Assistance with Development and Application of the TPB Travel Demand Model

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AECOM

July 19, 2013

2013 Task Orders

- T.O. 7 – Meetings and General Support
- T.O. 8 – Traffic Assignment
  - 8.1 – HOT-lane Modeling
  - 8.2 – HOV Modeling
  - 8.3 – Speed Validation
  - Added – tech memo, meetings, and simple HOV model
- T.O. 9 – Mode Choice and Transit Modeling
  - 9.1 – Network Preparation
  - 9.2 – Path Building
  - Added – AEMS→ModeChoice example/documentation

Draft Final Report

- Chapters submitted for review (6/12 - 7/1)
- MWCOG comments incorporated (7/15)
- TFS review and comments (7/19 - 8/16)
- Finalized by 8/30/2013

Report Outline

- Task Order 7
  - Chapter 1: Introduction
  - Chapter 2: Meetings and Technical Assistance
    - Interpreting AEMS Market Shares
- Task Order 8
  - Chapter 3: HOV Modeling
  - Chapter 4: HOT Lane Modeling
  - Chapter 5: Speed Validation – INRIX Data
    - Literature review by Bill Allen
  - Chapter 6: Using INRIX Data for Travel Models

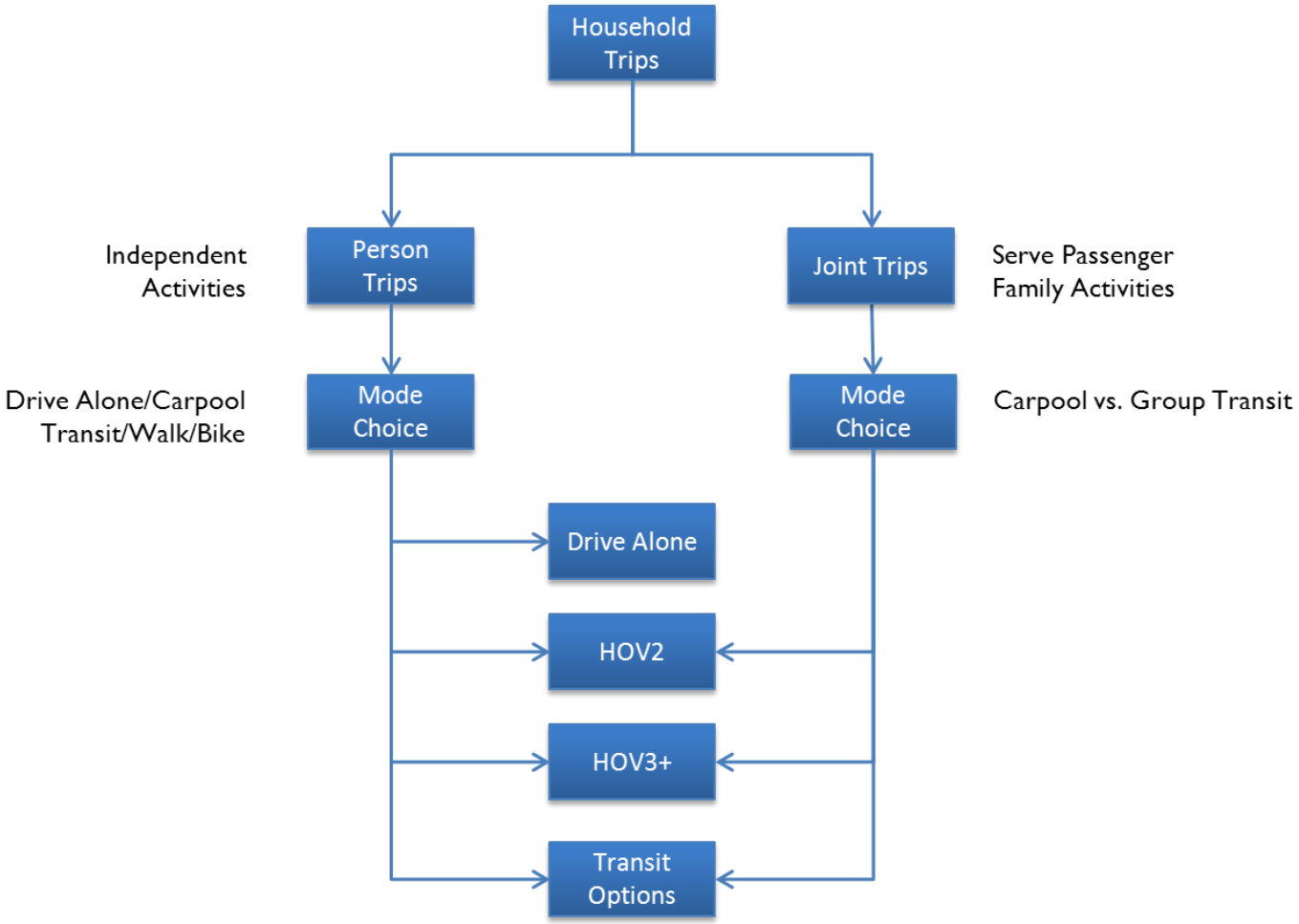
Report Outline (part 2)

- Task Order 9
  - Chapter 7: Converting TRNBUILD Networks to PT
  - Chapter 8: PT Path Building and Assignments
  - Chapter 9: PT Transit Fare Options
  - Chapter 10: ModeChoice Software
- Chapter 11: Summary of Recommendations
- Appendix
  - Quick References
  - Software User's Guides
    - LineSum and ModeChoice

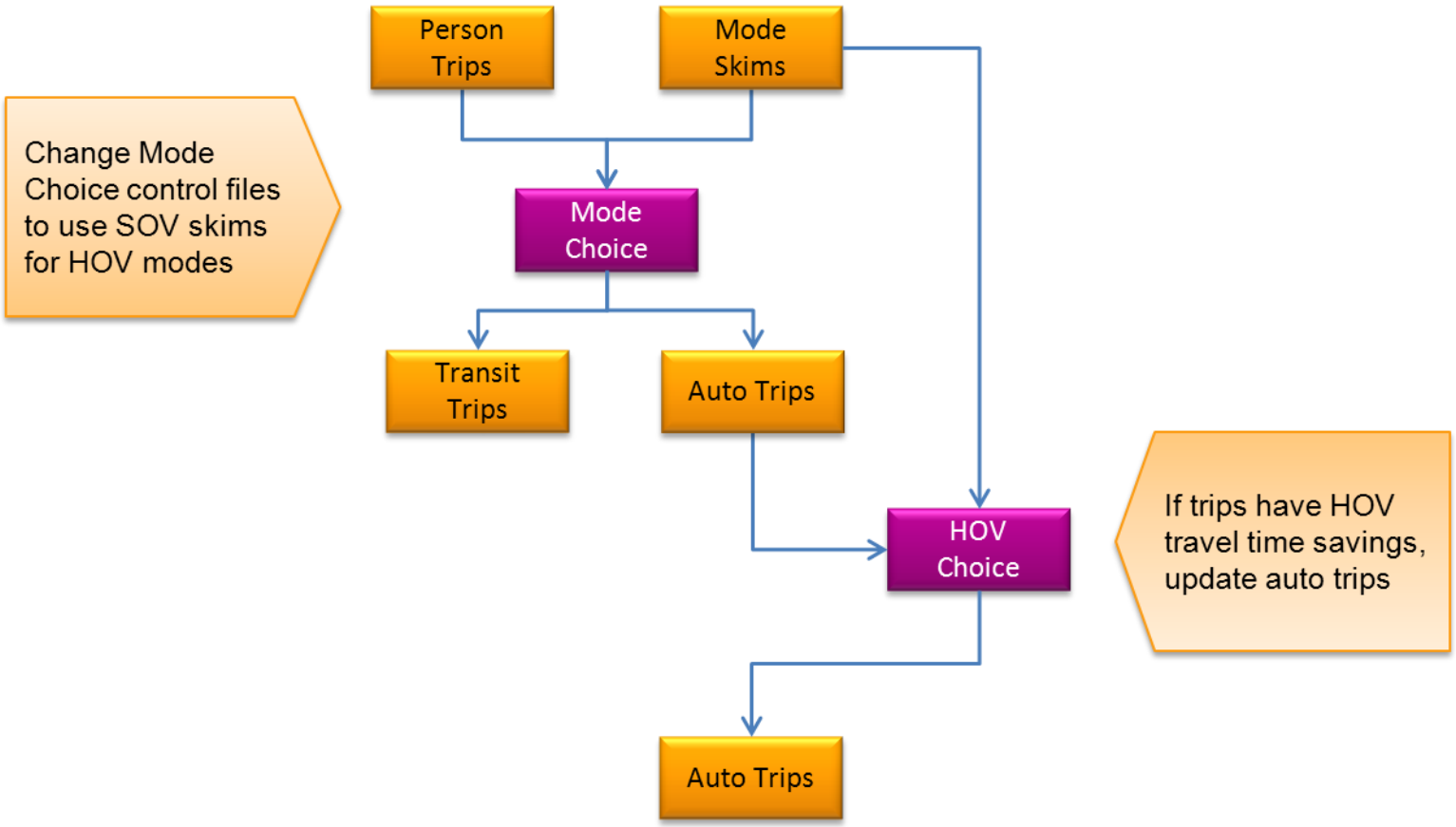
HOV Modeling Task

- Purpose/Objective
  - Test HOV modeling procedures that simplify the code and reduce overall run time
  - Model travelers who choose to form a carpool to save travel time or cost differently from family group travel
- Task Activities
  - Test multi-class traffic assignment options
  - Estimate a HBW HOV 3+ choice model using travel time differences and observed volumes from Shirley Highway HOV and general purpose lanes

Modeling Joint Travel Demand



HOV Choice Model



Model Estimation Results

$$HOV3p = (SOV + HOV2 + HOV3p) * \frac{(HOV3p) * (\exp(-\lambda * (\Delta TT))}{(SOV + HOV2) + (HOV3p * \exp(-\lambda * (\Delta TT))}$$

	Count	Background HOV		HOV Choice #1 λ1=0.15, λ2=0.10		HOV Choice #2 λ1=0.20, λ2=0.10	
	OBS	EST	EST/OBS	EST	EST/OBS	EST	EST/OBS
SOV	20,275	17,643	87%	15,152	75%	14,493	71%
HOV2	1,464	544	37%	986	67%	1,128	77%
HOV3+	6,266	3,167	51%	6,541	104%	7,193	115%
Total	28,005	21,354	76%	22,679	81%	22,814	81%

OBS=observed, EST=estimated

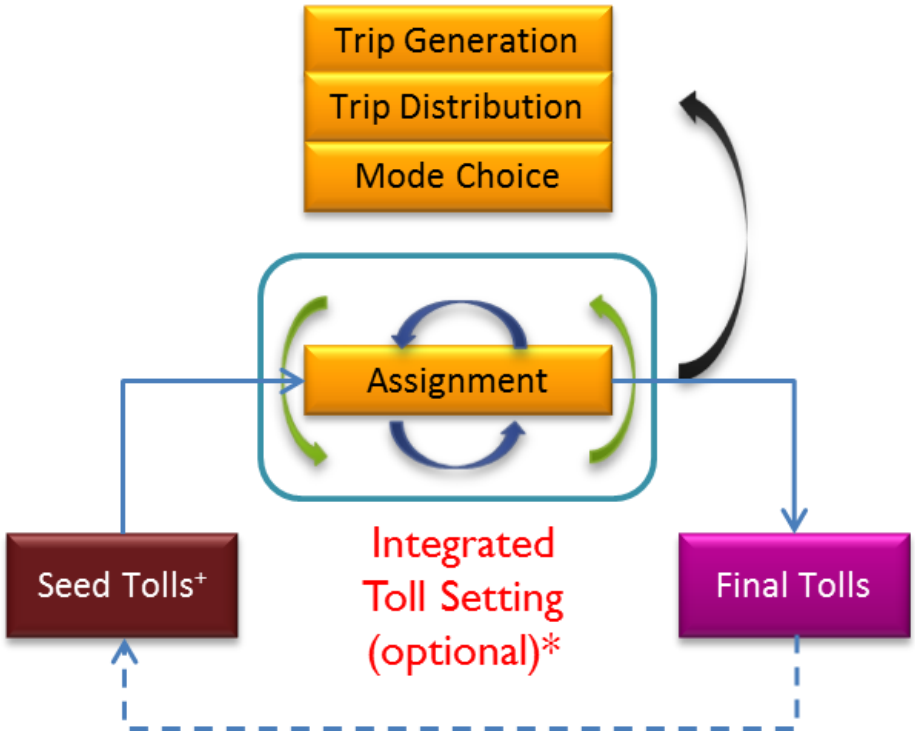
Existing HOT Lane Model

- HOT lane model using two full model runs
  - Ensures speeds for HOV 3+ traffic on HOT lanes are not degraded by the other traffic using the HOT lane
  - Doubles run time
- Uses 6 multi-class assignments for 4 time periods
  - Peaks include HOV3+ and non-HOV3+ assignments
- Separate toll-setting procedure that takes up to four days to run for a given analysis year
  - Dynamic tolls are not part of a standard model run

HOT Lane Modeling Task

- Purpose/Objective
  - Evaluate changes to the HOT lane procedures that simplify the model code and reduce overall run time
  - Add dynamic toll setting to the standard process
- Task Activities
  - Update scripts to include toll setting procedures
  - Add a toll / no-toll choice model to the assignment
  - Integrate and expand the HOV choice model
  - Test the performance of various iterative methods and convergence algorithms

Integrated Toll Setting Options

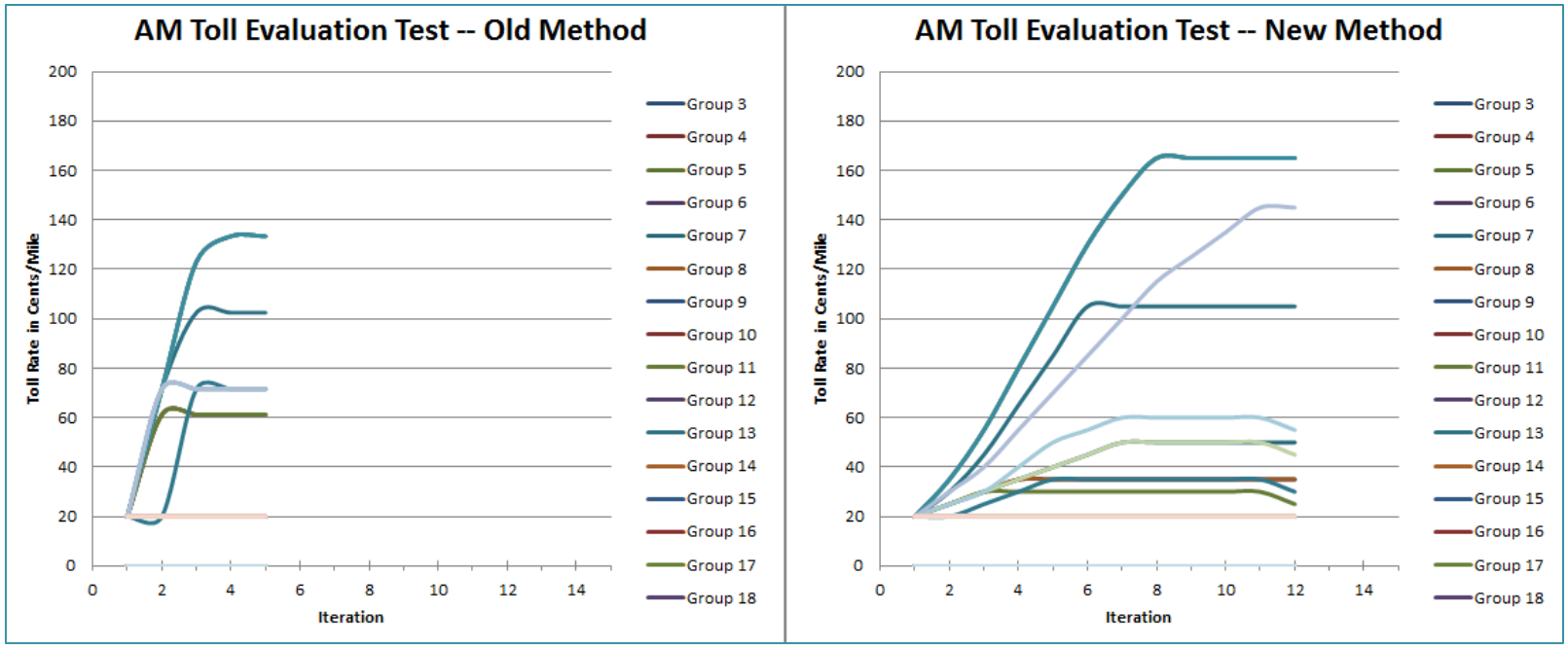


+ Fixed tolls or tolls set by the previous speed-feedback iteration

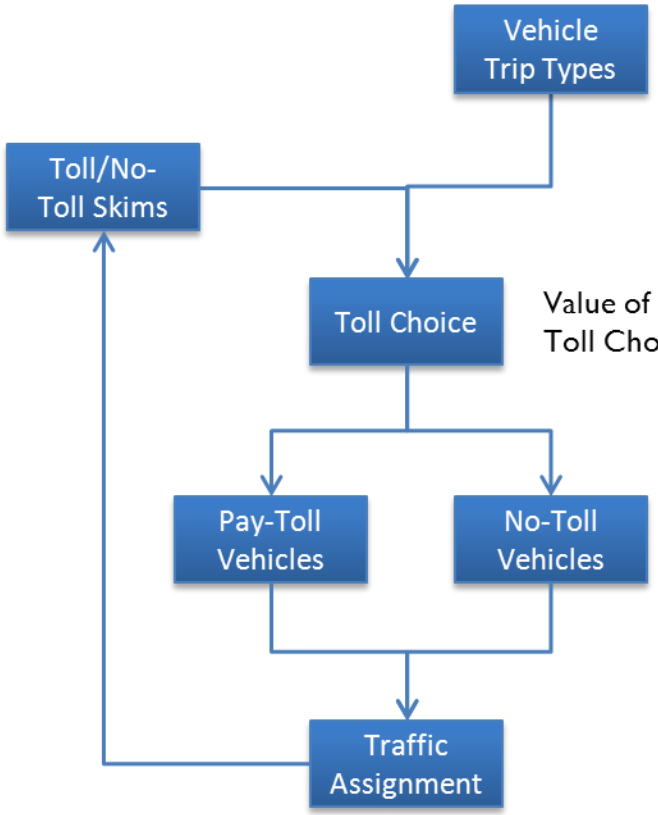
* Two levels of toll setting convergence criteria and search methods

Toll Setting Results

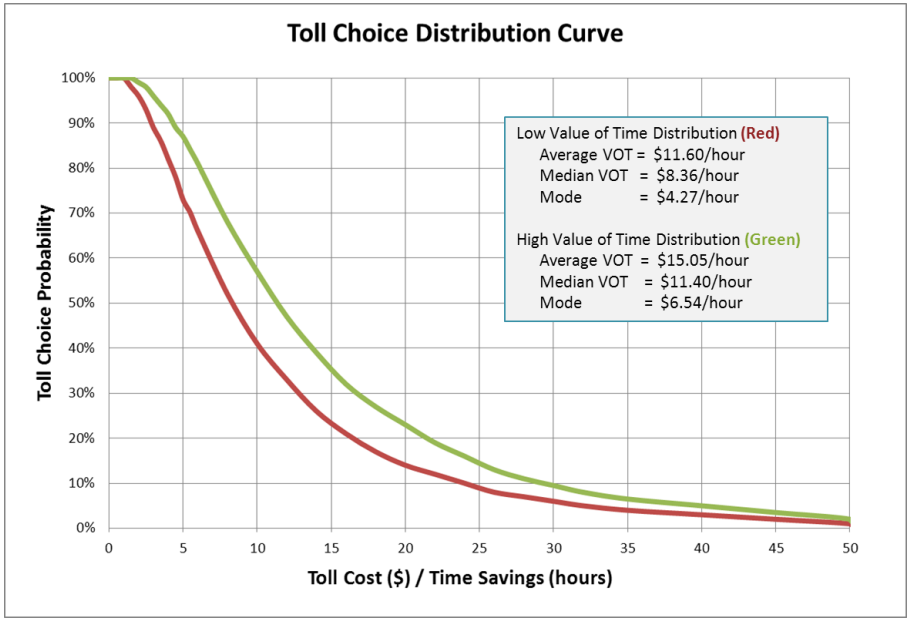
- Toll rates for 132 toll groups by iteration
  - Relatively few rates – some higher, most lower
  - More iterations needed for convergence



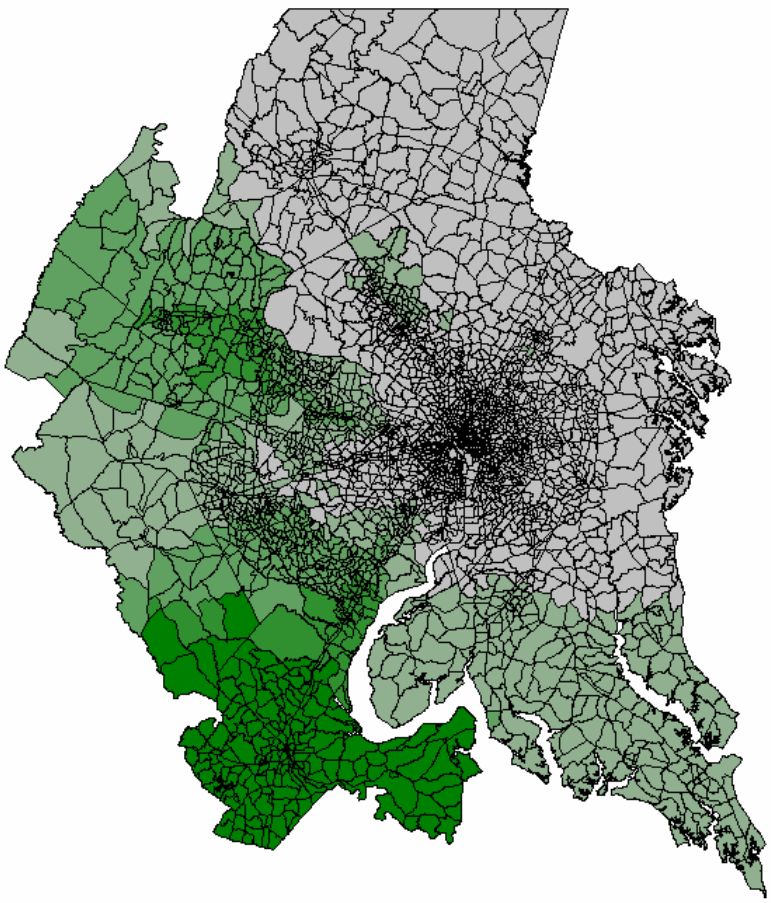
Traffic Assignments with Toll Choice



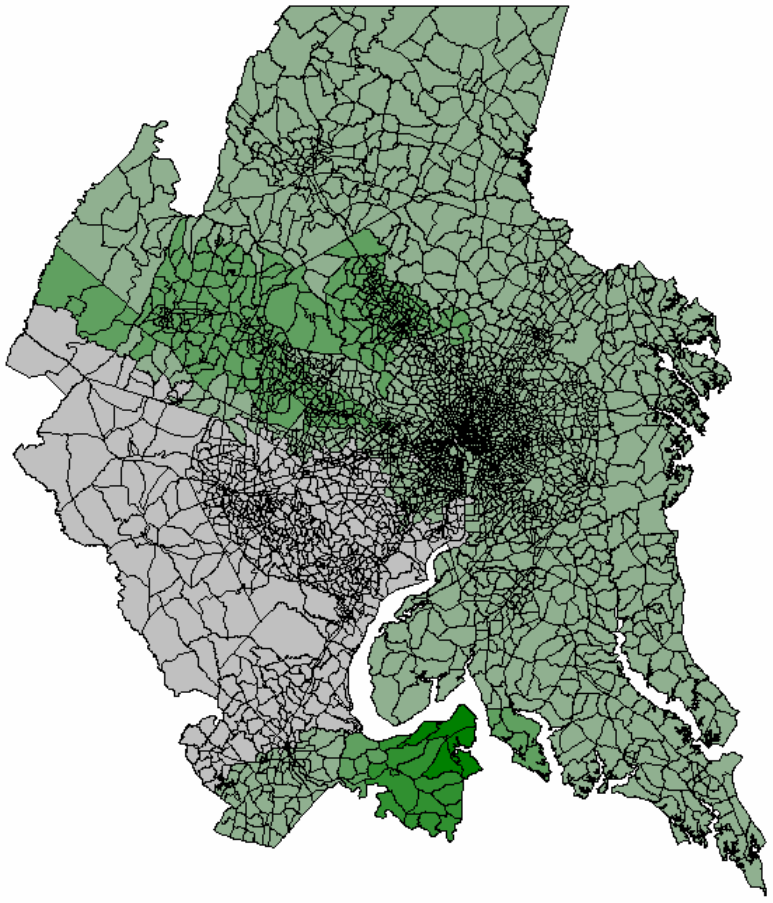
Value of Time by Vehicle Type
Toll Choice Probability Distribution



Who Saves Travel Time by Paying Tolls?



AM Peak SOV Origins



PM Peak SOV Origins

Initialization and Convergence Tests

Stopping criterion for UE traffic assignment (relative gap)		Seed tolls used at the start of the toll setting loop	
Within toll-setting loop	**Following toll-setting loop**	**Use same seed tolls for each SFB iteration**	**Use seed tolls from previous SFB iteration**
Normal RG threshold	Not used/needed	Test A-1	Test A-2
Relaxed RG threshold	Normal RG threshold	Test B-1	Test B-2

A-1	A-2	B-1	B-2
43.8 hours	71.5 hours	218 hours	46.5 hours

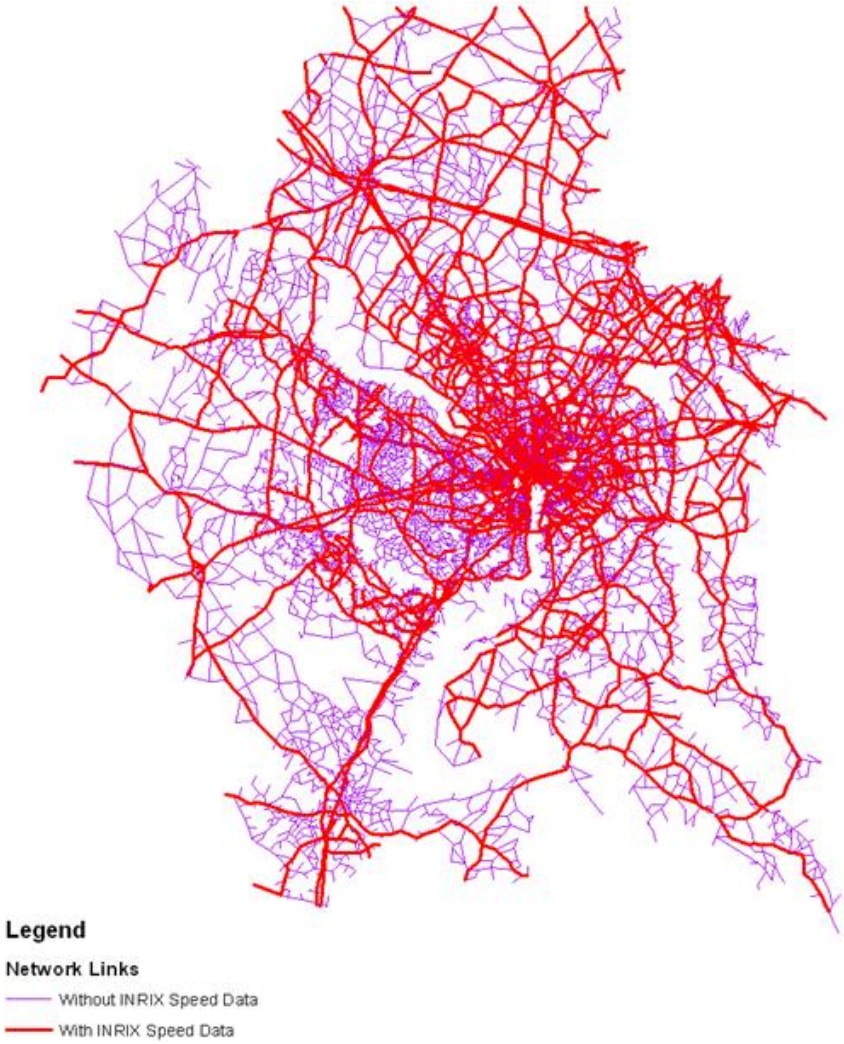
INRIX Speed Data Task

- Purpose/Objective
  - Given that the MWCOG model is a planning model with a static traffic assignment, should MWCOG be validating to observed speed data?
  - How are other agencies using operational speed data to validate their planning-level travel models?
  - How can MWCOG best use the INRIX speed data to improve the regional modeling process?
- Task Activities
  - Literature review
  - Compare INRIX speeds to model speeds

Observed Speed Literature

- INRIX provides high quality speed data
  - Good for highway performance monitoring/reporting
- Growing interest in using more sophisticated speed algorithms
  - Static assignments → dynamic traffic assignments
- Better-quality speed data highlight the fact that static models do not estimate observed speeds
  - It is inadvisable to match observed speeds at the expense of reasonable volume estimates

INRIX Coverage



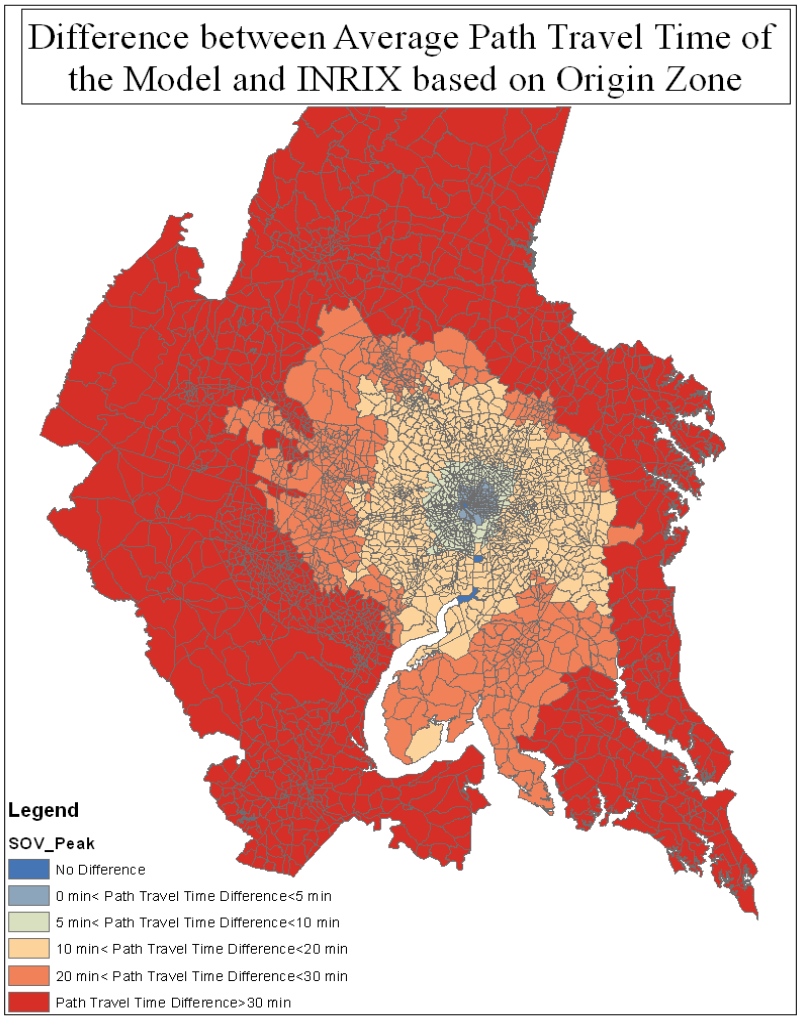
Facility Type	Coverage
Freeway	73.4%
Expressway	89.2%
Major Art.	90.3%
Minor Art.	56.8%
Collector	16.3%

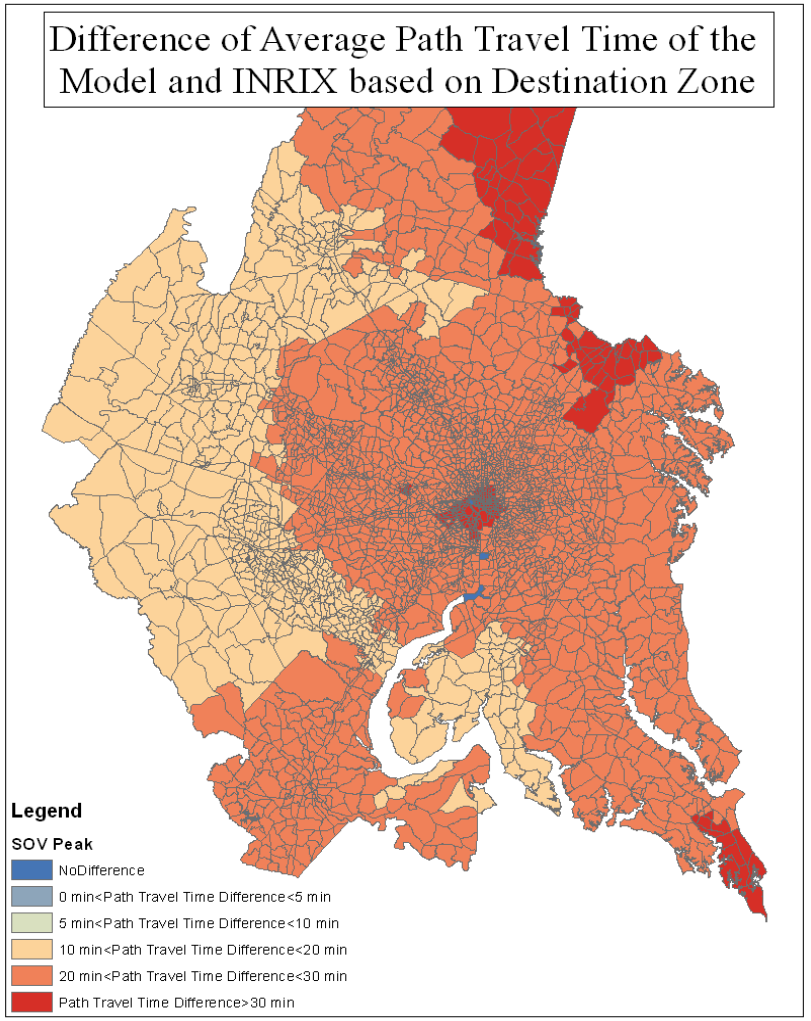
INRIX Speeds vs. Model Speeds

- Compare average speeds by facility type
  - MWCOG freeway speeds are lower than INRIX speeds in peak periods and higher in offpeak periods
  - Arterials and collectors are faster in the model
- Compared travel time skims for SOV, HOV2, and HOV3+ modes with/without INRIX speeds

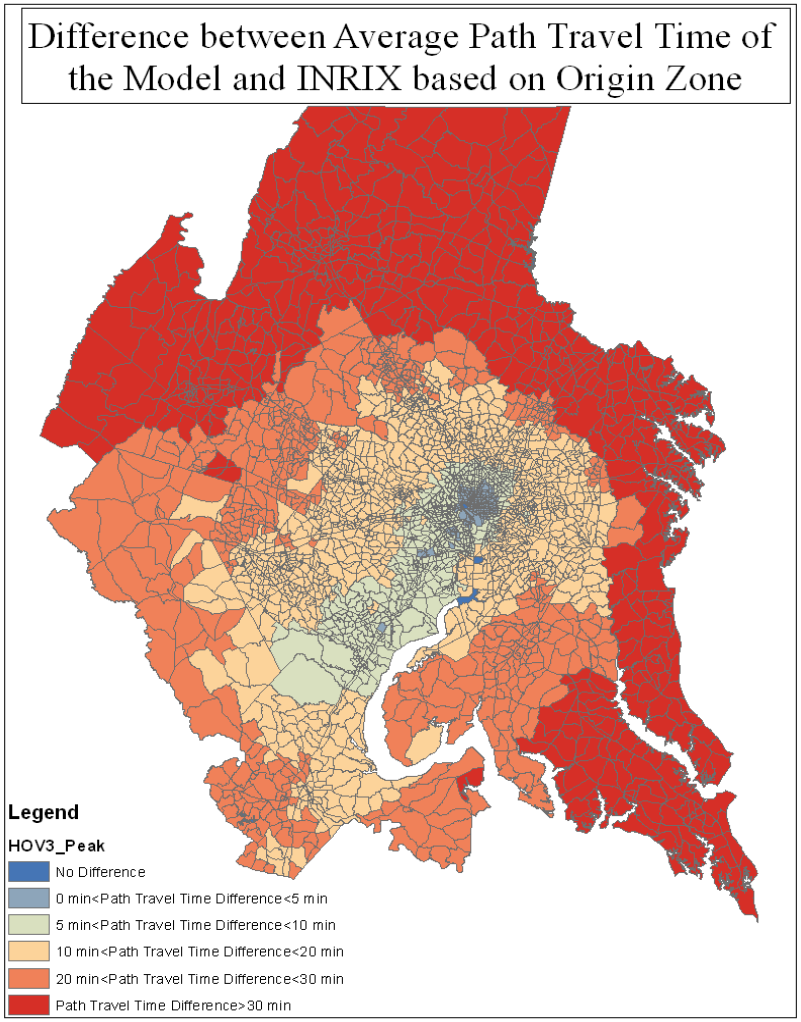
Period	Mode	Mean Travel Time (minutes) MWCOG	INRIX
Peak	SOV	81.5	57.0
	HOV2	79.6	56.7
	HOV3+	75.7	55.8
Offpeak	SOV	52.9	51.5
	HOV2	53.0	51.6
	HOV3+	53.0	51.6

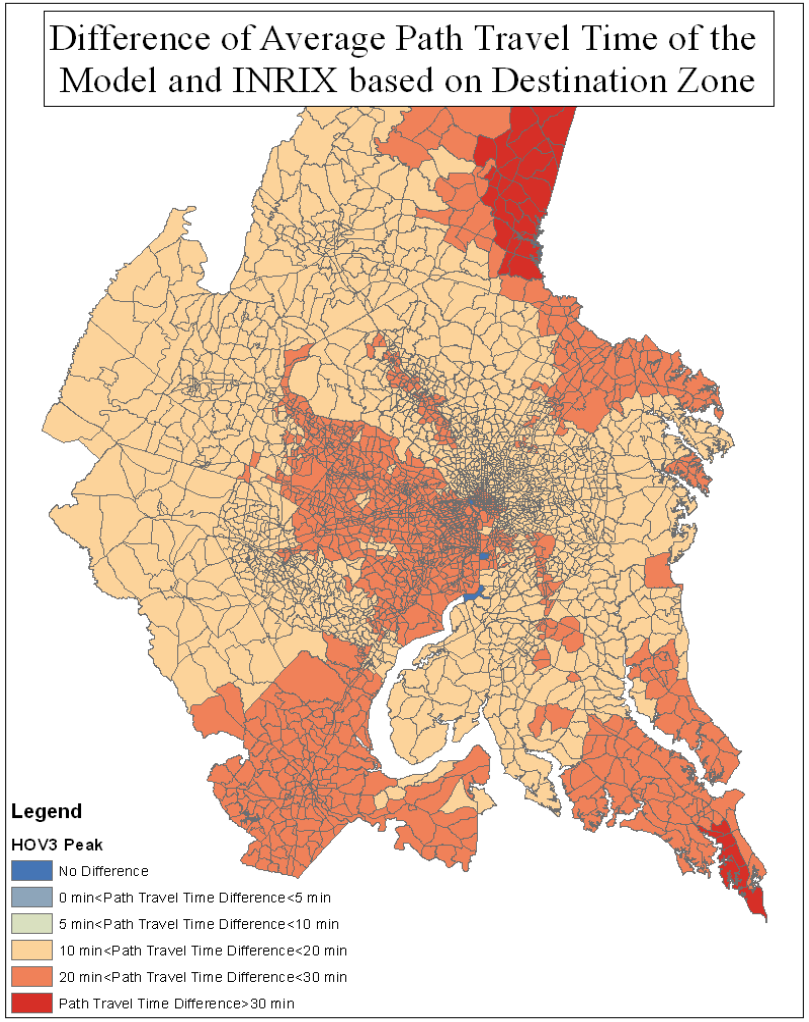
Impact of INRIX Speeds on SOV





Impact of INRIX Speeds on HOV3+





PT Conversion Task

- Purpose/Objective
  - Begin to migrate from TRNBUILD to Public Transport (PT) for transit networks, path building and assignment
    - Cube software maintenance: TRNBUILD→PT
    - Offers a number of advantages and challenges
- Task Activities
  - AECOM proposed a five-phase conversion process
  - Task Order 9 focused on first two phases
    - Network preparation
    - Path building and loading
  - Evaluated transit fare and mode choice options

TRNBUILD→PT Requirements

- PT uses an alternating sequence of transit and non-transit legs to define a transit path
  - Non-transit legs represent transfers between transit lines and access to and egress from transit lines
- TRNBUILD uses transit-only links, roadway links and transit routes to build transit paths
  - Paths may include multiple "non-transit" links (modes)
- PT requires…
  - Transit-only links integrated into a master network
  - Each non-transit path defined as one non-transit leg

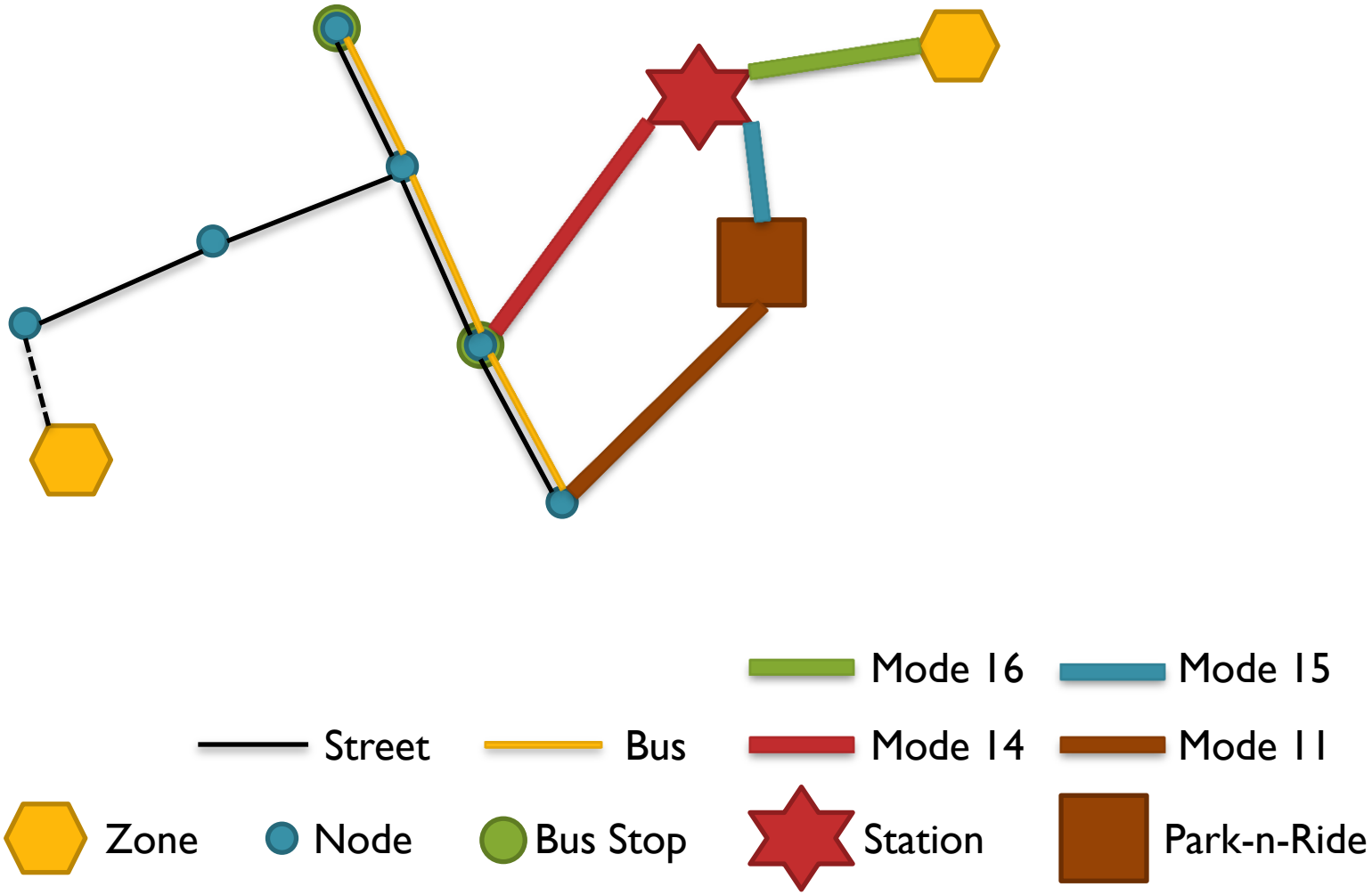
PT Network Preparation

- Develop rules and procedures for integrating transit-only links/nodes into a master network
  - Metrorail, commuter rail, light rail, access links, etc.
  - AECOM prototyped conversion options and scripts
  - MWCOG converted the transit routes and integrated the transit-only links into the highway network
- Design connection links/modes to enable PT to generate walk/drive/transfer non-transit legs
  - Distinguish between walk access/egress, park-n-ride, kiss-n-ride, and transfers between transit modes
    - Bus→bus, bus→Metrorail, light rail→Metrorail, etc.

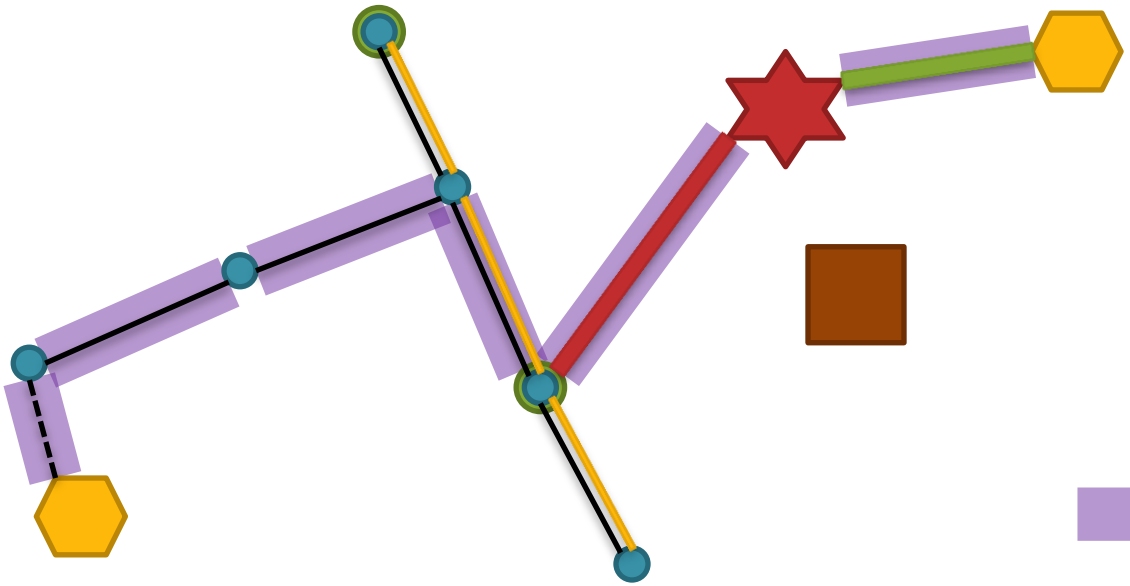
PT Generate Statements

- PT constructs non-transit legs using GENERATE
  - Includes NTLEGMODE, FROMNODE, TONODE, INCLUDELINK, EXCLUDELINK, etc.
    - From/to nodes used to distinguish zones from stops and bus stops from Metrorail and commuter rail stations
    - Include/exclude links used to control links used in path building
    - Each path "type" is assigned a unique non-transit leg mode
- Special access links were added to the master network to control PT non-transit leg generation
  - Connect Metrorail and commuter rails stations to highway nodes, park-n-ride lots, and nearby zones

Special Access Links



Walk Access to Metrorail Legs



PT GENERATE

NTLegMode ??

Mode 16

Street

Bus

Mode 14

Zone

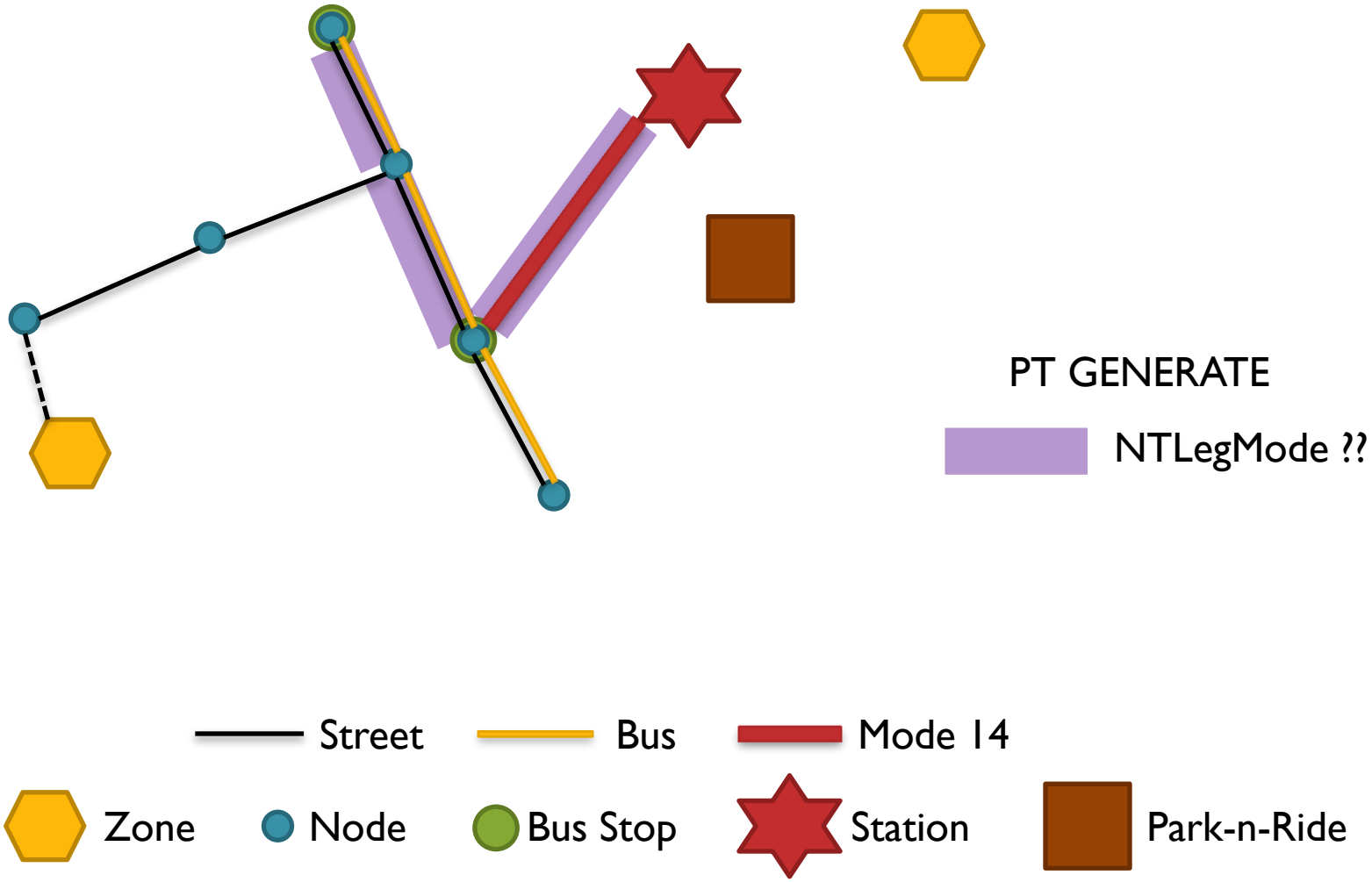
Node

Bus Stop

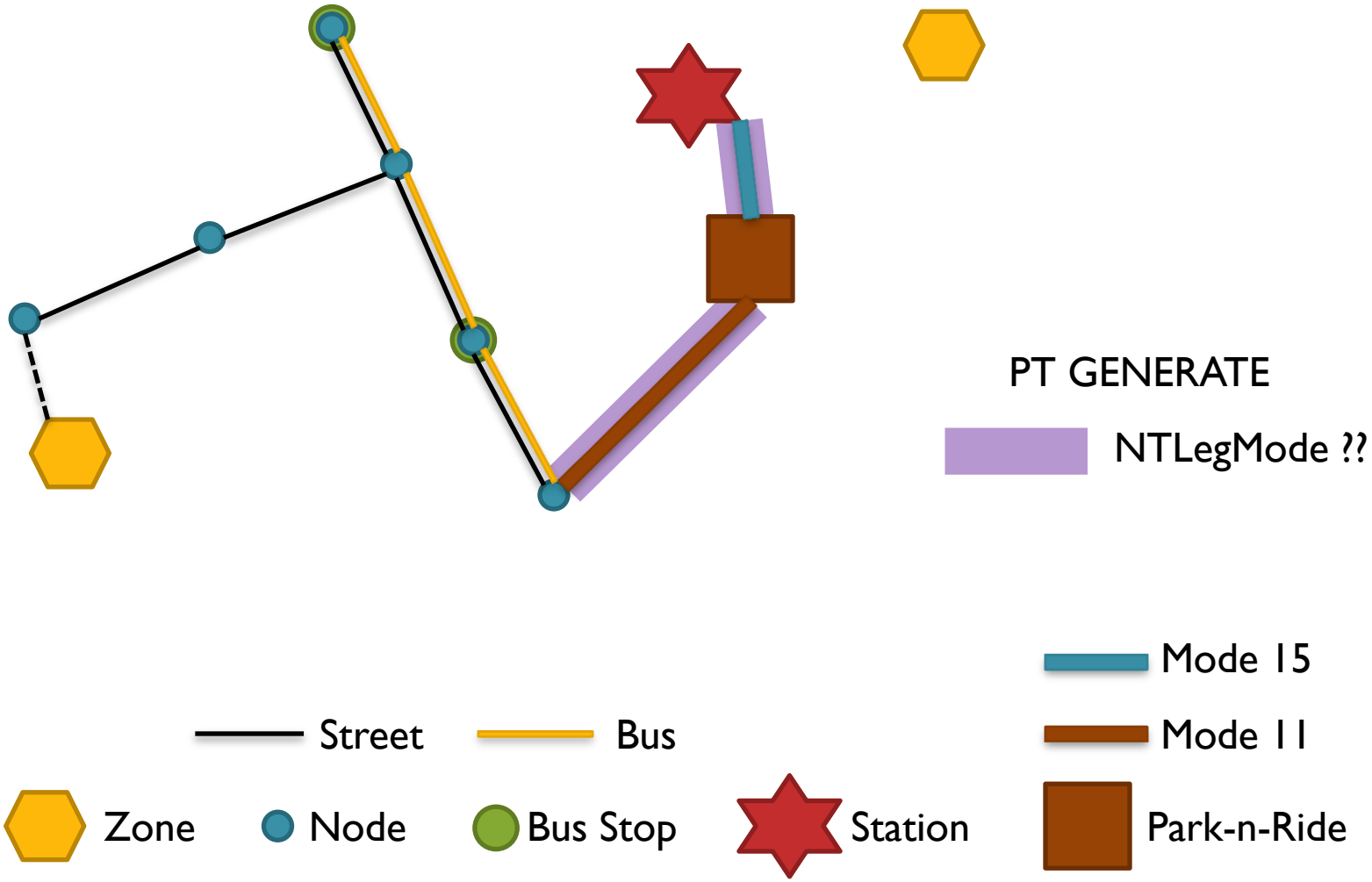
Station

Park-n-Ride

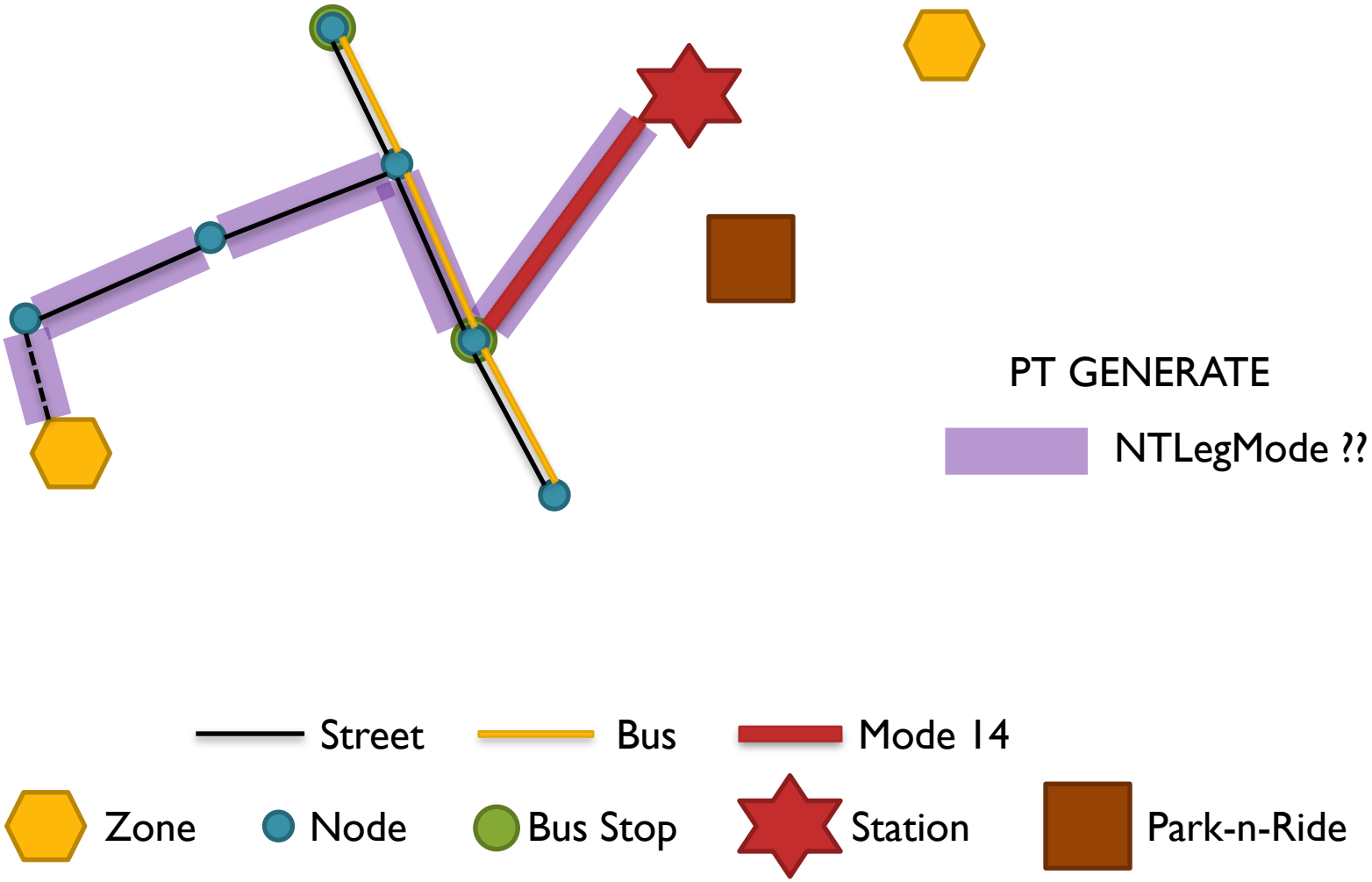
Bus Transfer to Metrorail Legs



Park-n-Ride to Metrorail Legs



Kiss-n-Ride to Metrorail Legs



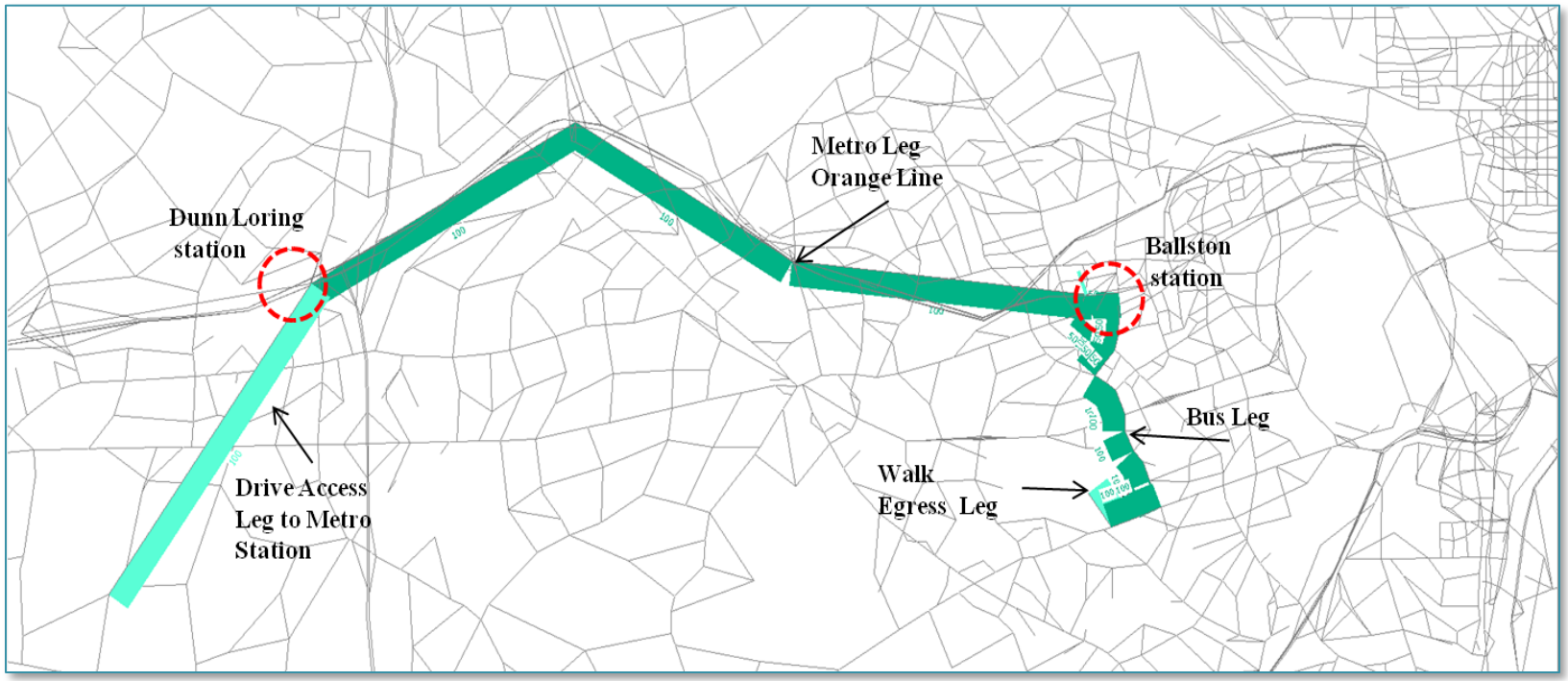
PT Path Building Task

- Purpose/Objective
  - Develop PT scripts to skim/load 22 transit path options
    - Two time periods (peak and off-peak), three access modes (walk, kiss-n-ride and park-n-ride), and four line-haul modes (bus-only, Metrorail-only, bus and Metrorail, and commuter rail)
- Task Activities
  - Validate integrated PT network prepared by MWCOG
    - Highway links, transit-only links, and special access links
  - Compare PT paths to TRNBUILD paths*
  - Evaluate PT fare calculation methods*

* Task efforts were adjusted due to delays in preparing the network

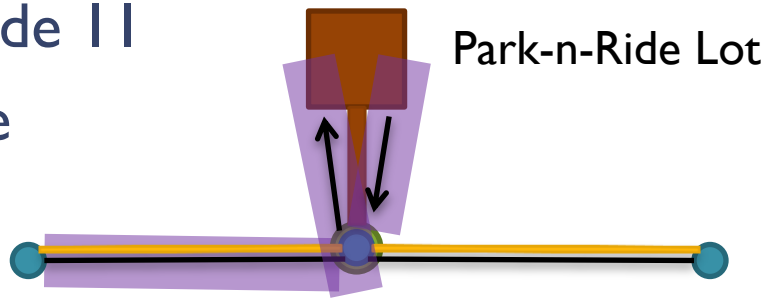
PT Path Building

- Path building scripts are relatively straight forward once non-transit legs are generated
  - On-screen path traces show NT legs as straight lines



PT Path Building Issues

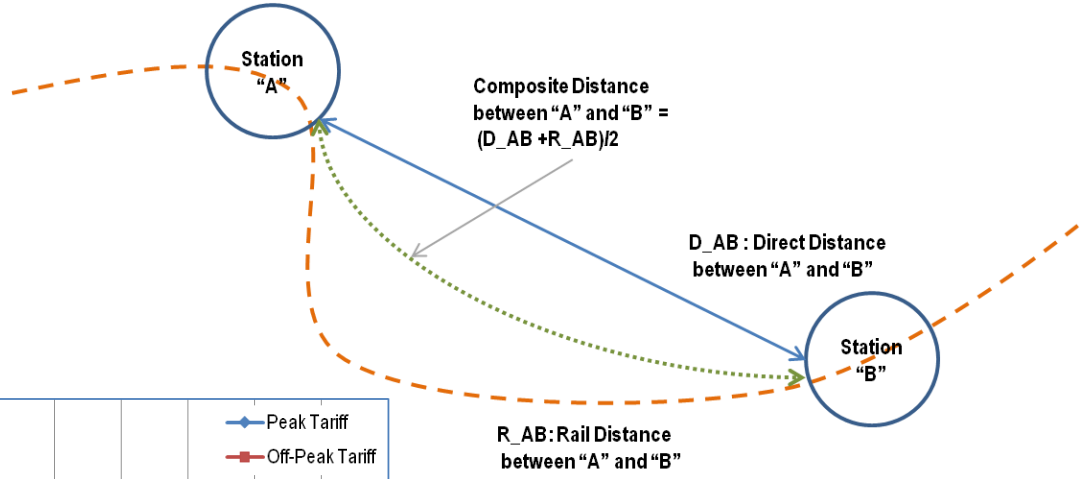
- PT does not generate first and last boarding station by mode like TRNBUILD does
  - PT does boarding and alighting stop by leg (not mode)
  - First and last Metrorail station used in fare calculation
    - Ignores Metrorail-to-Metrorail transfers
- Bus park-n-ride coding will need to be changed to work with PT Generate
  - Can't force it to use mode 11
  - Or the same node twice

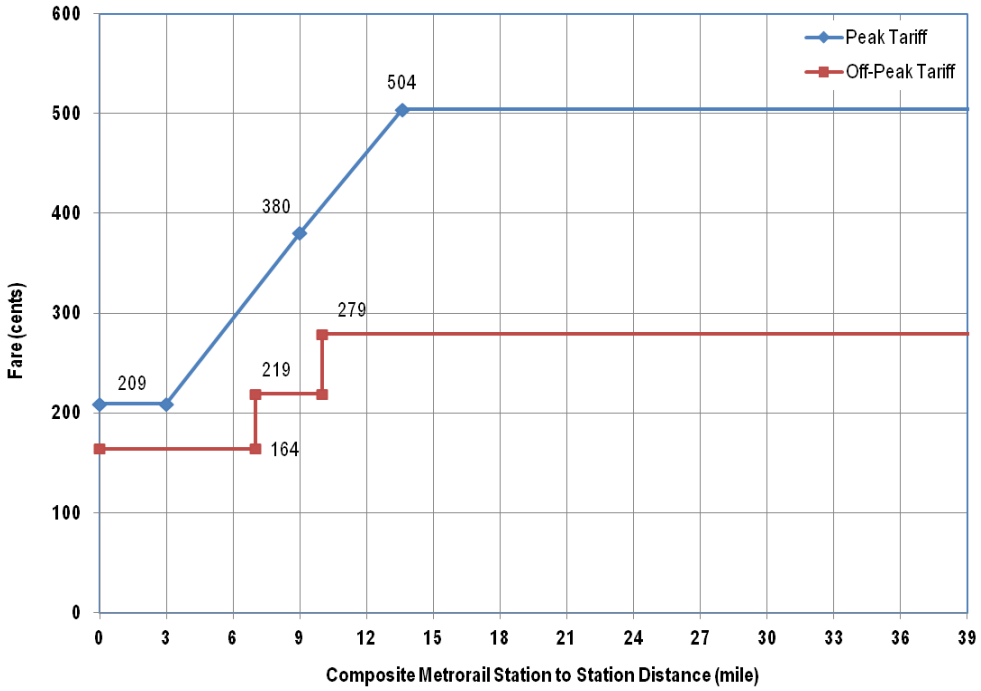


PT Fare Calculations

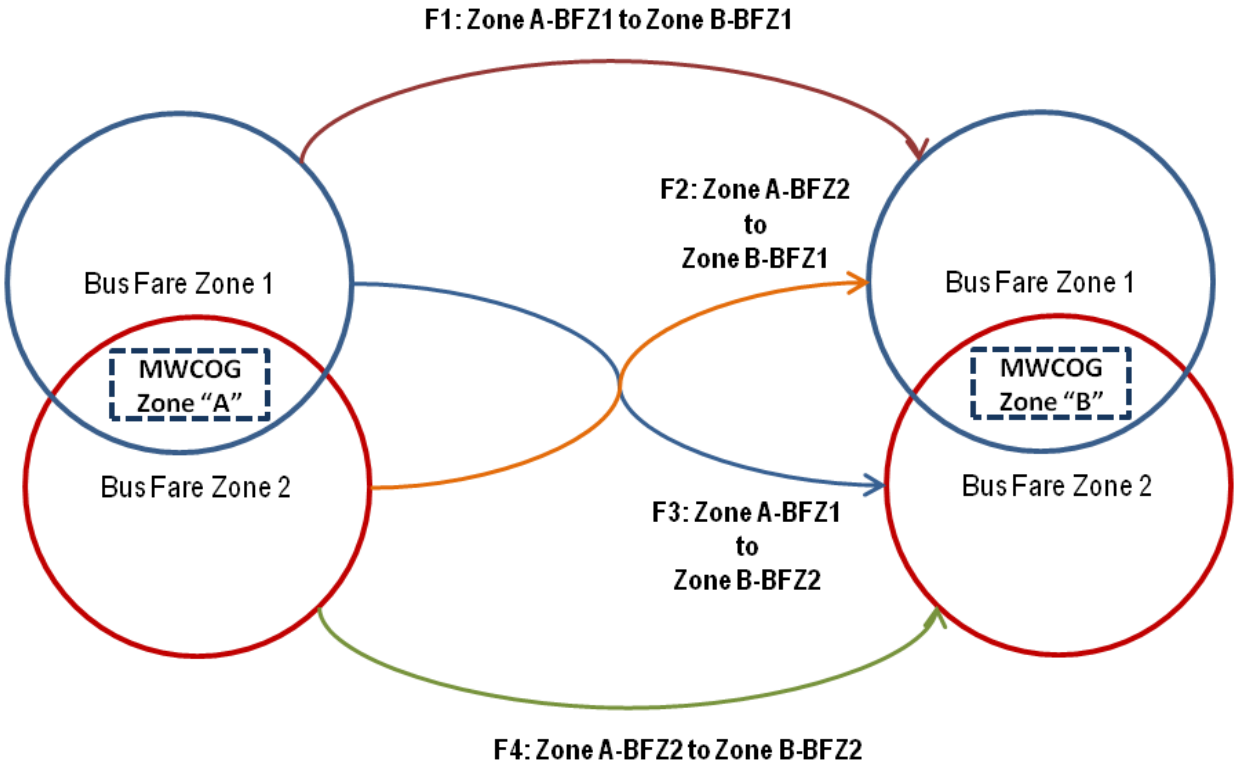
- PT includes new and sophisticated methods of integrating fare calculations into transit paths
  - Build path based on time → calculate fare → skim file
  - Build path based on time and fare = generalized cost
- MWCOG model includes complex procedures to estimate WMATA fare policies
  - Not easily replicated within PT
  - Various combinations of PT fare methods could approximate fare policies
    - Additional research is needed to select the best approach

Metrorail Fare Calculations



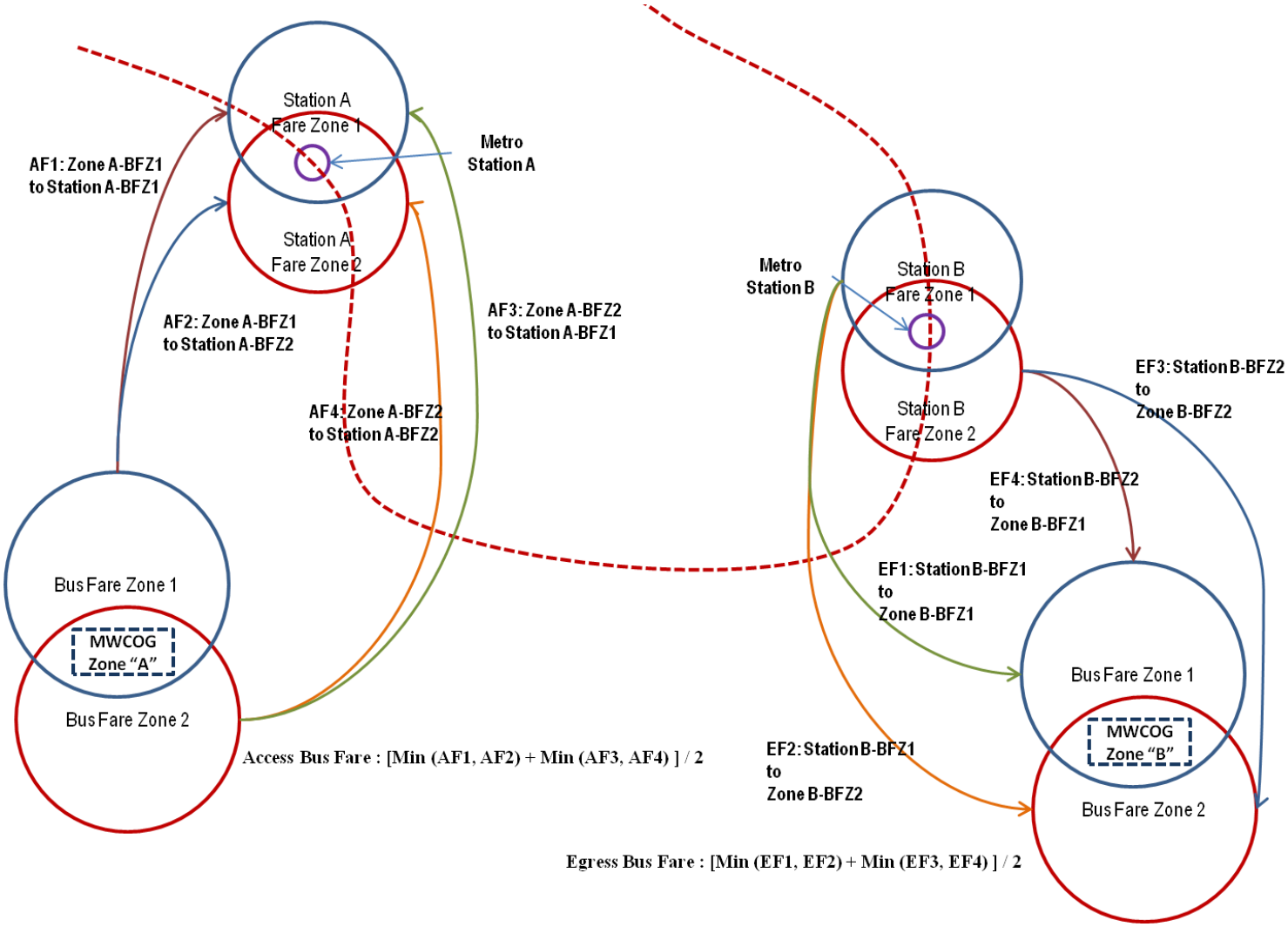


Bus-Only Fare Calculations



Bus Fare : [F1 + F2 + F3 + F4] / 4

Bus+Metrorail Fare Calculations



Mode Choice Software

- MWCOG Version 2.3 model uses AEMS.exe
  - AEMS is an old FORTRAN program with limited compiler options and no maintenance support
  - Complex, rigid, and poorly organized user interface with lots of duplication between trip purposes
- AECOM re-wrote AEMS as ModeChoice.exe
  - C++ program built on TRANSIMS Open Source library
  - Key-based user interface with re-usable model script
  - Built-in calibration option with constant constraints
  - Used in WMATA's RTSP, M-NCPPC's TransForM, and FDOT's CFRPM models

Mode Choice Tasks

- Reconfigure the WMATA ModeChoice setup to replicate the MWCOG HBW AEMS model
  - Show MWCOG what the user interface looks like
- Apply the ModeChoice software and compare the results to the MWCOG Version 2.3 model
  - Validate the model conversion
  - Estimate run time benefits
    - 15.5 minutes → 7.5 minutes (-48%)
- Complete software User's Guide
  - MWCOG model requires good documentation

ModeChoice Results

Trips by Mode	HBWI1Psn	HBWI2Psn	HBWI3Psn	HBWI4Psn	Total	Percent
AUTO	438,626	902,076	740,144	942,924	3,023,770	79.28%
TRANSIT	202,410	221,190	178,903	187,738	790,241	20.72%
SOV	365,712	765,623	632,549	801,826	2,565,710	67.27%
HOV	72,915	136,453	107,595	141,098	458,060	12.01%
SR2	52,935	100,735	79,710	104,376	337,756	8.86%
SR3	19,980	35,718	27,884	36,722	120,304	3.15%
WALK	194,044	159,757	115,854	51,381	521,035	13.66%
PNR	5,959	46,466	49,606	105,496	207,527	5.44%
KNR	2,408	14,967	13,444	30,861	61,679	1.62%
WK_CR	899	605	540	19	2,064	0.05%
WK_BUS	95,674	56,635	37,334	11,577	201,220	5.28%
WK_BUS_MR	53,972	41,748	34,778	7,549	138,047	3.62%
WK_MR	43,498	60,768	43,202	32,236	179,705	4.71%
PNR_CR	532	3,740	4,160	7,054	15,487	0.41%
PNR_BUS	914	4,118	3,696	7,902	16,630	0.44%
PNR_BUS_MR	729	6,226	6,879	16,477	30,310	0.79%
PNR_MR	3,784	32,381	34,871	74,063	145,100	3.80%
KNR_CR	60	353	384	686	1,483	0.04%
KNR_BUS	309	1,212	992	2,193	4,705	0.12%
KNR_BUS_MR	291	2,018	2,009	4,938	9,256	0.24%
KNR_MR	1,748	11,385	10,058	23,044	46,235	1.21%
Total	641,036	1,123,266	919,047	1,130,662	3,814,011	100.00%
Percent	16.81%	29.45%	24.10%	29.64%	100.00%	

AEMS Results (MWCOG V2.3.48)

Trips by Mode	HBWI1Psn	HBWI2Psn	HBWI3Psn	HBWI4Psn	Total	Percent
AUTO	438,626	902,076	740,143	942,924	3,023,769	79.28%
TRANSIT	202,410	221,190	178,904	187,739	790,242	20.72%
SOV	365,711	765,622	632,548	801,825	2,565,707	67.27%
HOV	72,915	136,454	107,595	141,098	458,062	12.01%
SR2	52,935	100,735	79,711	104,376	337,756	8.86%
SR3	19,980	35,719	27,884	36,723	120,306	3.15%
WALK	194,044	159,757	115,854	51,381	521,036	13.66%
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Percent	16.81%	29.45%	24.10%	29.64%	100.00%	

Difference (ModeChoice – AEMS)

Trips by Mode	HBWI1Psn	HBWI2Psn	HBWI3Psn	HBWI4Psn	Total	Percent
AUTO	0.13	0.19	0.16	0.28	0.60	0.00%
TRANSIT	-0.17	-0.20	-0.16	-0.26	-0.79	0.00%
SOV	0.41	0.69	0.56	0.85	2.60	0.00%
HOV	-0.27	-0.53	-0.42	-0.56	-1.71	0.00%
SR2	-0.09	-0.18	-0.17	-0.24	-0.58	0.00%
SR3	-0.19	-0.35	-0.24	-0.31	-1.10	0.00%
WALK	-0.19	-0.12	-0.08	-0.10	-0.40	0.00%
PNR	0.02	-0.06	-0.10	-0.12	-0.25	0.00%
KNR	0.00	-0.02	0.02	-0.03	-0.04	0.00%
WK_CR	-0.05	-0.02	0.04	0.05	0.01	0.00%
WK_BUS	-0.10	-0.10	0.01	-0.05	-0.23	0.00%
WK_BUS_MR	-0.06	-0.05	-0.08	0.02	-0.17	0.00%
WK_MR	0.02	0.06	0.06	-0.01	0.01	0.00%
PNR_CR	-0.02	0.01	0.02	-0.03	-0.03	0.00%
PNR_BUS	-0.04	-0.05	-0.01	-0.03	-0.02	0.00%
PNR_BUS_MR	0.00	0.00	-0.03	-0.04	-0.17	0.00%
PNR_MR	-0.02	-0.02	0.02	-0.02	-0.05	0.00%
KNR_CR	-0.03	0.05	-0.02	-0.03	-0.03	0.00%
KNR_BUS	0.00	0.01	-0.02	-0.04	-0.05	0.00%
KNR_BUS_MR	-0.03	-0.03	-0.02	0.03	-0.04	0.00%
KNR_MR	-0.03	0.04	-0.03	0.00	-0.01	0.00%
Total	0.11	0.10	0.00	0.08	0.35	0.00%
Percent	0.00%	0.00%	0.00%	0.00%	0.00%	

Summary of Recommendations (1)

- Traffic Assignment (HOV)
  - An HOV choice model can generate desired HOV volumes without the "two-step assignment" used in the current process.
  - Additional HOV count data and calibration work is needed before integrating an HOV choice model into the MWCOG modeling process.
  - AECOM recommends integrating an HOV choice model into the mode choice and assignment setups to reduce processing time and improve behavioral sensitivity of the model.

Summary of Recommendations (2)

- Traffic Assignment (HOT Lanes)
  - The HOT lane process prevented degradation of HOV speeds in a full multi-class assignment and incorporated toll-setting and toll-choice in the standard highway assignment process.
  - The savings in overall runtime was minimal.
  - AECOM recommends pursuing this concept further.

Summary of Recommendations (3)

- Traffic Assignment (INRIX data)
  - INRIX speed data has served to further highlight the fact that static models do not generate realistic speeds.
    - Low peak-period model speeds on freeways suggests it may be desirable to adjust the volume-delay function.
      - Detailed traffic counts on freeways with INRIX speed data are needed to calibrate the volume-delay function.
  - Since the primary purpose of estimating speeds in a static assignment model is to produce reasonable traffic volumes, it is inadvisable to be overly ambitious in calibrating volume-delay functions that reproduce observed speeds at the expense of reproducing observed traffic counts.

Summary of Recommendations (4)

- PT Conversion
  - Reconfiguring transit access links around Metrorail and commuter rails stations enables the PT Generate statement and path building procedures to construct transit paths with the desired access mode restrictions and line-haul mode options.
  - Additional coding techniques may be needed to enable the PT Generate process to properly build access links to bus park-n-ride lots.
    - A variety of potential solutions should be investigated before the PT access procedures are finalized.

Summary of Recommendations (5)

- PT Fare Calculations
  - The PT fare calculations cannot replicate the current fare calculation methods within the MWCOG model.
  - PT offers a number of features that could be useful in designing a new fare estimation process.
    - These options require further analysis and implementation testing especially if fares are included in building the path.

Summary of Recommendations (6)

- Mode Choice Model
  - Migrating the MWCOG mode choice model from the AEMS software to the ModeChoice program will reduce processing time, increase flexibility, simplify calibration efforts, and improve software maintenance.

Next Steps

- Finalize the report
- Meet with MWCOG to discuss potential tasks for FY 2014