Travel Demand Model Estimation and Validation: Experience from the USA

Cube 6

2013 China User Conference

June 19 - 23

Heejoo Ham, Ph.D
Director of Technical Support

citilabs

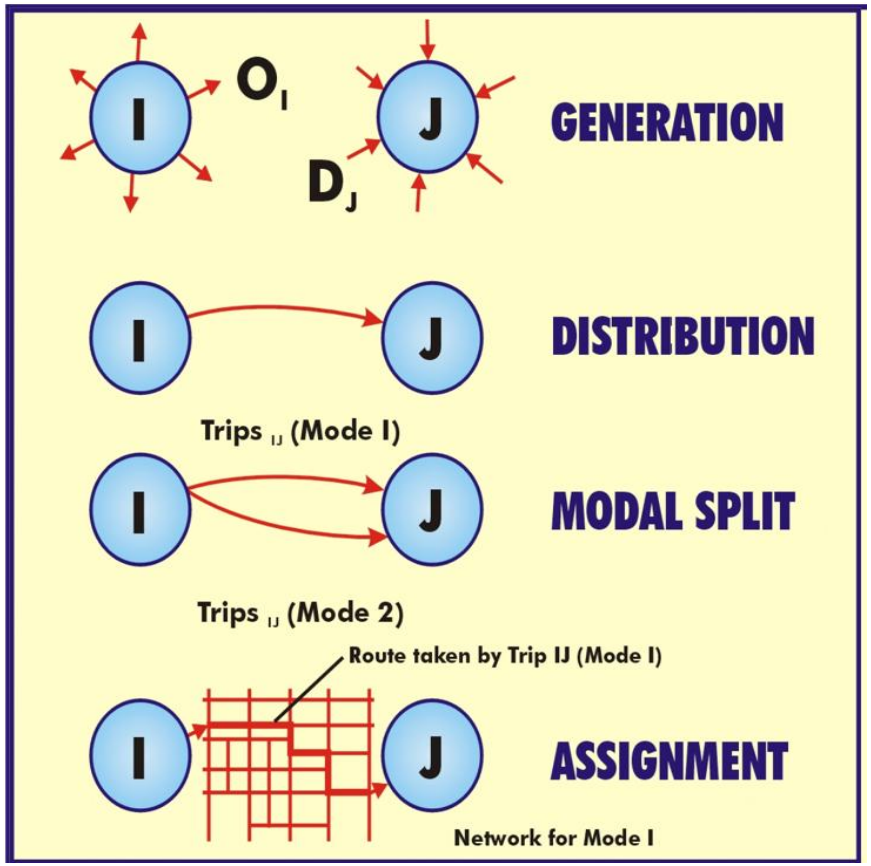
OVERVIEW

- Travel Demand Models
- Model Calibration & Validation
- Additional Information

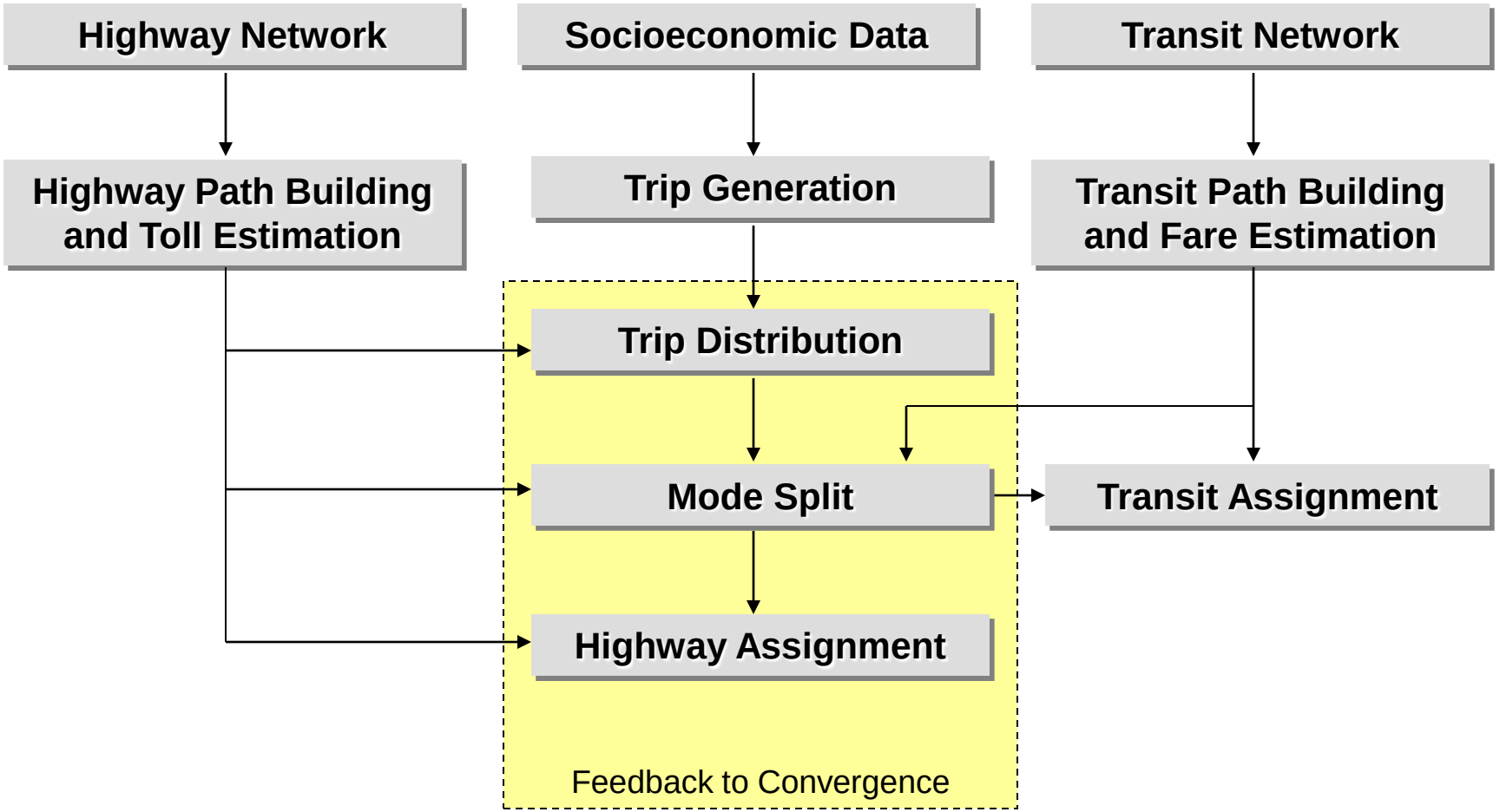
Travel Demand Models

The Basics for Four-Step Model

- Trip Generation- Who and Why Should I Go
  - Estimate total trip activity (trip ends) at each travel analysis zone (TAZ)
- Trip Distribution- Where to Go
  - Allocate trips between origin and destination zones
- Mode Choice- By What Means to Go
  - Allocate trips among the travel modes (SOV,HOV, Transit)
- Assignment- By What Route to Go
  - Assign (“load”) trips onto the transportation networks

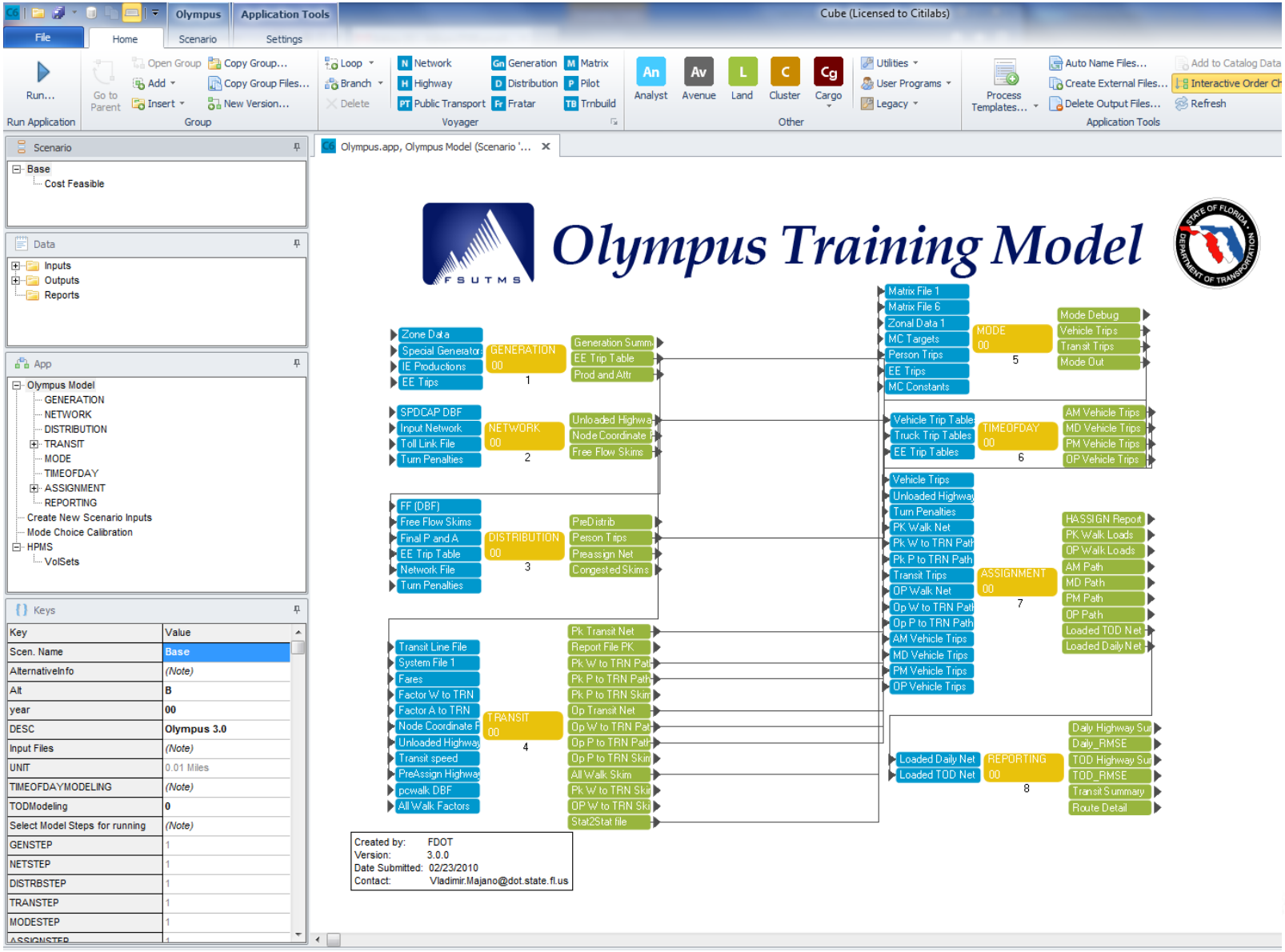


Standard Four-Step Travel Demand Model



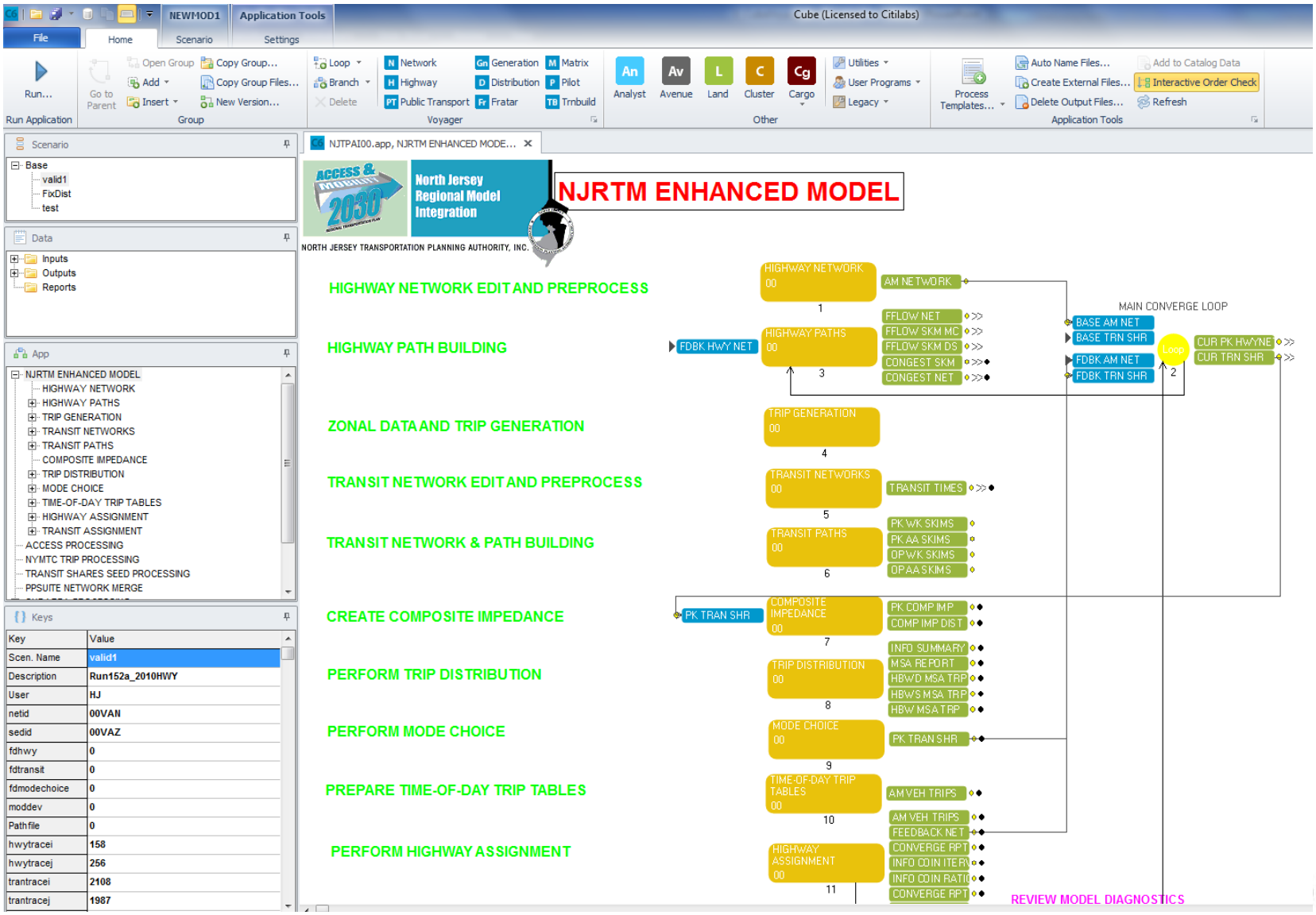
Cube 6

Example 1 of Cube Demand Models



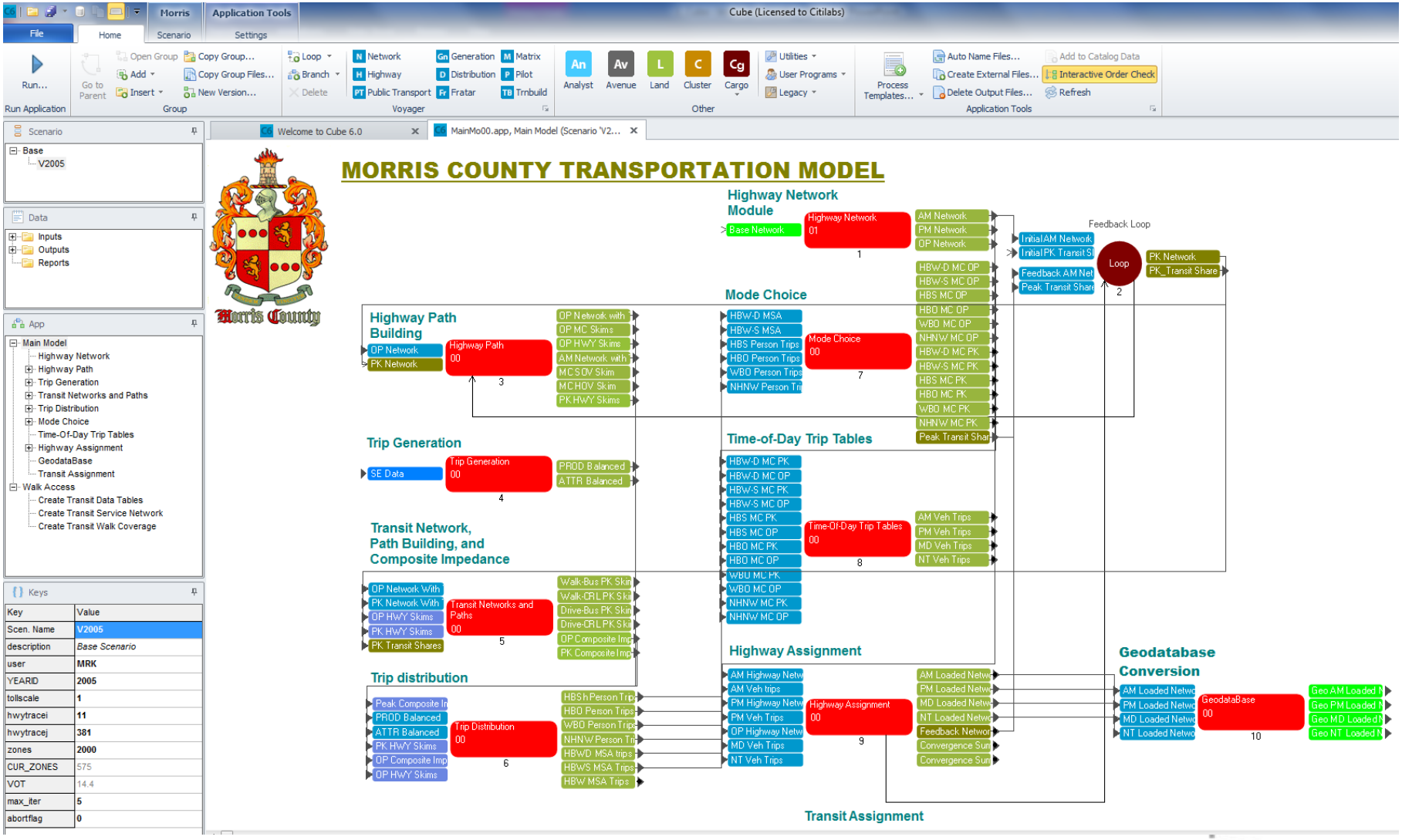
Cube 6

Example 2 of Cube Demand Models



Cube 6

Example 3 of Cube Demand Models



citilabs

Travel Demand Models

- Trip Generation: Cross-classification method for production and linear regression method for attraction
- Trip Distribution: Gravity model with friction factor
- Mode Choice: Nested logit model
- Time of Day: PA to OD
- Highway Assignment: Multi-class & Multi-mode UE
- Transit Assignment: Single or multiple routes

Travel Demand Model Process

- In US, the conventional 4 steps models are directly used to estimate the travel demands for both base and alternatives.
- For the base/future scenarios, a full feedback process is implemented.
- For the alternative scenarios, only mode choice and assignment are run under the fixed distribution to see an impact of trip conversion by mode choice analysis.

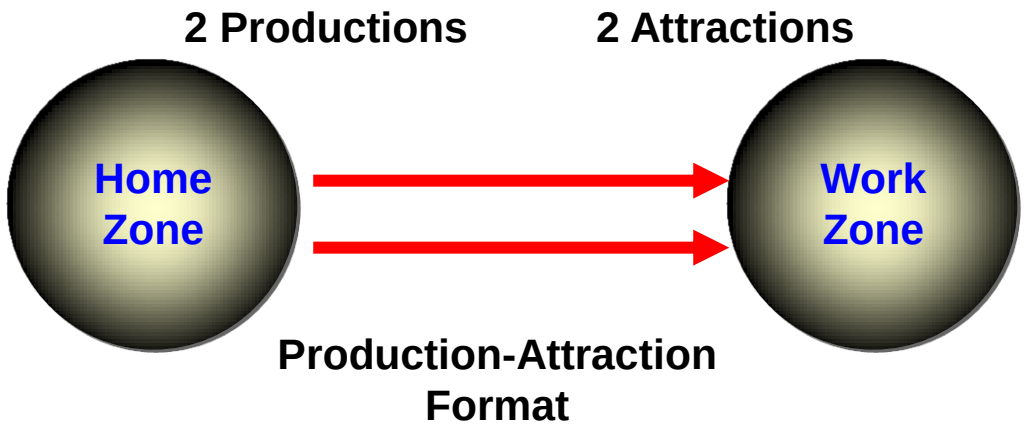
Trip Formats

ORIENTATION CONCEPTS

- Origin – Destination Format
  - Reflects True Direction of Travel
  - Required for Highway Assignment
  - Independent of Traveler Characteristics
- Production – Attraction Format
  - Independent of True Direction of Travel
  - Referenced to Traveler Characteristics
  - Enables Robust Model Specifications & Market Segmentation

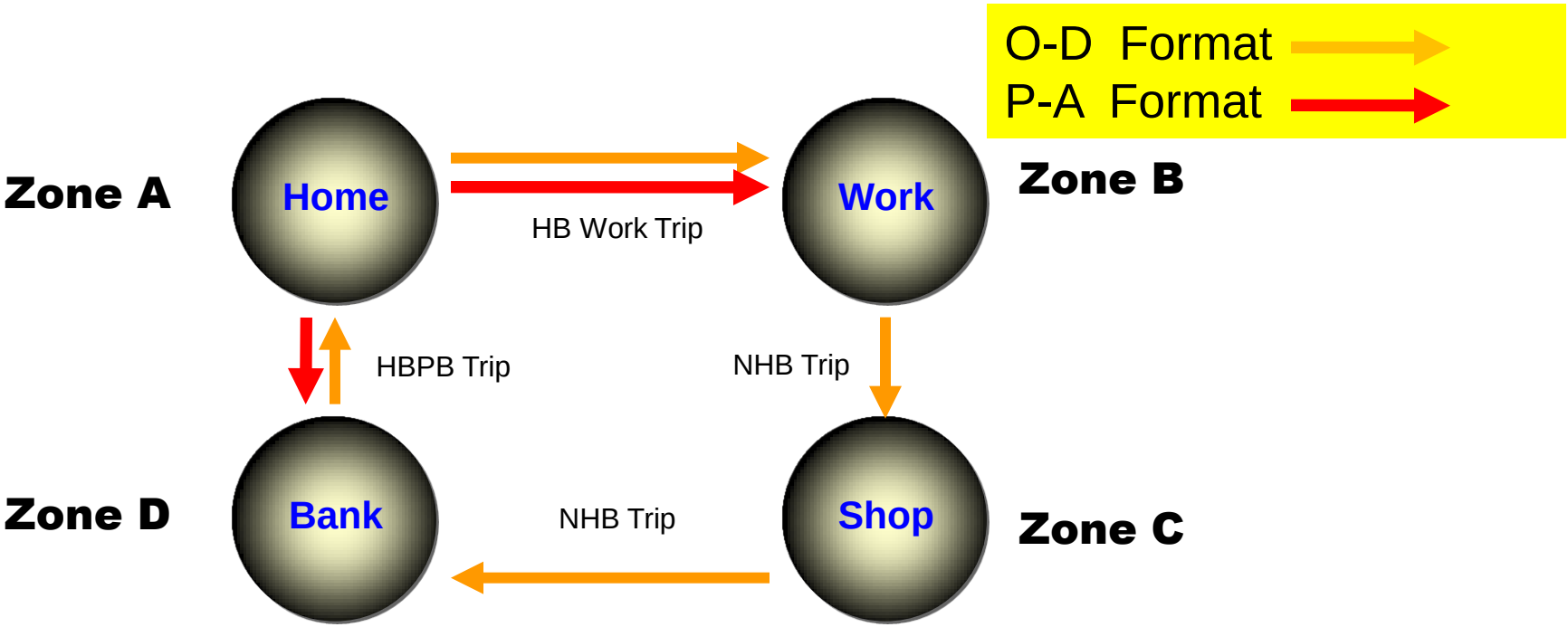
TRIP ORIENTATION FORMATS

Case I



Case II

EXTENDED TRIP CHAIN



Trip	Trip Purpose	Production	Attraction
1	HB Work	Zone A	Zone B
2	NHB	Zone B	Zone C
3	NHB	Zone C	Zone D
4	HB Per. Business	Zone A	Zone D

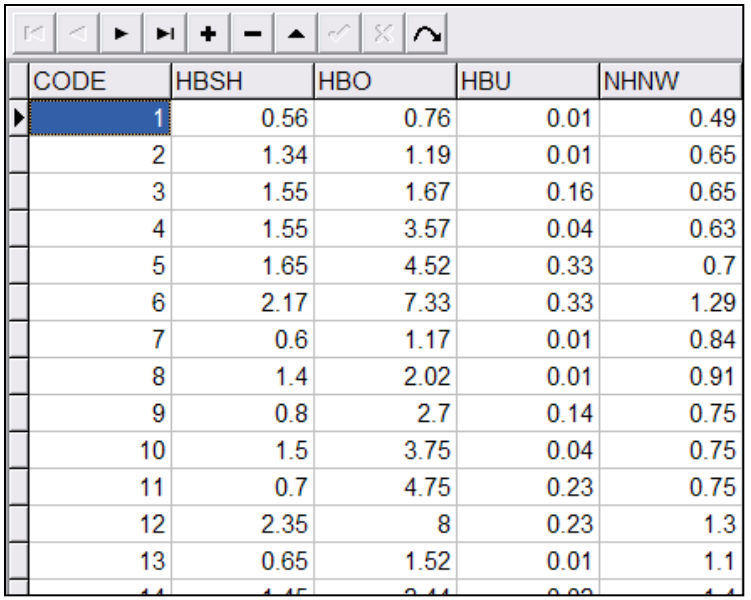
Trip Generation Model

TYPICAL TRIP GENERATION MODEL

- Productions: Cross-Classification
  - Persons/HH
  - Workers/HH
  - Auto Ownership/HH
  - Income
  - Life Cycle
- Attractions: Linear Regression
  - Households
  - Employment by Types (e.g. Basic, Retail, Service)
  - Area Type
  - Density

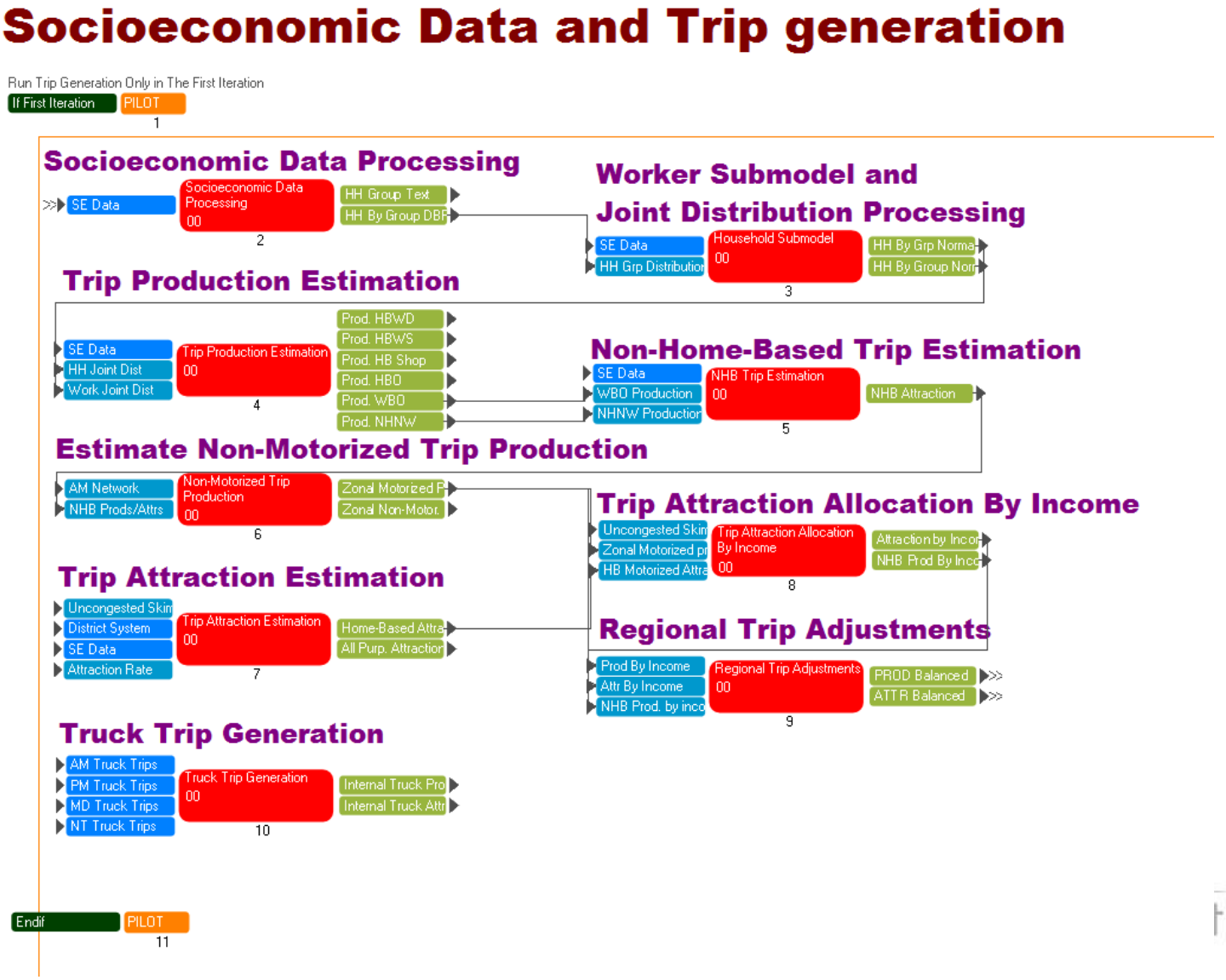
TRIP GENERATION ESTIMATION

- Cross-classification - Example
  - Household Lifecycle Groups (3)
    - With Retirees (at least 1)
    - With Children
    - Without Retirees or Children
  - Household Income Groups (5)
    - 0-15K
    - 15-35K
    - 35-75K
    - 75-150K
    - 150k+
  - Workers Per Household (4)
    - 0 Worker
    - 1 Worker
    - 2 Workers
    - 3+Workers
  - Persons Per Household (6)
    - 1 to 6+ Persons



CODE	HBSH	HBO	HBU	NHNW
1	0.56	0.76	0.01	0.49
2	1.34	1.19	0.01	0.65
3	1.55	1.67	0.16	0.65
4	1.55	3.57	0.04	0.63
5	1.65	4.52	0.33	0.7
6	2.17	7.33	0.33	1.29
7	0.6	1.17	0.01	0.84
8	1.4	2.02	0.01	0.91
9	0.8	2.7	0.14	0.75
10	1.5	3.75	0.04	0.75
11	0.7	4.75	0.23	0.75
12	2.35	8	0.23	1.3
13	0.65	1.52	0.01	1.1

EXAMPLE of TRIP GENERATION



Trip Distribution Model

- Gravity Model

$$Trip_{i->j} = \frac{P_i \times A_j \times f(\mathrm{Im}\, p_{i->j}) \times k_{i->j}}{\sum_{r=1}^{zones} A_r \times f(\mathrm{Im}\, p_{i->r}) \times k_{i->r}}$$

Where

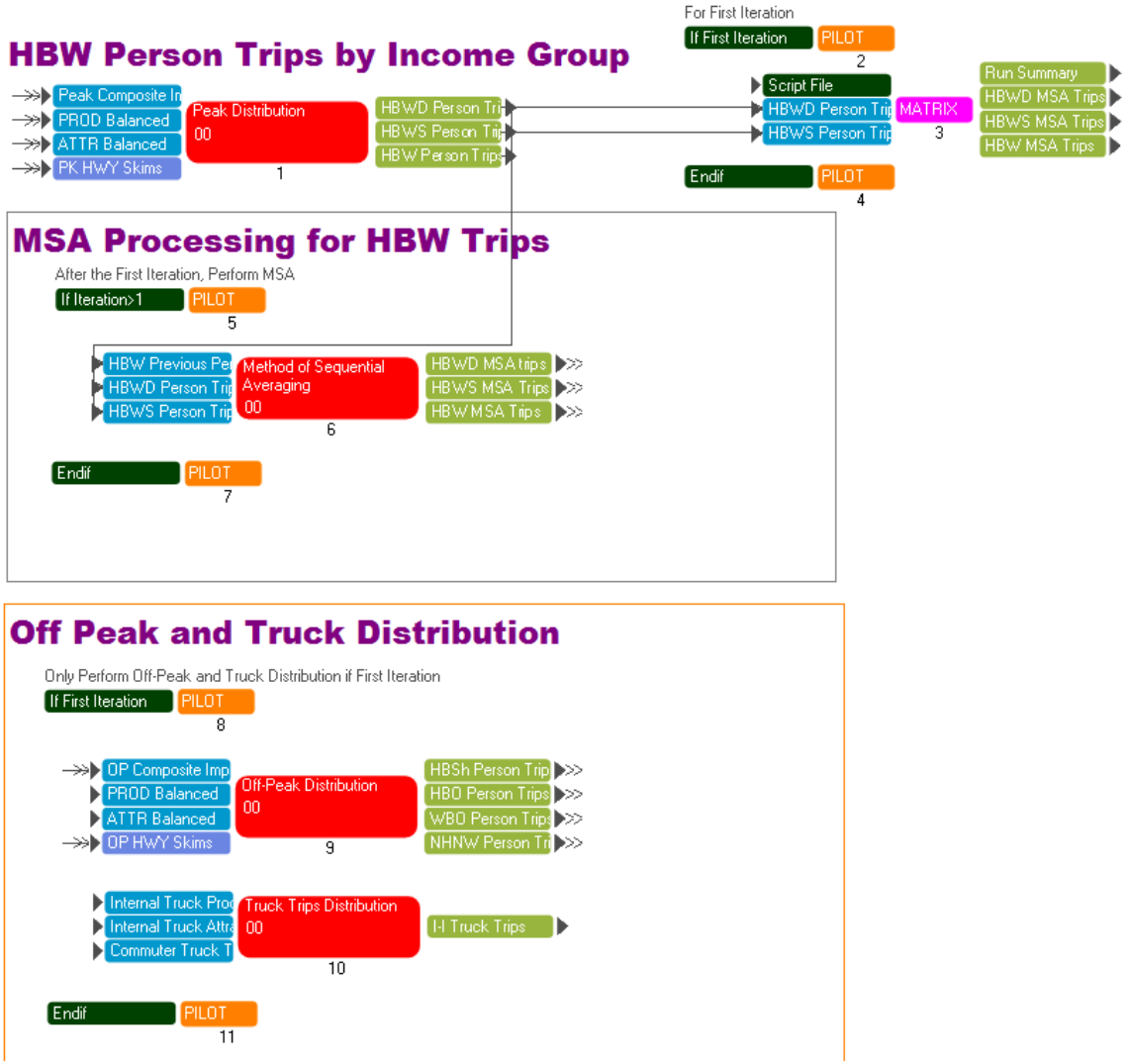
P_i	The number of trips produced from zone i
A_j	The number of trips attracted to zone j
$\mathrm{Im}\, p_{i->j}$	The travel impedance from zone i to zone j
$f(\mathrm{Im}\, p_{i->j})$	The friction factor, which is a function of travel impedance
$k_{i->j}$	The specific zone-to-zone adjustment factor

TRIP DISTRIBUTION ESTIMATION

- Gravity Model Structure
  - Stratified By Household ("Production") Characteristics
    - Income or Auto-Ownership
  - Composite Impedance Term
    - Measure of Spatial Separation
      - Includes Highway/Transit times and costs
      - Mode Choice Logsum Term
      - Potential Household Characteristics
        - » Value of Time
        - » Modal Bias Constants

EXAMPLE of TRIP DISTRIBUTION

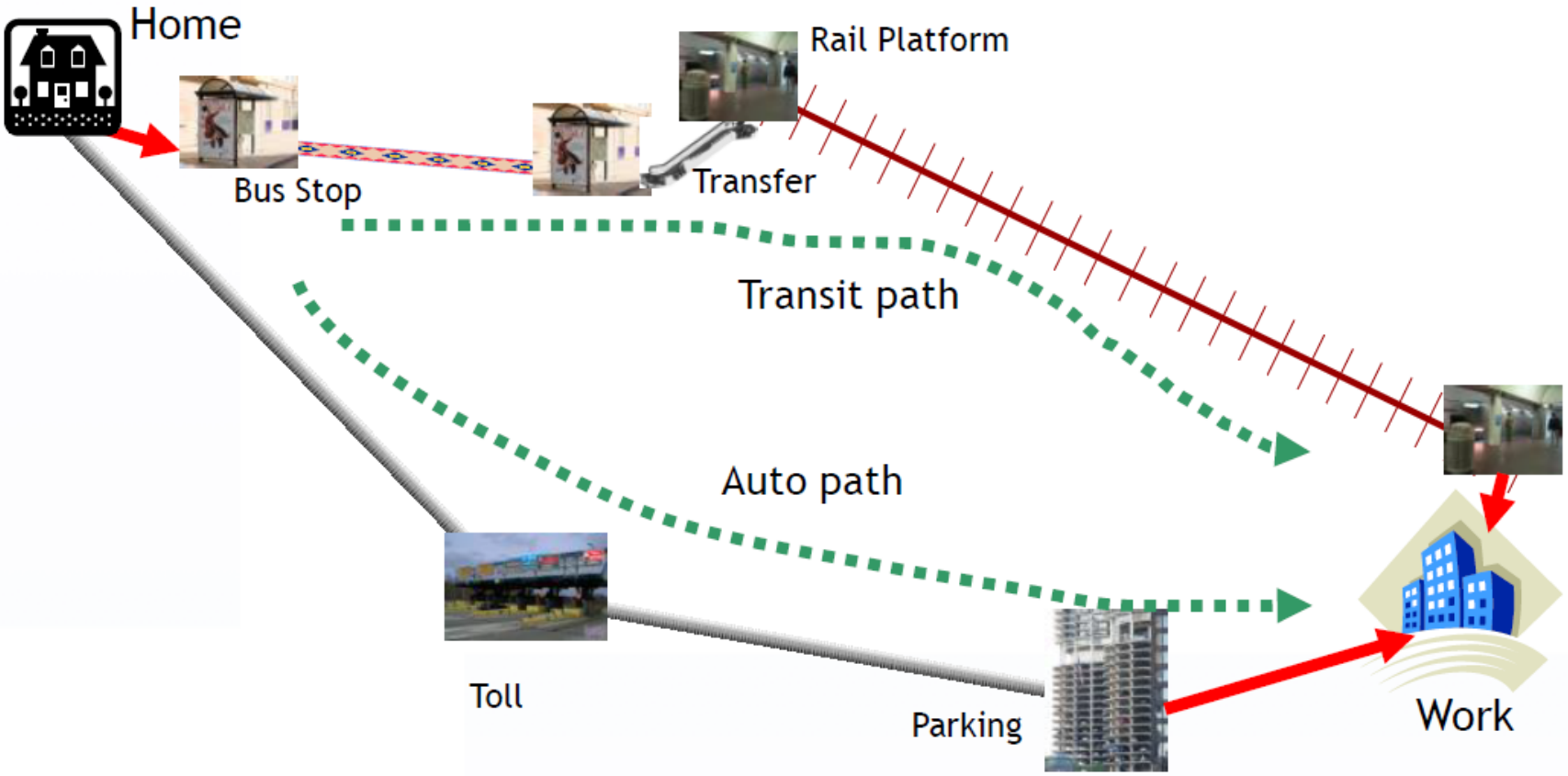
Trip Distribution



citilabs

Mode Choice Model

Mode Choice Model: *Purpose*



Travel Components Commonly Found in Utility Expressions

Auto Choices

- Auto in-vehicle time
- Toll
- Parking cost
- Auto operating cost
- Terminal time
- HOV time saving etc…

Transit Choices

- Bus & rail in-vehicle time
- Walk (access &r transfer) time
- Auto access time
- Wait time (initial & transfer)
- Number of transfers
- Transit fare etc…

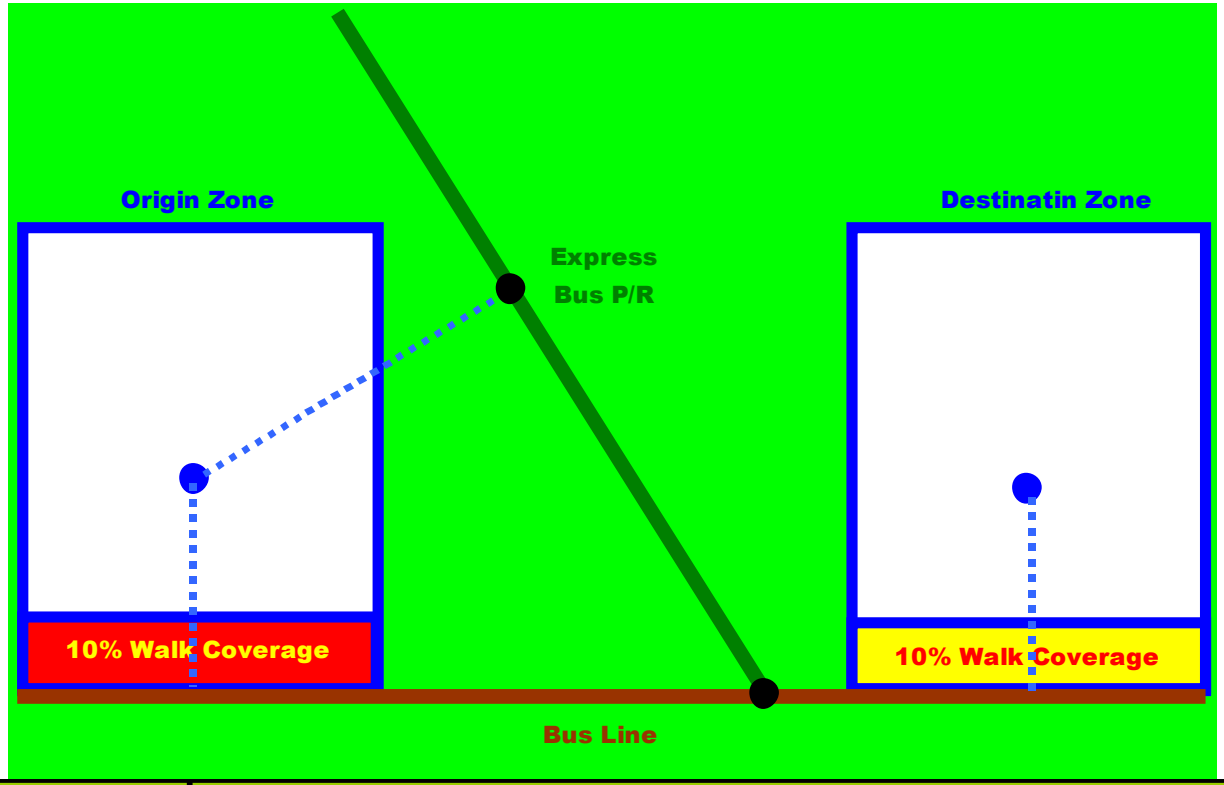
Utility Calculations

- Separate utilities are computed for each zonal interchange and time of day period to reflect the different travel paths and components
- Separate utilities are also produced for different trip purposes and travel markets, as each travel market has different "unknown" or "unmeasured" attributes
  - Access category (no transit, can walk, must drive)
  - Income/car-ownership segment (0-car, 1-car, 2+-car households or low, medium, high income households)
- Separate calculations are made for different access markets, to reflect the different number of trips in each market (can walk to transit, must drive to transit, no transit)
- Example: the Training Model calculates 18 different utilities for each zonal interchange = 3 purposes * 1 car-ownership * 1 access category * 6 submodes

MODE CHOICE MARKET SEGMENTATION

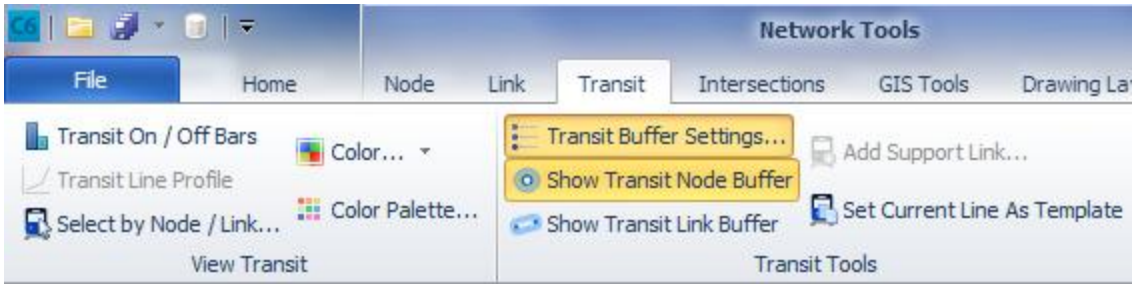
Household Variables Influence Portions of Trips in Each Market Segment.

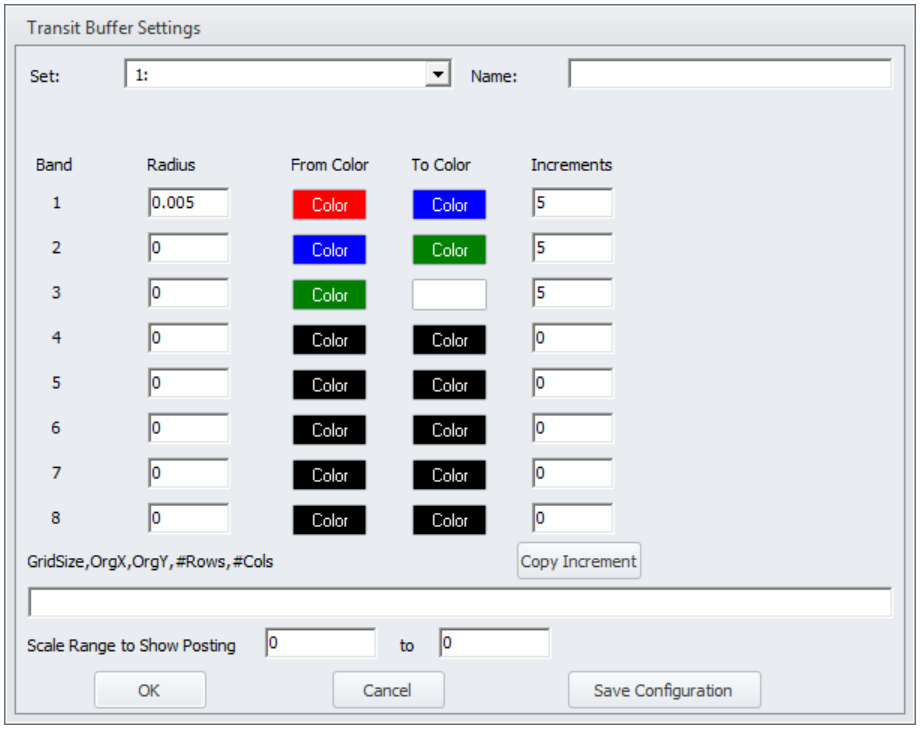
Example: Auto Ownership in Origin (Production) Zone Influences Drive & Drive to Transit Shares

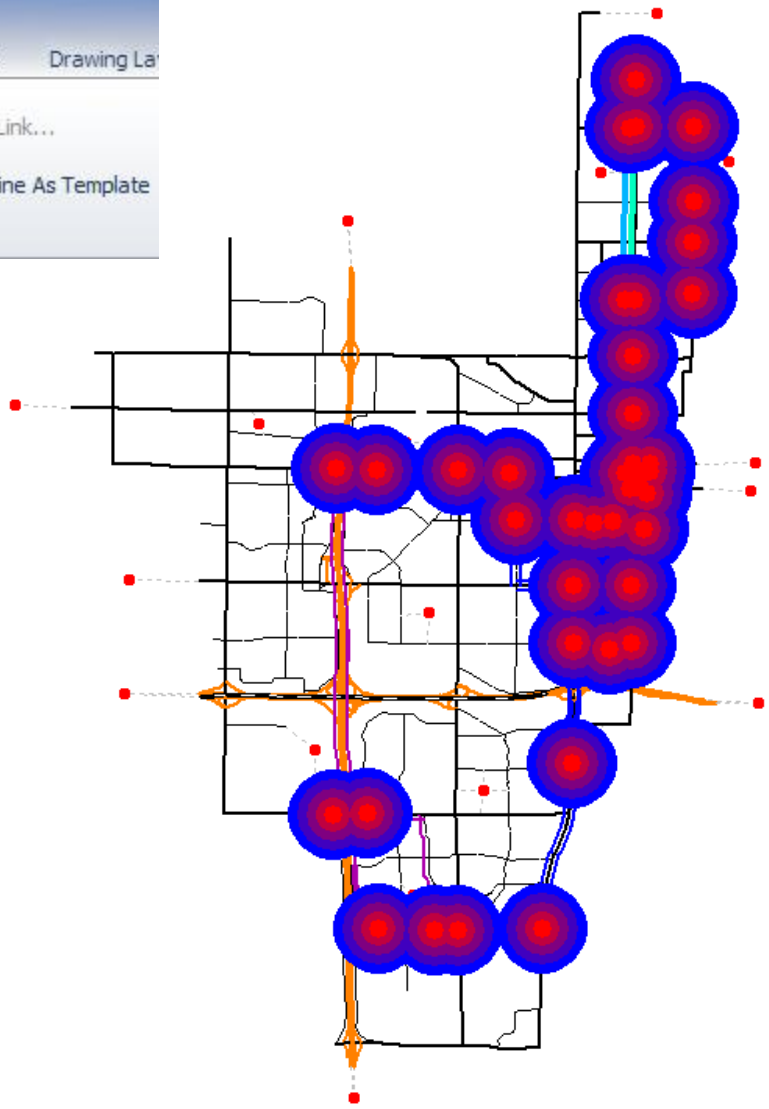


MARKET SEGMENT CALCULATIONS			COMPETING MODES AVAILABLE						
			TRANSIT MODES				AUTO MODES		
			LOCAL BUS		EXPRESS BUS				
MARKET SEGMENT	PERCENTAGE ALLOCATION	TRIP ALLOCATION	WALK	DRIVE	WALK	DRIVE	SOV	HOV2	HOV3
WALK - TRANSIT	1.0%	1	☑	☑	☑	☑	☑	☑	☑
DRIVE - TRANSIT	9.0%	9		☑		☑	☑	☑	☑
NO - TRANSIT	90.0%	90					☑	☑	☑

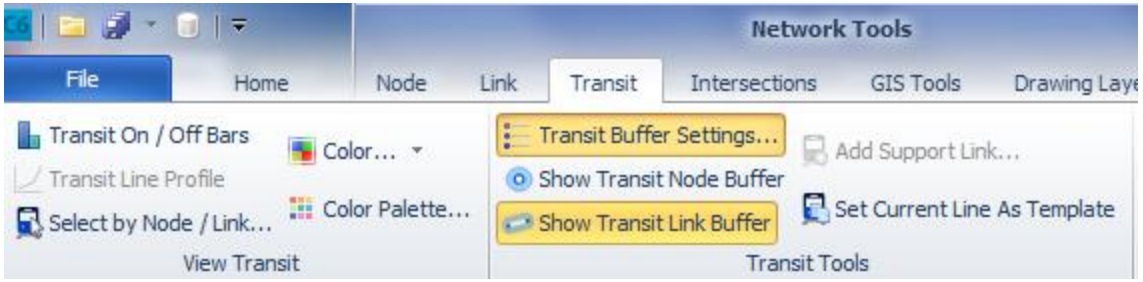
Transit Buffers – Stop

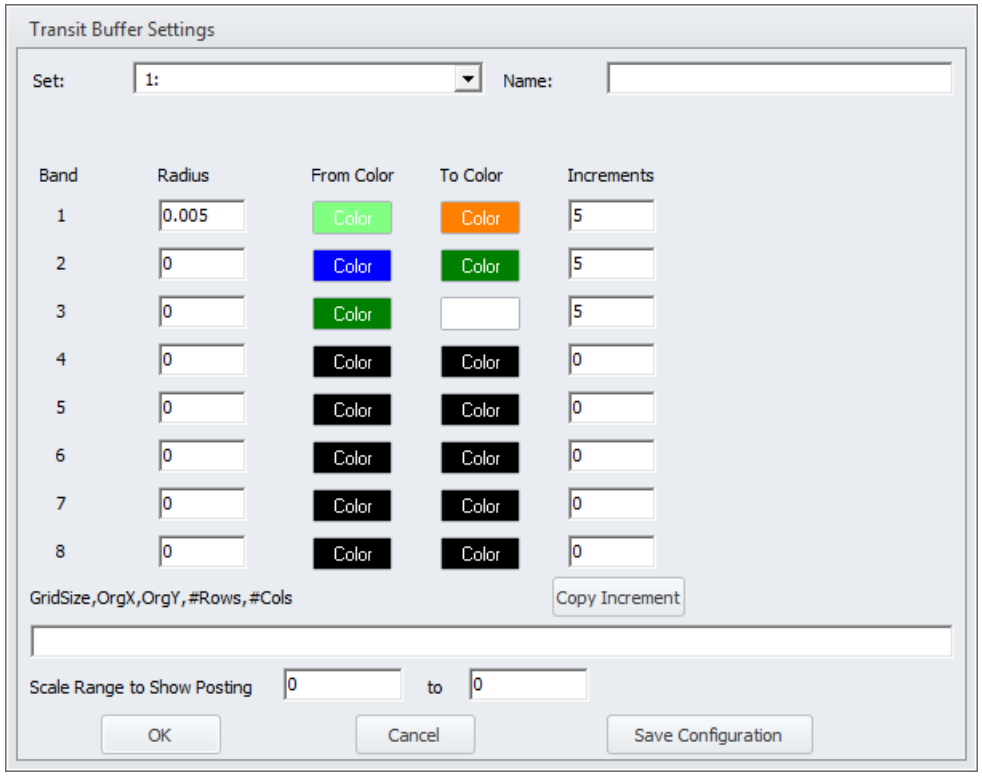


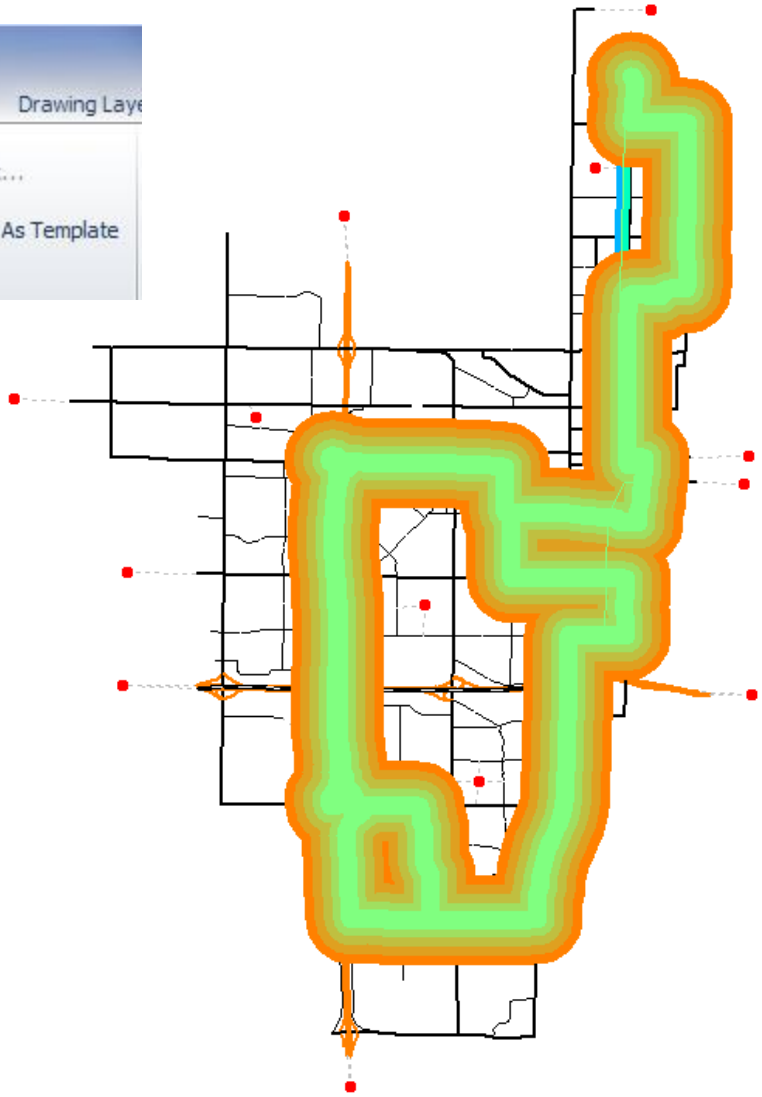




Transit Buffers – Link

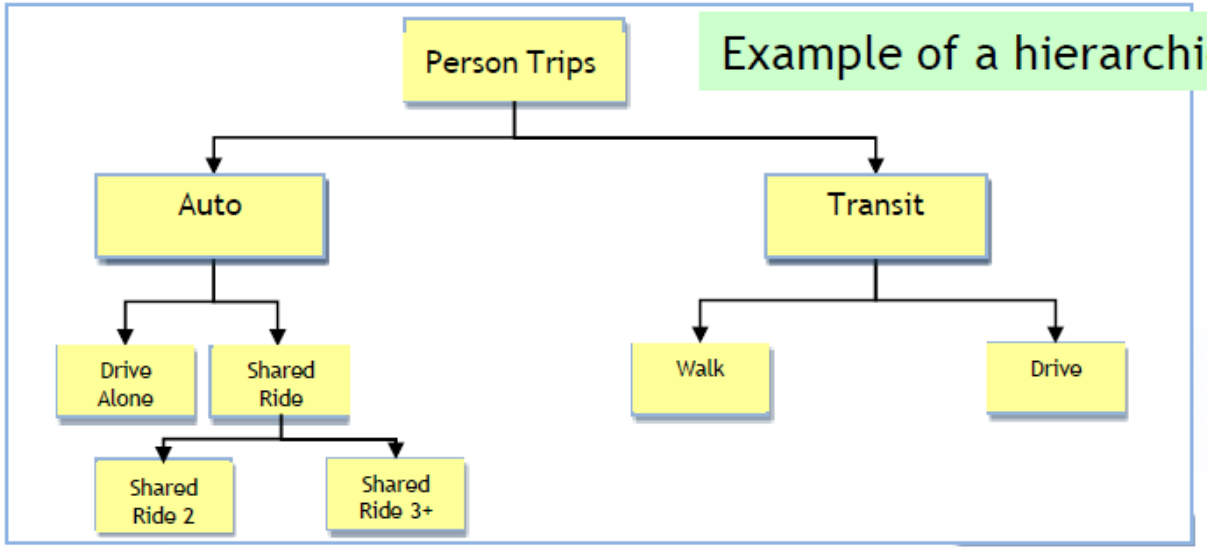






Mode Choice: *Nested Logit*

- A logit model with hierarchical structure
  - Similar choices are grouped into 'nests'
  - Multinomial mode choice models are a special case of nested logit model
- Utilities are initially calculated for the lowest level choices; these are then carried "up" the nest



Example of a hierarchical structure

Nested Logit: *Upper Level Computations*

How are the utilities of upper level nests calculated?
By using the logsum of choices at the lower level

Transit Nest

$$Logsum_{transit} = \ln(e^{U_{walk-transit}} + e^{U_{drive-transit}})$$

$$U_{transit} = \beta_{transit} * Logsum_{transit}$$

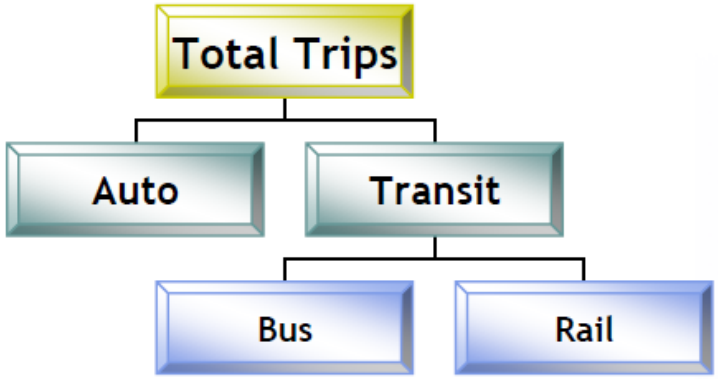
Auto Nest

$$Logsum_{auto} = \ln(e^{U_{drive-alone}} + e^{U_{shared-ride}})$$

$$U_{auto} = \beta_{auto} * Logsum_{auto}$$

Probability of taking transit: $$P_{transit} = \frac{e^{U_{transit}}}{e^{U_{transit}} + e^{U_{auto}}}$$

Mode Choice Calculations



Person Trip Between I and J 100

		Choices		
Attributes	**Coeff**	**Auto**	**Bus**	**Rail**
IVT (min)	-0.020	25	45	20
OVT (min)	-0.040	3	15	10
Cost (cents)	-0.003	200	100	150
Constant (K)		0	0.50	0.25
Transit Path Nest Coefficient			0.5	

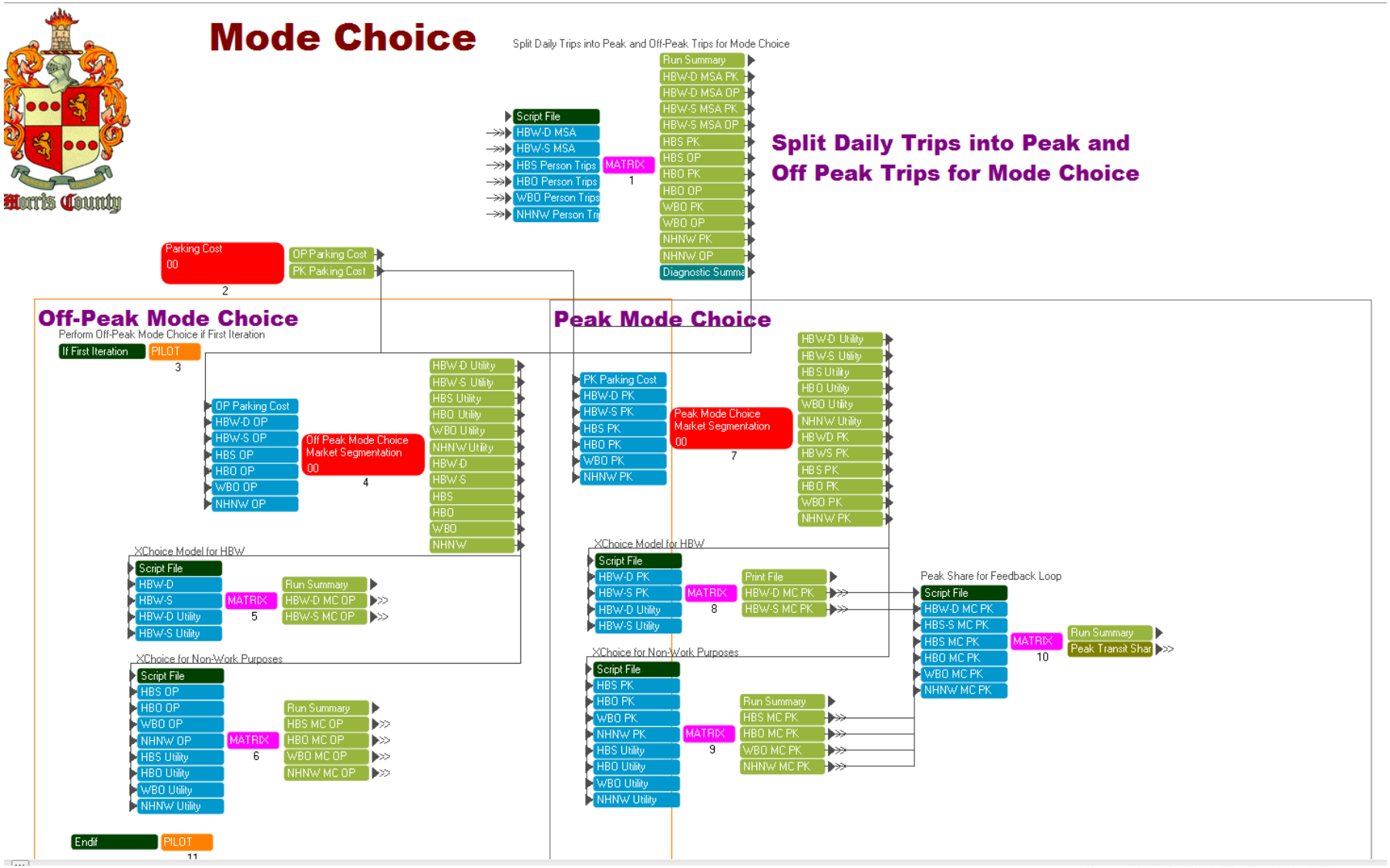
Utility	-1.2200	-2.6000	-2.0000
Exp(Utility) of bottom-level nest		0.0743	0.1353
Logsum (Utility of the nest)		-0.7813	
Exp(utility) of upper-level nest	0.2952	0.4578	
Auto-Transit Share	39%	61%	
Bus-Rail Share		35%	65%
Trips	39.2	21.5	39.3

Data from highway and transit skim files
Input to the mode choice
Obtained after mode choice calibration

-2.600 = { 0.50 + (-0.020*45) +
(-0.040*15) + (-0.003*100) } / 0.5

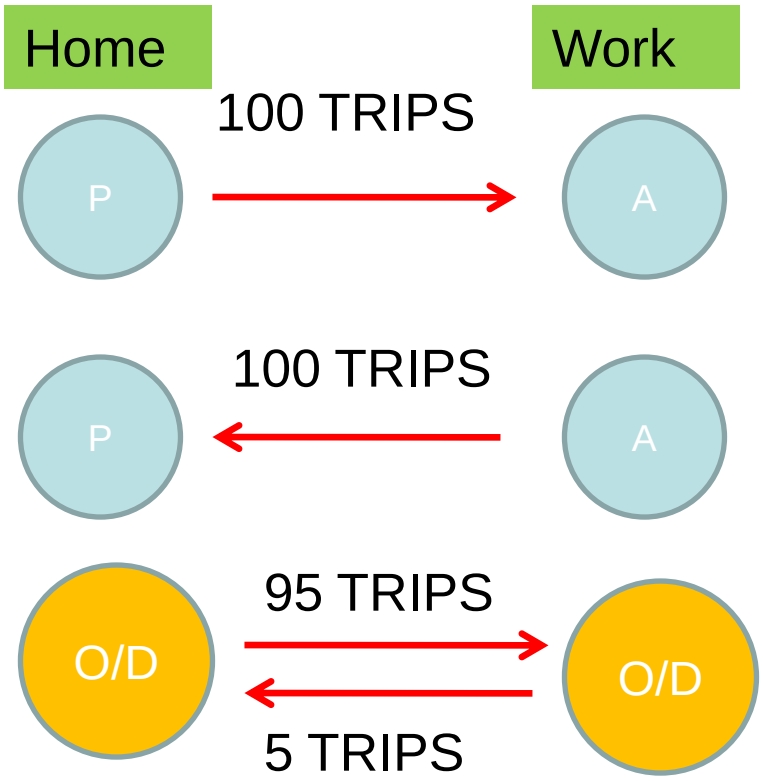
citilabs

EXAMPLE of MODE CHOICE



Time of Day Model

SAMPLE HIGHWAY TRIP CONVERSION



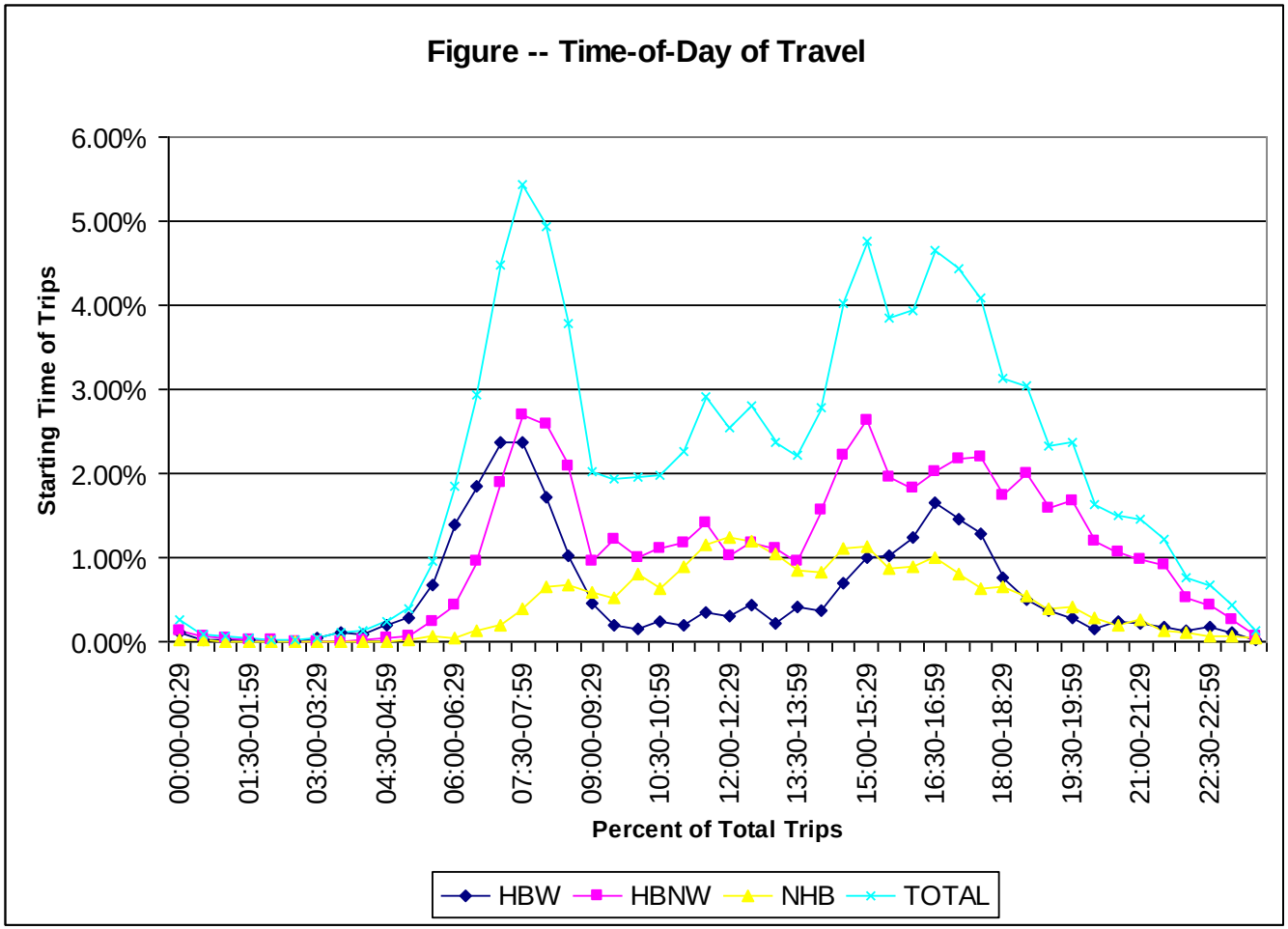
From survey data in the A.M. peak period, 100 HBW trips occurred, shown as P→A

Transpose matrix to represent reverse flow

From survey data in the A.M. peak period, 95% of trips travel from P →A and 5% travel from A → P. Trip table is now O-D format, ready for assignment

TIME OF DAY TRIP ALLOCATION

- Time of Day Travel Pattern



TIME OF DAY TRIP ALLOCATION

- Time of Day Trip Distribution - Example

P->A (From Home to Other)

Period	HBWD	HBWS	HBW	HBSH	HBO
AM	0.353	0.496	0.389	0.067	0.210
MD	0.066	0.096	0.074	0.202	0.113
PM	0.020	0.030	0.022	0.073	0.099
NT	0.062	0.074	0.065	0.094	0.086
TOTAL	0.501	0.696	0.550	0.436	0.508

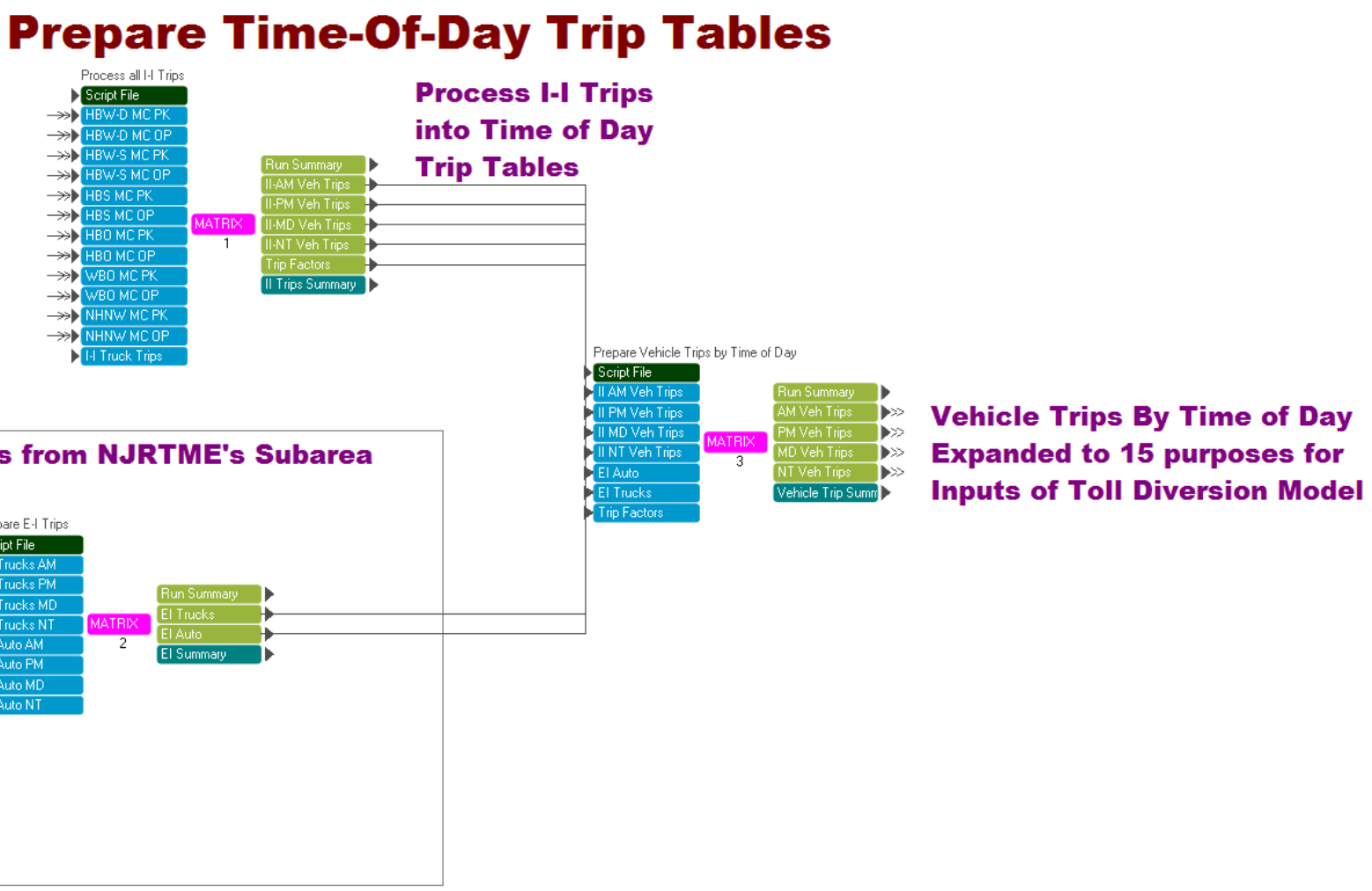
A->P (From Other to Home)

Period	HBWD	HBWS	HBW	HBSH	HBO
AM	0.004	0.016	0.007	0.011	0.030
MD	0.079	0.064	0.075	0.222	0.141
PM	0.296	0.153	0.259	0.165	0.155
NT	0.120	0.071	0.109	0.166	0.166
TOTAL	0.499	0.304	0.450	0.564	0.492

Non-Home-Based

Period	HBWD	HBWS	HBW
AM	0.062	0.121	0.097
MD	0.562	0.463	0.504
PM	0.282	0.223	0.247
NT	0.094	0.193	0.152
TOTAL	1.000	1.000	1.000

EXAMPLE of TIME OF DAY



Assignment Models

HIGHWAY NETWORK ASSIGNMENT

- Convert to Origin-Destination format
- Time of day allocation / directionality determined by household survey

User-Specified Functions

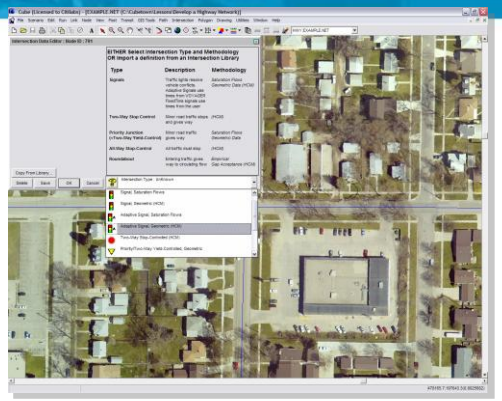
- V: expression giving total volume as a function of up to 20 VOL sets
  - e.g. V = VOL[1] + VOL[2] * 2.5 ; convert to passenger car equivalent units
  - Default function assumes all sets are summed if not explicitly coded
- TC[]: expression (indexed by LINKCLASS) giving congested time using any valid combination of link input, working, and system-defined arrays
  - Default is BPR form: TC = T0 * (1 + TCCOEFF * (V/C) ^ TCEXP),
    where TCCOEFF and TCEXP may be specified by LINKCLASS in PARAMETERS
    (default TCCOEFF = 0.15, default TCEXP = 4)
- COST[]: expression (indexed by LINKCLASS) giving generalized cost using any link input, working, and system-defined arrays (e.g. TIME)
  - Default COST = TIME
  - Example COST = TIME + (voc*LI.Distance + LI.Toll)/vot;
    where voc = vehicle operating cost ($/mile) and vot = value of time ($/minute)

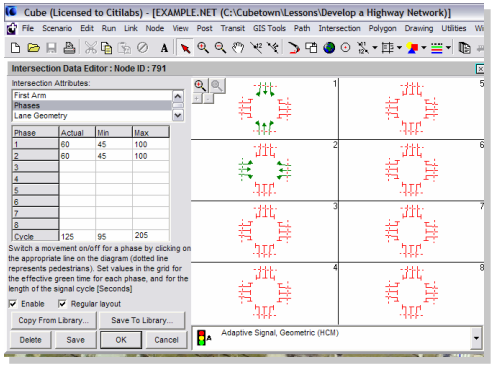
Intersection Modeling

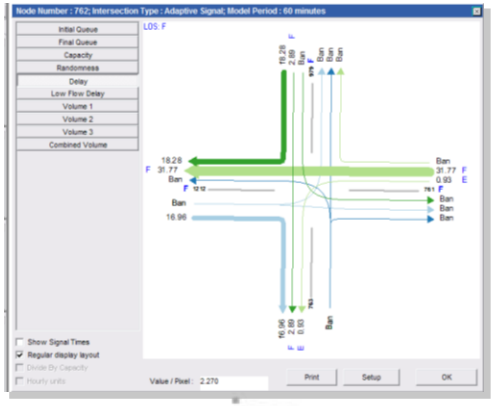
- Turning penalties can be incorporated into path cost by adding FILEI PENI and PATHLOAD… PENI=#
- Cube Voyager can also calculate turning movement delays based upon coded intersection configurations
- Steps:
  1. Link to input intersection data file
  2. Append PERIOD=60, SET=1 to FILEI JUNCTIONI=… in the script file
  3. Append PENI=1 to PATHLOAD statements
- Optional PARAMETERS:
  - TURNCOSTFAC: factor for converting turn times to COST units
  - TURNGAPWT: weighting factor for turning movements in GAP

Intersection Modeling

- Junction-based assignment
  - Major improvement over link-based assignment
  - Representation of intersection details
  - Use of full HCM methods during the assignment
  - Output of HCM level of service, turning movements, delays and queues







citilabs

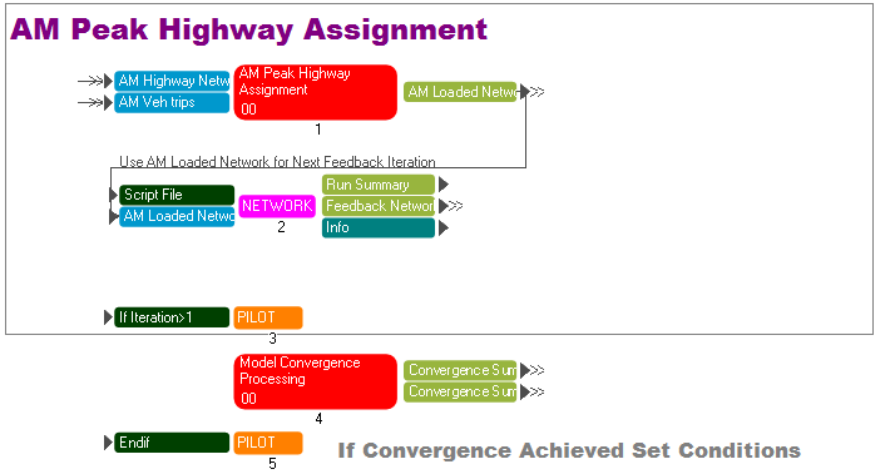
MMA Equilibrium

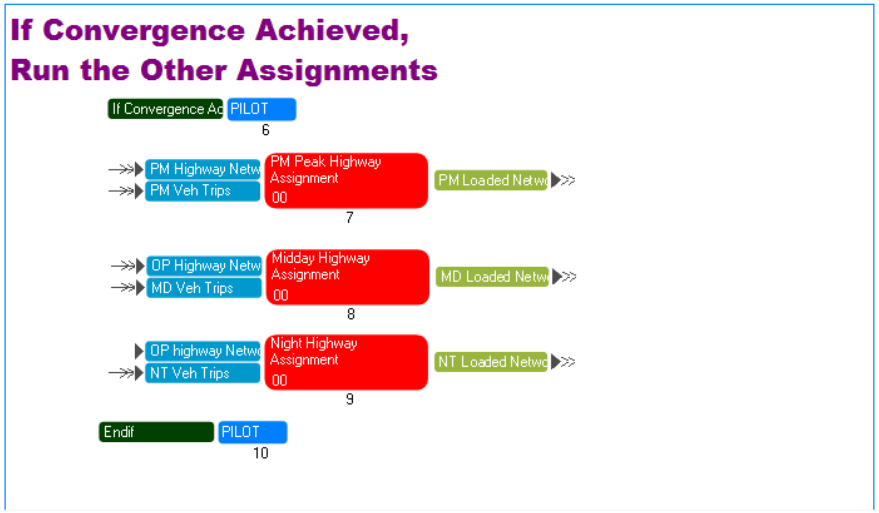
```
PROCESS PHASE=LINKREAD
T0 = (LI.DISTANCE/LI.SPEED)*60
C = LI.CAP
LINKCLASS = LI.FUNC_CLASS
IF (LI.FUNC_CLASS == 1,1.5) LINKCLASS=1 ; Freeways, tollways & HOV
IF (LI.FUNC_CLASS == 2-3) LINKCLASS=2 ; Ramps & expressways
IF (LI.FUNC_CLASS == 4-5) LINKCLASS=3 ; Arterial streets
IF (LI.FUNC_CLASS == 6) LINKCLASS=4 ; Local / collector
IF (LI.FUNC_CLASS == 9-10) LINKCLASS=10 ; Connectors /dummy
IF (LI.NAME='HOV') ADDTOGROUP=1
IF (LI.NAME='RAILACCESS') ADDTOGROUP=9
IF (ITERATION=0)
LW.COST_LOV = T0 + DIST_COST_LOV * LI.DISTANCE
LW.COST_HOV = T0 + DIST_COST_HOV * LI.DISTANCE
ENDIF
ENDPROCESS

PROCESS PHASE=ILOOP
PATHLOAD PATH = LW.COST_LOV VOL[1]=MI.1.1 EXCLUDEGROUP=1,9
PATHLOAD PATH = LW.COST_HOV VOL[2]=MI.1.2 EXCLUDEGROUP=9
ENDPROCESS

PROCESS PHASE=ADJUST
FUNCTION {
V=VOL[1]+VOL[2]
TC[1] = T0 *(1+0.18*(V/C)^8.5) ; Freeways, tollways & HOV
TC[2] = T0 *(1+1.00*(V/C)^5.0) ; Ramps & expressways
TC[3] = T0 *(1+0.70*(V/C)^5.0) ; Arterial streets
TC[4] = T0 *(1+1.40*(V/C)^5.0) ; Local / collector
TC[10]= T0 ; No congestion degradation on centroid connectors
}
LW.COST_LOV = TIME + DIST_COST_LOV * LI.DISTANCE
LW.COST_HOV = TIME + DIST_COST_HOV * LI.DISTANCE

FUNCTION COST= ((TIME + DIST_COST_LOV * LI.DISTANCE) * V1 + (TIME +
DIST_COST_HOV * LI.DISTANCE) * V2) / CmpNumRetNum(V,'=',0,1,V) ; cost function
ENDPROCESS
```

using LW variables

EXAMPLE of HIGHWAY ASSIGNMENT

Highway Assignment





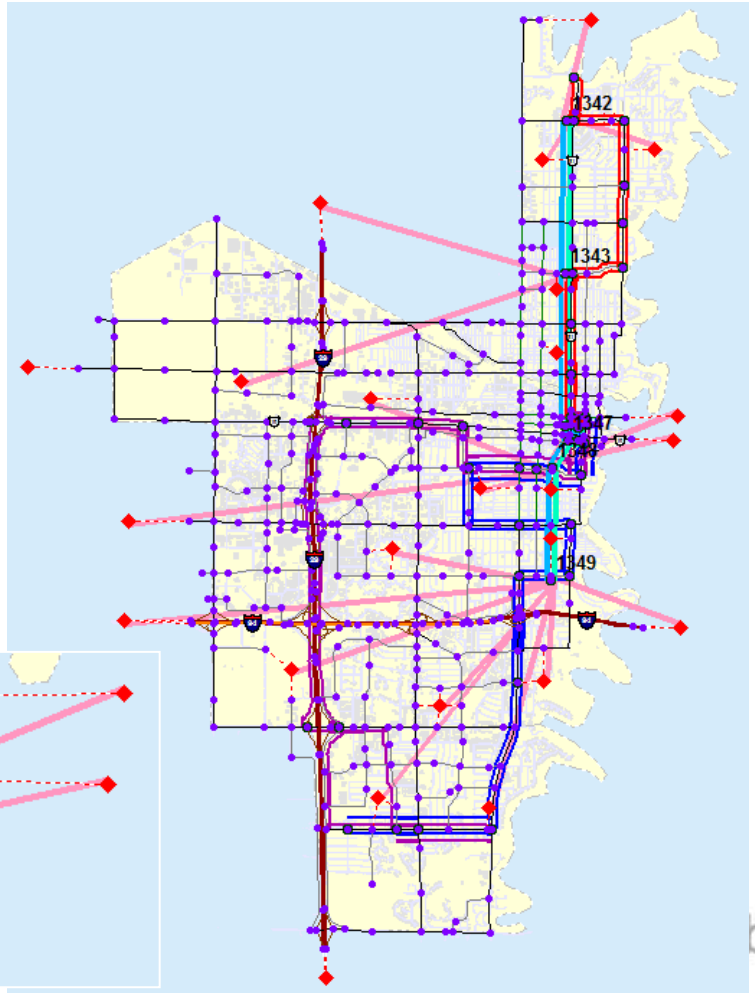
TRANSIT ASSIGNMENT

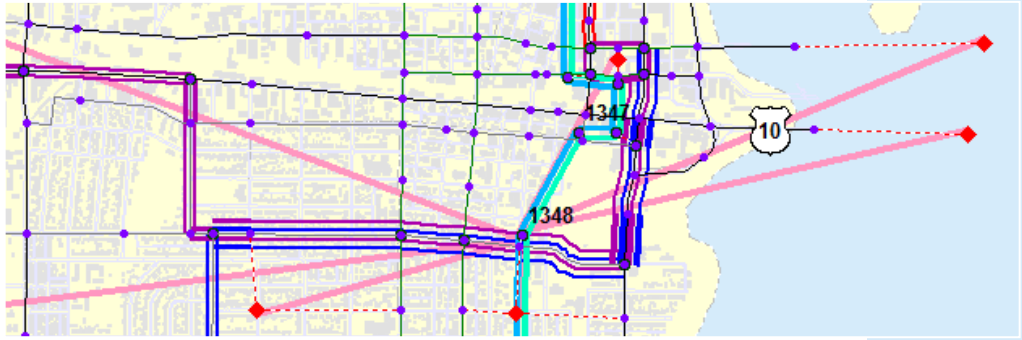
- Assign as Production-Attraction format
- Assign to peak & off-peak trips
- Used to Size Peak Station Demand and Parking Demand

Drive-Access Generation Examples

- Direct drive-access connection without parking nodes

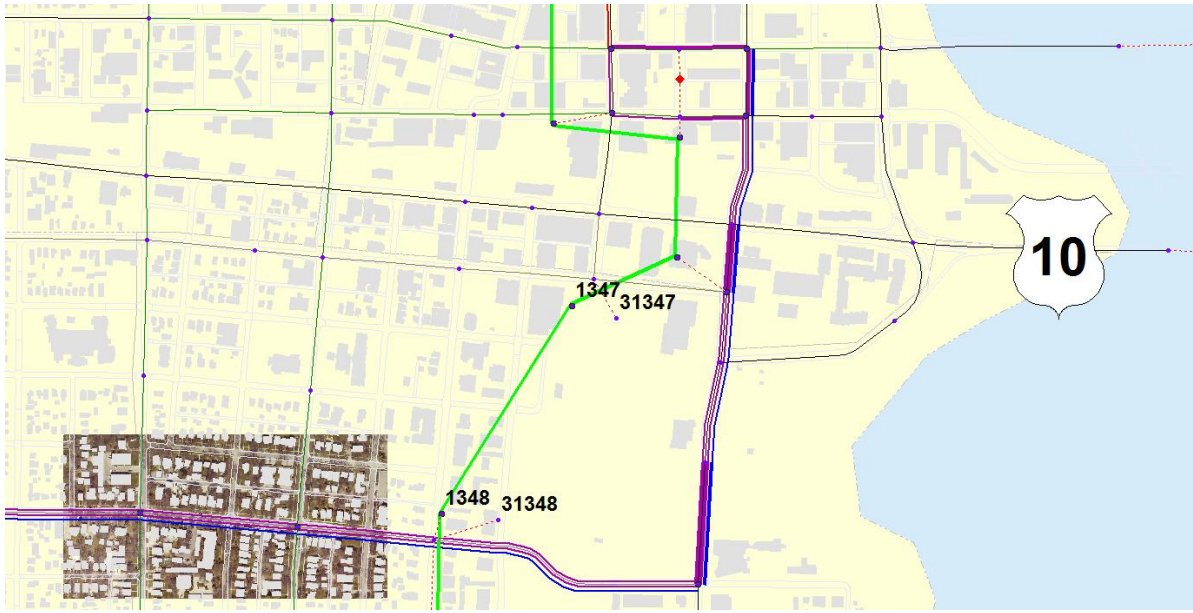
```
PROCESS PHASE = LINKREAD
    LW.WALKSPEED= 2.5
    LW.TRANTIME = 0.80*(li.DISTANCE*60/li.SPEED)
    LW.AUTOTIME = 1.00*(li.DISTANCE*60/li.SPEED)
    LW.WALKTIME = 1.00*(li.DISTANCE*60/LW.WALKSPEED)
ENDPROCESS

PROCESS PHASE = DATAPREP
   GENERATE,
    COST=LI.DISTANCE,
    EXTRACTCOST=LW.AUTOTIME,
    MAXNTLEGS=1,
    MAXCOST=999*3.0,
    LIST=T,
    NTLEGMODE=201,
    DIRECTION=1,
    FROMNODE=1-25, TONODE=1342-1343,1347-1349
                   ; RAIL SYSTEM ONLY
ENDPROCESS
```





➢ Drive-access connection with parking nodes

```
PROCESS PHASE = DATAPREP
   GENERATE,
    COST=LI.DISTANCE,
    EXTRACTCOST=LW.AUTOTIME,
    MAXNTLEGS=1,
    MAXCOST=999*3.0,
    LIST=T,
    NTLEGMODE=201,
    DIRECTION=1,
    ONEWAY=T,
    FROMNODE=1-25,
    ACCESSLINK= 31342-1342, 0.20, 0.01,
                31343-1343, 0.20, 0.01,
                31347-1347, 0.20, 0.01,
                31348-1348, 0.20, 0.01,
                31349-1349, 0.20, 0.01
                ; RAIL SYSTEM ONLY
ENDPROCESS
```

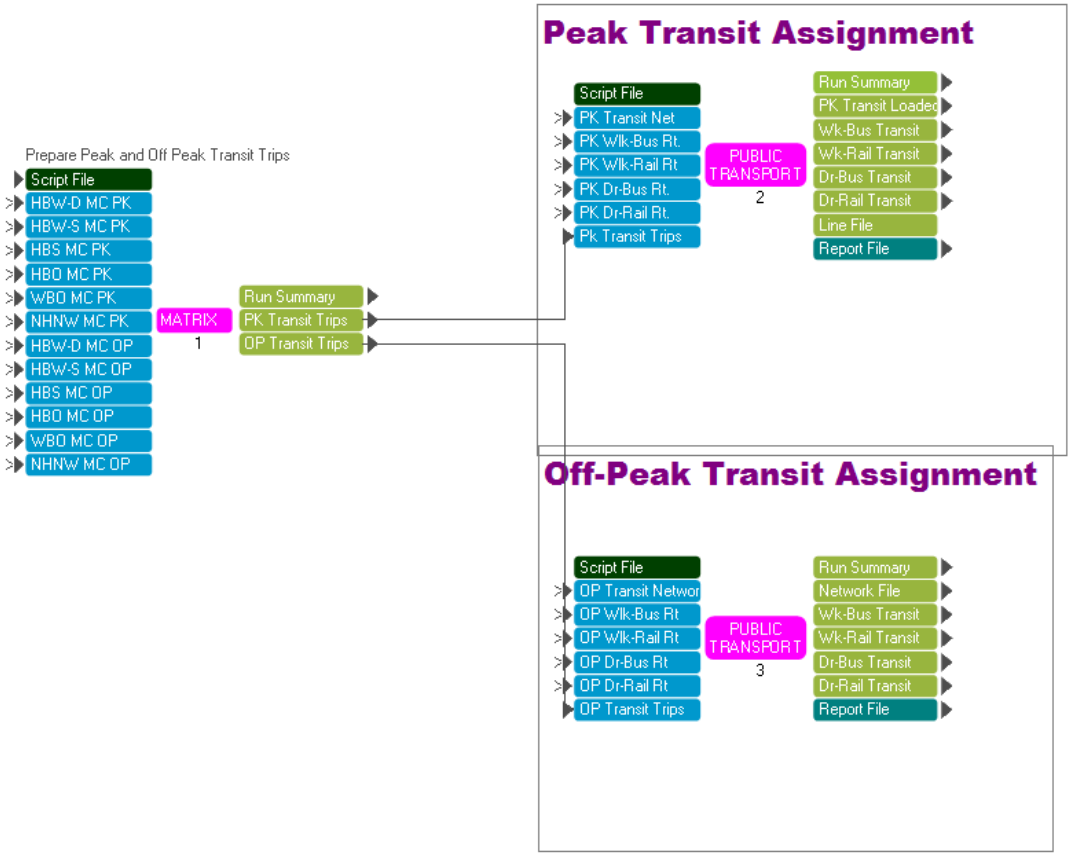



```
;;<<PT>>;;
NT LEG=1-1342 MODE=201 COST=1.75 DIST=0.63 ONEWAY=T XN=1153 1069 1175 1152 804 31342
NT LEG=2-1342 MODE=201 COST=1.24 DIST=0.42 ONEWAY=T XN=954 804 31342
NT LEG=3-1343 MODE=201 COST=0.53 DIST=0.13 ONEWAY=T XN=1266 31343
NT LEG=4-1347 MODE=201 COST=1.52 DIST=0.54 ONEWAY=T XN=962 766 966 974 975 758 759 750 751 31347
NT LEG=5-1347 MODE=201 COST=2.89 DIST=1.22 ONEWAY=T XN=1012 770 735 738 1238 739 740 1239 752 1010 751 31347
NT LEG=6-1347 MODE=201 COST=0.72 DIST=0.22 ONEWAY=T XN=976 758 759 750 751 31347
NT LEG=7-1348 MODE=201 COST=0.58 DIST=0.14 ONEWAY=T XN=1015 31348
NT LEG=8-1348 MODE=201 COST=1.52 DIST=0.54 ONEWAY=T XN=1014 741 744 1015 31348
NT LEG=9-1349 MODE=201 COST=0.81 DIST=0.24 ONEWAY=T XN=1021 31349
NT LEG=10-1349 MODE=201 COST=2.68 DIST=1.02 ONEWAY=T XN=1276 725 1145 723 1020 721 720 1021 31349
```

EXAMPLE of TRANSIT ASSIGNMENT

Morris County

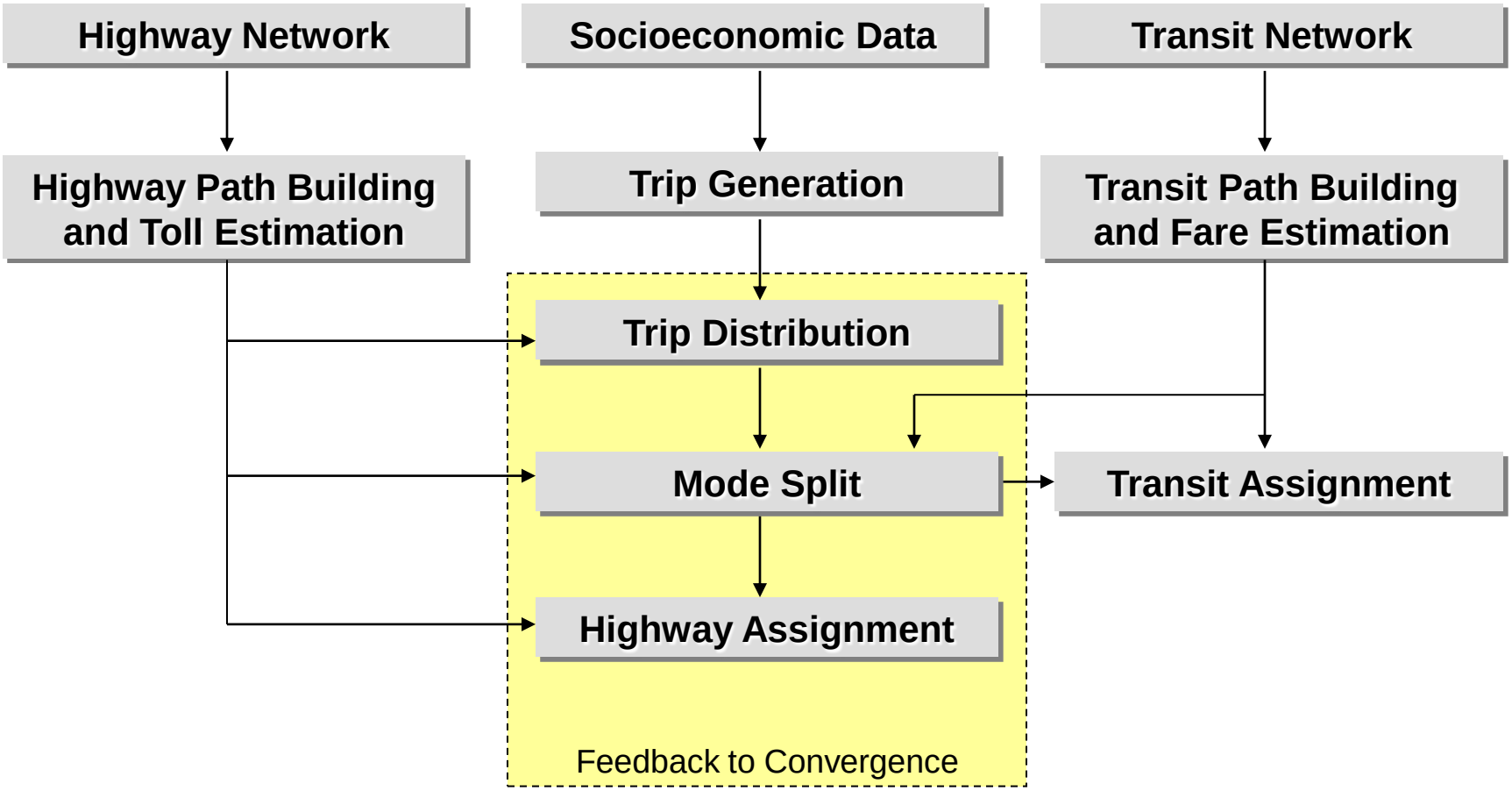
Transit Assignment



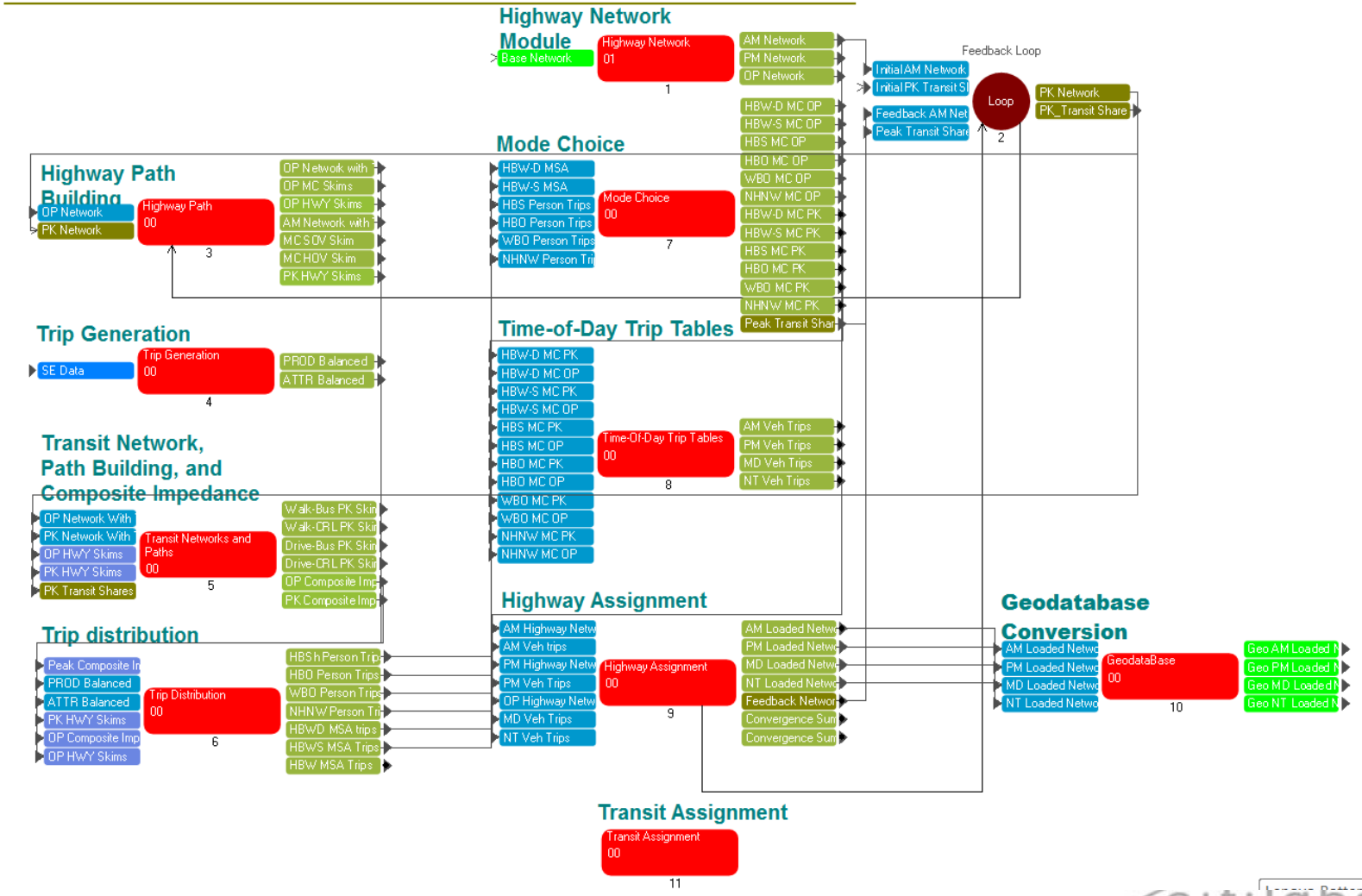
FEEDBACK PROCESSING CONCEPTS

- Objectives:
  - Ensure model consistency
  - Reasonable future year forecasts
- Issues:
  - Time of day periods
  - Convergence methodology
- Typical Methods:
  - Naive feedback
  - Method of successive averages (MSA)
  - Evans method

STANDARD FOUR-STEP DEMAND FORECASTING MODEL



FOUR-STEP MODEL WITH FEEDBACK



MODEL FEEDBACK PROCESS

- Method of Successive Averages – Trip Distribution

$$Trips_{adjusted} = (1-\alpha) \times Trips_{previous} + \alpha \times Trips_{current}$$

Where:

$Trips_{adjusted}$ = Adjusted trips (after trip distribution and before mode choice)

α = Weight factor, 1/(Number of Iterations) for 1/k MSA and ½ for ½ MSA

$Trips_{previous}$ = Trips from previous iteration

$Trips_{current}$ = Trips from gravity trip distribution model

MODEL FEEDBACK PROCESS (cont'd)

- Coincidence Ratio – Trip Distribution

$$coincidence \quad ratio = \frac{\sum_{t=1}^{T} \min\left\{\frac{f^m(t)}{F^m}, \frac{f^0(t)}{F^0}\right\}}{\sum_{t=1}^{T} \max\left\{\frac{f^m(t)}{F^m}, \frac{f^0(t)}{F^0}\right\}}$$

Where:

$f^m(t)$	=	frequency of trips for time interval t in iteration n
$f^0(t)$	=	frequency of trips for time interval t in iteration n-1
F^m	=	total O-D trips in iteration n
F^0	=	total O-D trips in iteration n-1
T	=	number of time interval

MODEL FEEDBACK PROCESS (cont'd)

- Percent RMSE – Highway Assignment

$$\%RMSE = \frac{\sqrt{\dfrac{\sum_i \left(f_i^n - f_i^{n-1}\right)^2}{k-1}}}{\dfrac{\sum_i f_i^{n-1}}{k}} \times 100$$

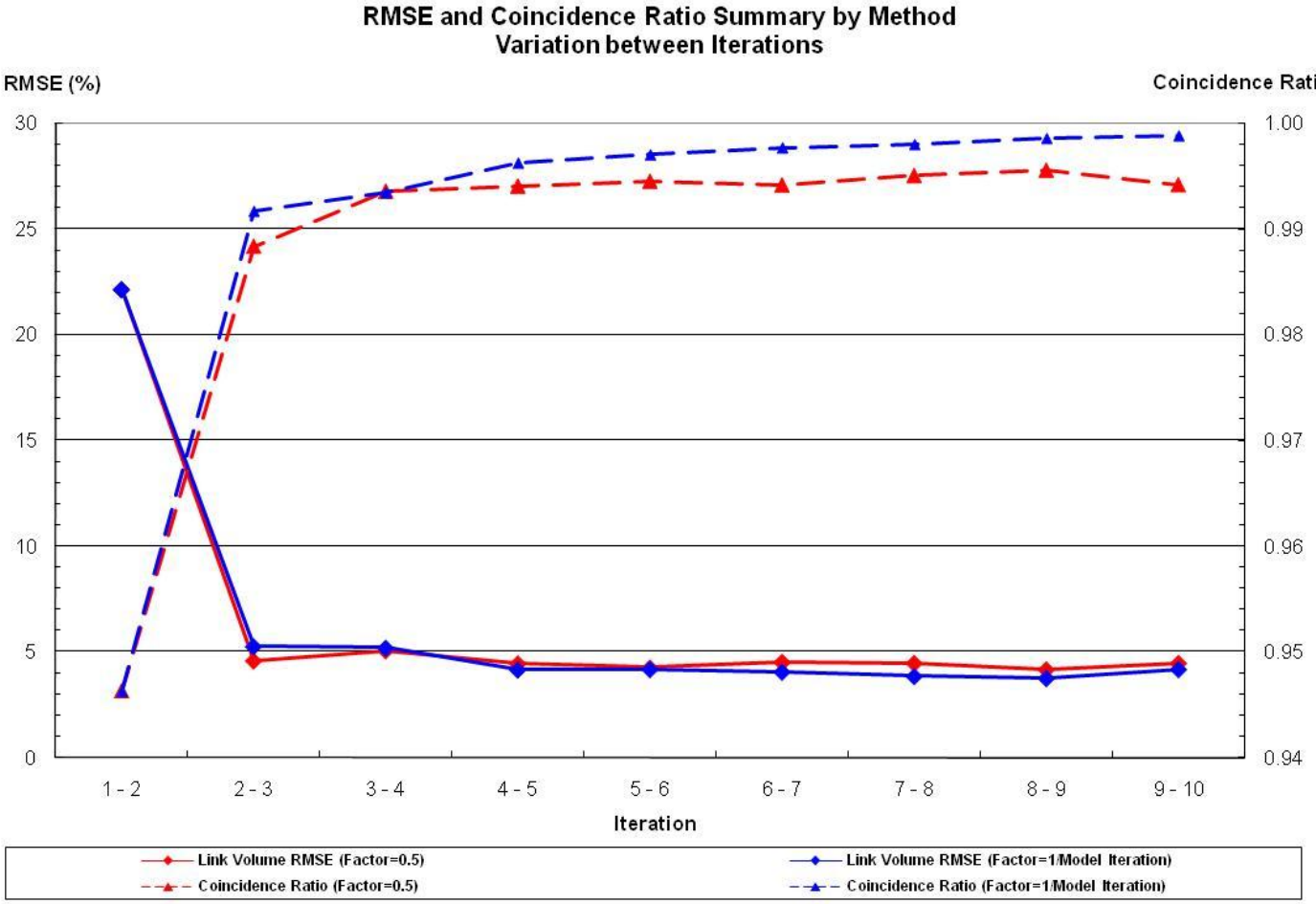
Where:

f_i^n = estimated link volume at link i for iteration n

k = number of total links

MODEL FEEDBACK PROCESS (cont'd)

- Convergence Performance



Model Calibration & Validation

Trip Generation Model

- Persons/Household & Workers/Household Sub-model Estimation Comparison

COUNTY	Persons/Household			Workers/Household		
	EST	OBS	EST/OBS	EST	OBS	EST/OBS
BERGEN	2.69	2.69	1.00	1.31	1.29	1.02
ESSEX	2.76	2.78	0.99	1.22	1.14	1.07
HUDSON	2.60	2.66	0.98	1.20	1.14	1.06
HUNTERDON	2.82	2.74	1.03	1.45	1.44	1.01
MERCER	2.74	2.71	1.01	1.28	1.26	1.02
MIDDLESEX	2.81	2.80	1.00	1.32	1.34	0.98
MONMOUTH	2.76	2.76	1.00	1.33	1.30	1.02
MORRIS	2.81	2.77	1.02	1.42	1.41	1.01
OCEAN	2.54	2.55	0.99	1.09	1.05	1.04
PASSAIC	2.98	3.00	0.99	1.27	1.27	1.00
SOMERSET	2.75	2.74	1.00	1.41	1.38	1.02
SUSSEX	2.84	2.86	0.99	1.38	1.44	0.96
UNION	2.81	2.83	0.99	1.27	1.27	1.00
WARREN	2.65	2.66	1.00	1.27	1.31	0.97
TOTAL	2.74	2.75	1.00	1.28	1.26	1.02

Note: Observation is summarized from Census.

Comparison of Trip Productions by Income Group

Trip Productions from Model by Income Group

INCOME	HBWD	HBWS	HBSH	HBO	HBU	WBO	NHNW	TOTAL
0-$14,999	115,534	52,775	188,107	473,496	42,629	29,368	170,336	1,072,244
$15,000-$34,999	470,164	118,835	326,900	1,122,280	41,488	125,158	366,891	2,571,717
$35,000-$74,999	1,282,778	455,821	699,505	2,526,212	95,534	630,364	818,217	6,508,430
$75,000-$149,999	1,407,772	488,522	591,415	2,729,794	111,974	756,692	804,401	6,890,571
>=$150,000	470,103	161,057	205,881	1,079,364	26,087	275,813	318,917	2,537,222
Total	3,746,351	1,277,010	2,011,808	7,931,146	317,712	1,817,395	2,478,762	19,580,184

Trip Productions from Household Survey by Income Group

INCOME	HBWD	HBWS	HBSH	HBO	HBU	WBO	NHNW	TOTAL
0-$14,999	116,865	51,860	188,235	482,193	40,261	28,062	172,769	1,080,246
$15,000-$34,999	476,824	118,820	326,973	1,137,007	40,675	124,964	372,829	2,598,091
$35,000-$74,999	1,281,997	453,993	698,596	2,518,653	91,761	629,676	828,595	6,503,270
$75,000-$149,999	1,390,464	483,622	589,060	2,691,024	106,830	756,341	812,597	6,829,937
>=$150,000	460,322	158,868	201,591	1,052,860	23,579	275,575	319,942	2,492,737
Total	3,726,472	1,267,163	2,004,455	7,881,737	303,105	1,814,617	2,506,732	19,504,281

Ratio of Trip Productions by Income Group (Model v.s Household Survey)

INCOME	HBWD	HBWS	HBSH	HBO	HBU	WBO	NHNW	TOTAL
0-$14,999	98.9%	101.8%	99.9%	98.2%	105.9%	104.7%	98.6%	99.3%
$15,000-$34,999	98.6%	100.0%	100.0%	98.7%	102.0%	100.2%	98.4%	99.0%
$35,000-$74,999	100.1%	100.4%	100.1%	100.3%	104.1%	100.1%	98.7%	100.1%
$75,000-$149,999	101.2%	101.0%	100.4%	101.4%	104.8%	100.0%	99.0%	100.9%
>=$150,000	102.1%	101.4%	102.1%	102.5%	110.6%	100.1%	99.7%	101.8%
Total	100.5%	100.8%	100.4%	100.6%	104.8%	100.2%	98.9%	100.4%

Trip Production Summary by Purpose and Mode

Trip Productions by Mode (Model)

Purpose	Total		
	Total	Non-Motorized	%Non-Motorized
HBWD	3,746,351	150,949	4.0%
HBWS	1,277,011	39,667	3.1%
HBSH	2,011,808	135,454	6.7%
HBO	7,951,944	878,764	11.1%
HBU	296,914	29,474	9.9%
WBO	3,320,209	291,957	8.8%
NHNW	4,884,567	499,607	10.2%
TOTAL	23,488,805	2,025,871	8.6%

Trip Productions by Mode (Survey)

Purpose	Total		
	Total	Non-Motorized	%Non-Motorized
HBWD	3,726,472	149,547	4.0%
HBWS	1,267,163	38,509	3.0%
HBSH	2,004,455	136,728	6.8%
HBO	7,881,737	876,208	11.1%
HBU	303,105	28,404	9.4%
WBO	3,262,427	287,742	8.8%
NHNW	4,904,220	504,967	10.3%
TOTAL	23,349,579	2,022,105	8.7%

Ratio of Productions by Mode (Model vs. Survey)

Purpose	Total		
	Total	Non-Motorized	%Non-Motorized
HBWD	1.01	1.01	1.00
HBWS	1.01	1.03	1.02
HBSH	1.00	0.99	0.99
HBO	1.01	1.00	0.99
HBU	0.98	1.04	1.06
WBO	1.02	1.01	1.00
NHNW	1.00	0.99	0.99
TOTAL	1.01	1.00	1.00

Note:
(1). Unallocated trips from HBU trip process were merged to HBO purpose.
(2). For WBO and NHNW purposes, trip ends instead of trip productions are listed.

- Comparison of HBW Trip Attractions by Income Group

Motorized HBW Trip Attractions by Income Group

Income Group	Model			Survey	Census	Model
	HBWD	HBWS	Total	%	%	%
0-$14,999	96,372	33,505	129,877	3.2%	3.0%	3.0%
$15,000-$34,999	358,280	125,362	483,642	12.6%	11.1%	11.0%
$35,000-$74,999	1,127,111	397,418	1,524,528	35.9%	34.7%	34.6%
$75,000-$149,999	1,252,418	442,501	1,694,918	37.4%	38.4%	38.5%
>=$150,000	419,357	148,095	567,452	11.0%	12.8%	12.9%
Total	3,253,538	1,146,880	4,400,418	100.0%	100.0%	100.0%

Note:
HBWD--- home-based work direct
HBWS--- home-based work strategic

Comparison of Trip Attractions by Income Group

Motorized Trip Attractions by Purpose by Income Group (Model)

Income Group	HBSH	HBO	WBO	NHNW	Total
0-$14,999	166,823	313,838	21,483	133,419	635,564
$15,000-$34,999	276,134	852,801	115,053	293,533	1,537,520
$35,000-$74,999	674,604	2,283,504	558,573	787,961	4,304,643
$75,000-$149,999	532,833	2,430,947	622,601	702,409	4,288,790
>=$150,000	182,662	922,399	216,340	277,537	1,598,937
Total	1,833,056	6,803,490	1,534,051	2,194,858	12,365,455

Motorized Trip Attractions by Purpose by Income Group (Survey)

Income Group	HBSH	HBO	WBO	NHNW	Total
0-$14,999	161,856	313,588	20,965	125,729	622,138
$15,000-$34,999	266,836	861,858	110,509	292,680	1,531,883
$35,000-$74,999	664,830	2,242,992	536,355	758,025	4,202,202
$75,000-$149,999	550,900	2,426,988	597,866	720,509	4,296,262
>=$150,000	189,536	935,352	207,331	285,429	1,617,647
Total	1,833,958	6,780,778	1,473,026	2,182,371	12,270,132

Ratio of Attractions by Purpose by Income Group (Model vs. Survey)

Income Group	HBSH	HBO	WBO	NHNW	Total
0-$14,999	1.03	1.00	1.02	1.06	1.02
$15,000-$34,999	1.03	0.99	1.04	1.00	1.00
$35,000-$74,999	1.01	1.02	1.04	1.04	1.02
$75,000-$149,999	0.97	1.00	1.04	0.97	1.00
>=$150,000	0.96	0.99	1.04	0.97	0.99
Total	1.00	1.00	1.04	1.01	1.01

Note:
For WBO and NHNW purposes, values are trip ends.

- Regional Trip Statistics

Regional Trips Summary

Source	Trip Productions					
	Total	Per Household	Per Person	Motorized	Per Household	Per Person
Model	19,580,184	8.09	2.94	17,776,573	7.34	2.67
Survey	19,504,281	8.05	2.93	17,643,117	7.29	2.65
Model/Survey	1.00	1.00	1.00	1.01	1.01	1.01

Expected range for trips per household is 7.5-10
Expected range for trips per person is 2.5-3.4

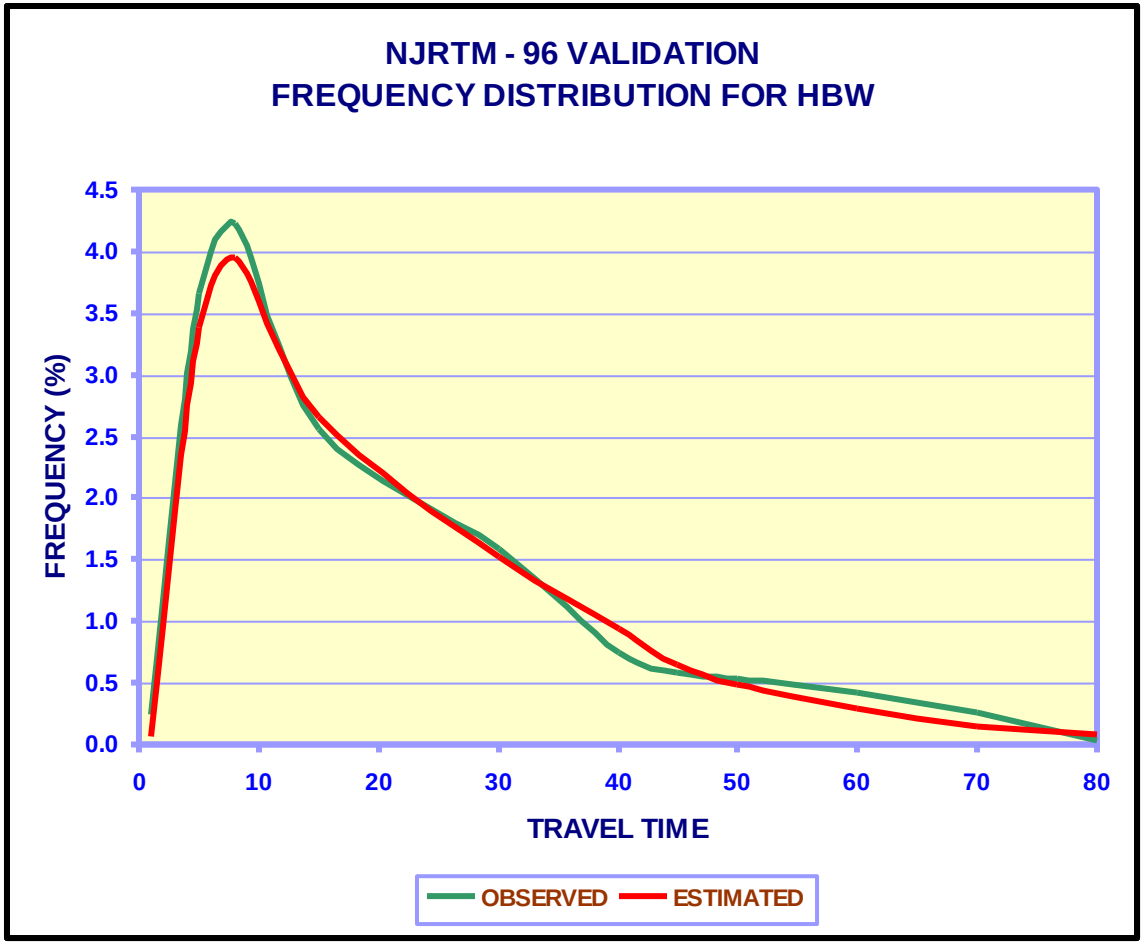
Household Life Cycle	TripProductions			Average Trips/Household	
	Model	Survey	Model/Survey	Model	Survey
Households with Retirees	3,611,461	3,468,137	1.04	5.84	5.61
Households with Children and No Retirees	10,072,899	10,034,749	1.00	12.15	12.11
Households without Children or Retirees	5,895,825	6,001,396	0.98	6.05	6.16
Total	19,580,185	19,504,281	1.00	8.09	8.05

Trip Distribution Model

TRIP DISTRIBUTION – VALIDATION ISSUES

- Intrazonal Trips
  - Estimation of Impedances
- Region-Specific Conditions
  - Natural Barriers
    - Bodies of Water
    - Terrain Conditions
  - Institutional Barriers
    - Tax Policies
    - Tolls
  - Other Issues
- Adjustment Techniques
  - Network Penalties
  - K-Factors

TRIP DISTRIBUTION CALIBRATION



OBS. AVG. (min.)	EST. AVG. (min.)
22.3	23.1

Final model must replicate trips by time interval. This proves the model allocates trips properly

citilabs

TRIP DISTRIBUTION VALIDATION

- Average Trip Length Comparison

Trip Distribution Summary

Purpose	Composite Impedance		Diff	Diff%
	Observed	Estimated		
HBWD	31.85	33.54	1.69	5.3%
HBWS	30.09	31.75	1.66	5.5%
HBSH	15.91	15.84	-0.07	-0.4%
HBO	15.99	15.62	-0.37	-2.3%
WBO	21.87	21.71	-0.15	-0.7%
NHNW	16.20	16.03	-0.17	-1.1%

Time and Distance Comparisons

Purpose	Travel Time		Distance	
	Observed	Estimated	Observed	Estimated
HBWD	31.49	33.33	13.51	14.15
HBWS	29.74	31.62	12.92	12.98
HBSH	15.67	15.65	5.69	5.63
HBO	15.61	15.28	5.72	5.62
WBO	21.00	21.14	9.66	9.63
NHNW	15.89	15.81	5.93	5.58

$I_C = 1.0 / (1.0/I_H + MS_T/I_T)$

Where:

I_C = Composite impedance for zonal pair i-j

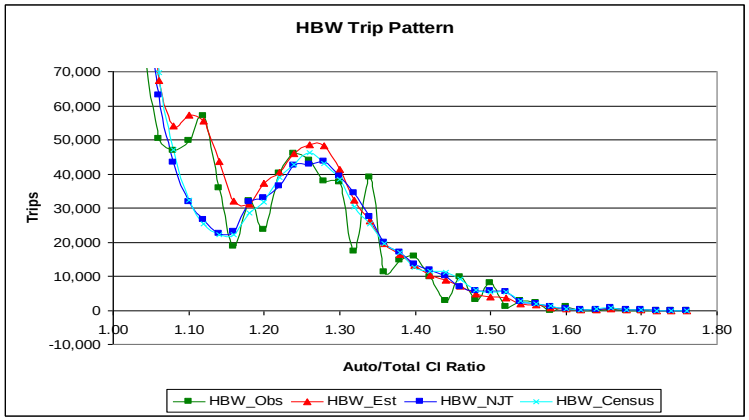
I_H = Highway impedance for zonal pair i-j for the "representative" auto mode

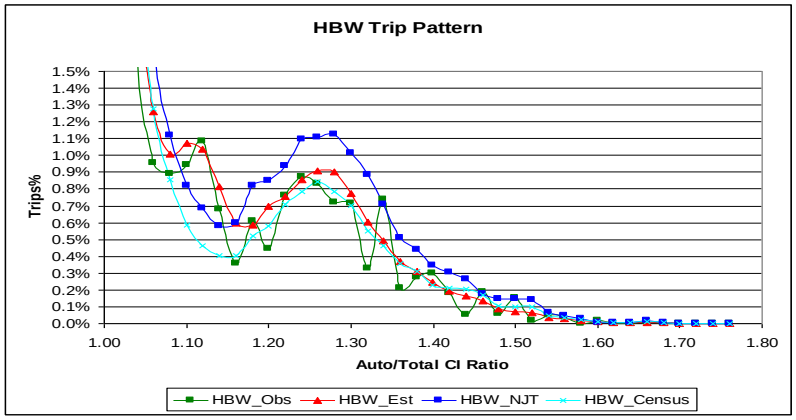
MS_T = Transit mode share for zonal pair i-j

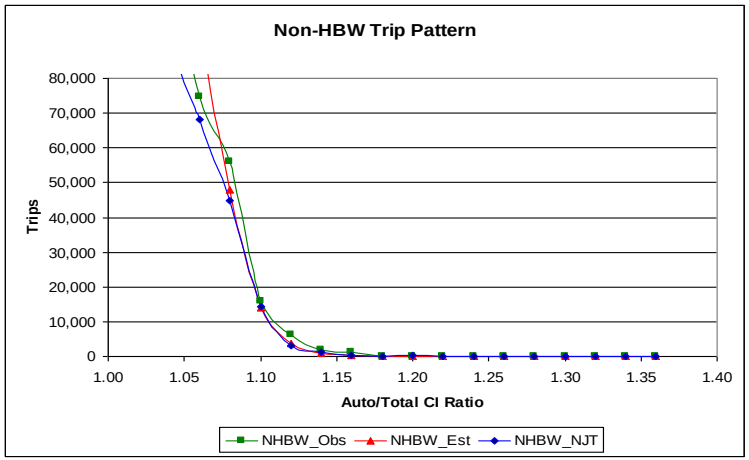
I_T = Transit impedance for zonal pair i-j for the "representative" transit mode

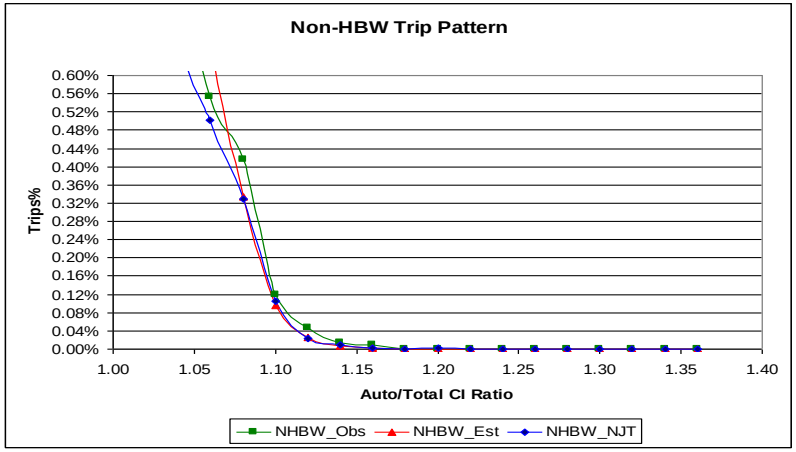
citilabs

Trip Pattern by Auto/Total CI Ratio



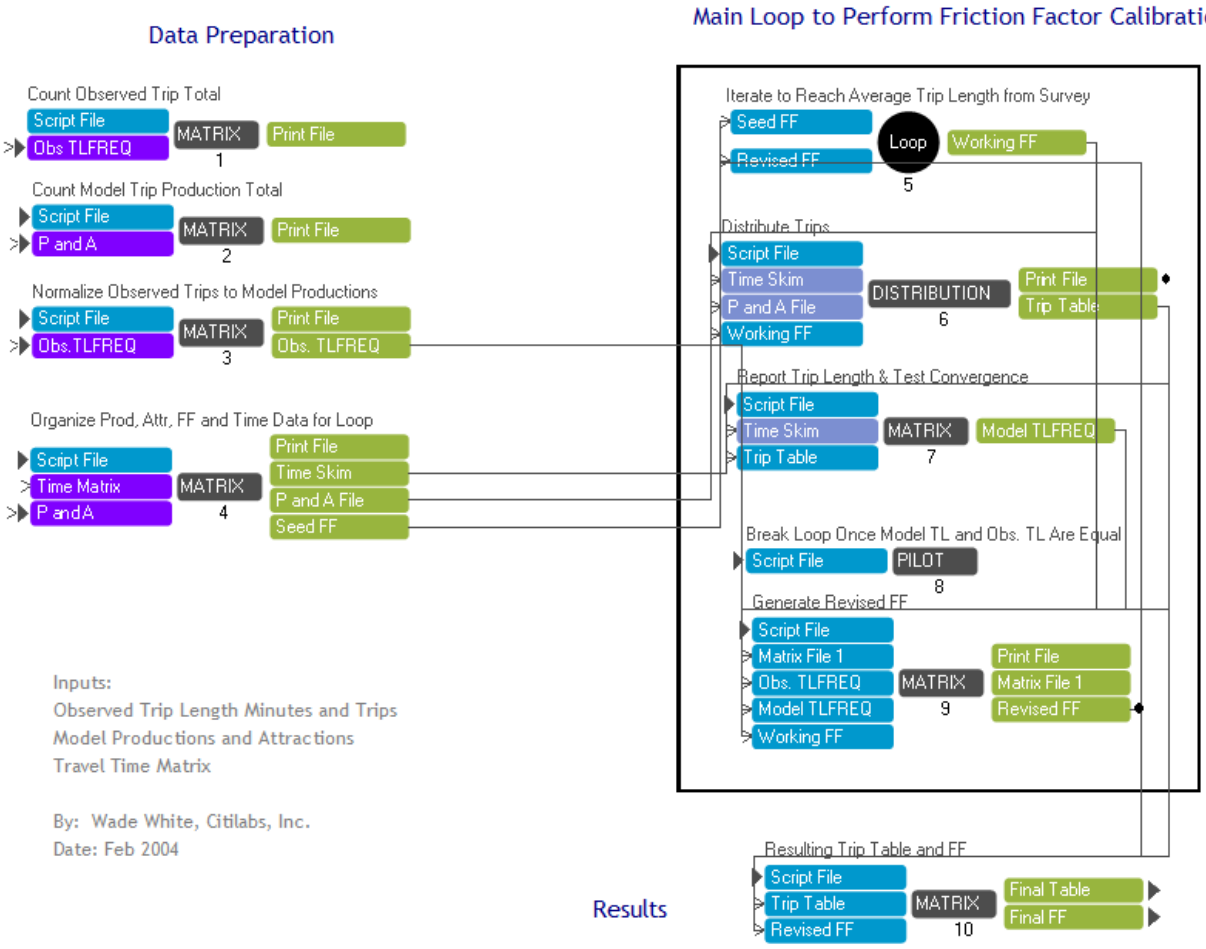






Calibration for Gravity Model

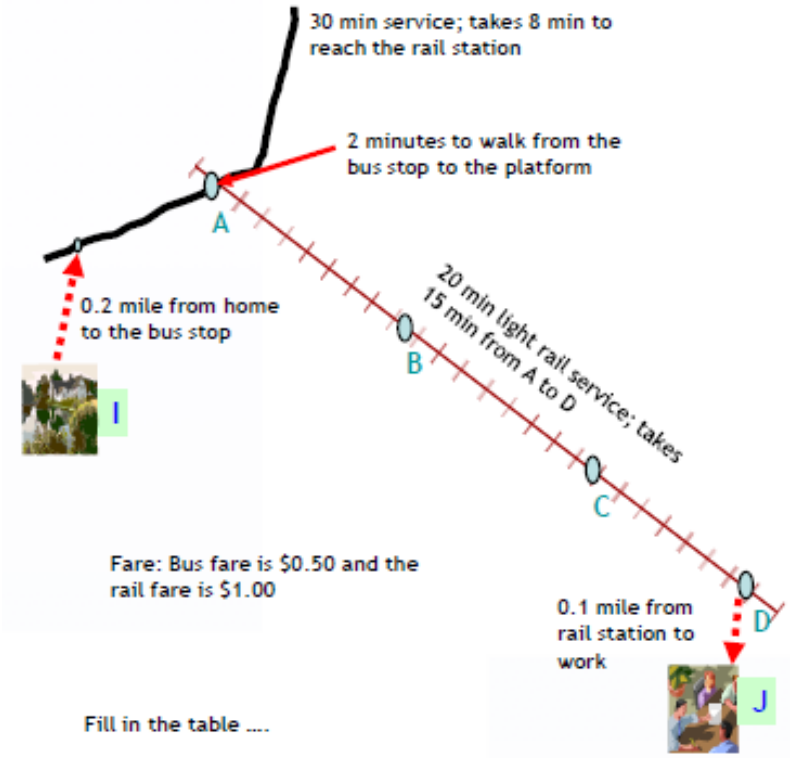
Calibrate Gravity Model Function
Single Purpose for Cube Voyager 4.X



citilabs

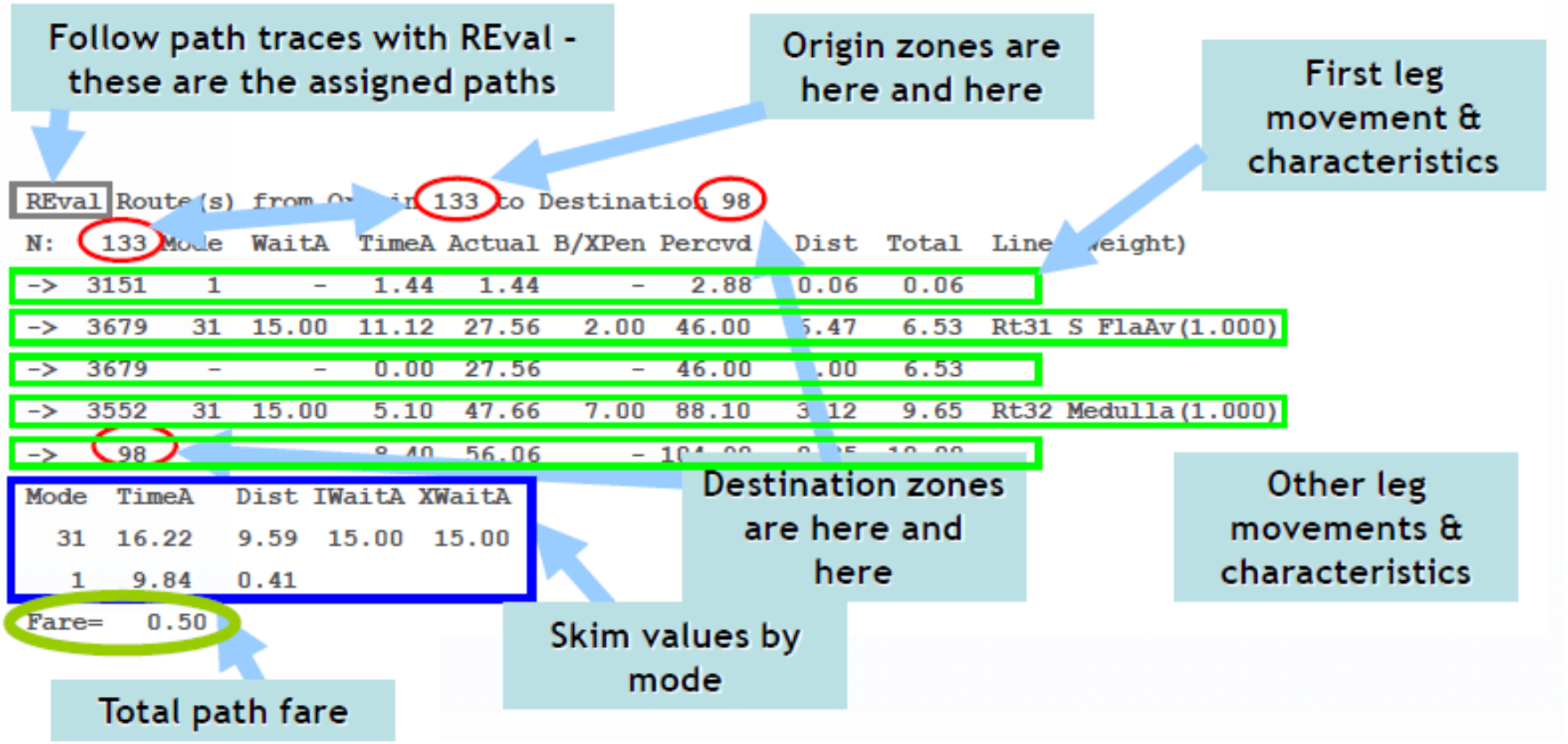
Mode Choice Model

Skim Calculation



Type of Skim	SKIMIJ	Value
Walk time	TIMEA(0,1)	7.2
Auto time	TIMEA(0,2)	0
Transfer time	TIMEA(0,4) + TIMEA(0,5)	2 + 0 = 2
Local bus time	TIMEA(0,101) + TIMEA(0,111)	8
Premium bus time	TIMEA(0,102) + TIMEA(0,112)	0
Circulator time	TIMEA(0,103) + TIMEA(0,113)	0
Light / Heavy rail time	TIMEA(0,104) + TIMEA(0,114)	15
Commuter rail time	TIMEA(0,105) + TIMEA(0,115)	0
Number of transfers	BRDINGS(0,TMODE) - 1	2 - 1 = 1
Initial wait time	IWAIT(0)	15
Transfer wait time	XWAIT(0)	10
Fare	FAREA(0)*100	150
Total time (all modes)	TIMEA(0,ALLMODES)	7.2 + 2 + 8 + 15 = 32.2

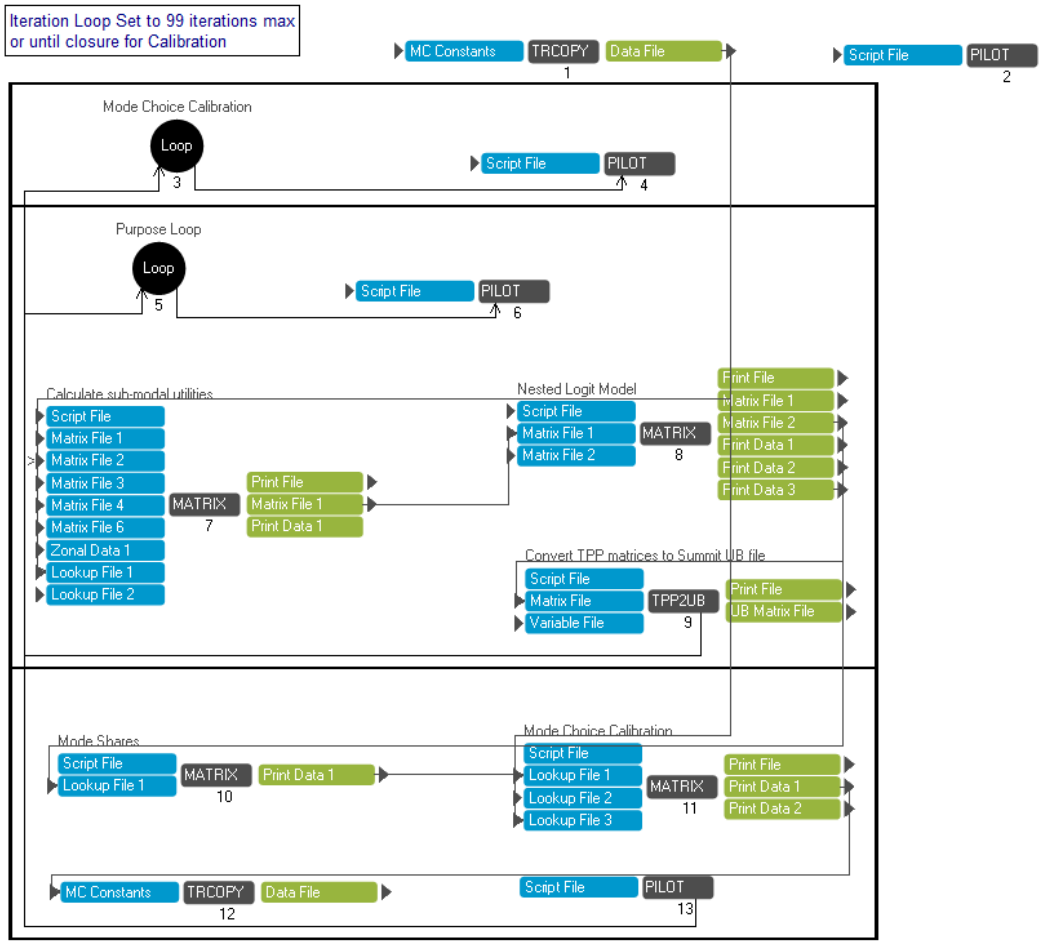
Path Trace Breakdown (TRACEI & TRACEJ)



citilabs

Calibration for Mode Choice Model

Mode Choice Calibration



citilabs

Highway Assignment Model

- Highway Assignment
  - Four Periods (AM/PM Peak Periods, Midday, Night)
  - Route Choice Assigns Vehicle Type/Path Conditions:
    - SOV, HOV, Truck
    - NonToll, Cash Toll, ETC Toll
    - Sensitive to Directional Toll biases
  - Assignment Options:
    - Standard BPR
    - 2000 HCM & Simple Queuing
    - Akcelik Method
    - Detailed HCM Method

Regional VMT Comparison

VMT Summary

Facility Type	Observed	Estimated	Ratio
Freeway	20,459,061	21,381,971	105%
Expressway	2,671,680	2,552,583	96%
Principal arterial divided	3,341,529	3,260,569	98%
Principal arterial undivided	2,915,434	2,943,843	101%
Major arterial divided	29,160	35,676	122%
Major arterial undivided	2,367,306	2,478,058	105%
Minor arterial	1,114,110	987,420	89%
Total	32,898,280	33,640,120	102%

Area Type	Observed	Estimated	Ratio
CBD	424,528	453,185	107%
Urban	4,789,400	4,967,504	104%
Suburban	18,772,525	19,275,159	103%
Rural	8,911,827	8,944,272	100%
Total	32,898,280	33,640,120	102%

RMSE Summary by Volume Group

RMSE Summary by Volume Group

Volume Group	Model v.s Desirable Percent Deviation		
	Model	NJRTM	FHWA
>=90,000	11	11	15
80,000-90,000	21	16	16
70,000-80,000	17	23	16
60,000-70,000	19	23	18
50,000-60,000	24	26	20
40,000-50,000	28	32	21
30,000-40,000	26	43	23
20,000-30,000	32	42	25
10,000-20,000	44	65	27
0-10,000	88	65	40-60
Total	35	50	35-40

Note:
Percent RMSE from U.S. Models
(Source:Model Validation and Reasonableness Checking Manual - FHWA)

Atlanta	27%
Chicago	47%
Dallas	43%
Norfolk	42%
Phoenix	37%
Tampa	46%
Washington	50%

- VMT/Volume Comparison by County

Observed Volume v.s Estimated Volume by Subregion

County	VMT			Volume		
	Observed	Estimated	Ratio	Observed	Estimated	Ratio
Bergen	2,948,949	2,904,781	99%	4,256,279	4,122,307	97%
Essex	2,402,024	2,680,549	112%	3,782,505	4,304,276	114%
Hudson	1,512,702	1,641,823	109%	2,461,370	2,624,184	107%
Hunterdon	1,171,362	1,137,260	97%	1,156,902	1,133,606	98%
Mercer	2,679,712	2,462,962	92%	2,986,784	2,699,285	90%
Middlesex	4,766,061	5,097,133	107%	5,670,767	6,221,359	110%
Monmouth	3,550,741	3,448,515	97%	2,559,064	2,459,363	96%
Morris	3,279,109	3,811,018	116%	3,538,268	4,100,614	116%
Ocean	2,085,785	1,975,002	95%	1,367,528	1,280,241	94%
Passaic	1,587,312	1,616,364	102%	2,612,437	2,757,743	106%
Somerset	3,089,158	3,149,370	102%	2,376,559	2,487,349	105%
Sussex	753,343	683,558	91%	626,646	577,899	92%
Union	1,930,198	1,980,792	103%	3,390,464	3,433,323	101%
Warren	1,188,622	1,076,122	91%	1,181,628	1,062,093	90%
Total(NJTPA+MERCER)	32,945,078	33,665,249	102%	37,967,201	39,263,642	103%

- VMT Comparison by City/Region

VMT, VHT, and Average Speed Statistics

City/Region	System VMT (x1000)	System VMT per Capita	Freeway VMT (x1000)	Principal Arterial VMT (x1000)	Average Peak Period Freeway Speed (mph)	Average Peak Period Principal Arterial Speed (mph)
NJTPA's 13 Counties + Mercer	**146,121**	**22**	**56,811**	**44,991**	**45**	**30**
Atlanta	95,110	37	38,650	14,575	43	27
Detroit	87,620	22	29,355	28,365	43	27
Boston	58,285	19	21,800	16,110	45	26
Kansas City	39,130	29	17,310	5,730	52	28
Baltimore	43,245	29	20,775	8,915	46	28

NOTE:
Source: 1999 Texas Transportation Institute Annual Mobility Study (for Regional Models other than NJTPA)

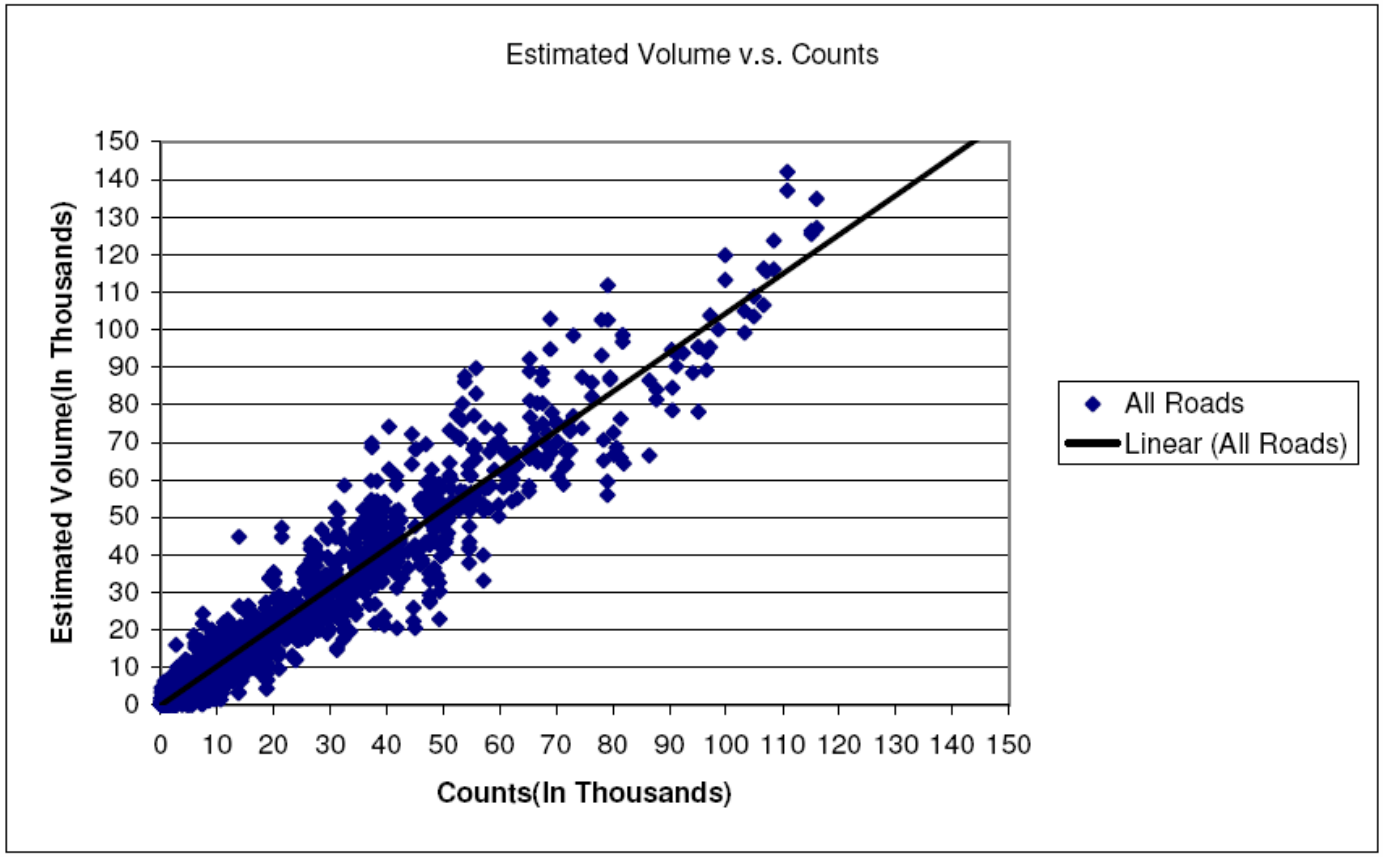
- RMSE Summary by Volume Group

R-Squared Analysis: Estimated Volume v.s Observed Count

Facility Type	Observations	R-Square
Freeway	427	87.5%
Expressway	167	75.2%
Principal Arterial Divided	215	60.3%
Principal Arterial Undivided	348	73.8%
Major Arterial Divided	4	NA
Major Arterial Undivided	479	37.3%
Minor Arterial	454	54.9%
All Roads	2,094	93.0%

FHWA recommended the regionwide R-square should be greater than 88%.
Source: Model Validation and Reasonableness Checking Manual. Feb. 1997.

- Model Volume vs Count



Screenline Summary

Screenline Summary

Screenline	Location	%With Counts	Observed	Estimated	Ratio	Truck%
1	Below I-80 (From I-80&I-280 Fork to Hudson River)	27	690,240	732,330	106%	6.4%
2	East of I-95 (From I-495 to I-78)	89	416,052	471,368	113%	5.0%
3	East of GSP (From NJ-3 to I-78 then turn to I-95)	47	901,388	929,286	103%	7.7%
4	Union<-->Middlesex (From I-280 to Goethals Bridge)	39	789,107	767,356	97%	7.5%
5	Lower Middlesex(NJ-27,US-1,I-95,US-130, CR-535,CR-527)	55	275,696	278,323	101%	10.4%
6	Morris Cross (From I-80 to I-287)	69	353,332	399,193	113%	7.1%
7	Morris Cross (From I-80 to I-78 then to NJ-28)	39	310,926	312,909	101%	10.4%
8	Upper GSP (From GSP,US-202 to I-80)	55	222,202	229,403	103%	7.9%
9	Upper Middlesex(From GSP to Outerbridge Crossing)	59	659,201	676,375	103%	6.8%
10	NY<-->NJ Land Border Crossing	70	309,459	320,341	104%	9.2%
11	Upper Delaware River Crossing	100	176,092	188,489	107%	13.0%
12	Lower Delaware River Crossing	100	249,294	256,446	103%	6.1%
13	In between NJ-18 & CR-520 (from CR-527 to Coast)	63	357,322	322,682	90%	2.9%
14	Middlesex Bay Crossing (GSP+US-9+NJ-35)	100	331,112	379,070	114%	3.5%
15	NY<-->NJ Hudson River Crossing	100	703,577	741,442	105%	5.2%
16	NY<-->NY Hudson River Crossing (Three Bridges)	100	214,495	228,607	107%	10.4%
17	Newark CBD Cordon Line	44	251,114	316,058	126%	11.2%
18	Downtown Jersey City Cordon Line	28	252,325	243,586	97%	0.2%
19	NJ Other<-->NJTPA+MERCER Border Crossing	53	299,344	309,956	104%	10.7%
20	Middlesex<-->Somerset Border (partial,from I-78 to I-95)	45	526,844	552,360	105%	7.2%
Total			41,893,110	42,830,431	102%	6.8%

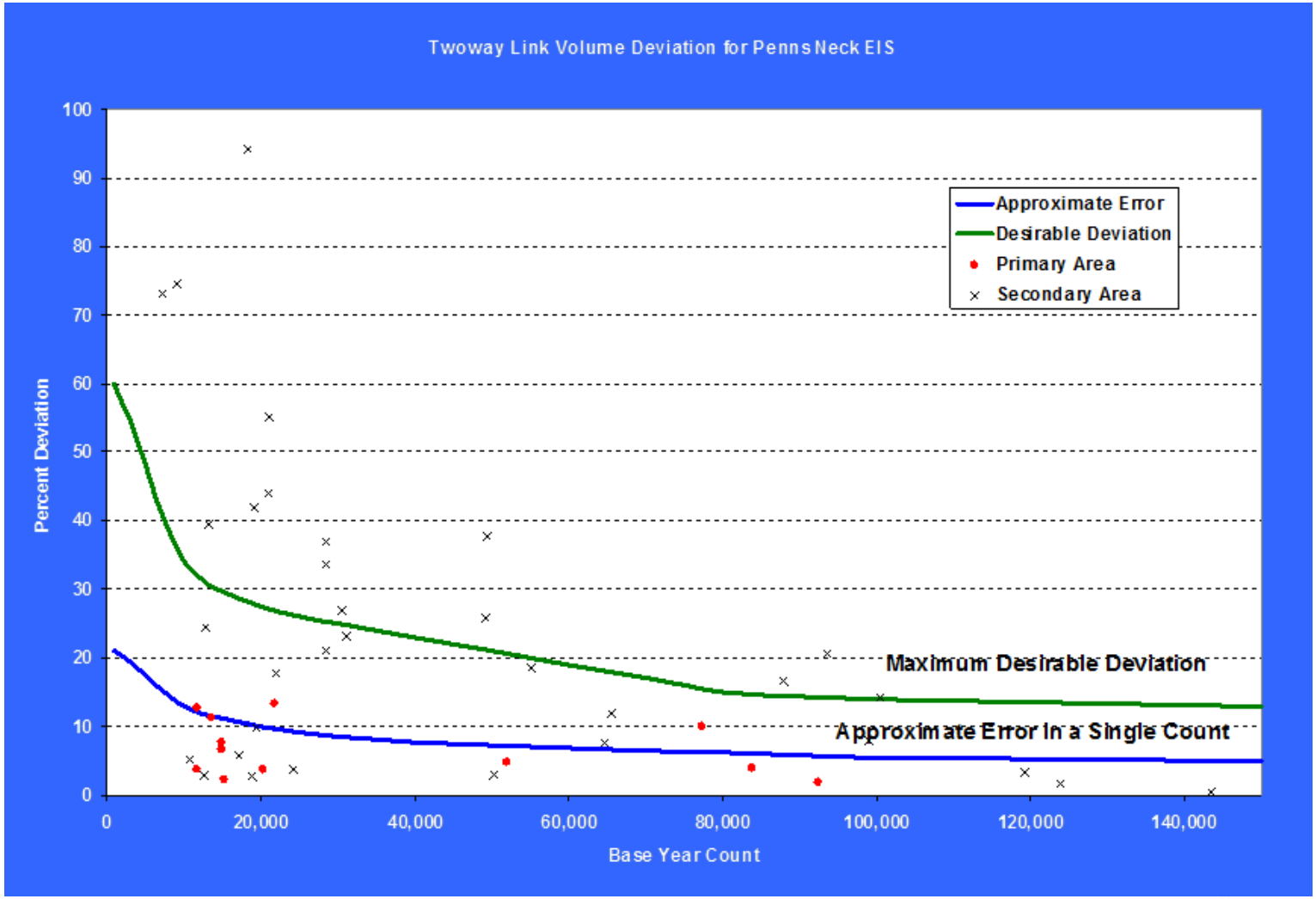
Notes: Anticipated percent deviation between the estimated and observed volumes expected to be within 5-15%.

Unweighted Speed Comparison

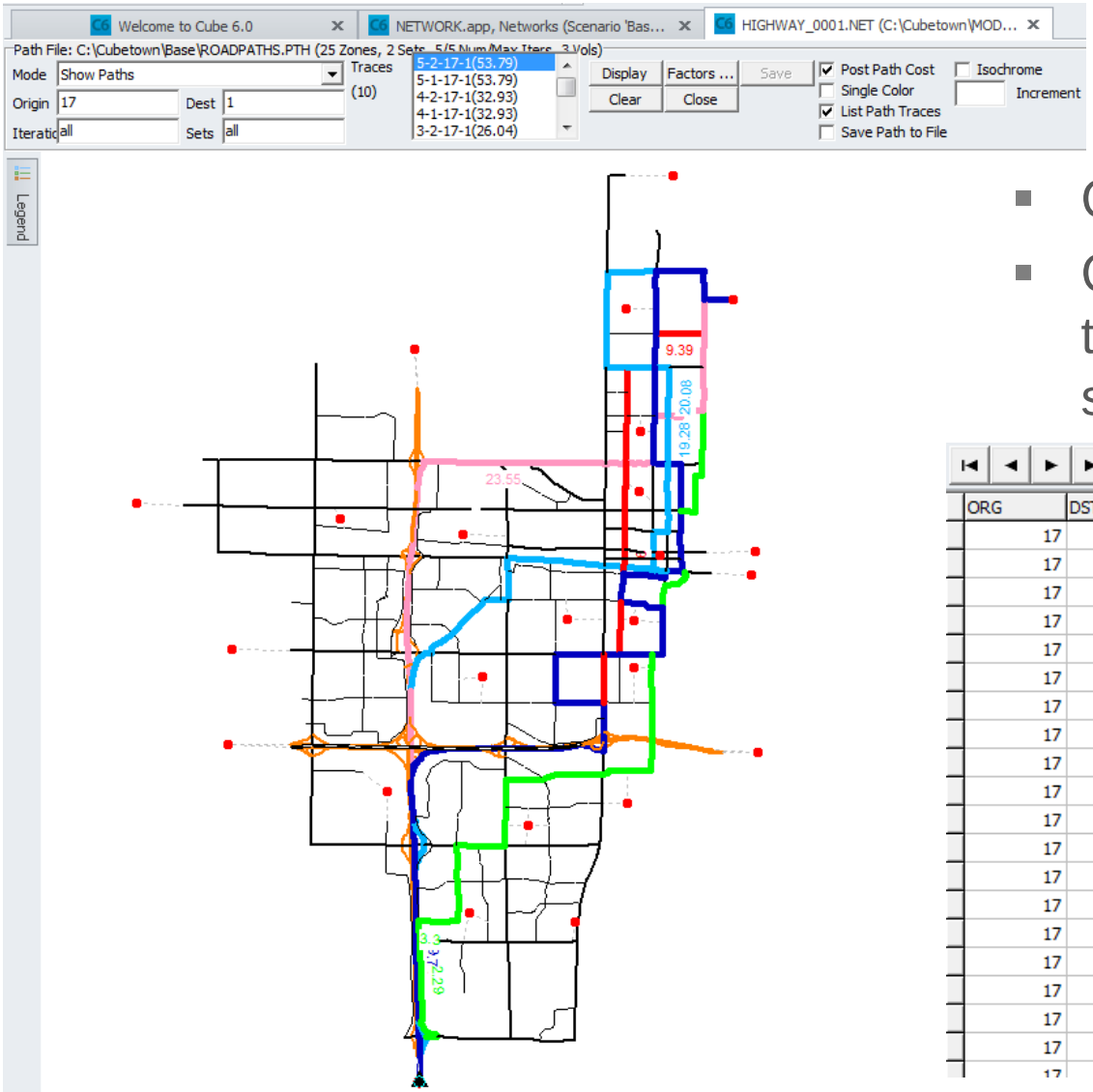
Speed Comparison by Period by Facility Type

Period	Facility Type	Observed Speed (All Runs)		Estimated Speed (All Runs)		Estimated Speed (All Links)		Summer Speed (PPSUITE)	
		Mean	Stand. Dev.	Mean	Stand. Dev.	Mean	Stand. Dev.	Mean	Stand. Dev.
AM	Freeway	50.15	13.74	53.32	15.95	57.78	14.79	57.93	10.56
	Expressway	51.43	10.54	48.81	10.83	46.80	11.32	42.64	7.59
	Principal arterial divided	29.01	12.48	36.09	13.99	44.67	10.87	34.14	6.72
	Principal arterial undivided	38.56	14.05	42.52	11.69	43.79	12.92	29.13	8.47
	Major arterial divided	31.79	12.88	40.39	10.08	39.84	10.09	32.50	5.22
	Major arterial undivided	21.91	11.66	32.39	13.58	37.59	13.54	26.10	7.28
	Minor arterial	21.26	9.98	28.24	9.81	30.66	9.78	19.86	8.31
	Collector/Local	32.20	5.21	32.63	2.60	16.97	6.30	19.70	5.74
	Average	34.57	16.70	43.41	15.96	37.53	14.64	28.00	15.45
MD	Freeway	57.95	8.77	62.04	8.17	64.19	11.03	60.19	5.81
	Expressway	48.33	9.39	53.46	5.63	52.83	5.86	44.97	3.34
	Principal arterial divided	34.96	9.38	40.45	10.37	48.70	8.10	35.19	5.65
	Principal arterial undivided	39.27	12.24	46.13	9.85	46.46	10.91	30.42	7.61
	Major arterial divided	27.48	11.99	41.87	9.24	43.08	8.18	32.98	5.00
	Major arterial undivided	24.24	13.13	36.15	12.32	40.45	10.80	27.07	6.52
	Minor arterial	23.10	11.20	30.07	8.58	32.18	8.25	21.37	7.13
	Collector/Local	33.94	4.93	32.69	2.55	17.85	5.53	19.97	5.61
	Average	36.54	17.56	48.47	14.65	40.33	13.90	29.40	14.91
PM	Freeway	51.13	10.74	45.49	19.38	54.75	16.99	58.11	10.29
	Expressway	41.97	9.00	47.77	12.45	44.55	11.92	43.81	5.17
	Principal arterial divided	25.68	12.82	35.22	14.58	43.29	11.71	30.76	9.32
	Principal arterial undivided	31.04	13.55	41.47	12.43	42.62	13.85	27.51	9.55
	Major arterial divided	30.75	12.99	38.90	11.89	37.19	13.93	31.91	5.06
	Major arterial undivided	25.75	12.96	30.31	15.72	36.09	14.60	25.11	7.52
	Minor arterial	20.75	9.70	26.05	12.37	29.51	10.89	18.63	8.85
	Collector/Local	30.74	4.14	32.69	2.55	15.80	7.24	19.36	5.91
	Average	33.36	16.32	39.79	16.98	36.04	15.32	26.96	15.90

REGIONAL MODEL DEVIATION COMPARISON



Building Paths using Path File



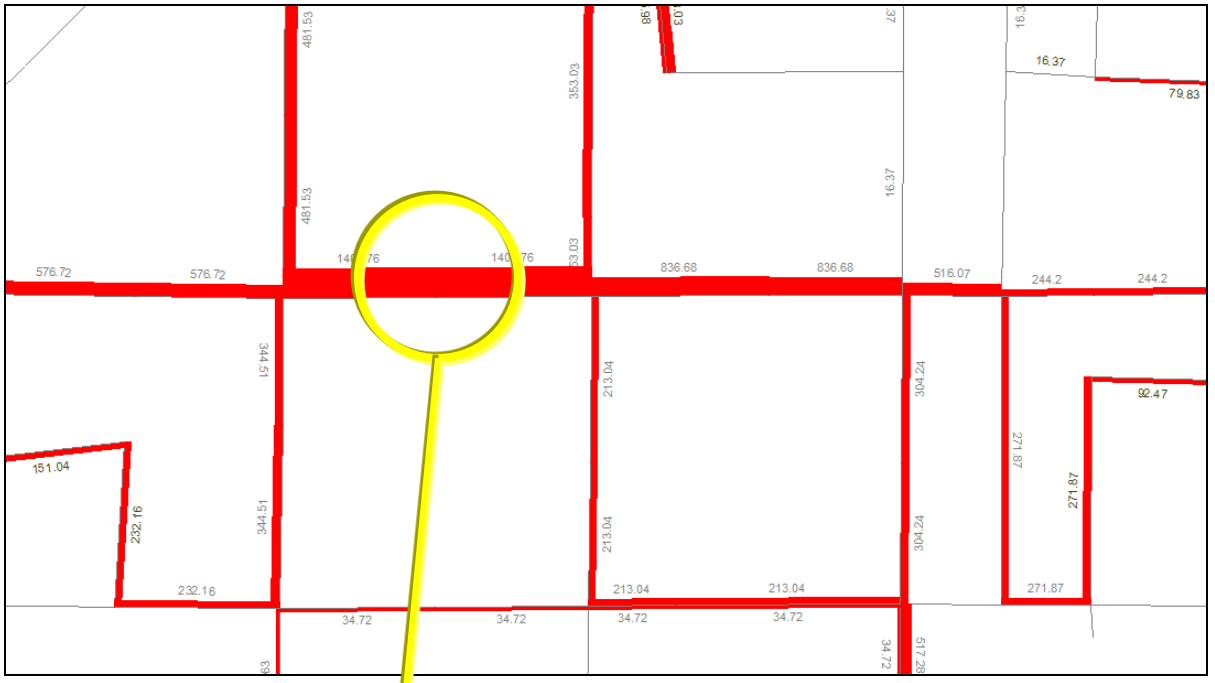
- Click 'Display' button
- Click 'Save Path to File' to save the searched shortest paths

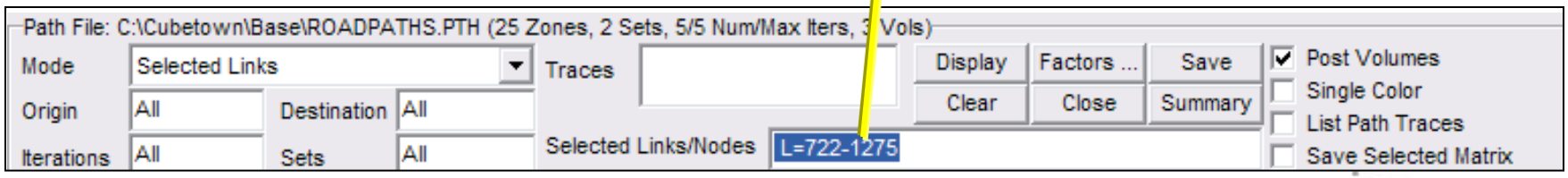
ORG	DST	NODE	COST1
17	1	487	0.35
17	1	489	0.56
17	1	479	1.37
17	1	481	1.65
17	1	467	1.85
17	1	468	2.41
17	1	469	2.64
17	1	544	2.79
17	1	543	2.94
17	1	551	3.35
17	1	550	3.68
17	1	555	3.76
17	1	554	3.82
17	1	547	3.86
17	1	1004	4.01
17	1	721	4.19
17	1	1273	4.43
17	1	719	4.71
17	1	718	4.88
17	1	989	5.27

Highway Select Link Analysis

Where's The Traffic Coming From or Going To?

- Select Link Map
  - Show where volumes are coming from and going to
  - Build select link trip table for district-to-district type summaries

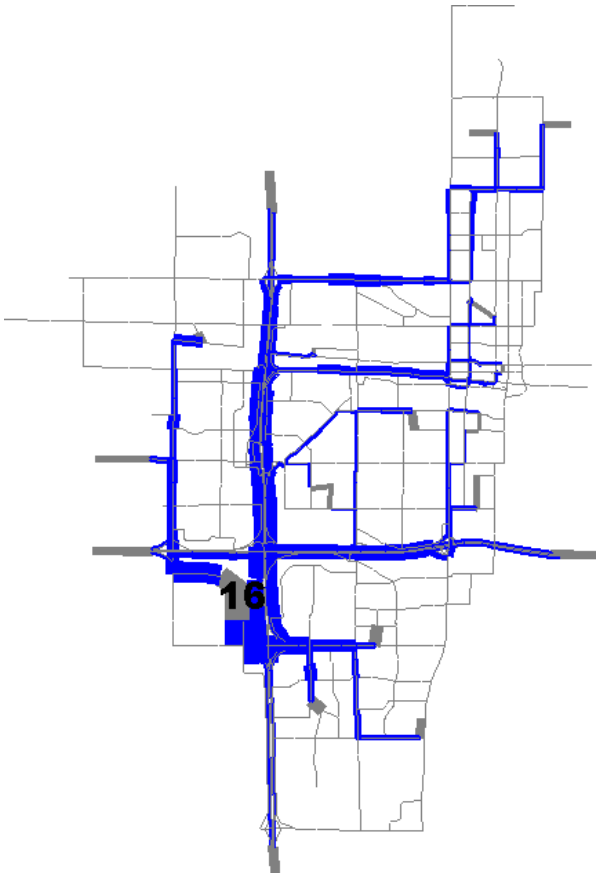




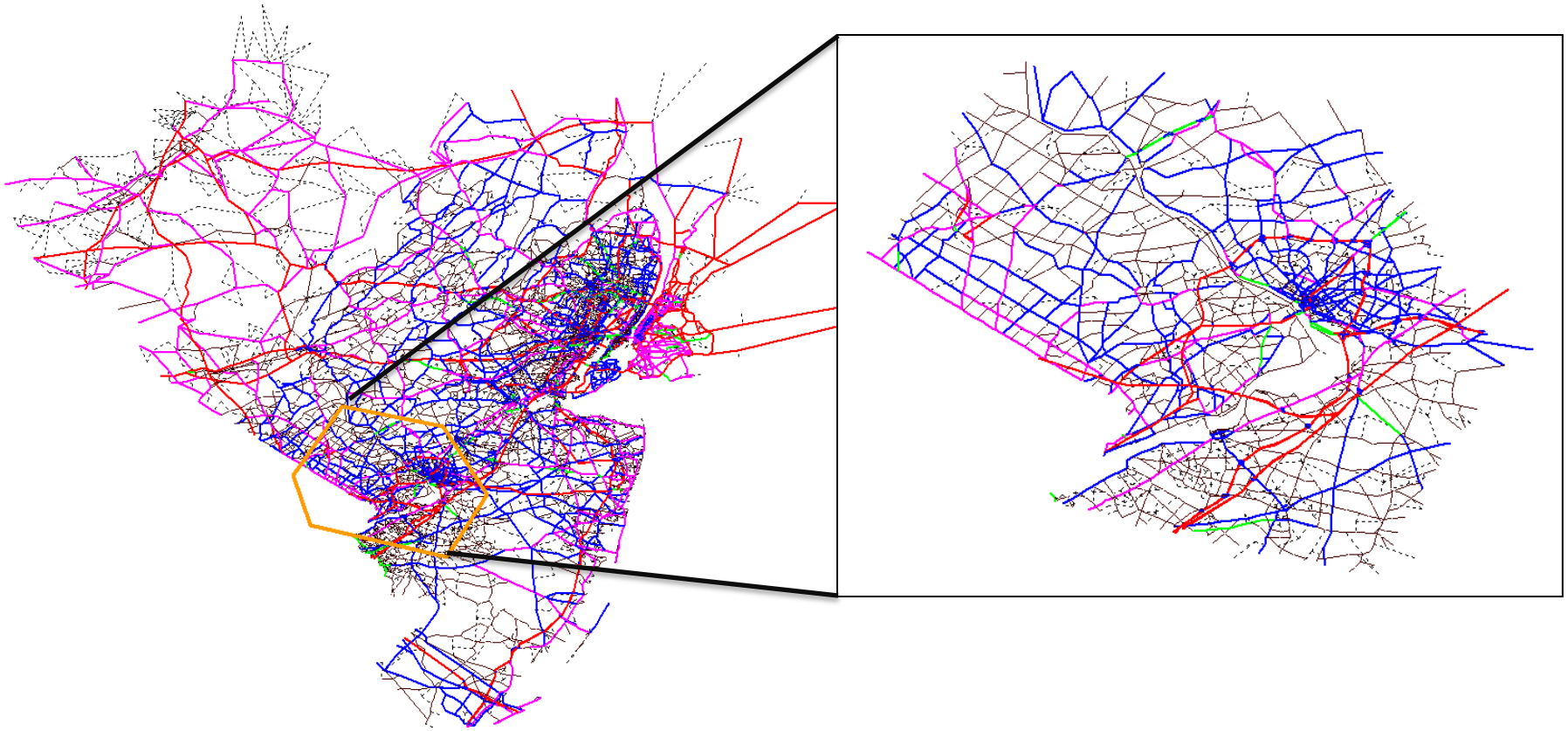
citilabs

Select Zone Analysis

- Select link analysis saves trips on paths that use certain links or nodes in a separate volume set in the output network
- When the link criterion specifies that a particular zone must be used, this is then called a “select zone” analysis
- Technique often used to study how project impacts distribute across network
- Add FUNCTION V = VOL[1] so as not to double-count select link volume
- In PATHLOAD, insert or append: MW[4]=MW[3], SELECTLINK=(N=16), VOL[2]=MW[4]

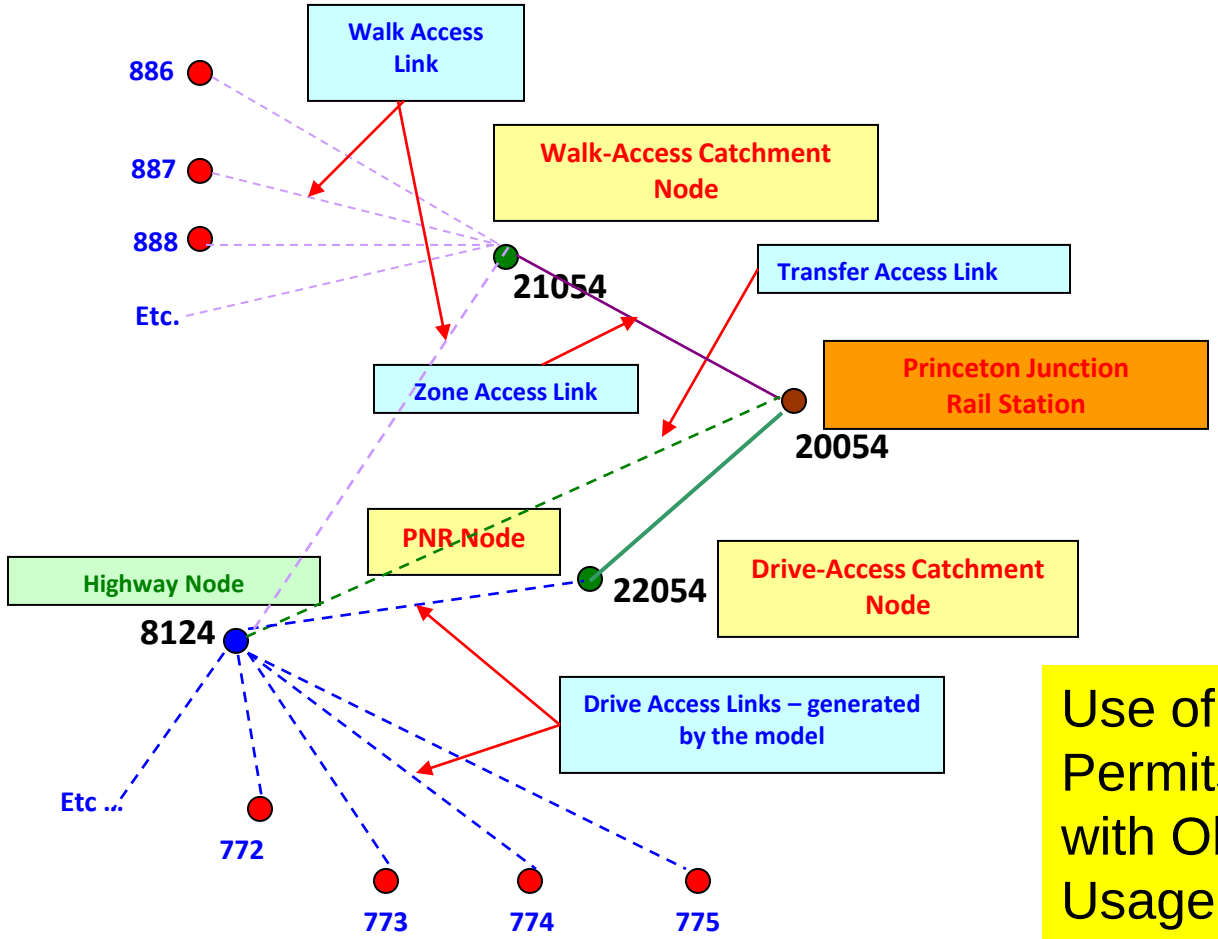


Highway Sub-Area Analysis



Transit Assignment Model

Mode Access Coding Procedures



Use of Catchment Links Permits Comparison with Observed Station Usage by Access Mode

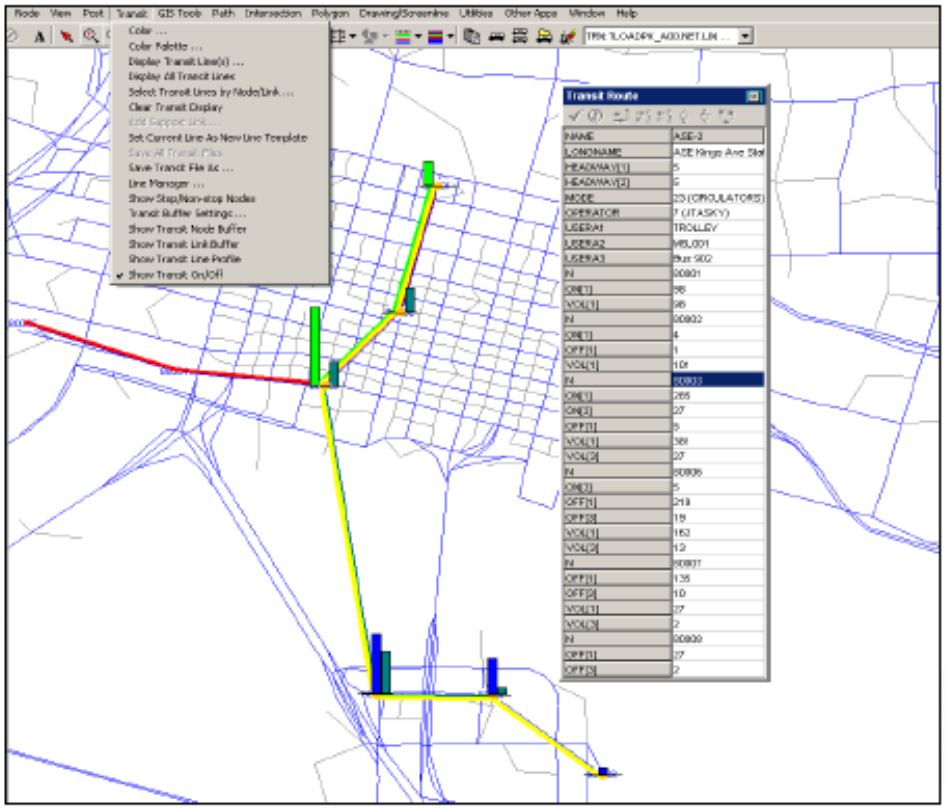
Transit Time Factors - Example

Area Type	Transit Mode	Link Facility Type					
		Freeway	Major Arterial	Minor Arterial	Major Collector	Frontage Road	Ramp
CBD	Local Bus	1.00	2.50	2.70	1.80	2.00	1.00
	Shuttle Bus	1.00	2.00	2.00	2.00	2.00	1.00
	Express Bus	1.00	2.10	2.60	1.70	1.50	1.00
	Light Rail	N/A	1.00	1.00	1.00	1.00	N/A
Urban	Local Bus	1.00	1.60	1.60	1.70	1.60	1.00
	Shuttle Bus	1.00	2.00	2.00	2.00	2.00	1.00
	Express Bus	1.00	1.50	1.10	2.20	2.20	1.00
	Light Rail	N/A	1.00	1.00	1.00	1.00	N/A
Suburban	Local Bus	1.00	1.80	1.10	1.60	1.60	1.00
	Shuttle Bus	1.00	2.00	2.00	2.00	2.00	1.00
	Express Bus	1.00	1.00	1.90	1.00	1.20	1.00
	Light Rail	N/A	1.00	1.00	1.00	1.00	N/A
Rural	Local Bus	1.00	2.00	2.00	1.40	1.20	1.00
	Shuttle Bus	1.00	2.00	2.00	2.00	2.00	1.00
	Express Bus	1.00	1.20	1.10	1.10	1.10	1.00
	Light Rail	N/A	1.00	1.00	1.00	1.00	N/A

Transit Run Time Comparison -Example

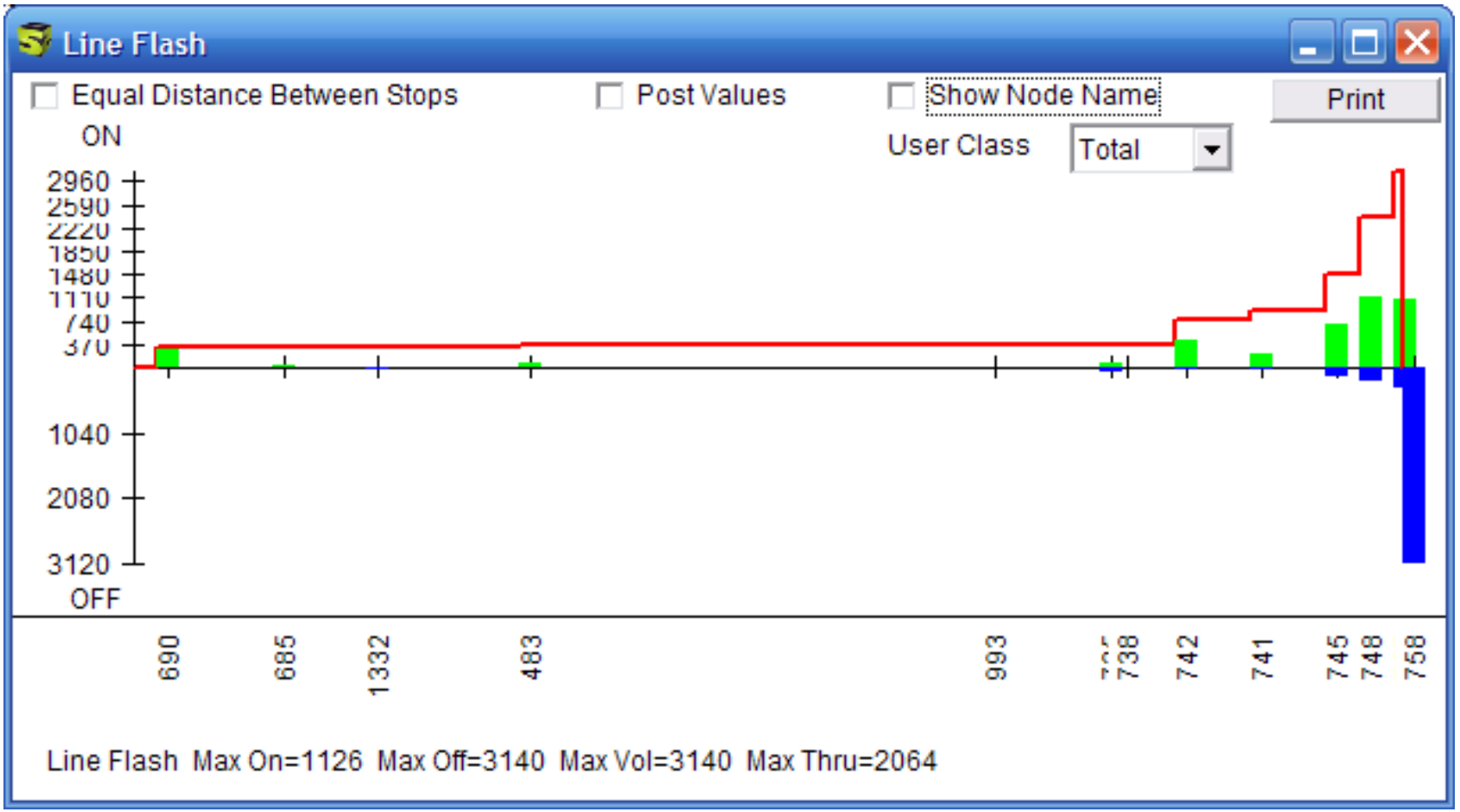
Route ID	Route name	Direction	CAT Bus Name	Headway (min)		Peak Runtime (min)			Off-Peak Runtime (min)		
				Peak	Off-Peak	Observed	Estimated	Difference	Observed	Estimated	Difference
202	ROUTE 001 EB	IN	Pulaski Heights	33	33	29.00	31.22	-2.22	29.00	32.03	-3.03
201	ROUTE 001 WB	OUT	Pulaski Heights	33	33	34.00	36.86	-2.86	34.00	38.17	-4.17
206	ROUTE 002 NB	IN	South Main	30	33	14.00	11.98	2.02	15.00	12.02	2.98
234	ROUTE 002 SB	OUT	South Main	30	33	15.00	14.38	0.62	16.00	14.48	1.52
208	ROUTE 003 EB	IN	Baptist Medical Center	32	35	47.00	40.90	6.10	52.00	45.94	6.06
239	ROUTE 003 WB	OUT	Baptist Medical Center	32	35	48.00	42.97	5.03	50.00	46.76	3.24
199	ROUTE 004 NB	OUT	Levy/Amboy	60	60	30.00	30.40	-0.40	29.00	28.20	0.80
189	ROUTE 004 SB_AMBOY	IN	Levy/Amboy	60	N/A	36.00	35.58	0.42			
117	ROUTE 004 SB_LEVY	IN	Levy/Amboy	N/A	60				27.00	25.52	1.48
214	ROUTE 005 EB	IN	West Markham	32	35	49.00	45.08	3.92	51.00	45.69	5.31
225	ROUTE 005 WB	OUT	West Markham	32	35	47.00	40.83	6.17	51.00	40.63	10.37
207	ROUTE 006 NB	IN	Granite Mountain	37	40	17.00	16.15	0.85	17.00	16.01	0.99
235	ROUTE 006 SB	OUT	Granite Mountain	37	40	21.00	16.05	4.95	21.00	16.46	4.54
200	ROUTE 007 NB	OUT	East Ninth	37	40	24.00	24.21	-0.21	24.00	24.39	-0.39
190	ROUTE 007 SB	IN	East Ninth	37	40	13.00	13.70	-0.70	13.00	14.10	-1.10

Station Activity Plot (Transit On/Off)

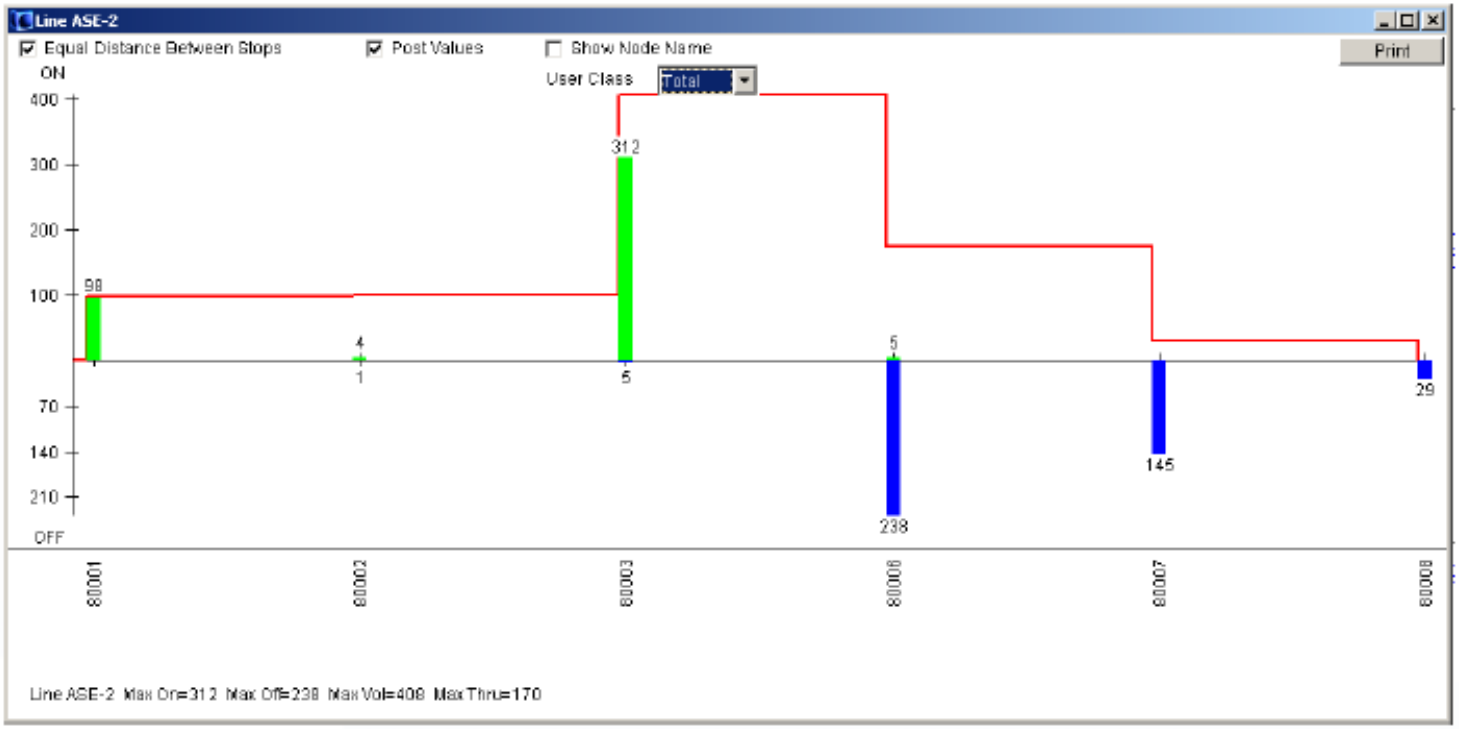


Use the loaded transit network for Transit On/Off plot

- Boardings and Alightings



Line Volumes at Stop (Transit Line Profile)



Use the loaded transit network for Transit Line Profile

Print File: *Line Loading Summary*

REPORT LINES UserClass=1

Name	Mode	Op	Stp	Cr	Distance	Time	Pass	PassDist	PassHr	
Rt10 Shuttle	31	1	33	-	4.18	8.10	20.15	40.78	1.34	Rt 10 Shuttle
Rt11 E Main	31	1	50	C	14.99	27.90	79.40	502.77	15.48	Rt 11 E Main CombeeRd
Rt20 GrovePk	31	1	67	C	16.48	29.16	65.57	299.01	9.17	Rt 20 Grove Pk Crys Lk
Rt21 Edgewd	31	1	69	C	17.15	33.47	72.21	282.57	9.26	Rt 21 Edgewood
Rt30 Clvd Ht	31	1	76	C	16.92	32.87	61.54	346.56	11.10	Rt 30 Cleveland Hts
Rt31 S FlaAv	31	1	59	C	14.94	26.85	303.95	999.15	31.90	Rt 31 S Fla Ave
.....										
Rt35 Regular	21	2	45	-	46.58	87.62	11.24	42.77	1.58	Rt 35 Regular Route
Rt35 Alt Expre	21	2	25	-	44.56	81.41	--	--	--	Rt 35 Alternate Express Rte
Rt50 Westside	21	2	21	-	9.49	23.21	25.66	81.53	3.33	Rt 50 Westside
Rt44 SWest	21	2	47	C	18.46	50.11	56.28	218.92	10.40	Rt 44 Southwest side
Total					557.97	1115.76	1,769.97	7,878.08	264.35	

Loading results

citilabs

Print File: *Transfer Summary*

```
-----------------------------------
REPORT  XFERSUM=MODE  UserClass=1
MODE      21      31       1      12
---------------------------------
 21    53.52   27.68 183.10    1.56
 31    18.48  329.84 717.59    0.44
  1   193.42  707.27     --      --
 12     0.44    1.56     --      --
```

Print File: *Stop Loading Summary*

```
REPORT LINEVOLS   UserClass=Total
Name              Mode   Op                 ONs
      N              ON           OFF       VOL
-----------------------------------------------
Rt10 Shuttle        31    1      Ons=     20.53
-------------------------------------------
   2849          13.94             --     13.94
   2909             --             --     13.94
   2949           0.29           0.04     14.19
   2983             --             --     14.19
..........
   2816           0.01             --      9.84
   2690           0.74           0.86      9.72
   2633           0.69           0.76      9.65
......
   2800             --           0.14      5.59
   2799             --           0.14      5.45
   2849             --           5.47        --
```

At stop node 2949:

0.29 people get on the bus Rt10 Shuttle
0.04 people get off the bus
14.19 people on the bus go beyond the stop

The LINEO File

- The file contains all lines in the PT transit network
  - The lines data contain loading information (i.e., boardings, alightings, and line and link loads) at each node
  - This ASCII file can be used to summarize results

Example

```
LINE  NAME='Rt10 Shuttle' LONGNAME='Rt 10 Shuttle',
       HEADWAY=60 HEADWAY[2]=60 MODE=31 ONEWAY=1 OPERATOR=1 TIMEFAC=1 N=2849,
       ON=33 2 VOL=33 2 N=-2886 VOL=33 2 N=2909 ON=0 OFF[2]=0 VOL=33 2,
       N=-2922 VOL=33 2 N=2949 ON=0 0 OFF[2]=0 VOL=33 2 N=-2968 VOL=33 2,
       N=-2976 VOL=33 2 N=-2986 VOL=33 2 N=2983 VOL=33 2 N=-2984 VOL=33 2,
       N=2982 VOL=33 2 N=-2981 VOL=33 2 N=2990 VOL=33 2 N=2989 VOL=33 2,
       N=2988 VOL=33 2 N=2992 VOL=33 2 N=2993 ON=4 OFF=2 0 VOL=35 2,
       .........
       VOL=31 1 N=-2634 VOL=31 1 N=2646 ON=3 OFF=11 0 VOL=23 0 N=2672,
       OFF=2 0 VOL=21 0 N=2695 ON=0 OFF=0 VOL=21 0 N=2696 ON=2 OFF=1 0,
       VOL=22 0 N=-2697 VOL=22 0 N=2710 ON=0 OFF=1 0 VOL=22 0 N=2711,
       OFF=0 VOL=21 0 N=2730 OFF=0 VOL=21 0 N=2745 ON=0 OFF=0 VOL=22 0,
       N=2775 OFF=0 VOL=22 0 N=2777 OFF=0 VOL=21 0 N=2802 OFF=0 VOL=21 0,
       N=-2801 VOL=21 0 N=2800 OFF=0 VOL=21 0 N=-2797 VOL=21 0 N=2799,
       OFF=1 0 VOL=20 N=-2798 VOL=20 N=-2793 VOL=20 N=-2820 VOL=20,
       N=2849 OFF=20
```

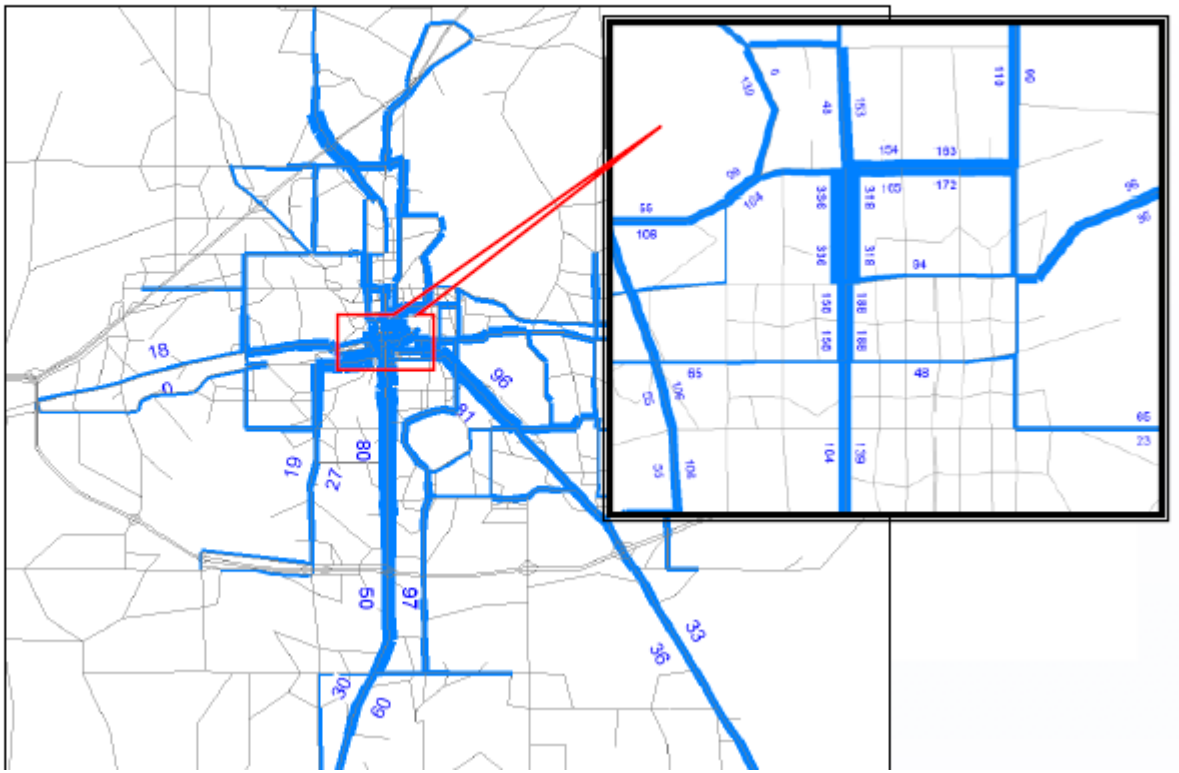
LINKO: *Summarizing & Displaying Results*

- LINKO DBFs are necessary to summarize the results when multiple assignments are done (for e.g., separate period assignments)
- DBI functionality in MATRIX module can be readily used to read DBF files

To get...	Use these keyword settings with LINKO...
Ons and Offs at each stop	NTLEGS=T, ONOFFS=T
Display transit loads on highway links	ONELINKREC=T, NTBYLINK=T

ONELINKREC: *Example of a Bandwidth Plot*

Shows transit volume on each street (thickness of the band width increases with increasing transit volume)



Stop2Stop

- PT script file

```
FILEO LINKO[1] = "{SCENARIO_DIR}\PSPTR01H.DBF"
FILEO STOP2STOPO[1] = "{SCENARIO_DIR}\Test_S2S_1.DBF",
 NODES=26-10000, ACCUMULATE=FIRSTLASTBYMODE
FILEO ROUTEO[1] = "{SCENARIO_DIR}\PSPTR01H.RTE",
```

- dBase Output File

I	J	FROMNODE	TONODE	MODE	ACCUM	VOL
1	2	789	804	2	4	1.58
1	2	791	804	2	4	5.13
1	2	792	804	2	4	1.28
1	2	10	804	2	4	8.03
1	2	1342	1342	1	4	3.84
1	2	1342	1343	1	4	7.99
1	2	1342	1344	1	4	2.84
1	2	1342	1345	1	4	2.62

Transit Assignment Summary

- Transfer between modes

All Modes

```
REPORT  XFERSUM=MODE  UserClass=1
MODE        1        2      100      200
-------------------------------------------
  1         --       -- 1,264.8    803.3
  2         --    471.4 2,591.4    995.1
100   1,294.9 2,561.2       --       --
200     773.1 1,025.3       --       --

MODE names:
  1 = Rail
  2 = Bus
100 = Walkcon
200 = Xfers
```

There 2 User Classes:
1=Walk Access
2=Drive Access

Transit Mode Only

```
REPORT  XFERSUM=TMODE  UserClass=1
TMODE       1       2
--------------------
  1     23.76  779.49
  2    749.37  717.14

MODE names:
  1 = Rail
  2 = Bus
```

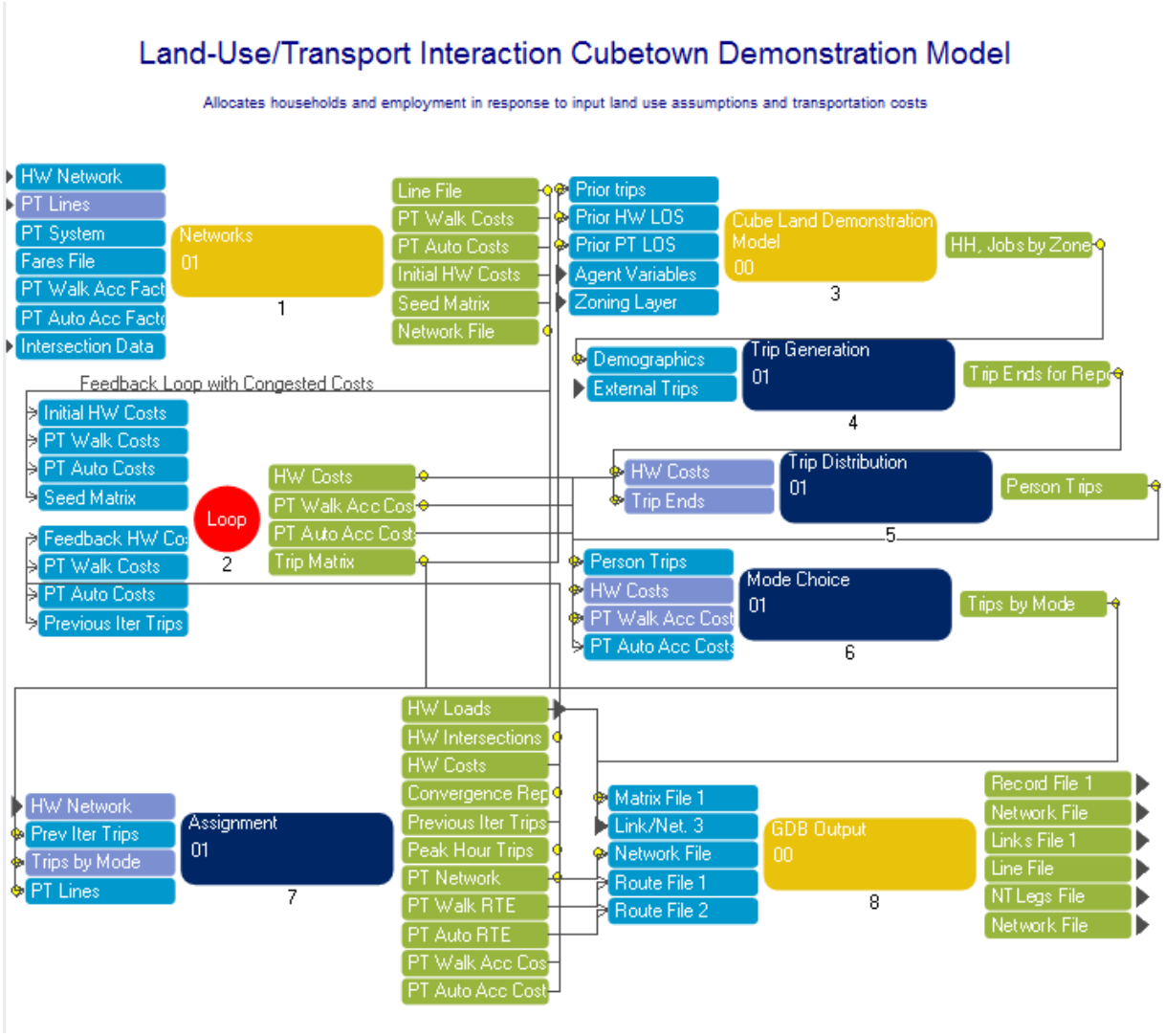
citilabs

Additional Information

citilabs

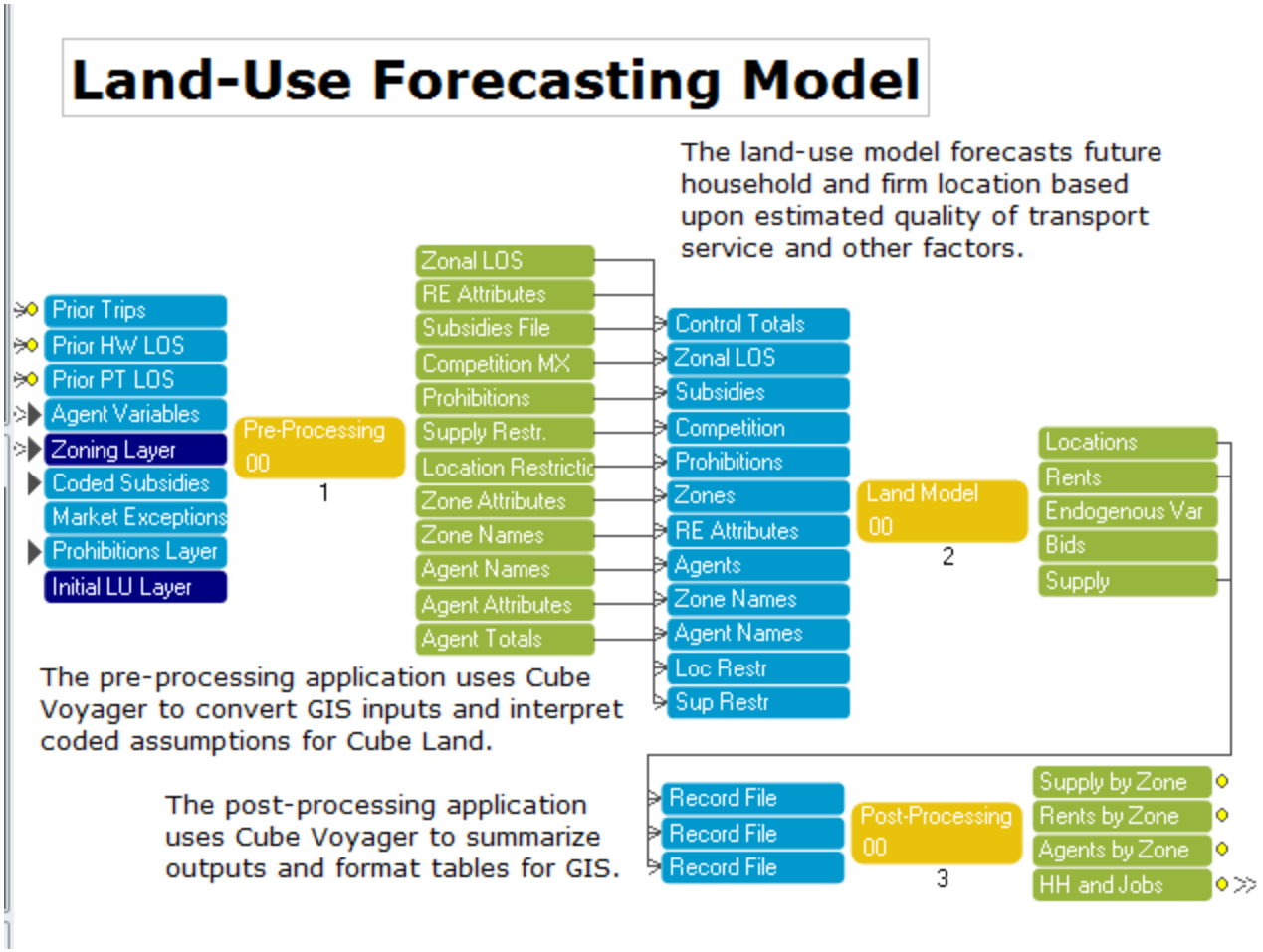
Land Use Model

Example of Land Use Model



citilabs

Example of Land Use Model

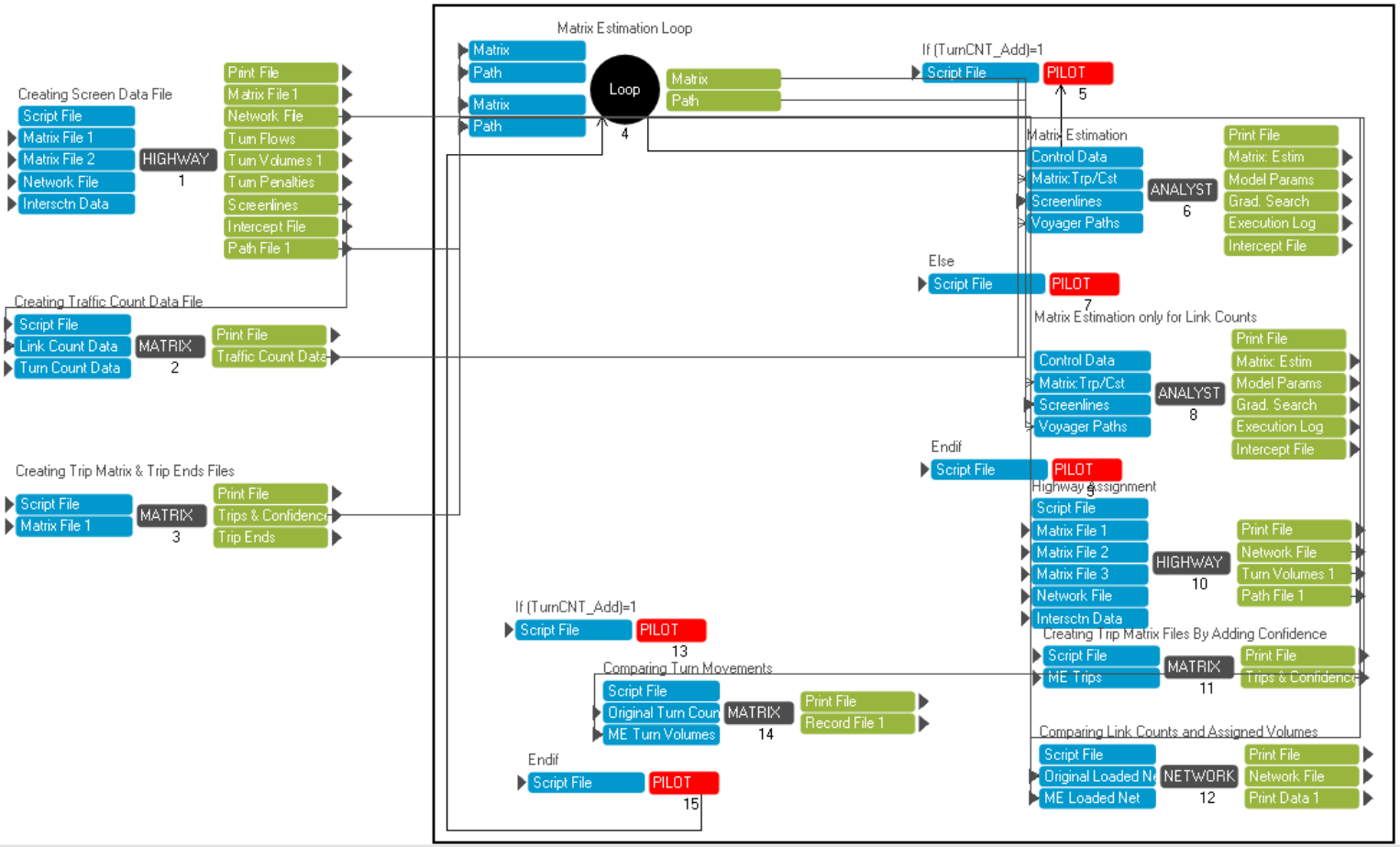


citilabs

O-D Estimation

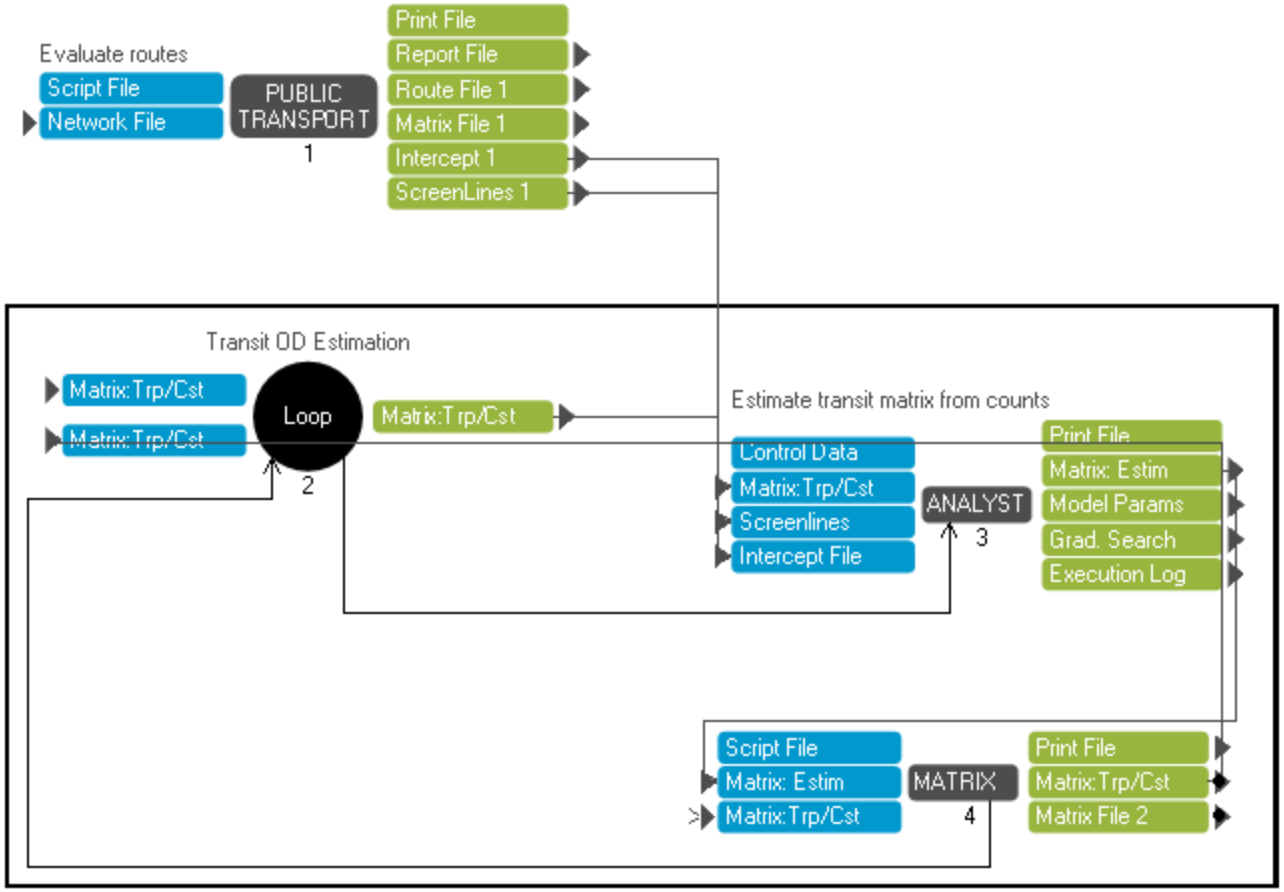
O-D Estimation for Auto

Matrix Estimation using Highway Path File in Cube Analyst



O-D Estimation for Transit

Public Transport O-D Estimation using Intercept File



Toll Analysis

Creating Toll Cost Matrices

- Notes:
  - `LINKIDARRAY=LI.TOLL,` `; link attribute`
  - `LINKIDCNTMW=3,` `; to store the number of toll links`
  - `LINKIDLASTUSE=4,` `; to store the toll cost in the last link`
  - `LINKIDMW=5-9` `; to store monotonic succession of link crossing information`

LINKIDARRAY		|S|	Specifies an array of link attributes; it must be either an LI.array or an LW.array.
LINKIDARRAY	**LINKIDCNTMW**	|I|	Specifies the MW[] in which to store the number of links in the list.
LINKIDARRAY	**LINKIDLASTUSE**	|I|	Specifies the MW[] in which to store the information for the last link in the list.
LINKIDARRAY	**LINKIDMW**	|IP|	List of MW numbers where the monotonic succession of link crossing information (beginning at 1) is to be stored. For example, `LINKIDMW=10-13,6,8` means that the first link's information will be stored in MW[10]; the second link's information will be stored in MW[11]; the fifth link's information will be stored in MW[6], and so on.
LINKIDARRAY	**LINKID#MW**	|IP|	List of MW numbers where the monotonic succession of numbers of the links (beginning at 1) is to be stored. For example, `LINKID#MW=10-13,6,8` means that the number of the first link will be stored in MW[10]; the second link will be stored in MW[11]; the fifth link will be stored in MW[6]. Link arrays can then be addressed directly by using these values. For example, `ANODE = A[MW[1]] xxx = LW.xyz[MW[2]].`

Creating Toll Entry/Exit Matrices

- Notes:
  - `LINKIDARRAY=LI.TOLL_LOC_NO,  ; link attribute`
  - `LINKIDMW=3,  ; Entry location for toll facility`
  - `LINKIDLASTUSE=4  ; Exit location for toll facility`

LINKIDARRAY		|S|	Specifies an array of link attributes; it must be either an LI.array or an LW.array.
LINKIDARRAY	**LINKIDCNTMW**	|I|	Specifies the MW[] in which to store the number of links in the list.
LINKIDARRAY	**LINKIDLASTUSE**	|I|	Specifies the MW[] in which to store the information for the last link in the list.
LINKIDARRAY	**LINKIDMW**	|IP|	List of MW numbers where the monotonic succession of link crossing information (beginning at 1) is to be stored. For example, `LINKIDMW=10-13,6,8` means that the first link's information will be stored in MW[10]; the second link's information will be stored in MW[11]; the fifth link's information will be stored in MW[6], and so on.
LINKIDARRAY	**LINKID#MW**	|IP|	List of MW numbers where the monotonic succession of numbers of the links (beginning at 1) is to be stored. For example, `LINKID#MW=10-13,6,8` means that the number of the first link will be stored in MW[10]; the second link will be stored in MW[11]; the fifth link will be stored in MW[6]. Link arrays can then be addressed directly by using these values. For example, `ANODE = A[MW[1]] xxx = LW.xyz[MW[2]].`

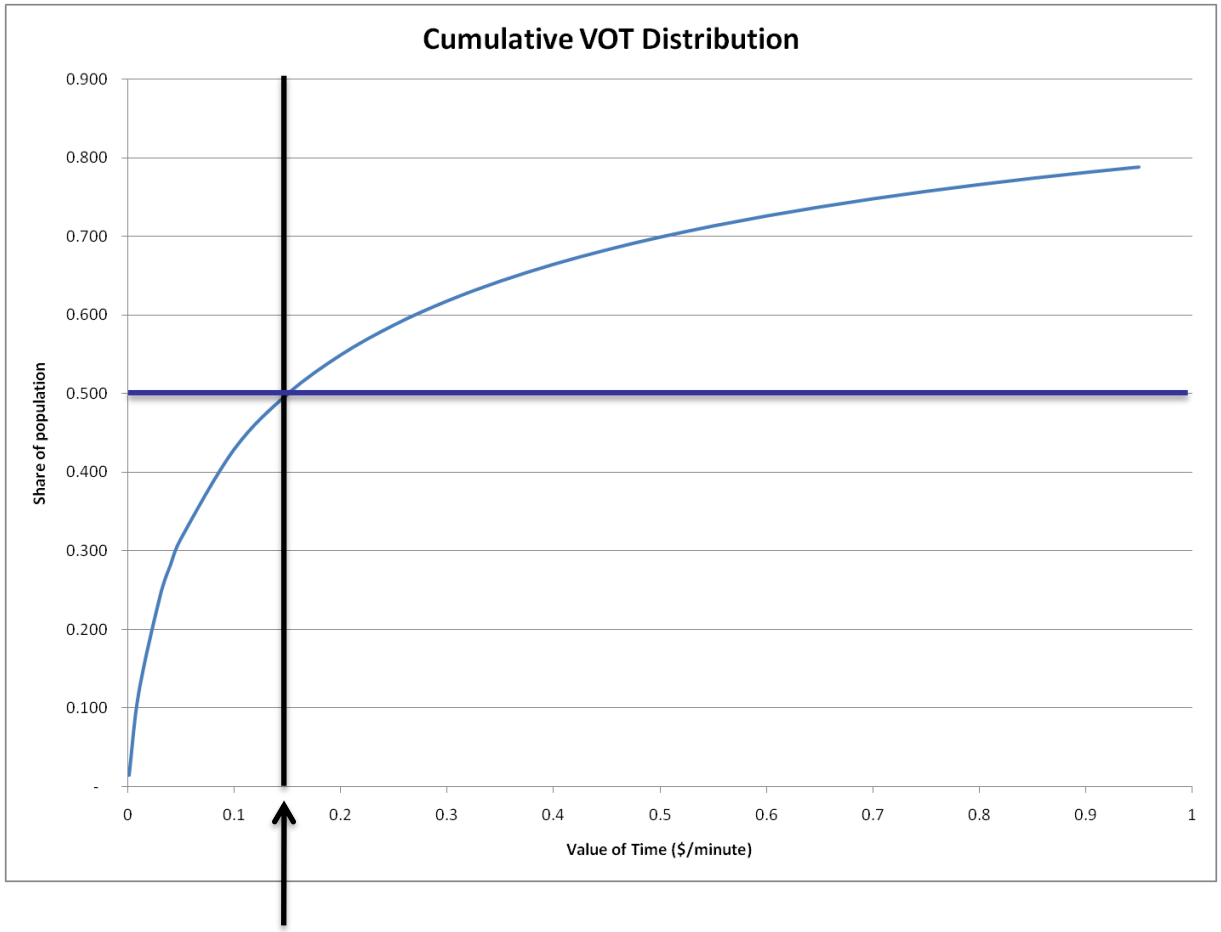
Distributed VOT Diversion Assignment

- Toll modeling technique based upon varying VOT with income
- Define a cumulative probability distribution function for VOT and determine what percentage of population is willing to pay the toll
- Statistical distributions
  - LOGNORMDIST, LOGNORMINV
  - NORMDIST, NORMINV
  - POISSONDIST, POISSONINV

```
PROCESS PHASE=LINKREAD
IF (li.LINKCLASS==1-2) LINKCLASS=2
IF (li.TOLL>0) ADDTOGROUP=1
ENDPROCESS
PROCESS PHASE=ILOOP
PATHLOAD PATH=COST, CONSOLIDATE=T,
 EXCLUDEGROUP=1, ; non-toll path
 MW[1]=PATHTRACE(TIME)
PATHLOAD PATH=COST, CONSOLIDATE=T,
 MW[2]=PATHTRACE(TIME),
 MW[3]=PATHTRACE(li.toll)
JLOOP
IF (MW[1]>MW[2])
MW[4] = MW[3]/(MW[1]-MW[2]) ; cost per minute saved
MW[5] = LogNormDist(MW[4],LOG(0.15),-1*LOG(0.10),1)
MW[6] = mi.1.1*MW[5] ; non-toll share
MW[7] = mi.1.1-MW[6] ; toll share
ELSE
MW[6] = mi.1.1
MW[7] = 0
ENDIF
ENDJLOOP
PATHLOAD  PATH=COST, CONSOLIDATE=T,
 EXCLUDEGROUP=1,
 VOL[1]=MW[6]
PATHLOAD  PATH=COST, CONSOLIDATE=T,
 VOL[2]=MW[7]
ENDPROCESS
```

Distributed VOT Assignment (2)

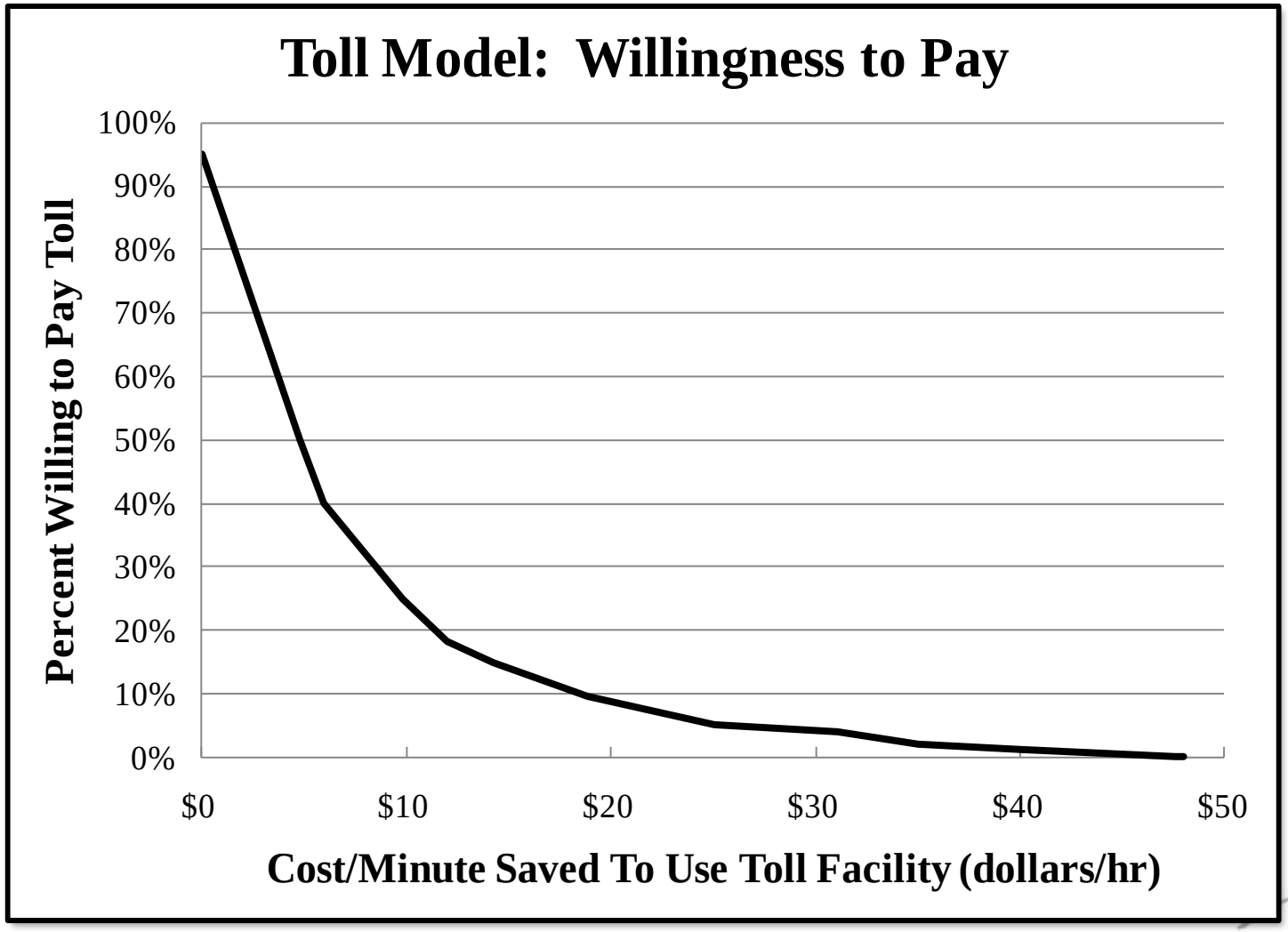
Return share with VOT less than cost per minute saved



Look up cost per minute saved for O-D pair

citilabs

Willingness-to-Pay Curve



Toll Diversion Logit Model

$$P_{toll} = \frac{1.0}{1.0 + e^{[a(T_{toll} - T_{free}) + b(C_{toll})]}}$$

where:

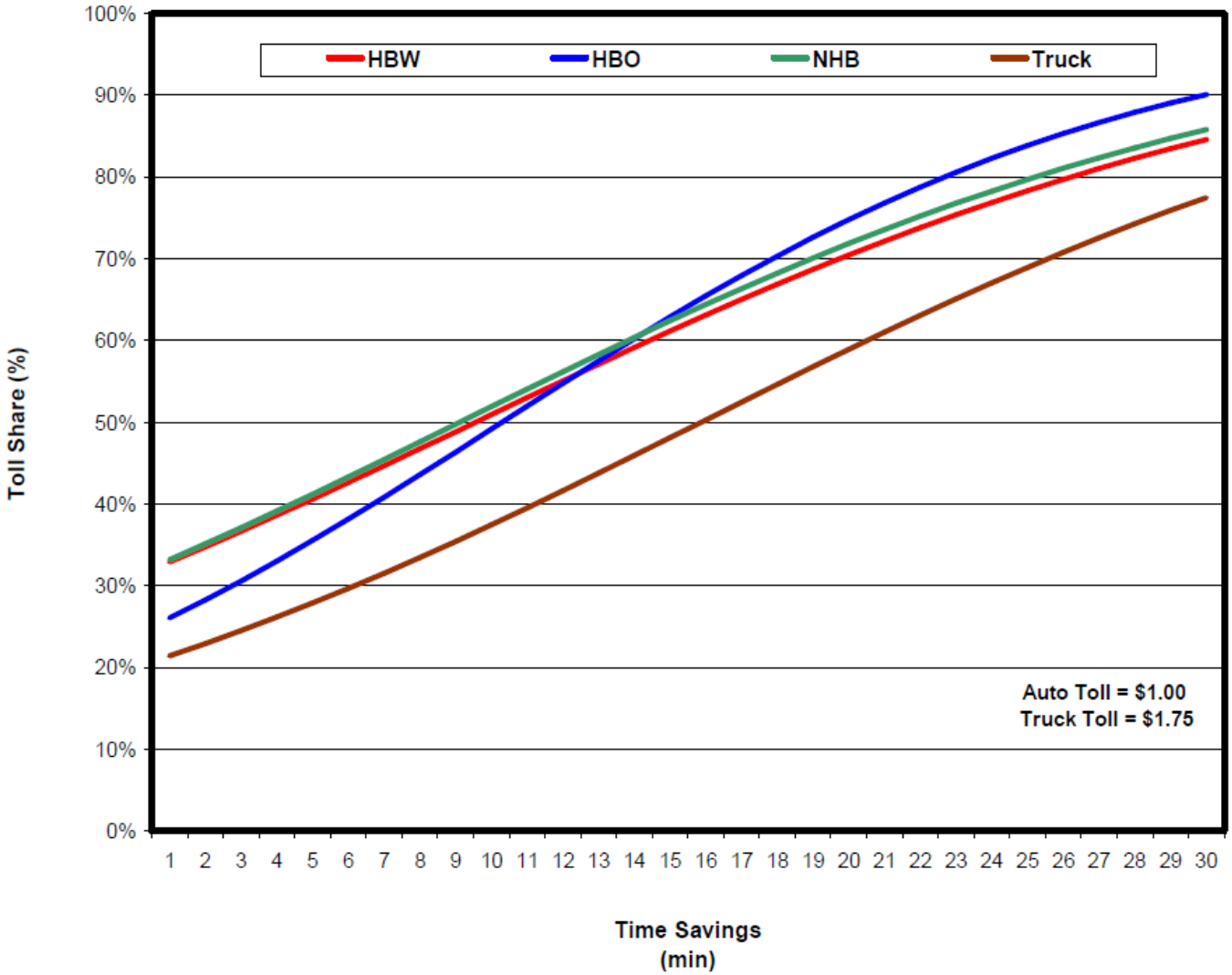
P_{toll}	=	Probability of utilizing the toll road route
T_{toll}	=	Travel time (minutes) via toll road route
T_{free}	=	Travel time (minutes) via free route
C_{toll}	=	Total toll (dollars) via the toll road route
a	=	Time calibration coefficient
b	=	Cost calibration coefficient

Toll Diversion Model Parameters

Toll Diversion Model Parameters

Trip Purpose / Mode	Time Coefficient (a)	Cost Coefficient (b)	Value of Time ($/hour)	Toll Bias Constant	Equivalent Penalty (min)
AUTO					
Home-Based Work	0.0833	3.4230	$16.06	0.4852	5.8
Home-Based Other	0.1122	0.5816	$11.57	0.5744	5.1
Non-Home-Based	0.0862	4.2470	$13.40	0.4002	4.6
TRUCK	0.0874	0.1757	$29.86	1.0800	12.4

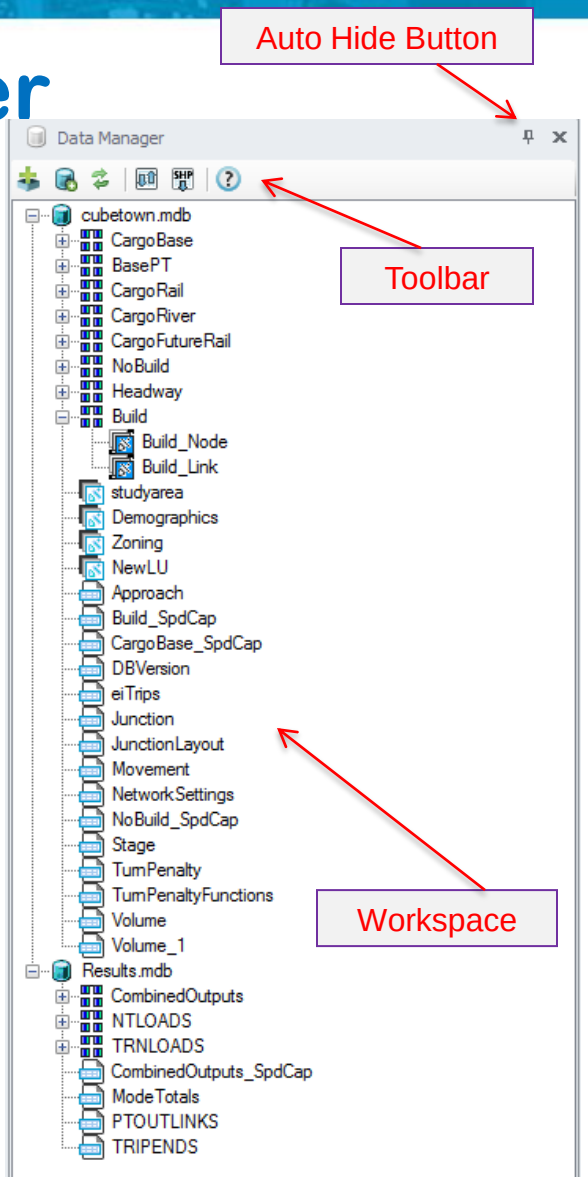
Sample of Toll Diversion Curves



Cube Geodatabase

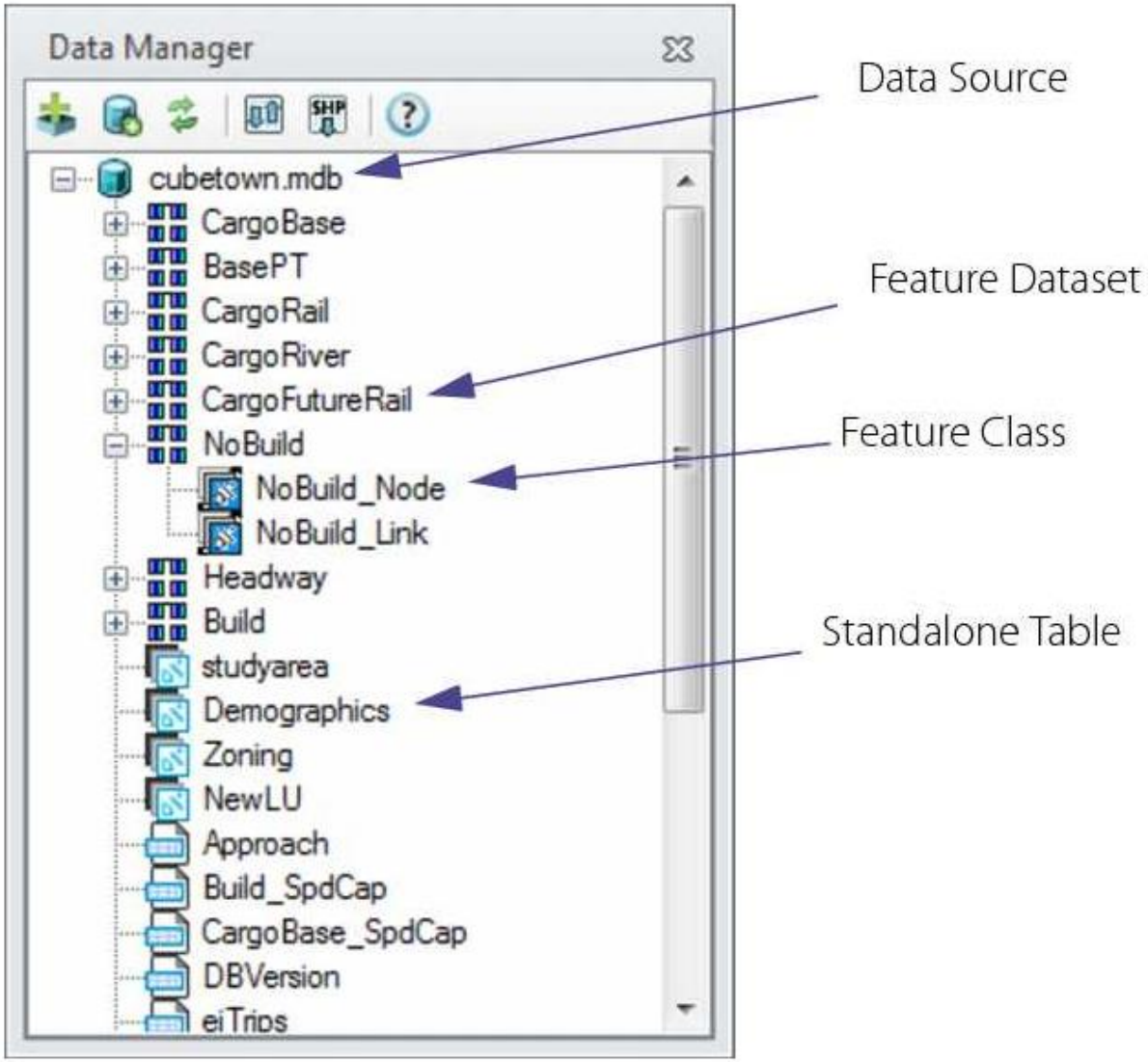
Anatomy of the Data Manager

- Toolbar buttons – provide access to commonly performed functions:
  - **Add Data** – to add a geodatabase or file folder to the workspace.
  - **Create Geodatabase** – to create a new file or personal geodatabase
  - **Refresh Workspaces** – Refresh all files and data currently shown in Data Manager
  - **Import/Export Data** – to import or export data to or from a geodatabase
  - **Build Network From Shape** – to build a Cube network from a feature class
  - **Help** — this help file
- Workspace – lists established connections to personal, file, and SDE geodatabases & their contents



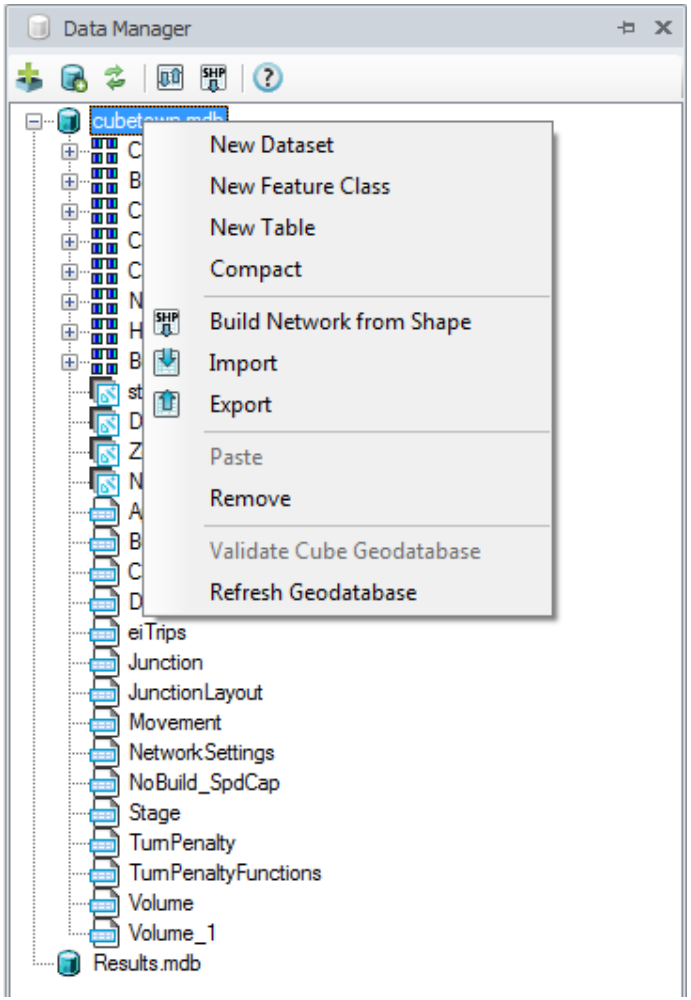
citilabs

Workspace


Data Manager
cubetown.mdb
CargoBase
BasePT
CargoRail
CargoRiver
CargoFutureRail
NoBuild
NoBuild_Node
NoBuild_Link
Headway
Build
studyarea
Demographics
Zoning
NewLU
Approach
Build_SpdCap
CargoBase_SpdCap
DBVersion
eiTrips
Data Source
Feature Dataset
Feature Class
Standalone Table

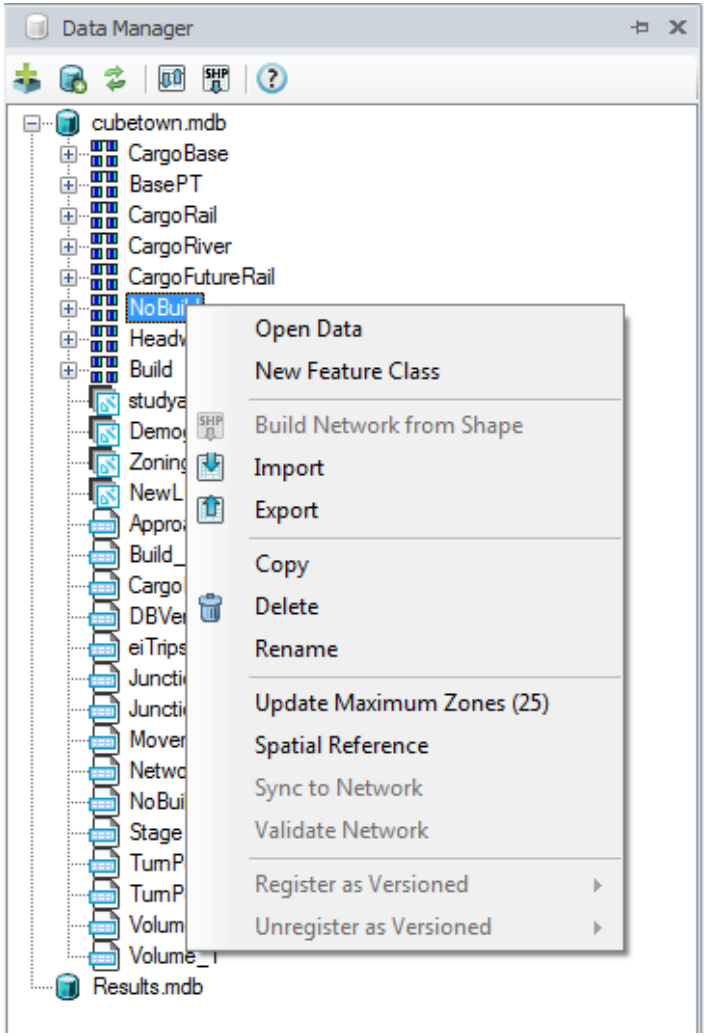
Geodatabase Command Menu

- New Dataset – Choose to add a new feature data set to a geodatabase
- New Feature Class – Create a new feature class
- New Table – Create a new table
- Compact – Compacting a Personal or File geodatabase
- Build Network from Shape – Create a new network feature data set from a line shape file
- Import, Export – Allow for the conversion of all supported input data types
- Remove – Remove the currently selected data
- Validate Cube Geodatabase – Convert a standard geodatabase to a Cube-compliant geodatabase

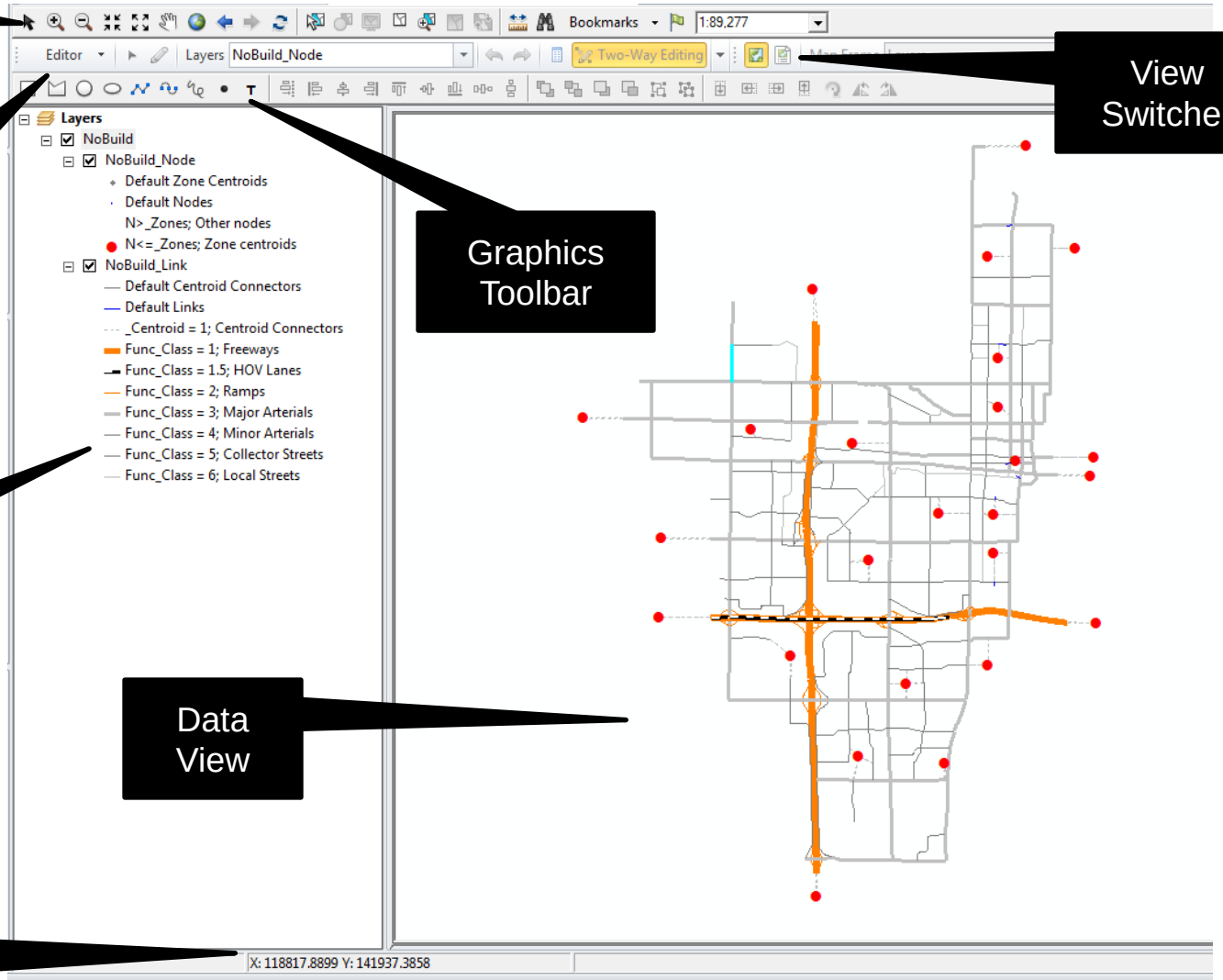


Feature Data Set Command Menu

- Open Data – Display the map of the feature data set
- New Feature Class – Create a new feature class
- Import, Export – Allow for the conversion of all supported input data types
- Copy – Copy the selected feature dataset or network to the clipboard
- Delete – Deletes the content from the geodatabase
- Rename – Change the name of the feature dataset or network
- Update Maximum Zones (#) – Opens a dialog box for modifying the maximum number of TAZ
- Spatial Reference – Display the spatial reference of the feature data set



GIS Window Components



Cube 6

Thank you!

Heejoo Ham – Citilabs
hham@citilabs.com

citilabs