

Current Modeling Practice

Expert Peer Panel Meeting
September 23 & 24, 2004



Current Modeling Practice

- Model Overview
- Transportation Network
- Truck/Commercial Vehicle Model
- Trip Generation
- Trip Distribution
- Income Stratification
- Mode Choice
- Trip Assignment



Model Overview



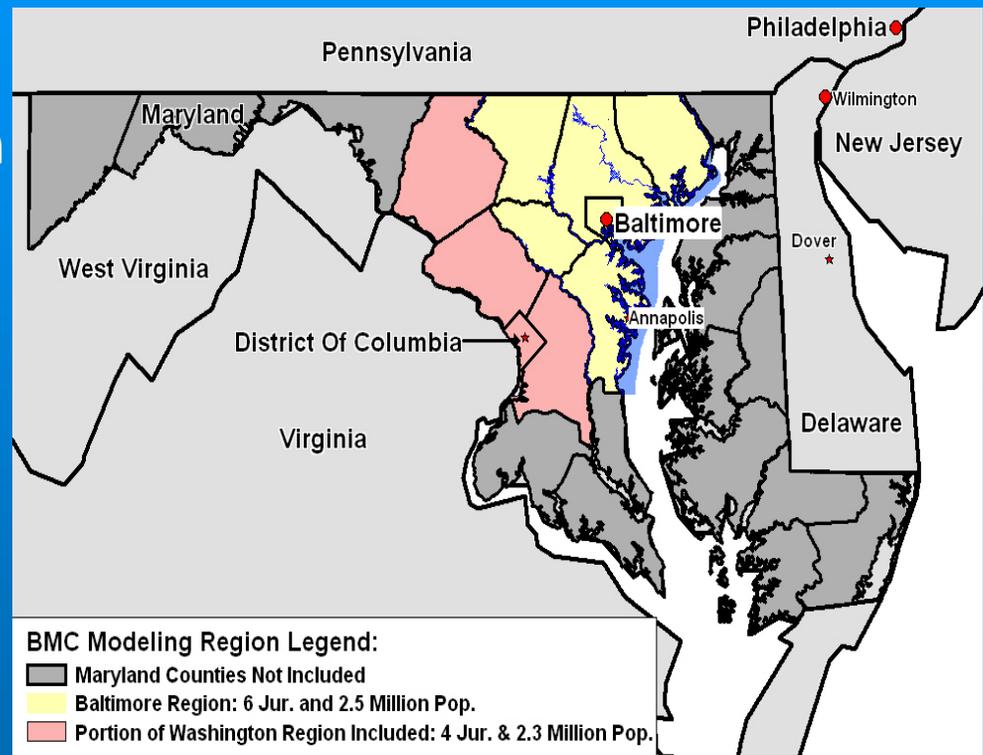
Baltimore Modeling Region

Traditional 4-Step TAZs

- 1,151 Baltimore Region
- 270 Washington Region
- 42 External Stations
- 1,463 Total

Links

- 32,000+ Highway and Transit Road/Rail Segments



Travel Demand Model Inputs

2000 Demographics

	Baltimore	Washington
Population	2,520,000	2,380,000
Households	960,000	930,000
Total Employment	1,530,000	1,650,000



Travel Demand Model Outputs

Person Trips Per HH	Baltimore	Washington
Home-Based Motorized Person Trips/HH	7.54	6.84
Non-Home-Based Motorized Person Trips/HH	2.04	1.82
Truck Trips/HH	1.02	0.79
Vehicle Trips/HH	5.42	5.95
Transit Trips/HH	0.23	NA
VMT (Million)	52.09	46.14
HPMS Non-Local VMT (Million)	60.84	NA



Travel Demand Model Flow

6 Vehicle Trip Purposes

- Home-Based-Work (HBW)
- Home-Based-Shop (HBSH)
- Home-Based-Other (HBO)
- Home-Based-School (HBSch)
- Work-Based-Other (WBO)
- Other-Based-Other (OBO)

3 Truck Purposes

- Medium Truck (2 axle 6 tires)
- Heavy Truck (3+ axles)
- Commercial Vehicle

BWI – Special Generator (21,500 Trips)

Through Trips

- 82,500–Passenger Vehicle
- 4,300–CV
- 1,800– MT
- 7,700–HT



Travel Demand Model

Average Weekday Trip Tables Are Generated and Distributed
Weekday Trip Tables Are Factored into 5 Time Periods before Assignment

- Midnight to 6:00 a.m.
- 6:00 a.m. to 10: a.m.
- 10:00 a.m. to 3:00 p.m.
- 3:00 p.m. to 7:00 p.m.
- 7:00 p.m. to Midnight

Initial Model Run Assigns A.M. Period Trip Table

Highway/Transit Skims Are Rebuilt from A.M. Period Network

- HBW, HBSch, HBO and WBO Are Distributed and Mode Share Is Estimated Using A.M. Peak Highway/Transit Skims
- HBSH, OBO, and Truck Trip Tables Use Initial Skim for Distribution and Mode Share



Land Use Inputs

Forecast at TAZ Level

- Households, Population, Labor Force, Median Income, Non-Institutional Group Quarters
- Retail, Non-Retail – Office, Industrial, Other, (School Employment)

4 Land Use Density Codes – Household density

- City Center
- Urban
- Suburban
- Rural



Transportation Network



Transportation Network

Transit Network

- Rail Links
- Transit Lines
- Fare (Mode- and Link-based)
- Walk Access
 - MapBasic Program Determines Coverage
 - TP+ Generated Walk Links
 - Manually Coded Walk Links
- Downtown Sidewalk Network
- Drive Access – MapBasic Program



Walk Access

**MapBasic/Excel Process to Calculate
Walk Access Share and Time for Each
Zone**

Walk Links Generated by TP+

**Certain Walk Links Forced When Zone Is
within Walk Shed but Link Not
Generated by TP+**



Walk Access (Continued)

MapBasic Process

- Create ½ Mile Buffer Around Bus Lines, ¾ Mile Buffer Around Rail Stations (Also Bus PnR) For Short Walk
- Create 1 Mile Long Walk Buffer (Not Used)
- Output For Each Zone
 - Short walk percent
 - Long walk percent
 - Zonal Area



Walk Access (Continued)

Spreadsheet Process

- Produces Short Walk Percent, Walk Time
- Walk Time
 - If 100% Short Walk
 - If transit adjacent, minimum of 0.25 miles or $\frac{1}{2}$ of the square root of the short walk area.
 - If transit bisects, minimum of 0.25 miles or $\frac{1}{4}$ of the square root of the short walk area.
 - If 0% short walk, no walk time
 - If 1-99% short walk maximum of 0.25 miles or 0.5 less $\frac{1}{2}$ of the square root of the short walk area.



MARC Drive Shed

MapBasic Program

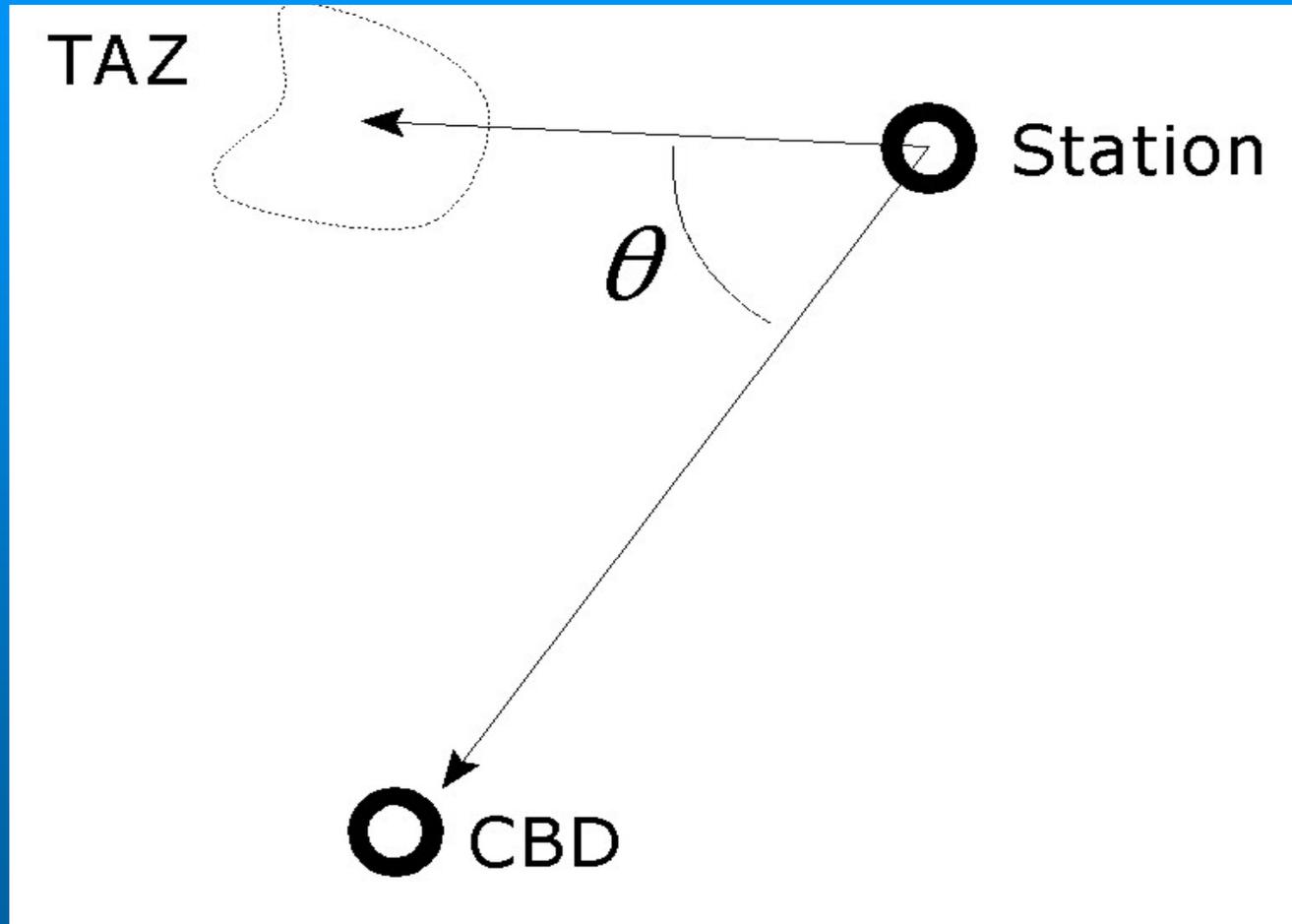
Three Categories of Stations

- Dependent on Mode, End of Line Status
- Maximum Distance 5, 10, or 15 Miles

Distance Shortened to Reduce Backtracking



Reduction In Shed Distance



Reduction In Shed Distance (Continued)

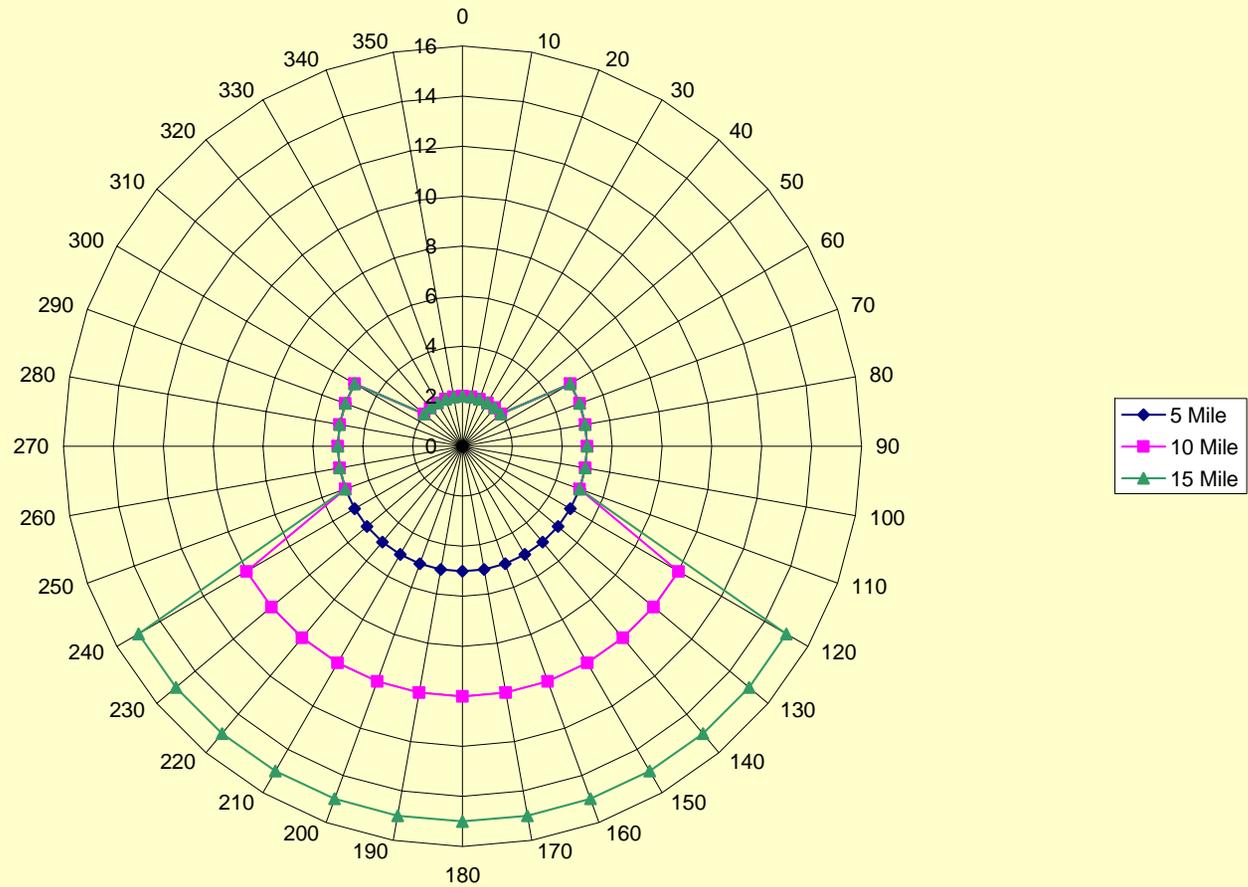
Shed Distance Reduced to 2 Miles for
 $\theta < 60^\circ$

Shed Distance Reduced to 5 Miles for
 $\theta < 120^\circ$

Concern About the Step Nature of This
Function



Current Drive Shed



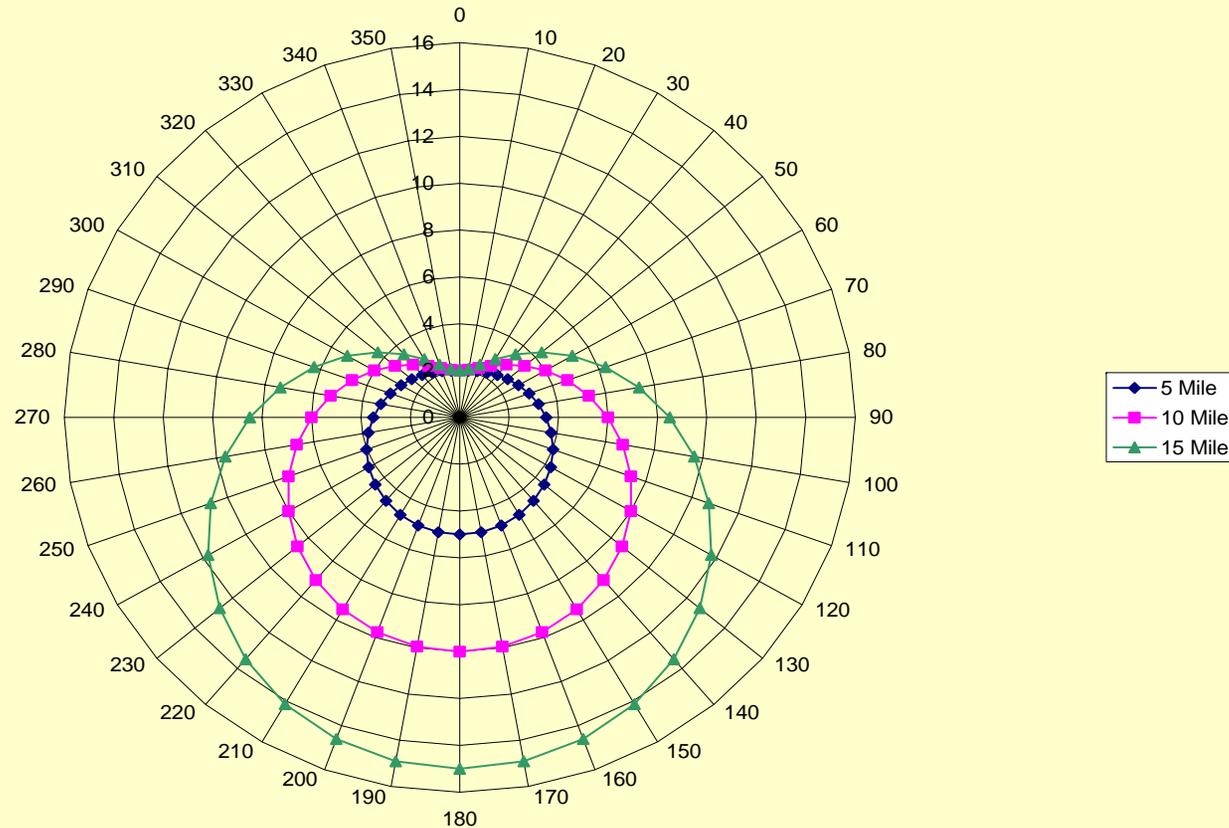
Proposed Drive Shed

**Sine Function to Gradually Vary
Maximum Distance between Minimum
and Maximum Drive Shed**

**Orient MARC Trips Away from
Washington Instead of Baltimore**

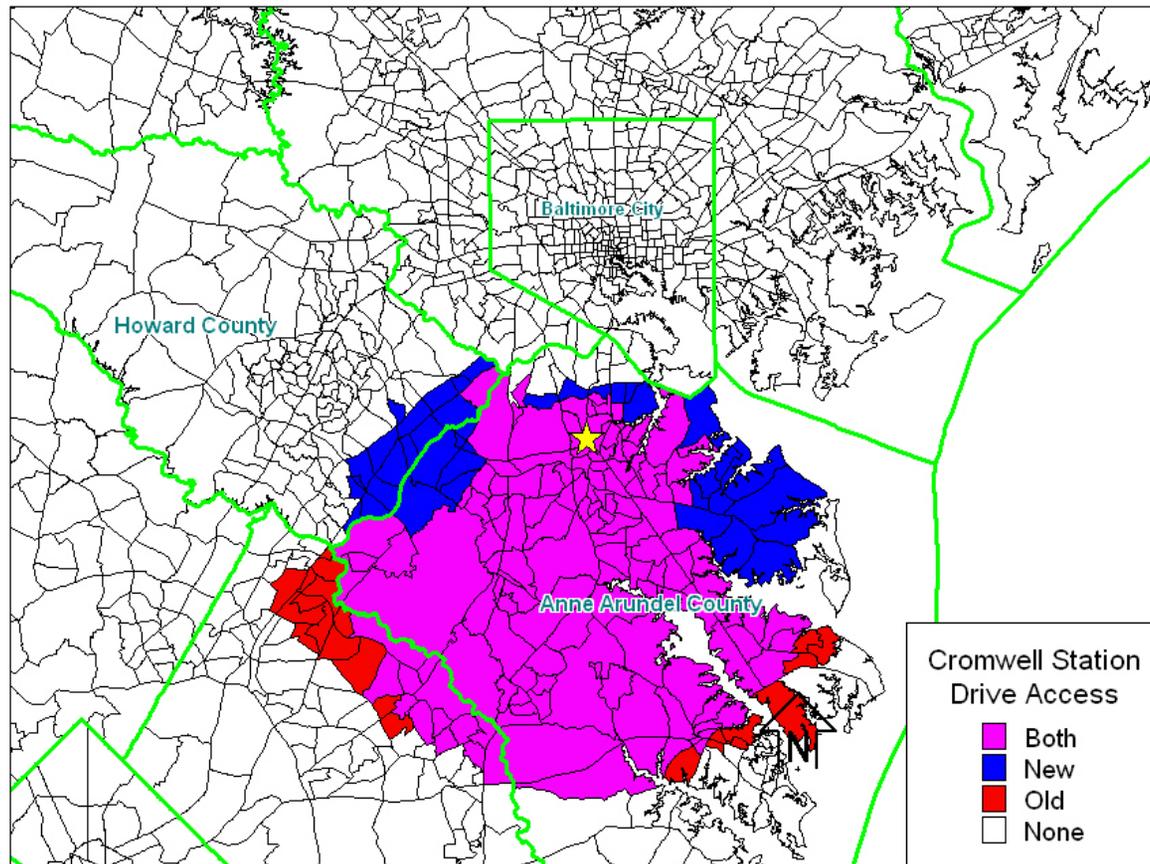


Proposed Drive Shed



Old vs. New Drive Sheds

Park and Ride Access to Cromwell Light Rail Station



Highway Networks

Master Network System – 3 Databases

- Existing, New, Changed
- Links use shape distance

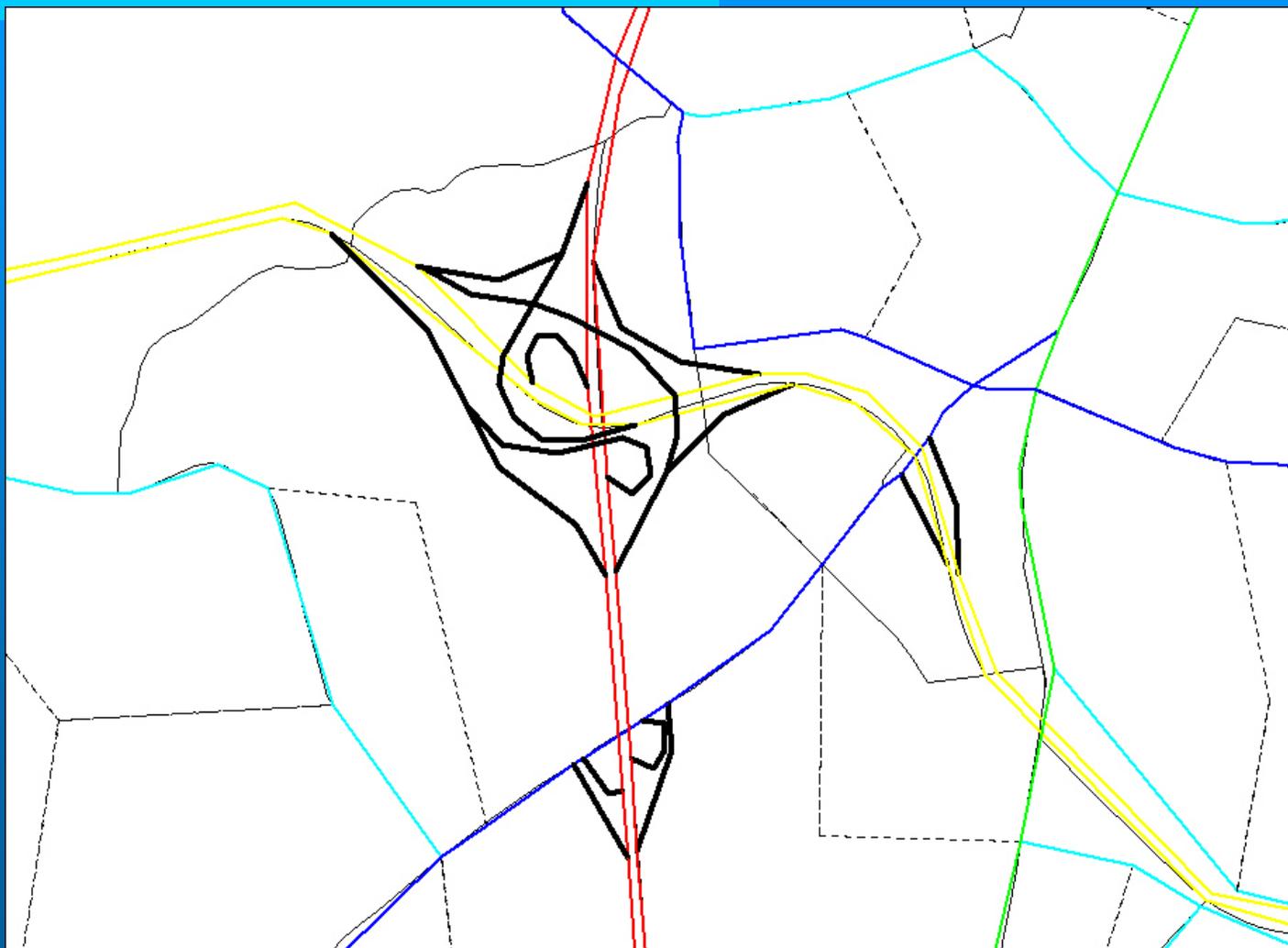
Implemented in MapInfo/Viper

Speed and Capacity Lookup

- Speed – Density Code and Functional Type
- Capacity – Density Code and Road Type



Master Network - GIS



Master Network - Viper



Truck/Commercial Vehicle Model



Truck Types

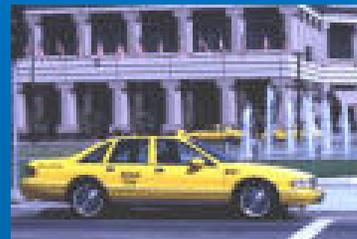
**Heavy Truck: 3+ Axles,
More Than 6 Tires**



**Medium Truck: 2-Axle,
6 Tires**



**Commercial:
Light/Medium Duty
Vehicles Used For
Business, Government**



Data Requirements

Medium and heavy trucks used 600+ classified counts

Commercial vehicles developed from manual observation

- Vehicles with Text or Logo or Carrying Equipment
- 113 observations; 1-2 hours midday

Observed trip tables synthesized from counts



Starting Model

Borrowed Linear Regression—Lehigh Valley, PA

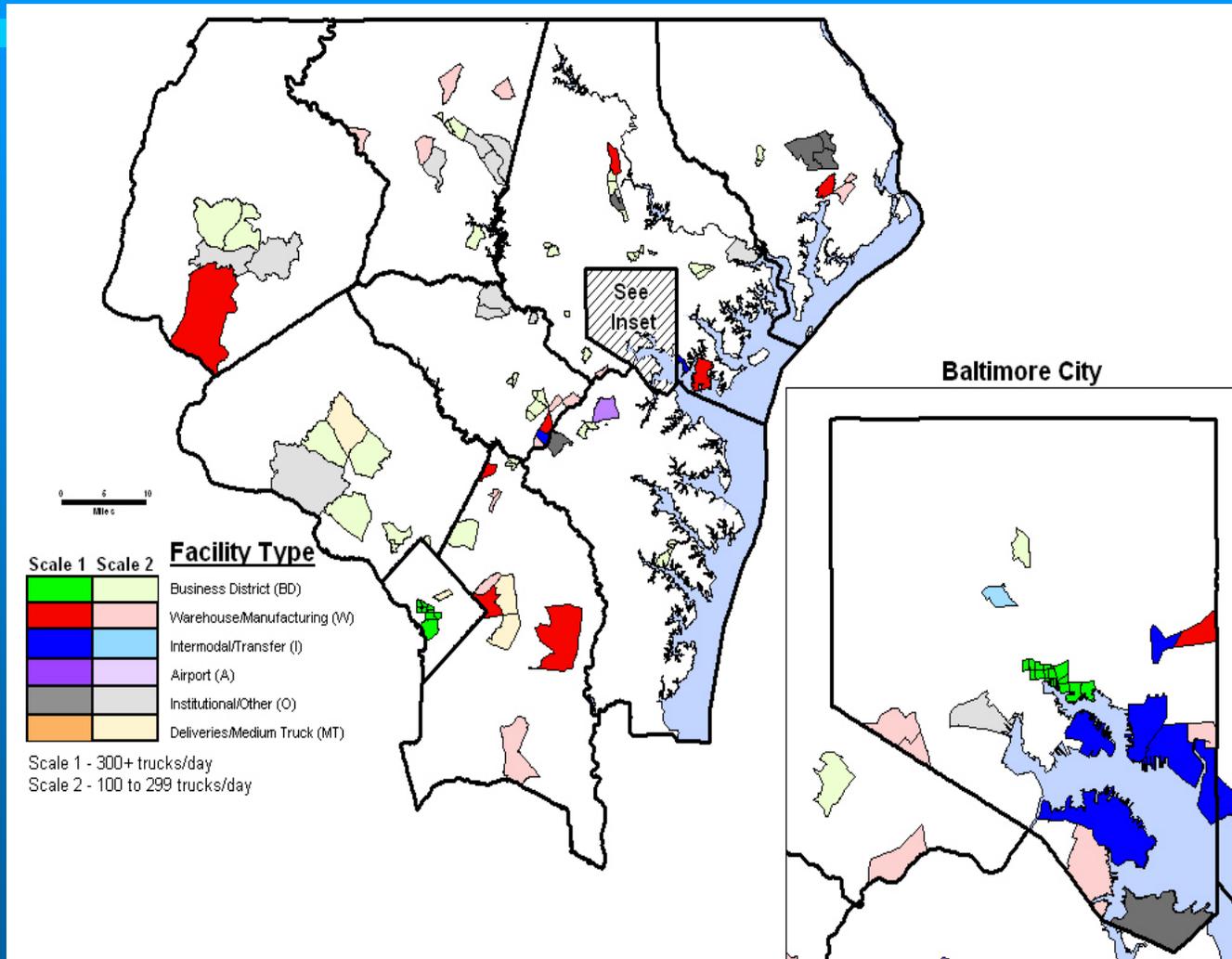
Based on Employment by Type (Industrial, Office, Retail) and HHs

- $CV=0.8*(0.454*IND)+(0.501*RE)+(0.454*OFF)+(0.146*HH)$
- $MT=0.7*(0.178*IND)+(0.177*RE)+(0.048*OFF)+(0.069*HH)$
- $HT=0.9*(0.199*IND)+(0.141*RE)+(0.029*OFF)+(0.068*HH)$

Adjustments Applied for Special Truck Zones, Jurisdiction, and Density



Truck Zones



Truck Zone Factors

Facility Type	Size	CV	MT	HT
Bus Dist,	Lg	1.2	1.3	1.1
Whse/Mfgr,	Lg	1.0	1.0	1.9
Inter/Trans,	Lg	1.0	1.0	3.8
Airport,	Lg	1.0	1.0	1.0
Inst/Othr,	Lg	1.0	1.0	2.7
Exp/Pkg,	Lg	3.0	1.3	2.0
Bus Dist,	Sml	1.0	1.2	1.3
Whse/Mfgr,	Sm	1.0	1.0	1.8
Inter/Trans,	Sm	1.0	1.0	3.0
Inst/Othr,	Sm	1.0	1.0	1.4
Exp/Pkg,	Sm	2.5	1.0	1.6



Delta Adjustment Factors

Compare Final Generated Trip Ends with
Observed Trip Ends (Count Matrix)

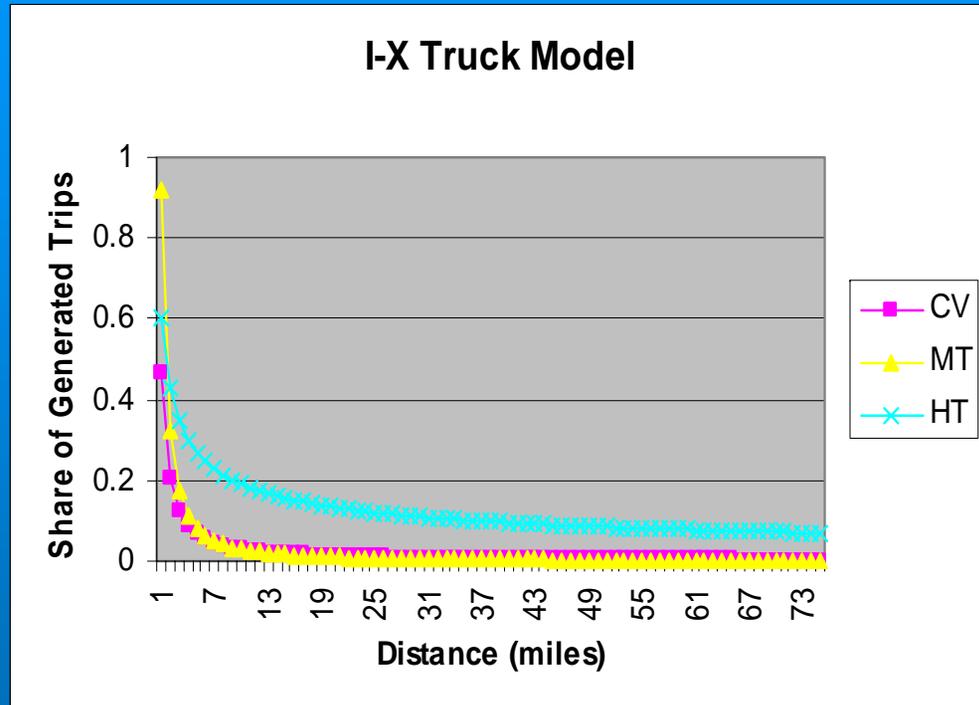
$\text{Delta} = \text{Observed} / \text{Generated}$

Apply Delta Adjustment Before
Assignment



I-X Truck Estimation

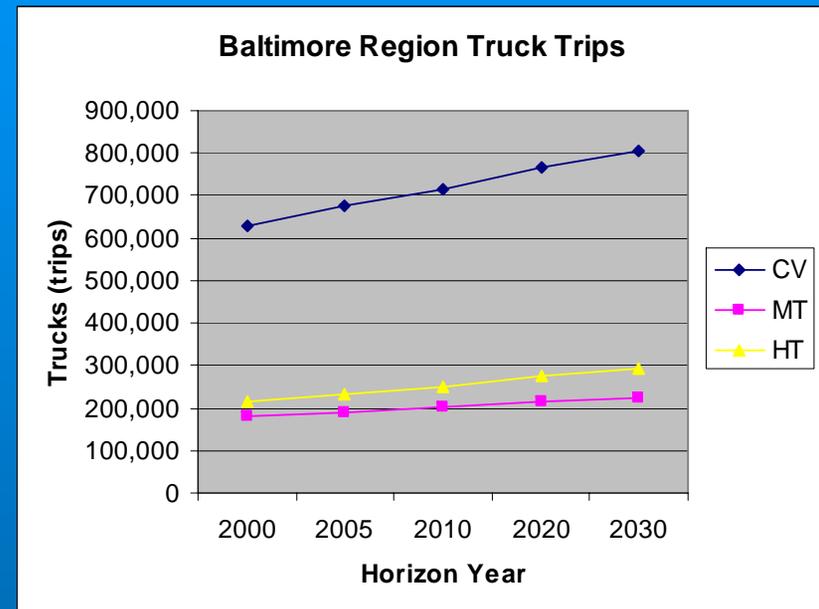
External Station
Truck Attractions
Are Based on
Observed Share
Share of Internal
Productions
Oriented Externally
Is Estimated As a
Share Based on
Distance to Closest
External Station



Truck Model Concerns

Delta Table Can Become Outdated for Future Years
Growth in Truck Trips Is Linked to Demographic Data and Projected to Increase 28% from 2000 to 2020

Freight News, Profile For Maryland Has Tonnage Increasing by 83% from 1998 to 2020



Trip Generation



Trip Productions

**Estimated from 1993 Home Interview
Motorized and Non-motorized Trips Are
Generated**

**6 Vehicle Trip Types (HBW, HBSh, HBO,
HBSch, WBO, and OBO)**

**Cross-classification of Household Size (4),
Vehicle Availability(4), and Density Code(4)**

- **Vehicle Shares Held Constant at Census Observation
Year**

No Distinction between I-I and I-X



HBW Person Trip Rates

Trip Purpose	Veh./ HH	Rural				Suburban			
		Persons/HH				Persons/HH			
		1	2	3	4+	1	2	3	4+
Total HBW	0	0.85	0.85	0.85	0.85	0.86	0.86	0.86	0.86
	1	0.95	0.95	0.95	0.95	1.01	1.01	1.92	1.92
	2		2.04	2.04	2.04		2.01	2.23	2.23
	3+			3.16	3.16			3.08	3.08
		Urban				City Center			
		Persons/HH				Persons/HH			
		1	2	3	4+	1	2	3	4+
Total HBW	0	0.70	0.70	1.83	1.83	0.67	0.67	0.79	0.79
	1	1.05	1.05	2.10	2.10	1.16	1.16	1.16	1.16
	2		2.02	2.10	2.10		2.82	2.82	2.82
	3+			4.39	4.39			3.46	3.46



Motorized/Non-Motorized Choice

Home-based

- Total Person Trips Are Produced
- Binary Logit Model Is Applied to Separate Motorized and Non-motorized Trips
 - TAZ Autos/capita Coefficient, Density Code Constant
 - Non-motorized share increases with density

	HBW	HBSH	HBO	HBSch
Autos/Capita	2.913	1.837	1.725	2.467
Rural	1.747	3.245	1.782	1.8739
Suburban	1.818	2.174	1.1212	0.0775
Urban	1.5515	0.6336	0.6896	- 0.4909
City Center	1.0552	- 0.0164	0.2325	- 1.2184



Motorized/Non-Motorized Choice (Continued)

Non-home-based

- Total and Motorized Trips Are Produced
- Non-motorized Is Difference



Trip Attractions

Motorized Trips Only

Developed from 1993 Home Interview at the
Regional Planning District (RPD=96)

Linear Regression

- $HBW=(1.73*RE+0.71*NRE)$
- $HBSH=(2.21*RE+0.36*HH)$
- $HBO=(3.6*RE+1.19*HH)$
- $HBSch=(5.17*SCHE+0.54*HH)$

WBO & OBO Trips Are Produced and Allocated
as Origins and Destinations

Density Code Factor is Applied



Density Code Factors

**Density Code
Factors Developed
from 1993
Comparing Total
Generated
Attractions With
Observed
Attractions**

	HBW	HBSH	HBO	HBSch
Rural	0.995	1.224	1.133	1.165
Suburban	1.014	1.018	1.114	0.878
Urban	0.879	0.736	0.883	0.654
City Center	0.879	0.346	0.883	0.316



Trip Distribution



Trip Distribution

Double Constrained Gravity Model

**Peak Highway Skims – HBW, HBW
HBSch, & WBO**

Free-flow Highway Skims – HBSch & OBO

Jurisdictional Time Barriers

- **Time Penalty Added to Highway Skims**
- **Vary by Purpose**



Income Stratification



Income Stratification

Applied to HBW, HBSh, and HBO Productions and Attractions

Three Income Categories (HH income, 1993 dollars)

- Less than \$10,000
- \$10,000 - \$30,000
- Greater than \$30,000

4 Steps

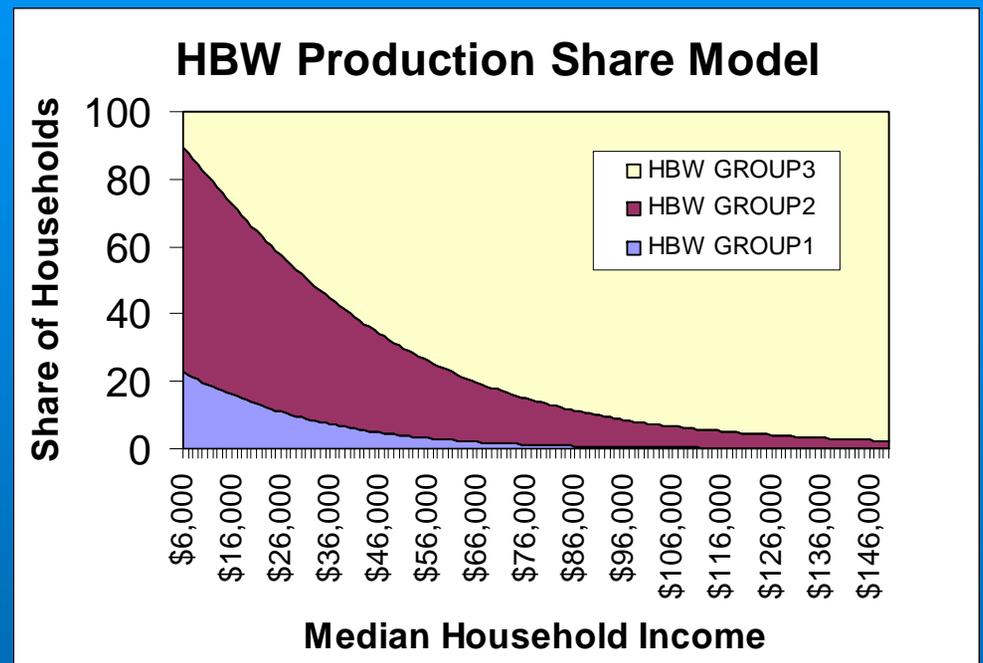
- Production Submodel
- Attraction Submodel
- FRATAR Allocation
- Balancing Process



Productions Submodel

Productions Shares
Estimated Using
Aggregate Share
Model - TAZ Median
HH Income

Separate Curves for
HBW, HBSh, and
HBO



Attraction Submodel

Based on accessibility to productions by income group

3 Steps

- **Productions by Purpose and Income Are Summed by Super-district**
- **Accessibility is the Row Sum of the Ratio of Productions to Travel Time Squared**
- **Incremental Logit Model Utilizes Population Density and Share of Productions for Each Income Group**



Incremental Logit Model HBW

$-0.84 \cdot \text{pden} - 0.0004 \cdot \text{IC1} - 0.0088 \cdot \text{IC2} - 0.0221 \cdot \text{IC3} - 2.11$

$-0.84 \cdot \text{pden} + 0.0034 \cdot \text{IC1} - 0.0077 \cdot \text{IC2} - 0.0230 \cdot \text{IC3} - 0.64$

$-0.84 \cdot \text{pden} - 0.0036 \cdot \text{IC1} - 0.0049 \cdot \text{IC2} - 0.0238 \cdot \text{IC3}$



Mode Choice



Mode Choice

Nested Structure

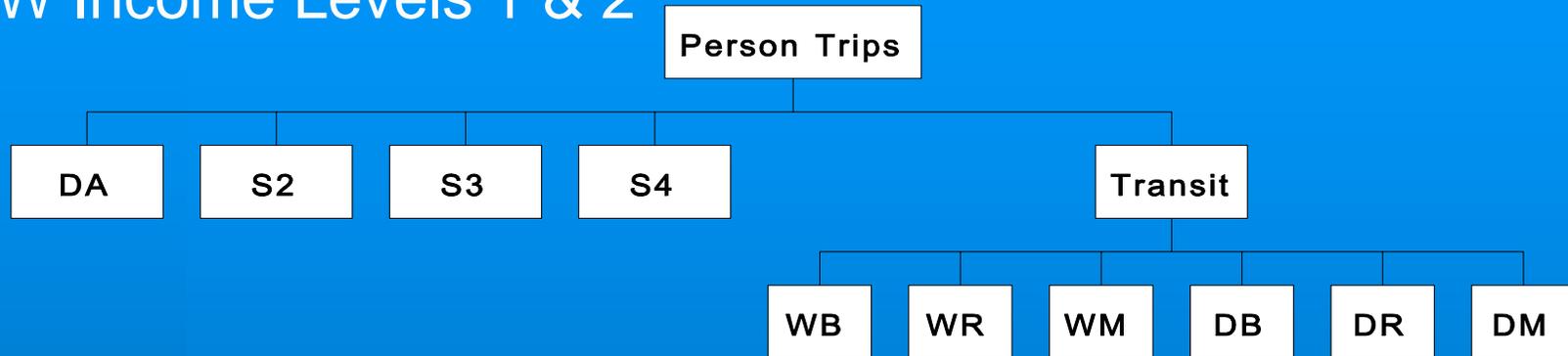
Ten modes

- SOV, HOV-2, HOV-3, HOV-4+
- Walk Bus, Walk Rail, Walk MARC
- Drive Bus, Drive Rail, Drive MARC

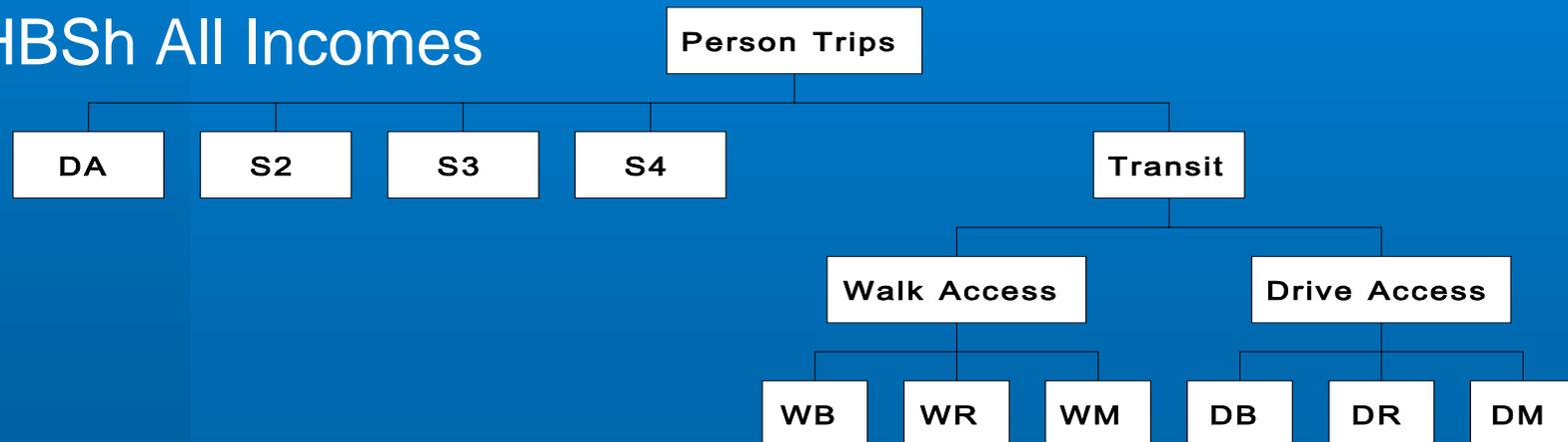


Mode Choice (Continued)

HBW Income Levels 1 & 2

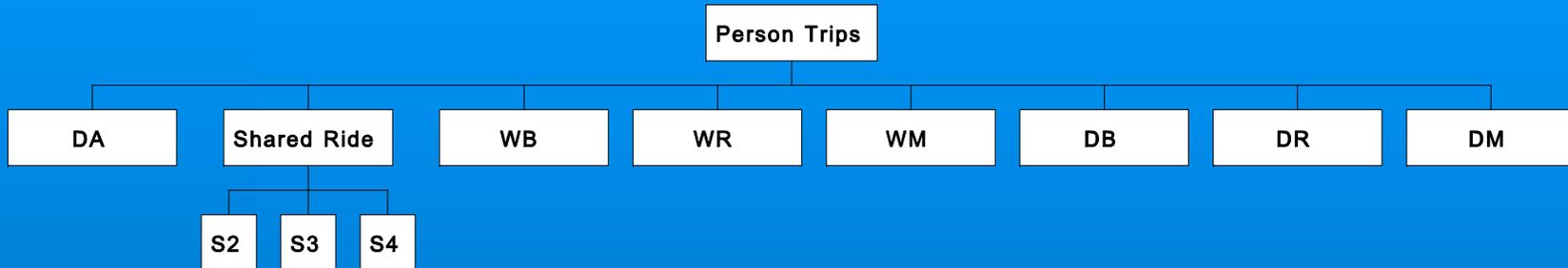


HBW Income Level 3
HBSH All Incomes

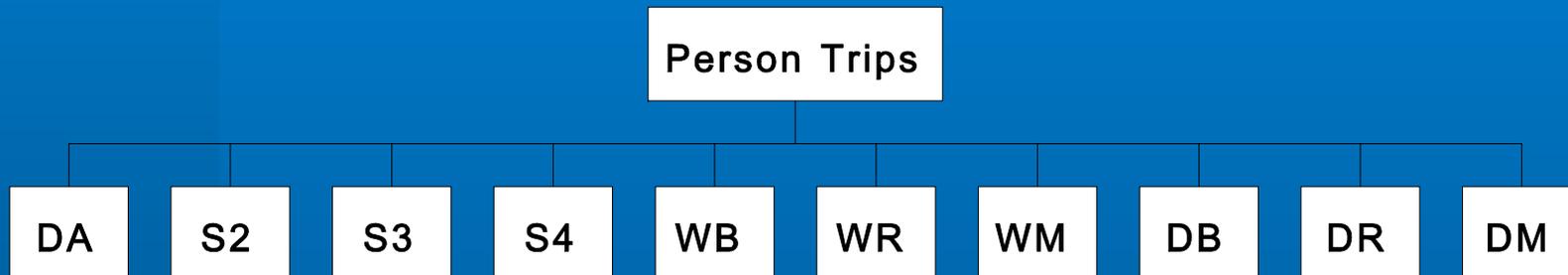


Mode Choice (Continued)

HBO All Incomes



WBO and OBO



Mode Choice (Continued)

HBSch trips based on survey shares

No Drive Access for HBSch

Recent Enhancements Completed or Underway to Prepare for SUMMIT Implementation

- **Remove Geographic Bias Constants**
- **Same IVT Coefficient for Transit and Highway**
- **Eliminate “Cliff” Function (Binary Short Drive)**



Mode Choice Model (Continued)

Separate Logit Calculations for Walk Access (All Modes), Drive Access (No Walk to Transit), and No Transit (No Walk or Drive to Transit)

Trips Multiplied by Share of Walk, Drive, and No Transit.



Trip Assignment



Trip Assignment

5 Time Periods

Equilibrium Assignment

PCE for Medium Trucks (1.5) and Heavy Trucks (2.0)

Drive Access to Transit Trips Also Assigned

BWI Special Generator Assigned



Equilibrium Assignment Parameters

LAMBDA=0

GAP=0.005

AAD=0.5

RAAD=0.005

PDIFF=1

RMSE=0.1

PDIFFVALUE=0

Time Period	Number of Iterations	AAD	RAAD	RMSE	Gap
1 (12 mid. – 6:00 AM)	2	2	0.003	43	0.03756
2 (6:00 AM – 10:00 AM)	10	44	0.014	160	0.00314
3 (10:00 AM – 3:00 PM)	5	57	0.017	278	0.00109
4 (3:00 PM – 7:00 PM)	7	78	0.025	276	0.00479
5 (7:00 PM – 12 mid.)	4	16	0.008	106	0.00325



Modified BPR Curve

Freeway

$$1 + 0.2\left(\frac{V}{C}\right)^{10}$$

Non-freeway

$$1 + 0.05\left(\frac{V}{C}\right)^{10}$$

