# IMPLEMENTATION OF THE VERSION 2.3 TRAVEL DEMAND MODEL

Presentation to the TPB Technical Committee

December 3, 2011

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

# Overview



- Background
- Description of the Version 2.3 Travel Model
  - Network differences
  - Model differences
- Model performance
  - Validation
  - Application:  Air Quality Conformity of the 2011 CLRP
- Looking ahead
- Conclusions

# BACKGROUND

# Recent presentations



- Presentations on the Ver. 2.3 Travel Model to the Tech. Comm. in the last 2 years
  - April 1, 2011: Milone, Ronald. "Update on the Version 2.3 travel demand model development"
  - Jan. 7, 2011: Milone, Ronald. "Briefing on the Version 2.3 travel demand model development"
  - Dec. 3, 2010: Moran, Mark "Update on the Version 2.3 travel demand model development"
  - Feb. 5, 2010: Milone, Ronald. "Status Report on the Version 2.3 Travel Demand Model"

# Version 2.3 model is adopted



- TPB staff has completed Ver. 2.3 model work using 2011 CLRP networks and Round 8.0a land activity
- The Ver. 2.3 Travel Model became the adopted regional travel model for the Metropolitan Washington Region when the TPB adopted the following two resolutions at its 11/16/11 meeting:
  - R5-2012: The TPB determines that the 2011 CLRP conforms to all requirements of the Clean Air Act Amendments of 1990.
  - R6-2012: The TPB approves the 2011 CLRP.
- Adoption entails
  - The **inputs** to the analysis: 2011 CLRP network and input assumptions
  - The **travel model** used in the conformity assessment
  - **Findings** of the conformity analysis

# Model documentation



- Two draft documents, released to the Travel Forecasting Subcommittee on 11/18/11
  - *Calibration Report for the TPB Travel Forecasting Model, Version 2.3.36, on the 3,722-Zone Area System*. Draft report. Nov. 18, 2011.
  - *User's Guide for the TPB Travel Forecasting Model, Version 2.3.36, on the 3,722-Zone Area System*. Draft report. Nov. 18, 2011.
- Available in PDF format
  - TFS web page: Click "Documents" (www.mwcog.org/transportation/committee/committee/default.asp?COMMITTEE_ID=43)
  - "Model Documentation and Data Requests" web page (www.mwcog.org/transportation/activities/models/documentation.asp)
- 30-day review period ending Dec. 18
  - We welcome your comments on documentation
  - Please e-mail me any comments or suggestions (mmoran@mwcog.org)

# DESCRIPTION OF THE VERSION 2.3 TRAVEL MODEL

# Ver. 2.3 vs. 2.2: Major differences, 1



- More zones: Number of TAZs: 2,191 => 3,722
  - Which leads to more detailed highway networks
- Calibrated/validated with new data sets
  - 2007/2008 COG Household Travel Survey (HTS)
  - 2007 traffic counts
  - Transit on-board surveys
    - 2008 Metrorail Survey
    - 2008 Regional Bus Survey, supplemented by the Fairfax Connector Bus Survey
    - 2007-2008 On-Board Survey of Maryland Transit Administration (MTA) Riders, i.e., riders of MARC train service
    - 2005 Virginia Railway Express (VRE) Passenger Survey

# Ver. 2.3 vs. 2.2: Major differences, 2



- Model refinements, such as
  - 15-choice, nested logit (NL) mode choice model, with **transit assignment capability**
  - Trip generation: Non-motorized travel now estimated for both work and non-work (in Ver. 2.2, it was only work)
  - Enhanced traffic assignment convergence
    - Relative gap of $10^{-4}$ or 300 user equilibrium (UE) iterations, whichever comes first (Ver. 2.2 used a fixed number of UE iterations: 60)
  - Added/modified time-of-day periods used in traffic assignment
  - Updated "medium" and "heavy" truck models
  - Subdivided NHB trip purpose into two purposes:
    - Non-home work (NHW)
    - Non-home other (NHO)

# Minor updates to the model

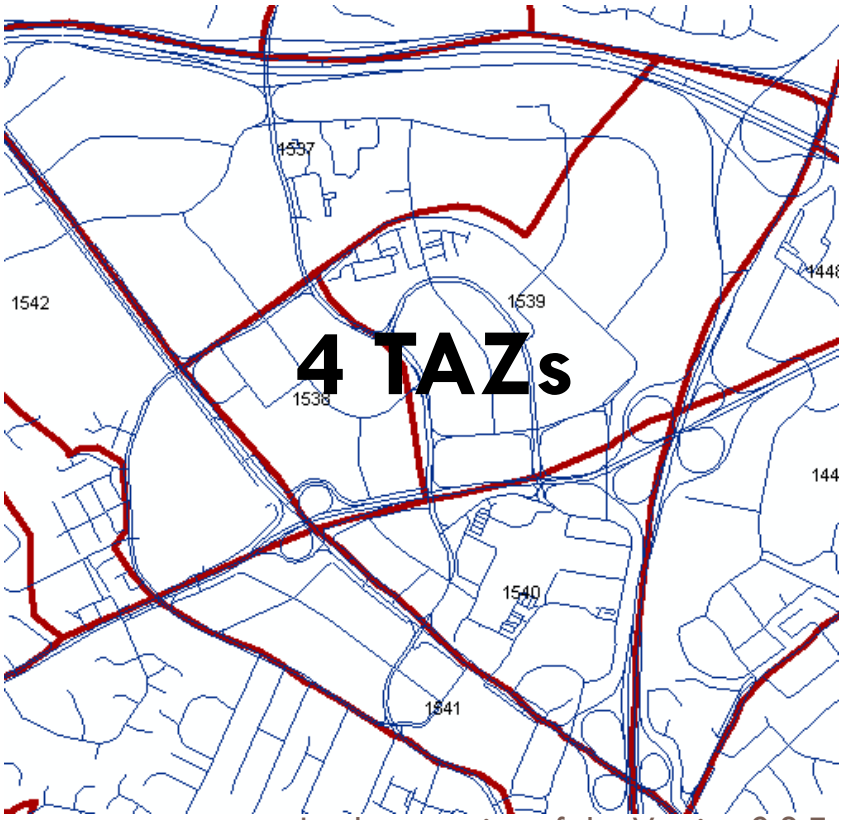


- Minor updates to the model are called "builds" or revisions and are indicated in the 3rd number in the model version (2.3.X)
- Build 37 (Version 2.3.37) is the latest revision of the Version 2.3 Travel Model
- The draft documentation is for Ver. 2.3.36. When it comes out of draft, it will be for Ver. 2.3.37.

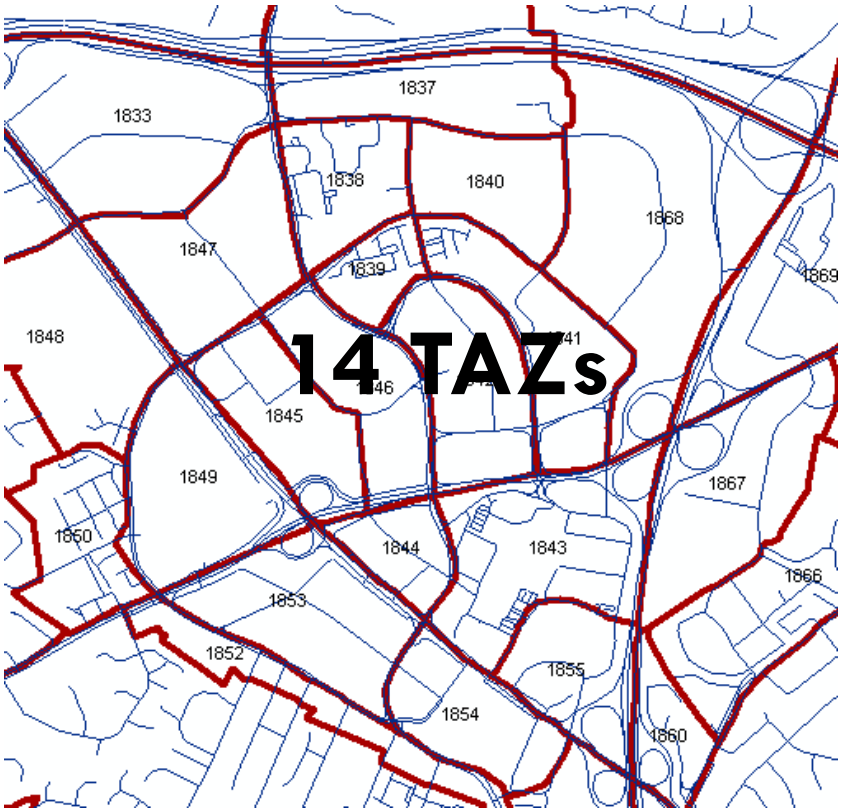
# 2,191-TAZ system vs. the new 3,722-TAZ system: Tysons Corner



2,191 TAZ System



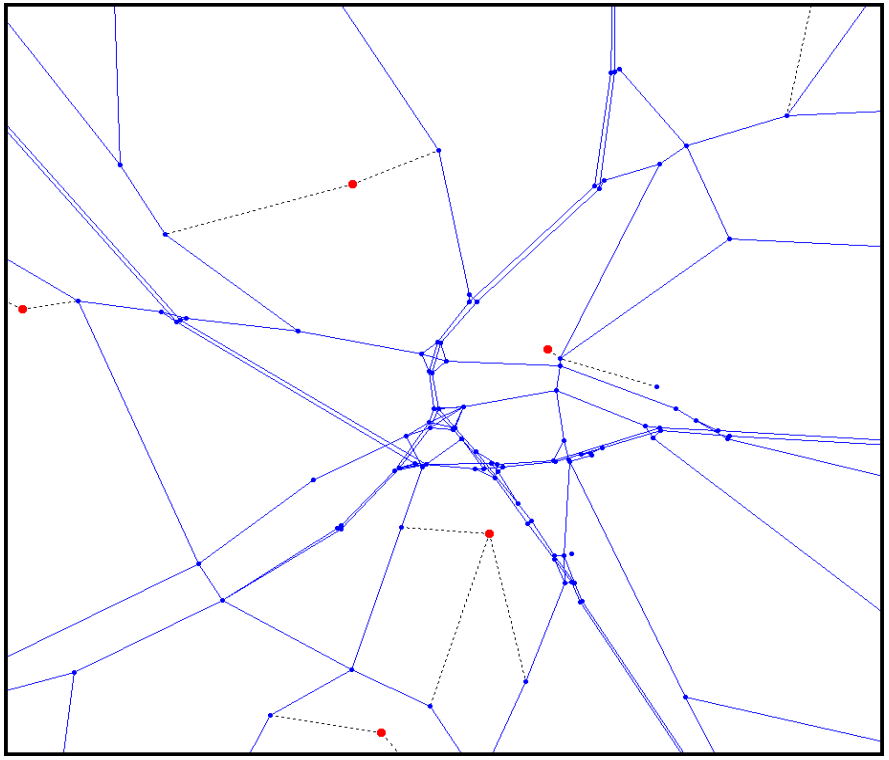

3,722 TAZ System



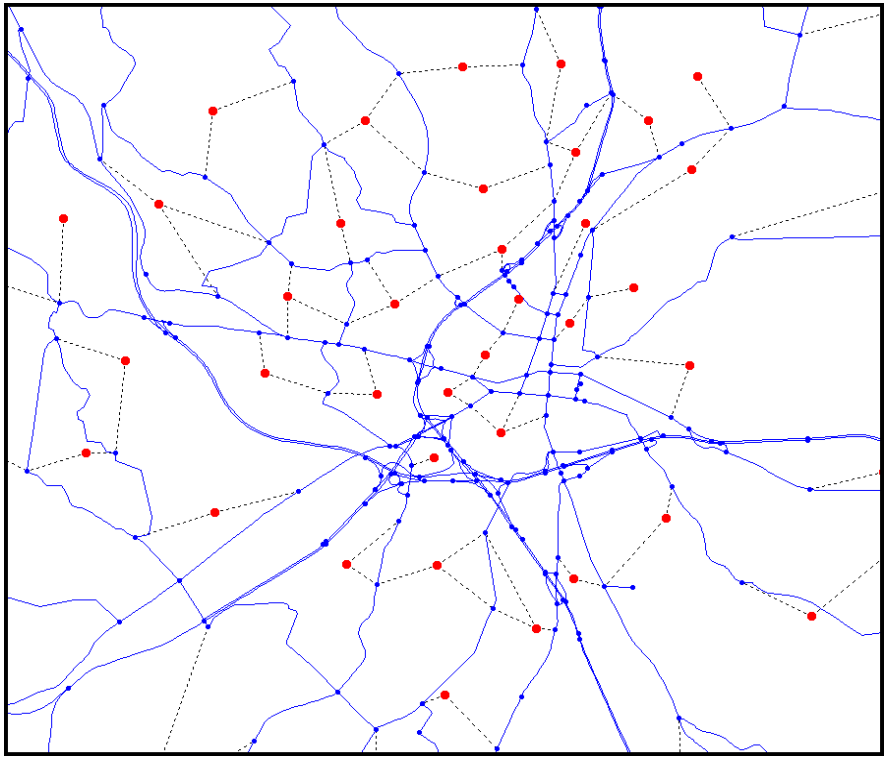
# More detailed networks: Example: City of Frederick, Maryland



2,191 TAZ Highway Network



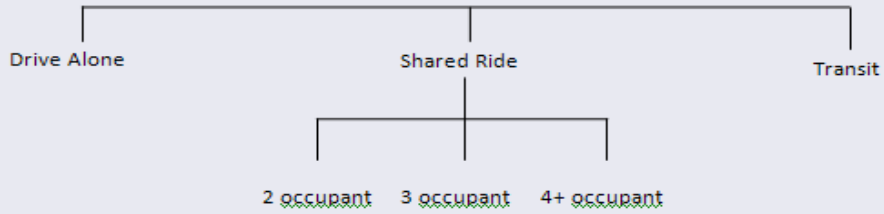
3,722 TAZ Highway Network



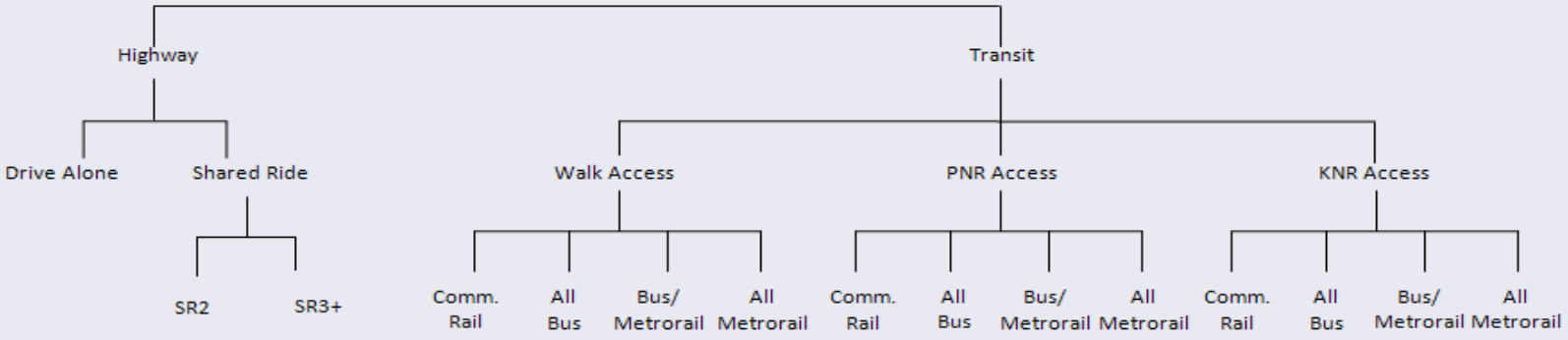
# Mode choice
# (5-choice sequential multinomial logit => 15-choice nested logit)



## Version 2.2 Modeled Choice Set




## Version 2.3 Modeled Choice Set



# Mode choice: Treatment of LRT, BRT, streetcar



- Nesting structure of the TPB Version 2.3 NLMC model does not include *explicit* branches for specialized transit modes, such as light-rail transit (LRT), bus rapid transit (BRT), and streetcar.
- From this, one might conclude that the mode choice model is not designed to deal with these special transit modes.
- In fact, however, **the model is designed to deal with these special transit modes.**
- For details, consult either the calibration report or the user's guide.

# Trip generation: Increased purposes and modes



| Version 2.2 on 2,191 TAZ | |
|---|---|
| **Purpose** | **Mode** |
| Home-Based Work | Motorized |
| | Non-motorized (Walk/Bike) |
| Home-Based Shop | Motorized |
| Home-Based Other | Motorized |
| Non-Home-Based | Motorized |

| Version 2.3 on 3,722 TAZ | |
|---|---|
| **Purpose** | **Mode** |
| Home-Based Work | Motorized |
| | Non-motorized (Walk/Bike) |
| Home-Based Shop | Motorized/ |
| | Non-motorized |
| Home-Based Other | Motorized/ |
| | Non-motorized |
| Non-Home-Based Work | Motorized/ |
| | Non-motorized |
| Non-Home-Based Other | Motorized/ |
| | Non-motorized |

# Time of day & traffic assignment: More time periods are addressed



| Version 2.2 on 2,191 TAZ | |
|---|---|
| Time Period | Hours |
| AM | 6 AM- 9 AM |
| PM | 4 PM-7 PM |
| Other | 12 AM- 6 AM<br>9 AM- 4 PM<br>7 PM- 12 AM |

| Version 2.3 on 3,722 TAZ | |
|---|---|
| Time Period | Hours |
| AM | 6 AM- 9 AM |
| PM | 3 PM- 7 PM |
| Midday | 9 AM- 3 PM |
| Other/Night | 12 AM- 6 AM<br>7 PM- 12 AM |

# MODEL PERFORMANCE: VALIDATION

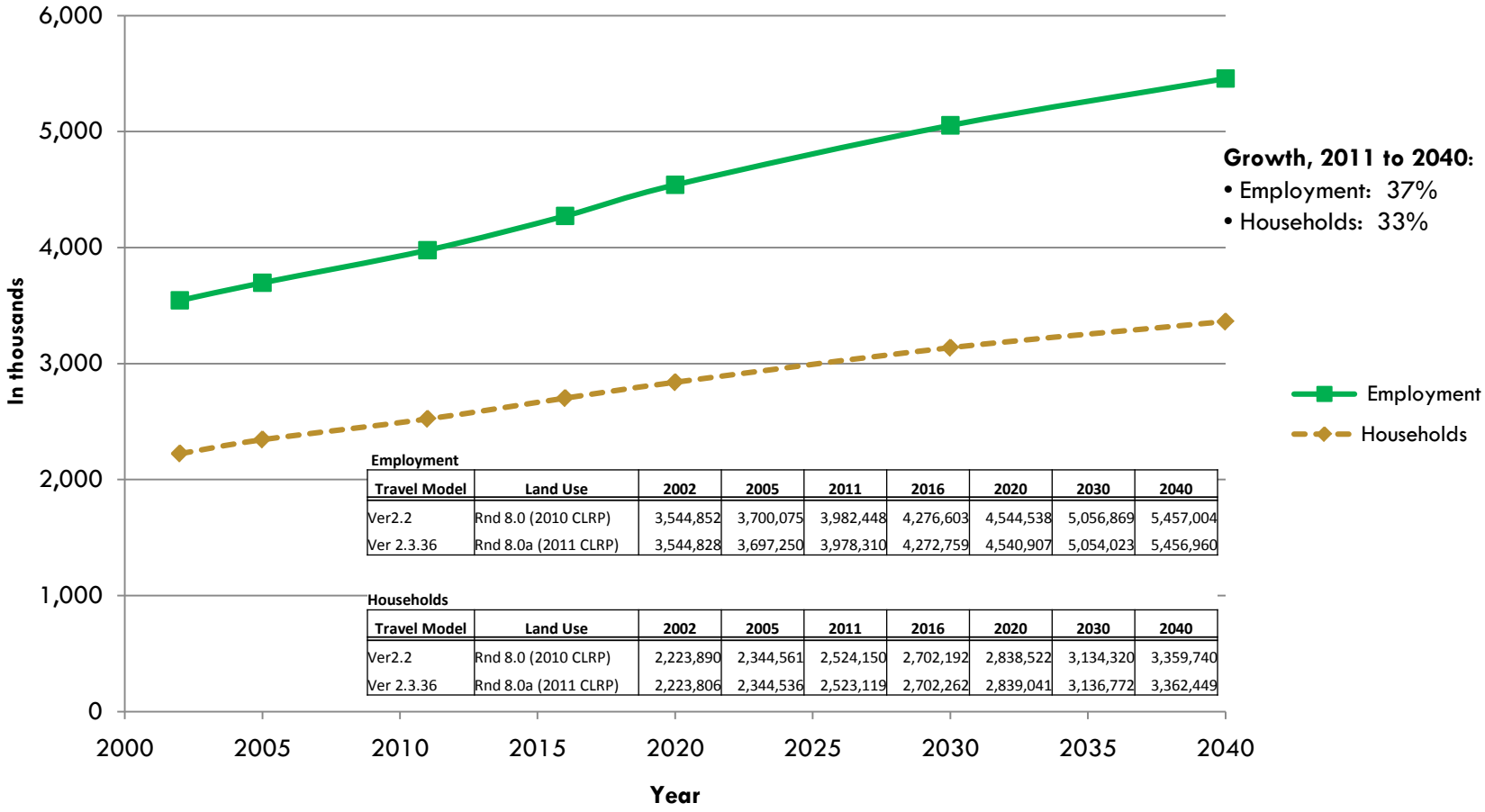
See the calibration report and the 11/18/11 TFS presentation for validation summaries

# MODEL PERFORMANCE: AIR QUALITY CONFORMITY OF THE 2011 CLRP

All the following summaries are for the 22-jurisdiction, TPB modeled area

# Comparison of HHs and Jobs Round 8.0a Land use






Employment

| Travel Model | Land Use | 2002 | 2005 | 2011 | 2016 | 2020 | 2030 | 2040 |
|---|---|---|---|---|---|---|---|---|
| Ver2.2 | Rnd 8.0 (2010 CLRP) | 3,544,852 | 3,700,075 | 3,982,448 | 4,276,603 | 4,544,538 | 5,056,869 | 5,457,004 |
| Ver 2.3.36 | Rnd 8.0a (2011 CLRP) | 3,544,828 | 3,697,250 | 3,978,310 | 4,272,759 | 4,540,907 | 5,054,023 | 5,456,960 |

Households

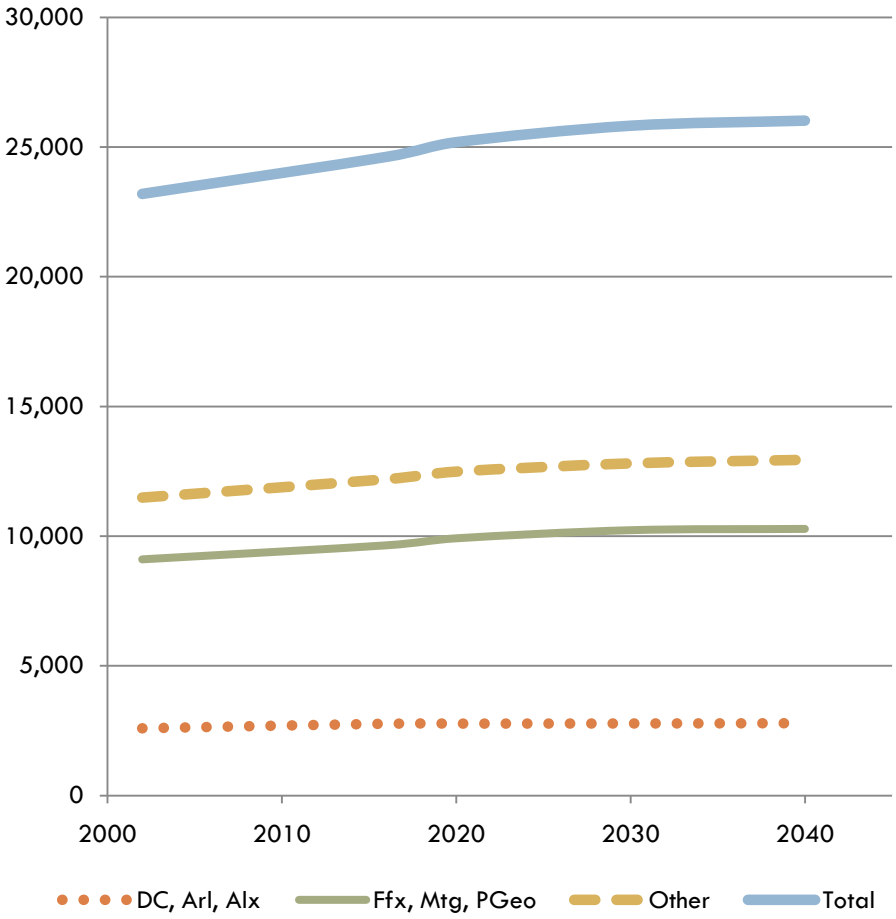
| Travel Model | Land Use | 2002 | 2005 | 2011 | 2016 | 2020 | 2030 | 2040 |
|---|---|---|---|---|---|---|---|---|
| Ver2.2 | Rnd 8.0 (2010 CLRP) | 2,223,890 | 2,344,561 | 2,524,150 | 2,702,192 | 2,838,522 | 3,134,320 | 3,359,740 |
| Ver 2.3.36 | Rnd 8.0a (2011 CLRP) | 2,223,806 | 2,344,536 | 2,523,119 | 2,702,262 | 2,839,041 | 3,136,772 | 3,362,449 |

# Lane miles, 2011 CLRP, Ver. 2.3.36



- Lane miles in DC, Arl., and Alex. grow at only 8% from 2002 to 2040
- Lane miles in in Fairfax, Montgomery, and Prince George's counties are forecast to grow by 13%
- Forecasted growth rate for the entire modeled area: 12%

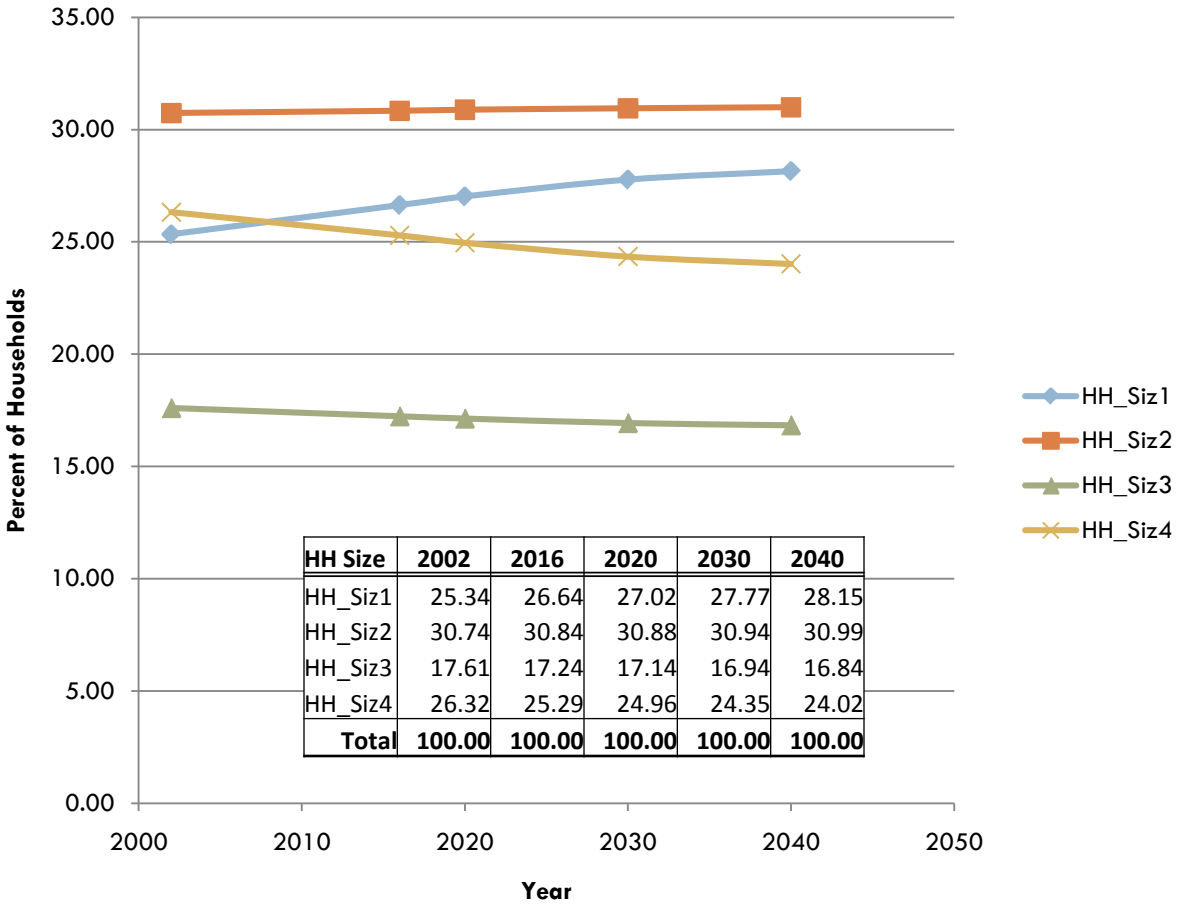
| | 2002 | 2016 | 2020 | 2030 | 2040 |
|---|---|---|---|---|---|
| DC, Arl, Alx | 2,594 | 2,775 | 2,779 | 2,784 | 2,795 |
| Ffx, Mtg, PGeo | 9,109 | 9,650 | 9,921 | 10,234 | 10,284 |
| Other | 11,491 | 12,195 | 12,487 | 12,802 | 12,938 |
| Total | 23,195 | 24,620 | 25,186 | 25,820 | 26,016 |



# Est. HH size by year, Ver. 2.3.36



- Forecasts of 1-person household share increasing
- Forecasts of 2-person household share holding constant
- Forecasts of 3- and 4-person household shares are declining
- **Reason: Cooperative forecasts of households and population imply declining household size**

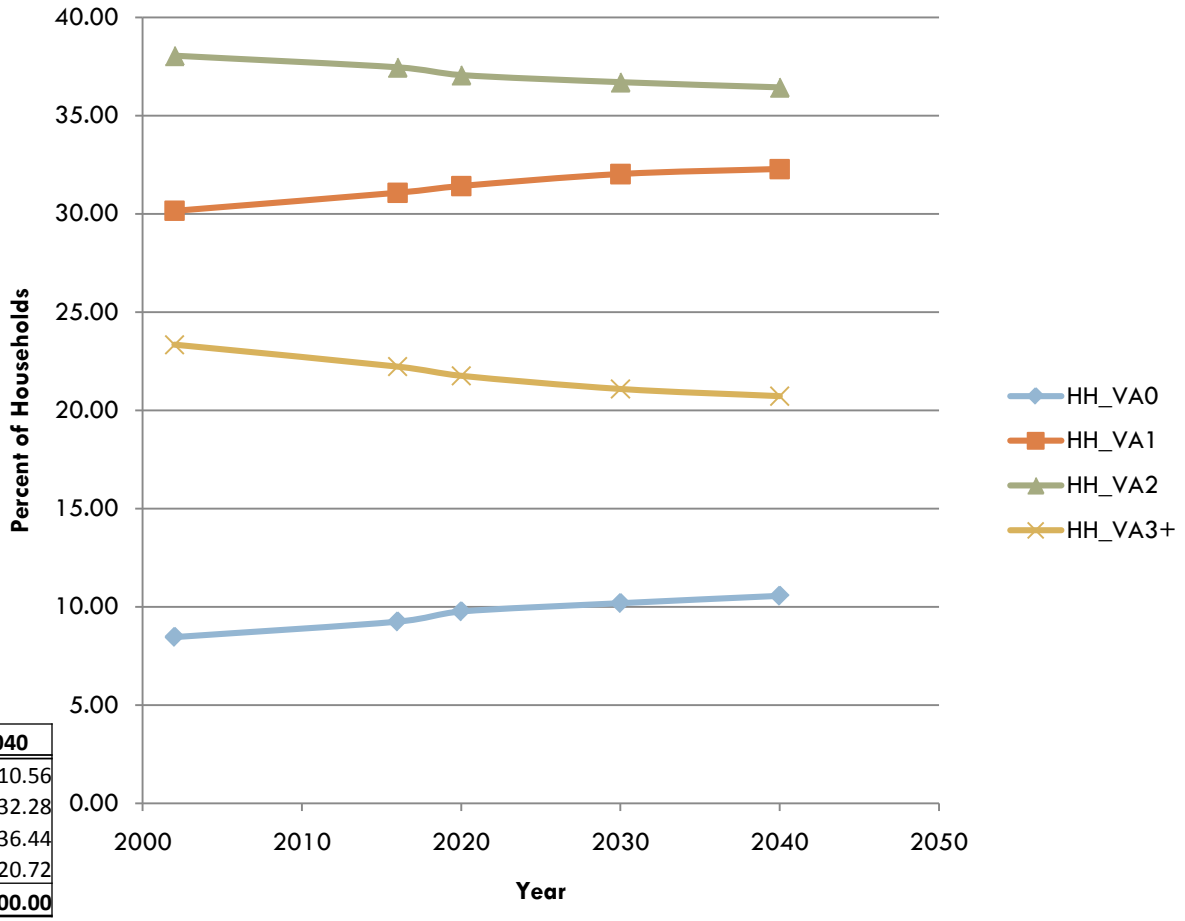



| HH Size | 2002 | 2016 | 2020 | 2030 | 2040 |
|---|---|---|---|---|---|
| HH_Siz1 | 25.34 | 26.64 | 27.02 | 27.77 | 28.15 |
| HH_Siz2 | 30.74 | 30.84 | 30.88 | 30.94 | 30.99 |
| HH_Siz3 | 17.61 | 17.24 | 17.14 | 16.94 | 16.84 |
| HH_Siz4 | 26.32 | 25.29 | 24.96 | 24.35 | 24.02 |
| **Total** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** |

# Est. HH vehicles available by year, Ver. 2.3.36



- Forecasts of zero- and one-vehicle household shares increasing
- Forecasts of two- and three plus-vehicle household shares are decreasing
- **Reason: Declining household sizes and increasing transit accessibility**

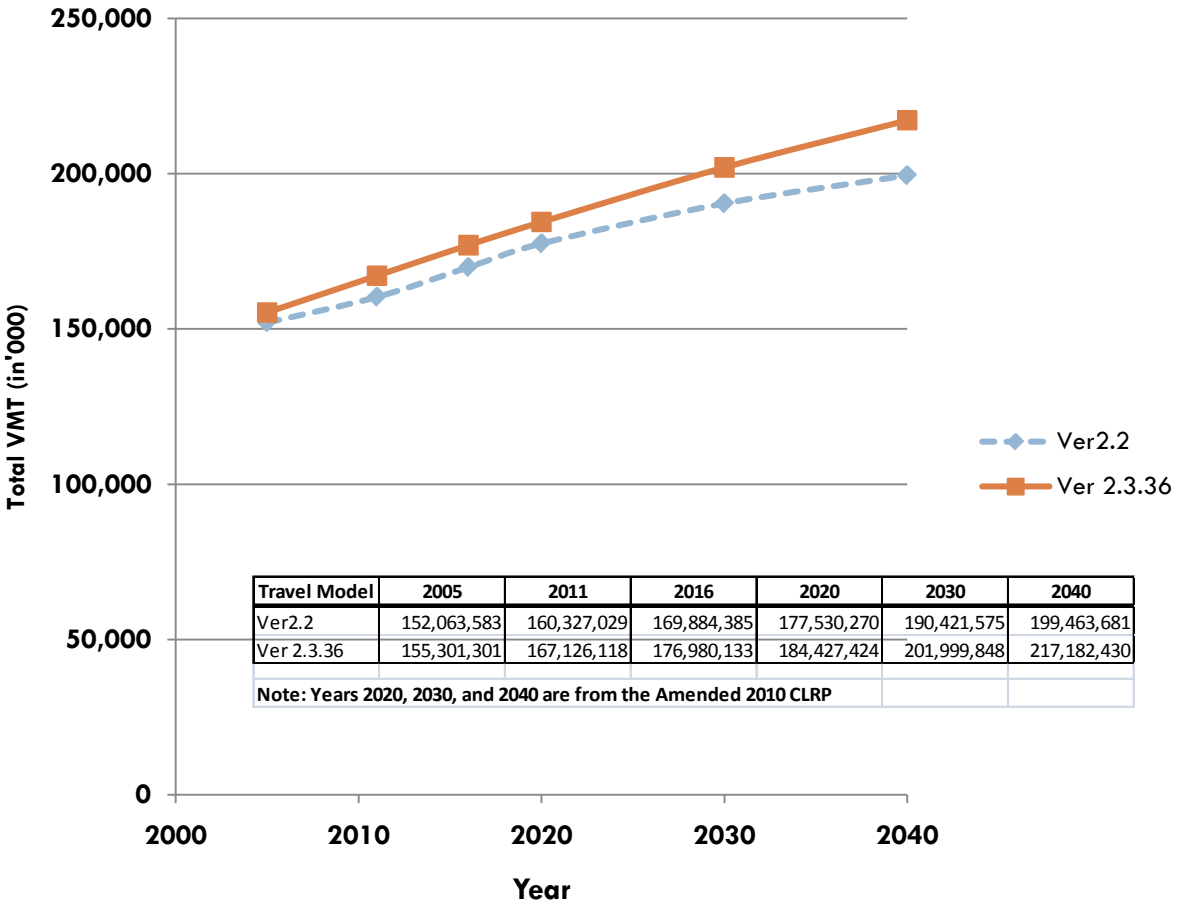



| Veh. Av. | 2002 | 2016 | 2020 | 2030 | 2040 |
|---|---|---|---|---|---|
| HH_VA0 | 8.47 | 9.25 | 9.77 | 10.19 | 10.56 |
| HH_VA1 | 30.15 | 31.07 | 31.42 | 32.03 | 32.28 |
| HH_VA2 | 38.04 | 37.45 | 37.06 | 36.70 | 36.44 |
| HH_VA3+ | 23.34 | 22.22 | 21.75 | 21.08 | 20.72 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

# Comparison of total VMT, Ver. 2.3.36 vs. Ver. 2.2



- Ver. 2.3 VMT is higher than that of Ver. 2.2, in part, because the network is more detailed
- What used to be **intra**-zonal travel is now **inter**-zonal travel



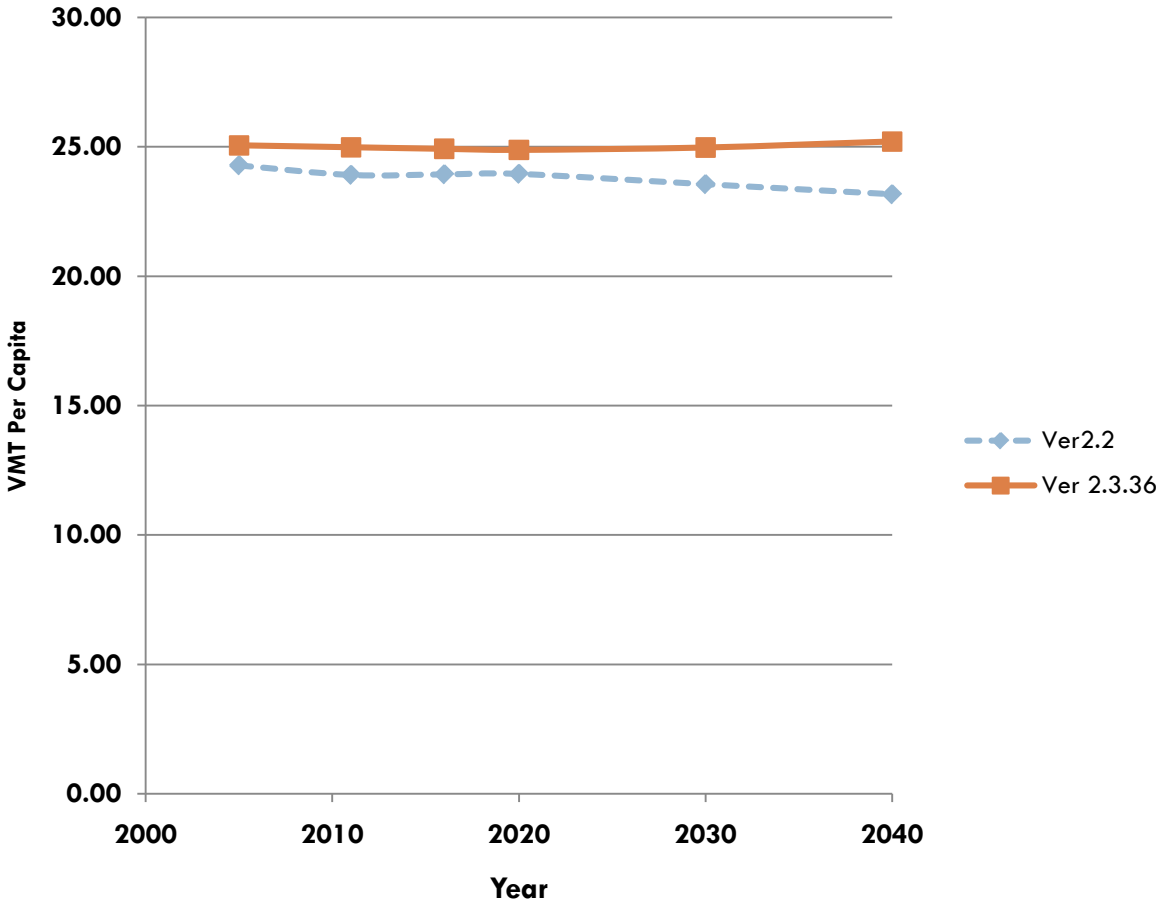

| Travel Model | 2005 | 2011 | 2016 | 2020 | 2030 | 2040 |
|---|---|---|---|---|---|---|
| Ver2.2 | 152,063,583 | 160,327,029 | 169,884,385 | 177,530,270 | 190,421,575 | 199,463,681 |
| Ver 2.3.36 | 155,301,301 | 167,126,118 | 176,980,133 | 184,427,424 | 201,999,848 | 217,182,430 |

Note: Years 2020, 2030, and 2040 are from the Amended 2010 CLRP

# Comparison of VMT per capita (per day), Ver. 2.3.36 vs. Ver. 2.2

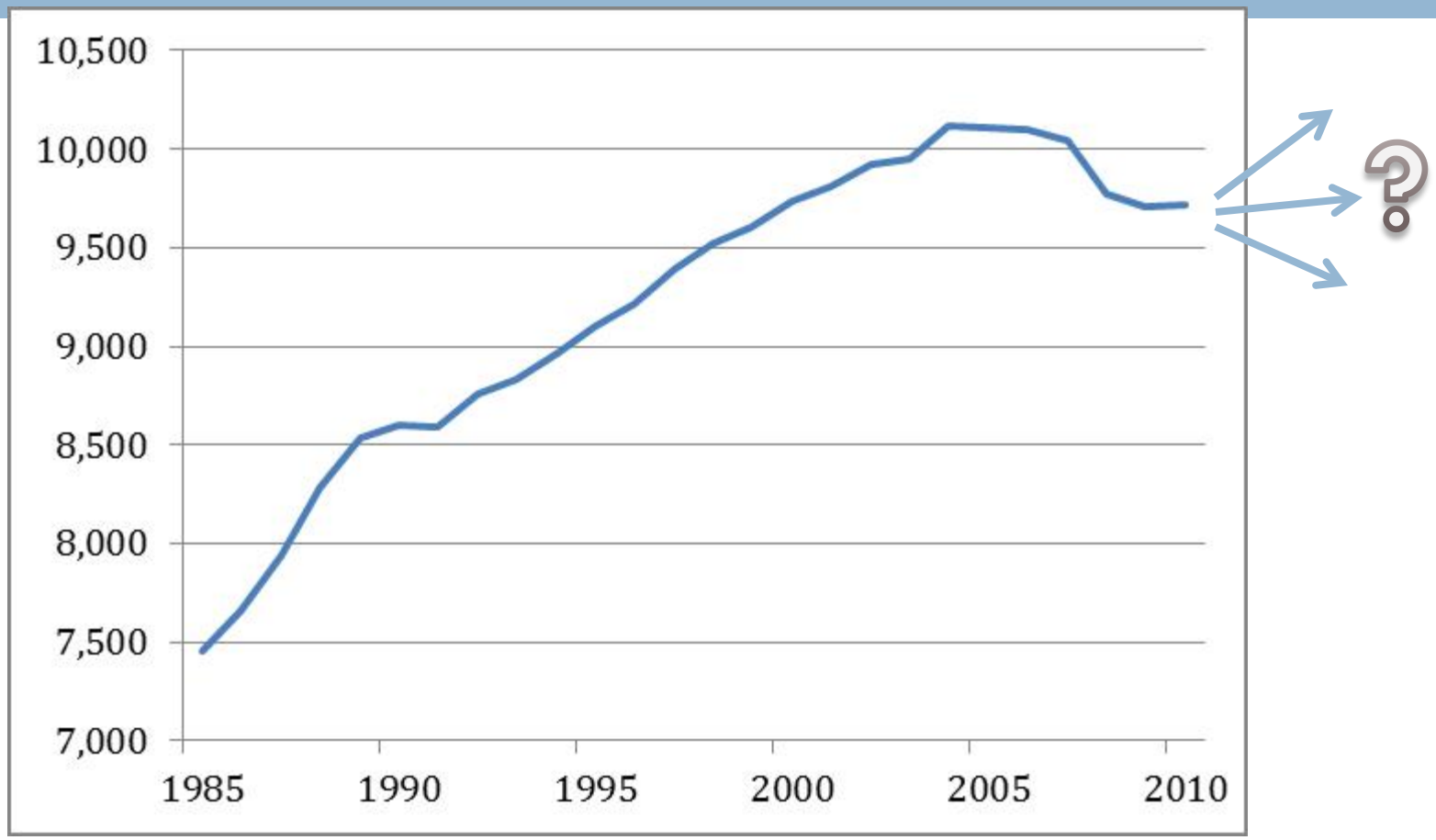


- Ver. 2.3 does not replicate the slight decline in forecasted VMT per capita that was seen in the Ver. 2.2 model
- Version 2.3:
  - In the inner jurisdictions, VMT **drops over time**
  - In the outer jurisdictions, VMT **goes up over time**



# U.S. trend since 1985, VMT per capita (per year)

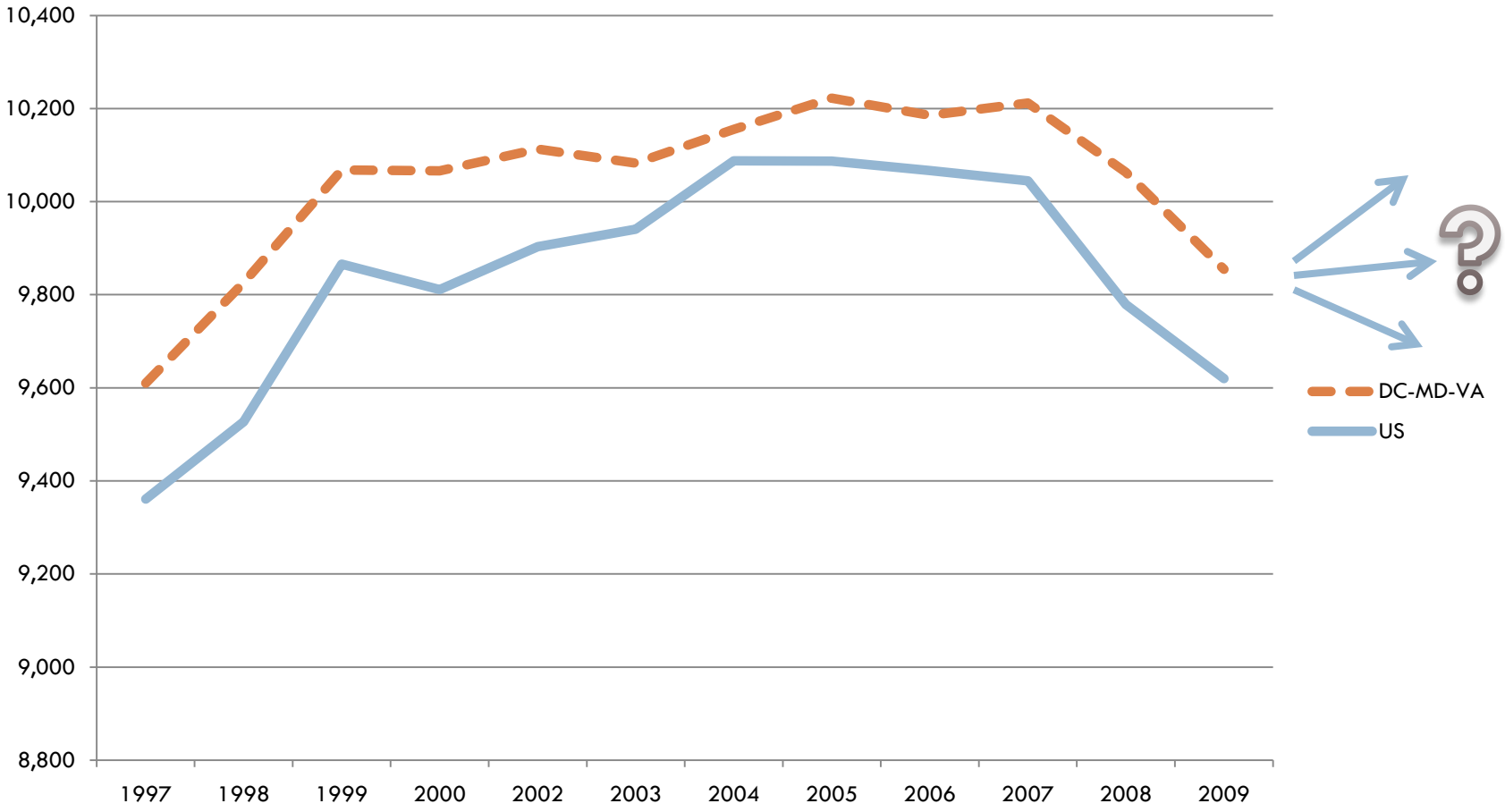





Source: FHWA, Census Bureau, taken from http://www.ssti.us/archives/548

# Local vs. U.S. trends since 1997, VMT per capita (per year)



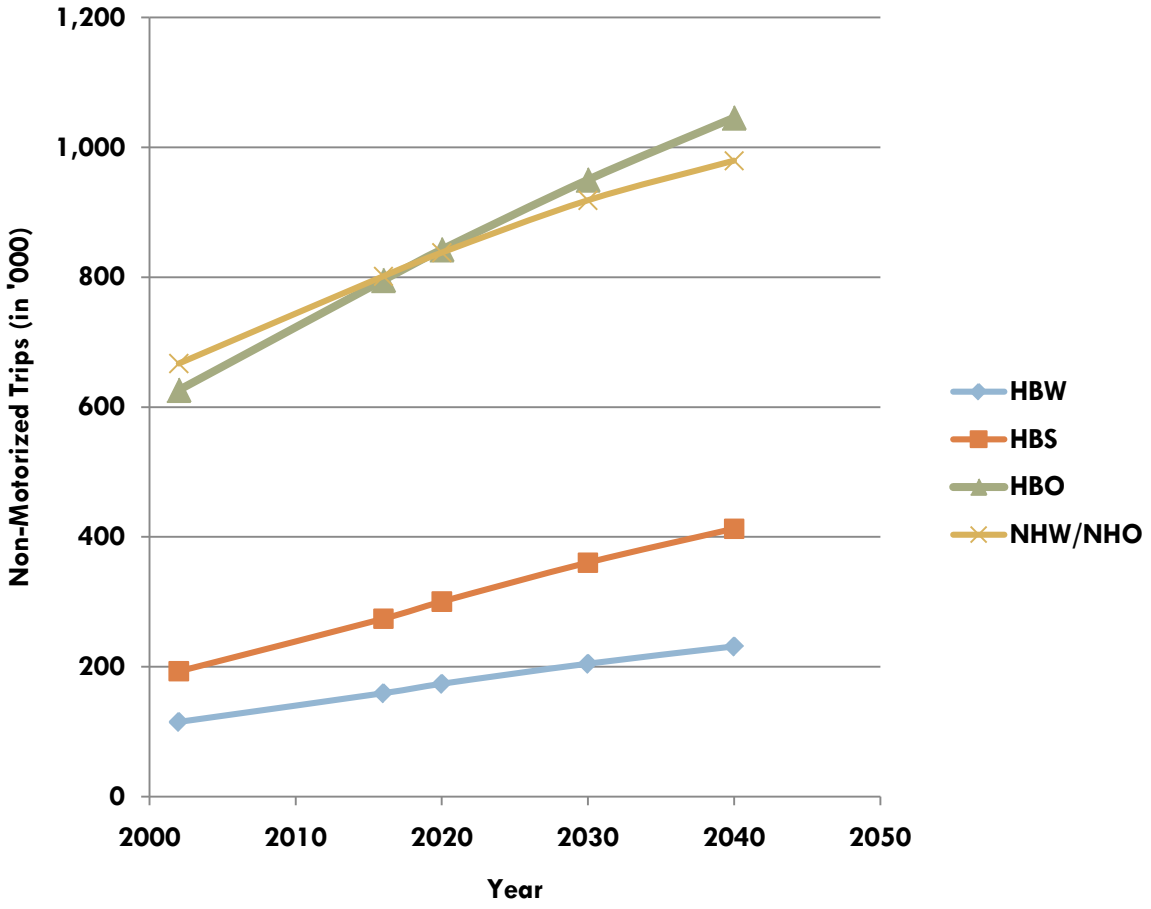



Source: U.S. Bureau of Transportation Statistics (http://www.bts.gov/publications/state_transportation_statistics/)

# Non-motorized travel (bike & pedestrian), Ver. 2.3.36



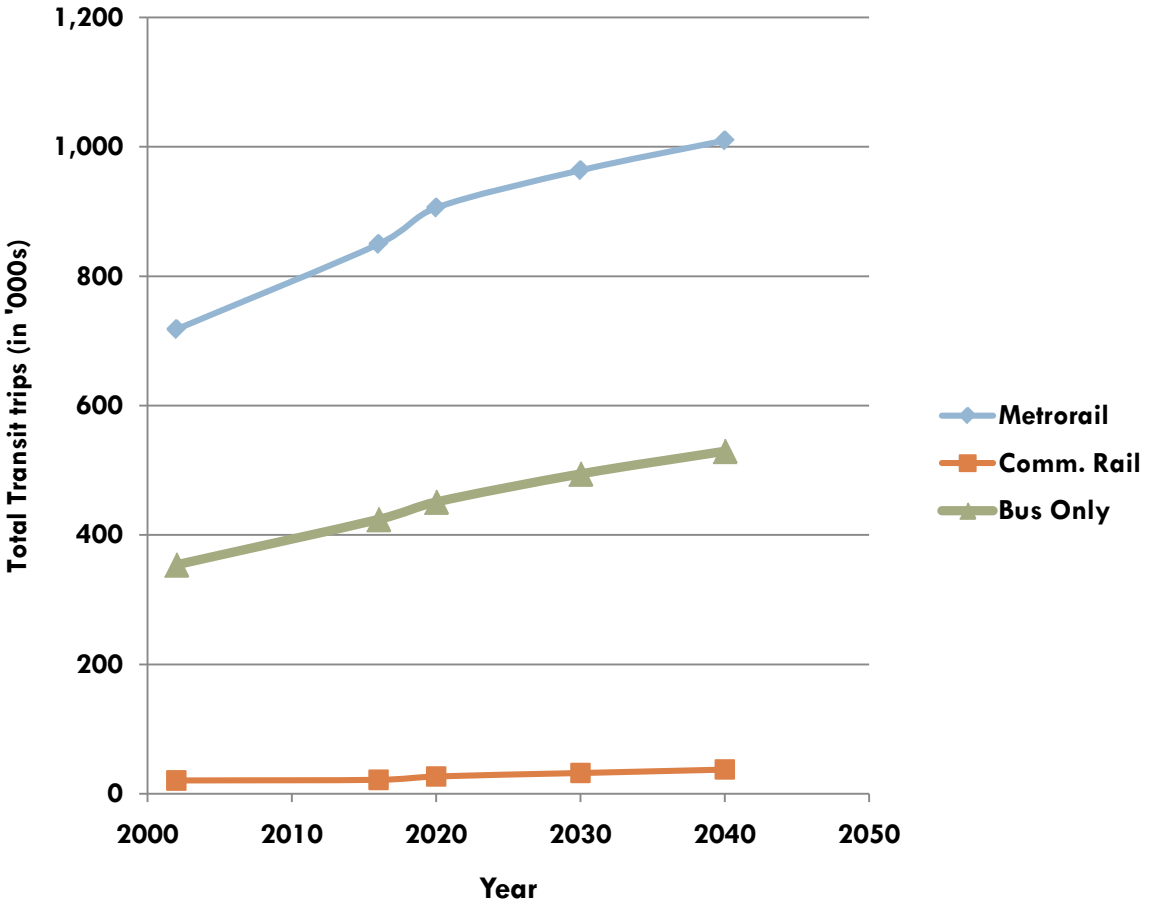
- Non-motorized travel forecasts increase as mixed use density grows in the region
- Growth is shown for all modeled purposes
- Non-motorized growth rate is higher than that of motorized travel



# Transit person trips by transit submode, Ver. 2.3.36



- Transit trips are growing across all transit submodes
- Metrorail has the highest rate of growth
- Bus has the second highest growth rate
- Commuter rail shows only moderate growth
- Note: **Forecasts reflect the transit constraint** that affects Metrorail trips to and through the regional core (2020 is the constraint year)



# Global average travel time, distance, speed, and delay forecasts, Ver. 2.3.36



| | 2002 | 2016 | 2020 | 2030 | 2040 |
|---|---|---|---|---|---|
| Trip Distance (mi) | 10.1 | 10.1 | 10.1 | 10.2 | 10.3 |
| Trip Time (min) | 17.2 | 18.5 | 18.8 | 20.0 | 22.2 |
| Trip Speed (mph) | 35.1 | 32.7 | 32.2 | 30.5 | 27.7 |
| Trip Delay (min) | 4.7 | 5.9 | 6.2 | 7.2 | 9.2 |
| % Trip Time in Delay | 27.3% | 32.0% | 32.8% | 36.1% | 41.6% |

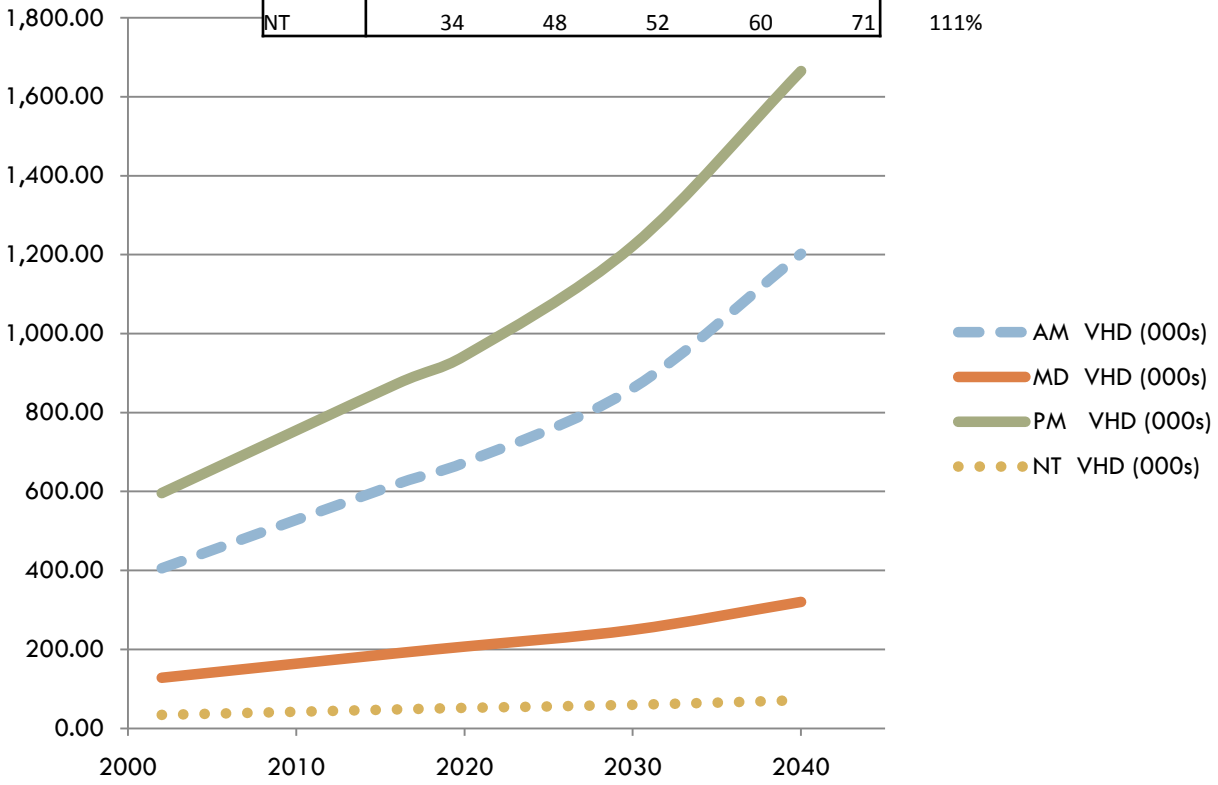
- Model is showing decreasing trip speeds, from 35 mph in 2002 to 28 mph in 2040
- Model is showing increasing trip delay, from 4.7 minutes per trip in 2002 to 9.2 minutes per trip in 2040
- Caveat: The regional model is validated to link volumes at the screenline level, but is not validated to link speeds. Consequently, estimated speeds from the regional travel model should be not be construed as true operational speeds.

# Avg. vehicle hours of delay, Ver. 2.3.36



From 2002 to 2040, avg. vehicle hours of delay is forecast to increase by almost 200% for the AM period

| | 2002 | 2016 | 2020 | 2030 | 2040 | % Diff |
|---|---|---|---|---|---|---|
| AM | 405 | 619 | 673 | 862 | 1,202 | 197% |
| MD | 128 | 190 | 207 | 249 | 320 | 150% |
| PM | 596 | 873 | 944 | 1,223 | 1,665 | 179% |
| NT | 34 | 48 | 52 | 60 | 71 | 111% |

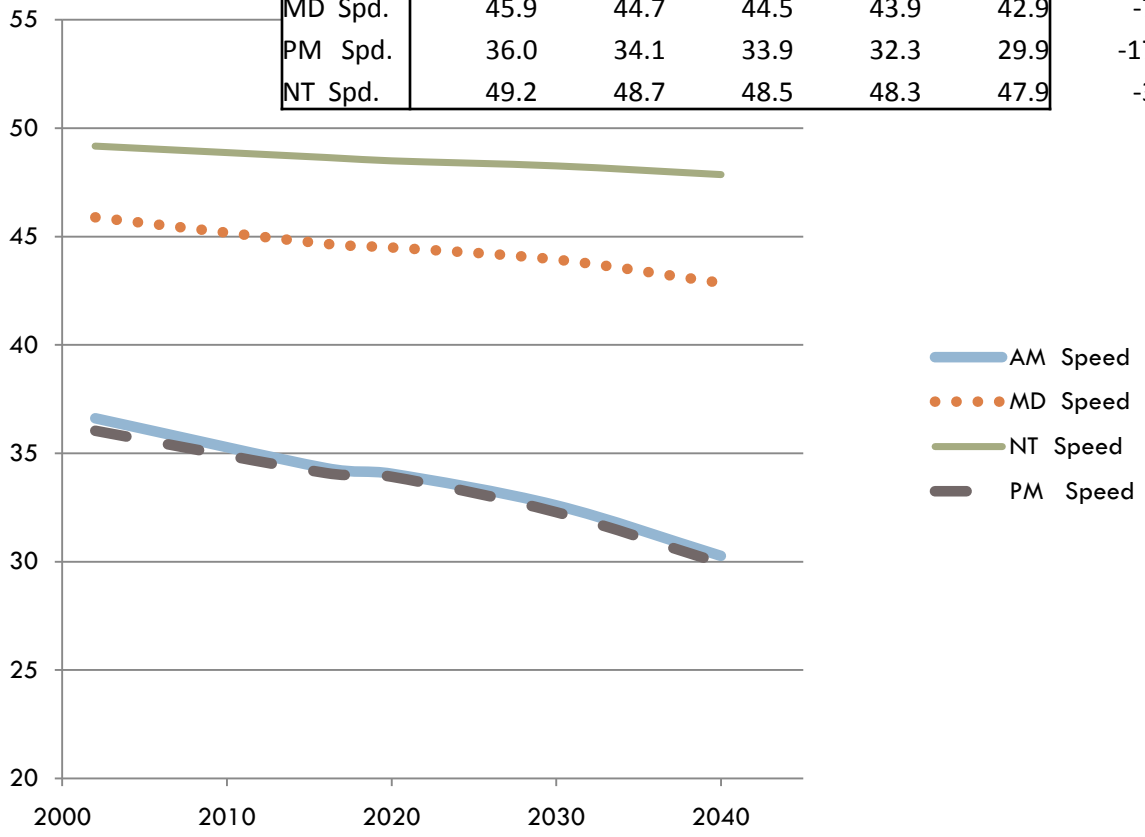


# Avg. highway speed, Ver. 2.3.36



From 2002 to 2040, avg. highway speeds are forecast to decrease by about 17% for the AM period

| | 2002 | 2016 | 2020 | 2030 | 2040 | % Diff |
|---|---|---|---|---|---|---|
| AM Spd. | 36.6 | 34.3 | 34.1 | 32.6 | 30.3 | -17% |
| MD Spd. | 45.9 | 44.7 | 44.5 | 43.9 | 42.9 | -7% |
| PM Spd. | 36.0 | 34.1 | 33.9 | 32.3 | 29.9 | -17% |
| NT Spd. | 49.2 | 48.7 | 48.5 | 48.3 | 47.9 | -3% |




Caveat: The regional model is validated to link volumes at the screenline level, but is not validated to link speeds. Consequently, estimated speeds from the regional travel model should be not be construed as true operational speeds.

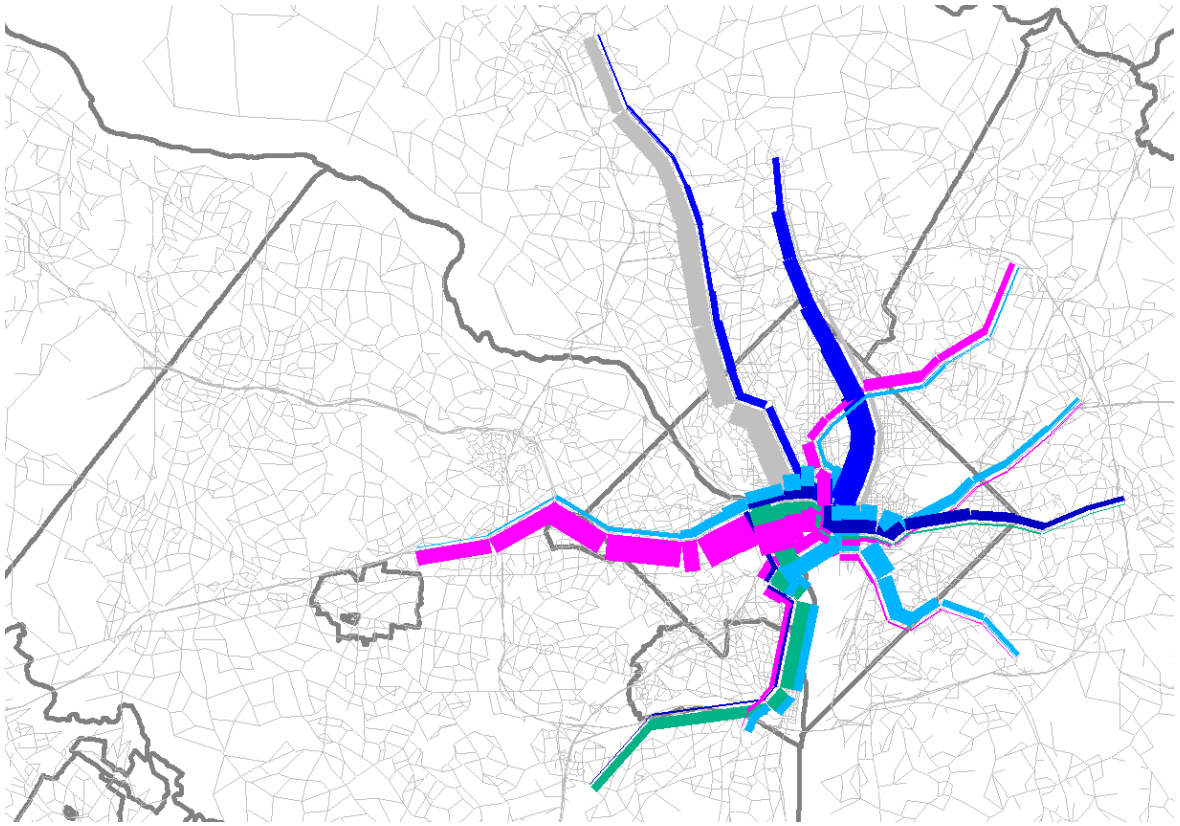
# Transit assignment



- A new capability
- All transit modes are assigned (Metrorail, commuter rail, bus, LRT, etc.)
- Summaries of the transit assignment can be done for all transit modes or a subset of modes
  - The only transit assignment results we have looked at are Metrorail person trips, summarized by Metrorail station groups
  - Grouping analogous to screenlines in highway assignment

# Estimated 2007 Peak Metrorail Volume

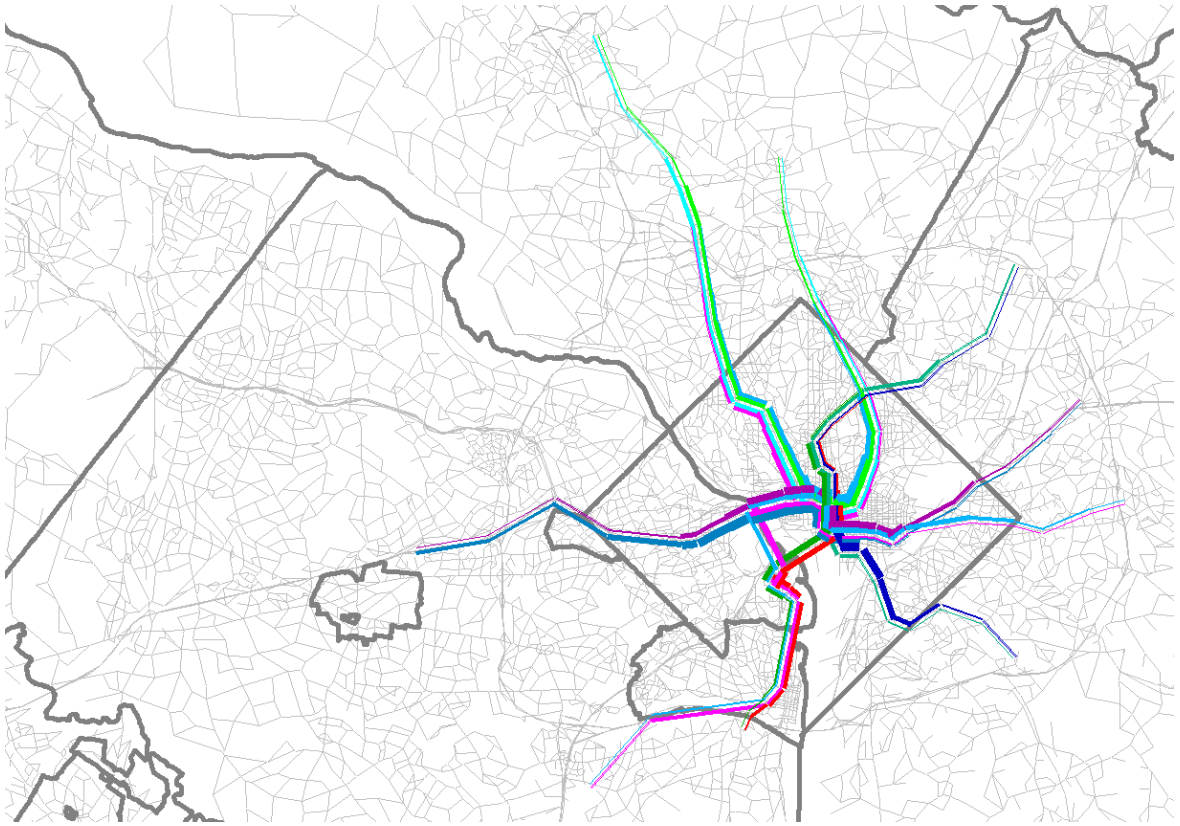




2000 transit person trips per pixel

# Estimated 2007 Off-peak Metrorail Volume

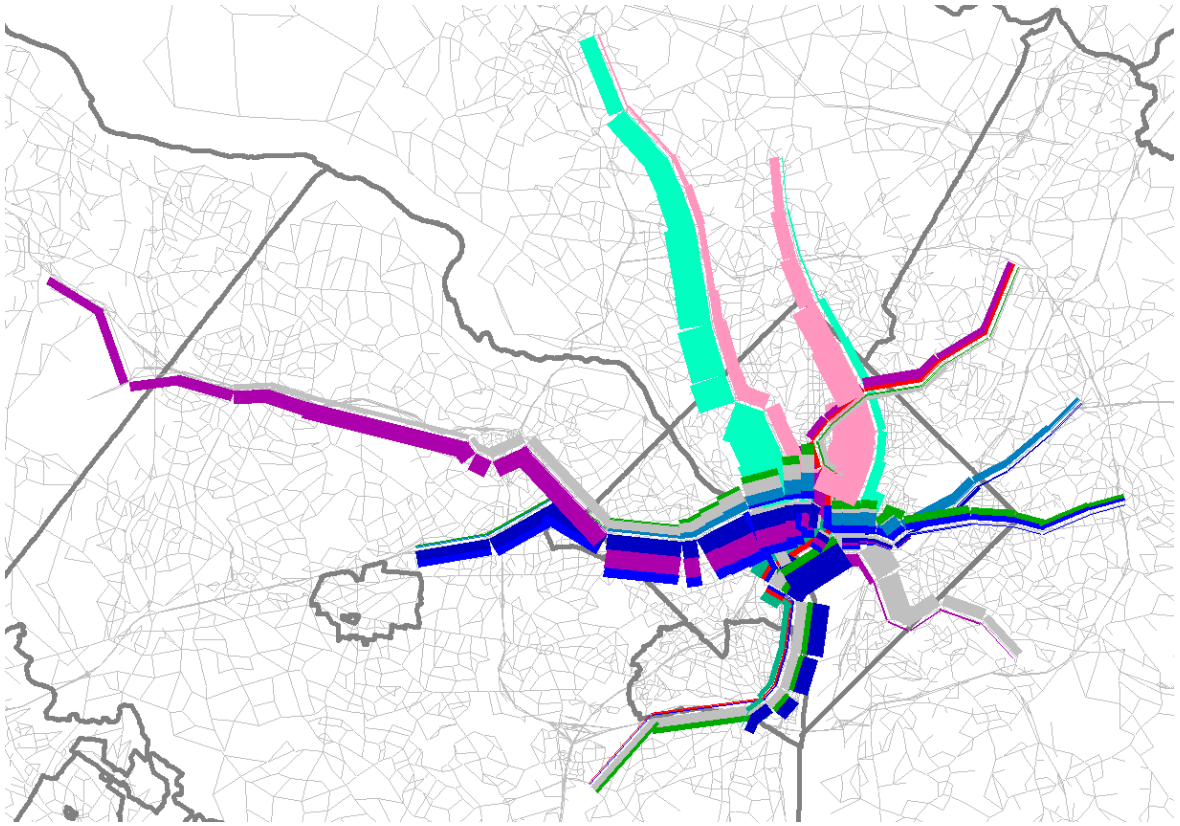




2000 transit person trips per pixel

# Estimated 2040 Peak Metrorail Volume

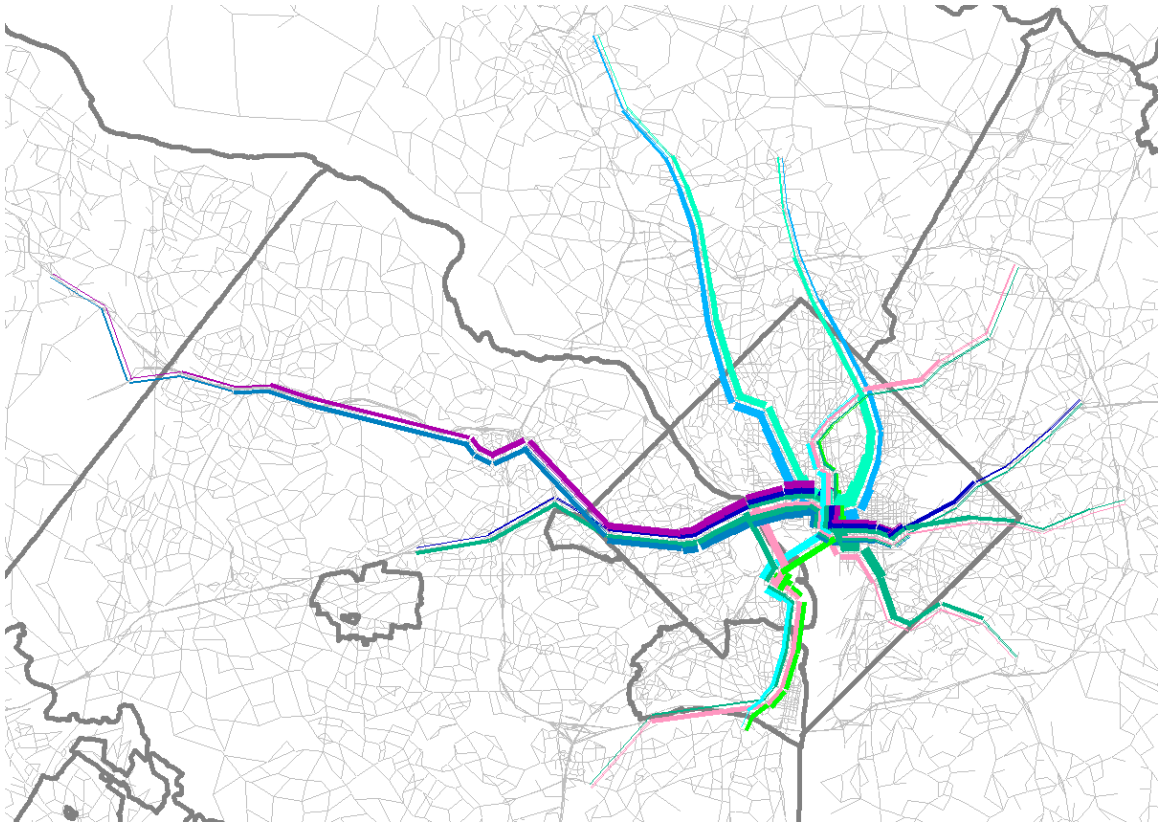




2000 transit person trips per pixel

# Estimated 2040 Off-peak Metrorail Volume





2000 transit person trips per pixel

## Metrorail assignment results, 2007

Metrorail assignment results will be added to the final version of the calibration report

| Est. and Obs. 2007/2008 Total Weekday Metrorail Productions & Attractions by Station Groups | | | | | | | |
|---|---|---|---|---|---|---|---|
| TPB Ver. 2.3 travel model, 3,722 TAZ | | I-I and I-X/X-I transit | | | | | |
| | | Observed 2008 | | Estimated 2007 | | Est/Obs | Est/Obs |
| | Metrorail Segment | Prods | Attrs | Prods | Attrs | Prods | Attrs |
| 1 | Red Line - "A" route MD outside Beltway | 56,808 | 14,571 | 49,565 | 16,070 | 0.87 | 1.10 |
| 2 | Red Line - "A" route MD inside Beltway | 26,662 | 27,751 | 30,394 | 36,148 | 1.14 | 1.30 |
| 3 | Red Line - "A" route DC non-core | 39,433 | 20,366 | 32,473 | 15,246 | 0.82 | 0.75 |
| 4 | Red Line - DC core | 77,420 | 244,253 | 50,469 | 172,417 | 0.65 | 0.71 |
| 5 | Red Line - "B" route DC non-core | 37,861 | 18,574 | 46,870 | 16,287 | 1.24 | 0.88 |
| 6 | Red Line - "B" route MD | 45,877 | 12,223 | 48,987 | 15,639 | 1.07 | 1.28 |
| 7 | Green Line - "E" route MD | 35,182 | 10,346 | 26,124 | 8,173 | 0.74 | 0.79 |
| 8 | Green Line - "E" route DC non-core | 28,928 | 15,757 | 28,080 | 16,058 | 0.97 | 1.02 |
| 9 | Green Line - DC core | 21,386 | 58,090 | 19,794 | 60,153 | 0.93 | 1.04 |
| 10 | Green Line - "F" route DC non-core | 27,328 | 25,498 | 28,800 | 21,276 | 1.05 | 0.83 |
| 11 | Green Line - "F" route MD | 46,024 | 6,575 | 32,128 | 3,470 | 0.70 | 0.53 |
| 12 | Blue/Yellow Line - VA Fairfax | 43,511 | 3,382 | 41,580 | 4,387 | 0.96 | 1.30 |
| 13 | Blue/Yellow Line - VA Alexandria | 19,638 | 15,575 | 15,953 | 17,833 | 0.81 | 1.14 |
| 14 | Blue/Yellow Line - VA Core | 53,475 | 62,198 | 52,937 | 43,877 | 0.99 | 0.71 |
| 15 | Orange Line - VA Fairfax | 51,403 | 10,798 | 50,208 | 9,449 | 0.98 | 0.88 |
| 16 | Orange Line - VA Arlington non-core | 45,199 | 25,858 | 47,620 | 37,708 | 1.05 | 1.46 |
| 17 | Orange/Blue Line - VA/DC core | 47,110 | 195,738 | 50,202 | 219,259 | 1.07 | 1.12 |
| 18 | Orange/Blue Line - DC non-core | 17,677 | 7,161 | 26,146 | 8,776 | 1.48 | 1.23 |
| 19 | Orange Line - DC/MD | 35,728 | 6,552 | 25,714 | 5,740 | 0.72 | 0.88 |
| 20 | Blue Line - DC/MD | 28,970 | 4,354 | 26,516 | 3,017 | 0.92 | 0.69 |
| | **Total** | 785,621 | 785,621 | 730,560 | 730,983 | 0.93 | 0.93 |
| | **DC/VA Core Total** | 199,391 | 560,279 | 173,402 | 495,706 | 0.87 | 0.88 |
| | Percent RMSE | | | 48.4% | 218.7% | | |
| | Standard deviation | | | 13,270.9 | 59,960.8 | | |
| Notes: | | | | | | | |
| | Includes both internal and external travel, even though we model only internal transit trips | | | | | | |

# LOOKING AHEAD

# Issues



- Running time is still excessive
- TPB staff has noticed that some runs "hang"
  - Under investigation
- Traffic count coverage is still too low
  - We are collecting 2010 counts for next validation
- Model refinement will continue this year
  - Example: Examining the area type assigned to various TAZs
  - New model version will likely be released in about a year

# Next Steps



- "Replication runs" are in motion to double-check Version 2.3 model results
- Version 2.3 transmittal package is being prepared
  - Memorandum documenting files prepared
  - Transfer medium: COG FTP site
- Feedback on documentation is welcomed
- Version 2.3 refinement activities will be ongoing
- Next production model release including refinements: Mid to late 2012

# Upcoming regional planning work



- State Implementation Plan (SIP) update
  - Years studied: 2002, 2007, 2017, 2025
  - Will involve new EPA MOVES model
- TPB Regional Transportation Priorities Plan (RTPP)
  - Examination of transportation and land use scenarios
  - Will carry on with work begun previously with the Version 2.2 model

# Local project planning studies likely involving Version 2.3 travel model



- Virginia (projects in motion)
  - Transaction 2040 (NVTA)
  - I-66 Multimodel Study (NVDOT)
  - I-66 Outside the Beltway (VDOT Central Office)
- Maryland (potential project planning areas)
  - ICC Volume Re-evaluation Study (MDSHA)
  - MD 586 Veirs Mill Road Study (MDSHA)
- District of Columbia and Federal studies?

# Availability of the model



- Available upon written request
- See the "Model Documentation and Data Requests" web page for information about the recommended procedure to request the model (http://www.mwcog.org/transportation/activities/models/documentation.asp)
  - E-mail or signed letter to Ron Kirby, Director, DTP
  - Correspondence should be as specific as possible regarding what model version, data, and/or documentation is requested.
  - Correspondence should also indicate how you intend to use the data/model, naming the specific study or research project, if applicable. This will help ensure that we give you the most appropriate model or data.
- Model will be made available on our FTP site (no more CDs/DVDs)

# Conclusions, 1



- The Version 2.3 Travel Model is now the adopted regional travel model for the Metropolitan Washington Region region
- Documentation is available on the COG website
- Ver. 2.3 enhancements, including
  - More TAZs and greater detail in transportation networks
  - New calibration/validation data sets
  - 15-choice nested logit mode choice, w/ transit assign.
  - Trip generation:  Non-motorized travel for all trip purps.
  - Enhanced traffic assignment convergence criteria

# Conclusions, 2



- "Builds" of the Version 2.3 model (2.3.X)
  - 36: Draft documentation
  - 37: Transmittal version of the model
- Transmittal package is in preparation
- Model is to be used in a number of upcoming studies
- Appreciate feedback on model and documentation from external users

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