	51.4%
19	394	442	**0.89**	42	20	47.6%	401	442	**0.91**	42	20	47.6%
20	1,037	958	**1.08**	14	14	100.0%	1,039	958	**1.08**	14	14	100.0%
22	559	558	**1.00**	118	26	22.0%	571	558	**1.02**	118	26	22.0%
23	156	140	**1.11**	24	8	33.3%	157	140	**1.12**	24	8	33.3%
24	253	296	**0.85**	28	4	14.3%	253	296	**0.85**	28	4	14.3%
25	14	10	**1.40**	8	2	25.0%	16	10	**1.60**	8	2	25.0%
26	372	318	**1.17**	20	12	60.0%	373	318	**1.17**	20	12	60.0%
27	177	154	**1.15**	16	8	50.0%	178	154	**1.16**	16	8	50.0%
28	31	28	**1.11**	10	2	20.0%	32	28	**1.14**	10	2	20.0%
31	111	72	**1.54**	20	12	60.0%	111	72	**1.54**	20	12	60.0%
32	76	40	**1.90**	8	4	50.0%	76	40	**1.90**	8	4	50.0%
33	104	80	**1.30**	14	6	42.9%	108	80	**1.35**	14	6	42.9%
34	74	84	**0.88**	14	10	71.4%	74	84	**0.88**	14	10	71.4%
35	792	854	**0.93**	42	30	71.4%	803	854	**0.94**	42	30	71.4%
36	48	24	**2.00**	6	4	66.7%	48	24	**2.00**	6	4	66.7%
37	49	38	**1.29**	10	8	80.0%	50	38	**1.32**	10	8	80.0%
38	152	168	**0.90**	18	14	77.8%	158	168	**0.94**	18	14	77.8%
Total	**10,678**	**10,498**	**1.02**	**1,211**	**448**	**37.0%**	**10,799**	**10,498**	**1.03**	**1,211**	**448**	**37.0%**

2002, 2005 & 2030 results

Inputs: Households & jobs



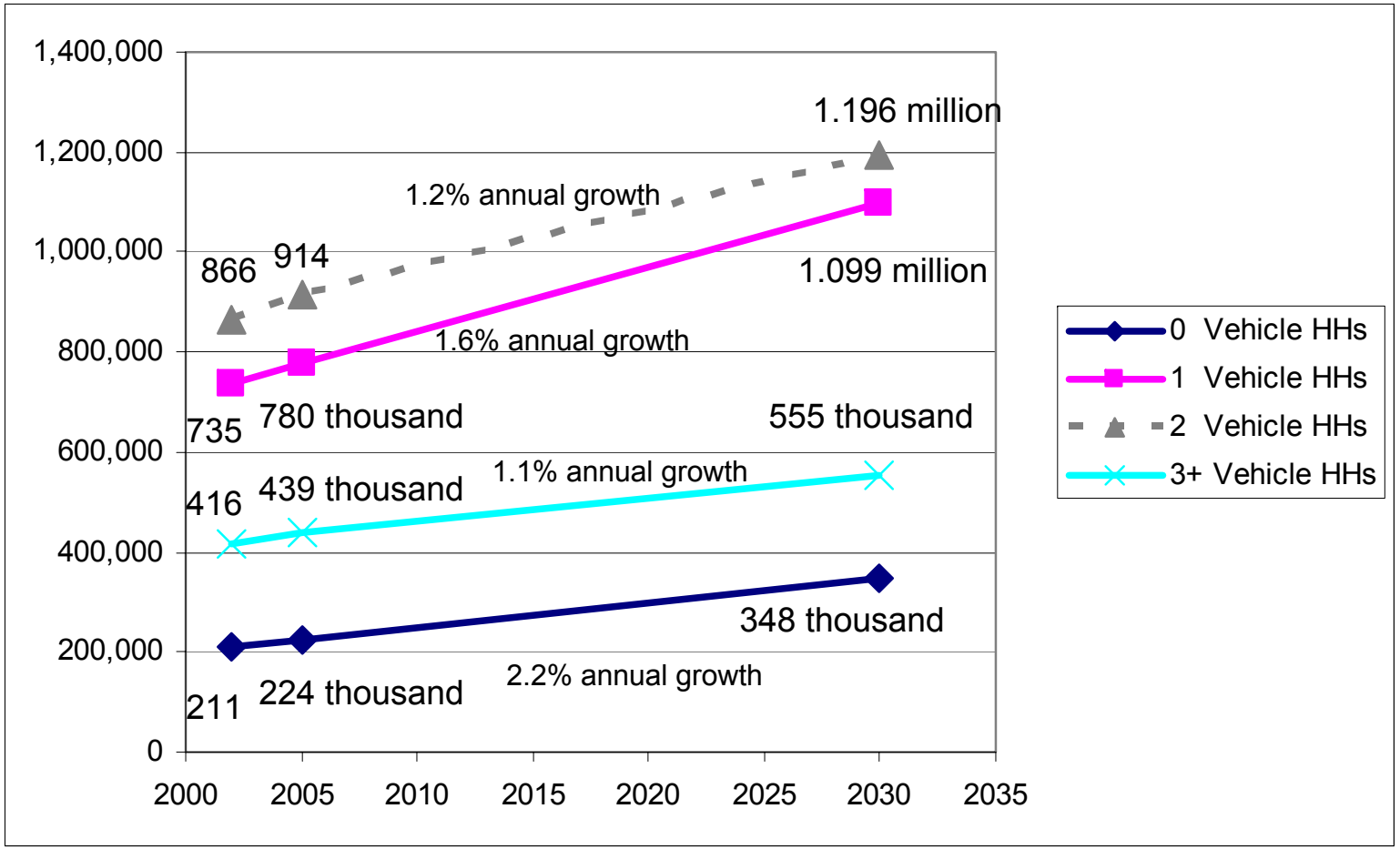
COG Cooperative Forecasts, Round 7.1

Inputs: Households & jobs

	2002	2005	2030	Diff. (05 - 02)	Ratio (05/02)	Diff. (30 - 05)	Ratio (30/05)
1 Households	2,228,949	2,357,238	3,199,982	128,289	1.06	842,744	1.36
2 Employment	3,548,630	3,709,533	5,156,567	160,903	1.05	1,447,034	1.39
3 HH Population	5,843,440	6,160,526	8,133,627	317,086	1.05	1,973,101	1.32
4 HH & GQ Population	5,966,696	6,294,528	8,282,368	327,832	1.05	1,987,840	1.32

Demographic imputs, Round 7.1

Model results
Households by vehicle availability

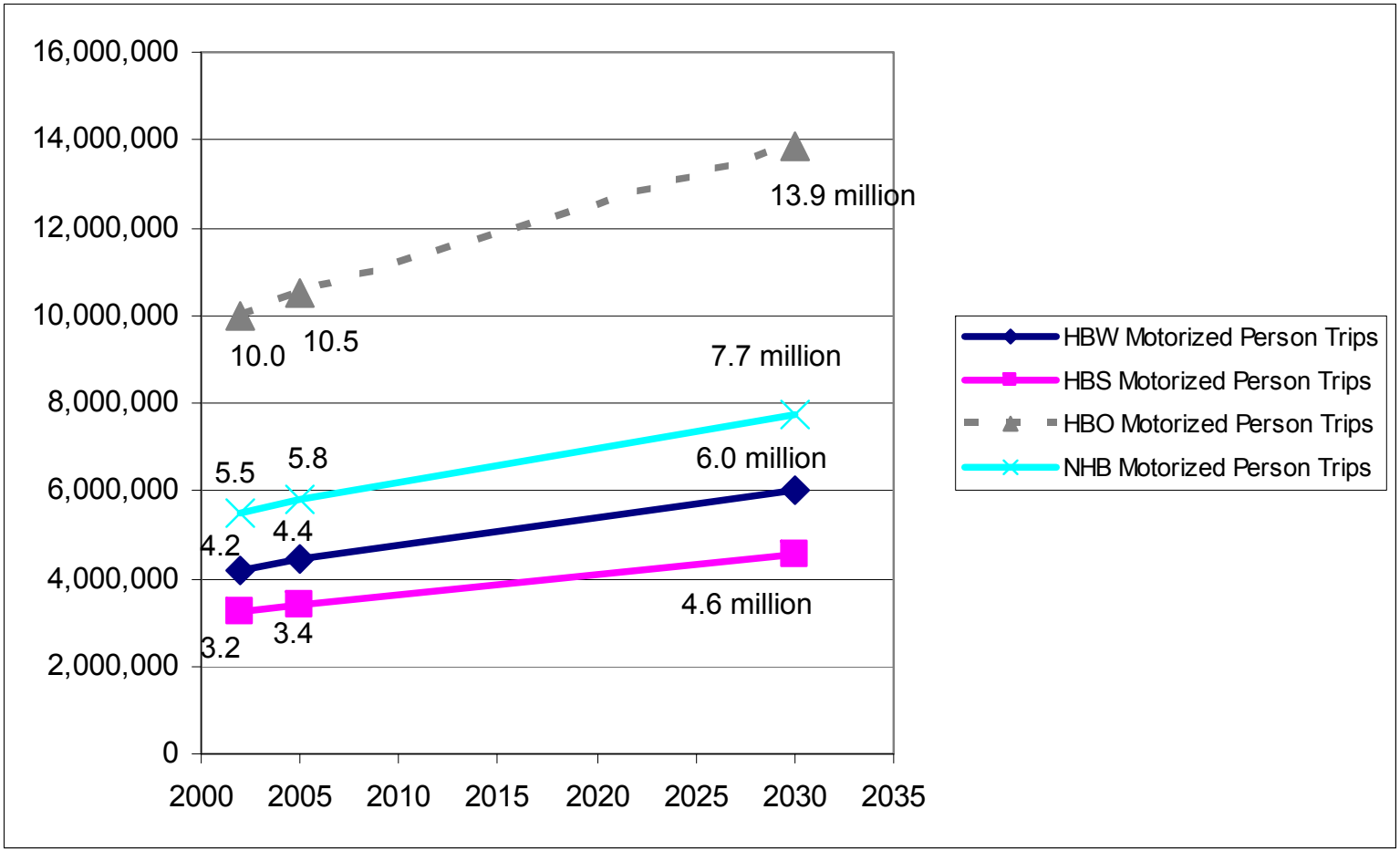


Model results
Households by vehicle availability

	2002	2005	2030	Diff. (05 - 02)	Ratio (05/02)	Diff. (30 - 05)	Ratio (30/05)
31 0 Vehicle HHs	211,392	224,091	347,987	12,699	1.06	123,896	1.55
32 1 Vehicle HHs	735,324	779,793	1,099,262	44,469	1.06	319,469	1.41
33 2 Vehicle HHs	865,874	914,162	1,196,198	48,288	1.06	282,036	1.31
34 3+ Vehicle HHs	416,325	439,107	555,270	22,782	1.05	116,163	1.26
35 HHs Subtotal	2,228,915	2,357,152	3,198,718	128,237	1.06	841,566	1.36

Version 2.2 travel model with nested-logit mode choice model in the speed feedback loop

Model results
Motorized person trips by purpose



Model results
Motorized person trips by purpose

	2002	2005	2030	Diff. (05 - 02)	Ratio (05/02)	Diff. (30 - 05)	Ratio (30/05)
36 HBW Motorized Person Trips	4,199,041	4,445,636	5,990,062	246,595	1.06	1,544,426	1.35
37 HBS Motorized Person Trips	3,233,010	3,419,362	4,564,846	186,352	1.06	1,145,484	1.33
38 HBO Motorized Person Trips	9,972,430	10,532,163	13,870,970	559,733	1.06	3,338,807	1.32
39 NHB Motorized Person Trips	5,498,041	5,818,211	7,722,241	320,170	1.06	1,904,030	1.33
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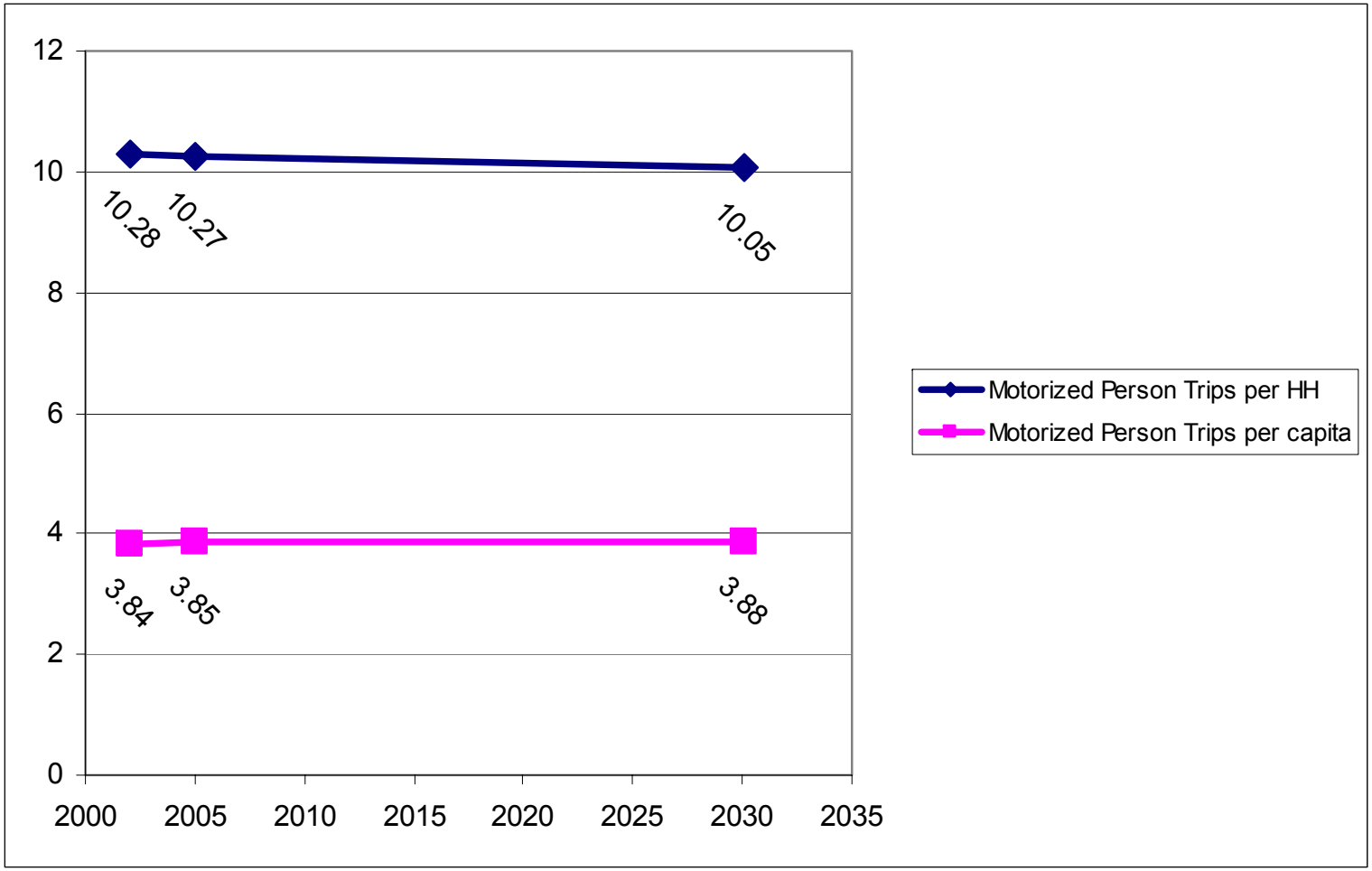
40 Total Motorized Person Trips	22,902,523	24,215,372	32,148,118	1,312,849	1.06	7,932,746	1.33

Version 2.2 travel model with nested-logit mode choice model in the speed feedback loop

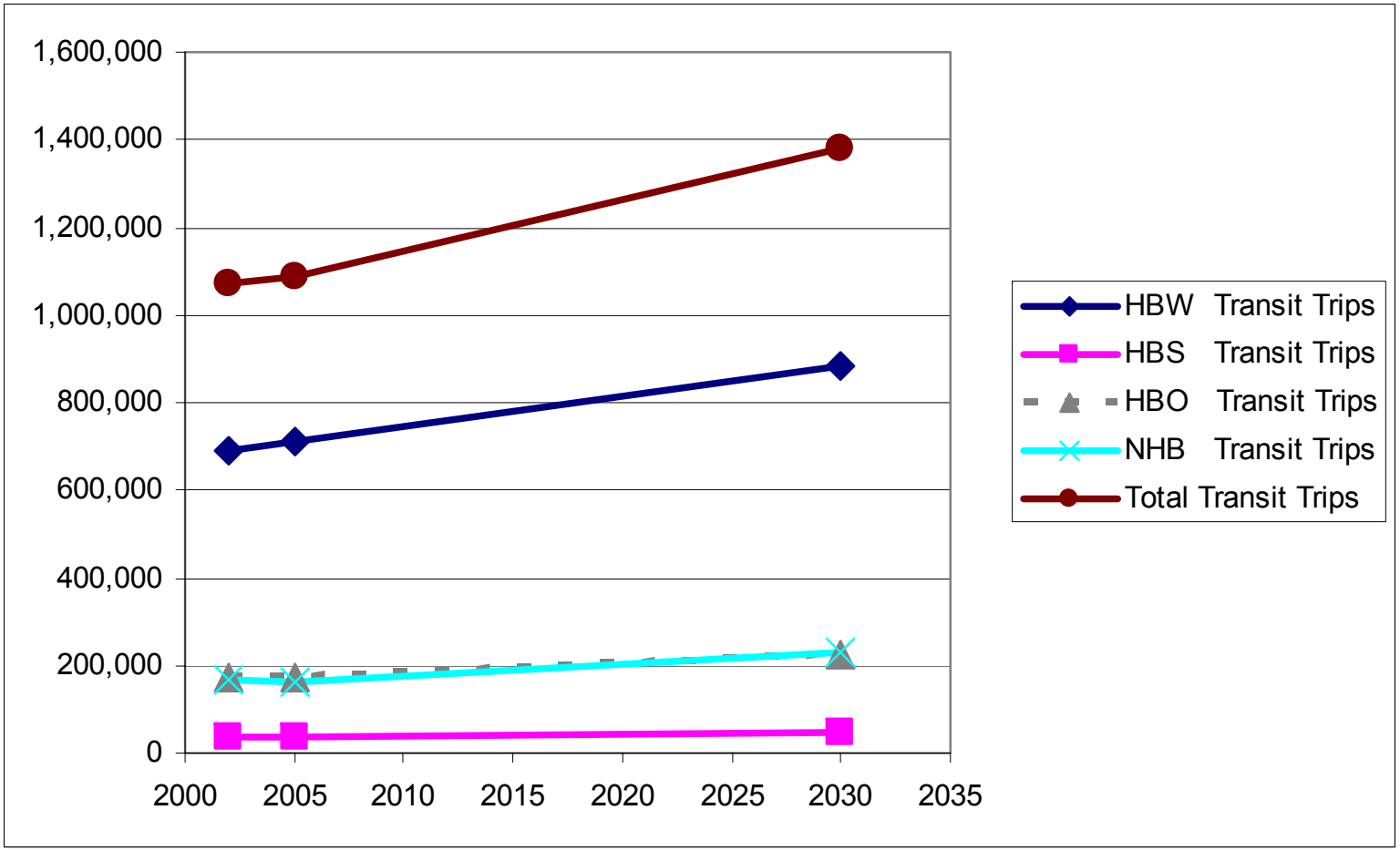
Model results
Auto driver/pax. trips & auto occupancy

	2002	2005	2030	Diff. (05 - 02)	Ratio (05/02)	Diff. (30 - 05)	Ratio (30/05)
HBW Auto Person Trips	3,506,900	3,732,262	5,108,457	225,362	1.06	1,376,195	1.37
HBS Auto Person Trips	3,197,282	3,380,917	4,518,368	183,635	1.06	1,137,451	1.34
HBO Auto Person Trips	9,799,139	10,361,153	13,645,540	562,014	1.06	3,284,387	1.32
NHB Auto Person Trips	5,329,811	5,655,453	7,493,916	325,642	1.06	1,838,463	1.33
Total Auto Person Trips	21,833,133	23,129,784	30,766,282	1,296,651	1.06	7,636,498	1.33
44 HBW Auto Driver Trips	3,137,235	3,336,701	4,532,008	199,466	1.06	1,195,307	1.36
45 HBS Auto Driver Trips	2,604,853	2,752,599	3,661,151	147,746	1.06	908,552	1.33
46 HBO Auto Driver Trips	7,496,437	7,924,806	10,411,679	428,369	1.06	2,486,873	1.31
47 NHB Auto Driver Trips	4,225,740	4,498,096	6,010,900	272,356	1.06	1,512,804	1.34
48 Total Auto Driver Trips	17,464,266	18,512,203	24,615,738	1,047,937	1.06	6,103,535	1.33
49 HBW Auto Passenger Trips	369,665	395,561	576,449	25,896	1.07	180,888	1.46
50 HBS Auto Passenger Trips	592,429	628,318	857,217	35,889	1.06	228,899	1.36
51 HBO Auto Passenger Trips	2,302,702	2,436,347	3,233,861	133,645	1.06	797,514	1.33
52 NHB Auto Passenger Trips	1,104,071	1,157,357	1,483,016	53,286	1.05	325,659	1.28
53 Total Auto Passenger Trips	4,368,867	4,617,581	6,150,544	248,714	1.06	1,532,963	1.33
54 HBW Auto Occupancies	1.12	1.12	1.13	0.00	1.00	0.01	1.01
55 HBS Auto Occupancies	1.23	1.23	1.23	0.00	1.00	0.00	1.00
56 HBO Auto Occupancies	1.31	1.31	1.31	0.00	1.00	0.00	1.00
57 NHB Auto Occupancies	1.26	1.26	1.25	0.00	1.00	-0.01	0.99
58 Total Auto Occupancies	1.25	1.25	1.25	0.00	1.00	0.00	1.00

Model results
Motorized person trips per HH, capita



Model results
Transit trips by purpose

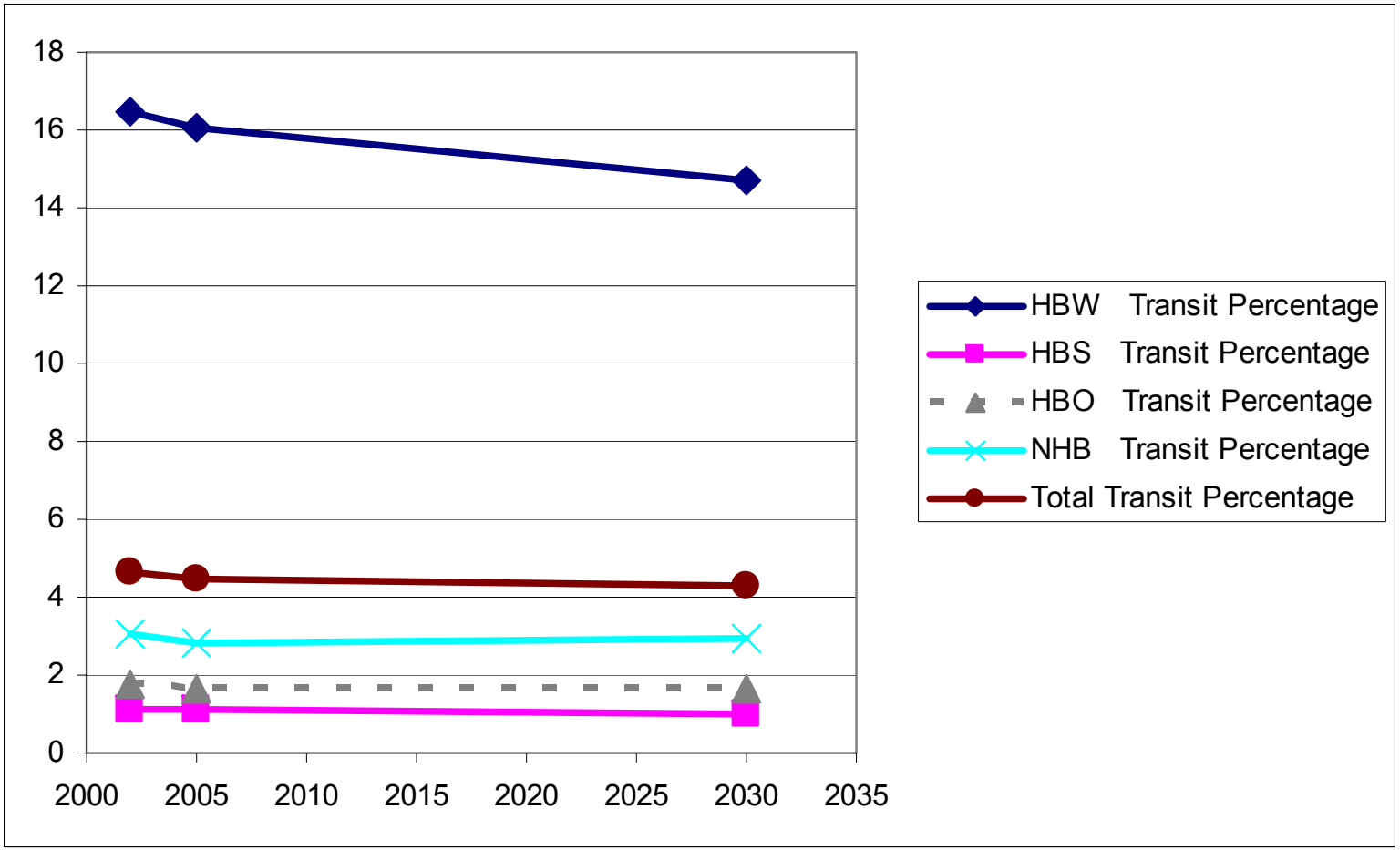


Model results
Transit trips by purpose

	2002	2005	2030	Diff. (05 - 02)	Ratio (05/02)	Diff. (30 - 05)	Ratio (30/05)
59 HBW Transit Trips	692,140	713,375	881,605	21,235	1.03	168,230	1.24
60 HBS Transit Trips	35,728	38,445	46,477	2,717	1.08	8,032	1.21
61 HBO Transit Trips	173,291	171,011	225,430	-2,280	0.99	54,419	1.32
62 NHB Transit Trips	168,230	162,758	228,325	-5,472	0.97	65,567	1.40
63 Total Transit Trips	1,069,390	1,085,588	1,381,836	16,198	1.02	296,248	1.27

Version 2.2 travel model with nested-logit mode choice model in the speed feedback loop

Model results
Transit percent by purpose

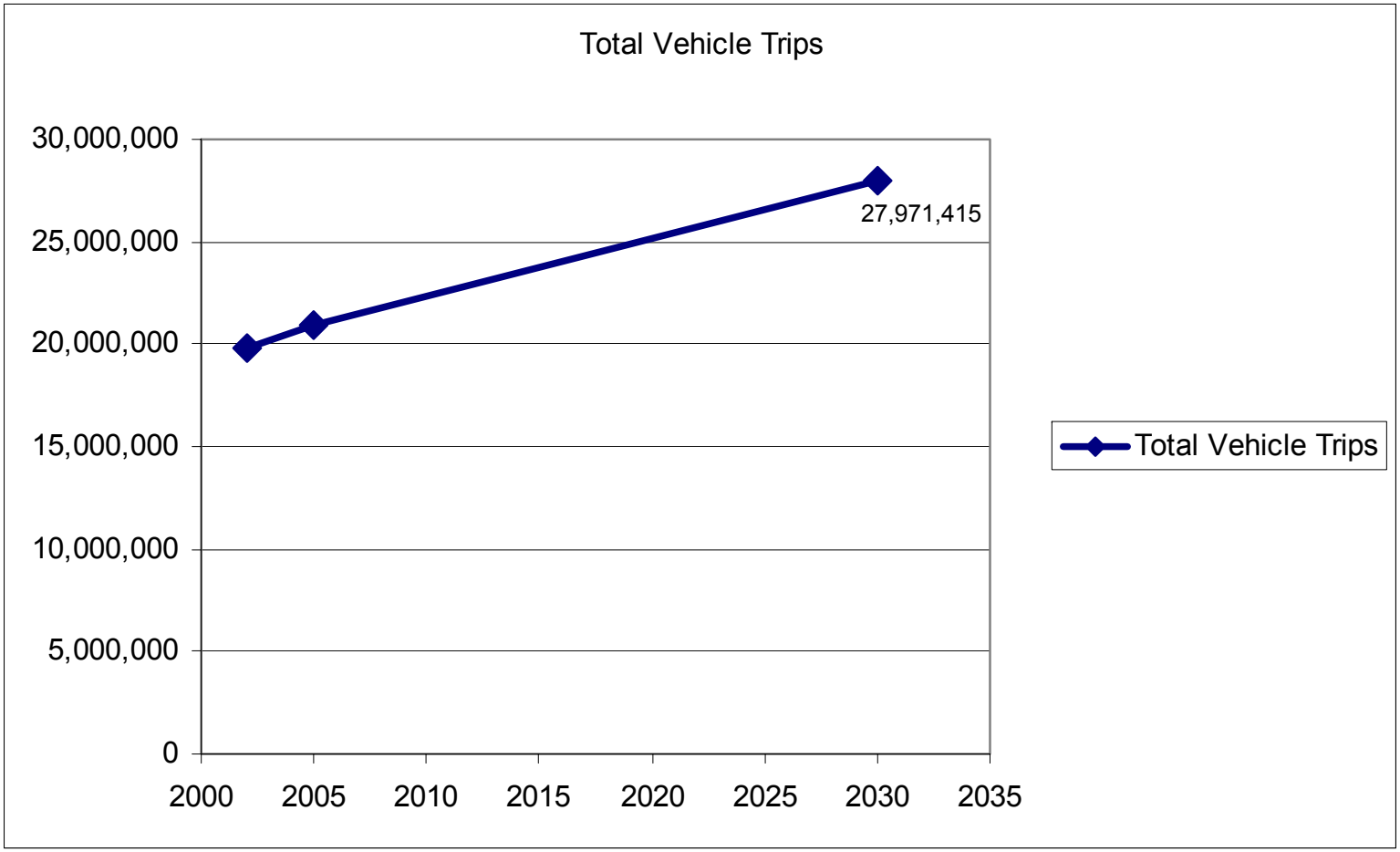


Model results
Transit percent by purpose

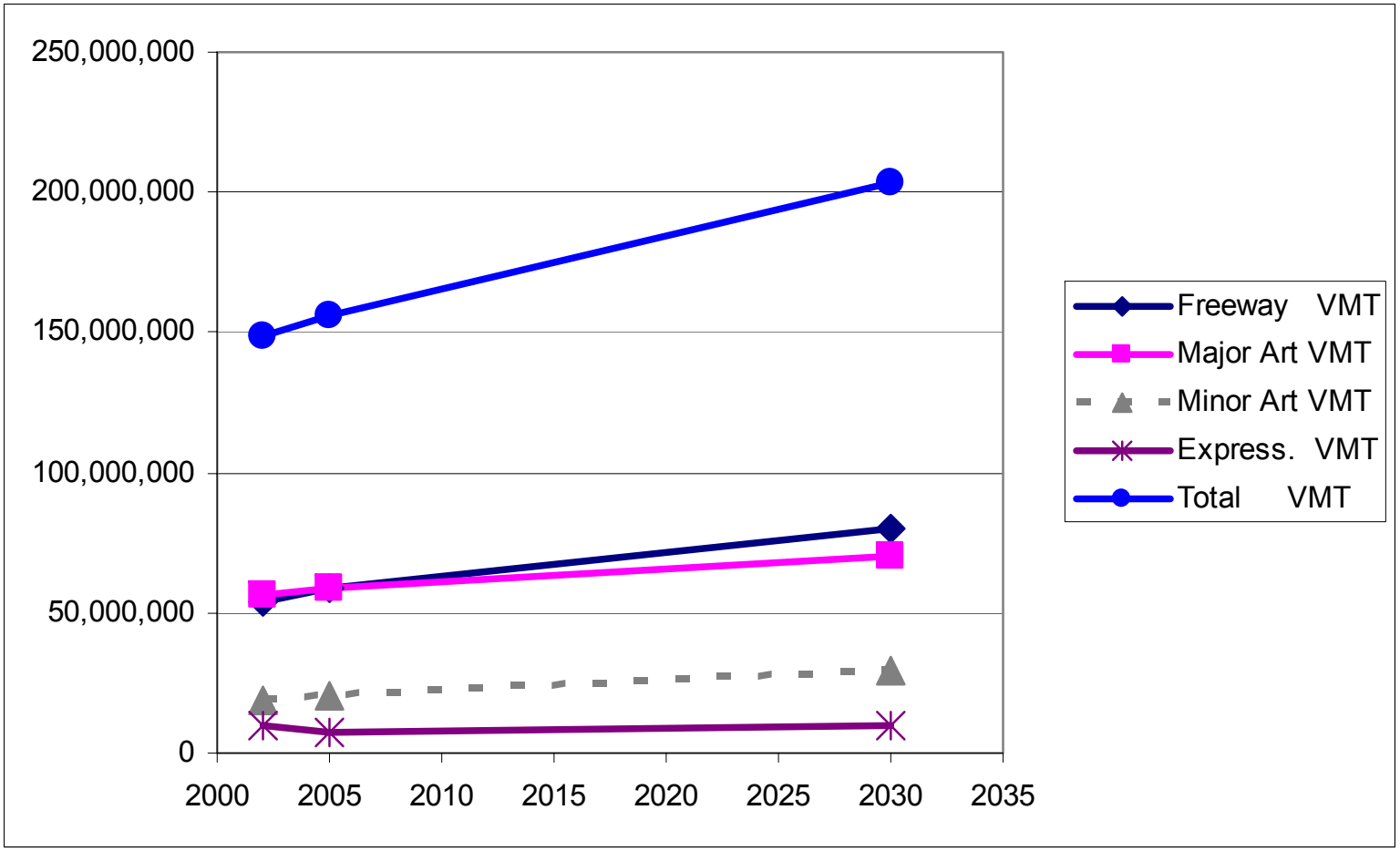
	2002	2005	2030	Diff. (05 - 02)	Ratio (05/02)	Diff. (30 - 05)	Ratio (30/05)
64 HBW Transit Percentage	16.48	16.05	14.72	-0.43	0.97	-1.33	0.92
65 HBS Transit Percentage	1.11	1.12	1.02	0.01	1.01	-0.10	0.91
66 HBO Transit Percentage	1.74	1.62	1.63	-0.12	0.93	0.01	1.01
67 NHB Transit Percentage	3.06	2.80	2.96	-0.26	0.92	0.16	1.06
68 Total Transit Percentage	4.67	4.48	4.30	-0.19	0.96	-0.18	0.96

Version 2.2 travel model with nested-logit mode choice model in the speed feedback loop

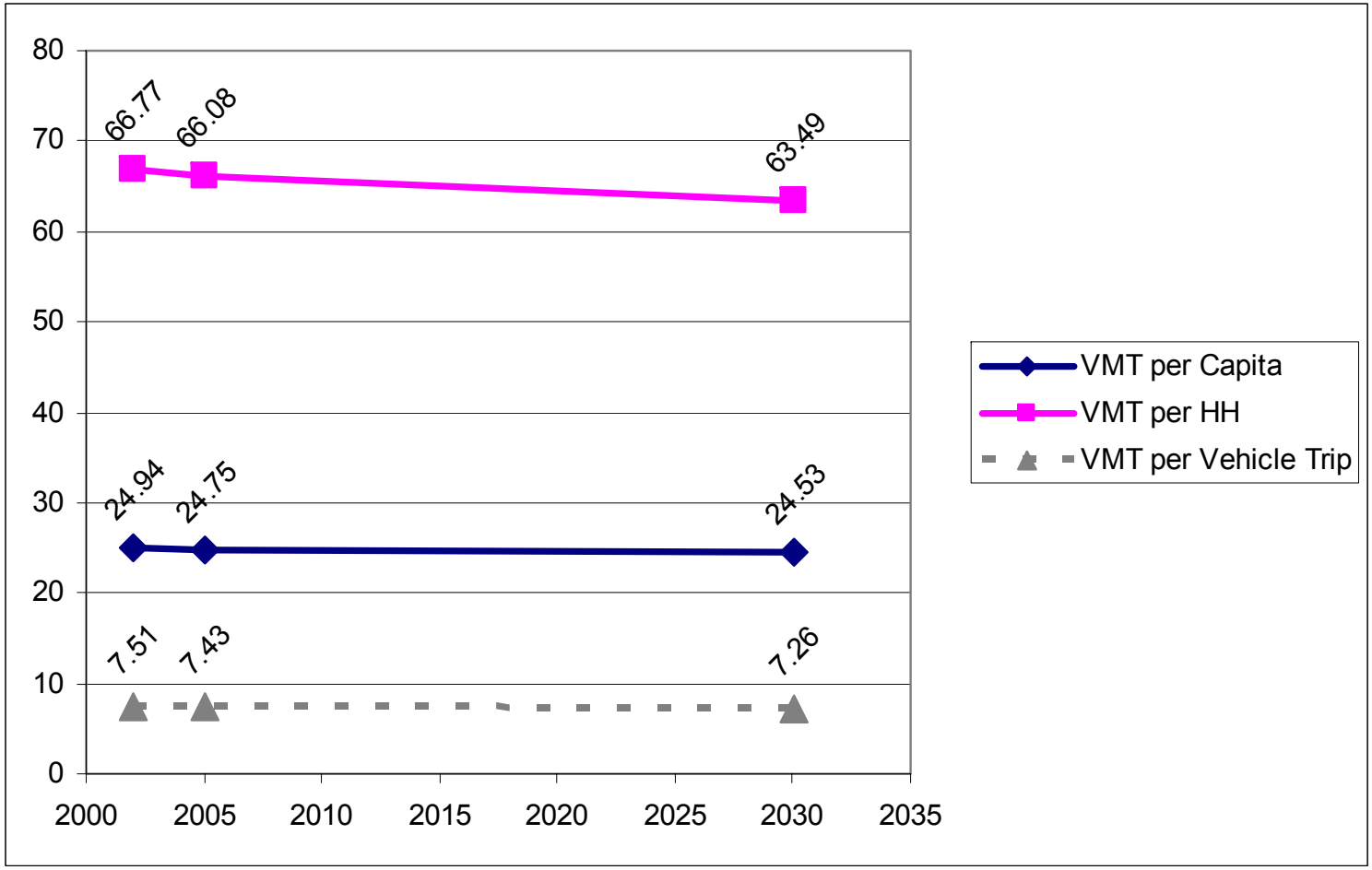
Model results
Total vehicle trips



Model results
VMT by facility type



Model results
VMT per capita, HH, vehicle trip



Model results
Vehicle trips and VMT

	2002	2005	2030	Diff. (05 - 02)	Ratio (05/02)	Diff. (30 - 05)	Ratio (30/05)
76 Total Vehicle Trips	19,806,805	20,967,688	27,971,415	1,160,883	1.06	7,003,727	1.33
83 Total VMT	148,827,840	155,770,946	203,176,661	6,943,107	1.05	47,405,714	1.30
84 VMT per Capita	24.94	24.75	24.53	-0.19	0.99	-0.22	0.99
85 VMT per HH	66.77	66.08	63.49	-0.69	0.99	-2.59	0.96
86 VMT per Vehicle Trip	7.51	7.43	7.26	-0.08	0.99	-0.17	0.98

Version 2.2 travel model with nested-logit mode choice model in the speed feedback loop

Other developments, 1

- Bought new Quad Core desktop
  - CPU: One Quad Core Xeon Processor X5365, 3.0 GHz
  - Benchmarking with Windows XP Pro
    - 34-hour model run on old server => 18 hours on new workstation
  - Converted desktop to a “server”
    - Reinstalled OS: WinXP => Windows Server 2003
    - No significant degradation in performance
    - Just as with older server, modelers use the new “server” via Windows Remote Desktop Connection

Other developments, 2

- Bought new Quad Core desktop (continued)
  - 2.27 TB storage array moved from old travel model server (tms1) to the new “server” (tms2)
  - New “server” (tms2) is now used for production work
  - Planning to buy a 2nd CPU for the new travel model server
- Have received final network coding guide from AECOM

Conclusions

- At the regional level, the Version 2.2 travel model with nest-logit mode choice in the speed feedback loop is performing reasonably for 2002, 2005, 2030
- Ver. 2.2 travel model with NL MC is resource intensive
  - Run times went up 40%, from about 24 hours to 34 hours
  - Number of output files went from 970 (Ver. 2.2 with MNL MC) to 1,900 (Ver. 2.2 with NL MC)
- However there are ways to address the increasing demands
  - New, faster hardware (e.g., Quad Core chips)
  - Use of distributed processing (Cube Cluster)
  - Streamlining of model application code (see “Next Steps” slides)

Next steps, 1 of 2

- May 2008
  - Add new truck models: Ver. 2.2 => Ver. 2.3
  - Recalibrate NL MC model to 2002
  - Transit assignment for 2002, 2005, and 2030
  - Assess model results at the station-group level for Metrorail
  - Goal: Draft report

Next steps, 2 of 2

- July 2008 and beyond
  - Sensitivity tests
    - Fare sensitivity
    - Adding/removing a bus line
    - Removal of an important link (e.g., a bridge)
  - Model streamlining
    - Model uses two sets of percent walks: Eliminate MNL walk percents
    - Model creates two sets of transit skims, old MNL-style and newer NL-style: Eliminated MNL-style percent walks
    - Cube Cluster (distributed processing)
    - Reduce the number of speed feedback loops (6 => 4?)