CCRPC Land Use & Travel Demand Model Training

Technical Training Session Handout

Chittenden County Metropolitan Planning Organization

Chittenden County Regional Planning Commission

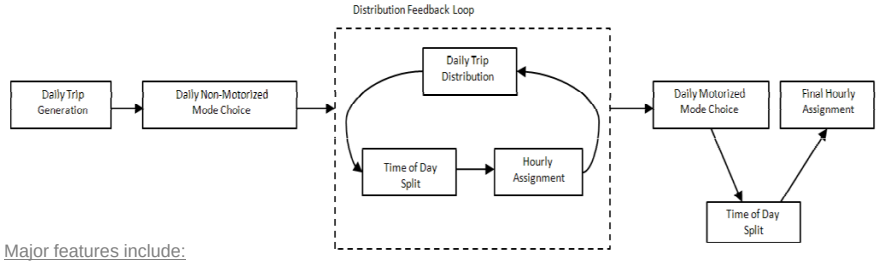
September 7, 2011
CCRPC Main Conference Room

What to Expect from this Training

- Introduction to the new CCMPO Daily regional travel demand model (*Version 3.2.0*)
- Detailed examination of each of the main model components including:
  - Trip Generation
  - Trip Distribution
  - Mode Choice
  - Vehicle Assignment
  - Land Use Allocation
- Provide this audience with enough information to better understand model strengths and model weaknesses, as well as how/when/why to utilize the model for certain regional planning applications

Overall Model Structure

- Traditional 4-Step travel demand model process
  - With pre-distribution non-motorized mode choice module
- Distribution-Assignment feedback loops ensure agreement between travel times input to distribution and those produced by assignment
- Mode Choice step was deliberately not included in D-A feedback since transit usage in the region is low

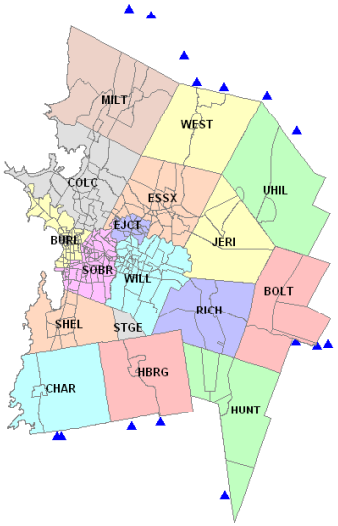


Major features include:
--Daily model with 24-hourly assignments
--Link & Intersection Delay are represented
--Includes a Land Use Allocation Module
--Includes a Medium/Heavy Truck Model

TRIP GENERATION

- Transportation Analysis Zone (TAZ) Structure
- Estimation and Methodology
- Assumptions
- General Usage Guidelines

TRIP GENERATION – TAZ Structure



- 352 Traffic Analysis Zones
  - 335 internal TAZs representing 19 cities and towns
  - 0.62 TAZs per square mile
  - 17 external TAZs representing major points of entry
- 58,336 households (2005)
  - Source – CCRPC 'Grand List'

		# of Vehicles			
		0	1	2	3+
Household size	1	4%	18%	2%	0%
	2	1%	9%	21%	4%
	3	1%	3%	8%	4%
	4+	0%	3%	13%	7%

- 93,217 employees (2005)
  - Source – InfoUsa, VT DET
  - *Retail*
  - *Commercial*
  - *Industrial*
  - *Institutional*
  - *K-12*
  - *Accommodations*
  - *College_Univ*
  - *Special Retail*
  - *Special Commercial*

TRIP GENERATION – Trip Productions

- Trip Production model structure:
  - 3 internal passenger trip purposes
  - 3 commercial trip purposes (trucks)
  - 3 external trip purposes

Trip Type	Abbreviation	Description
Home Based Work	HBW	A trip where one end is home and the other end is work
Home Based Other	HBO	A trip where one end is home and the other end is NOT work
Non Home Based	NHB	A trip where neither end is home.
Light Commercial	L_Comm	A trip made by a commercial vehicle with 4 tires.
Medium Commercial	M_Comm	A trip made by a commercial vehicle with 6 tires.
Heavy Commercial	H_Comm	A trip made by a commercial vehicle with >6 tires.
Internal to External	IX	A trip originating inside of the model and terminating outside of the model zone geography.
External to Internal	XI	A trip originating outside of the model zone geography and terminating inside of the model.
External to External	XX	A trip originating and terminating outside of the model geography, but passing through the model en route.

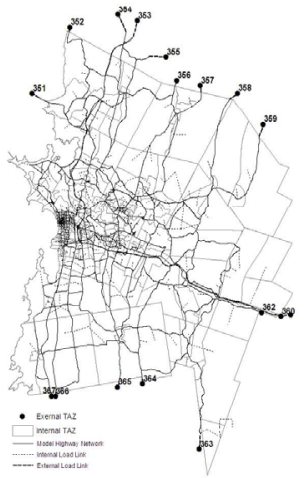
TRIP GENERATION – Trip Productions

- Base Year Trip Production model yields roughly 774,200 daily trips

Trip Type	# of Trips	% of Total
Home Based Work	77,800	10.0%
Home Based Other	253,600	32.8%
Non Home Based	232,400	30.0%
Light Commercial	101,400	13.1%
Medium Commercial	12,500	1.6%
Heavy Commercial	3,000	0.4%
Internal to External	33,000	4.3%
External to Internal	58,700	7.6%
External to External	1,800	0.2%
Total Person Trips	774,200	100.0%

TRIP GENERATION – External Travel

- Total [IX, XI and XX] trips are set to match base year traffic count data at the external stations
- XX was derived from an I-89 license plate study - applied as a fixed input trip table
- IX trips are estimated using 2000 Census data and vary by town
- XI trips are estimated based on total attractions in each TAZ and the distance from the external station (*distributed using the gravity model*)
- External trips account for 12% of total demand and 40% of network VMT
- User-specified growth rate for external trips is applied for future year analyses (e.g. 1% per year or based on regression of historical counts)



TRIP DISTRIBUTION

- Traditional doubly-constrained gravity model for all trip types
  - External trips are singly constrained

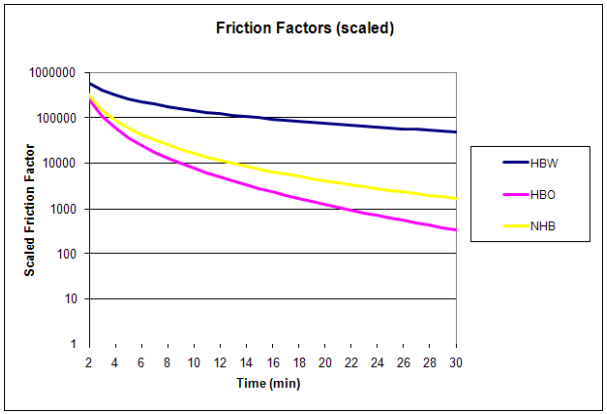
$$T_{ij} = P_i * \frac{A_j * f(d_{ij})}{\sum_{\text{all zones } z} A_z * f(d_{iz})} \quad \text{(Constrained to Productions)}$$

$$T_{ij} = A_j * \frac{P_i * f(d_{ij})}{\sum_{\text{all zones } z} P_z * f(d_{iz})} \quad \text{(Constrained to Attractions)}$$

Where:	T_{ij}	=	the forecast flow produced by zone *i* and attracted to zone *j*
	P_i	=	the forecast number of trips produced by zone *i*
	A_j	=	the forecast number of trips attracted to zone *j*
	d_{ij}	=	the impedance between zone *i* and zone *j*
	$f(d_{ij})$	=	the friction factor between zone *i* and zone *j*

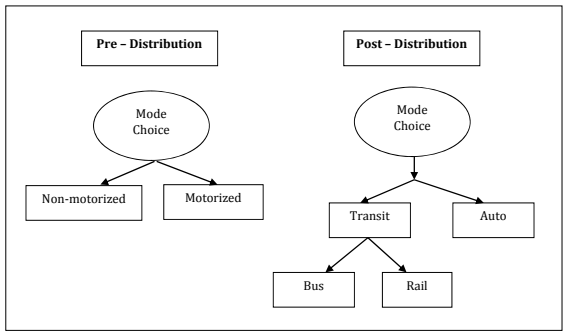
TRIP DISTRIBUTION

- Friction Factors by Trip Purpose (HBW, HBO, NHB)



MODE CHOICE

- Two mode choice models are applied:
- Pre-Distribution binomial logit model
  - Urban form variables (household, employment, and intersection density) are used to derive the share of walk/bike non-motorized trips
  - These trips are removed from the PA matrices leaving only motorized trips for distribution
- Post-Distribution nested multinomial logit model
  - Uses common variables such as IVTT, OVTT, Distance, Cost and Access/Egress times
  - No Rail in the region currently although the model contains this functionality



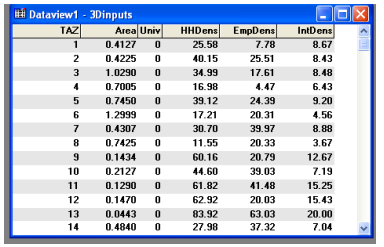
MODE CHOICE

- Pre-Distribution binomial logit model
  - Urban form variables (household, employment, and intersection density) are used to derive the share of walk/bike non-motorized trips
  - These trips are removed from the PA matrices leaving only motorized trips for distribution

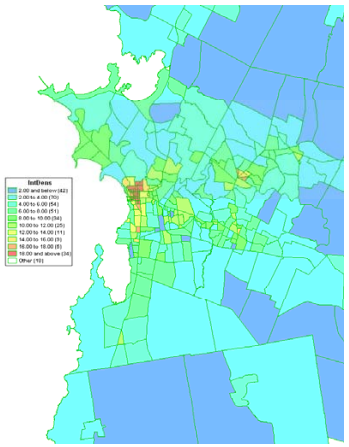
$$V_i = \alpha + \beta_1 University + \beta_2 HH\_DENS + \beta_3 EMP\_DENS + \beta_4 INT\_DENS$$

i = walk/bike

Non-motorized	β_1	β_2	β_3	β_4	α
HBW	1.0	0.0035	0.007	0.0025	-3.2
HBW	1.0	0.0035	0.007	0.0025	-2.6
HBW	1.0	0.0035	0.007	0.0025	-5.4


Dataview1 - 3Dinputs

TAZ	Area	Univ	HHDens	EmpDens	IntDens
1	0.4127	0	25.58	7.78	8.67
2	0.4225	0	40.15	25.51	8.43
3	1.0290	0	34.99	17.61	8.48
4	0.7005	0	16.98	4.47	6.43
5	0.7450	0	39.12	24.39	9.20
6	1.2999	0	17.21	20.31	4.56
7	0.4307	0	30.70	39.97	8.88
8	0.7425	0	11.55	20.33	3.67
9	0.1434	0	60.16	20.79	12.67
10	0.2127	0	44.60	39.03	7.19
11	0.1290	0	61.82	41.48	15.25
12	0.1470	0	62.92	20.03	15.43
13	0.0443	0	83.92	63.03	20.00
14	0.4840	0	27.98	37.32	7.04



MODE CHOICE

- Post-Distribution nested multinomial logit model
  - Uses common variables such as IVTT, OVTT, Distance, Cost and Access/Egress times
  - Separate work (HBW) and non-work (HBO & NHB) mode choice models
  - No Rail in the region currently although the model contains this functionality

$$V_i = \alpha + \beta_1 WalkTime + \beta_2 PeakIVTT + \beta_3 \text{OVTT} + \beta_4 \text{Distance} + \beta_5 \text{Cost} + \beta_6 \text{XFer}$$
$$i = \text{auto, bus, rail}$$

Work Mode Choice Parameters

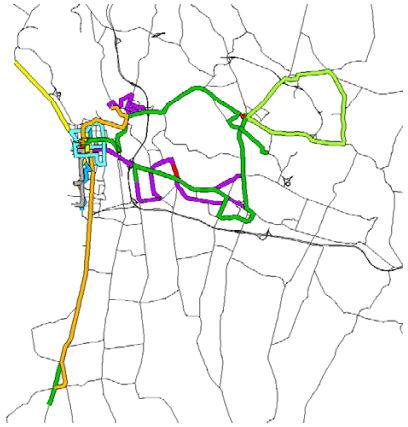
Parameters	Auto	Bus	Rail
Logsum coefficient(s)	*0.75*	*0.75 / 0.50*	*0.75 / 0.50*
Constant	--	-1.246	-1.558
WalkTime	--	-0.04	-0.04
PeakIVTT	-0.02	-0.02	-0.016
OVTT	-0.04	-0.04	-0.04
Distance	--	--	--
Cost	-0.02	-0.2	-0.2
Xfer	--	-0.2	-0.16

Non-Work Mode Choice Parameters

Parameters	Auto	Bus	Rail
Logsum coefficient(s)	*0.75*	*0.75 / 0.50*	*0.75 / 0.50*
Constant	--	-1.886	-2.070
WalkTime	--	-0.04	-0.04
PeakIVTT	-0.015	-0.02	-0.016
OVTT	-0.03	-0.04	-0.04
Distance	--	--	--
Cost	-0.02	-0.2	-0.2
Xfer	--	-0.2	-0.16

MODE CHOICE – Transit Network

- Variables in the mode choice model are derived by skimming the transit network to calculate zone-to-zone transit shortest path travel impedances
- CCTA Bus Routes are represented as individual Inbound & Outbound routes



Dataview2 - Routes

Route_ID	Route_Name	Track	Time	Distance	Mode	Headway
1	UMall/Airport OB	1	6.44	1.00	1	30
2	UMall/Airport IB	2	5.99	1.00	1	30
6	South End/Shelburne OB	6	8.66	1.00	1	10
7	South End/Shelburne IB	7	8.68	1.00	1	10
8	North Ave OB	10	3.87	1.00	1	10
9	North Ave IB	11	6.27	1.00	1	10
12	College Street Shuttle OB	18	1.62	1.00	1	10
13	College Street Shuttle IB	19	1.47	1.00	1	10
14	PARC South IB	20	1.72	1.00	1	10
15	PARC South OB	21	1.65	1.00	1	10
16	Williston OB	22	10.07	1.00	1	15
17	Williston IB	23	8.95	1.00	1	15
18	South MEadows OB	24	2.94	1.00	1	20
19	South Meadows IB	25	3.05	1.00	1	20
20	Ledgewood OB	28	2.53	1.00	1	15
21	Ledgewood IB	29	3.29	1.00	1	15
22	ONE loop	30	5.27	1.00	1	10
23	Essex Center Loop	5	9.16	1.00	1	10
24	Essex Junction IB	4	7.24	1.00	1	15
25	Riverside/Winooski OB	16	6.15	1.00	1	15
26	Essex Junction OB	3	10.62	1.00	1	15
27	Riverside/Winooski IB	17	3.43	1.00	1	15

TIME OF DAY MODELS

- Diurnal Distributions are applied in conjunction with auto occupancy factors to convert daily P-A format person trip matrices to hourly O-D format vehicle trip matrices which are assigned onto the highway network.

Auto Occupancy Factors

Trip Purpose	2009 NHTS Chittenden County	2009 NHTS Vermont	2009 NHTS National	**Model**
HBW	1.07	1.07	1.12	**1.15**
HBO	1.51	1.55	1.71	**1.81**
NHB	1.40	1.35	1.84	**1.52**

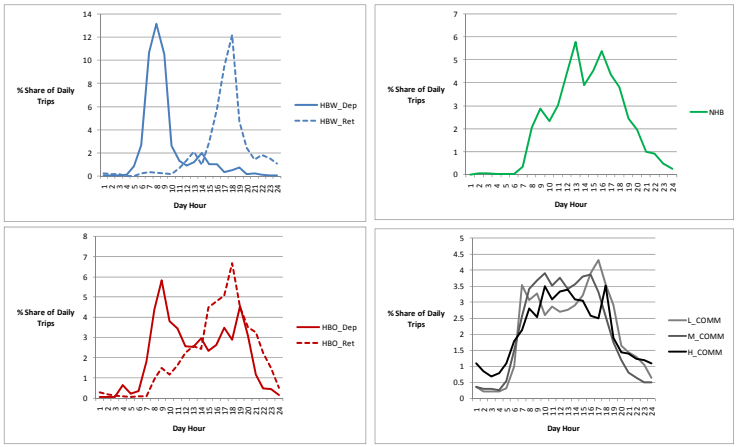
1,000 person trips x (1.15 persons/vehicle) = 870 vehicle trips

1,000 person trips x (1.81 persons/vehicle) = 552 vehicle trips

1,000 person trips x (1.52 persons/vehicle) = 658 vehicle trips

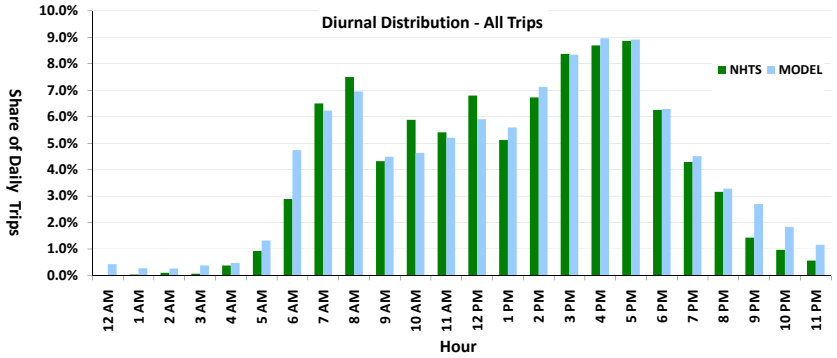
TIME OF DAY MODELS

- Diurnal Distributions are specified for each trip purpose in the file *hourlyLookupTable.bin*
- Unique shares for departing and returning trip directions



TIME OF DAY MODEL

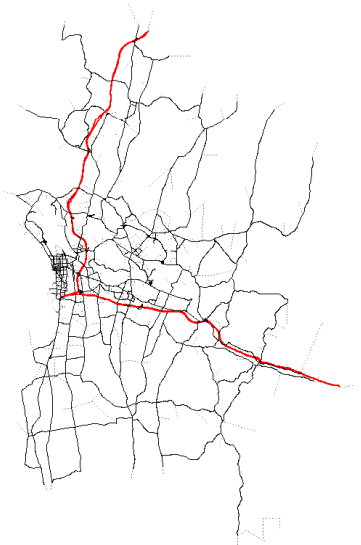
- Validation of Time of Day Models
  - Is the model predicting the right amount of regional vehicle travel over the course of an entire average weekday?
  - Compare Model versus NHTS Trips by Purpose by Time of Day



Base Year Inputs – Highway Network

Facility	Links	Lane Miles	% Share
Interstate	66	166	11%
Limited Access Hwy	18	18	1%
Principal Arterial	285	159	10%
Minor Arterial	178	163	11%
Major Collector	163	174	11%
Urban Local	54	165	11%
Rural Major Collector	313	305	20%
Ramps	80	18	1%
Internal Centroid	530	325	21%
External Centroid	17	32	2%
Total	1,704	1,523	100%

Facility	Speed (mph)	Capacity (vphpl)
Interstate	65	1,900
Limited Access Hwy	50	1,900
Principal Arterial	45	1,600
Minor Arterial	35	1,200
Major Collector	35	800
Urban Local	25	800
Rural Major Collector	30	650
Ramps	35	1,170
Internal Centroid	15	5,000
External Centroid	30	5,000



Source: TransRoads_RDS layer from VT Center for Geographic Information

VEHICLE ASSIGNMENT

- User Equilibrium vehicle assignment
- Multi-Class assignment – Autos, Medium Trucks, Heavy Trucks
- Model includes delay from five sources
  - Volume-dependant link delays
  - Volume-dependant node delays
  - Global turn penalties – 10 seconds per left turn
  - Facility Type penalties – 60 seconds for ramp access from surface streets to reduce short interstate trips
  - Specific Turn prohibitions
- Logit-Based Volume-Delay Function (built-in TransCAD IITPR.vdf)

$$d = D_l + I_l$$

$$D_l = t_0 \cdot c_1 \left[\frac{1}{1 - \frac{c_2}{1 + exp\left(c_3 - c_4 \cdot \frac{x}{C}\right)}} \right] \qquad I_l = d_0 \cdot p_1 \left[1 + \frac{p_2}{1 + exp\left(p_3 \cdot p_4 \cdot \frac{x}{X}\right)} \right]$$

Where:

D_l = link delay
t_0 = freeflow travel time
x = traffic flow
C = link capacity
c_1, c_2, c_3, c_4 = link parameters

I_l = node delay
d_0 = freeflow travel time of intersection
x = traffic flow
X = node capacity
p_1, p_2, p_3, p_4 = node parameters

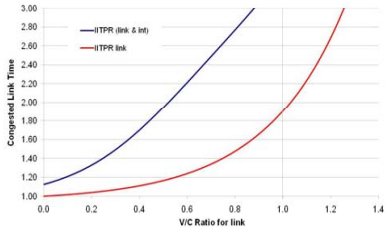
VEHICLE ASSIGNMENT

- Volume-Delay Function Parameters

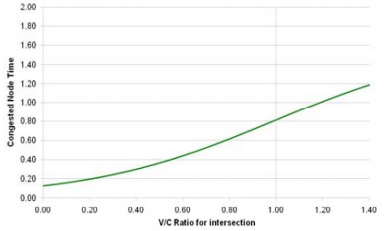
LinkClass	Class Type	Speed	CapPerLane	c1	c2	c3	c4	p1	p2	p3	p4
1	Interstate	65	1,900	1.0	1.0	6.5	6.3	0.04	500	3.0	3.0
2	Limited Acces Highway	50	1,900	1.0	1.0	6.5	6.3	0.04	500	3.0	3.0
3	Principal Arterial	45	1,600	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
4	Minor Arterial	35	1,200	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
5	Major Collector	35	800	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
6	Urban Local	25	800	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
7	Rural Major Collector	30	650	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
8	Ramps	35	1,170	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
9	Internal Load Link	15	5,000	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
10	External Load Link	30	5,000	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
11	Special Use	40	1,600	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
12	Special Use 2	50	1,820	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
15	Special Use 3	40	900	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
18	Commuter Rail	55	900	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0
19	PNR Access	25	650	1.0	1.0	3.0	3.0	0.04	500	3.0	3.0

Capacity = LOS C-D Threshold

Link Delay and Total Delay for non-Freeway Facility



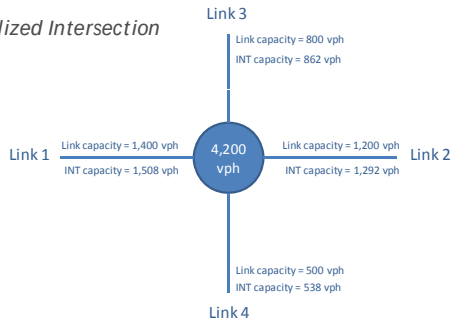
Node Delay for non-Freeway Facility



VEHICLE ASSIGNMENT

- Allocation of Intersection Capacity to Links
  - Based on intersection configuration capacity lookup table
  - Different rules applied for signalized versus un-signalized intersections
    - *All intersection delay is assigned to minor leg(s) with stop control*

Signalized Intersection



Link Segment	Link Capacity (vph)	Share	Node Capacity (vph)	INT Capacity (vph)
1	1,400	36%		1,508
2	1,200	31%	x 4200 =	1,292
3	800	21%		862
4	500	13%		538
Total	3,900	100%		4,200

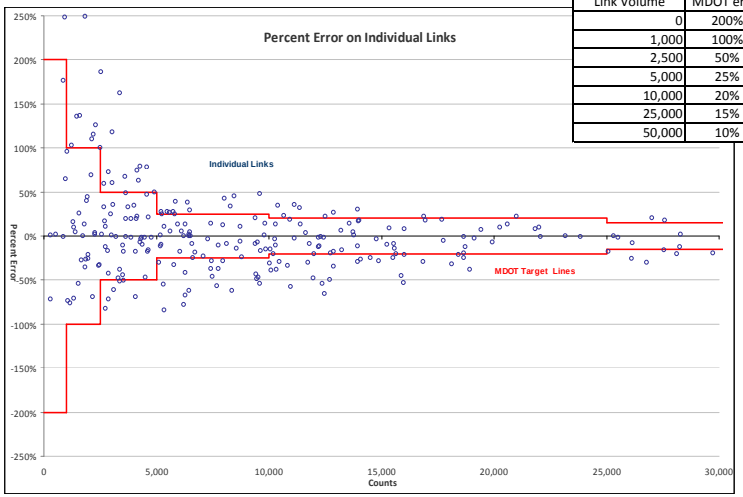
Sample of lookup table

	Minor Lane Group	
Major Lane Group		Single
	Single	2100
	Left Turn Bays	2700
	Left & Right Turn Bays	3100
	Left + 2 Through	3675
	Left, Right, & 2 Through	4125

VEHICLE ASSIGNMENT

- Scattergrams to illustrate individual link errors

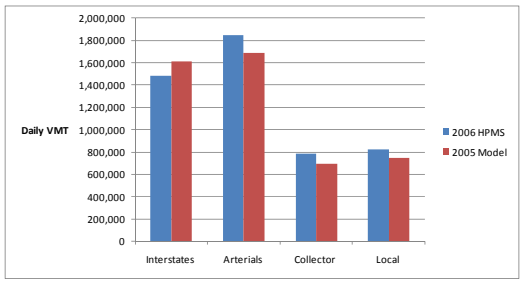
(Upper Bound) Link Volume	MDOT error
0	200%
1,000	100%
2,500	50%
5,000	25%
10,000	20%
25,000	15%
50,000	10%



VEHICLE ASSIGNMENT

- Comparisons against Highway Performance Monitoring System (HPMS) estimates of total regional daily VMT

Facility Type	2006 HPMS Ave Daily VMT	2005 Model VMT
Interstates	1,486,680	1,615,444
Arterials	1,848,952	1,690,501
Collector	782,123	693,263
Local	825,693	748,476
Total	4,943,448	4,747,684



TRUCK MODEL

- The CCMPO daily travel model includes a truck component
- Commercial vehicle trips are tracked through trip generation and distribution. Medium and Heavy trucks are assigned separately from auto and light trucks using multi-class vehicle assignment
- Truck Model includes:

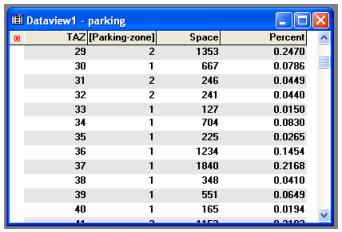
Light Commercial (4-tires)
Eg. Plumber's van
L_COMM

Medium Commercial (6-tires)
Eg. Box rental truck
M_COMM

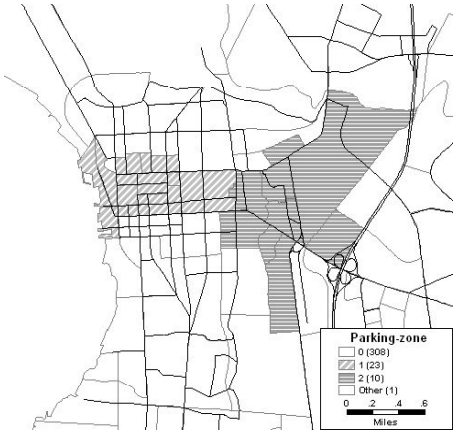
Heavy Commercial (6+ tires)
Eg. Tractor trailer
H_COMM

PARKING RE-ALLOCATION MODEL

- Can be used to represent parking re-allocation areas and implementation of shuttle lot facilities
- *Parking.bin* is used to identify TAZs that functionally share parking as parking zones (travelers do not always park at their final destination – park then walk)

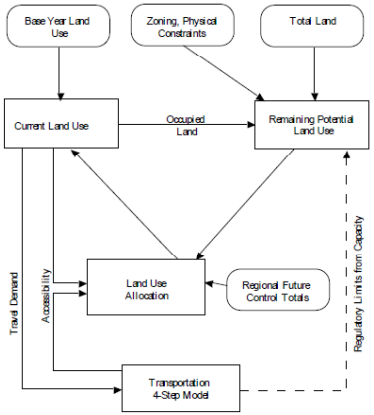


TAZ	[Parking-zone]	Space	Percent
29	2	1353	0.2470
30	1	667	0.0786
31	2	246	0.0449
32	2	241	0.0440
33	1	127	0.0150
34	1	704	0.0830
35	1	225	0.0265
36	1	1234	0.1454
37	1	1840	0.2168
38	1	348	0.0410
39	1	551	0.0649
40	1	165	0.0194

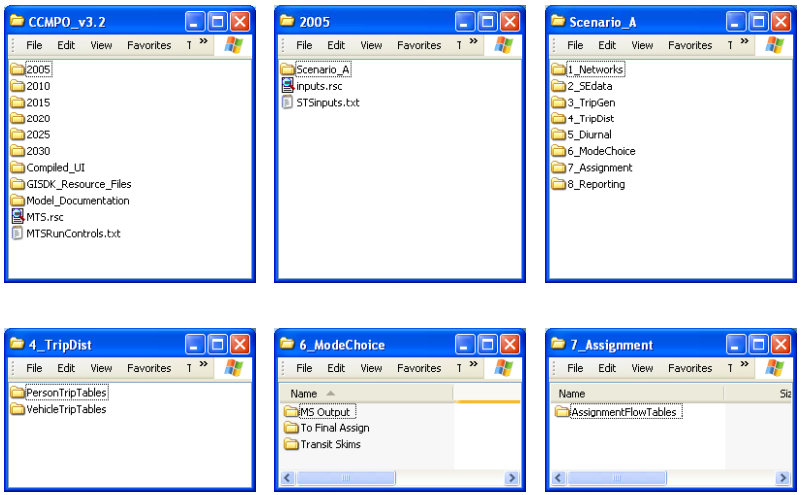


Land Use Allocation Module

- Land Use Allocation Module (LAUM) allocates housing and employment to TAZs based on:
  - Availability of land in each TAZ (*allowable*)
  - Land uses already in place (*existing*)
  - Permitted land uses already in place (*permitted*)
  - Accessibility of each TAZ (composite impedances) calculated by the mode choice models
  - User-defined county-wide future analysis year control totals

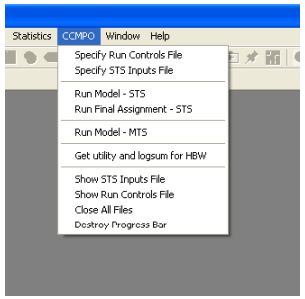


MODEL DIRECTORY STRUCTURE



Running the Travel Model

- CCMPO Model is executed in TransCAD v5.0 (Build 1545)
- Model is fully automated via a series of GISDK scripts that perform trip generation, distribution, mode choice, and assignment as well as input/output processing
- As a Multi-Time Step (MTS) run which integrates the Land Use Allocation Module and processes a number of future analysis years using user-specified time increments (typically 5-yr)
- CCMPO Model can be executed as a Single-Time Step (STS) run which processes a single analysis year
- CCMPO Model GUI adds a menu option to the standard TransCAD menu bar with inputs specified via a master control input text file




```
// ************************************************************************
//                    TRANSCAD Run Controls
// ************************************************************************
// Specifiy array of nodes to record turning movements
// ************************************************************************
// 1 = Create turning movements output,
g_TM_nodes      =  {380, 381, 1134, 535, 539, 704, 525, 435}
// ************************************************************************
// Specify Name of Assignment Query File
// ************************************************************************
// Query file
g_assignQueryFileName  =  "selectLinkQuery.qry"
// ************************************************************************
// Specify Names of Other Inputs/Outputs
// ************************************************************************
// Highway Network
g_highway_Array = {"CCMPO_Highways_2005.dbd",
// ************************************************************************
```

FUTURE WORK & WRAP-UP

- Peer Review Process & Findings
- Future Improvements
- Model Release Agreements
- CCRPC Modeling Website
- Other questions

Model Release Agreements

CCRPC asks for a signed agreement prior to releasing model files to interested parties

- Requires documentation of any model changes to obtain CCRPC support of work
- Requests any improvements be provided back to CCRPC for potential inclusion in future model updates
- Limited availability of CCRPC staff for assistance
- Delivery of model files includes 2005 base year model and networks associated with the 2030 Metropolitan Transportation Plan (now in the update process)

CCRPC Modeling Website

- Summarizes CCRPC modeling efforts
- Includes documentation of new model releases
- Check with CCRPC staff before starting any major analyses to ensure you have the most current information

http://www.ccmpo.org/modeling/

Other Questions & Discussion

- Short Demo Depending on Time Availability
  - Demonstration of how to set up MTS and then an STS for a scenario
  - Show Flow Map of output
  - Show Attribute Table of output
    - Assignment flow tables of hourly volumes
- Specific questions ?
  - Model uses ?
  - Model runtime ?
- To be driven by the audience